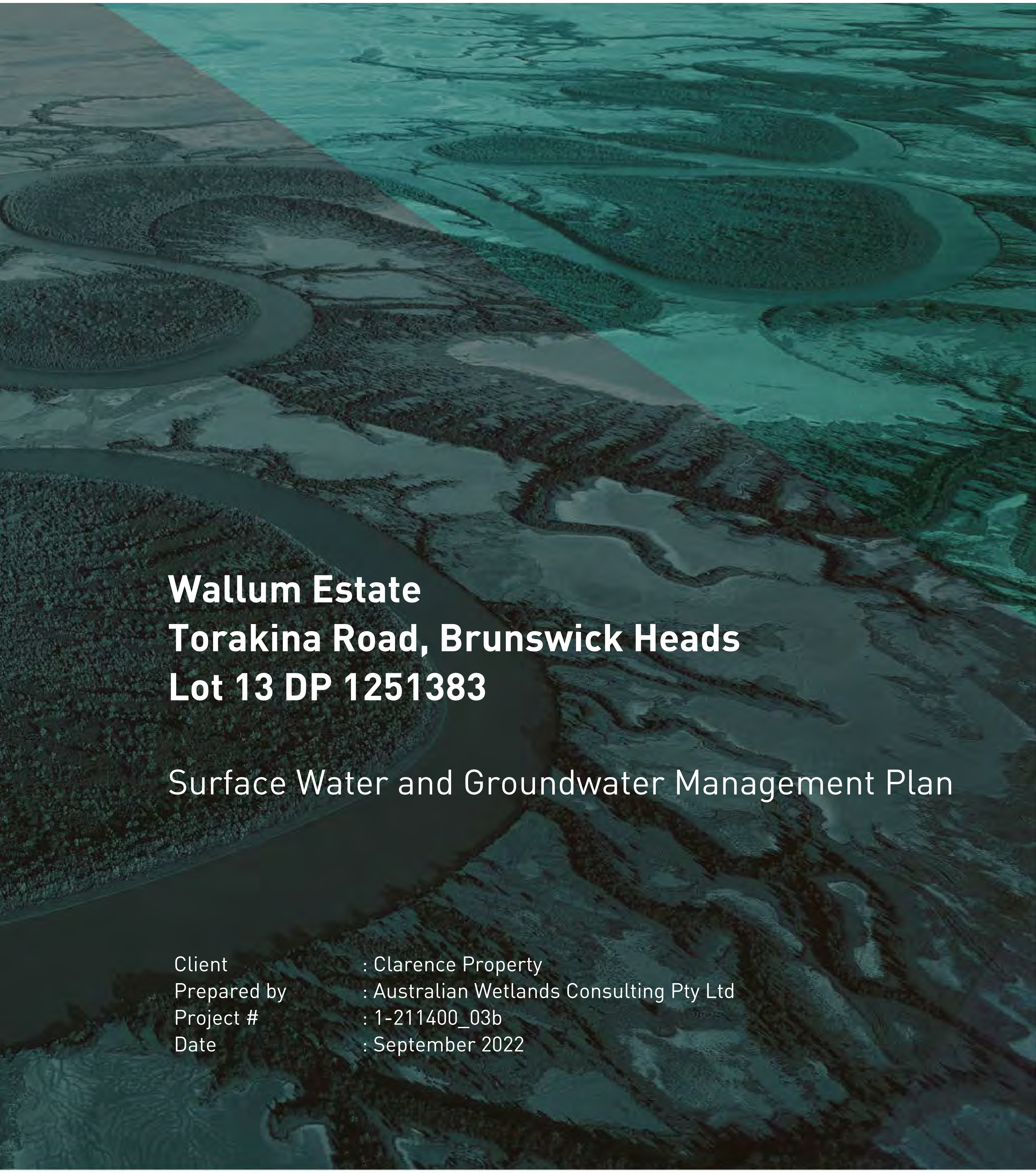

Wallum Estate
Torakina Road, Brunswick Heads
Lot 13 DP 1251383

Surface Water and Groundwater Management Plan

Client	: Clarence Property
Prepared by	: Australian Wetlands Consulting Pty Ltd
Project #	: 1-211400_03b
Date	: September 2022

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AWC

Wallum Estate
Torakina Road, Brunswick Heads
Lot 13 DP 1251383

Surface Water and Groundwater Management Plan

Project control

Project name: **Wallum Estate**
Torakina Road, Brunswick Heads
Lot 13 DP 1251383

Surface Water and Groundwater Management Plan

Job number: 1-211400_03
Client: Clarence Property
Contact: James Fletcher

Prepared by: Australian Wetlands Consulting Pty Ltd

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Date:	Revision:	Prepared by:	Reviewed by:	Distributed to:
20/08/2021	A	Jesse Munro	Damian McCann	James Fletcher (Clarence Property)
14/09/2022	B	Jesse Munro	Minor amendment only	James Fletcher (Clarence Property)

Table of Contents

List of Tables

List of Figures

1 Introduction and Background

1.1 Proposed Development

Development consent is sought to undertake a staged subdivision to create 131 lots upon land described as 15 Torakina Road, Brunswick Heads (Lot 13 in DP 1251383). The application proposes the subdivision of the land in 3 stages comprising, 123 residential lots, three (3) medium density lots, one (1) residue lot and three (3) public reserves together with associated public roads and infrastructure services (water, sewer, drainage and stormwater management works), bulk earthworks, tree removal and vegetation management works (refer Figure 1.1).

The development occupies approximately 13.33 ha (43.7 %) of the site. Residual land outside of the development footprint (~17.2 ha) will be managed for biodiversity and comprises public reserves (P1, P2, P3 and P4). Public reserves will be dedicated to Council once required works are completed. The portion of the site east of the road reserve flanking Simpsons Creek (10.24 ha) will also be dedicated to Council.

1.2 Document Scope

This document provides a framework to monitor and detect adverse impacts to the groundwater and surface water reserves of the property and management strategies to protect the downstream aquatic habitat. The primary objectives include:

- Collection and formation of baseline data sets to compare future monitoring results through the construction and occupation phase of the proposed development, including:
    - Groundwater level
    - Groundwater quality
    - Surface water quality
- Specify a monitoring program for construction and occupational phases
- Establish action criteria for construction and occupation phase monitoring
- Provide an action response plan

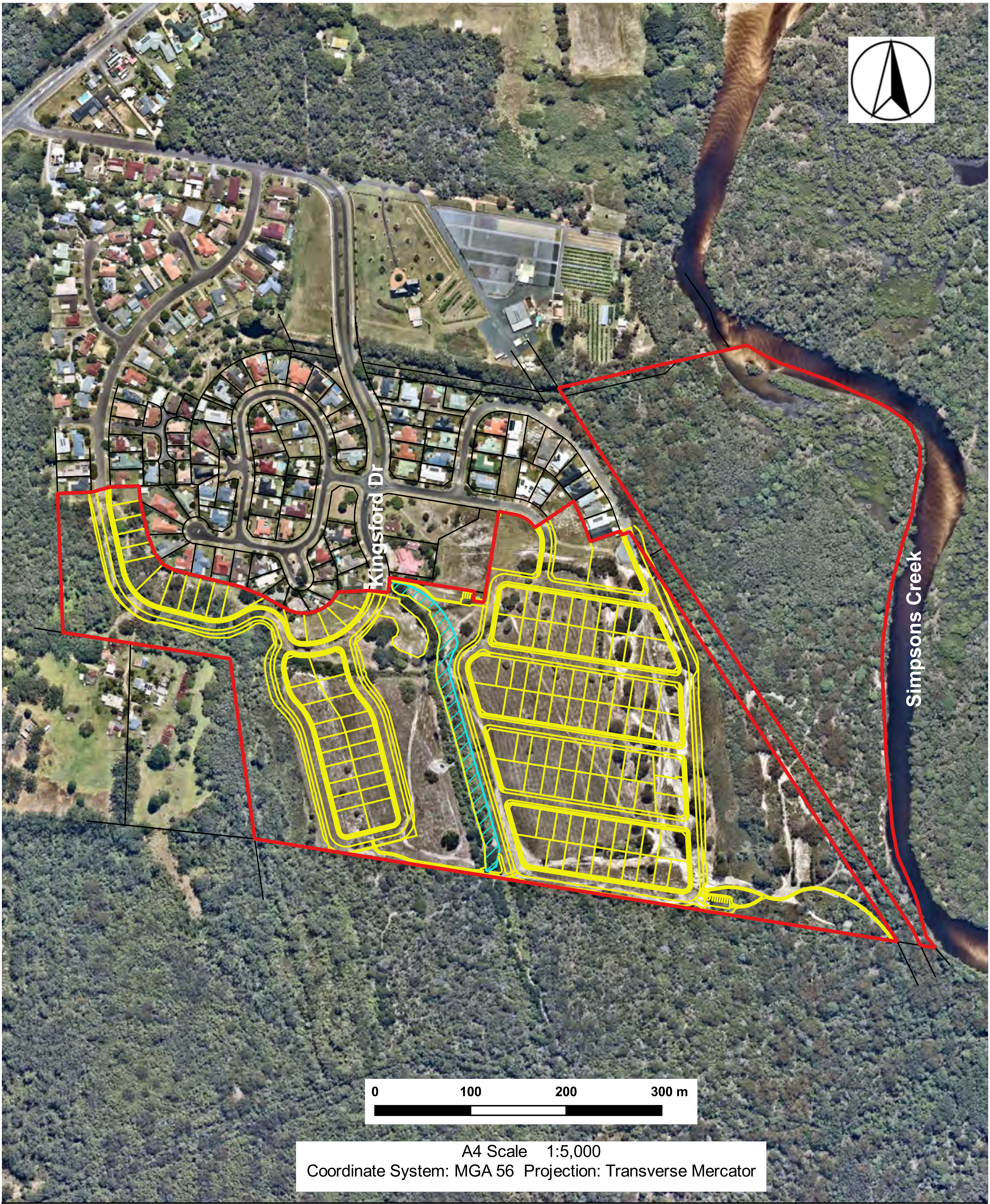
1.3 Adaptive Management

This document is designed to be adaptive and will be reviewed and amended intermittently after evaluation of conditions, data and management strategies if required. Adaptive management considers all data collection and re-evaluates management.

1.4 CEMP

Site specific Construction Environmental Management Plans (CEMP) will be prepared for each construction stage that will reiterate all required construction stage monitoring. The preparation of the CEMPs is the responsibility of the lead contractor and will be prepared to the satisfaction of the consent authority.

CEMPs will detail the environmental management hierarchy (e.g. Site Superintendent, Environmental Manager) and relevant responsibilities.



AWC

Legend

Site

Layout

Side Swale

Figure 1.1 Proposed Development

Data source:
Aerial - Nearmaps
Layout - Cilviltech

Date:7-09-22
Job No:211400
Drawn:ED
Checked:DM

2 Site Detail

2.1 Topography

The site is relatively flat with a slight rise in the west. A central constructed drainage line dominates the surface drainage, with lateral flows of groundwater expressing and flowing from the site. The drainage line flows in a southerly direction towards Everitt's Creek and on to Simpsons Creek, and the Brunswick River.

The drainage line accepts surface flows (stormwater) from the existing urban area to the north. There are various smaller constructed drainage lines delivering surface flows to the primary drainage line.

Figure 2.1 shows the topography of the subject site.

2.2 Soil

The New South Wales Department of Planning, Industry and Environment's *eSPADE 2.1* (https://www.environment.nsw.gov.au/eSpade2WebApp) shows the site to be located on the Black Rock (br) Landscape in which sediments are of aeolian origin. The following is a summary of the soil landscape description found in *Soil Landscapes of the Lismore Ballina 1:100,000 Sheet* (Morand 1994):

Soils:	Deep (>300cm), well drained Podzols on dunes; Deep (>300cm), imperfectly drained Humus Podzols and Peaty Podzols in depressions and deep (>200cm), waterlogged Acid Peats in swales; Deep (>300cm), rapidly drained Siliceous Sands on newer, seaward dunes.
Colour:	brownish black to black (topsoil-A_1 horizon); light grey to brownish grey (A_2 horizon; brownish black to reddish black with depth
Texture:	organic loamy sand (often fibric) or coarse sand in topsoils grading to fibric spongy loam to light clay with depth
Structure:	single grained in topsoil, massive at depth
pH:	4.0 to 6.0
Geology:	Quaternary (Pleistocene) beach and dune sands.
Limitations:	Non-cohesive, highly permeable, **highly acid soils** of low fertility. Organic soils in swales with permanently high watertables

Soil investigations show the soils to be generally sand based with some areas of peat and organic matter. There is an aquitard comprised of a dense sand layer, forming indurated sands which forms a perched aquifer. There is notably routine surface water accumulated in depressions on site suggesting infiltration rates are relatively low.

Several acid sulfate soil (ASS) assessments have been undertaken at the site which determined there was no acid sulfate soil. Notwithstanding, the site has been classified as Class 3 on the ASS risk mapping as detailed in the Byron Local Environmental Plan 2014 (LEP 2014), and an Acid Sulfate Soil Management Plan has been prepared primarily aimed at monitoring for detection.

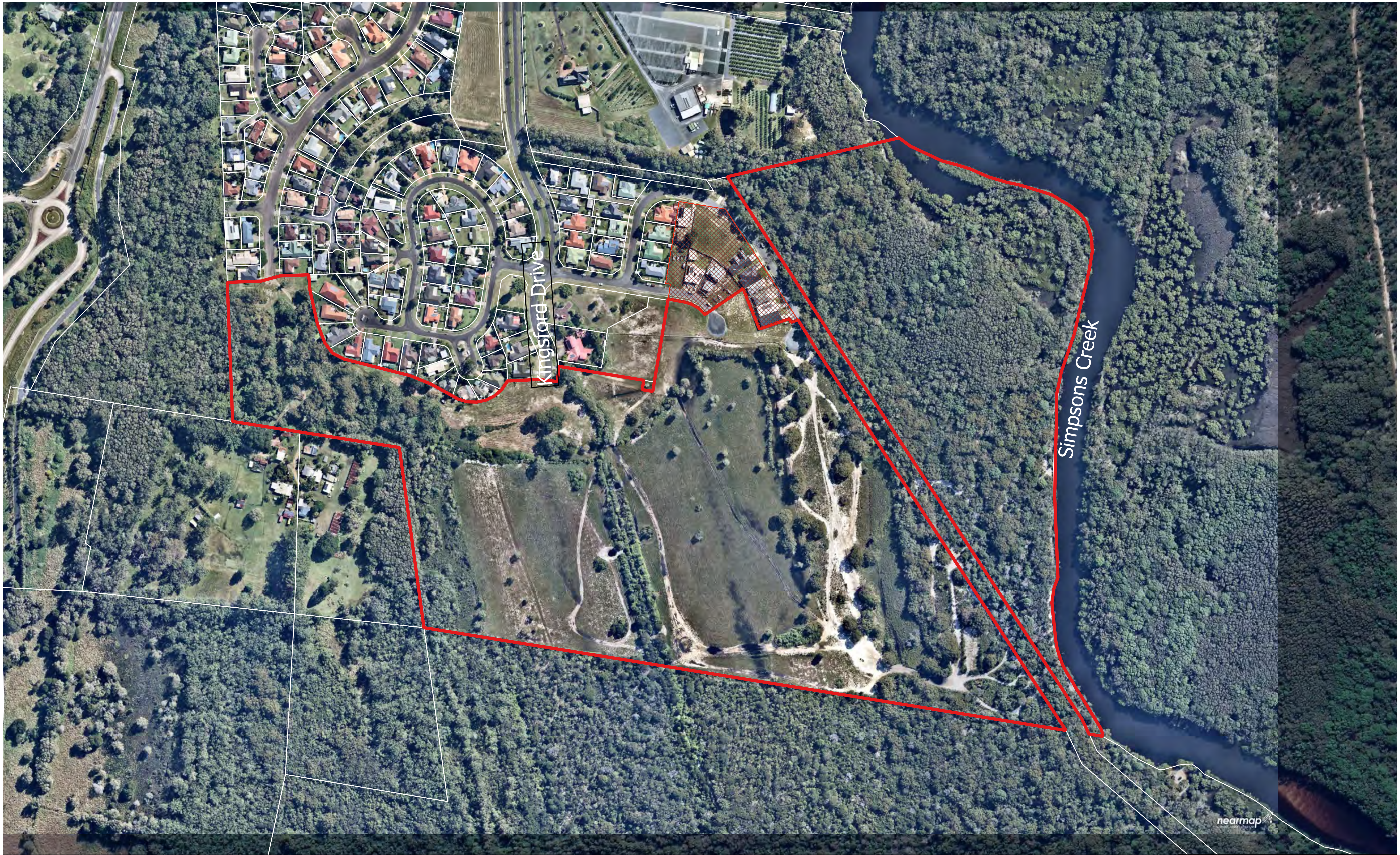


Figure:	2.1 The subject site
File:	1-211400-BaysideBrunswick_ClarenceProperty
Source:	Aerial Image - Near Maps 2021

0 50 100 150 200 m

Legend

- Stage 1A (Approved)
- Site
- PROPOSED_LAYOUT_21 entities
- Layout
- BYRON_SHIRE_CADASTRAL entities

A3 Scale 1:3500
Coordinate System: MGA 56 Projection: Transverse Mercator

3 Groundwater Management

3.1 Potential Impacts to Groundwater

Land use change has the potential to modify groundwater hydrology of a site. Urbanisation reduces infiltration through soil to groundwater through an increase in impervious surfaces (roads and roofs). Although best practice stormwater management is proposed at the Wallum Estate through treatment and infiltration, groundwater stores will be monitored to detect changes. The primary potential impacts to groundwater are discussed below.

3.1.1 Reduction of Groundwater Level

Reduction of infiltration area and groundwater recharge will potentially cause impacts to the following:

- Reduced groundwater levels can cause exposure of acid sulfate soils to oxygen and subsequent acid production
- Impacts to groundwater dependent ecosystems (GDE)
- Modified hydrology in the downstream receiving environment

3.1.2 Contamination

Groundwater contamination from nutrients, heavy metals and hydrocarbons is a potential issue through the construction and occupation phases of the Wallum Estate development. Groundwater at the site expresses to the surface water drains and eventually discharges to Everitt's Creek, Simpsons Creek and then the Brunswick River.

3.1.3 Acid Sulfate Soils

Although there has not been ASS detected on site, despite several investigations the site is mapped as having a moderate probability of ASS. If acid sulfate soils are exposed through soil excavations or groundwater lowing, acid production may result in dissolved iron and aluminum entering ground water reserves and subsequently discharging to the surface water drainage system. These elements are known to be toxic and cause other associated detrimental impacts to downstream aquatic environments. An ASS management plan has been prepared to detect if ASS has been disturbed based primarily on visual indicators.

The site is a naturally occurring acid environment with protection of habitat for acid frog species an important consideration. Neutralisation of acidic water, both surface and ground, is not a recommendation for this site.

3.1.4 Preliminary Modelling

Preliminary groundwater modelling is currently being undertaken by Martens & Associates Pty Ltd. The assessment will use groundwater level and rainfall data, to provide a pre versus post development groundwater regime and enable trigger levels to be set for groundwater levels including for sensitive receivers including acid frog habitat and groundwater dependent ecosystems. The assessment report is due in September 2021 and preliminary modelling has been used to inform the project design to date.

3.1.5 Groundwater Dependent Ecosystems

The development poses a risk to groundwater dependant ecosystems (GDE's) through modification (reduced or increased) in groundwater levels and groundwater quality. Changes in groundwater hydrology could adversely impact forested wetland communities – with either too little water causing a transition to more terrestrial vegetation assemblages and too much water causing localised die-back and potential intrusion of aquatic vegetation.

The NSW State Groundwater Dependent Ecosystems Policy (NSW Department of Land & Water Conservation (DLWC, 2002) has five key principles that aim to manage and protect these valuable systems in a practical sense. Table 3.1 provides commentary on the principles in relation to the proposed Wallum Estate development.

Vegetation assessments completed (JWA, 2011) show a varied assemblage of vegetation communities over the site including forest, heath and estuarine groups. There are several swamp sclerophyll forest and woodland communities which include key species as *Eucalyptus robusta* (Swamp Mahogany), *Melaleuca quinquenervia* (Broad Leaved Paperbark). Much of the site is covered with a low closed wet heath that is routinely slashed. Three Endangered Ecological Communities (EEC) are located on the subject site including 'Swamp sclerophyll forest on coastal floodplain', 'Swamp oak forest flood plain forest', and 'Coastal saltmarsh'. The vegetation types along with the known shallow water table suggest a high likelihood of GDEs occurring on site. There are expansive areas of retained vegetation and habitat creation proposed in the development layout.

GDEs will be monitored as a proxy to detect change in groundwater levels and quality.

Table 3.1 Principles of the NSW State Groundwater Dependent Ecosystems Policy in relation to the proposed development

NSW GDE Policy Principles	Comment
Principle One: The scientific, ecological, aesthetic and economic values of groundwater-dependent ecosystems, and how threats to them may be avoided, should be identified and action taken to ensure that the most vulnerable ecosystems are protected.	Site groundwater hydrology will be maintained through the infiltration of the stormwater treatment systems.
Principle Two: Groundwater extractions should be managed within the sustainable yield of aquifer systems, so that the ecological processes and biodiversity of their dependent ecosystems are maintained and/or restored. Management may involve establishment of threshold levels that are critical for ecosystem health, and controls on extraction in the proximity of groundwater dependent ecosystems.	There is no groundwater extraction planned as part of the proposed development.
Principle Three: Priority should be given to ensuring that sufficient groundwater of suitable quality is available at the times when it is needed: • For protecting ecosystems which are known to be, or are most likely to be, groundwater dependent; and, • For groundwater dependent ecosystems which are under an immediate or high degree of threat from groundwater-related activities.	There is not expected to be a shortage of groundwater in the locality, due to the low-lying topography and proximity to Everitt's Creek and Simpson Creek. The threat to groundwater levels is not considered 'high degree'.
Principle Four: Where scientific knowledge is lacking, the Precautionary Principle should be applied to protect groundwater dependent ecosystems. The development of adaptive management systems and research to improve understanding of these systems is essential to their management.	There is ongoing monitoring of GDE health and distribution, groundwater levels and groundwater quality planned through the construction and occupation phase of the development (refer Section 3).
Principle Five: Planning, approval and management of developments and land use activities should aim to minimise adverse impacts on groundwater dependent ecosystems by: • Maintaining, where possible, natural patterns of groundwater flow and not disrupting groundwater levels that are critical for ecosystems; • Not polluting or causing adverse changes in groundwater quality; and • Rehabilitating degraded groundwater systems where practical.	The Wallum Estate has a proposed stormwater management strategy that includes infiltration to recharge groundwater storage and maintain groundwater levels. Additionally, stormwater management treat stormwater, reducing pollutants to levels appropriate for receiving environments. Further details are provided in the stormwater management plan prepared by Civiltech (2021). GDEs will be protected in residual land and habitat creation.

3.2 Historic Groundwater Monitoring

Groundwater levels and groundwater quality have been monitored on the site for more than ten years and is ongoing, providing an excellent picture of groundwater character and implications for the proposed development. Details and results are provided below.

3.2.1 Groundwater Level

AWC have monitored groundwater levels at four locations on the site since 2017. These monitoring wells and loggers were installed to ascertain the groundwater level, gradient and hydroperiod in relation to the primary drain. Two other locations have been monitored intermittently since 2012. A summary of the data is provided in Table 3.2, locations of the bores is shown on Figure 3.1. A groundwater level gradient is evident decreasing towards the primary drain (i.e. Logger 4 levels are generally higher than Logger 3, and Logger 1 values are higher than Logger 2).

Table 3.2 Summary groundwater level statistics for recent AWC bores

	mAHD						
	Logger 1	Logger 2	Logger 3	Logger 4	Logger 5*	3A	4A
Min	3.63	TBC**	3.21	3.37	0.065	2.76	2.88
Max	4.79		4.08	4.50	1.359	3.82	4.04
Ave	4.22		3.73	3.93	0.596	3.81	3.85
median	4.24		3.73	3.94	0.543	3.61	3.81
90th %ile	4.54		3.97	4.33	1.104	3.28	3.65
75th %ile	4.38		3.89	4.15	0.722	2.99	3.43
25th %ile	4.10		3.59	3.76	0.351	2.78	3.31
10th %ile	3.76		3.48	3.42	0.218	2.76	2.88
count (n)	14185	20266	27094	10070	5370	18845	43050
Dates	01/2017 08/2019	01/2017 07/2021	01/2017 05/2021	01/2017 10/2020	08/2019 12/2020	09/2012 04/2014	11/2012 07/2020

* Logger 5 was deployed in an existing piezometer that measured groundwater level in the deep aquifer
** data statistics for Logger 2 to be confirmed

3.2.2 Groundwater Quality

A groundwater quality assessment was undertaken in 2012-2013 comprising 12 monthly samples from seven bores. Currently an additional groundwater quality assessment and baseline data set is being developed. Further detail on these two assessments is provided below.

3.2.2.1 Current Baseline Data Set Collection

AWC and Martens and Associates Pty Ltd are currently collecting a baseline data set of groundwater quality across the site. There are 16 groundwater bores being utilised, some of which were existing, some recently constructed. Figure 3.1 shows the locations of the monitoring wells. Six bores will have 12 months of samples collected and analysed to form the current baseline data set.

3.2.2.2 Historic Groundwater Sampling

AWC collected 12 months of groundwater quality samples from seven bores between March 2013 and February 2014. Figure 3.1 shows the locations of the monitoring wells. Monitoring bores 3B, 4B and 5 are deep bores showing the deep aquifer, all other bores show the perched aquifer. Table 3.1 shows the average values from the 12-month monitoring effort.

The results show the shallow aquifer bores have a pH values range of 3.47-3.95, with the deep aquifer showing higher values with a range of 4.95-5.04. The low pH values in the shallow aquifer reiterate the naturally acidic environment of the site.

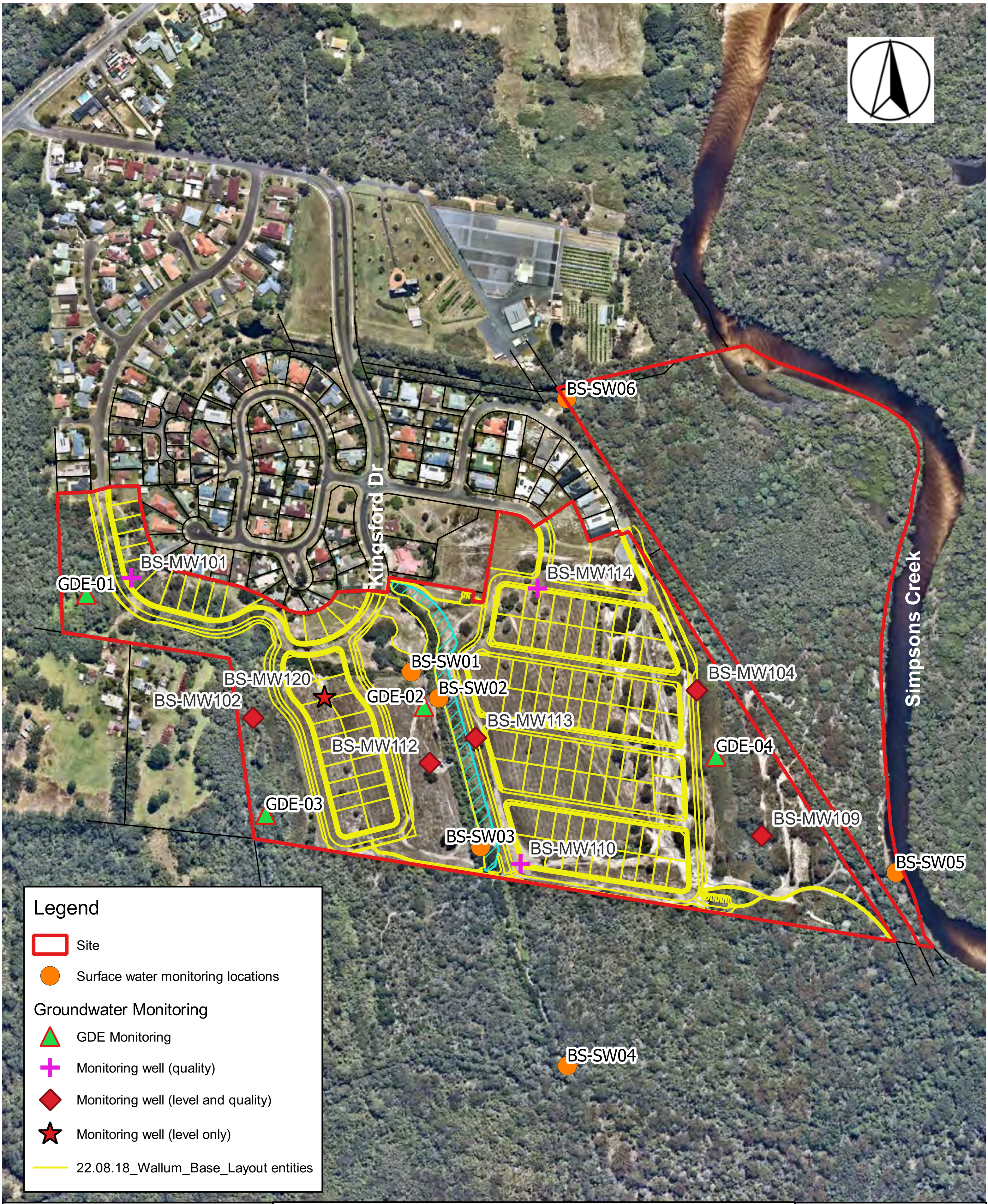
Total Phosphorus (TP) values range from 0.011-0.062 mg/L in the shallow aquifer which is generally in line with the default trigger values of 0.05 mg/L as determined by ANZECC (2000) for slightly disturbed ecosystems, lowland rivers in SE Australia. Similarly the ANZECC default trigger value for filterable reactive phosphorus (phosphate) value of 0.02 mg/L is generally complied with.

Recorded Total Nitrogen (TN) values generally exceed the ANZECC default trigger value of 0.5 mg/L with a range of 0.79-1.19 mg/L in the shallow aquifer sites. NO_x recorded values generally comply with the ANZECC default trigger value of 0.04 mg/L with a range of 0.011-0.081 mg/L. Ammonia concentrations, with a range of 0.042-0.352 mg/L in the shallow aquifer, exceed the ANZECC default trigger value of 0.02 mg/L with the deep aquifer values being higher.

The variability in values across the site, and within the data collected at each site, suggests there is an external influence on groundwater quality. Surrounding land use is confined to urban to the north, with a wholesale production nursery included though there is a constructed drain separating the nursery from the subject site. The source of the elevated nutrients has not been identified at this stage, though it may not be anthropogenic.

Table 3.3 Historic (2013-2014) groundwater quality summary (mean values)

	Parameter	Bore 1	Bore 2	Bore 3A	Bore 3B	Bore 4A	Bore 4B	Bore 5
LABORATORY ANALYSIS - EAL	Bicarbonate (alkalinity) (mg/l $CaCO^3$ equivalent)	1.67	0.000	0.000	16.0	0.000	21.3	21.5
	Total Phosphorus (mg/l P)	0.062	0.027	0.011	0.030	0.040	0.037	0.083
	Phosphate (mg/l P)	0.020	0.014	0.006	0.013	0.021	0.010	0.028
	Total Nitrogen (mg/l N)	0.840	0.897	0.793	1.191	1.516	0.459	0.534
	Total Kjeldahl Nitrogen (mg/l N)	0.812	0.854	0.775	1.18	1.43	0.43	0.511
	NO_x	0.027	0.043	0.011	0.011	0.081	0.007	0.009
	Nitrate (mg/l n)	0.009	0.022	0.013	0.011	0.040	0.009	0.009
	Nitrite (mg/l n)	0.020	0.035	0.003	0.008	0.059	0.002	0.006
	Ammonia (mg/l n)	0.303	0.104	0.042	0.652	0.191	0.352	0.403
	Sodium (mg/l)	8.08	10.3	36.4	12.4	17.6	39.0	43.3
	Potassium (mg/l)	0.408	0.314	0.111	0.921	0.472	1.65	1.58
	Calcium (mg/l)	1.19	0.123	0.296	1.78	1.14	5.04	5.14
	Magnesium (mg/l)	1.30	1.45	8.07	3.84	4.24	3.69	4.72
	Sodium absorption ratio	1.20	1.76	2.77	1.20	1.73	3.24	3.31
	Chloride (mg/l)	19.6	27.2	84.1	35.7	44.7	79.5	88.4
	Sulfur	1.72	1.51	4.73	3.33	2.79	1.94	1.31
	Sulfate (mg/l SO_4^{2-})	5.45	4.66	15.08	9.66	8.52	5.74	3.93
	Chloride/ sulfate ratio	3.55	6.58	6.60	4.27	5.54	16.6	28.2
	Silver (mg/l)	ND	ND	ND	ND	ND	ND	ND
	Aluminium (mg/l)	0.184	0.115	1.170	1.15	0.707	0.441	0.370
	Arsenic (mg/l)	ND	ND	0.001	ND	0.001	0.003	0.001
	Cadmium (mg/l)	ND	ND	ND	ND	ND	ND	ND
	Chromium (mg/l)	ND	ND	0.001	0.001	0.001	0.001	0.001
	Copper (mg/l)	ND	0.003	0.002	0.003	0.002	0.035	0.002
	Iron (mg/l)	0.080	0.073	0.757	0.488	0.843	3.870	3.307
	Manganese (mg/l)	0.001	0.009	0.001	0.016	0.012	0.032	0.034
	Nickel (mg/l)	ND	0.001	0.001	ND	0.002	0.001	0.001
	Lead (mg/l)	ND	0.002	0.001	0.002	0.002	0.016	0.002
	Selenium (mg/l)	ND	ND	0.002	ND	ND	ND	ND
	Zinc (mg/l)	0.001	0.004	0.005	0.005	0.010	0.070	0.009
	Mercury (mg/l)	ND	ND	ND	ND	ND	ND	ND
MULTIPROBE (HYDROLAB MS5)	Temp (°c)	23.0	20.6	20.9	21.3	21.4	21.6	20.6
	SpCond (µs/cm)	78	130	296	113	144	288	324
	Sal (ppt)	0.025	0.062	0.144	0.049	0.061	0.141	0.166
	pH (units)	3.95	3.47	3.96	4.98	3.95	5.03	5.04
	Orp (mv)	369	499	253	193	271	202	203
	Turbsc (NTU)	97.9	161.1	23.04	6.99	145.9	5.14	3.21
	LDO (%sat.)	76.0	19.3	5.61	1.25	0.194	72.4	2.14
	LDO (mg/l)	6.73	1.45	0.156	0.058	0.013	5.22	0.022
	TDS (g/l)	0.050	0.087	0.192	0.074	0.094	0.187	0.215



AWC

0 100 200 300 m

A4 Scale 1:5,000
Coordinate System: MGA 56 Projection: Transverse Mercator

Figure 3.1 Groundwater monitoring wells (quality and level), surface water monitoring and GDE monitoring locations

Data source:
Aerial - Nearmaps
Layout - Cilviltech

Date:14-09-22
Job No:211400
Drawn: ED/JM
Checked: JM

3.3 Groundwater Monitoring Plan

3.3.1 Detecting Adverse Impacts

Management of any detrimental impacts to the Simpsons Creek will firstly need to recognise when adverse impacts are occurring. Results of monitoring during the construction and operational phases will be compared with the collated baseline data set.

Once the baseline data set has been finalised, action criteria can be established based on statistical analysis. Table 3.4 provides a summary of the monitoring in relation to groundwater.

Table 3.4 Groundwater monitoring Summary

	Aim	Section
Groundwater level	Determine change in groundwater levels resulting from the proposed development.	Section 3.3.2
Groundwater quality	Determine if there is a reduction in groundwater quality resulting from the proposed development.	Section 3.3.4
Acid Sulfate Soil	Determine if there is disturbance of acid sulfate soils and subsequent impact on surface and groundwater	Section 3.1.3 and Section 3.3.4.1
Groundwater Dependent Ecosystems (GDE)	Determine if there is a detrimental impact on GDEs because of the proposed development	Section 3.3.3

3.3.2 Groundwater Levels

The objective of the monitoring groundwater levels across the site is to determine whether the development has any discernible effect on groundwater levels in the medium to long term. There will be changes in surface conditions post construction and subsequent effect on infiltration which is ameliorated through the development design.

Six groundwater monitoring bores will have groundwater level loggers deployed at the locations shown on Figure 3.1. Data points will be collected on an hourly basis with collated data calibrated to mAHD.

3.3.2.1 Detecting Change

Groundwater levels will be monitored at the six nominated monitoring wells using data logging equipment. Data will be extracted and analysed and compared with the baseline data set to detect differences and then determine if they are the result of the development or seasonal variability.

3.3.3 Groundwater Dependent Ecosystem Monitoring

Monitoring of groundwater levels, groundwater quality, and surface water quality will inform potential impacts to the groundwater dependent ecosystems at the site. However, detecting detrimental impacts to the groundwater dependant vegetation will also be monitored. It is proposed to undertake annual vegetation surveys at four permanent locations within groundwater dependent ecosystems at the site. The aim will be to determine if there is a shift in vegetation assemblage and vegetation health resulting from a potential change in groundwater characteristics.

Four permanent monitoring sites will be installed and assessed in accordance with the Biodiversity Assessment Method (DPIE 2020) to determine a Vegetation Integrity Score (VIS) for each vegetation plot of 20 x 50 m (0.1 ha). Each plot will be permanently marked using star pickets, GPS coordinates and mapped. Preliminary locations of proposed monitoring sites are shown on Figure 3.1. These locations are to be finalised by an ecologist, on site, with consideration of a scoping field survey to find suitable habitat and survey location.

Vegetation plots will also include a permanent photopoint to assess vegetation cover over time. At each inspection a visual assessment will be completed within the vegetation community to assess general health of vegetation and note any dieback or other signs of stress.

GDE monitoring is scheduled to commence in August-September 2021 with the aim of completing a baseline data set.

3.3.4 Groundwater Quality Monitoring

The objective of groundwater quality monitoring is to create a baseline data set prior to any major works on site to allow comparison with data collected during the construction and operational phases. There is the potential for the proposed urban development to impact groundwater quality through various processes including infiltration of contaminated (nutrients) surface waters during both the construction and occupation phases.

Sixteen groundwater monitoring bores have been installed however six will be used for collection of samples for laboratory analysis; Figure 3.1 shows their location. Collection is in accordance with *Groundwater Sampling and Analysis – A Field Guide* (Sundarum *et al*, 2009). Groundwater is collected using a 50mm bore pump or hand bailer. The sampler is to ensure the sample bottles/jars are appropriate for the test being undertaken. This can be confirmed with the analysis laboratory. Purging of groundwater from each sampling bore is required; briefly, at least three times the volume of the bore (3 x πR^2 x height) is purged and passed through a flow cell attached to the multiprobe until the physicochemical parameters stabilise at which point the sample is collected. Samples are stored on ice and delivered to the laboratory for analysis as soon as possible.

Groundwater quality data will be collected monthly for a minimum 12 months. Statistical analysis of baseline data will provide groundwater quality targets and trigger levels. Analytes to be assessed are provided in Table 3.5. Upon commencement of the construction phase, monthly sample collection and analysis will be initiated with results compared against the baseline data set and groundwater quality targets. Groundwater samples in the proximity of retained acid frog habitat and areas of created acid frog habitat will be subject to fortnightly sampling (for pH, depth and conductivity only), for an initial period of six months, reducing to monthly thereafter.

Table 3.5 Groundwater monitoring analytes

Groundwater Quality Sampling – Water Quality Analytes			
Phys/chem	Nutrients	Salts	ASS Parameters:
pH * Conductivity * Total Dissolved Salts (TDS) * Total Suspended Solids (TSS)	Total Phosphorus (TP) Phosphate Total Nitrogen (TN) Nitrite Total Kjeldahl Nitrogen Nitrate Ammonia	Calcium Magnesium Potassium Sodium Chloride Sulfur	Fe (total) Al (total Cl:SO_4 ratio
* = also used for ASS indicators (refer Section 3.3.4.1)			

3.3.4.1 Acid Sulfate Soil

Water quality indicators of ASS disturbance include:

- pH
- Conductivity
- Total Dissolved Salts (TDS)
- Total Iron (Fe)
- Total Aluminum (Al)
- Chloride to Sulfate Ratio (Cl:SO4)

These parameters will be included in any groundwater (and surface water) sampling and laboratory analysis undertaken (refer Table 3.5).

3.3.4.2 Groundwater Quality Monitoring Schedule

Collection of water quality samples from six of the existing bores for laboratory analysis will be undertaken monthly for a minimum 12 months to form a baseline data set (refer Section **Error! Reference source not found.**). During the construction phases of the proposed subdivision works, monthly sampling will be undertaken details of which are to be determined as part of the construction stage specific CEMPs.

3.3.4.3 Groundwater Quality Action Criteria

Once the baseline data set has been completed data will be interrogated to determine the action criteria. Each monitoring well will have a separate set of criteria as there is variation in the baseline quality.

3.4 Management Strategies

Ongoing monitoring and comparison with a pre-determined action level based on the baseline data will provide a trigger values will be a prompt for further investigation. Where it is concluded there is a development related impact, rectification option will need to be investigated with consideration of spatial and temporal effects and practicality. Discussion and potential contingency actions are provided below.

3.4.1 Surface Water Quality

Surface water quality can affect groundwater quality through infiltration of contaminated water. Surface water monitoring is proposed as part of the overall environmental monitoring of the proposed development. The Environmental Manager will consider results of the surface water monitoring program if deleterious results of the groundwater quality monitoring are detected.

3.4.2 Groundwater Quality

It may be difficult to determine the source of poor groundwater quality if detected. The existing urban area upstream of the proposed development does not have any substantial stormwater treatment systems. If groundwater monitoring shows a reduction in quality contingencies for rectification may include:

- Investigations to isolate sources (i.e. internal or external to the Wallum Estate, e.g. may be sewer infiltration)
- Assessment of surface/stormwater monitoring results to detect a correlation
- Extraction of groundwater, treatment and re-injection
- Modification of works practices
- Specialist consultants may need to be engaged

3.4.3 Maintenance of Groundwater Levels

The stormwater management strategy for the site includes infiltration to recharge groundwater as a priority. If a decrease in groundwater levels is detected, when compared to baseline monitoring, the following may be considered:

- Assessment of spatial differences in groundwater levels and determine priority action areas
- Inspection of the stormwater treatment and infiltration systems to ensure functional
- Creation of additional infiltration systems; these could be inground, open base cells in public areas or private properties
- Injection of additional water to recharge groundwater
- Modification of standing water levels in the primary drain to influence the groundwater levels

3.4.4 Acid Sulfate Soils

There have been several ASS assessments of the site, which are detailed in the *Wallum Estate, Brunswick Heads - Acid Sulfate Assessment* (AWC, 2022a). None of the assessments detected ASS, despite the site being mapped with a moderate probability of ASS occurring. Nonetheless, a *Wallum Estate - Acid Sulfate Soil Management Plan* (AWC, 2022b) has been prepared detailing construction phase monitoring to detect ASS if it was encountered, including routine visual inspections for indicators and groundwater and surface sampling and analysis.

Disturbance of ASS during the construction phase may be detected through surface water and groundwater monitoring, and through the site-specific monitoring that will be detailed in the site/stage specific CEMPs. Rectification of construction phase impacts will be undertaken in accordance with the ASSMAC Guidelines and require input from suitably qualified practitioners to provide advice and ensure compliance with management objectives.

Disturbance of the existing soil profile includes drainage channel realignment, trenching for services, topsoil removal and stockpiling, drain widening, acid frog habitat (pond) construction, bridge and abutment construction, and pool and footing construction during the dwelling construction phase. Any exceedance of the target criteria specified in the ASS Management Plan (AWC, 2021b) and the site/stage specific CEMP will be rectified as per the ASSMAC Guideline (Stone et al, 1998) to the satisfaction of Byron Shire Council and/or other relevant authority.

Where ASS impacts are detected resulting from a decrease in groundwater levels, rectification should focus on correcting groundwater levels.

4 Surface Water Management

4.1 Potential Impacts to Surface Water

Surface water quality typically degrades with urbanization, with higher sediment, nutrient and other contaminant loads common. A Stormwater Management Plan has been prepared by Civiltech (2021) to address potential water quality impacts.

The downstream receiving environment is tidal and includes Everett's Creek, Simpsons Creek, the Brunswick River and finally discharging to the Pacific Ocean. Simpson's Creek sits within the Cape Byron Marine Park. Declining water quality discharging from the site during construction and operational phases is a key risk to these downstream environments.

4.1.1 Contamination

Surface water can be impacted by contamination of a very wide range of contaminants though the primary pollutants of concern on this site are nutrients, particularly species of nitrogen and phosphorus, metals and petroleum hydrocarbons.

4.1.2 Sedimentation

Erosion and sedimentation are a key concern for both the construction and operational phases. Sedimentation of water courses smother aquatic habitats and modify hydrological flow paths, flow rates and volumes.

4.1.3 Acid Sulfate Soils

Refer Section 3.1.3, Section 3.3.4.1 and Section 3.4.4. As groundwater expresses in the primary drainage network, disturbed and activated ASS may be indicated through analysis of surface water.

4.2 Surface Water Monitoring Plan

Monitoring of surface water quality will be undertaken during the construction and continue into the occupation phase of the proposed development.

A baseline data set is currently being collected and will enable creation of water quality trigger values (refer Section 4.3). During the construction phase routine sample collection and laboratory analysis will be undertaken monthly, from the six locations shown on Figure 3.1. Analytes to be tested are shown in Table 4.1.

Table 4.1 Surface water monitoring analytes

<table>
<tr><th colspan="5">Surface Water Quality Sampling – Water Quality Analytes</th></tr>
<tr><td rowspan="2"><u>Phys/chem</u>
pH *
Conductivity *
Total Dissolved Salts (TDS) *
Total Suspended Solids (TSS)</td><td rowspan="2"><u>Nutrients</u>
Total Phosphorus (TP)
Phosphate
Total Nitrogen (TN)
Nitrite
Total Kjeldahl Nitrogen
Nitrate
Ammonia</td><td rowspan="2"><u>Salts</u>
Calcium
Magnesium
Potassium
Sodium
Chloride
Sulfur</td><td><u>ASS</u>
Fe (total)
Al (total
$Cl:SO_4$ ratio</td><td><u>Hydrocarbons</u>
Total Recoverable Hydrocarbons (TRH - speciated)</td></tr>
<tr><td><u>Biological</u>
Chlorophyll '*a*'
Algal biomass</td><td><u>Metals</u>
Lead
Arsenic
Mercury</td></tr>
</table>

Table 4.2 Surface water sampling schedule (Baseline, construction, and occupation phase)

	Baseline data collection	Construction phase	Occupation phase
Sampling frequency	Monthly	Monthly	Quarterly
Comment	12 samples required (five collected)	Routine monthly sampling	Continue for two years after subdivision certificate for final stage is issued by consent authority

4.3 Surface Water Baseline Data Set

AWC have started compiling a baseline data set comprised of six sites (refer Figure 3.1) with monthly monitoring undertaken since January 2021. Water quality analytes are detailed in Table 4.1 and sampling schedule in Table 4.2. The interim mean values (from five sampling events) are shown in Table 4.3. Default water quality trigger values are shown for general comparison; trigger values shown are sourced from the ANZECC Guidelines (ANZECC, 2000) and ASSMAC (Stone et al, 1998) for ASS parameters. Total Suspended Solids (TSS) has a widely used objective of 50 mg/L for construction phase discharge.

The results suggest the existing surface water quality is impacted by the surrounding land use. TSS values are above 50mg/L for sites SW-01 and SW-02. All phosphorus and nitrogen species are above the respective ANZECC guideline values; however it is conceded that those trigger values are stringent and are essentially unachievable in an urbanised catchment; similarly all sites exceed the Chlorophyll 'a' value.

Interestingly the ASS indicators ($Cl:SO_4$ ratio, aluminium, and iron) show exceedances suggesting there is ASS somewhere in the catchment that is being activated though none was detected in the investigations.

Petroleum hydrocarbons have been detected in five of the six sample points. ENV Solutions have undertaken a contaminated land assessment at the site and detected hydrocarbons and determined they were naturally occurring (ie not petroleum based).

Table 4.3 Interim surface water baseline data set (mean values only, five sampling events (Jan-July 2021). Default trigger values have been shown for comparison only.

Parameter	Default trigger value	SW-01	SW-02	SW-03	SW-04	SW-05	SW-06
pH	7.0-8.5 #	4.22	4.29	4.56	4.97	6.16	5.73
Conductivity (EC) (dS/m)		0.12	0.12	0.10	0.11	1.67	0.23
Total Dissolved Salts (mg/L)		82.55	81.46	71.26	74.66	1136	158.0
Total Suspended Solids (mg/L)	50 ##	88	106	26.6	10.3	4.0	4.3
Total Phosphorus (mg/L P)	0.03 #	0.47	0.27	0.17	0.25	0.23	0.58
Phosphate (mg/L P)	0.005 #	0.29	0.20	0.11	0.17	0.14	0.53
Total Nitrogen (mg/L N)	0.3 #	2.79	2.03	1.25	1.16	0.75	1.40
Total Kjeldahl Nitrogen (mg/L N)		2.76	2.01	1.22	1.14	0.73	1.19
NOx	0.015 #	0.03	0.02	0.03	0.02	0.03	0.20
Nitrate (mg/L N)		ND	0.02	0.01	ND	0.04	0.22
Nitrite (mg/L N)		0.05	0.04	0.04	0.03	0.02	0.03
Ammonia (mg/L N)	0.015 #	0.15	0.13	0.12	0.11	0.11	0.26
Sodium (mg/L)		13.51	14.11	12.95	13.16	267.16	31.36
Potassium (mg/L)		0.82	0.90	0.76	0.98	10.60	3.63
Calcium (mg/L)		2.15	2.59	2.18	2.41	14.38	5.65
Magnesium (mg/L)		2.76	2.67	2.34	2.31	32.50	4.58
Sodium Absorption Ratio (SAR)		1.43	1.46	1.45	1.46	6.15	1.98
Chloride (mg/L)		143.0	80.8	61.0	39.1	442.3	85.4
Sulfur		5.43	3.66	4.07	3.04	25.51	6.77
Sulfate (mg/L SO42-)		16.3	11.0	12.2	9.1	76.5	20.3
Chloride/Sulfate Ratio	### 0.5	6.43	8.18	4.49	6.16	7.02	3.77
Chlorophyll 'a' (mg/L)	0.004#	0.15	0.12	0.03	0.03	0.02	0.04
Algal Biomass (mg/L)		10.18	8.18	1.84	1.88	1.06	2.72
Aluminium (mg/L)	### 0.005	0.69	0.80	0.65	0.55	0.44	0.42
Iron (mg/L)	### 0.5	0.40	0.47	0.94	1.45	1.01	0.87
Total Recoverable Hydrocarbons (TRH) (µg/L or ppb)							
C10-C14 Fraction		88	ND	ND	57	ND	ND
C15-C28 Fraction		120	170	140	960	ND	130
C29-C36 Fraction		110	200	77	1365	ND	130
C10-C16 Fraction		84	ND	ND	ND	ND	ND
C16-C34 Fraction		200	310	ND	1960	ND	220
C34-C40 Fraction		ND	ND	ND	1300	ND	ND
Sum C10-C36 Fraction		275	380	220	480	ND	250
ND = not detected/below detectable limits # = ANZECC default trigger vale (estuaries) ## = standard construction discharge limit ### = Indicator value for ASS (ASSMAC)							

4.4 Management Strategies (Surface Water Quality)

Ongoing monitoring and comparison with a pre-determined action level based on the baseline data set will alert management to a potential development related impact. Rectification of the impacts will need to be investigated with consideration to spatial and temporal effects, stakeholder values and practicality.

Surface water quality can affect groundwater quality through infiltration of contaminated water. Surface water monitoring is proposed as part of the overall environmental monitoring. The Environmental Manager will consider results of the surface water monitoring program if deleterious results of the groundwater quality monitoring are detected.

5 Action Response Plan

Should the results of groundwater sampling and analysis be outside the relevant trigger values be recorded the Groundwater Action Response Plan will be enacted (refer Table 5.1).

Table 5.1 Groundwater and Surface Water Action Response Plan

Performance Criteria	Action	Response
Groundwater quality*		
No decrease in groundwater quality due to proposed development (construction and operational stages)	1. Check and validate data a. Re take sample to confirm concentration/value 2. Notify management (Site Superintendent, Environmental Manager) 3. Undertaken Phase 1 investigation to confirm trigger exceedance is development (construction/operation) related a. If necessary engage suitably qualified person b. Review/consider recent conditions (weather, land use activities, construction activities) c. Review/consider other relevant monitoring data d. If investigation confirms trigger exceedance is not related to construction activities, record data and cease investigation 4. If trigger level exceedance is development related confirm if the activities have caused or have the potential to cause substantial environmental harm a. Notify Environmental Manager, Site Superintendent and relevant agencies as soon as practicable (whether or not it is development related) 5. Notify Environmental Manager and other relevant agencies if performance measures are exceeded as soon as practicable 6. Complete an Investigation Report and provide to all stakeholders and other relevant agencies with 21 days of identifying the incident 7. Prepare rectification proposal, engage stakeholders and remediate	Where it has been determined that development related impacts have caused a trigger exceedance, implementation of contingency and remedial measures is required. These may include, but not limited to, the following: • Review monitoring program and Groundwater Management Plan and revise if necessary • Investigate reasonable and feasible remedial measures • Review water management infrastructure (e.g. WSUD) and repair/renew if necessary
Groundwater Level		
No significant decrease or increase in groundwater levels due to the proposed	1. Check and validate data 2. Notify management (Site Superintendent, Environmental Manager) 3. Undertaken Phase 1 investigation to confirm trigger exceedance is development (construction/operation) related a. If necessary, engage suitably qualified person b. Review/consider recent conditions (weather, land use activities, construction activities)	Where it has been determined that development related impacts have caused a trigger exceedance, implementation of contingency and remedial measures is required. These

Performance Criteria	Action	Response
development	c. Review/consider other relevant monitoring data d. If investigation confirms trigger exceedance is not related to construction activities, record data and cease investigation 4. If trigger level exceedance is development related confirm if the activities have caused or have the potential to cause substantial environmental harm a. Notify Environmental Manager, Site Superintendent and relevant agencies immediately as soon as practicable (whether or not it is development related) 5. Notify Environmental Manager and other relevant agencies if performance measures are exceeded as soon as practicable 6. Complete an Investigation Report and provide to all stakeholders and other relevant agencies with 21 days of identifying the incident 7. Prepare rectification proposal, engage stakeholders and remediate	may include, but not limited to, the following: • Review monitoring program and Groundwater Management Plan and revise if necessary • Investigate reasonable and feasible remedial measures • Review water management infrastructure (e.g. WSUD) and repair/renew if necessary
Surface Water		
No significant increase in pollutant concentrations in surface water due to the proposed development	1. Check and validate data a. Retake sample and analysis to confirm exceedance 2. Notify management (Site Superintendent, Environmental Manager) 3. Undertaken Phase 1 investigation to confirm trigger exceedance is development (construction/operation) related a. If necessary engage suitably qualified person b. Review/consider recent conditions (weather, land use activities, construction activities) c. Review/consider other relevant monitoring data d. If investigation confirms trigger exceedance is not related to construction activities, record data and cease investigation 4. If trigger level exceedance is development related confirm if the activities have caused or have the potential to cause substantial environmental harm a. Notify Environmental Manager, Site Superintendent and relevant agencies immediately as soon as practicable (whether or not it is development related) 5. Notify Environmental Manager and other relevant agencies if performance measures are exceeded as soon as practicable	Where it has been determined that development related impacts have caused a trigger exceedance, implementation of contingency and remedial measures is required. These may include, but not limited to, the following: • Review monitoring program and Groundwater Management Plan and revise if necessary • Investigate reasonable and feasible remedial measures • Review water management infrastructure (e.g. WSUD)

Performance Criteria	Action	Response
	6. Complete an Investigation Report and provide to all stakeholders and other relevant agencies with 21 days of identifying the incident 7. Prepare rectification proposal, engage stakeholders and remediate	and repair/renew if necessary
* No groundwater quality or surface water quality action criteria have been assigned, these will be determined upon competition of the baseline data set		

6 References

AWC (2021a) Bayside *Estate, Brunswick Heads – Acid Sulfate Soil Assessment.* A report prepared for Clarence Property (Document No.: 1-201299_01a, Revision B, dated 04/08/2021)

AWC (2021b) *Wallum Estate – Acid Sulfate Soil Management Plan.* A report prepared for Clarence Property (Document No.: 1-211400_04a, Revision A, dated 04/08/2021)

DLWC (2002) *NSW State Groundwater Dependent Ecosystems Policy*. NSW Department of Land & Water Conservation, NSW Government

JWA (2011) *Amened Ecological Assessment Volume 1 and Volume 2 – Lot 73 DP 851902, Bayside Way Brunswick Heads*. A report to Codlea Pty Ltd

Stone, Y., Ahern C. R., and Blunden, B. (1998). *Acid Sulfate Soils Manual*. Acid Sulfate Soil Management Advisory Committee (ASSMAC), Wollongbar, NSW. Australia.

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