Gerroa Sand Resource

Water Management Plan

Appendix E of Quarry Environmental Management Plan

Version 2 | Revision 3

Issued – February 2023

Contents

Tables

Figures

Document Control

Version	Date	Reason	Reviewed	Approved
V1r1	2008	Original plan included within QEMP	Cleary Bros	Cleary Bros
V2r1	4/11/22	Draft plan for Agency review	M Hammond	H Cleary
V2r2	11/1/22	Updated following DPE review	M Hammond	DPE
V2r3	21/2/23	Updated following DPE Water comment	M Hammond	H Cleary

1. Introduction

This Water Management Plan (WMP) forms part of the Quarry Environmental Management Plan (QEMP) for the Gerroa Sand Resource (Project). This WMP has been prepared to meet the requirements of the Consolidated Approval for Project 05/0099, as modified and approved by the Minister for Planning (the Consent). The WMP sets out the surface water and groundwater management measures and strategies that will be employed on the Project to meet the requirements of the Consent, including the management of acid sulphate soils. Cleary Bros will submit the WMP (including supporting subplans) to the Secretary for approval prior to commencing any ground disturbance or extractive activities within the Modification 1 – Extraction Area, and commit to implementing the WMP as approved by the Secretary on the site.

2. Purpose and Objectives

The purpose of this WMP is to describe how the Project impacts on soil and water resources will be minimised and managed and address the requirements of Schedule 3 conditions 9 – 15A of the Consent.

The key objective of the WMP is to ensure that impacts on water quality are minimised. To achieve this objective, the following will be undertaken:

- ensure best management practice controls and procedures are implemented during construction activities to avoid or minimise erosion/sedimentation impacts and potential impacts to water quality of local waterways and groundwater in the vicinity of the Project;
- ensure appropriate measures are implemented to address the relevant regulatory requirements;
- ensure the functioning of the vegetation communities in the vicinity of the Project are not adversely affected as a result of the Project.

3. Requirements

This Water Management Plan has been prepared to ensure compliance of the Project against three key statutory requirements including:

- Environmental Planning and Assessment Act 1979 and Development Consent 05/0099
- Protection of the Environment Operations Act 1997 and Environmental Protection Licence (EPL) 4146
- Water Management Act 2000 and Water Access Licence (WAL) 43272.

A summary of the requirements of the subordinate approvals of each of the above are described in this section, along with a link to the management measures that address these requirements.

3.1 Development Consent 05/0099

Requirement	Link to Water Management Plan
Sch 3 Cond 9 – Discharges	Section 8 – Surface Water
Sch 3 Cond 9A & 9B – Water Supply	Section 7 – Site Water Balance
Sch 3 Cond 9C, 9D, & 9E – Flood Management	Section 6 – Flood Management
Sch 3 Cond 10 – Water Quality Objectives	Section 8 – Surface Water and Section 9 – Groundwater

Requirement	Link to Water Management Plan
Sch 3 Cond 11 – Water Management Plan	This Plan
Sch 3 Cond 12 – Erosion and Sediment Control Plan	Section 8.1 – Erosion and Sediment Control Plan
Sch 3 Cond 13 – Surface Water Monitoring Program	Section 8 – Surface Water Management and Section 11.1 – Surface Water Monitoring Program
Sch 3 Cond 14 – Ground Water Monitoring Program	Section 9 – Groundwater Management and Section 11.2 – Groundwater Monitoring Program
Sch 3 Cond 15 – Acid Sulphate Soils Management	Section 10 – Acid Sulphate Soils Management Plan and Section 11.1 – Surface Water Monitoring Program
Sch 3 Cond 15A – Site Water Balance	Section 7 – Site Water Balance

3.2 EPL4146

Requirement	Link to Water Management Plan
2 – Discharges to Air and Water and Applications to Land	Section 8 – Surface Water
3 – Pollution of waters	Section 8 – Surface Water and Section 9 – Groundwater

The EPA have released a licencing fact sheet *Using environment protection licensing to control water pollution* (2013) to provide a framework for the licencing of water discharges from licensed premises such as the Gerroa Sand Resource. This fact sheet adopts a risk based approach to licensing, and builds upon Section 120 of the POEO Act which makes it an offence to pollute waters (unless regulated by a license or regulation under Section 121 and 122). Using this fact sheet, the EPA has adopted a policy whereby licences limit only those pollutants with potential environmental impacts, and do not impose undue costs by placing requirements on substances unlikely to cause an impact. Licences are not intended to regulate those pollutants with little or no potential to be present at levels that pose a reasonable risk of harm to health or the environment.

3.3 WAL43272

WAL43272 permits the use of 56 ML of water from the Metropolitan Coastal Sands Groundwater Source. The Water Access Licence does not include any requirements specific to the Licence, however refers to the relevant conditions of the Water Sharing Plan. These requirements and where they are addressed in the Water Management Plan are as follows:

- Take of Water – Ensuring that the take of water under this licence in any water year does not exceed the available water determination for that year – refer to Section 7 – Site Water Balance.
- Monitoring and Recording – Recording the volume of water taken and the purpose for which it is taken – refer to Section 11 – Monitoring Program and Section 12 – Review and Reporting.
- Reporting – Notify the Minister in the event of any breach of Water Licence – refer to Section 12.5.

Cleary Bros holds works approvals 10MW119337 and 10MW119338 for the existing and new dredge pond respectively, and has applied to add these to WAL43272 as nominated works on the licence.

4. Plan Development and Consultation

The Water Management Plan for the original Project was approved by the then Department of Planning on 29 May 2009 as part of the consolidated Quarry Environmental Management Plan in 2009. This Water Management Plan has been updated following the approval of Modification 1 by Mark Hammond, an experienced environmental professional with over 15 years practical experience developing and implementing water management plans on mine and quarry sites. A range of specialist consultants have contributed to the content of the Plan including:

- Dr James Fox (Land & Water Consulting) – prepared the *Acid Sulphate Soil Management Plan* which is included as Annexure C) to this Water Management Plan.
- Iain Hair (Douglas Partners) – *Groundwater Issues* Report (Douglas Partners 2019), available at https://www.planningportal.nsw.gov.au/major-projects/projects/mod-1-condition-changes-9, which included relevant background, management measures, water licencing matters, and monitoring program associated with groundwater.
- Dr Camilla West (HEC Pty Ltd) – *Gerroa Sand Quarry Dredge Pond Water Balance and Creek Impact Assessment* (HEC 2019), available at https://www.planningportal.nsw.gov.au/major-projects/projects/mod-1-condition-changes-9, which included relevant background, management measures, water licencing matters, and monitoring program associated with surface water.

The above authors have been endorsed as the authors of the relevant documents by the Department of Planning and Environment.

The draft Water Management Plan (including Acid Sulphate Soil Management Plan) was provided to the Environment Protection Agency and DPE Water for their input prior to finalisation. The EPA advised on 14 November 2022 that they do not review or approve management plans, however provided direction to the EPA's water management guidelines on their website. These guidelines have been considered in the preparation of this plan, and no further changes are required in response to the EPA's comments. DPE Water provided feedback on the draft plan on 13 January 2023, with a range of comments on water licencing, flood management, the water quality objectives, monitoring, and erosion and sediment control strategies. In response to these comments, Cleary Bros have made the following changes:

- Section 7 (Site Water Balance) has been rewritten such that the focus of this section is on the determination of groundwater inflows to the dredge ponds from the coastal sands aquifer (water take) as a result of quarrying activities, including after closure. Section 11.3 (Water Take) has also been updated.
- Cleary Bros have now secured miscellaneous works approvals for the dredge ponds and applied to update WAL43272 to include them as nominated works on the licence.
- Section 6 has been updated to describe the predicted impacts of returning the northern section of the existing dredge pond to the floodplain on the local environment. This includes predicted impacts to water quality and flows in Blue Angle Creek and the water quality of the existing dredge pond.
- Section 5 has been updated to expand on the departures of surface and groundwater quality from the water quality objectives identified in the water monitoring program to date.
- Section 5 has been updated to include the background monitoring completed to date on the hydraulic conductivity of the soils of the existing Swamp Sclerophyll Forest communities.
- Section 8.1 (Erosion and Sediment Control Plan) has been updated to provide further detail on the Erosion and Sediment Control structures to be implemented on the site.

5. Existing Environment

On average, the site receives 1,312mm rainfall each year, with average annual evaporation of 1,254mm[1]. Rainfall is generally well spread throughout the year, with higher rainfall recorded in late Summer and Autumn (average of 154mm in March), while later Winter and Spring are generally drier (average of 73mm in September). Land in the vicinity of the dredge pond is predominantly cleared pasture used for grazing, with a history of turf farming in some parts of the Project Area. The quarry is located within the catchment of Blue Angle Creek which is a tributary of the Crooked River. Natural surface levels within the Modification area generally range from 1 mAHD adjacent to Blue Angle Creek to 3 mAHD on the footslopes of a northwest-southeast trending ridge. In the north-eastern section of the site, a sand ridge with elevation up to 9 mAHD separates the two arms of the proposed extension area. The alluvial and estuarine sediments including the topsoil layer within the Project Area have been confirmed as Acid Sulphate Soils (Douglas Partners 2018). The land to the west of the Project Area is used for agricultural purposes, with grazing and cropping activities contributing additional nutrient load to the local environment.

The proposed excavation by both mobile plant and dredge operation will expose ASS material both within and below a current oxidising environment. Coarse texture soils (the clean and silty sands) exposed in faces or floors of excavations at or above groundwater level are vulnerable to rapid oxidation due to their relatively high permeability and often negligible buffering capacity. Water moving relatively quickly through coarse material may create large volumes of contaminated leachate. Clay or clayey sand bands, which may contain higher sulphide levels, may be expected to oxidise at a slower rate than sandy soils but generate leachate over an extended period.

On the basis of the tonnage and currently indicated average (approximately 0.2%S) existing and potential sulfidic acidity of materials to be disturbed, the project is indicated to be within a XH (Extra high level of treatment) category for which a comprehensive environmental management plan (EMP) must be formulated to provide for ongoing management and monitoring of the effects of the disturbance of ASS through the entire operation period of a project. An Acid Sulphate Soil Management Plan has been developed and is included as Annexure C – Acid Sulphate Soil Management Plan.

Quaternary alluvial sands form a shallow water table aquifer at the Quarry and adjacent areas, and forms part of the Metropolitan Coastal Sands Groundwater Source within the Greater Metropolitan Region Groundwater Sources Water Sharing Plan. Cardno (2018) identified a generally consistent, north-east trending groundwater flow direction, towards the main drainage channel which continues northward into Blue Angle Creek and thence Crooked River. On a local scale recharge to the shallow water table aquifer would be through direct infiltration of rainwater and seepage of surface water from stream beds. Comparison of groundwater and surface water levels are suggestive of direct connection between the dredge pond and the shallow groundwater aquifer. Testing of the hydraulic conductivity of an undisturbed section of sand below the Swamp Sclerophyll Forest was undertaken in 2020 using both AS1547 (Field Permeability (Constant Head)) and the laboratory-based AS1289.6.7.1 (Permeability of a soil (Constant Head)). The laboratory analysis was utilised to confirm the validity of the field measurement. The field measurement returned a Saturated Hydraulic Conductivity of 2.48 m/day, which is reasonably consistent with the laboratory measurement of 1.21 m/day. These baseline values can be used to assess any changes to groundwater connectivity between the dredge pond and aquifer following emplacement of material in the dredge ponds.

Surface water in the main channel is tidally influenced in the vicinity of the dredge pond (Douglas Partners 2019). The quarry is split by the drainage channel leading to Blue Angle Creek, with the new extraction area on the north side and processing plant on the southern side of the channel. The existing dredge pond drains

[1] SILO data for -34.78 150.78 accessed 24/1/2023. Evaporation is Morton evaporation over shallow lakes.

a small catchment immediately south of the dredge pond (up to the Berry siltstone ridgeline near the present Berry Beach Road), which otherwise does not catch any significant runoff from surrounding areas. An overflow pipe has been constructed through the bund wall close to the processing plant, to prevent overtopping and failure of bunds in an extreme event. The area of the new dredge pond drains a small upslope catchment associated with the spur to the northwest of the Project Area (in the vicinity of the weather station), with no other significant sources of drainage from surrounding areas.

The Project site includes areas that are inundated during episodic flooding events. The Flood Study (Cardno 2019) identified that parts of the Project Area would currently be inundated in flood events equal to or exceeding the 5 year ARI event. A flood bund has been constructed in parts of the existing dredge pond to ensure no overtopping of the dredge pond batter in a flood event up to and including the 100 year ARI event. Additional flood bunding is required to exclude floodwaters from the new dredge pond and has been designed to minimise potential impacts on adjoining landowners.

The water quality of the existing dredge pond has been monitored on a monthly basis since 2007 for pH, electrical conductivity, and water level. An extended suite has also been tested on a quarterly basis. The minimum, maximum, median and average measurements for each water quality analyte is summarised in Table 1, alongside the objective levels from the Development Consent. Table 1 demonstrates that certain water quality objectives for the dredge pond are not always met, and based on groundwater monitoring from further afield suggest the objective levels are not reflective of the local environment.

Table 1 - Historical Water Quality of the Dredge Pond

Analyte	Dredge Pond				DC Objectives
	Min	Median	Mean	Max	
Conductivity (µS/cm)	376	601	660	1040	< 1,500
pH (pH units)	6.4	7.9	7.8	8.8	6 - 8.5
Total Algae (cells/mL)	525	33,025	136,767	2,070,000	< 15,000*
Cyanophyta (cells/mL)	0	25,600	107,189	2,070,000	< 15,000*
Total phosphorus (µg/L)	3	20	46	790	< 30
Total nitrogen (µg/L)	40	500	618	6,900	< 350
Chlorophyll-a (µg/L)	<1	4.5	7	49	< 5
Faecal coliforms (No./100mL)	1	20	120	2,100	< 1000
Enterococci (No./100mL)	<1	20	44	690	< 230
Sodium (mg/L)	33	53	55	91	< 400
Potassium ion (mg/L)	1	5	5	8	< 50
Magnesium ion (mg/L)	9	13	14	22	< 50
Chloride (mg/L)	16	76	83	140	< 300
Sulphate ion (mg/L)	25	76	110	1300	< 250
Bicarbonate ion (mg/L)	<2	99	96	313	< 750
Dissolved iron (mg/L)	<0.05	<0.05	0.1	0.8	< 6
Total Ammonium-N (µg/L)	<10	20	30	360	< 20
Turbidity (NTU)	1	5.3	10.2	97.9	1 – 20*
Dissolved Oxygen (DO) (mg/L)	4.2	9.0	9.0	11.3	> 6*
DO (%)	51.9	100	98.9	125.0	80-110%*

* Objectives apply to surface water only. All other objectives apply to both surface and groundwater

The water quality objectives can be broken into two main groups – those driven by changes in the nutrient balance of the water, and those less influenced by the nutrient balance of the water. Those parameters that are less influenced by the nutrient balance of the water include electrical conductivity (EC), major ions, dissolved iron, turbidity, faecal coliforms and enterococci, and to a lesser extent pH and dissolved oxygen. Those directly affected by the nutrient balance of the water include nitrogen and phosphorus species, algae, cyanobacteria, and chlorophyll, and to some extent pH and dissolved oxygen.

The analytes less influenced by the nutrient balance of the water typically meet the water quality objectives, with only occasional measurements outside the objective levels. All electrical conductivity and major ion concentrations have met the objectives since the current sampling program commenced in 2007, with the exception of a single anomalous sulphate measurement in 2009. This single measurement is an order of magnitude difference from the adjoining values, and doesn't appear possible when considering the electrical conductivity and cation concentrations recorded for that sample, and as such is likely a laboratory reporting error.

Dissolved iron concentrations have remained within the water quality objectives since 2007. Turbidity concentrations have occasionally exceeded the water quality objective, typically when dredging close to the sampling point, and as such are unlikely to reflect the turbidity of the broader water body. Faecal coliform has exceeded the objectives twice, in March 2014 and December 2016, while the enterococci concentration exceeded the water quality objective in a single sample in March 2012. Each of these results are anomalous and not linked to changes in any other analyte.

Those analytes that are closely related to the nutrient balance are commonly outside the objective levels. These measurements likely stem from the use of fertilisers for agricultural activities upgradient and outside of the Project Area, and unrelated to the Project, with higher concentrations of nitrogen and phosphorus recorded in groundwater bores between these land uses and the dredge pond. This has likely contributed to total algae (and cyanobacteria) concentrations regularly above the objective levels. These species typically display seasonal variations in concentrations, with levels in the Winter and Spring months (normally sampled June and September) below the objective level, while those in Summer and early Autumn consistently above the objective level. This trend has existed since the commencement of the current sampling program in 2007, and is likely driven by solar radiation intensity rather than site factors.

Chlorophyll-A concentrations have shown considerable variability throughout the monitoring period, and as for turbidity, show higher concentrations during periods when dredging has occurred closer to the sampling point, albeit showing a poor correlation with turbidity. Dissolved oxygen concentrations have remained above the criteria of 6 mg/L for all but 4 (of 65) samples since 2007. These four samples appear to occur during or immediately following periods of high rainfall during Summer and early Autumn, likely attributable to aerobic breakdown of biological material that has washed into the dredge pond following these heavy rainfall events. pH levels also show a pattern approximately linked to climate with lower pH levels (6.4 – 7.5) observed during periods of above average rainfall, while levels are generally higher (8.0 – 8.8) during drier periods. The lower levels following wetter periods are likely related to increased flushing of oxidised pyrites in the surrounding aquifer as local groundwater levels rise in response to the increased rainfall. Conversely, the higher pH levels during drier periods are likely attributable to lower exchanges with the local aquifer at these times.

Regular monitoring of Blue Angle Creek has been undertaken since 2019 at the upstream (Site B) and downstream (Site C) extents of the modification area for pH and electrical conductivity, with monitoring data showing considerable influence from the brackish Crooked River estuary as well as an influence from the acid sulphate soils of the catchment. Median pH at the upstream and downstream points between March 2019 and November 2021 was 6.4 and 6.9 respectively, while the median electrical conductivity at these points was 1675 and 7820 respectively.

Cleary Bros has monitored the pH and EC of two farm dams (Dam 3 and Dam 4) within the modification area monthly since March 2019. These dams show considerable natural fluctuations in water quality related to these parameters, with Dam 3 showing occasional brackish influences. A summary of water quality within these dams is included in Table 2. Periods of higher EC in Dam 3 correspond with low water levels in this dam, likely related to greater tidal exchange of water as a proportion of total inflows during dryer periods. Also noticeable is the lower pH values (<6.5) in Dam 3 typically relate to periods of low electrical conductivity, however this trend is not observed in Dam 4. As Dam 3 is situated across an existing drain, it is likely that this dam is closely linked to water quality in Blue Angle Creek. Dam 4 in contrast is likely more closely linked to the alluvial aquifer, with no direct linkages to the drainage channels.

Table 2 – Water Quality of farm dams (Dam 3 and Dam 4)

Farm Dam	pH (pH units)			Electrical Conductivity (µS/cm)		
	Min	Mean	Max	Min	Mean	Max
Dam 3	5.8	7.1	8.6	131	420	3,040
Dam 4	6.0	6.9	7.7	114	260	341

Groundwater quality has been measured at a series of monitoring bores in the vicinity of the existing dredge pond since 2009, with longer records available for some bores. Regular monitoring of groundwater in the vicinity of the modification area has been undertaken since June 2019 (NB02, NB03, and NB04), with further background monitoring since March 2020 (MW07). Groundwater quality across the site is highly variable, with influences from naturally occurring acid sulphate soils and brackish estuary water observable in the newer bores at various times. A summary of all water quality data, including the minimum, mean, and maximum of all monitoring bores is presented in Table 3.

Table 3 - Historical Groundwater Quality

Analyte	MW1			MW1A			MW2B		
	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max
Conductivity (µS/cm)	260	4,559	8,010	90	199	350	300	769	1310
pH (pH units)	3.4	5.7	7.0	3.7	5.4	6.3	6.3	7.1	7.7
Total Phosphorus (µg/L)	<10	272	4780	<10	190	780	<10	133	580
Total Nitrogen (µg/L)	1,100	4,260	51,100	900	2,820	10,100	700	990	1,400
Chlorophyll-a (µg/L)	<1	2	20	<1	7	90	<1	<1	6
Faecal coliforms (No./100mL)	<1	121	3,700	<1	159	1,600	<1	5	150
Enterococci (No./100mL)	<1	41	1,700	<2	38	200	<1	14	270
Sodium (mg/L)	230	1,055	1,480	14	27	36	38	60	92
Potassium (mg/L)	<1	4	14	<1	2	8	1	3	4
Magnesium (mg/L)	12	127	199	3	5	7	9	13	26
Chloride (mg/L)	60	1,698	2,550	18	38	56	57	107	198
Sulphate (mg/L)	4	297	600	<1	11	48	8	78	660
Bicarbonate (mg/L)	<1	54	540	3	13	40	122	170	211
Dissolved Iron (mg/L)	0.16	33.0	120	0.4	1.5	4.4	0.1	4.2	22.5
Ammonium (mg/L)	<0.01	2.87	49.5	<0.01	0.03	0.18	<0.01	0.46	1.3

Analyte	MW3A			MW04(07)			NB02		
	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max
Conductivity (µS/cm)	176	592	1,030	60	506	892	189	284	408
pH (pH units)	6.0	7.0	8.0	4.5	6.3	7.7	4.8	5.5	6.0
Total Phosphorus (µg/L)	<10	205	900	<10	265	1750	10	140	330
Total Nitrogen (µg/L)	600	2120	23,200	100	880	4,000	500	1650	3,400
Chlorophyll-a (µg/L)	<1	<1	3	<1	<1	7	<1	1	4
Faecal coliforms (No./100mL)	<1	54	890	<1	4	40	<1	3	20
Enterococci (No./100mL)	<1	310	15,000	<1	20	680	<1	<2	5
Sodium (mg/L)	4	36	77	11	45	81	21	33	45
Potassium (mg/L)	<1	3	6	<1	4	11	3	5	6
Magnesium (mg/L)	2	7	18	2.5	11	25	4	6	8
Chloride (mg/L)	8	63	146	33	74	172	31	54	90
Sulphate (mg/L)	<1	47	990	<1	40	138	17	26	34
Bicarbonate (mg/L)	62	140	246	<1	67	182	7	11	16
Dissolved Iron (mg/L)	0.18	5.0	22.0	<0.05	3.5	44	1.55	2.4	6.02
Ammonium (mg/L)	<0.01	1.42	22.3	<0.01	0.06	0.4	0.04	0.26	1.49
Analyte	**NB03**			**NB04**			**MW7**		
	Min	**Mean**	**Max**	**Min**	**Mean**	**Max**	**Min**	**Mean**	**Max**
Conductivity (µS/cm)	102	300	613	6,100	8,225	9,650	5,490	6,409	7,700
pH (pH units)	4.8	5.8	6.9	5.4	6.1	6.5	3.7	4.0	4.3
Total Phosphorus (µg/L)	20	118	280	<10	32	60	50	174	400
Total Nitrogen (µg/L)	700	2,300	9,200	1,200	1,570	1,900	600	1,510	2,700
Chlorophyll-a (µg/L)	<1	<1	<1	<1	<1	2	<1	5	36
Faecal coliforms (No./100mL)	<1	40	370	<1	3	28	<2	5	24
Enterococci (No./100mL)	<1	5	39	<2	<2	2	<1	8	36
Sodium (mg/L)	13	36	72	1,040	1,309	1,430	765	972	1,340
Potassium (mg/L)	3	6	11	32	39	42	22	30	38
Magnesium (mg/L)	1	5	10	17	163	228	163	216	232
Chloride (mg/L)	18	57	135	351	2,591	3,210	832	1,209	1,580
Sulphate (mg/L)	<1	17	38	34	304	468	1,940	2,339	2,740
Bicarbonate (mg/L)	8	47	312	1	111	221	<1	<1	<1
Dissolved Iron (mg/L)	0.25	1.3	2.91	2.7	53.7	92.7	58.9	93.2	109
Ammonium (mg/L)	<0.01	0.61	3.67	0.12	0.73	0.94	0.08	0.13	0.18

It is noted that the objective levels were generally adopted from the NSW Surface Water Quality Objectives for the protection of surface water values, and provide a poor representation of the background environment of the site. A comparison of the water quality objectives and the groundwater monitoring completed to date is provided below.

pH

pH levels are regularly recorded below the objective level for most bores due to the influence of acid sulphate soils, with those closer to the dredge pond generally within the objective level due to the moderating effect of the large body of water.

Conductivity and Major Ions

MW1 has recorded electrical conductivity and major ion concentrations consistently above the objective levels. Analysis of the major ion species of this bore shows a different fingerprint to the other bores, as well as that of seawater. The EC is similar to that recorded in a nearby bore hosted in the underlying Berry Siltstone strata (GW105025), and as such MW1 is likely screened within this unit.

Bores NB03, NB04, and MW7 also show EC and major ion concentrations above the objective levels, which relate to their close proximity to the brackish influence of Blue Angle Creek and its tributaries. These three bores show considerable variation in these species, dependent on flows in Blue Angle Creek and the local groundwater level.

Nitrogen and Phosphorus Species

The concentrations of total nitrogen and total ammonium in all bores has almost always measured above the objective level throughout the period of monitoring, suggesting the water quality objectives are not reflective of the background levels of nitrogen in the aquifer. This trend has also been established through background monitoring of the bores adjacent to the new dredge pond prior to development, and a background bore established to the west of the site (MW7). Similarly, the concentration of total phosphorus has consistently exceeded the objective level in all groundwater monitoring bores, with significant variability evident between sampling events.

Chlorophyll-A

Chlorophyll-A concentrations have occasionally exceeded the objective levels in approximately half of the monitoring bores, with exceedances more prevalent during the initial 10 years of extraction from the Extension Area. Over the past 5 years, only 3 exceedances have been recorded across 2 bores, and have followed periods of significantly above average rain, likely attributable to some flushing effects.

Microorganisms

Faecal coliform levels have remained below objective levels for all but four samples (of 667) since the current monitoring program began in 2007. These outliers were in all cases once-off events, with the 95th percentile of all samples less than 5% of the objective level. Enterococci levels have also consistently remained below the objective level, with 10 (of 664) results above the objective level since 2007, and enterococci detectable in less than half of the samples collected since this time.

Dissolved Iron

Dissolved iron concentrations have exceeded the objective level at times for all but two of the current groundwater monitoring bores. Those bores with minimal influence from dredging, including MW1, NB03, and MW7, appear to show consistently higher concentrations of dissolved iron, suggesting that the dredge pond may be having a moderating effect on dissolved iron concentrations of the adjacent aquifer. It is likely that the anaerobic depositional environment of Foys Swamp has favoured the retention of reduced iron species.

Groundwater level data for the monitoring network, including the current investigation levels representing the 2 standard deviation limits, are summarised in Table 4. They show considerable variability linked largely to climatic variations, indicative of the natural groundwater regime of the area.

Table 4 - Historical Groundwater Levels and Investigation Levels (as at January 2022)

Monitoring bore	Historical Water Level (mASL)				Investigation Levels (2 standard deviation from mean at Jan 2022)	
	Min	Mean	Median	Max	Min	Max
MW1	0.64	1.23	2.03	1.55	0.56	3.51
MW1A	2.69	2.86	2.98	3.07	2.37	3.58
MW2B	0.69	1.37	1.25	1.72	0.47	1.87
MW3A	0.65	1.37	1.265	1.76	0.39	2.08
MW04(07)	0.49	1.08	0.975	1.44	0.14	1.74
NB02	0.56	0.91	0.845	1.42	0.40	1.37
NB03	0.54	1.24	1.235	2.25	0.31	2.13
NB04	0.6	1.00	1.035	1.47	0.57	1.42
MW7 (background)	0.35	0.86	0.805	1.62	-	-

The location of all surface and groundwater monitoring sites are shown in Figure 1. A number of groundwater bores in addition to those listed above are shown in Figure 1 as "Discontinued". The then Department of Planning approved the decommissioning of groundwater bore MW06(07) on 12 October 2012, due to the progression of the dredge pond. The Department of Planning and Environment subsequently approved the decommissioning of groundwater bore MW05 on 1 February 2017, due to ongoing issues with this bore. The *Groundwater Issues Report* (Douglas Partners 2009) for Modification 1 proposed a revision of the groundwater monitoring program, which added new groundwater bores to the west of Blue Angle Creek surrounding the new dredge pond, while discontinuing monitoring from some groundwater bores around the existing dredge pond that were not significantly contributing to the groundwater monitoring program. Those bores that were proposed to be discontinued in an updated Water Management Plan included MW1D, MW2A, MW3C, MW4, MW01(07), MW02(07), MW03(07), and MW05(07). A summary of current and historical monitoring bores for the site, including references where relevant to bores listed in the Development Consent, is provided in Table 5.

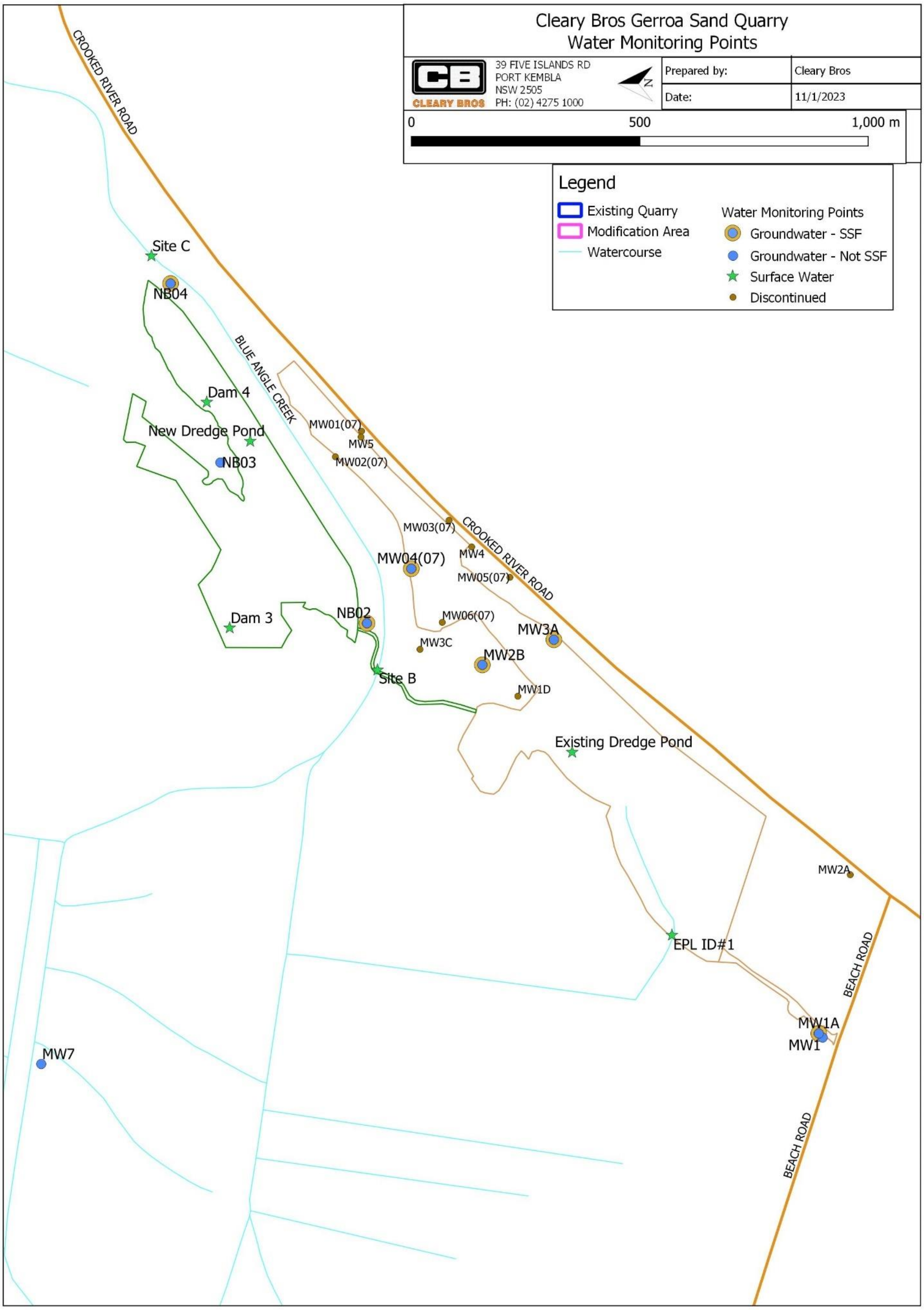


Figure 1 - Water Monitoring Sites

Table 5 – Monitoring Bore Nomenclature and Current Status

Monitoring Bore Name	Reference to bore in Development Consent	Current Status
MW1	"WM1"	Current
MW1A	"WM1A"	Current
MW2A	"WM2A"	Discontinued (Mod 1)
MW2B	Not referenced	Current
MW3A	"WM3A"	Current
MW4	"WM4"	Discontinued (Mod 1)
MW5	"WM5"	Discontinued (2017)
MW01(07)	"1/Aug07"	Discontinued (Mod 1)
MW02(07)	"2/Aug07"	Discontinued (Mod 1)
MW03(07)	"3/Aug07"	Discontinued (Mod 1)
MW04(07)	"4/Aug07"	Current
MW05(07)	"5/Aug07"	Discontinued (Mod 1)
MW06(07)	"6/Aug07"	Decommissioned (2012)
NB02	Not referenced	Current
NB03	Not referenced	Current
NB04	Not referenced	Current
MW7 (background)	Not referenced	Current

6. Flood Management

The Development Consent requires the preparation of a detailed design for the flood mitigation bunds, their progressive construction around the perimeter of the new dredge pond, and a three-yearly review of their adequacy. This flood bund has been designed to exclude flood waters for events up to the 100 year ARI (incorporating climate change forecasts) including a 500mm buffer to allow for wind and wave run up. The detailed design for the flood mitigation bund is included as Annexure B. Due to the nature of the site, the 100 year ARI level varies across the floodplain, with the required crest of the flood bund varying between 3.37 mAHD in the western parts of the site to 3.30 mAHD in the northernmost parts as shown in Figure 2. A surface water diversion drain will also be constructed around the northwestern extent of the new dredge pond in later years to drain water from the hill once quarrying begins in this area. The flood bund is intended to prevent surface water inflows during and following high rainfall events, however due to the porous nature of the sandy soils in the local area, there will be ongoing exchanges of water between the dredge ponds and the surrounding alluvial aquifer.

To minimise the risk of flooding of adjoining properties, part of the existing dredge pond (the section northeast of the processing plant) will be returned to the flood plain. This will include the removal of a small section of flood bund from the existing dredge pond (shown as a red line in Figure 2) and the infilling and construction of a new flood bund spanning the narrowest part of the existing dredge pond (shown as a dark blue line in Figure 2). The infill and bund construction near the processing plant will occur progressively over the early years of extraction from the new dredge pond as material becomes available, with the existing bund removed once the new bund has been developed to its design level. The flood modelling undertaken for the Modification area indicated that following these changes, the isolated northern section would receive floodwater inflows in a 5 year ARI event.

Ordinarily the salinity (electrical conductivity) of the water in Blue Angle Creek in the vicinity of the dredge ponds is higher than the water in the surrounding monitoring bores and dredge ponds. However monitoring undertaken during periods of higher flow in Blue Angle Creek indicate the salinity of the surface water reduces to a level lower than the surrounding groundwater and dredge ponds. A reduction in salinity of the dredge ponds is also observed at these times, however due to rainfall dilution rather than surface water inflows. Following the removal of this flood bund, it is likely the former dredge pond salinity will reduce further with the inflows of freshwater. There may be a slight increase in the salinity of Blue Angle Creek, however this is likely to be undetectable due to the significant flows that would be present at the time. Once the flood subsides, the water in the former dredge pond will continue to exchange with the alluvial aquifer, reducing the salinity and major ion concertation of the aquifer until an equilibrium is reached. The measured pH of Blue Angle Creek during higher flows has generally approximated 7, which is similar to the dredge pond during wetter periods. As such, it is likely that pH levels of Blue Angle Creek, the dredge pond and the surrounding aquifer will not be significantly affected through the return of the former dredge pond to the floodplain. For other analytes including nutrient species (N, P) and dissolved iron, species concentrations within the dredge pond have typically recorded lower levels than the surrounding aquifer, and this is likely to remain unchanged following the removal of the flood bund.

The flood study for the Modification area identified that the “CP” area would need to be extracted separately from the remainder of the Modification area to prevent impacts to adjacent properties. To meet this aim, once extraction has been completed in the “CP” area, a flood bund will be constructed behind the advancing dredge pond (as shown spanning the northeastern finger in Figure 2). This northeastern area will be returned to the floodplain to ensure flooding of adjacent properties is not exacerbated as a result of dredging. There is some overlap in the “CP” and “South” areas to allow for the progressive dredging into the “South” area while backfilling of the flood bund within the “CP” area is carried out. Prior to the removal of any flood bunds, water quality monitoring will confirm that the water contained within the area to be returned meets the discharge criteria described in Section 8. The removal of flood bunds will not be undertaken during flood events, such that there will not be any surface water flows to or from the dredge pond as an immediate result of bund removal. Once the “CP” area has been returned to the floodplain, extraction of the remaining areas can proceed without exacerbating flooding on adjacent properties.

Flood bunds will be progressively constructed in the manner shown in Annexure A, using the design shown in Annexure B. Flood bunds will be constructed from either locally sourced material (such as topsoil treated as required under the ASSMP) or from VENM materials. Flood bunds will be surveyed following construction to confirm they have been constructed to the design level.

Cleary Bros will engage a hydrologist to review the flood model in 2025 and every three years thereafter. The purpose of this review will be to check the adequacy of the flood bunds using the most recent data available (hydrological, meteorological, climate). In the event the review identifies overtopping of the dredge pond in the 100 year ARI (incorporating climate change forecasts), the flood bund will be altered as required to ensure protection under the revised model.

In the event that extreme rainfall requires dewatering of either dredge pond, discharges will be undertaken as described in Section 8.

Figure 2 – Surface Water and Flood Control Structures

7. Site Water Balance

The Site Water Balance has been compiled based on the information provided in the Environmental Assessment for Modification 1, and updated following feedback from DPE - Water. It includes surface water data and predicted site usage data prepared by Dr Camilla West of Hydro Engineering & Consulting (HEC) as part of the *Gerroa Sand Quarry Dredge Pond Water Balance and Creek Impact Assessment* (HEC 2019), the Aquifer Interference Assessment prepared by Mr Iain Hair of Douglas Partners as part of the *Groundwater Issues* Report (Douglas Partners 2019), and rainfall and evaporation data sourced from the SILO database for the Gerroa site.

The site consists of two reservoirs (dredge ponds), which are connected to the coastal sands aquifer through the porous bed and banks of the ponds. Water exchanges freely between the reservoirs and the aquifer, with these transfers supporting the local groundwater flows and the functioning of the Swamp Sclerophyll Forest around the dredge ponds. The volume of the dredge ponds are variable in response to rainfall, groundwater level changes, and dredging activities, however have been estimated as 1,030 ML for the existing dredge pond (HEC 2019) and between 0 ML and 460 ML in the new dredge pond, depending on the stage of extraction. The excavated nature of these reservoirs below the lowest foreseeable groundwater level means that they will always contain sufficient water to support site operations. In the unforeseeable event that they were both dry, site activities would be ceased. Movements of water between the dredge ponds and the aquifer at varying stages of site development are shown in Figure 3 to Figure 5, and are dependent on the following variables:

- Rainfall inflows to the dredge ponds;
- Evaporation from the dredge ponds;
- Pumping of water to and from the dredge ponds, either as part of the sand slurry or to balance water levels;
- Runoff of water from the sand slurry back into the dredge pond;
- Extraction of sand from the dredge pond below the immediate groundwater level, creating a void;
- Water leaving the site entrained in exported sand; and
- Water extracted for dust suppression and vegetation establishment purposes.

Rainfall

1,312 mm of rain falls across the site in an average year[2], contributing 243 ML to the existing dredge pond and up to 197 ML to the new dredge pond (dependent on size), through rain falling directly on the dredge pond surface. These volumes ignore the minor contributions from surface runoff.

Evaporation

1,254 mm of water evaporates from the surface of the dredge ponds in an average year[2], removing 232 ML of water from the existing dredge pond and up to 188 ML from the new dredge pond. The evaporation from the dredge ponds is entirely offset by the rainfall contributions to the dredge ponds in an average year, with a minor surplus of rainfall.

Pumping of Water and Runoff back into dredge pond

At the maximum production rate of 80,000 t/year, approximately 23.2 ML/year water will be required to pump the sand from the new dredge pond to the processing plant (based on a sand density of 2.3 t/m^3 and water making up 40% by volume of slurry). This same amount would be pumped from the existing dredge

[2] SILO data for -34.78 150.78 accessed 24/1/2023. Evaporation is Morton evaporation over shallow lakes.

pond to the new dredge pond to balance water levels in the ponds. Most of the slurry water would re-enter the existing dredge pond predominantly via the tailing pipeline, with some contribution through stockpile runoff. A small proportion of water would remain entrained in the stockpiled sand.

Water Entrained in Exported Sand

At the maximum production rate of 80,000t/year, approximately 2.6 ML/year water is expected to be exported from the site through water entrained within the exported sand. This has been calculated based on a sand density of 2.3 t/m^3 (34,800m^3 sand) and a moisture of 7.5%, which is at the upper end of typical measured sand moistures.

Replacement of Sand with Water in the Void

At the maximum production of 80,000 t/year, approximately 34,800 m^3 of sand will be removed from the new dredge pond creating a void in the landscape. The part of this void below the current groundwater level will fill with water until an equilibrium is reached, and in the absence of contributions from other sources, these inflows will come from the surrounding alluvial aquifer. At maximum production, the area of the void will increase by approximately 1 ha each year. In a typical year the groundwater level is approximately 1 metre below the ground surface. As such, 24.8 ML of water will be required to replace the volume of sand removed below the groundwater table in an average year at maximum production.

Water Extracted for Dust Suppression, Watering and Emergency Response

Water is required for watering haul roads and for watering new seedlings until their establishment, in the absence of rainfall. Approximately 1.1 ML will be required annually for road watering, and a further 0.1 ML for vegetation establishment. Water for these purposes is sourced from a pump with standpipe drawing from the existing dredge pond. Water from the dredge ponds would also be made available to emergency services if required in an emergency.

Consolidated Water Balance and Site Water Take

Figure 3 to Figure 5 present the water transfers within the site and the predicted exchanges with the aquifer in an average year at three stages of site development. Figure 3 depicts water transfers in the first year of extraction, Figure 4 depicts the final year of extraction, and Figure 5 depicts water transfers after site closure. Where water flows into the dredge ponds from the surrounding aquifer, there would be a take of water from the Metropolitan Coastal Sands Groundwater Source. The Water Balance Model shows groundwater inflows to the new dredge pond at the maximum extraction rate in an average rainfall year would reduce from 24.2 ML in the first year to 16.1 ML in the final year. Meanwhile, the existing dredge pond would contribute 6.9 ML to the aquifer (ie. water flowing back into the aquifer) in each year of the Project life. Cleary Bros understands that the Greater Metropolitan Region Groundwater Sources Water Sharing Plan does not currently permit crediting of water returned to an aquifer, and as such the 6.9 ML contribution from the existing dredge pond cannot be claimed as a credit for the purposes of determining water take.

During the initial years of extraction from the new dredge pond, rainfall inflow and evaporation outflow would be minimal due to the small surface area of the pond (modelled at 1 ha), with a small surplus of rainfall contributing to the new dredge pond. As the surface area of the new dredge pond increases over time, the surplus of rainfall over evaporation would increase the contribution to the dredge pond, reducing the inflows from the aquifer. All other transfers would remain unchanged throughout the Project life, and are dependent on the production rate. The water take from the existing dredge pond would be unchanged throughout the Project life, and once again dependent on the production rate.

Once extractive activities have ceased on the site, all water transfers except for rainfall and evaporation would also cease. Due to the surplus of rainfall over evaporation at the site, both dredge ponds would contribute water to the aquifer after closure, and as such there would be no water take. A summary of water take at different stages of site operations is provided in Table 6.

Table 6 – Water Take at Different Stages of Operations

Stage of Quarry	Take from Existing Dredge Pond (ML)	Take from New Dredge Pond (ML)	Total Take (ML)
First Year	-6.9	24.2	24.2
Final Year	-6.9	16.1	16.1
After Closure	-10.7	-8.7	0.0

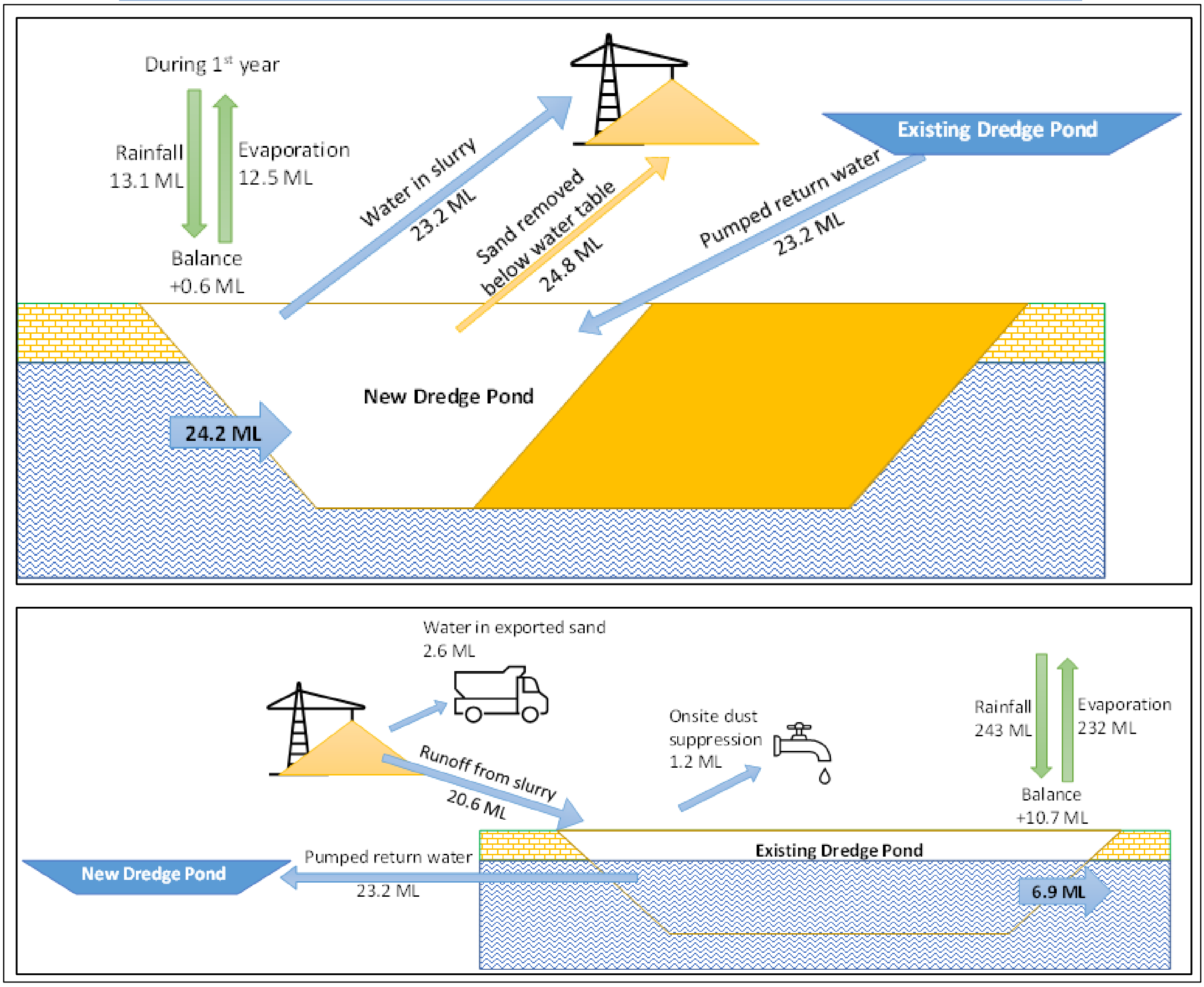


Figure 3 – Site Water Balance - New and Existing Dredge Ponds in First Year

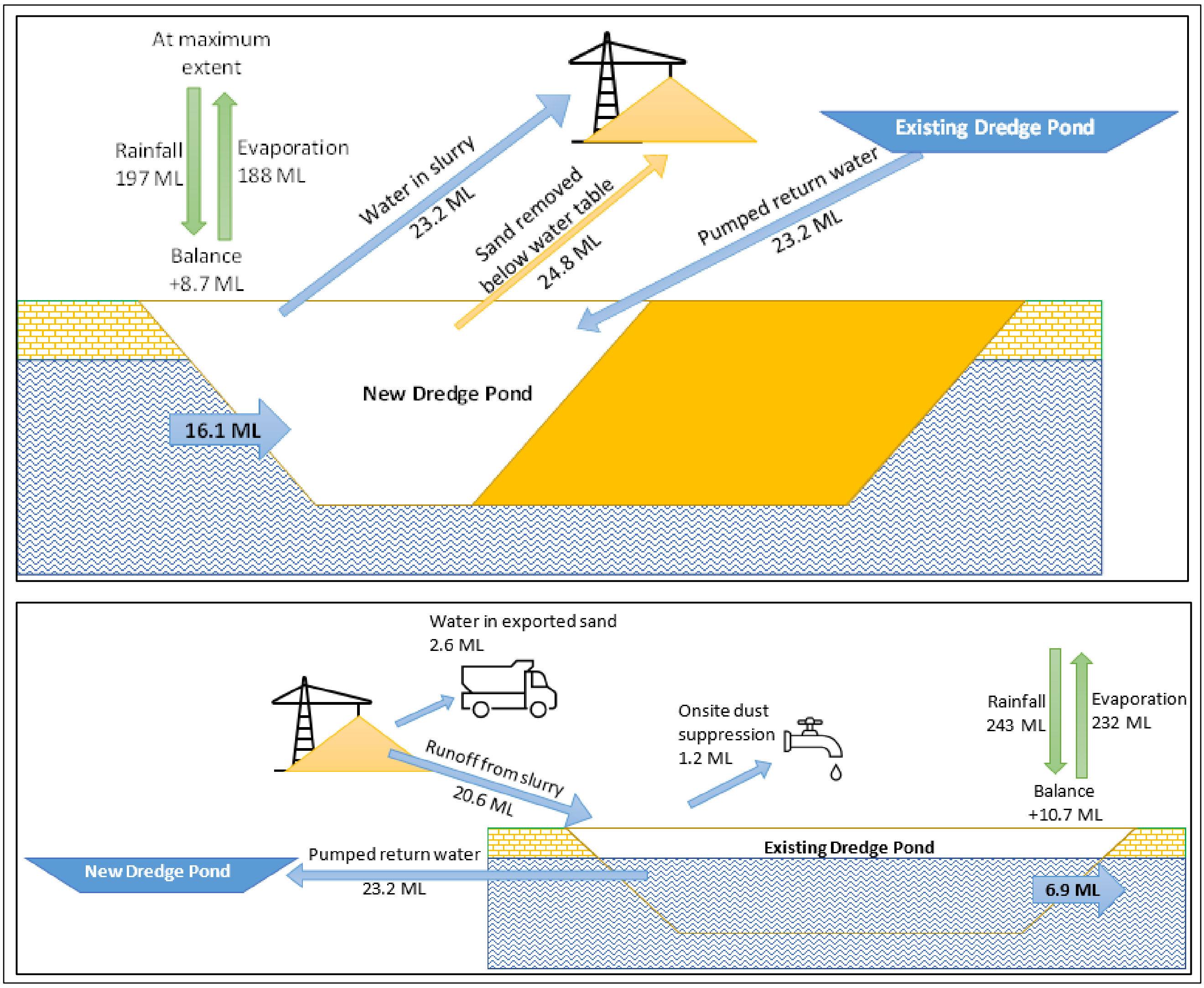


Figure 4 – Site Water Balance - New and Existing Dredge Ponds in Final Year

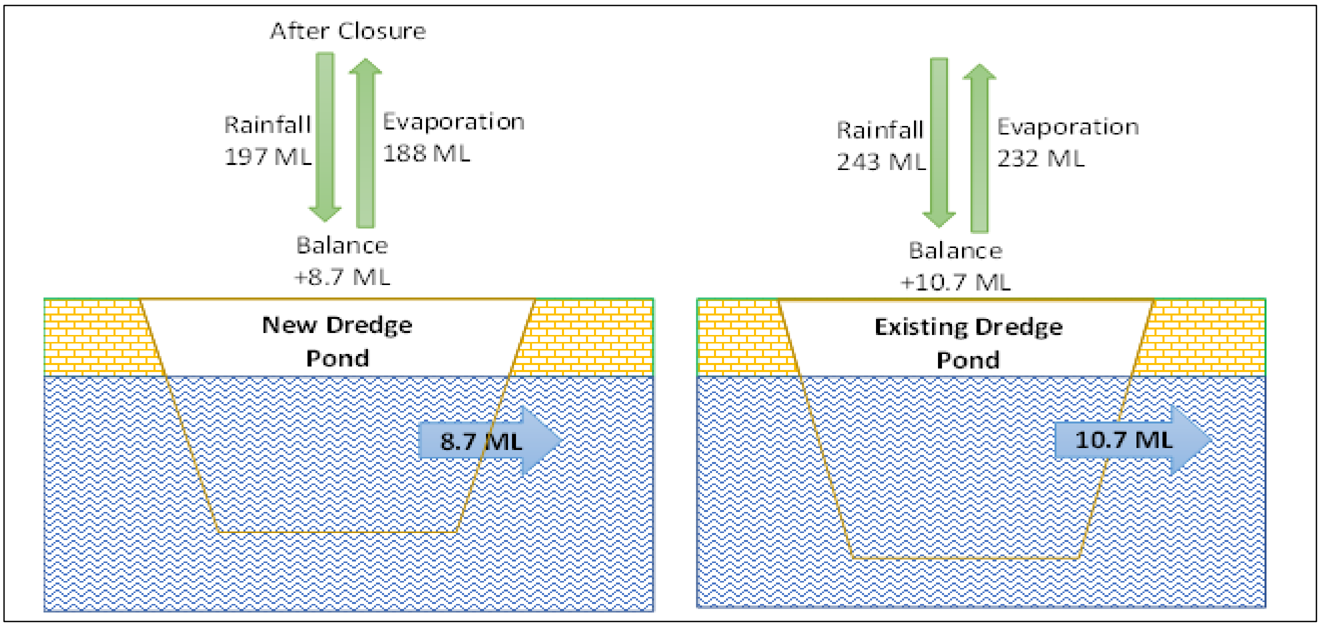


Figure 5 – Site Water Balance - New and Existing Dredge Ponds in After Closure

The Water Balance model has depicted water take based on average rainfall and evaporation, which is appropriate given the extended life of the site. Interrogation of the annual evaporation figures in the SILO dataset indicates there is only a minor difference between the minimum annual evaporation and maximum annual evaporation, and that there is a poor relationship between annual evaporation and annual rainfall. However, the SILO dataset shows greater variability in the annual rainfall for the site, which ranges between 630 mm and 3,129mm (mean 1,312mm). During a year that is significantly drier than the average, there evaporation from the dredge ponds will exceed rainfall, which will increase the water take from the aquifer in that year. This will however be balanced by the significant rainfall surplus in wetter than average years, where there will be a negative take of water from the aquifer. As such, the calculations of water take have been based on average rainfall and evaporation which are appropriate for a multi-decadal project such as this.

As shown in Table 6, 24.2 ML of water would be taken from the Metropolitan Coastal Sands Groundwater Source in Year 1 of extraction from the new dredge pond when extracting at the maximum production rate of 80,000 t/year of sand. This would reduce to 16.1 ML take in the final year of operations, and 0 ML after closure. Cleary Bros currently holds Water Access Licence (WAL) 43272, which includes 56 units of the Metropolitan Coastal Sands Groundwater Source. Under historical allocations, this is equivalent to 56 ML of annual entitlements, well above the 16.1 – 24.2 ML expected to be taken from the aquifer annually. As such, Cleary Bros hold sufficient entitlements to allow the lawful take of water from the aquifer in accordance with the Water Management Act 2000. The processes for monitoring the take of water in accordance with the conditions of WAL43272 are described in Section 11.

8. Surface Water Management

The Performance Objectives for the surface water management system include the water quality objectives described in the Consent, maintaining the bed and bank stability of the dredge pond, and meeting any water quality discharge limits of EPL4146. Surface water quality objectives for the Project are listed in Table 1.

There are currently no specific discharge criteria in EPL4146, however the licence requires compliance with Section 120 of the POEO Act 1997, which prohibits the pollution of waters. The EPA fact sheet *Using environment protection licensing to control water pollution* (2013) specifies a risk-based approach to licensing, where limits are only applied to those pollutants that may be at levels that pose a reasonable risk of harm to health of the environment. Due to the nature of the sites activities and connectivity of the dredge ponds to the broader coastal sands aquifer, it is considered that the only non-trivial pollutants in the dredge pond to receiving surface waters are likely to be pH and suspended solids.

To minimise the risk of surface water pollution from dredge pond discharges, the following design and management measures will be implemented on the site:

- Flood protection has been installed around the existing dredge pond to a height of at least 3.2 metres AHD where natural ground level is less than 3.2 metres AHD. This will prevent any uncontrolled discharges from the existing dredge pond in a flood event up to the 100 year ARI level.
- Flood protection will be constructed progressively around the new dredge as it expands to a height of between 3.3 and 3.37 mAHD as described in Section 6. This will prevent any uncontrolled discharges from the new dredge pond in a flood event up to the 100 year ARI level.
- The wet sorter is located immediately beside the existing dredge pond so that wash water draining from the sand slurry will return directly to the pond.
- A pump and pipeline have been installed to transfer water from the existing dredge pond to the new dredge pond, to ensure the balance between the ponds is maintained.

- Provision is made for the existing dredge pond to overflow via a 150 millimetre diameter pipe, delivering overflow water to a sediment pond and then passing through the flood bund to discharge into Foys Swamp on the other side.
- Sediment fencing will be progressively installed around the periphery of the new dredge pond prior surface disturbance as described in the Erosion and Sediment Control Plan (Section 8.1).

The following management measures will be implemented on the site:

- Maintain continuity of the flood bunds to prevent ingress of flood water to the site.
- Maintain the sealed access road with a well-drained and clean surface to minimise material tracking from the site on the wheels of departing vehicles.
- During any uncontrolled or controlled discharge from either dredge pond, all dredging and processing activities will be suspended.
- Ensure that refuelling of mobile plant is carried out in a designated refuelling area and that maintenance of mobile machinery is undertaken well away from either dredge pond, where practicable.
- Maintain and operate all plant and equipment to minimise the risk of contaminants escaping to soil or water.
- Implement the management requirements of the Erosion and Sediment Control Plan (Section 8.1). In particular:
    - maintain sediment fencing around recently disturbed areas to prevent sediment leaving the site;
    - ensure that completed sections of the new dredge pond foreshore and associated batters remain stable and do not erode to add turbidity to the pond.
- Monitor surface water in accordance with the surface water monitoring program in Section 11.
- A controlled discharge will only be undertaken from the site to restore the dredge ponds to their normal levels following a significant rainfall event.
- A controlled discharge will only be undertaken where the turbidity of the dredge pond is less than 20 NTU, and pH monitoring verifies that the water quality of the dredge pond either meets the water quality objectives (pH 6.0 – 8.5) or is closer to neutral (pH 7) than the surface water flows in Blue Angle Creek when measured at the flood gates.
- Review the performance of the surface water management strategies as part of the Annual Review described in Section 12.3.

The above design and operational management measures will ensure that site activities do not cause non-trivial pollution of surface waters.

8.1 Erosion and Sediment Control Plan

This Erosion and Sediment Control plan has been prepared with reference to and to be consistent with the Landcom publication *Managing Urban Stormwater: Soils and Construction, Volume 1, 4th Edition, 2004* (the 'Blue Book').

8.1.1 Introduction

The Project is divided into two main areas – the existing dredge pond and associated site infrastructure, and the new dredge pond. All surface infrastructure associated with the site drains to the existing dredge pond, which acts as a large settling basin for these unsealed areas. A flood bund will be progressively constructed around the new dredge pond as the pond expands, which will have the secondary effect of retaining any runoff from the majority of disturbed areas within this area. The flood bunds will also have the effect of excluding runoff from undisturbed areas around the periphery of the dredge pond, allowing unobstructed flow from these areas to the adjoining drainage lines. As the new dredge pond extends to the west, a swale drain will be constructed along the base of the hill to redirect flow around the outside of the dredge pond to the north and south.

Having regard to the unique circumstances of the Project, the potential risk of erosion and sedimentation that is addressed in this plan is as follows:

- erosion during dredging operations caused by wind, vehicle movement, rainfall or wave action;
- sediment movement during initial disturbance for clearing and topsoil stripping;
- sediment movement around the periphery of the new dredge pond;
- erosion of final batters both within the foreshore zone and in the dry zone above.

The above risks are addressed in the following sections. The key features of the Erosion and Sediment Control Plan are shown in Figure 6.

8.1.2 Erosion Control During Sand Extraction

While the site is functioning as a sand quarry, procedures to be observed to control erosion include:

- internal roadways and the loading area are to be kept moist when in use to minimise erosion initiated by vehicles;
- activities involving disturbance to dry sand will cease during periods of high wind when there is visible evidence of material escaping to the wind as a result of mobilisation by machinery;
- topsoil stockpiles will be stabilised unless the topsoil is to be used for rehabilitation within four weeks of stockpiling;
- prior to sand extraction in the vicinity of the western hill, clean water cut-off drains will be installed immediately upslope of the new dredge pond as shown in Figure 6. These drains will be sized to convey runoff from a 2 min-10% AEP storm event, and convey runoff from this area to Foys Swamp;
- the rate of sand quarrying will be controlled to match product dispatch to avoid accumulating excessive stockpiles;
- finished surfaces will be stabilised as soon as possible following shaping to minimise exposure to erosion;
- completed sections of the dredge pond foreshore and batters are to be inspected at least quarterly and any erosion damage repaired.

8.1.3 Sediment Control During Sand Extraction

Clearing and Topsoil Stripping

Prior to any disturbance for clearing or topsoil stripping, geotextile sediment fencing will be installed around the periphery of the work area where there is a slope away from the dredge pond, as shown in Figure 7. This will include the length of the eastern Project boundary where it parallels Blue Angle Creek, as well as the western limits adjoining Foys Swamp. The sediment fencing is designed to catch sediment from sections of the flood bund prior to their stabilisation, and in other areas that have been topsoil stripped ahead of dredging.

Sediment fencing will remain in place until the flood bund slope or other ground disturbance draining to the sediment fence has been stabilised to a similar level of ground cover as adjoining undisturbed areas. Sediment fencing is not required on any slope leading into the working area of the dredge pond as any sediment movement in that direction will be collected by the dredge pond.

Maintenance

Sediment fencing is to be inspected at least monthly and after any significant rainfall event. Any necessary maintenance is to be undertaken whenever the need is apparent. Sediment shall not be allowed to build up in front of sediment fencing.

8.1.4 Protection of Final Landform

Finished surfaces will have a geotechnically stable slope for the length of the internal and external banks. Stabilisation works are to commence on these surfaces as soon as profiling is complete. Habitat creation and vegetation planting shall be in accordance with the Landscape and Rehabilitation Management Plan.

Sand dune batters and the dredge pond foreshore are to be inspected quarterly in the post quarrying period and maintenance undertaken until such time as stability is confirmed. Should it be found that wave action continually erodes a section of foreshore, a hydrologist will be consulted as to measures to permanently stabilise the location.

Once adequate stabilisation has been achieved, such that there is minimal sediment generation or erosion from completed sections of the site, the sediment fence will be progressively removed and reused or disposed of at a licenced waste facility. Other water management structures, including swale drains, will remain as part of the final landform.

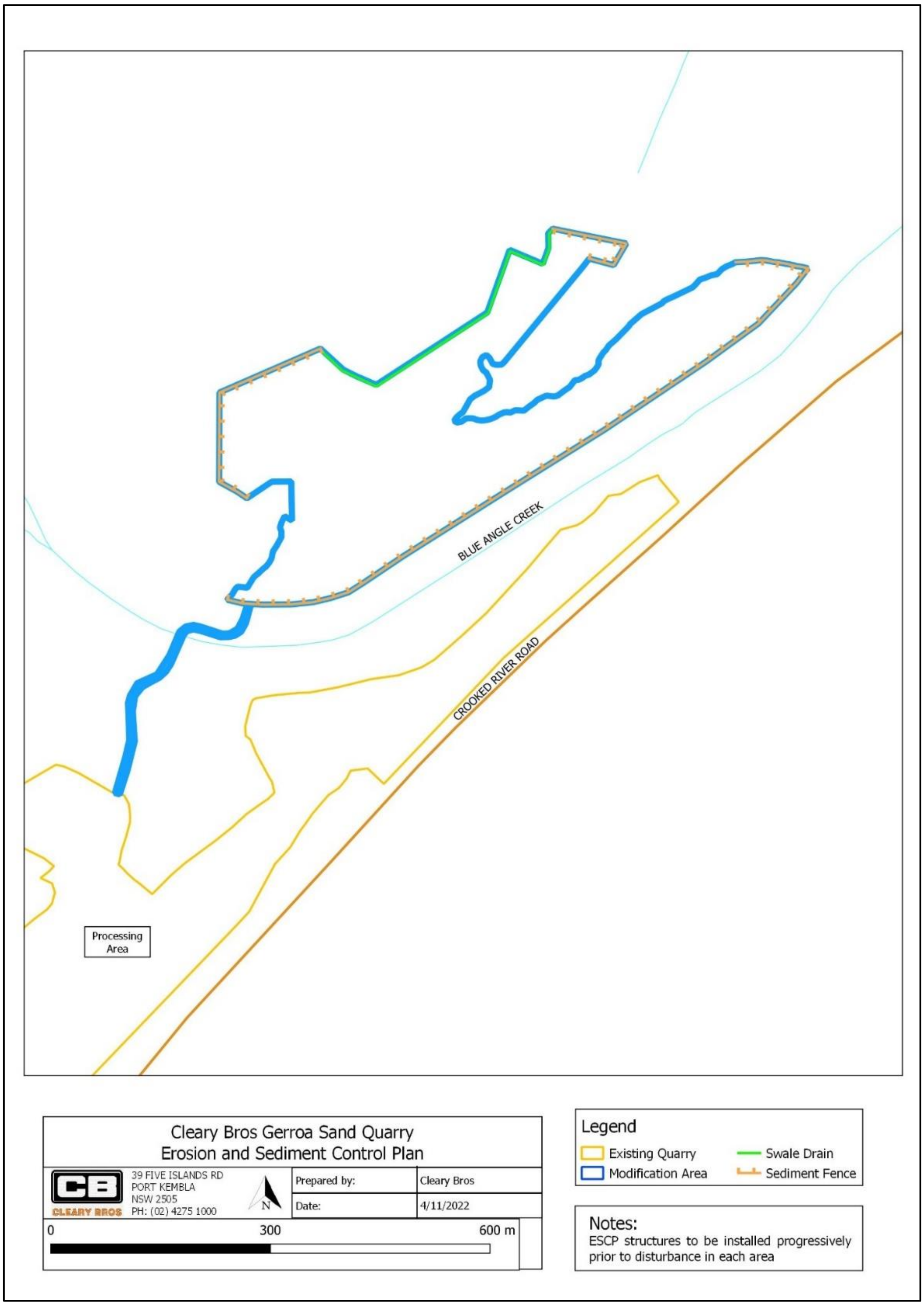
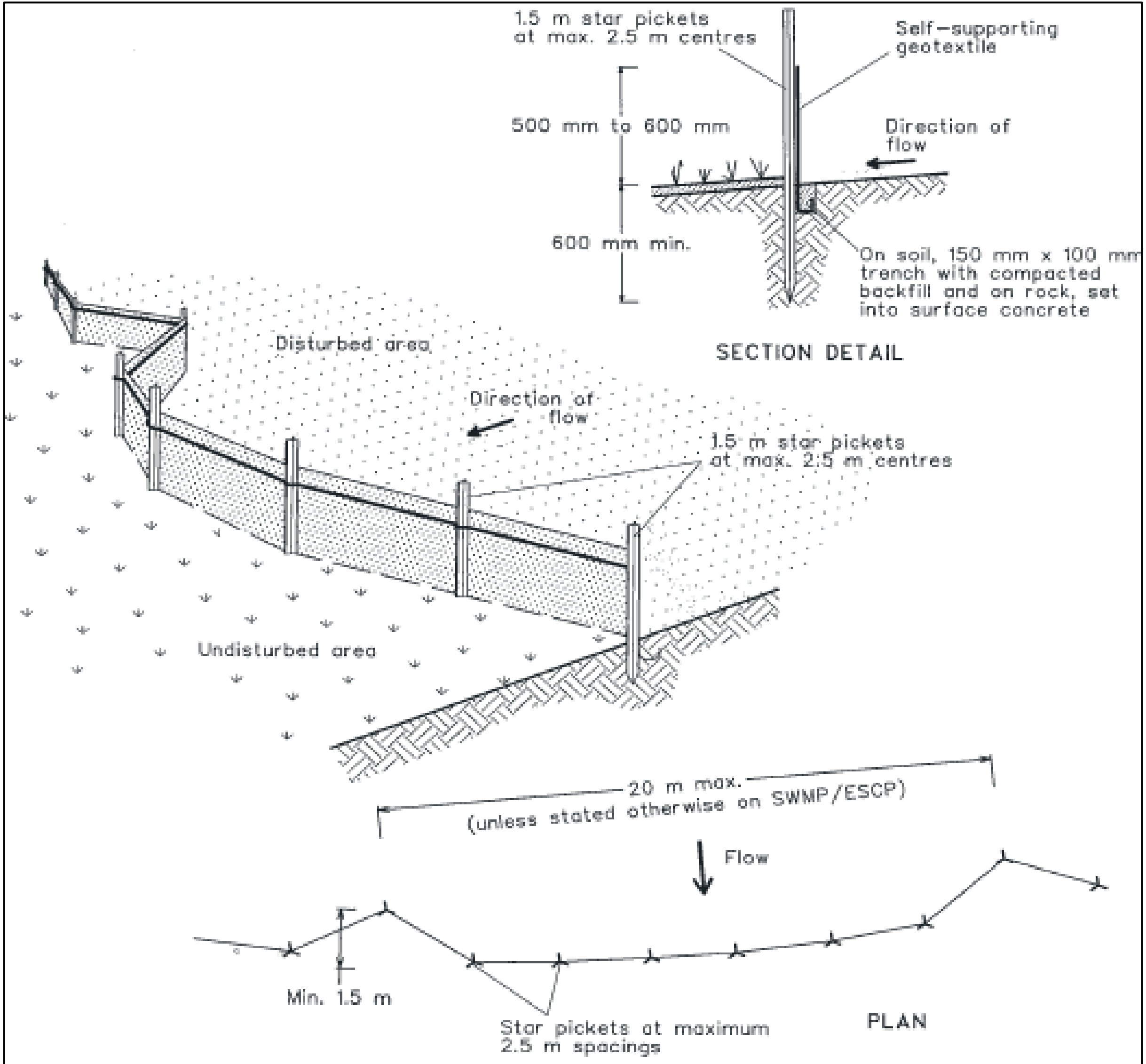


Figure 6 – Erosion and Sediment Control Plan



Construction Notes

1. Construct sediment fences as close as possible to being parallel to the contours of the site, but with small returns as shown in the drawing to limit the catchment area of any one section. The catchment area should be small enough to limit water flow if concentrated at one point to 50 litres per second in the design storm event, usually the 10-year event.
2. Cut a 150-mm deep trench along the upslope line of the fence for the bottom of the fabric to be entrenched.
3. Drive 1.5 metre long star pickets into ground at 2.5 metre intervals (max) at the downslope edge of the trench. Ensure any star pickets are fitted with safety caps.
4. Fix self-supporting geotextile to the upslope side of the posts ensuring it goes to the base of the trench. Fix the geotextile with wire ties or as recommended by the manufacturer. Only use geotextile specifically produced for sediment fencing. The use of shade cloth for this purpose is not satisfactory.
5. Join sections of fabric at a support post with a 150-mm overlap.
6. Backfill the trench over the base of the fabric and compact it thoroughly over the geotextile.

Figure 7 – Sediment Fence construction

9. Groundwater Management

The Performance Objectives for the groundwater management system include aiming to meet the groundwater quality objectives described in the Consent, maintaining groundwater connectivity and flows between the alluvial aquifer and the dredge ponds, and minimising impacts to groundwater dependent ecosystems. Groundwater quality objectives which the Project will aim to meet are listed in Table 1. Objectives associated with maintaining groundwater connectivity include maintaining groundwater levels across the monitoring network within two standard deviations of the historical averages (unless attributable to climactic factors), as well as ensuring no significant difference in hydraulic conductivity of emplaced high-hydraulic conductivity material from that of the adjoining areas. Finally, the Project will aim to cause no unplanned adverse impact on the groundwater dependent ecosystems, including adjoining vegetation communities forming the Conservation Area for the Project.

In order to meet these objectives, the following design measures will be implemented on the site:

- Where imported material is used for foreshore rehabilitation, emplace high hydraulic conductivity material at 50 metre intervals along completed sections of the dredge pond foreshore to maintain comparable groundwater flow to the surrounding vegetation communities as existed prior to excavation. The emplaced material is to have a hydraulic conductivity similar to corresponding areas that have not been excavated.
- The hydraulic conductivity of the emplaced material will be measured in accordance with Field AS1547 (Permeability (Constant Head)). This testing will be undertaken at 20 metre intervals along completed sections of emplaced material. Each test will be compared against the corresponding background site to ensure the hydraulic conductivity of the emplaced material is not significantly less than the background site. Background testing was undertaken in 2020, with Saturated Hydraulic Conductivity measured at 2.48 m/day as per AS1547.
- Three additional groundwater monitoring bores have been installed around the periphery of the new dredge pond (NB02, NB03, NB04), and a further background monitoring bore has been installed to the west of the dredge pond, as shown in Figure 1 (MW7).
- Monitoring has been discontinued in several groundwater bores around the existing dredge pond as these bores do not add significant value to the groundwater monitoring program (MW1D, MW2A, MW3C, MW4, MW5, MW01(07), MW02(07), MW03(07), and MW05(07)).

The following management measures will be implemented on the site:

- Groundwater monitoring program will be implemented as described in Section 11.
- The Environmental Officer will review all groundwater monitoring results on a monthly basis, who will maintain auditable records confirming that the review has taken place.
- In the event that the water level in any bore lies outside the range of two standard deviations from the mean (of that bore) for more than 6 months and does not follow a trend that can be attributed to climatic events as evident in other monitoring bores, dredging and processing activities will stop and a hydrogeologist engaged to investigate as follows:
  - Temporary bores or spears will be installed in the vicinity of the affected bore (based on the advice of the hydrogeologist) to identify the size and distribution of any anomaly.
  - The hydrogeologist will assess the significance of the variance from the expected groundwater behaviour
  - If the hydrogeologist considers that the variance is significant and is likely to adversely impact the Swamp Sclerophyll Forest community, they will recommend an appropriate remedial action plan. This plan may include the adjustment to the placement strategy for panels of

high hydraulic conductivity material or other strategy based on the particular case. The remedial action plan will be submitted to the DPE for approval, and once approved, implemented on the site.

- Should any other groundwater impacts be identified as a result of the groundwater monitoring program, the matter will be referred to a hydrogeologist for advice prior to implementing measures to mitigate, remediate and/or compensate for those impacts, as may be appropriate.

10. Acid Sulphate Soil Management Plan

This section provides a summary of the Acid Sulphate Soil Management Plan (ASSMP) prepared by Dr James Fox of Land and Water Consulting, which is included as Annexure C to the Water Management Plan. This summary outlines the key management measures, monitoring requirements, action criteria, and contingency measures to be employed on the site to manage the risk of acid sulphate soils. The ASSMP was prepared with reference to the following previous studies and guidance manuals:

- Douglas Partners (November 2018) Acid Sulfate Soil Management Plan, Proposed Sand Quarry Extension;
- National Acid Sulfate Soils Guidance: National acid sulfate soils identification and laboratory methods manual (June 2018);
- EPA's Acid Sulfate Soils Manual (1998)

The ASSMP included the results from the detailed acid sulphate soil sampling program undertaken by Environmental and Natural Resource Solutions (ENRS) in 2021 for the stages labelled "CP" and "South" in Figure 2. A further update of this plan will be required following detailed sampling in the stages labelled "West" and "Middle", and which will be submitted to the Planning Secretary for approval prior to any extraction within these stages.

The ASSMP and following summary describe the management measures that are to be employed during extraction activities, including measures to be undertaken to ensure processing fines are deposited below the average groundwater level. The action criteria for surface water and groundwater monitoring (including for trace metals) with respect to acid sulphate soils, as well as contingency measures to be employed in the event these are exceeded are also included in this section of the Water Management Plan, as described in the ASSMP.

10.1 Extraction Methodology

The proposed dredging methodology is staged as outlined below:

1. Mechanical excavation of an area approximately 5m by 25m to a depth of approximately 3m to facilitate floatation of the dredge;
2. Mechanical excavation will continue to assist with sump enlargement until the excavation footprint is approximately 25m by 50m;
3. Dredge the material within approved area to the target depth using a cutter suction dredge;
4. Dredge material is pumped to the existing Site processing plant for hydro-cycloning to separate the sand resource from reject material;
5. Reject materials (fines) will be piped back into the existing dredge pond for disposal below the permanent groundwater table.

10.2 Responsibilities

The Quarry Manager is responsible for ensuring that the requirements of the ASSMP are met, and that the mitigation measures prescribed in the ASSMP are implemented in accordance with the specified performance criteria.

All other site personnel are responsible for implementing the processes prescribed in the ASSMP, as applicable to their work activities.

All workers will receive training on the basic recognition and identification of ASS as part of the Site Induction for the site.

10.3 Management Measures

10.3.1 Initial Excavation Treatment

Material excavated from the dredge pond during steps 1 and 2 of the extraction methodology (Section 10.1) will be managed in accordance with the Stockpile Management protocols of the ASSMP (Section 5.6.1 of Annexure C). This will include the establishment of a lime-based treatment pad, with all materials excavated on to this pad. The process for managing this material will be as follows:

1. Treatment area will be compacted using heavy equipment to reduce permeability of soils.
2. Lime will be applied across the compacted treatment pad at a rate of 5kg/m^2.
3. Excavated material will be placed on the prepared pad, either directly by the excavator, or using a haul truck where required.
4. Lime will be spread across the stockpile at a rate of 34kg aglime (which has been adjusted based on 250 superfine aglime local supply NV of 97%) per tonne of raw material.
5. Material will be turned over and mixed using an excavator to ensure lime is spread through stockpile.
6. The treated material will be sampled in accordance with Table 5-3 of the ASSMP. This will involve taking one composite sample for every 500m^3 (1000t) of treated material and testing for the chromium reducible sulphur suite.
7. In the event neutralising capacity does not exceed existing plus potential acidity by a factor of 1.5, steps 4-6 will be repeated until verification is achieved.
8. Following verification, the stockpiled material will be placed back into the excavated dredge pond over time (once the dredge is established), and the material will form part of the continuous dredging process.

10.3.2 Dredge Pond Batter Treatment

The final batters of the dredge pond, which are at the extraction limits, will be cut using an excavator to ensure a stable final landform while maximising the utilisation of the sand resource from the approved footprint. Material excavated in this manner will be placed directly into the dredge pond (below water level) and as such no specific treatment is required, with the management measures described in Section 10.3.3 applicable. However, the exposed batters will need to be limed to treat any acid that may be generated from these newly exposed faces. The exposed batters will be treated as follows:

1. Excavator cuts final dredge pond batter.
2. Lime will be spread across the exposed batter at the rate of 3.4kg/m^2, which allows for the treatment of the outer 10cm of batter which may become exposed (using 97% NV aglime at the rate of 34kg/t).
3. Verification testing is not required, however pH of the new dredge pond will be monitored in real-time to ensure adequate control.

10.3.3 Dredging and Processing Measures

The dredging and washing process is a wet process with the sand pumped as a slurry to the processing plant where the saleable sand is sorted from any oversize material (such as cobbles) and fines. The fines are then captured at the base of the processing plant where they are fed back into the existing dredge pond. To reduce the risk of oxidation of these fines, they will be piped below the water surface to ensure they are disposed below the lowest groundwater table. The pipeline will run at a steady grade with the end of the pipeline weighted to ensure sub-aqueous disposal. This process will ensure the fines are not significantly exposed to the air to limit any potential for oxidation. An automatic water quality station which measures pH on the surface of the dredge pond and at depth close to the site of deposition will ensure that the pH of the existing dredge pond is not significantly altered through the deposition of fines in this manner.

The stockpiled sand will be stored above ground and exposed to oxygen in the atmosphere. While the processing plant should remove any considerable sulphides in the sand that could oxidise, the pH of any leachate running from the stockpile will be tested weekly, and the total oxidisable sulphur of the sand in the stockpile will be tested monthly. The base of the stockpiles will have a gradient towards the dredge pond to ensure any leachate is directed towards the dredge pond. These measures will ensure there is minimal risk of acid generation from the stockpiled sand.

10.4 Monitoring and Action Criteria

Table 7 summarises the monitoring program and action criteria to minimise the risks associated with acid sulphate soils. These are consolidated in Section 11 alongside the other monitoring measures of the Water Management Plan.

Table 7 – ASS Monitoring Summary

Site	Frequency	Parameter	Acceptable Level	Trigger Response
Existing dredge pond New dredge pond	Continuous (minimum daily)	pH	≥ 6.5	Confirm result using hand-held probe undertake monthly testing suite
Existing dredge pond New dredge pond Site B Site C Rejects Pipeline	Monthly	pH	≥ 6.5	Confirm result and implement contingency measures if trigger levels are confirmed by re-testing
		Dissolved oxygen	≥ 3mg/L; and ≥ 50% saturation	
		Total alkalinity, Total acidity	Positive net acidity	
		Dissolved metals (listed in Table 8)	See Table 8	
		Turbidity, EC, Temperature	Monitor only	N/A
MW1 MW1A MW2B MW3A MW04(07) MW7 NB02 NB03 NB04	Quarterly	pH EC Major ions (Ca, Mg, Na, K, SO_4, Cl) Total Alkalinity Total Acidity Dissolved metals (listed in Table 8)	See Table 8 and Table 9	Confirm result and implement contingency measures if trigger levels are confirmed by re-testing

10.4.1 Interim Action Criteria for Dissolved Metals

The action criteria for dissolved metals are triggered in the event both of the following criteria are met for any groundwater or surface water site:

- Rolling median of 5 consecutive samples is greater than the trigger (Sep 2022 maximum + 1 SD); and
- 3 consecutive samples are greater than the trigger (Sep 2022 maximum + 1 SD).

The Tier 1 and Tier 2 trigger values for each dissolved metal is listed in Table 8 for surface water and groundwater.

Table 8 – Interim Dissolved metals action criteria (calculated from 95% ANZG values)

Dissolved metal	Surface water (µg/L)	Groundwater (µg/L)
Aluminium	55	2,700
Arsenic	24	24
Boron	370	370
Barium	137	137
Beryllium	1.3	1.3
Cadmium	0.8	2.0
Chromium	13	30
Cobalt	2.8	2.8
Copper	6	13
Manganese	1900	1,900
Nickel	44	105
Lead	20	48
Selenium	11	11
Vanadium	12	12
Zinc	152	152
Mercury	N/A	N/A
Iron	326[1]	See Table 9

[1] Existing dredge pond only. Other surface water criteria to be developed as per Section 10.4.2.

10.4.2 Refinement of Site-Specific Action Criteria

Once eight sample points have been collected for each sample site, a Tier 1 80th percentile will be calculated per analyte for each site and represent the Limit A (Tier 1) upper trigger criteria. The 95th percentile will also be calculated and will represent the Limit B (Tier 2) upper trigger.

Once these site-specific limits have been developed, the action criteria for dissolved metals are triggered in the event both of the following criteria are met for surface water and groundwater:

- Limit A: Rolling median of five (5) samples is greater than Tier 1 trigger (80th%ile);
- Limit B: Three (3) consecutive individual exceedances greater than Tier 2 trigger (95th%ile) occur.

Action criteria for dissolved iron in groundwater have already been developed and are included in Table 9.

Table 9 – Dissolved iron site-specific action criteria for groundwater

Bore	Limit A (mg/L)	Limit B (mg/L)
MW1	47.2	74.63
MW1A	1.512	4.215
MW2B	5.64	12.945
MW3A	6.432	17.63
MW04(07)	4.268	17.8
NB02	2.522	4.082
NB03	1.72	2.754
NB04	80.5	92.46

10.5 Contingency Measures

In the event any Action Criteria are triggered as described in Section 10.4, the relevant monitoring point will be re-sampled to confirm the result. In the event the re-sample returns a result that does not trigger the action criteria, no additional action will be undertaken. Where re-sampling confirms the action criteria have been triggered, Cleary Bros will implement the following:

- Stop dredging and processing activities
- Notify the Planning Secretary and relevant agencies as described in Section 12.5.
- Consult with a suitable environmental consultant, and implement one or more of the following depending on the nature of the exceedance (such as the relevance of the trigger to acid sulphate soil development) and the risk to the receiving environment:
    - Where the trigger relates to the existing dredge pond or nearby groundwater bores, consider in-line lime dosing of the rejects pipeline at 40g/L (may be adjusted based on testing).
    - Where the trigger relates to the new dredge pond or associated surface water monitoring sites, consider in-line lime dosing of the return water pipee to achieve an alkalinity >60 mg/L.
    - Where the trigger relates to groundwater, consider the contingency measures described in Table 5-8 of the ASSMP.
- Review the adequacy of the ASSMP and update management strategies as appropriate.

Dredging and processing activities will recommence once either the appropriate contingency measure(s) has been implemented or further sampling demonstrates conformance with the action criteria.

11. Monitoring Program

11.1 Surface Water Monitoring

Source

The project approval requires preparation of a surface water monitoring program for the project (schedule 3, conditions 11 and 13). This section presents the surface water monitoring program.

This section also describes the monitoring of discharges from the dredge pond (condition 9), and monitoring associated with the erosion and sediment control plan (condition 12), the Acid Sulphate Soil Management Plan (condition 15), flood management (condition 9E), and for water licencing requirements (condition 15A)

Baseline data — Details of previous recordings of surface water quality in the main channel leading to Blue Angle Creek and Foys Swamp, as well as acid sulphate soil investigations are described in Section 4.

Monitoring parameters for surface water are listed in Table 10 below.

Table 10 – Surface Water Monitoring Protocols

Frequency	Site	What	Method	Objective
Daily (during production)	Existing dredge pond	Water level, pH (surface), pH (at depth)	Fixed automatic monitoring station*	Table 1
	Modification dredge pond	Water level, pH	Fixed automatic monitoring station*	Table 1
	Blue Angle Creek above floodgates (Site C)	Water level, pH	Fixed automatic monitoring station*	Monitor only
Weekly	Leachate from sand stockpile	pH	Field measurement	Table 1
Monthly	Existing dredge pond; Modification dredge pond; Site B, Site C, Rejects pipeline	pH, EC, DO, turbidity, temperature, alkalinity, acidity, dissolved metals	Field or grab sample and analysis at a NATA certified lab, on the same day that groundwater bores are sampled.	Table 1; Table 7; Table 8
	Sand stockpile	Sulphur content (TOS)	Grab sample and analysis at a NATA certified lab	<= 0.03%
Quarterly	Modification dredge pond	Bank and bed monitoring; flood bund monitoring; erosion and sediment control monitoring	Foreshores, batters, and flood bunds around the full perimeter of the working area are to be inspected for evidence of instability, as well as the adequacy of the current sediment and erosion controls	No significant soil instability or erosion. ESCP controls in place as per plan.
	Existing dredge pond; Modification dredge pond	List of analytes in Table 1 (in addition to monthly suite)	Field or grab sample and analysis at a NATA certified lab, on the same day that groundwater bores are sampled.	Table 1
Following construction of each section of flood bund	Modification dredge pond	Crest of flood bund	Survey	Flood bund conforms to heights described in Figure 2
During any discharge from a dredge pond	Affected dredge pond	pH, turbidity	Field measurement	pH: 6.0 – 8.5 Turbidity ≤ 20

* in the event of a failure of the fixed automatic monitoring station, measurements will be manually recorded daily when dredging is undertaken, or weekly if not dredging.

11.2 Groundwater Monitoring

Source: The project approval requires preparation of a groundwater monitoring program for the project (schedule 3, conditions 11 and 14). This section presents the groundwater monitoring program.

Baseline data: An analysis of previous recordings of groundwater levels and quality in boreholes surrounding the Project and correlation with water levels in the dredge pond is included in Section 4.

Monitoring parameters for groundwater are listed in Table 11 below.

Table 11 – Groundwater Monitoring Protocols

Frequency	Site	What	Method	Objective
Monthly (on same day as dredge pond monitoring)[1]	MW1, MW1A, MW2B, MW3A, MW04(07), NB02, NB03, NB04, MW7	Water level	Dip meter	Not move outside the range of two standard deviations from its mean level for more than six months, except when following a trend attributable to climatic effects, as evident in other monitoring bores
Quarterly (on same day as dredge pond monitoring)[1]	MW1, MW1A, MW2B, MW3A, MW04(07), NB02, NB03, NB04, MW7	List of groundwater analytes in Table 1, acidity, dissolved metals	Field or grab sample and analysis at a NATA certified lab	Table 1; Table 7; Table 8; Table 9
Annual[1]	Swamp Schlerophyll Forest	Ecosystem health	Assessment by ecologist	No discernible deterioration of ecosystems or vegetation, attributable to measured changes in groundwater levels or quality
Following emplacement of imported material for batter construction	Dredge pond batter	Hydraulic conductivity of emplaced material	Field Permeability at 20m intervals by geotechnician	Field Permeability not more than one order of magnitude less than the corresponding background site

[1] Monitoring used to assess impacts to groundwater dependent ecosystems and vegetation.

11.3 Water Take

The methods for monitoring water take associated with WAL43272 are listed in Table 12.

Table 12 – Water Take monitoring protocols

Process	Rationale	Method	Frequency
Rainfall	Measurement of rainfall inflows to dredge ponds	Site weather station or SILO data in the event of any data loss	Aggregated annually
Evaporation	Measurement of evaporation losses from dredge ponds	SILO data for period of Morton evaporation over shallow lakes	Aggregated annually
Water in Slurry	Water used to transport sand slurry to processing plant	Flow meter at outlet of dredge; corrected for density	Recorded daily

Process	Rationale	Method	Frequency
Sand removed below water table	Void space created below water table.	Site production recorded from weighbridge converted to volume, and corrected for current groundwater level below surface of current extraction area	Aggregated monthly and corrected annually
Sand sales	Water entrained in sand exported from site	Site production recorded from weighbridge, corrected monthly for moisture based on dried measurements	Recorded daily and adjusted for sand moisture
Pumped return water	To transfer the water pumped in the sand slurry back to the new dredge pond	Water meter record on pump	Recorded monthly
Runoff from slurry	Water which was used to pump sand, and drains to the existing dredge pond	Calculated by subtracting Water Entrained in Sand (Sales) from Water in Slurry	Calculated monthly
Dust suppression	Water used for supressing dust on haul roads	Water meter record on pump / standpipe	Recorded monthly
Seedling watering	Water used for watering establishing seedlings in revegetation	Water meter record on pump / standpipe	Recorded monthly

Water take associated with groundwater inflows to the new dredge pond will be calculated annually as follows:

Evaporation + Water in Slurry + Sand Removed Below Water Table	Minus	Rainfall + Pumped Return Water

Water take associated with groundwater inflows to the existing dredge pond will be calculated annually as follows:

Evaporation + Pumped Return Water + Dust Suppression / Seedling Watering	Minus	Rainfall + Runoff From Slurry

12. Review, Improvement and Reporting

Regular reviews of environmental monitoring data and management strategies will be undertaken to ensure the Water Management Plan meets its objectives. This will include formal and informal checks as follows:

- Ad-hoc review of alerts from fixed monitoring equipment in response to pre-configured trigger values.
- Monthly internal review of water monitoring data by the Environmental Officer.
- Annual Review completed by the Environmental Officer following the end of each financial year (reporting period).
- Independent Environmental Audits conducted on a three-yearly basis.

12.1 Ad-hoc Reviews

The fixed automatic monitoring infrastructure installed in each dredge pond and in Blue Angle Creek will be configured to send an alert to the Production Manager and Environmental Officer in the event the objective levels are exceeded. On receipt of an alert, the Environmental Officer will investigate and if required implement corrective actions in accordance with this plan. This will be most applicable in the event of any changes in pH, with corrective actions managed in accordance with the Acid Sulphate Soil Management Plan (Section 10).

12.2 Monthly Internal Review

The Environmental Officer will review all incoming water monitoring data on a monthly basis. This will include a review of all water monitoring data received against the objective levels, and to informally assess any unexpected changes to water quality or levels. The review will include an assessment of groundwater levels against the performance targets specified in Section 11.2.

12.3 Annual Review

The Annual Review will be prepared by the Environmental Officer within two months of the end of the reporting year (July to June) and will:

- describe the works carried out in the last 12 months and the works planned for the next 12 months;
- include a summary of the water monitoring results for the Project during the past year;
- include a review and update (if required) of the site water balance model, and a summary of total water take for the year including maximum instantaneous rates of water take;
- reporting measures listed in the Acid Sulphate Soil Management Plan (Annexure C – Acid Sulphate Soil Management Plan);
- include a comprehensive review of the monitoring results over the previous year, which includes a comparison of these results against the relevant:
    - impact assessment criteria and objectives;
    - monitoring results from previous years;
    - requirements of this Water Management Plan; and
    - predictions in the environmental assessment (EA);
- identify any non-compliance during the previous year and describe what actions were (or are being) taken to rectify the non-compliance and avoid recurrence;
- identify any trends in the monitoring results over the life of the Project;
- identify any discrepancies between the predicted and actual impacts of the Project, and analyse the potential cause of any significant discrepancies;

- describe any measures that will be implemented over the next year to improve the environmental performance of the project; and
- review the suitability of the Water Management Plan and the associated strategies, plans and programs.

An electronic copy of the Annual Review will be provided to the Planning Secretary and members of the Community Consultative Committee, as well as uploaded to the Cleary Bros website.

12.4 Independent Environmental Audit

Every three years, Cleary Bros will engage a suitable qualified, experienced, and independent person(s) to undertake an independent environmental audit. The audit will be conducted in accordance with Schedule 5 Condition 5 of the Development Consent, with the auditor approved by the Planning Secretary.

An audit report will be prepared and submitted to the Planning Secretary, relevant agencies, and the CCC representatives within one month of completing the audit. The submission will contain Cleary Bros' response to any recommendations contained in the audit report.

12.5 Corrective Actions and Improvement Measures

In the event the performance criteria or objective levels described in Section 11 are exceeded the corrective actions listed in Table 13 will be implemented. Most corrective actions represent management measures only and will be reported as part of the Annual Review only.

Table 13 – Corrective Actions

Issue	Action	Rationale
Dredge pond water quality below lower pH objective level	Implementation of corrective actions in accordance with the Acid Sulphate Soil Management Plan (Section 10.5)	Return dredge pond pH to objective range
Dredge pond water quality outside of water quality objectives (other than pH)	Review against historical data and background water quality where possible.	Assess if change is primarily attributable to dredging activities, or related to natural factors or other land uses in area
Sand stockpile leachate outside pH objectives	Monitor existing dredge pond pH levels. Apply aglime if required to balance pH.	pH of leachate may over time alter dredge pond water quality if not well managed
Sulphur content of processed sand outside objective levels	Reprocess sand and retest stockpile	Minimise risk of oxidation of pyrites within sand stockpile
Dredge pond bank instability	Repair bank to restore profile	Maintain stability of dredge pond batters and adjoining land
Damage to flood bund	Repair flood bund to design profile	Maintain flood protection
Damage to sediment controls	Restore sediment controls	Minimise sedimentation of adjoining land and receiving waters
Discharge of water to or from dredge pond	Cease dredging for duration of discharge	Minimise risk associated with discharge

Issue	Action	Rationale
Groundwater bore level outside of 2 SD's of average for 6 continuous months not attributable to weather **Deterioration in health of Swamp Sclerophyll Forest**	Cease dredging until investigation complete; engage a qualified hydrogeologist to assess the significance of the variation from expected behaviour and recommend remedial action if appropriate in line with the requirements of the Development Consent (Sch 3 Cond 14(e)); notify DPE of event	Minimise potential impacts to Swamp Sclerophyll Forest
In situ density of material emplaced on dredge pond batter significantly greater than background	Undertake remedial measures, such as placing a greater number of panels of higher hydraulic conductivity material below the waterline in place of existing bed material	Maintain the existing hydraulic flow within the coastal sands aquifer
Water take recorded above WAL allocation	Cease production until site has required water allocations; notify NRAR of any exceedance	Ensures Cleary Bros hold required entitlements for water take

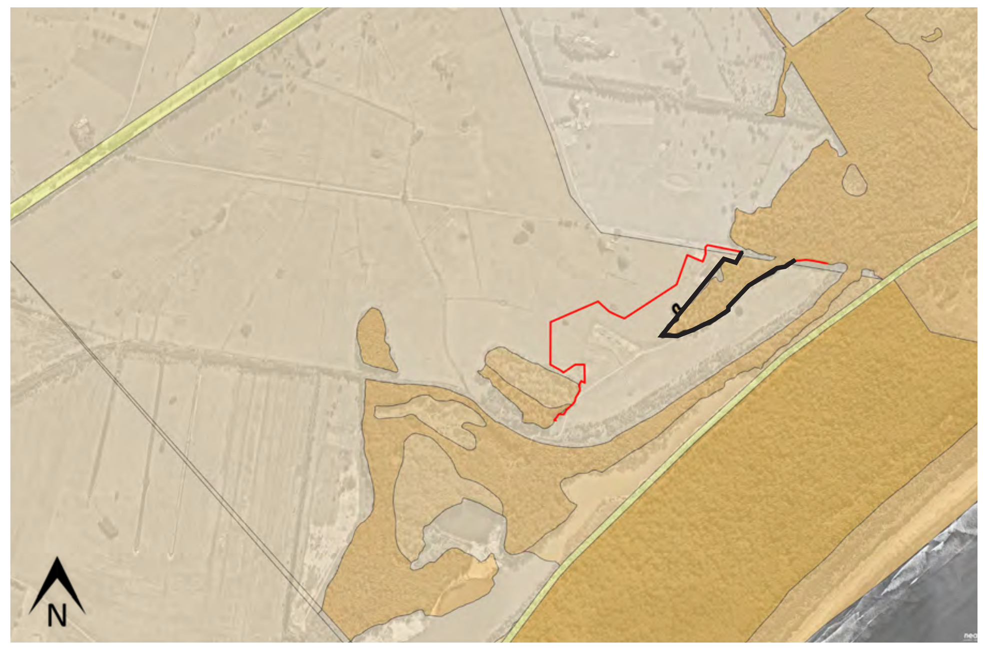
Where an issue represents a breach of a regulatory requirement, including the Development Consent, EPL4146, or WAL, Cleary Bros will notify the appropriate regularly authority as follows. For an environmental incident which causes or threatens to cause material harm, the Environmental Officer on becoming aware of the incident will immediately notify the Planning Secretary of the nature of the incident using the incident reporting form on the Major Projects portal. The Environmental Officer will also notify other relevant agencies as appropriate using their preferred reporting methodology.

In the event of any non-compliance with the conditions of the Development Consent (and which has not already been reported as an incident), the Environmental Officer will notify the Planning Secretary of the non-compliance within 7 days of becoming aware of the non-compliance using the incident reporting form on the Major Projects portal. The notification will include condition of the Development Consent that the quarry is non-compliant with, why it does not comply and the reasons for the non-compliance (if known) and what actions have been, or will be, undertaken to address the non-compliance

12.6 Water Management Plan Review

The Water Management Plan and supporting monitoring strategies, subplans and programs will be reviewed annually as part of the Annual Review process, as well as within three months of an Independent Environmental Audit or approval of a modification to the Development Consent. The Plan will also be reviewed within three months of any incident related to the water management infrastructure of the site, or that adversely impacts on the water resources of the receiving environment. The Water Management Plan will also be reviewed in the event any of the action criteria for Acid Sulphate Soils are triggered. In the event the review identifies that changes are required to the WMP or supporting subplans, these will be undertaken within 6 weeks of the review and submitted to the Planning Secretary for approval.

Annexure A – Cross sections of Typical Bank Arrangement



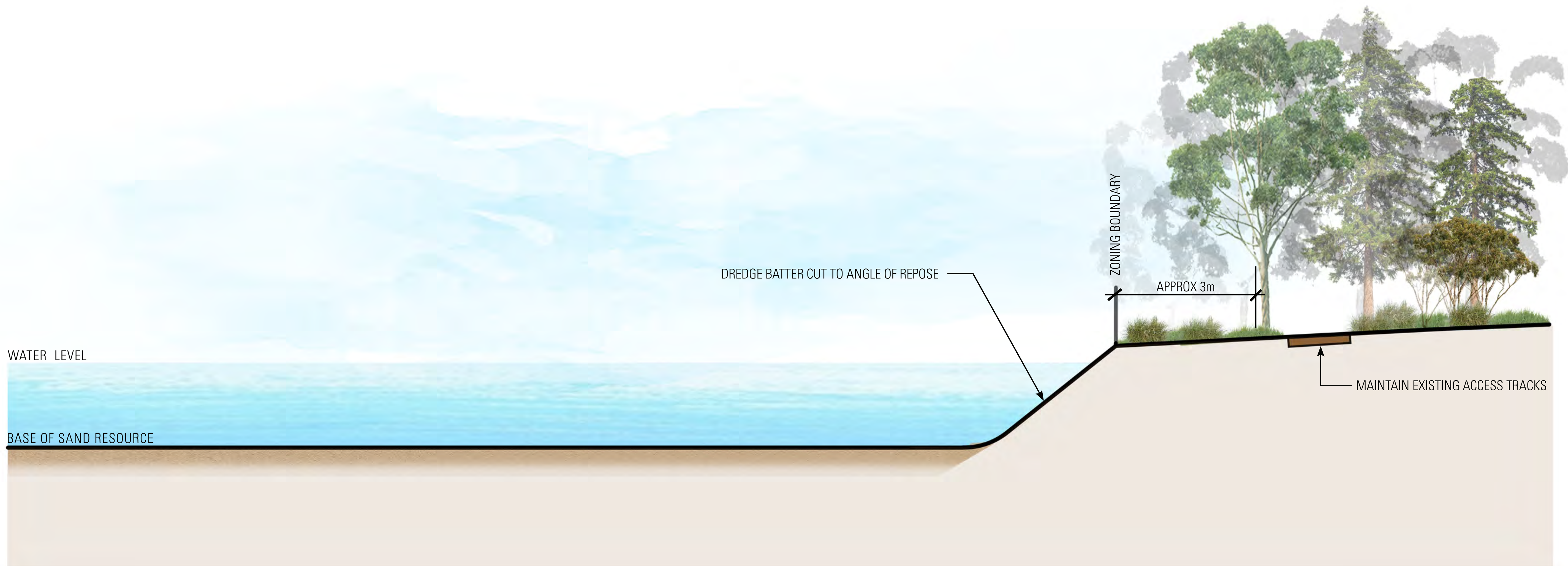
KEY PLAN

N.T.S

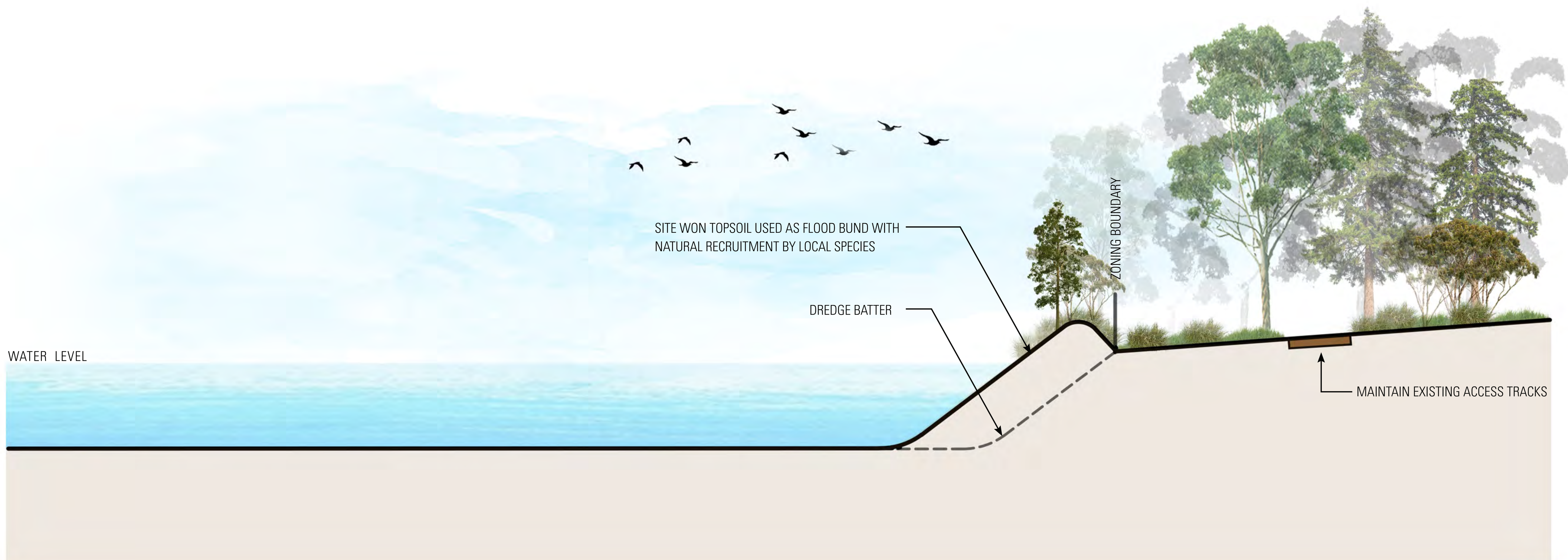
LEGEND

- LOCATION 1
- MODIFICATION EXTENT
- E1 - NATIONAL PARKS AND NATURE RESERVES ZONING
- E2 - ENVIRONMENTAL CONSERVATION ZONING
- E3 - ENVIRONMENTAL MANAGEMENT ZONING
- RU1 - PRIMARY PRODUCTION ZONING
- RU2 - RURAL LANDSCAPE ZONING
- SP2 - INFRASTRUCTURE ZONING

TYPICAL CROSS SECTION 1: **PRIOR TO DREDGING**



TYPICAL CROSS SECTION 2: **DURING DREDGING**



TYPICAL CROSS SECTION 3: **POST DREDGING**

Issue 1	11.07.19	As submitted in Reponse to Submisisons
Issue 2	04.04.22	Dredge pond footprint added; Land zoning shown in key plans; Cross section extents added; Location 4 removed.

LOCATION 1: DREDGE ADJACENT TO EXISTING MATURE VEGETATION

Cardno

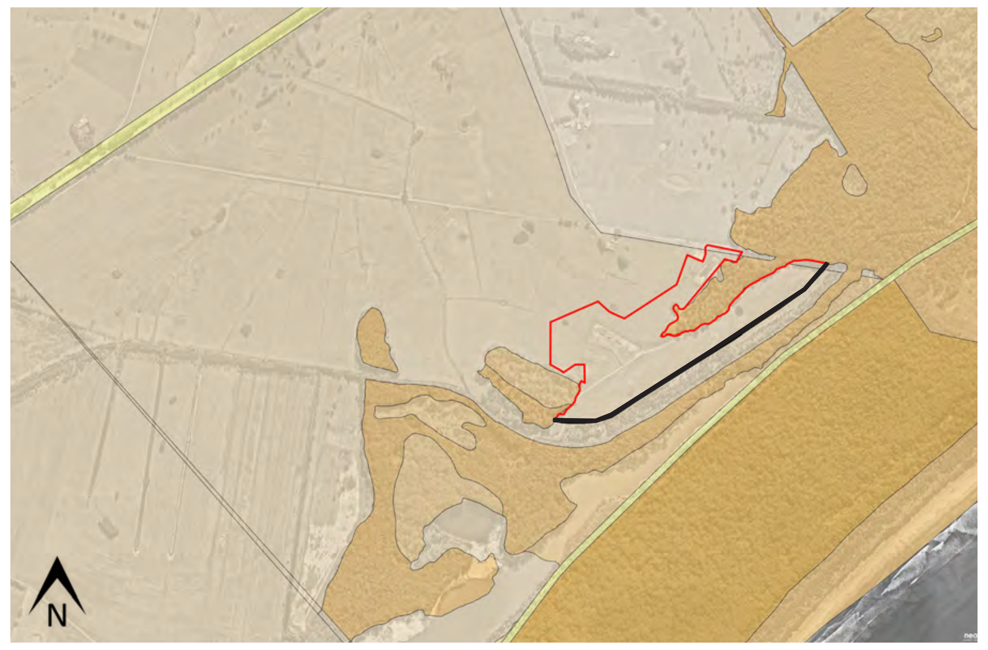
landscape architecture
urban design
environmental management

NOTE: CROSS SECTIONS NOT TO SCALE

CB

CLEARY BROS PTY LTD GERROA SAND MINE TYPICAL CROSS SECTIONS

DATE	PROJECT NO.	DRAWING NO.	ISSUE
04.04.22	82017007 - 06	L2001	2



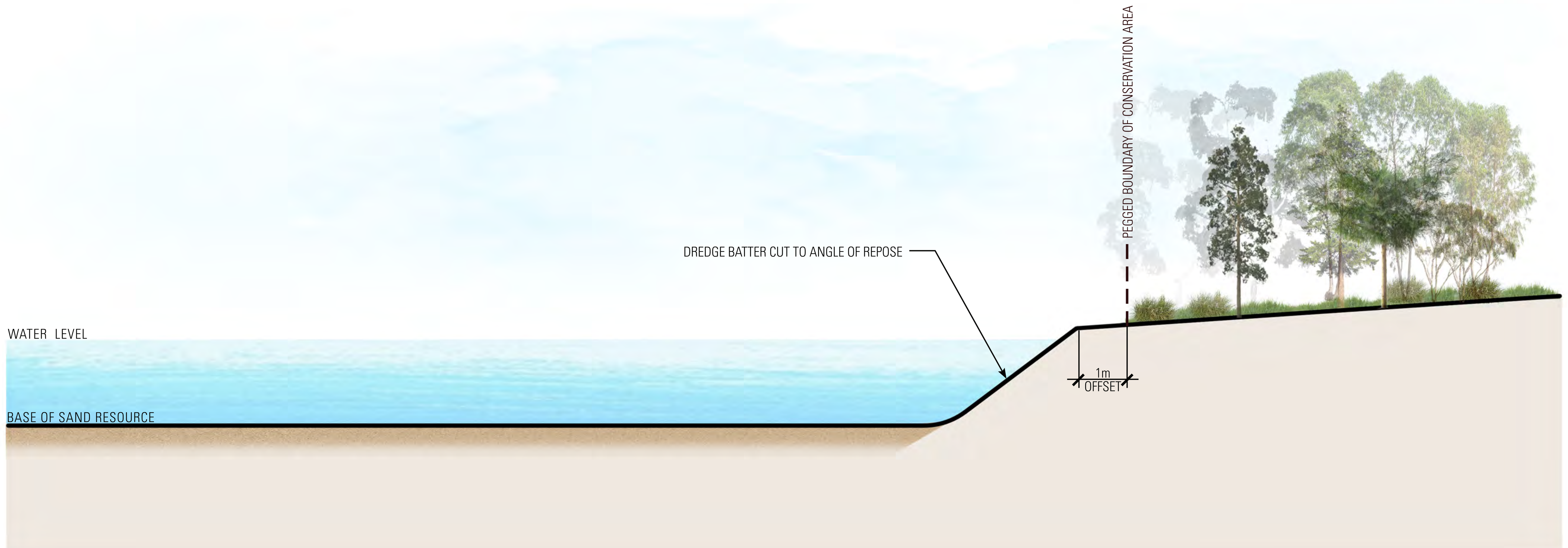
KEY PLAN

N.T.S

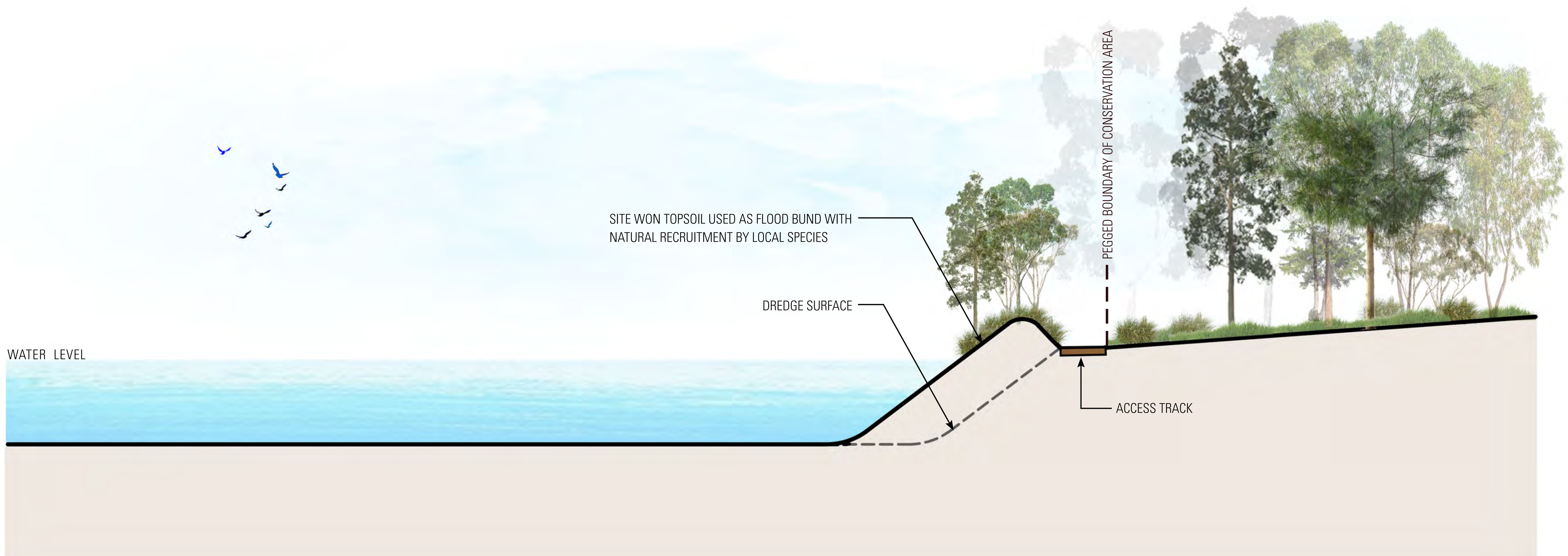
LEGEND

- LOCATION 2
- MODIFICATION EXTENT
- E1 - NATIONAL PARKS AND NATURE RESERVES ZONING
- E2 - ENVIRONMENTAL CONSERVATION ZONING
- E3 - ENVIRONMENTAL MANAGEMENT ZONING
- RU1 - PRIMARY PRODUCTION ZONING
- RU2 - RURAL LANDSCAPE ZONING
- SP2 - INFRASTRUCTURE ZONING

TYPICAL CROSS SECTION 1: **PRIOR TO DREDGING**



TYPICAL CROSS SECTION 2: **DURING DREDGING**



TYPICAL CROSS SECTION 3: **POST DREDGING**

Issue 1	11.07.19	As submitted in Reponse to Submisisons
Issue 2	04.04.22	Dredge pond footprint added; Land zoning shown in key plans; Cross section extents added; Location 4 removed.

LOCATION 2: DREDGE ADJACENT TO PLANTED CONSERVATION AREA 2C1

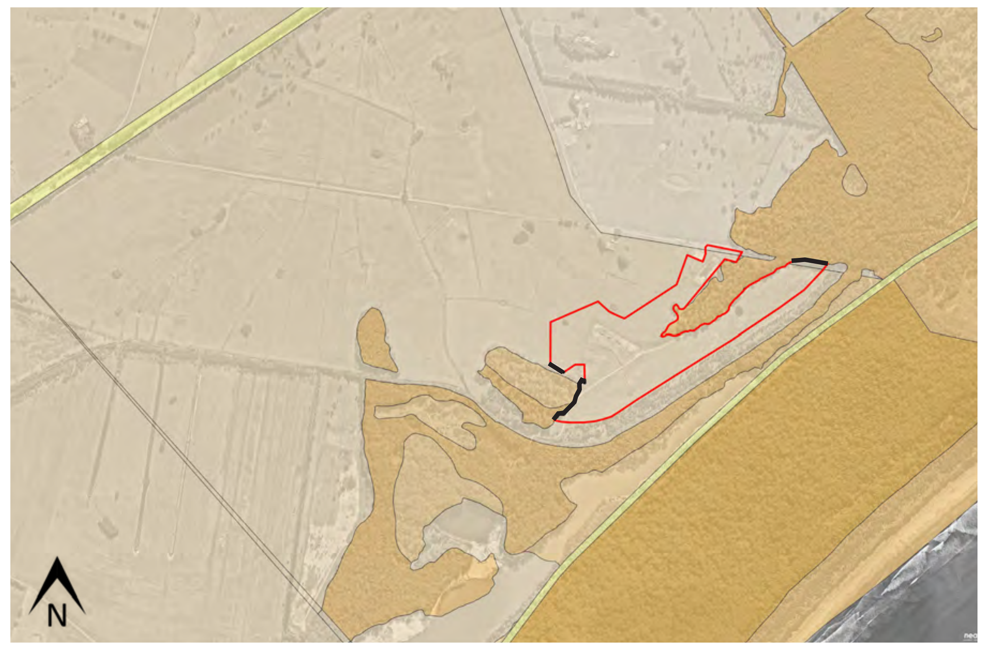
Cardno®

landscape architecture
urban design
environmental management

NOTE: CROSS SECTIONS NOT TO SCALE

CLEARY BROS PTY LTD GERROA SAND MINE TYPICAL CROSS SECTIONS

DATE	PROJECT NO.	DRAWING NO.	ISSUE
04.04.22	82017007 - 06	L2002	2



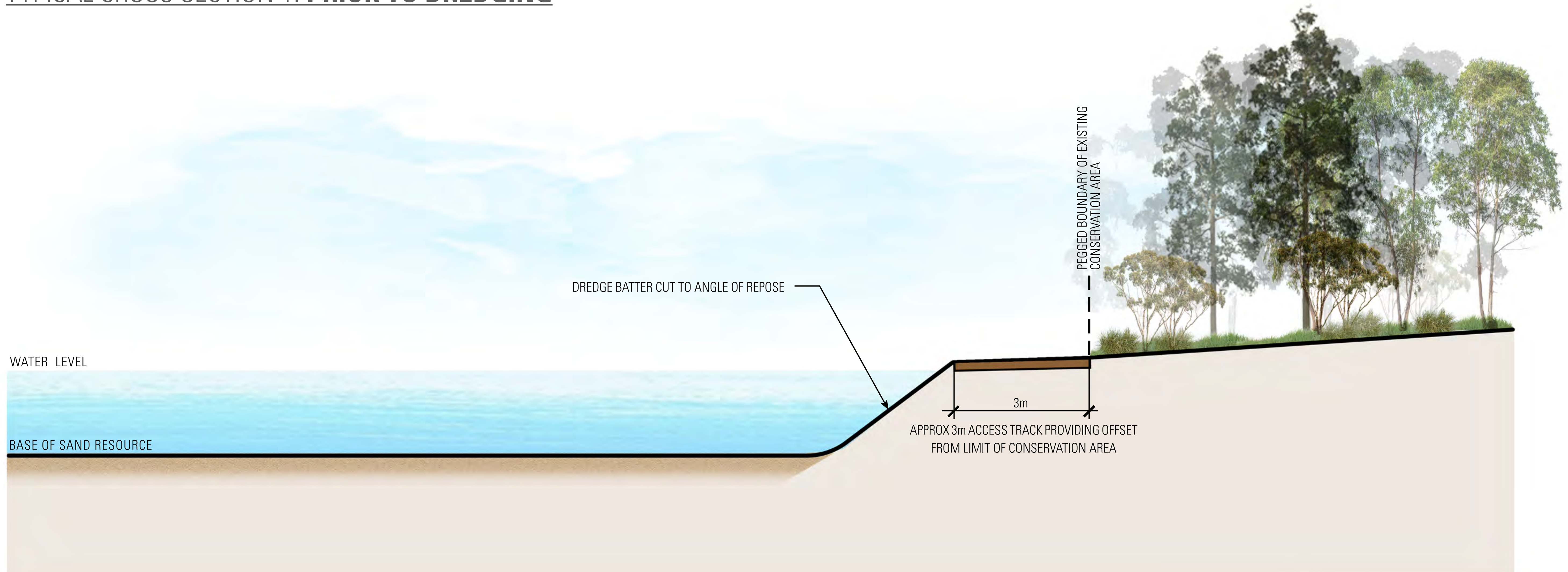
KEY PLAN

N.T.S

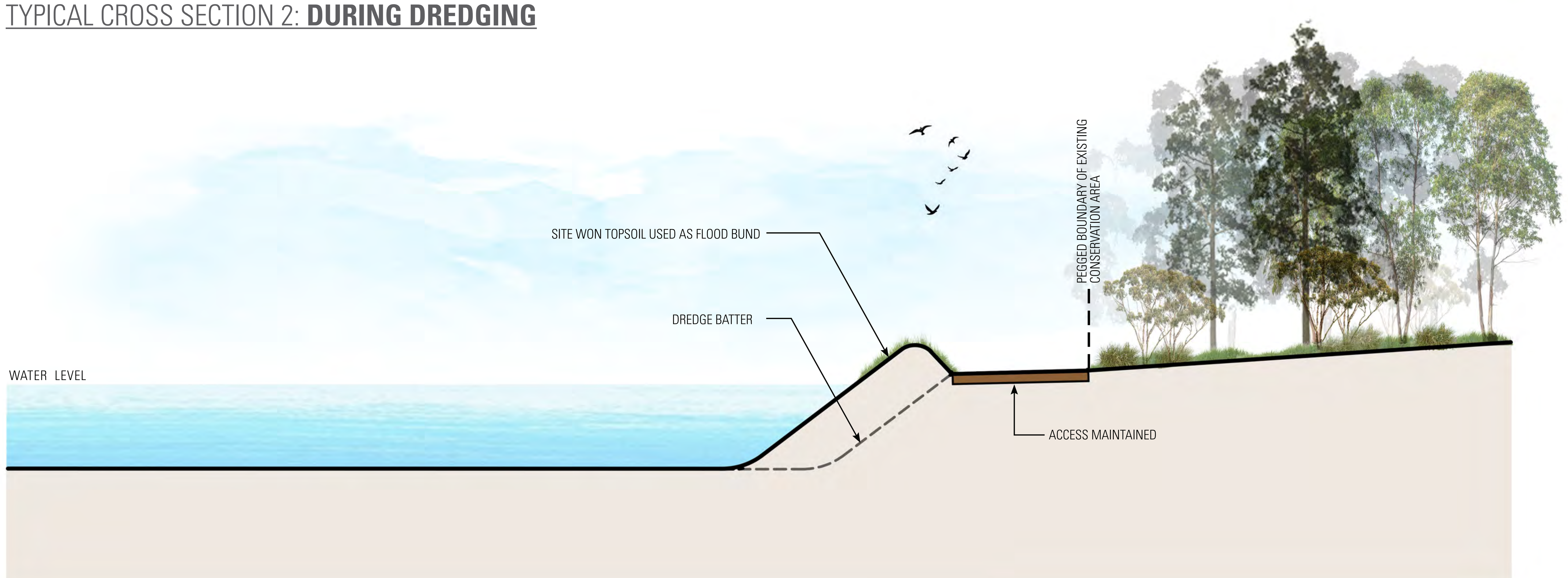
LEGEND

- LOCATION 3
- MODIFICATION EXTENT
- E1 - NATIONAL PARKS AND NATURE RESERVES ZONING
- E2 - ENVIRONMENTAL CONSERVATION ZONING
- E3 - ENVIRONMENTAL MANAGEMENT ZONING
- RU1 - PRIMARY PRODUCTION ZONING
- RU2 - RURAL LANDSCAPE ZONING
- SP2 - INFRASTRUCTURE ZONING

TYPICAL CROSS SECTION 1: **PRIOR TO DREDGING**



TYPICAL CROSS SECTION 2: **DURING DREDGING**



TYPICAL CROSS SECTION 3: **POST DREDGING**

Issue 1	11.07.19	As submitted in Reponse to Submisisons
Issue 2	04.04.22	Dredge pond footprint added; Land zoning shown in key plans; Cross section extents added; Location 4 removed.

LOCATION 3: DREDGE ADJACENT CONSERVATION AREA 4

Cardno

landscape architecture
urban design
environmental management

NOTE: CROSS SECTIONS NOT TO SCALE

CLEARY BROS PTY LTD GERROA SAND MINE TYPICAL CROSS SECTIONS

DATE	PROJECT NO.	DRAWING NO.	ISSUE
04.04.22	82017007 - 06	L2003	2

Annexure B – Flood Bund Detailed Design

Stantec

Stantec (Australia) Pty Ltd
Ground Floor, 16 Burelli Street
Wollongong NSW 2500
Tel: 02 4231 9600 Fax: 02 4228 6811

CB

CLEARY BROS PTY LTD

GERROA SAND MINE
PROPOSED BUND
LOT 2 DP 1111012

COVERSHEET

Rev.	Date	Description	Des.	Verif.	Appd.
1	16/9/2022	ISSUED FOR CLIENT REVIEW	MPR	SB	SB

Role	Name	Date
Drawn	ACD	16/9/2022
Checked	BAH	16/9/2022
Designed	MPR	16/9/2022
Verified	SB	16/9/2022
Approved	SB	16/9/2022

Status: FOR CONSTRUCTION

DATUM	Scale	Size
AHD	N.T.S	A1

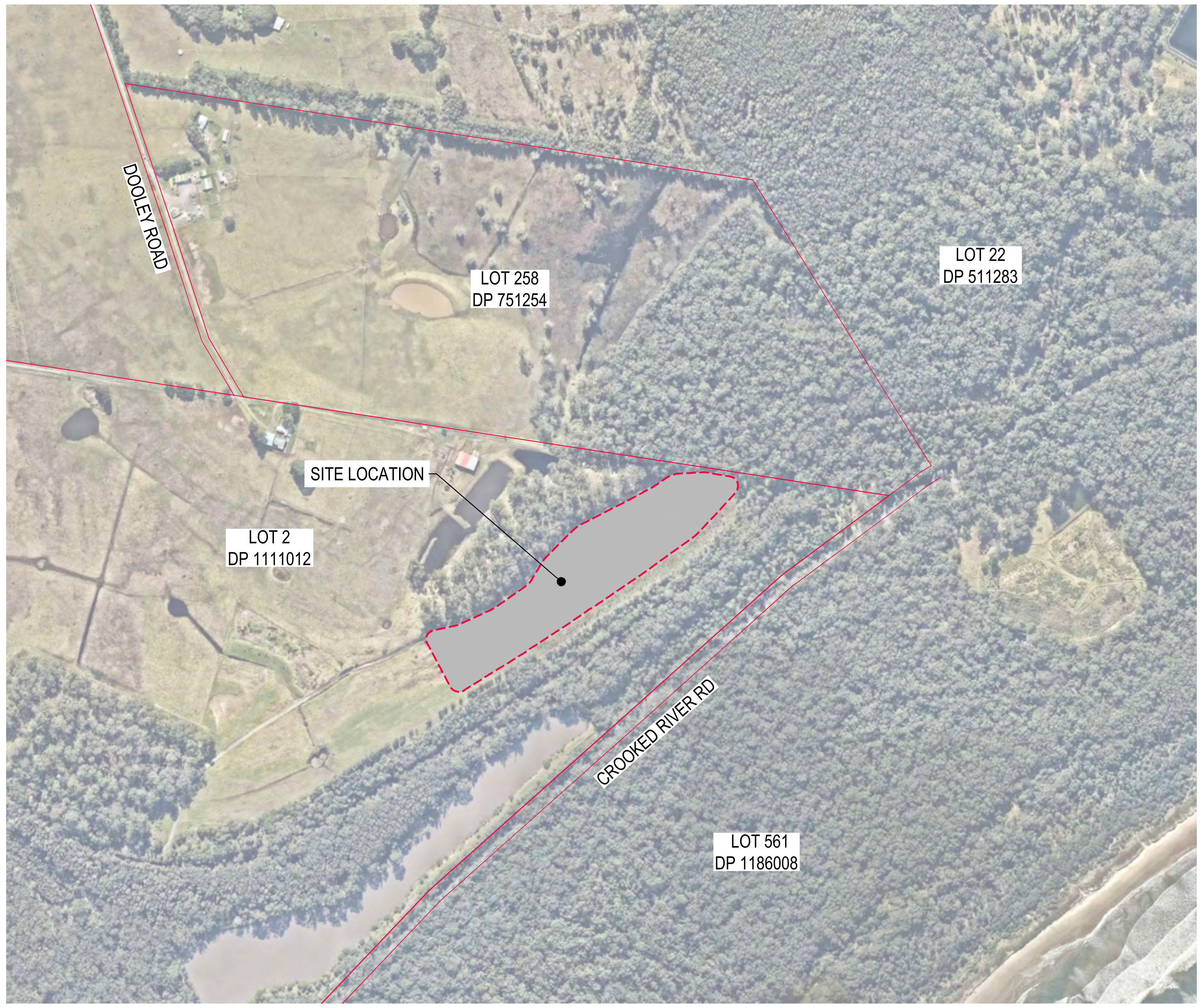
Drawing Number	Revision
82017007-06-C1000	1

DATE PLOTTED: 16 September 2022 12:05 PM BY : MICHAEL RENKO

GENERAL CIVIL CONSTRUCTION NOTES

1. DIMENSIONS ARE IN METERS UNLESS NOTED OTHERWISE.
2. THE CONTRACTOR SHALL CARRY OUT A DIAL BEFORE YOU DIG APPLICATION AND ARRANGE A PRE-CONSTRUCTION MEETING WITH SERVICE AUTHORITIES (IF REQUIRED) TO ESTABLISH THE LOCATION OF UTILITY SERVICES AND SPECIAL REQUIREMENTS.
3. PRIOR TO CONSTRUCTION THE CONTRACTOR MUST ENSURE ALL EXISTING SERVICES ARE LOCATED BY THE RELEVANT ACCREDITED LOCATOR AND POTHOLED TO CONFIRM LOCATION AND DEPTH PRIOR TO ANY WORKS. THE CONTRACTOR MUST ALLOW FOR THE COSTS FOR ANY CO-ORDINATION WITH SERVICE PROVIDERS.
4. ANY RELEVANT CIVIL, SERVICE PLANS SHALL BE READ IN CONJUNCTION WITH THE ENCLOSED DOCUMENTATION. ANY DISCREPANCY IN THE PROJECT DOCUMENTATION AFFECTING WORKS SHOWN ON THIS DOCUMENTATION SHALL BE REFERRED TO THE SITE SUPERINTENDENT OR PROJECT ENGINEER AND AN INSTRUCTION OBTAINED BEFORE PROCEEDING WITH WORKS SO AFFECTED.
5. VERIFY SETOUT DIMENSIONS SHOWN ON THESE DRAWINGS BEFORE COMMENCING WORKS.
6. ALL SETOUT TO BE AS PER DIGITAL SET OUT .dwg FILE. ALIGNMENT OF SERVICES TO BE AS PER .dwg FILE.
7. THE CONTRACTOR SHALL UNDERTAKE THE NECESSARY SURVEY SETOUT FOR THE WORKS.
8. IF DISCREPANCIES ARE FOUND, CONSTRUCTOR MUST CONTACT CARDNO IMMEDIATELY.
9. CONTRACTOR TO VISIT SITE AT TENDER STAGE AND CONFIRM THE TYPE AND EXTENT OF REMOVAL/REINSTATEMENT/DISPOSAL OF ANY ITEMS.
10. NO WORK TO BE UNDERTAKEN ON ADJOINING LAND WITHOUT THE WRITTEN CONFIRMATION FROM SITE SUPERINTENDENT/LAND OWNER.
11. ALL EXISTING TREES TO BE MAINTAINED DURING THE WORKS.
12. THE CONTRACTOR SHALL ARRANGE A PRE-CONSTRUCTION MEETING WITH SERVICE AUTHORITIES TO ESTABLISH THE LOCATION OF UTILITY SERVICES AND SPECIAL REQUIREMENTS.
13. ALL NEW WORKS TO MAKE SMOOTH JUNCTION WITH EXISTING.
14. ALL CONSTRUCTION AND BUILDING WORKS SHALL BE RESTRICTED TO BETWEEN 7.00am AND 5.00pm MONDAYS TO SATURDAYS (INCLUSIVE) AND PROHIBITED ON SUNDAYS AND PUBLIC HOLIDAYS UNLESS WRITTEN APPROVAL TO VARY THE HOURS IS GRANTED BY COUNCIL.

NORTH



LOCALITY PLAN
SCALE 1:5000

NOTE
1. IMAGE SOURCED FROM METRO MAP (SEPTEMBER, 2022)

SCHEDULE OF DRAWINGS

DRAWING No.	DESCRIPTION
82017007-06-C1000	COVER SHEET
82017007-06-C1001	GENERAL NOTES, LOCALITY PLAN & DRAWING SCHEDULE
82017007-06-C1002	GENERAL ARRANGEMENT LAYOUT PLAN AND TYPICAL BUND CROSS SECTION

0 100 200 300 400 500m
SCALE 1:5000 (A1), 1:10000 (A3)

Rev.	Date	Description	Des.	Verif.	Appd.
1	16/9/2022	ISSUED FOR CLIENT REVIEW	MPR	SB	SB

Stantec
Stantec (AUSTRALIA) Pty Ltd | ABN 17 007 820 322
Ground Floor, 16 Burelli Street
Wollongong NSW 2500
Tel: 02 4231 9600 Fax: 02 4228 6811
Web: www.stantec.com

Role	Name	Date
Drawn	ACD	16/9/2022
Checked	BAH	16/9/2022
Designed	MPR	16/9/2022
Verified	SB	16/9/2022
Approved	SB	16/9/2022

Client: CLEARY BROS PTY LTD

Project: GERROA SAND MINE
PROPOSED BUND
LOT 2 DP 1111012

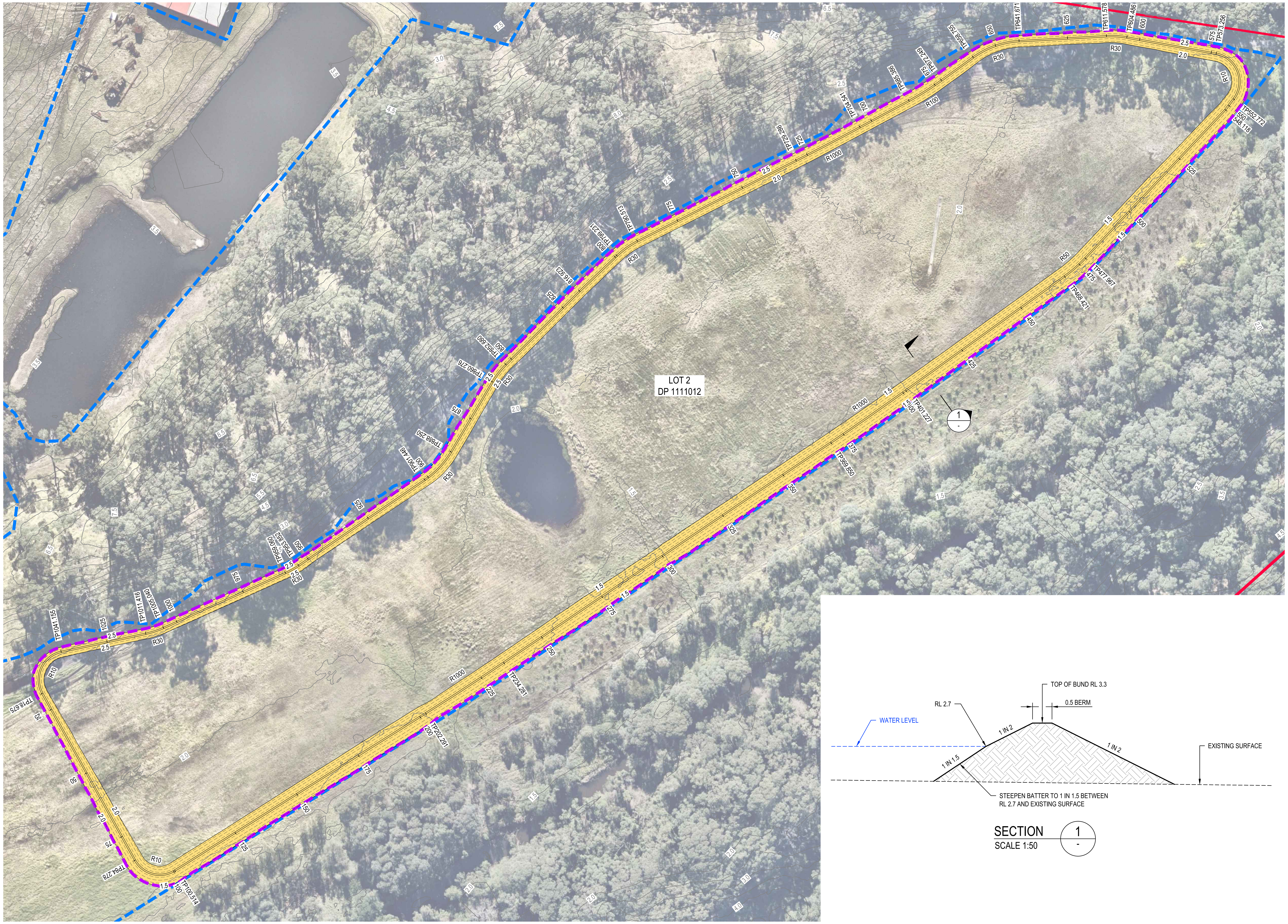
Title: GENERAL NOTES, LOCALITY PLAN AND DRAWING SCHEDULE

Status: FOR CONSTRUCTION

DATUM	Scale	Size
AHD	1:5000	A1

Drawing Number: 82017007-06-C1001
Revision: 1

XREFs: 82017-007-06 - E1 IMAGE; 82017-007-06 - G1 TITLE BLOCK
CAD File: U:\FY17007-06_Gerroa Mod\Drawings\Build\Civil\C1000\82017007-06-C1001.dwg



GENERAL ARRANGEMENT
SCALE 1:750

SECTION 1
SCALE 1:50

EARTHWORKS VOLUMES

PROPOSED CUT	0m³
PROPOSED FILL	4,825m³
BULK EARTHWORKS BALANCE	4,825m³ (FILL)

NOTE

1. IMAGE SOURCED FROM METRO MAP (SEPTEMBER, 2022).
2. EARTHWORKS VOLUMES CALCULATED FROM EXISTING SURFACE TO FINISHED DESIGN SURFACE LEVEL.
3. FLOOD MITIGATION BUND FOR STAGE CP AS SHOWN ON THIS PLAN CAN PREVENT INUNDATION OF THE MODIFICATION 1 - EXTRACTION AREA FROM A FLOOD OF 1% AEP WITH 0.5m FREEBOARD.

LEGEND

- 10.0 (dashed) — DESIGN SURFACE CONTOURS (0.5m INTERVAL)
- 10.0 (solid) — EXISTING SURFACE CONTOURS (0.5m INTERVAL)
- EXISTING PROPERTY BOUNDARY
- PROPOSED BUND
- APPROVED EXTRACTION LIMIT BOUNDARY
- PROPOSED WORKS BOUNDARY

0 1 2 3 4 5m
SCALE 1:50 (A1), 1:100 (A3)

0 15 30 45 60 75m
SCALE 1:750 (A1), 1:1500 (A3)

DATE PLOTTED: 16 September 2022 12:05 PM BY : MICHAEL RENKO

XREFs: 82017-007-06 - G1 LEGEND; 82017-007-06 - E1 IMAGE 2; 82017-007-06 - G1 TITLE BLOCK; 82017-007-06 - E1 CONT ALS; 82017-007-06 - D1 CONT
CAD File: U:\FY17007-06_Gerroa Mod\Drawings\Build\Civil\C1000\82017007-06-C1002.dwg

Rev.	Date	Description	Des.	Verif.	Appd.
1	16/9/2022	ISSUED FOR CLIENT REVIEW	MPR	SB	SB

Stantec
Stantec (AUSTRALIA) Pty Ltd | ABN 17 007 820 322
Ground Floor, 16 Burelli Street
Wollongong NSW 2500
Tel: 02 4231 9600 Fax: 02 4228 6811
Web: www.stantec.com

Drawn	ACD	Date 16/9/2022
Checked	BAH	Date 16/9/2022
Designed	MPR	Date 16/9/2022
Verified	SB	Date 16/9/2022
Approved	SB	Date 16/9/2022

Client: CLEARY BROS PTY LTD

Project: GERROA SAND MINE
PROPOSED BUND
LOT 2 DP 1111012

Title: GENERAL ARRANGEMENT LAYOUT PLAN AND TYPICAL BUND CROSS SECTION

Status: FOR CONSTRUCTION

DATUM		Scale	Size
AHD		AS SHOWN	A1

Drawing Number: 82017007-06-C1002
Revision: 1

Annexure C – Acid Sulphate Soil Management Plan

Acid Sulfate Soil Management Plan

Gerroa Sand Quarry - NSW

Cleary Bros (Bombo) Pty Ltd

November 2022

LWC
Land and Water Consulting

Document Status

Version	Doc type	Reviewed by	Approved by	Date issued
DR003	Draft Report	Dr James Fox	Dr James Fox	14 October 2022
FR001	Final		Dr James Fox	27 October 2022
FR002	Final		Dr James Fox	31 October 2022
FR003	Final		Dr James Fox	1 November 2022

Project Details

Project Name	Gerroa Sand Quarry - NSW
Client	Cleary Bros (Bombo) Pty Ltd
Client Project Manager	Matt Lemcke
LWC Project Director	James Fox
LWC Project Manager	
Authors	Dr James Fox
File Reference	LWC - W-AV-Gerroa Extension - ASSMP_FR003

Land & Water Consulting

4 – 8 Goodwood Road, Wayville SA 5034
Telephone (08) 8271 5255
www.lwconsulting.com.au

EXECUTIVE SUMMARY

Land & Water Consulting (LWC) was engaged by ENRS Pty Ltd on behalf of Cleary Bros (Bombo) Pty Ltd to prepare an Acid Sulfate Soil Management Plan (ASSMP) for material to be dredged from Gerroa Sand Mine, New South Wales (the Site). A site location plan provided as Figure 1.

As part of the characterisation of the sediment material to be dredged (undertaken in 2021), it was identified that the material has the potential to generate acid when exposed to oxygen. The objective of this ASSMP is to ensure that potential risks to the environment are mitigated during the dredging processes.

The procedures detailed as part of the ASSMP are to be adopted for the duration of the dredging and dewatering activities. Contingency measures, as detailed in the ASSMP, are to be actioned, as required based on field measurements and/ or observations.

Material (including PASS) unsuitable for use as fine concrete aggregate will be returned (with addition of neutralising materials if required) to the current dredge pond for burial below the permanent groundwater table. This strategy continues the current methods of extraction and treatment practice that has successfully managed the acid sulfate risk during the operation of the Gerroa Sand Quarry to date.

Observations of the current working method and review of water quality results from within the Gerroa Sand Quarry indicate that:

- Water removed from the pumped slurry is returned almost directly to the current pond via run-off from the discharge/processing area.
- The exposure time during extraction, processing (including discharge of reject fines) and stockpiling, has been to date insufficient to cause complete oxidation of pyritic material and increase in the water acidity within the dredge pond in comparison with the pH of the groundwater sampled from the nearby monitoring bores.

As the new area has a higher ASS risk than historically excavated areas, Cleary Bros are committing to additional management tasks for the extension area and contingency measures activated by

- All exposed surfaces (batters) must be limed to prevent acid generation via oxidation of sulfidic soils.
- All stockpile bases are to be limed
- Contingency Measure 1: The piped return of rejects (fines) to the pond floor is to be limed (dependant on ongoing operational monitoring results). The fines are most likely to carry the sulfidic material (pyrite) and therefore may need liming at a higher rate than in situ materials.

A preliminary liming rate for in line dosing is calculated and presented in Section 5.6, if required.

Note - The feed in pipeline from the existing dredge pond for water balance must contain/ maintain >60 mg/L alkalinity and the dissolved metals content must not exceed Site trigger values (ANZG 2018 marine ecosystem 95% protection – in lieu of absence of background data. Note that iron (Fe) is excepted due to known high Fe content).

The fines (rejects) post hydro-cyclone are piped to the existing dredge pond for submerged disposal. The fines are likely to exhibit PASS characteristics. High %S has been reported in the material (e.g. BH8) and in the event in-line dosing is required as contingency measure 1, would result in maximum liming rate of 950 kg $CaCO_3$ per tonne of material. This would not represent all fines piped to the pond, and the optimum strategy is to lime at 95% upper confidence limit of all liming rates obtained (Table A-1) until operational data can be obtained from the in line pipe and the dosing rate can be optimised based on net acidity.

The preliminary in line dosing for piped returns (if required as contingency measure 1) is 40 kg/m^3 of material (0.04 kg/L).

Operational testing of fines pipe should comprise collection of samples for net acidity testing (use chromium reducible sulfur suite) and adjust liming rate accordingly.

This ASSMP contains requirements for surface and groundwater monitoring during operations.

A statement of limitations is provided as Appendix E.

Definition of Acronyms

AHD	Australian Height Datum
ALS	Australia Laboratory Services
AS	Australian Standard
ASS	acid sulfate soil
DQO	Data Quality Objectives
EPA	Environmental Protection Authority
JSEA	Job Safety and Environment Analysis
LWC	Land and Water Consulting
LR	Liming rate
Eurofins	Eurofins – MGT Laboratory Pty Ltd
MW	Monitoring well
NATA	National Association of Testing Authorities
NEPM	National Environmental Protection Measures
WH&S	Work, Health and Safety
PASS	Potential acid sulfate soil
PPE	Personal Protective Equipment
QAQC	Quality Assurance Quality Control
EPA	Environmental Protection Authority
TDS	Total Dissolved Solids

CONTENTS

FIGURES AT REAR

LIST OF FIGURES AND TABLES (IN TEXT)

APPENDICES

1 INTRODUCTION

Land & Water Consulting (LWC) was engaged by ENRS Pty Ltd on behalf of Cleary Bros (Bombo) Pty Ltd to prepare an Acid Sulfate Soil Management Plan for material to be dredged from Gerroa Sand Mine, New South Wales (the Site). A site location plan provided as Figure 1. All data was collected by ENRS.

As part of the characterisation of the sediment material to be dredged it was identified that the material has the potential to generate acid when exposed to oxygen (ENRS 2021). The objective of this ASSMP is to ensure that potential risks to the environment from Acid Sulfate Soil are mitigated during the dredging processes.

The procedures detailed as part of the ASSMP are to be adopted for the duration of the dredging activities. Contingency measures, as detailed in the ASSMP, are to be actioned, as required based on field measurements and/ or observations.

This plan has been prepared in accordance with the following guidelines:

- Stone, Y, Ahern, C.R., Blunden, B (1998). Acid Sulfate Soils Manual 1998. Acid Sulfate Soil Management Advisory Committee, Wollongbar, NSW, Australia.
- Simpson, SL, Mosley, L, Batley, GE and Shand, P (2018). National Acid sulfate soils guidance: Guidelines for the dredging of acid sulfate soil sediments and associated dredge spoil management, Department of Agriculture and Water Resources, Canberra, ACT. CC BY 4.0
- Water Quality Australia (WQA - 2018) *National Acid Sulfate Soil Guidelines - Guidelines for the dredging of acid sulfate soil sediments and associated dredge spoil management*.
- Water Quality Australia (WQA - 2018) *National Acid Sulfate Soil Guidelines – National guidance for dewatering of acid sulfate soils in shallow groundwater environments.*

1.1 PROJECT DESCRIPTION

The modifications to the existing approval result from the need to extend the Gerroa Sand Quarry site to continue operations in a sustainable manner. The proposal seeks extraction in the northern portion of the Site as shown in Figure 1

The extraction would be serviced by the existing on site infrastructure, with no increase in overall throughput. The project comprises the development of a dredge pond to the north of the current extraction area as identified by Figure 1. This portion of the site has been identified as containing a significant amount of sand resource. This area is currently utilised as grazing land for cattle, with negligible native vegetation clearing required.

It is understood that:

1. Sand extraction will occur through suction dredge. Water will be piped from the disposal pond area to the new extraction area to balance water levels in the aquifer. The dredge slurry will be piped from the new extraction area to the existing cyclone located adjacent to the existing pond system.
2. Separated sand products will then be stored within existing stockpiling locations on site before the product is transported using existing transport routes. The extension to the extraction area will not result in any increase to the approved volume of material extracted on site per year.
3. Tailings are kept wet and disposed to the existing dredge pond (submerged)

1.1.1 Methodology

The methodology used to extract the majority of sand from the dredge pond extension will be the same as that currently in use and as described above. The initial stages (referred to as Stage 1 in this ASSMP) of dredge pond development will require mechanical excavation of an area approximately 5m by 25m to a depth of approximately 3m to facilitate floatation of the dredge. Mechanical excavation will continue to assist with sump enlargement until the excavation footprint is approximately 25m by 50m. Once the dredge has been floated there will be no changes to the extraction process (referred to as Stage 2 in this ASSMP).

The dredge pipeline (250mm polypipe) that connects the dredge to the separation system will travel along the eastern edge of an existing access track that connects the new extraction area with the existing one with no track widening required. The pipeline will be laid directly on the ground or raised on concrete plinths as required. Short sections of the pipe may be buried where necessary (for example at track intersections or crossings).

It is expected that an initial dredge pond will be developed in northern section of the proposed extension area where, based on the findings of the ASS Investigation (ENRS 2021) the lowest risk for ASS disturbance exists.

The proposed dredging methodology is staged as outlined below:

Stage 1:

- Mechanical excavation of an area approximately 5m by 25m to a depth of approximately 3m to facilitate floatation of the dredge;
- Mechanical excavation will continue to assist with sump enlargement until the excavation footprint is approximately 25m by 50m;
- PASS spoil generated by mechanical excavation to be treated in accordance with Section 5 of this ASSMP.

Stage 2:

- Dredge the material within delineated area (Figure 1) to the target depth using a cutter suction dredge;
- Dredge material is pumped to the existing Site processing plant for hydro-cycloning to separate the sand resource from PASS/unsuitable material;
- Reject materials (PASS and those unsuitable for use as concrete fines) will be submerged within the existing dredge pond (with addition of neutralising materials if required) below the permanent groundwater table (sub-aqueous disposal).

1.1.2 Dredge depth

Exploratory drilling of the site has shown that immediately below the shallow layer of sandy topsoil lies a beneficial sand resource. The sand resource varies in thickness across the Site and includes a clay band of up to 2 metres thick in parts.

The southern zone of the expansion has identified sand resources of up to 6m, whilst the northern zone has identified sand resources of 6m - 12m deep. This sequence of sand with minor clay lenses is in description to the existing dredge pond subsurface material description.

The gradation (sizing) and physical properties of the sand in the proposed sand extension are apparently similar to the sand in the existing dredge pond therefore the sand will be suitable for incorporation in the production of concrete, which is the primary use of the existing dredge pond sands. Where practicable, the sand will be extracted to the full depth of the sequence to maximise the beneficial use of the resource.

Boreholes installed through the scope of the 2021 ASS investigation by method of vibrocore within the initial expansion area achieved a maximum investigation depth of 6.1m below the current ground level. Previous assessment undertaken by Douglas Partners extended five bores to depths ranging from 7.2 – 14.5 m (and completion as groundwater monitoring wells NB1 – NB5). Sampling programs to assess the extent of Acid Sulfate Soil may be staged and as such further characterisation within this area maybe be undertaken to extend the extent to the dredge cut.

1.1.3 Volume

The extraction area is similar in topography to the existing dredge pond and is located to the north-west and west of the existing dredge pond. The area of the proposed dredge pond extension is approximately 15 hectares and contains an estimated 1.2 million tonnes of sand as determined by exploratory boreholes carried out in the area.

In accordance with the conditions of approval no more than 80,000 tonnes of quarried material can be transported from the Site per year.

1.1.4 Duration

Proposed extraction and processing operations at the Site may take place until 31 July 2038.

1.1.5 Disposal

Consistent with the operation of the existing operation, reject materials (PASS and those unsuitable for use as concrete fines) are transferred to the invert of the existing dredge pond using a low pressure pipeline below the permanent groundwater table (sub-aqueous disposal).

1.2 ACID SULFATE SOILS

Acid sulfate soil (ASS) is the common term for soil which contains chemical compounds known as metal sulfides. Soil containing metal sulfides is usually not a concern when it remains undisturbed or covered by water, in which state it is termed Potential Acid Sulfate Soil (PASS). If PASS is exposed to air, it can pose a risk to water quality (Figure 1-3).

ASS forms when there is a combination of:

- waterlogged and/ or oxygen-free conditions
- a source of sulfate from seawater or saline groundwater
- the presence of organic matter and metals such as iron.

In these conditions, naturally occurring bacteria obtain energy from carbon in organic matter to convert sulfate to sulfide. Sulfide in the soil then reacts with metals to form metal sulfides (PASS) that release acid when exposed to air.

If exposed to air, the metal sulfides react with oxygen to produce sulfuric acid, which can seriously affect water and soil quality. Heavy metals and other toxicants can also be released and dissolved oxygen concentration in water is likely to be low in affected areas.

ASS can lead to reduced pH, decreased oxygen concentration in water and the release of heavy metals such as cadmium and lead, and metalloids such as arsenic. Acid and other contaminants can enter waterways and wetlands when soils are rewetted.

Decline in water and soil quality poses a risk to:

- aquatic ecosystems
- human health
- infrastructure
- primary industries
- social amenity of waterways.

Human activities can be affected through poor drinking water quality and limiting recreation when foul odours are released by the chemical reactions occurring in ASS.

Infrastructure damage can include corrosion of metal and weakening of concrete structures such as weirs, bridge pylons and fencing.

These effects can be very expensive to treat. While many ecosystems have the capacity to absorb and neutralise acid, some aquatic organisms may be killed by the lower pH, exposure to heavy metals or a lack of dissolved oxygen in the water column.

Brief definition of terms used in connection with acid sulfate soils

- Potential ASS (PASS) —soils or sediments that contain sulfides and with the potential to oxidise and become severely acidic
- Actual ASS (AASS) —soils or sediments that once contained sulfides but that have oxidised and become severely acidic
- Monosulfidic black oozes (MBOs)/monosulfidic materials—readily mobilised and highly reactive sulfidic material
- Sulfidic sediments/material—similar meaning to PASS, more precise definition
- Sulfuric material—similar meaning to AASS, more precise definition
- Pyrite— (FeS_2) an iron sulfide mineral that is a common component of sulfidic material

The risk of acidification of acid sulfate materials can be determined indirectly by an acid-base accounting approach (Ahern, McElnea and Sullivan 2004). Net acidity, a measure of the acid- producing capacity of the sediments (Ahern, McElnea and Sullivan 2004), is estimated as:

Net acidity = Potential sulfidic acidity + Actual acidity + Retained acidity – Acid neutralising capacity

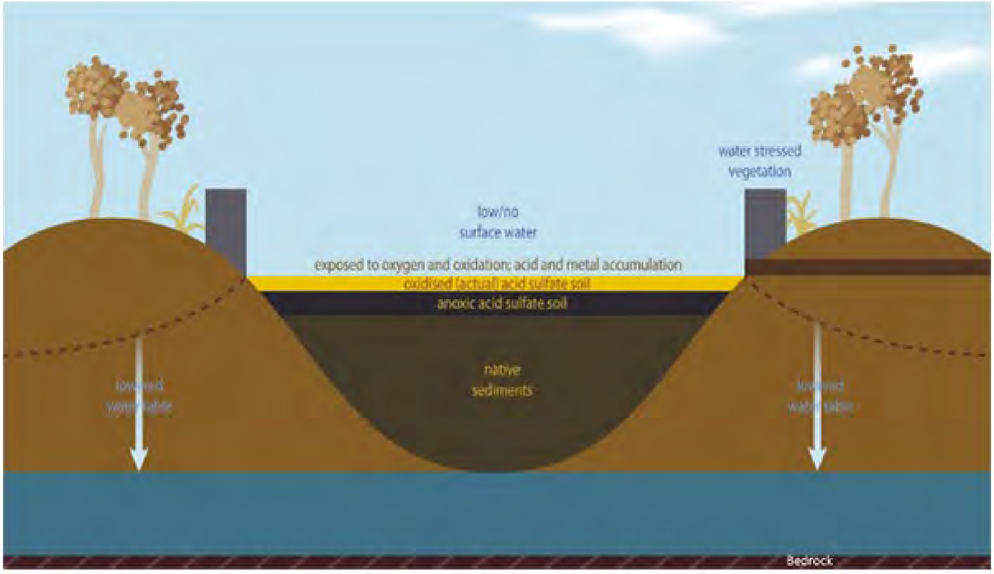


Figure 1-1 Exposure and oxidation of acid sulfate soil in a drying scenario (not to scale) (Department of Agriculture, Water, and the Environment, 2022)

1.3 OBJECTIVE

The objective of the ASSMP is to provide management actions to ensure that potential risks to the environment are mitigated during the dredging processes as part of the Project.

The ASSMP is required to present adaptive management and monitoring strategies to be implemented at spatial and temporal scales that enable effective outcomes. The ASSMP also establishes an agreed outline for the management of disturbed materials, including environmental management triggers and response requirements that are transparent to stakeholders.

2 PREVIOUS INVESTIGATIONS

In preparation of this ASSMP two (2) previous investigations, which included sampling within the Modification 1 – Extraction Area to analyse the extent of acid sulfate soils, have been used to provide a site setting and characterisation within the existing environment;

1. Douglas Partners (2018): Report on Acid Sulfate Management Plan – Proposed Sand Quarry Extension (submitted as part of the Environmental Assessment for Modification 1); and

2. ENRS (2021): Acid Sulfate Soil Investigation (Appendix D)

2.1 Douglas Partners

- This report provides a summary of all previous resource definition programs as well as the results of shallow test pit investigations undertaken throughout the complete extent of the extension area.

- The field screening and laboratory testing of samples obtained during the current and previous investigations within or adjacent to the proposed extension area indicate that:

    - pH field levels (pH_F) values indicative (i.e. pH ≤ 4) of ASS conditions were noted in only three samples from the 2.1 – 2.5 m depth range in Pits 304, 310 and 601. However, the laboratory testing results indicate AASS conditions, with varying (0.003 – 0.35%S) remaining PASS components, in samples at depths in the range 0.0 – 2.1 m from eight (601, 604 – 606, 610 – 613) of the DP test pits;

    - Test values in the range $4 < pH_F < 5$ (i.e. acid soils) were recorded in 35 of 218 samples from the 0.1 – 3m depth range in the DP 300 and 600 series test pits and the Network Geotechnics (NG) SR series bores;

    - Field oxidised pH level (pH_{FOX}) values indicative of PASS conditions were recorded from samples in all of the NG SR series bores, in 17 of 26 of the DP 300 series test pits and 14 of 15 of the DP 600 series test pits.

    - Laboratory chromium reducible sulfur suite results confirmed PASS conditions in the single analysed sample from the DP 300 series test pits, in three of five analysed samples from the NG SR series bores and 16 of the 20 analysed samples from the DP 600 series test pits. Average and maximum existing plus potential acidity values of approximately 0.2%S and 0.72%S are indicated by these results.

2.2 ENRS

ENRS (2021) provided the following details regarding the conditions of the initial dredge extension area (see Figure 2 at rear):

- Twenty-four (24) soil cores were collected, terminating at depths ranging from 2.6 - 6.1 m below the ground level at the time of investigation. Soil cores were logged with representative samples collected for field screening and further laboratory analysis (chromium reducible sulfur suite method) where required to determine the potential presence of PASS materials;

- Field screening during logging was undertaken on two hundred and eighteen (218) samples, with laboratory CrS analysis undertaken on ninety-five (95) samples;

- Field screen results in the profile indicate that pH field levels range between 4.2 to 7.3 with field oxidised pH level (pH_{FOX}) ranging between 1.23 to 5.9;
- Titratable actual acidity was recorded between <2 mol H+/t (limit of reporting) and 33 mol H+/t;
- All oxidisable inorganic sulfur (SCR) was below the level of reporting (0.02% S) in all but eight (8) samples. Of these, six (6) were ≥ 0.03% demonstrating that pyritic materials were present and above the action criteria indicating PASS;
- Chromium reducible sulfur (CrS) was reported at ≥ 0.03% S in seventy one (71) of the samples analysed;
- Laboratory calculated liming rates ranged from <1 kg $CaCO_3$/t to 239 kg $CaCO_3$/t;
- From review of borehole logs, field screening and the results of laboratory analysis the materials presenting the highest PASS risk within the upper ground profile (<3 mBGL depth) are those primarily comprising of black clay/ silt. During this investigation this material type was encountered in the upper ground profile in several of the boreholes installed for this program. Whilst field screening results of this material were predominately characterised by a vigorous/ violent reaction and pH change of >3, the laboratory reported sulfur (%) and corresponding liming rates were highly variable. From review of the results it is inferred that there is a higher prevalence of this near surface high risk unit in the southwestern portion of the investigation area;
- Through the deeper profile (>3 mBGL depth) to the maximum investigation depth CrS results were variable, however, materials primarily comprising of or with accessory black clay/silt were noted to generally be correlated with increased laboratory reported sulfur (%);
- Where the results of laboratory CrS analysis identified PASS material, under/overlying samples were analysed for CrS to delineate the material vertically. Results of CrS analysis did not identify any laterally extensive units of PASS material within the investigation area.
- Field screening supported by laboratory analysis of samples from BH2 report maximum sulfur (%) of 0.129% within 3 mBGL. As such this area has been assessed to be of low risk for incidence of near surface PASS. It is understood that the quarry design will see the initial mechanical excavation of the dredge pond commenced in this area.

Based on these results, this ASSMP was developed to outline the mitigation measures for the dredging program. **All material to be dredged is defined as ASS**.

3 CONCEPTUAL MODEL

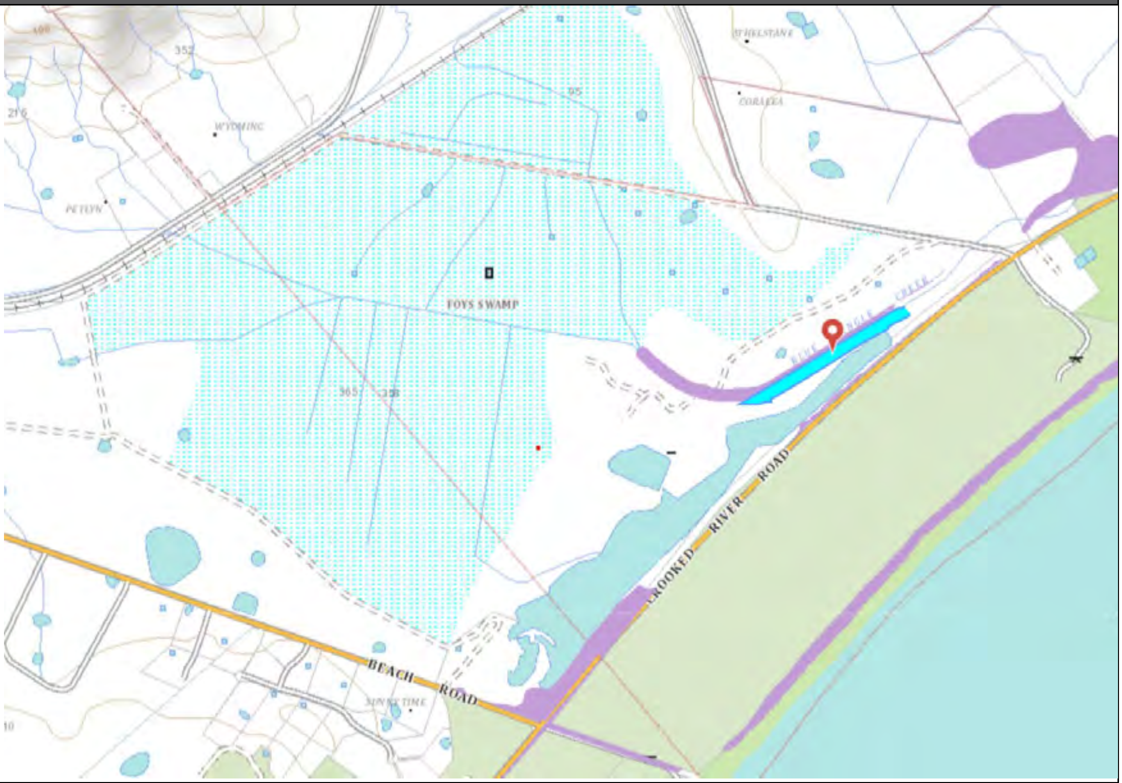
3.1 Site Setting

Details describing the physical and environmental features of the Site are presented in Table 3-1.

Table 3-1 Site Environmental Setting

Item	Description
Topography	The site is located adjacent to Seven Mile Beach, approximately 40 km south of Wollongong. The proposed quarry extension area (Figure 1) comprises an irregularly shaped area, totalling approximately 15 ha, extending approximately 890 m westward from the canalised course of Blue Angle Creek and having a maximum northeast-southwest extent of approximately 990m. The current western edge of the operating dredge pond, which fronts Crooked River Road, is located, at its closest extent, approximately 110 m southeast of the proposed extension area. Natural surface levels within the proposed extension area generally range from RL 1 relative to Australian Height Datum (AHD) adjacent to Blue Angle Creek to RL 3 on the footslopes of a northwest-southeast trending ridge. Reported (CB) water levels in the drain within Foys Swamp bordering the western edge of the proposed extension area has been excavated to <RL 0.4. Similarly water levels in Blue Angle Creek Main Channel adjacent to the proposed extension area also indicate excavation levels of <RL 0.4 within this canalised section of the stream course. In the north-eastern section of the site, a sand ridge with elevation up to RL 9 separates the two arms of the proposed extension area.
Climate	The Site is characterised by a temperate coastal climate. The mean maximum temperatures range from around 17.3°C in winter to 25.1°C in summer and the average annual rainfall is around 1053mm per year (Kiama AWS 068242 ~13.5km north-northeast of the site) with most of the rainfall occurring January to July. Rainfall is lowest generally from August to December.
Geology	The Site was previously subject to an Acid Sulfate Management Plan (Douglas Partners, 2018) which provides a detailed description of the geological and hydrogeological setting. The following provides a summary of key information from the preceding ASSMP (DP, 2018) supplemented with contemporary data where available. Reference to the Wollongong 1:250 000 Geological Series Sheet and the Shellharbour-Kiama Area 1:50 000 and 1:25 000, Coastal Quaternary Map Series Sheet (Figure 2 and 4, at rear) indicates that the existing Gerroa Sand Quarry and proposed extension area lie within the drainage basin of Crooked River that discharges to the Shoalhaven Bight approximately 3.5 km to the northeast. The basin is bounded to the northwest (near the alignment of the South Coast Railway some 1.5 km to the northwest) by a topographic bedrock high of Berry Siltstone (map unit Ps) of Permian age. Southeast-trending spurs of this bedrock high also extend to near the intersection of Crooked River and Beach Roads and within the central section of the site. The bedrock is overlain by sediments of Quaternary (Holocene) age, which may be separated into the following broad deposition modes of surface occurrence from the present-day beach: • Sandy beach (map unit Qhbb) and dunes of aeolian marine sand (map unit Qhbr) located between the current seafront and extending up to 400 m west of the Crooked River Road. The beach ridge system controls the drainage path of Blue Angle Creek which flows northeast before joining the Crooked River. • Tidal, delta flat, marine sand (including sand sheets), silt, clay and gravel (map unit Qhef) covering most of the proposed extension area. • Fresh water swamp, organic mud, peat, clay, silt and marine sand deposits (map unit Qha) within the Foys Swamp area and extending westerly to the South Coast Railway. This unit is mapped as overlying estuarine basin and bay deposits (map unit Qhem) of clay, silt, shells, fluvial or marine sand.
Hydrogeology and Hydrology	Within the proposed extension area, three standpipe piezometers have been installed for the purpose of groundwater level and quality monitoring (DP, 2018: NB02, NB03 and NB04), with monitoring subsequently undertaken since April 2020. Groundwater levels gauged between April 2020 to June 2022 support a south-eastern groundwater flow direction north of Blue Angle Creek, with NB03 positioned upgradient of the extension area and NB02 and NB04 positioned downgradient. Groundwater levels within these bores is generally within the range of 1-1.5 mAHD, which is consistent with test pit observations made during the Acid Sulfate Soil Investigation (ENRS, 2021). During early

Item	Description
	2022 a strong gaining response to sustained rainfall observed between February to April when the Site received ~1180mm of rain as captured by the Site AWS. The report titled *Groundwater Issues Report* (DP, 2019) previously established that the prevailing groundwater flow direction is from the east, through the pond, and then to the west towards Blue Angle Creek. The CB monitoring bores, in and adjacent to the current sand quarry, have indicated moderate variation in groundwater levels but a consistent, northeast-trending flow gradient (about 0.3%) adjacent to the dredge pond, possibly reflects the topographic bedrock high adjacent to the southern side of Beach Road. Elsewhere, there is a generally easterly-trending flow gradient of about 0.1% -0.2% towards the shore but with local apparent even flatter gradients and reversals of gradient, suggesting that groundwater mounding within the dunes sheds both eastward to the sea and westward to the main drainage canal which continues northward as Blue Angle Creek (tidal below flood gates at the northern end of the site) and thence Crooked River (tidal). The CB measurements of the current dredge pond level for the periods 1993 to 2000, 2005 to 2018 and 2018 to 2022 indicated that: • The yearly maximum dredge pond level (in years of less than median rainfall) typically moved within a limited range (approximately RL 1.7 – 1.9) with an average maximum of approximate RL 1.8. • The increase in dredge pond level corresponded closely with the rainfall in excess of the median value. • The maximum dredge pond level (approximately RL 2.4 – Apr/May 2022) occurred during a year of high rainfall indicating the rapid effect of rainfall on the groundwater regime. • For daily rainfall events generally in excess of 100 mm or close spaced rainfall events totalling about 100 mm there was typically a similar rise in the dredge pond level. • The minimum dredge pond level (RL 0.2 – Jan/Feb 2020) is approaching mean sea level. • During the period September 2010 to June 2022, the dredge pond level moved within the range RL 0.2 – 2.4, but with a descending trend towards the minimum level, consistent with the recent cumulative rainfall deficit, while the water level in Blue Angle Creek moved within the range RL 0.1 – 1.5 . It is noted that the water level in the creek is controlled by flood gates. Measurement of the pH of the dredge pond water and drainage canal water (at Blue Angle Creek) and groundwater in the CB monitoring bores has also been carried out on a regular basis since 1993 and indicates: • The dredge pond pH has generally moved with the range 6.0 – 9.0 (moderately acidic to strongly alkaline). • The lowest dredge pond pH values were measured in periods of heavy rainfall at the end of July 1998 and extreme rainfall in mid-August 1998. This may reflect the flushing of organic acids or sulfuric acid from the oxidation of pyritic material in the sand aquifer. • The pH of Blue Angle Creek below the flood gates at the northern end of the CB property (ie adjacent to the north-eastern extent of the proposed quarry extension) has historically generally ranged between 6.6 and 7.8, but with a lower pH reading of 4.8 being associated with transient stream flushing event during wet weather. During the period January to August 2018, the pH ranged from 6.75 – 7.5. For comparison, pH readings as low as 3.2 have been recorded in drains within Foys Swamp, upstream (west) of the proposed quarry extension area.
Groundwater Use	Review of the NSW Office of Water (NOW) registered bore database identified several groundwater bores within 1000m of the Site, however, none of these are located downgradient of the established hydraulic gradient of the extension area (flowing due southeast towards blue angle creek). Groundwater bores within the 1000 m Site buffer are predominantly monitoring bores associated with the former Gerroa landfill (~300m east of the Site) and the Gerroa sewerage treatment plant (~900m northeast of the Site). Two stock/ domestic bores are registered ~1,100m north of the extension area. No information regarding water quality was available for bores proximal to the extension area.
Acid Sulfate Soils (ASS)	The detailed assessment of ASS across the site is documented in the Acid Sulfate Soil Investigation Report (ENRS, 2021) with a summary of all the historic Acid Sulfate Soil investigations compiled in the previous Acid Sulfate Management Plan (Douglas Partners, 2018). Refer Table A-1.
Areas of Environmental Value	Various listings on the NSW Biodiversity Values Map in and adjacent to the proposed dredge area (https://www.lmbc.nsw.gov.au/Maps/index.html?viewer=BOSETMap) – specifically biodiverse riparian land.

Item	Description
	
Surrounding Land Uses	The predominant land use in the area surrounding the Site appears to generally comprise pastoral land use. The area immediately south of the extension is occupied the existing mining operation and the area to the east of Crooked River Road is designated Seven Mile Beach National Park.’
Current Land Use	The site is currently designated as pastoral land and part of the Project Area is used for grazing purposes.
Proposed Land Use	Development as a sand mine

3.2 ASS / Surface Water Characterisation

Key characteristics of the Project/ Project Area relevant to the ASS Management Procedures are detailed in Table 3-2. Figures 5 – 10 (at rear) present PASS distribution by depth.

Figure 3-1 presents historical hydrochemical data for the existing dredge pond. Key observations:

- pH generally slightly alkaline for long periods between July 2007 and present day, with few (3)/ minor excursions below pH 7 over this period.
- Bicarbonate alkalinity has been around 100 mg/L $CaCO_3$ between July 2007 and present day.
- Soluble iron low since July 2009 (presumably filtered)
- Conductivity (EC) is largely unremarkable over the data period.
- Both sulfate and chloride relatively stable between 50 and 150 mg/L over the data period.

Table 3-2 *Key Characteristics of the Project/ Project Area Relevant to the ASS Management Procedures*

Project Aspect	Description
Location of ASS	For the purpose of this plan, all material to be dredged is to be treated as ASS.
Nature of ASS	Refer Table A1 – 219 field screened samples with 95 laboratory analysis (chromium reducible sulfur suite). A total of 71 of these samples has been classified as PASS (based on Net Acidity). S% ranges from 0.3% to 5.1% across the 95 samples analysed.
Density of Solids in Dredging Slurry	Prior to reaching the hydrocyclone, there will be around 40-60% of solids in the dredge slurry with the remainder being water from the sand aquifer or the existing dredge pond.
Dredging Location	Refer Figure 1
Receiving Environment	There is no direct discharge from the dredge pond into a receiving water body. The only water leaving the Site will be groundwater. Down hydraulic gradient wells can be counted as the receiving environment.

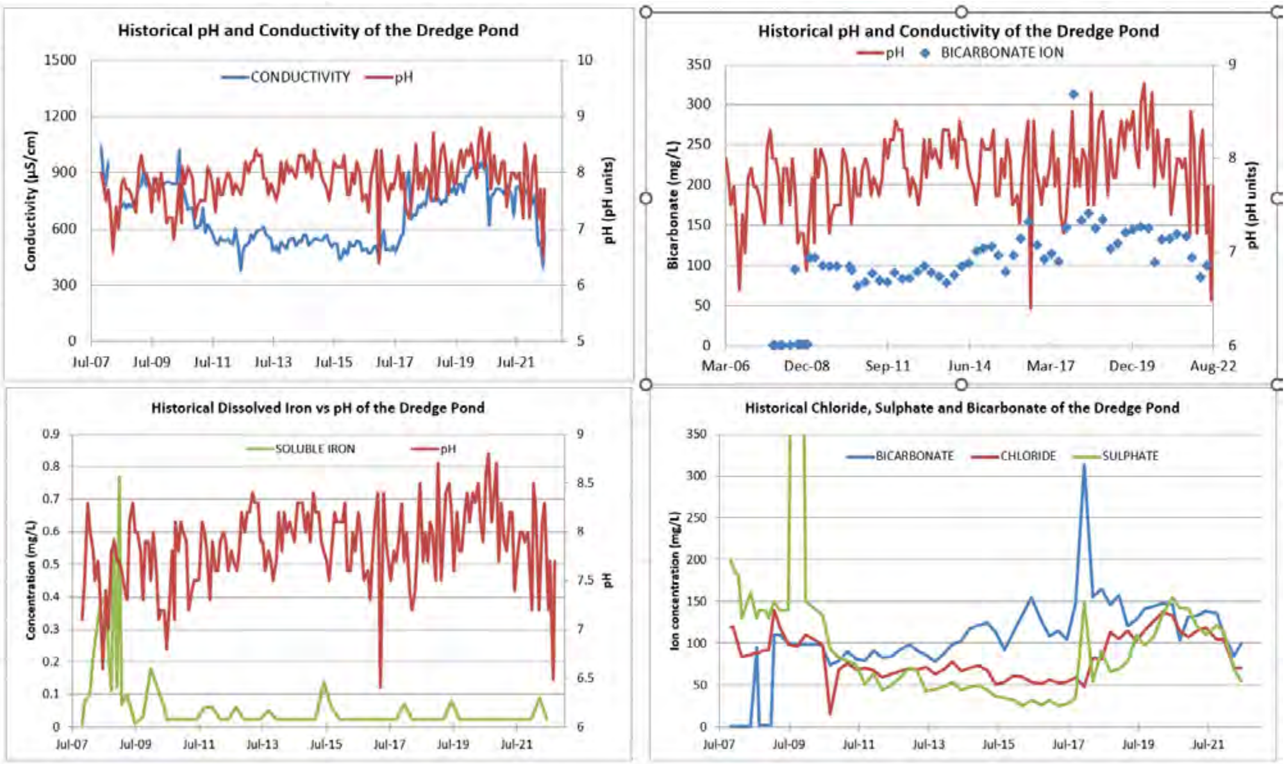


Figure 3-1 Hydrochemical data/ trends for the existing dredge pond

3.3 Groundwater

Groundwater has been monitored, sampled, and analysed at locations since October 2007. The analytical schedule has comprised major ions, nutrients, chlorophyll and *Escherichia coli* and has not included dissolved metals.

Groundwater was analysed for dissolved metals in September 2022 (Table A-3) and such data is compared to default ANZG 2018 (ANZECC 2000) criteria, modified for hardness as outlined for surface water data in Section 5.7.

Note that aluminium and zinc both exceed the default criteria and this infers that these elements have a background distribution that is elevated above such criteria. Selenium and vanadium are reported with a limit of reporting above the default ANZG criteria, though this is not expected to represent an elevated risk profile (consistently below limit of reporting).

3.4 Materials/ Waters/ Effluents

With respect to the methodology described, there are three distinct materials/ effluent associated with the process that requires consideration, as summarised in Table 3-3.

Table 3-3 Materials/ waters/ effluent associated with the process

Material / Effluent	Reference	Description
Existing dredge pond water.	Return water pipeline	Transfers water from the existing dredge pond to the new dredge pond to balance water levels in the ponds. Alkalinity of this water is important so as to not increase any acid burden to the new dredge pond and also mitigate exposed PASS during dredge.
Materials dredged from the new area pre-processing.	Dredge pipeline	A pressurised pipeline that pumps the slurry from the dredge to the processing plant.
Reject fines separated from the dredge post processing.	Rejects pipeline	A low pressure pipeline collecting the fine reject at the base of the plant and transferring the material to the existing dredge pond.

4 RESPONSIBILITIES AND TRAINING

4.1 RESPONSIBILTIES

During construction works, the following levels of responsibility shall exist:

- The Project Manager is responsible for ensuring that the requirements of the ASSMP are met.
- The Site Manager is responsible for ensuring the mitigation measures prescribed in the ASSMP are implemented at the Site in accordance with the specified performance criteria.
- All other site personnel are responsible for implementing the processes prescribed in the ASSMP, as applicable to their work activities.

ENRS, environmental consultant, is responsible for providing Cleary Bros (Bombo) Pty Ltd with advice, as required.

4.2 TRAINING

All equipment operators, supervisors and subcontractors engaged in the dredging, ASS treatment and verification works shall participate in induction training for acid sulfate soils. This training will include basic recognition and identification of ASS, plus an outline of the requirements of the ASSMP. It is the responsibility of the Contractor's Site Manager to verify attendance at induction training prior to commencement of site works.

5 ADAPTIVE MANAGEMENT

5.1 Overview

The best way to manage acid sulfate soil is to determine where it might occur and avoid exposing affected soils to oxygen. However by nature of the operations avoiding exposure of affected soils is not possible, and so in accordance with national guidance an adaptive management approach is implemented.

Required (national guidance) activities involved in the adaptive management of acid sulfate soil are:

- describe current condition of soils
- identify questions to be answered (e.g. what are the threats and consequences)
- identify management objectives and options
- predict response to management options
- implement chosen options
- monitor results
- evaluate response
- refine management options by evaluating and fine tuning predictions and management objectives.

These activities are presented figuratively as Figure 5-1.

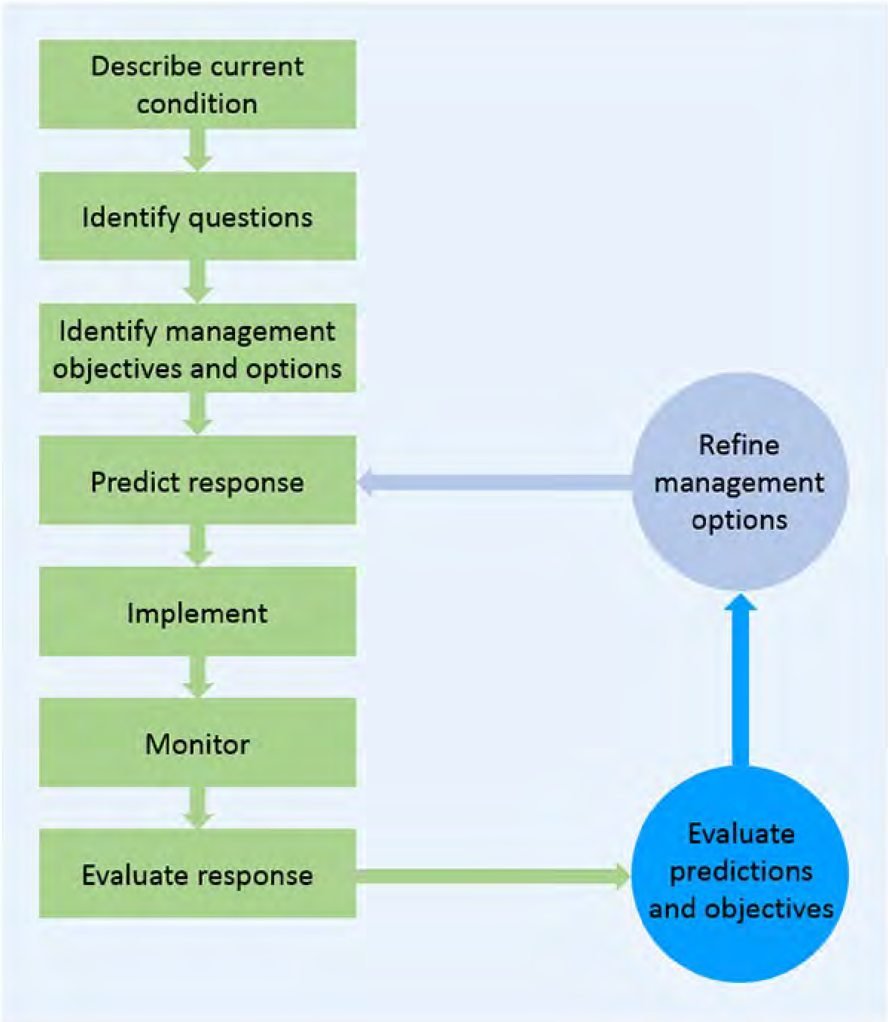


Figure 5-1 Adaptive management of acid sulfate soils

5.2 Current condition of soils

Please refer to Section 2 and 3.

5.3 Questions to be answered (e.g. what are the threats and consequences)

What are the risks associated with the ASS in the project area?

> *Based on the Project methodology (including the construction of a lined dewatering pad), the main risk is that of acidic water reaching the marine environment. The management measures detailed in this document address this key risk.*

Table 5-1 Required questions/ information (Simpson et al., 2018) and ASSMP responses (this plan)

Questions / Information Required (Simpson et al., 2018)	Response
An overview of the project that summarises the key dredging aspects relating to the dredging scale (volumes, area) and methods of dredging and material transport, and of the general land disposal location (current use, values, et cetera).	Section 1
Site description (topography, geology, hydrology, ecologically sensitive surrounding areas);	Section 2
Detailed maps of soils (including ASS), contaminants, water, groundwater.	Section 3
Comprehensive description of the dredged materials, including physical properties of the soils, sediments, ASS, contaminants, (field and laboratory test results).	Section 3
Methodology for classifying ASS (field screening tests, action Levels, et cetera).	Section 1
Avoidance and beneficial reuse.	Section 3
Site preparation (for example construction, pads, bunding) and related environmental measures.	Section 5.6
Treatment site and procedures (for example methodology and liming rates for PASS, performance criteria and verification testing) and location (treatment site preparation and management).	Section 5.6
Dewatering and disposal of waters (returned by pipe to dredging location).	Dewatering not required. Section 5.6.3
Other hazard mitigation strategies (for example silt controls, minimising oxidation of PASS, leachates), including testing and verification.	Section 5.6

Questions / Information Required (Simpson et al., 2018)	Response
Runoff, effluent leachate interception (for example silt ponds, barriers, drains);	Section 5.6
Other monitoring plans (for example water quality, dust, odours);	Section 6
Groundwater monitoring, including bore hole plans.	Section 5.6
Monitoring and reporting requirements.	Section 5.7
Contingency plans (for example acidic leachate detected).	Section 5.8
Safety (chemical storage, for example lime, and spill response).	Section 6
Review, validation testing, reporting and auditing (for example of performance criteria).	Section 7
Community / stakeholder liaison; and	Section 7.2
Closure.	Section 5.10

5.4 Management objectives and options

Long-term management requires regular monitoring and reduction of additional inputs of sulfate. Regular wetting and drying in some systems can also help prevent the build-up of large quantities of acid.

Depending on the risk level and local conditions, acidification may be neutralised by:

- applying alkaline products such as lime
- planting vegetation or increasing organic matter inputs to encourage micro-organisms to metabolise acidity and metals

- diverting saline groundwater to disposal basins maintaining water levels with temporary regulators
- reinstating wetting and drying patterns to wet soils and prevent the build-up of sulfidic sediments through dilution with freshwater flows.

The principal management strategy selected for the excavated or dredged sand (including AASS and PASS) is for the removal of pyritic fines and oversize materials (predominantly shells) by washing and hydrocycloning to reduce pyritic content to levels suitable for use of the processed sand as fine concrete aggregate.

Material (including PASS) unsuitable for use as fine concrete aggregate will be returned (with addition of neutralising materials if required) to the current dredge pond for burial below the permanent groundwater table. This strategy continues the current methods of extraction and treatment practice that has successfully managed the acid sulfate risk during the operation of the Gerroa Sand Quarry to date.

Observations of the current working method and review of water quality results from within the Gerroa Sand Quarry indicate that:

- Water removed from the pumped slurry is returned almost directly to the current pond via run-off from the discharge/processing area or via rapid infiltration of the sand profile about the working area.
- The exposure time during extraction, processing (including discharge of reject fines) and stockpiling, has been to date insufficient to cause complete oxidation of pyritic material and increase in the water acidity within the dredge pond in comparison with the pH of the groundwater sampled from the nearby monitoring bores.

As the new area has a higher ASS risk than historically excavated areas, Cleary Bros are committing to additional management tasks for the extension area:

- All exposed surfaces (batters) must be limed to prevent acid generation via oxidation of sulfidic soils.
- All stockpile bases are to be limed
- Contingency Measure 1: The return water pipeline is to be limed (dependant on ongoing operational monitoring results).
- Contingency Measure 2: The piped return of rejects (fines) to the pond floor is to be limed. (dependant on ongoing operational monitoring results). The fines are most likely to carry the sulfidic material (pyrite) and therefore may need liming at a higher rate than in situ materials.

The fines are most likely to carry the sulfidic material (pyrite) and therefore need liming at a higher rate than in situ materials.

A preliminary liming rate for in line dosing is calculated and presented in Section 5.6.

Note - The feed in pipeline from the existing dredge pond for water balance must contain/ maintain >60 mg/L alkalinity and the dissolved metals content must not exceed Site trigger values (ANZG 2018 marine ecosystem 95% protection – in lieu of absence of background data. Note that iron (Fe) is excepted due to known high Fe content).

5.5 Response to management options (prediction)

Maintaining PASS in a saturated state minimises oxidation and so keeping the materials wet and then disposing under water in the dredge pond will prevent oxidation of sulfides and prevent the soils becoming actual acid sulfate soil (DER, 2015).

When considering unconfined disposal of dredged material in water bodies, the site characteristics may strongly influence the risks posed by the dredged materials (Simpson et al., 2018).

The water body in this instance is an existing dredge pond that has little ecological value in terms of benthic habitat.

The disposal site is retentive with a suitable bathymetry (depth) and hydrology (lack of currents, wave patterns, increased erosion elsewhere). The capacity of the dredge pond is sufficient to receive the materials in a saturated state and retain the materials in a saturated state. The predicted success of the management strategy is high where materials are beneath the water. Material must not be allowed to mound up and above the water level.

5.6 Implementation of chosen options

The material must remain saturated. Any material that cannot be maintained saturated must be treated.

5.6.1 Stockpile management

The stockpiling of PASS is not expected / planned. Untreated ASS that is stockpiled on land may develop into a long-term management problem due to oxidation leading to very low pH. Effective contingency management strategies need to be developed based on appropriate measures and considerations during the project planning stages. As a contingency measure, a neutralisation treatment pad will be prepared should there be some unexpected breakdown in operational processes that means material cannot be disposed to the dredge pond.

5.6.1.1 Treatment Pad

For treatment of large volumes of material, neutralisation is carried out on a treatment pad. The treatment pad must collect and isolate the leachate from the surrounding environment, while being able to efficiently accommodate the machinery (in terms of size and weight) and the ASS itself. Dear et al.,(2014) outlines that soils may be neutralised on a temporary treatment pad, mixed in situ as part of the removal process, or alternatively the soils may be neutralised as they are placed permanently. For this project mixing on a pad is recommended.

5.6.1.2 Impervious base

A layer of compacted non-ASS clayey material (>0.1 metres thick) is to be placed on the surface of the treatment pad to reduce the infiltration of leachate to the soil and groundwater (Figure 5-2).

In fully contained situations, an impervious physical barrier may also be an option, such as a bunded concrete slab or layer of bitumen. An impervious base is particularly beneficial due to the sandy area. The base layer should be slightly domed or sloped to prevent leachate from pooling in the treatment pad area.

5.6.1.3 Guard layer

A guard layer of neutralising agent should be spread onto the surface of the treatment pad before the placement of soils (Figure 5-2). This will reduce risk by neutralising acidic leachate generated in the treatment pile and not neutralised during the treatment process. This is especially relevant to the first layer of ASS that is placed for treatment before application of the neutralising agent. The guard layer will help protect groundwater quality.

The minimum guard layer rate beneath any treated-in-place ASS will be 5 kilograms fine aglime per m^2 per vertical metre of fill. Where the highest detected sum of existing and potential acidity is more than 1.0% S-equivalent, the rate will be at minimum 10 kilograms fine aglime per m^2 per vertical metre of fill.

Note: Reapplication of the guard layer will be necessary under temporary treatment pads, as the guard layer is likely to be removed with the treated soil. Guard layers may need to be applied between each compacted ASS layer as a precaution in environmentally sensitive areas, areas with high levels of sulfides or where soils are difficult to mix.

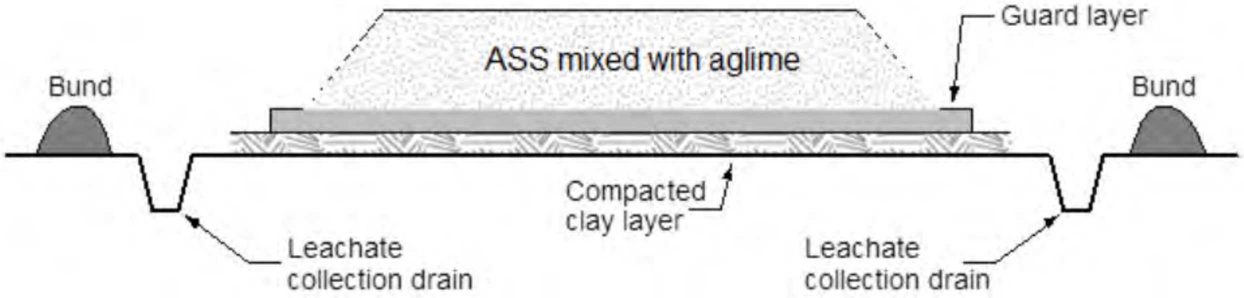


Figure 5-2 Schematic cross-section of a typical treatment pad, including a compacted clay layer, guard layer, leachate collection system and containment with bunding (Dear et al., 2014)

5.6.1.4 Pad Location

The Treatment pad must be located on stable ground, away from overland flow paths and preferably in a location where bund and leachate collection pond construction does not disturb in situ ASS.

Keeping treatment pads some distance from surface water bodies will help to avoid instances of accidental release of pollutants to water. Treatment pads should be set up to allow maximum treatment batch sizes of 500 m^3, as it is difficult to representatively sample larger batches, and re-treatment of large, failed batches is expensive.

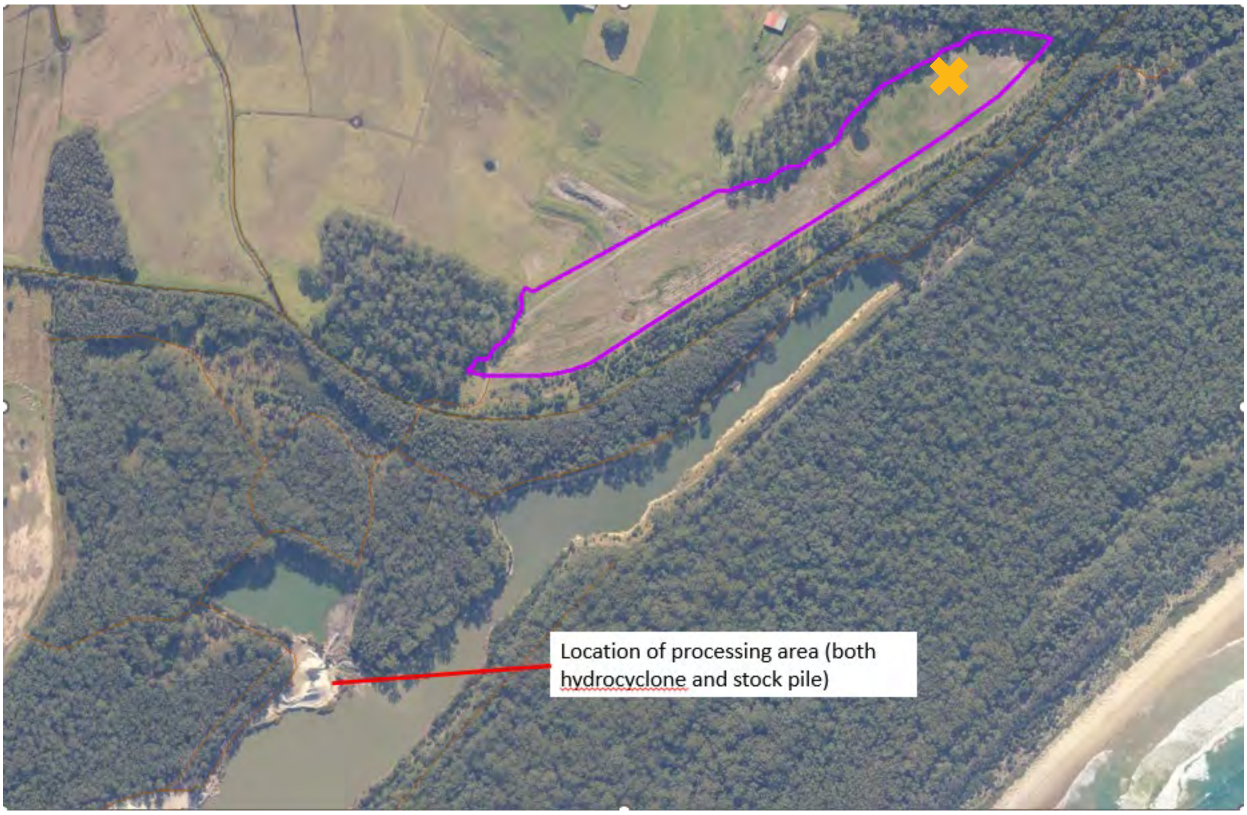


Figure 5-3 Proposed location of stockpile and treatment pad area (cross)

For permanently placed treatment pads, design considerations include siting, stormwater management, minimisation of potential migratory pathways for leachate, reaction products and salinity and the creation of a stable and non-erodible final landform.

This final landform must be accurately surveyed and both the extent and depth of the treated soils should be recorded (e.g. survey with a hand-held GPS, differential GPS, lot numbers or conventional survey, depending on the level of accuracy needed), and reported to the relevant local government and any other relevant authorities.

Local governments will need this information to enable them to make informed decisions about future land uses that could potentially impact on these areas. This information should be recorded in the closure report and be publicly available.

5.6.1.5 Spatial tracking

Accurate spatial tracking of large volumes of ASS during the neutralisation process (e.g. survey with a hand-held global positioning system (GPS), differential GPS, lot numbers or conventional survey, depending on the level of accuracy needed), is essential to make sure that initial soil testing can be correlated with prescribed treatment and any required verification testing.

5.6.1.6 Treatment Dosing - Stockpiles

Unexpected stockpiles of ASS fines shall be managed by the addition of fine grade agricultural lime to neutralise identified ASS materials

The liming rates recommended by the laboratory are summarised in Table 5-5 accounting for a factor of safety of 2 (already applied to these values).

Table 5-2 Liming rates for long term / unexpected stockpiles

Reference	Liming Rate (kg $CaCO_3$ per tonne of material)	Type of Value	Notes	Use
LR1	33	average	This value is the average liming rate multiplied by a safety factor of 2	Use the average value (LR1) – this is a reasonable liming rate to adopt *in general* **except** for any material excavated from the area around ENRS investigation location BH8 (**Figure 5-4**) - LR2 must be adopted for such material.
LR2	950	maximum	There is one outlier reporting a net acidity of 5.1%S (BH08, depth of 1.6 m – clay with high organics). This value appears to be a significant outlier (represents 1 in 95 samples).	

Note that these values must be adjusted based on the effective neutralising value (ENV) of the source of neutralisation chosen, which at best is 97% - i.e. the liming rate is = ((LR / ENV)*100).

A factor of safety of 2 is recommended and has been applied in Table 5-2 due to the sandy nature of the material and the high volume of water to be pumped (i.e. the potential for lime to be lost).

For conversion of Liming Rate to tonnes/ m^3 of wet dredge sediment, the dosing rate (kg $CaCO_3$/ tonne of sediment) is to be multiplied by the wet bulk density of sediment in tonnes/m^3. The dosing rate through the in-line dosing system (if required as a contingency measure) is to be adjusted in the field depending on the dredge rate and percentage of solids in the dredge slurry. Dry density is given as 1.23 tonnes /m^3 uncompacted.

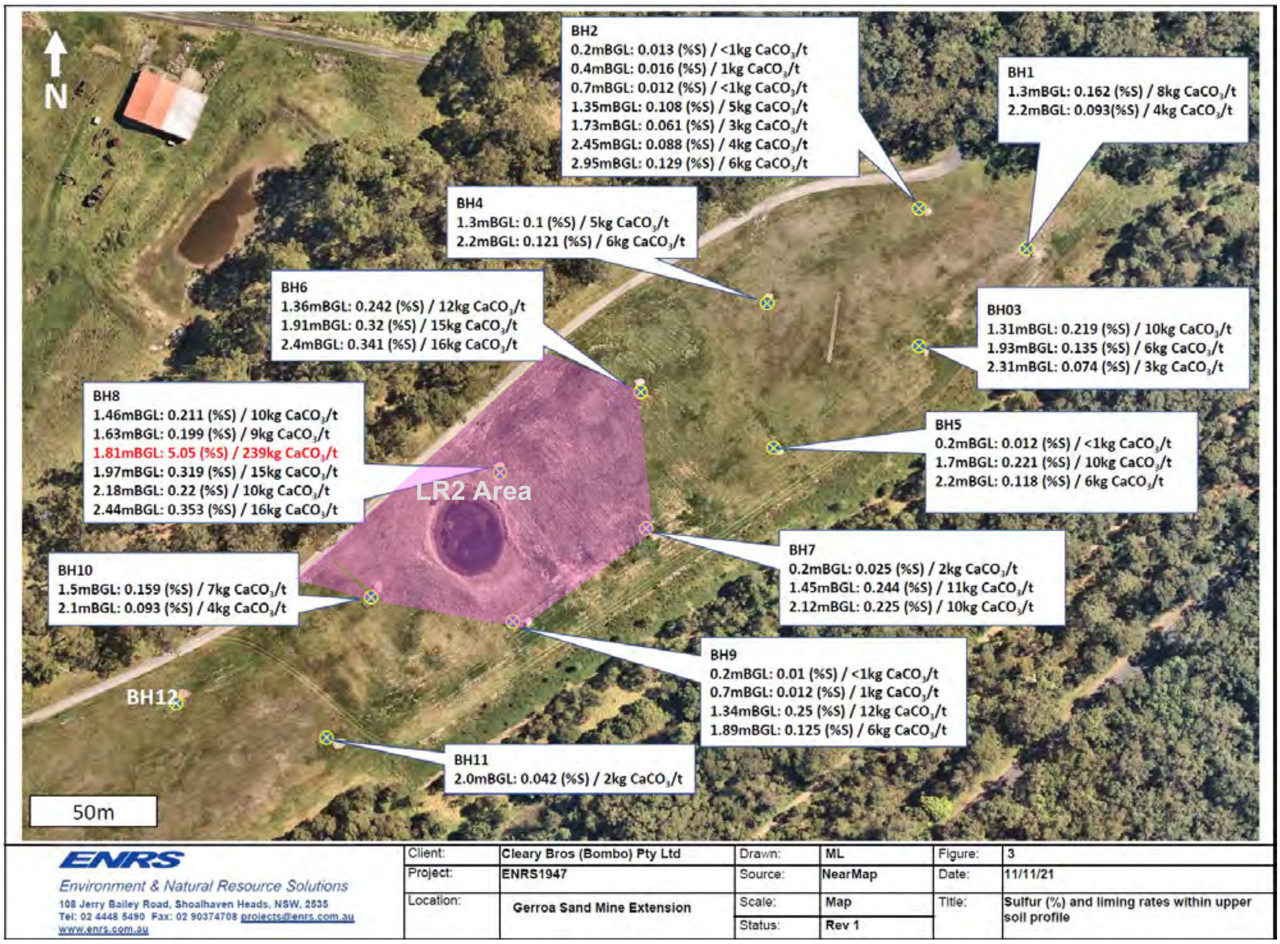


Figure 5-4 Sulfur (%) in material tested in ENRS locations 2021

Care should be taken when using more soluble neutralising agents such as hydrated lime, $Ca(OH)_2$, to avoid the possibility of 'overshooting' the required pH to alkaline levels that may impact on the receiving environment. Soluble neutralising agents may also be more readily flushed from the system before full oxidation of potential ASS occurs. Additional workplace health and safety issues are associated with highly alkaline neutralising agents such as hydrated lime $Ca(OH)_2$ and quicklime CaO.

5.6.1.7 Verification Testing - Neutralisation

Table 5-3 summarises the verification testing and assessment methodology to be adopted FOR TREATMENT EFFICACY. The rate of verification testing is volume specific. The success of the ASS neutralisation can only be verified with a full acid-base account (chromium reducible suite); **pH testing alone is not sufficient**. These performance criteria equate to there being no positive calculated net acidity (using acid base accounting) in the soil following treatment. Soil that has been treated by neutralisation techniques and has not met these criteria should be retreated and re-tested until the performance criteria are met.

Table 5-3 Summary of Verification Testing and Assessment Methodology

Item	Details
Sampling / Equipment	Visual inspection is required to be undertaken by personnel experienced in observing field indicators of acid sulfate soils. Samples must be collected in accordance with: National Acid Sulfate Soils Guidance: National acid sulfate soils sampling and identification methods manual June 2018 (Sullivan, L, Ward, N, Toppler, N and Lancaster, G 2018, National Acid Sulfate Soils guidance: National acid sulfate soils sampling and identification methods manual, Department of Agriculture and Water Resources, Canberra ACT. CC BY 4.0.). ▪ The use of composite samples for laboratory analysis is acceptable when taking samples for verification purposes after management treatments have been applied. ▪ Ideally, each soil sample should be equivalent to 200–500 g of air dry soil to allow sufficient sample mass for physical and chemical analysis. The volume required to give this mass is dependent upon the bulk density of the sample. The required minimum soil sample quantity should be confirmed with the chosen analytical laboratory before sample collection commences. ▪ Any visible shell, carbonate nodules and other large fragments (such as wood, charcoal and stones) should be noted and then removed from the samples in the field. However, biological remnants such as small roots may contain RIS and should not be removed from the soil sample. ▪ Upon collection in the field, soil samples should be immediately placed in leak proof containers that minimise the sample's contact with air and to avoid moisture loss from the sample (for example soil placed in sealable plastic bags with air extruded). ▪ It is recommended that the polymer bags used should be of a thickness at least 30 µm and composed of High Density Polyethylene (HDPE) to minimise diffusion of oxygen into the sample. Bags composed of HDPE are nearly an order of magnitude more effective in restricting oxygen diffusion than bags of equivalent thickness composed of Low Density Polyethylene (LDPE). ▪ Soil materials should be immediately chilled and kept cold (less than 4 °C) in the field to aid preservation. Unless overloaded with samples, a portable 12 V car freezer or sealed cold box containing dry ice have been demonstrated to be effective, but if these options are not available, the use of freezer bricks and sealed cold boxes should be employed for cooling. ▪ It is preferable that samples reach the selected laboratory within 24 h of collection. For transport and short-term storage during transit, samples should be kept chilled and stored in an insulated container so that they reach the laboratory at less than 4 °C. ▪ If samples cannot be received by the laboratory within 24 h of collection, the samples must be managed by additional strategies aimed at sample preservation. Such methods include: o Quick oven drying the sample at 80–85 °C in a large capacity fan-forced convection oven (care must be taken not to overload the oven's moisture removal capacity). These oven-dried samples must then be stored in sealed containers in a low humidity environment. Oven-drying is not appropriate for samples that require laboratory incubation, monosulfide and metal analysis as preserved field moist samples are required for each of these procedures.

Item	Details
	o Freezing the sample in sealed, air-tight containers. o Vacuum sealing and storing in either a cold (that is less than 4 °C) or frozen state. ▪ Note that samples stored in a refrigerator (that is not in a frozen state in a freezer) commonly start to oxidise within days, as indicated by a lowering of pH, and sometimes even by the formation of jarosite. ▪ It is important to inform the laboratory both prior to and when samples are about to be delivered for analysis to allow the laboratory to prepare for timely sample pre-treatment to minimise the potential for oxidisation of RIS in soil samples. ▪ It is also important to require the laboratory to confirm the time and date of receipt of the samples and indicate the time and date and method by which the samples were pre-treated prior to analysis. This information is critical as delays in either transport or pre-treatment can lead to inconsistencies in field and laboratory data and laboratory results that do not reflect conditions in the field at the time of sampling.
Sampling Locations	▪ The volume of (stockpiled) treated soil present on/ in the disposal location
Sampling Rate	According to Dear et al., (2014), the minimum volumetric rates (depending on original existing plus potential acidity of untreated material) are: ▪ <0.5% S-equivalent (<312 mol H^+/tonne) – 1 per 1,000 m^3 ▪ 0.5-2% S-equivalent (312 – 1247 mol H^+/ tonne) – 1 per 500 m^3 ▪ 2% S-equivalent (>1247 mol H+ /tonne) – 1 per 250 m^3 . **Sample ratio in this case is 1 sample per 500 m^3 of treated material.** Quality assurance and control samples comprise duplicate samples collected at a rate of 1 in 20 primary samples: ▪ 1 intra laboratory sample for every 20 primary samples ▪ 1 inter laboratory sample for every 20 primary samples
Analysis	Analysis must be at laboratories that carry a current National Association of Testing Authorities accreditation for the chromium reducible sulfur suite.
Action Criteria	The following conditions shall be met at both sampling locations to demonstrate adequate neutralisation of Net Acidity in treated ASS materials (Dear et al. (2014)): ▪ The neutralising capacity of the treated soil must exceed the existing plus potential acidity of the soil by at least a safety factor of 1.5; ▪ Post-neutralisation, the soil pH (pHKCl) is to be greater than 6.5; and ▪ Excess neutralising agent should stay within the treated soil until all acid generation reactions are complete and the soil has no further capacity to generate acidity. Note: This generally precludes the use of materials with appreciable soluble alkalinity (for example burnt lime, quicklime) for permanent soil amelioration.

Item	Details
	If these criteria are not met, the contingency measures as detailed in Section 5.8.2 are to be actioned.
Sampling Frequency	Post neutralisation and repeat sampling and analysis after every round of treatment required.
Monitoring and Reporting	The Quarry Manager shall be responsible for ensuring that adequate treatment and verification testing is undertaken. In the event that the dredged material/ dewater elutriate require further treatment, the Environmental Officer shall be responsible for selecting the appropriate course of action (in consultation with the environmental consultant, if required). The Environmental Officer shall maintain a register of testing results and a record of inspections. A summary report of all test results and inspections shall be compiled and maintained by the Environmental Officer each week. These reports will be available for consultation with stakeholders, if required.

5.6.2 Batter Management

All exposed excavation surfaces are to be treated with LR1 (Table 5-5).

5.6.3 Disposal of Fines

The reject material (PASS) is piped to a specific deep part of the dredge pond, to reduce risk of oxidation of fines (and mounding of fines). This will entail:

- 150-200mm polypipe running out the base of the plant.
- The polypipe will have a steady grade running the short distance to the dredge pond, with guy ropes to the land ensuring the pipe is satisfactorily located.
- The end of the pipe will be weighted to sink it, but still connected to the surface by a float to keep it off the bottom and at a controlled depth.

5.7 Monitoring

To demonstrate the effective management of ASS, monitoring of surface water and groundwater are to be undertaken, as well as in line dosing as a contingency if required as set out in Section 5.8.4.

5.7.1 Surface Water Criteria

Over time, in accordance with national guidance (ANZG, 2018), site specific guideline values should be developed based on temporal acquisition of data and formulation of 90th%ile of each dissolved metal. This requires 8 data points. Until this number of data points have been collected, dissolved metals should not exceed the guideline values presented in Appendix C.

The guideline values have been formulated as follows:

- Based on the salinity of the dredge pond as recorded in September 2022 (338 mg/L Total Dissolved Solids, TDS) the ANZG 2018 freshwater criteria (95% protection) are adopted as default criteria for metals (Appendix C).

- Metals are considered to be potentially relevant chemical substances based on natural occurrence and susceptibility of solubilisation owing to changes in pH.
- Where relevant, metals criteria has been adjusted based on water hardness, using calcium and magnesium concentrations for the existing dredge pond. The standard ANZG values for cadmium, chromium (III), copper, lead, nickel, zinc are based on a hardness of 30 mg/L $CaCO_3$. The hardness of dredge pond water is 141 mg/L. Therefore the criteria for cadmium, chromium (III), copper, lead, nickel, zinc can be adjusted as presented in Appendix C to provide hardness modified trigger values (HMTV).
- The current concentration of zinc in surface water (existing dredge pond) exceeds the HMTV for zinc. Groundwater also exceeds such value and this infers that zinc concentrations are naturally elevated above the default ANZG (2018) criterion. For zinc, the groundwater data has been used to formulate a tier 1 criterion based on maximum reported groundwater concentration plus 1 standard deviation. The same approach was adopted for barium as there is no ANZG criteria for barium.
- There are no listed criteria in ANZECC (2000) (and ANZG 2018) for beryllium and vanadium; therefore the supporting data in Volume 2 of ANZECC (2000) was reviewed including the given extrapolation factors and these data were adopted.

When sufficient data points have been collected, an 80^{th}%ile is then calculated per analyte and represent Limit A (Tier 1) upper 'trigger' criteria. The 95^{th}%ile is also calculated and is Limit B (Tier 2).

Non-compliance is when:

- Rolling median of five (5) samples is greater than Tier 1 trigger (80^{th}%ile of collected data); and
- Three (3) consecutive individual exceedances greater than Tier 2 trigger (95^{th}%ile) occur

(DES, 2021).

5.7.2 Groundwater criteria

When sufficient data points have been collected (n=8), an 80^{th}%ile will be calculated per analyte and represent Limit A (Tier 1) upper 'trigger' criteria. The 95^{th}%ile is also calculated and is Limit B (Tier 2).

Non-compliance is when:

- Rolling median of five (5) samples is greater than Tier 1 trigger (80^{th}%ile of collected data); and
- Three (3) consecutive individual exceedances greater than Tier 2 trigger (95^{th}%ile) occur

(DES, 2021).

In the interim, the criteria presented in Appendix C-3 are used, and are applied as follows:

- Rolling median of five (5) samples is greater than the Tier 1 trigger (September 2022 maximum plus one standard deviation); and
- Three (3) consecutive individual exceedances greater than the Tier 1 trigger.
- Refer Section 5.8 for dealing with non-conformances

5.7.3 Materials/ Water/ Effluent

Monitoring notes for the pipelines are presented in the table below.

Table 5-4 Monitoring schedule for pipelines

Material / Effluent	Reference	Description	Monitoring
Existing dredge pond water.	Return water pipeline	Transfers water from the existing dredge pond to the new dredge pond to balance water levels in the ponds. Alkalinity of this water is important so as to not increase any acid burden to the new dredge pond and also mitigate exposed PASS during dredge.	The dredge pond is monitored as part of the surface water monitoring program. The dredge pond sample should be collected near the intake of the pump for the return water pipeline and tested for: ▪ Turbidity; ▪ Electrical Conductivity (EC, calculate salinity as Total Dissolved Solids based on the EC); ▪ pH; ▪ temperature and dissolved oxygen; ▪ dissolved metals including trace metals (Al, As, B, Ba, Be, Cd, Cr, Co, Cu, Mn, Ni, Pb, Se, V, Zn, Hg, Fe) ▪ net acidity/ alkalinity
Materials dredged from the new area pre-processing.	Dredge pipeline	A pressurised pipeline that pumps the slurry from the dredge to the processing plant.	This pipeline is pressurised and transfers natural dredge material to the processing plant. There is little value in sampling and analysis of

Material / Effluent	Reference	Description	Monitoring
			the pre-process material. No sampling is scheduled.
Reject fines separated from the dredge post processing.	Rejects pipeline	A low pressure pipeline collecting the fine reject at the base of the plant and transferring the material to the existing dredge pond.	This will be sampled using an offtake prior to entry of the material into the dredge pond. Analyse and record parameters for: ▪ Turbidity; ▪ Electrical Conductivity (EC, calculate salinity as Total Dissolved Solids based on the EC); ▪ pH; ▪ temperature and dissolved oxygen; ▪ dissolved metals including trace metals (Al, As, B, Ba, Be, Cd, Cr, Co, Cu, Mn, Ni, Pb, Se, V, Zn, Hg, Fe) ▪ net acidity/ alkalinity Action criteria are presented in Table 5-5.

5.7.4 Surface water

The water within the existing and new dredge pond must be monitored on a monthly basis for:

- Turbidity;
- Electrical Conductivity (EC) used as calculation of salinity (Total Dissolved Solids);
- pH;
- temperature and dissolved oxygen;
- dissolved metals including trace metals (Al, As, B, Ba, Be, Cd, Cr, Co, Cu, Mn, Ni, Pb, Se, V, Zn, Hg, Fe)

Crucial parameters in the case of PASS are pH and dissolved oxygen. **Parameters must be reviewed and recorded.**

Sampling is to occur at the locations shown in Figure 11.

Three (3) real time pH logging sensors are to be deployed at the following locations:

- Within the new dredge pond to be moved as required by the dredging program;
- Within the existing dredge pond at a shallow placement; and
- Within the existing dredge pond at the depth of reject material placement.

On the spot sampling is to be undertaken with an alkalinity test kit and an appropriately calibrated Water quality metre capable of reading pH, dissolved oxygen, and salinity. Requirements are presented in Table 5-4.

Should the verification sampling of waters indicate a change in pH or acidity outside of the criteria described in Table 5-4, then contingency measures will be actioned. This will include a stop works (for the discharging activities) followed by either lime treatment and/ or slowing the outflow of dewatered elutriate from the system to allow for additional liming and mixing of the waters prior to discharge.

Table 5-5 Summary of Verification Testing and Assessment Methodology – Surface water

Item	Details
Sampling Equipment	Field alkalinity testing kit (Hach unit or similar) and Acidity Test Kit (Model AC-DT | Hach Australia or similar). Three (3) real time pH logging sensors are to be deployed at the following locations: ☐ Within the new dredge pond to be moved as required by the dredging program; ☐ Within the existing dredge pond at a shallow placement; and ☐ Within the existing dredge pond at the depth of reject material placement. For sampling, an appropriately calibrated Water quality meter capable of reading pH, dissolved oxygen and salinity is to be used on a monthly basis. Calibration records are to be maintained. Sampling is to be undertaken in accordance with: ▪ Approved methods for the sampling and analysis of water pollutants in NSW – Environment Protection Authority 2022
Sampling Locations	Refer Figure 11 – Sampling is to be completed by the Project's environmental supervisor as well as pipelines summarised in Table 5-4. Sampling is to occur by submerging the water quality probes in the water. The probe is not to be placed on the surface bottom, rather it should be suspended in the water column. **All sampling must be in accordance with:** ***Approved methods for the sampling and analysis of water pollutants in NSW – NSW EPA January 2022*** Samples are to be collected at the following locations: **Real time pH monitoring locations:** - New dredge pond: indicative location would be sufficient ass it will need to be moved as the pond evolves - Existing dredge pond as per the shape file: near surface - Existing dredge pond as per the shape file: at depth of reject material sub aqueous placement **Surface water monitoring locations:** 1= Site B 2= Existing dredge pond 3= Site C 4= New dredge pond **Pipelines** ▪ Rejects Pipeline (at off-take)

Item	Details
Analysis	▪ Turbidity; ▪ Electrical Conductivity (EC) used as basis to calculated Total Dissolved Solids; ▪ pH; ▪ temperature and dissolved oxygen; ▪ dissolved metals ((Al, As, B, Ba, Be, Cd, Cr, Co, Cu, Mn, Ni, Pb, Se, V, Zn, Hg, Fe))
Action Criteria (Check samples)	The following conditions shall be met at sampling locations to demonstrate adequate neutralisation of Net Acidity in treated ASS materials (Dear et al. (2014)): ▪ pH of water (≥6.5) based on real-time or monthly monitoring; ▪ dissolved oxygen (greater than 3 mg/L, greater than 50% saturation; monthly monitoring); ▪ For surface water only: Turbidity of effluent waters are within target range for receiving environment (for example less than 50 mg TSS/L); ▪ No net acidity. ▪ Over time, in accordance with national guidance, site specific guideline values should be developed based on temporal acquisition of data and formulation of 90_{th}%ile of each dissolved metal. This requires 8 data points. Until this has been established, dissolved metals should not exceed the guideline values presented in Appendix C. If these criteria are not met, the contingency measures as detailed in Section 5.8.2 (and 5.8.4) are to be actioned.
Sampling Frequency	Sampling frequency will be monthly for check samples, noting real time pH monitoring is to be applied.
Quality Control	Quality assurance and control samples comprise duplicate samples collected at a rate of 1 in 20 primary samples: ▪ 1 intra laboratory sample for every 20 primary samples ▪ 1 inter laboratory sample for every 20 primary samples Laboratories must be National Association of Testing Authorities (NATA) Accredited.
Monitoring and Reporting	The Quarry Manager shall be responsible for ensuring that adequate verification testing is undertaken. In the event that the dredge pond requires neutralisation, the Environmental Officer shall be responsible for selecting the appropriate course of action (in consultation with the environmental consultant, if required). The Environmental Officer shall maintain a register of testing results and a record of inspections. A summary report of all test results and inspections shall be compiled and maintained by the Environmental Officer. These reports will be available for consultation with stakeholders, if required.

5.7.5 Groundwater

Refer to **Table 5-5 Summary of Verification Testing and Assessment Methodology – Groundwater.**

Groundwater in the project area is to be monitored over the course of operations to assess excursion of metals and other parameters (e.g. acidity) from the dredge pond/ operational areas.

Groundwater quality parameters that can be used to indicate the presence of ASS materials include a soluble sulfate to soluble chloride (SO_4^{2-}:Cl^-) of more than 0.25, and a pH of less than 4 (for example DER 2015).

The analysis of groundwater (and drain water) for SO_4^{2-}:Cl^- ratio has frequently been used as an indicator of ASS. As seawater has a sulfate concentration of approximately 2700 mg/L and chloride concentration of approximately 19 400 mg/L, the SO_4^{2-}:Cl^- ratio of seawater and coastal landscapes on a mass basis is 0.14. The ratio of dominant ions in saline water remains approximately the same when diluted with rainwater, and therefore, estuaries, coastal saline creeks and associated groundwater can be expected to have similar dominant anion ratios to seawater. Any other source of sulfate ions (such as the oxidation of RIS) in these locations can lower this ratio and hence provide an indication of the possible presence of ASS materials in the surrounding landscape.

A SO_4^{2-}:Cl^- ratio of greater than 0.5 is a strong indicator of an extra source of sulfate from RIS oxidation.

The utility of the SO_4^{2-}:Cl^- ratio to identify ASS materials diminishes as the salinity of groundwater approaches that of freshwater.

Dissolved metals data is not readily available except soluble Fe (iron). 95^{th}%ile values have been calculated for soluble Fe at each groundwater monitoring location (intra-well comparison) – refer Table 5-6. The 80^{th}%ile values represent Limit A upper 'trigger' criteria, - five successive tests above Limit A and three successive tests above Limit B is an exceedance requiring contingency action (DES, 2021).

Table 5-6 Percentiles for soluble Fe in water sampled at each well

								Limit A		Limit B	
Variable	**NumObs**	**# Missing**	**10%ile**	**20%ile**	**25%ile(Q1)**	**50%ile(Q2)**	**75%ile(Q3)**	**80%ile**	**90%ile**	**95%ile**	**99%ile**
MW1	52	17	0	0	0	2.31	42.18	47.52	63.29	74.63	101.4
MW1A	22	45	0.046	0.498	0.543	1.055	1.39	1.512	3.808	4.215	4.364
MW3A	52	15	0	0	0	1.305	5.01	6.432	14.69	17.63	21.85
MW04(07)	69	0	0	0.025	0.025	0.13	2.6	4.268	9.72	17.8	31.76
NB2	13	56	0.31	1.602	1.68	1.96	2.48	2.522	2.742	4.082	5.632
NB3	13	56	0.05	0.294	0.36	0.85	1.66	1.72	2.472	2.754	2.879
NB4	13	56	0.54	9.38	19.4	33.7	73	80.5	90.94	92.46	92.65
MW07	9	60	47.12	73.12	82.6	92.4	105	106.6	109	109	109

Table 5-7 Summary of Verification Testing and Assessment Methodology – Groundwater

Item	Details
Sampling Equipment	Field alkalinity testing kit (Hach unit of similar) and Acidity Test Kit, Model AC-DT | Hach Australia. Appropriately calibrated Water quality metre capable of reading pH, dissolved oxygen, and salinity. Calibration records are to be maintained.
Sampling Locations	1. NB02 2. NB03 3. NB04 4. MW1 5. MW1A 6. MW2B 7. MW3A 8. MW04(07) 9. MW7 Refer Figure 12.
Sampling	Sampling is to be in accordance with : ▪ AS/NZS 5667.11 Water quality: sampling guidance on sampling of groundwaters. ▪ Approved methods for the sampling and analysis of water pollutants in NSW – Environment Protection Authority 2022 ▪ Note – metals must be field filtered
Action Criteria	The following conditions shall be met: ▪ No significant difference from baseline (Table A-2) for parameters listed in "Analysis" (below); When sufficient data points have been collected (minimum n=8), an 80^{th}%ile is then calculated per analyte and represent Limit A (Tier 1) upper 'trigger' criteria. The 95^{th}%ile is also calculated and is Limit B (Tier 2). Non-compliance is when: ▪ Rolling median of five (5) samples is greater than Tier 1 trigger (80^{th}%ile of collected data); and ▪ Three (3) consecutive individual exceedances greater than Tier 2 trigger (95^{th}%ile) occur (DES, 2021). Where these criteria are not met, the contingency measures as detailed in Section 5.8.3 are to be actioned.

Item	Details
Sampling Frequency	Sampling frequency will be quarterly throughout the operation. The monitoring frequency can reduce to six monthly once 8 rounds of data are collected and there are no significant changes from baseline.
Analysis	To be undertaken at a National Association of Testing Authorities (NATA) accredited laboratory for the suite of chemical substances as follows: ▪ Major ions (Ca, Mg, Na, K, SO_4^{2-}, Cl^-) ▪ Alkalinity and acidity ▪ pH and total dissolved solids ▪ dissolved metals (Al, As, B, Ba, Be, Cd, Cr, Co, Cu, Mn, Ni, Pb, Se, V, Zn, Hg, Fe)
Monitoring and Reporting	The Quarry Manager shall be responsible for ensuring that adequate verification testing is undertaken. Where a divergence from baseline (Table A-2) is noted, then the Environmental Officer shall be responsible for selecting the appropriate course of action (in consultation with the environmental consultant, if required). The Environmental Officer shall maintain a register of testing results and a record of events.

5.8 Evaluate response

5.8.1 Non-Conformance

A non-conformance is a failure to meet specific performance indicators outlined in Table 5-5 and Table 5-7 or deviation from the requirements of the ASSMP.

During the works, the following procedure is to be followed in the event of a non-conformance with any requirements of this ASSMP:

1) The Quarry Manager shall be notified immediately upon the occurrence of a non-conformance.

2) The Environmental Officer shall assess the nature of the non-conformance and notify the Quarry Manager immediately if the non-conformance is considered to have caused or could potentially cause environmental harm.

3) The non-compliance shall then be further investigated including but not limited to the following:

   a) Laboratory samples reporting non-compliance shall be requested for re-analysis at the laboratory with a sub-sample of each non-complying sample being requested to be sent to a secondary laboratory for verification.

   b) Subject to 3(a), the medium exhibiting non-compliance shall be re-tested to verify the non-compliance, by way of five samples (replicates) at each of the non-complying locations.

   c) Where the non-compliance is confirmed, contingency action/ review shall be instigated.

5.8.2 Contingency Measures – dredge pond

In the event of non-compliances as discussed in Section 5.8.1 temporary discharge of fines must cease and advice from a suitable environmental consultant be sought, however dosing with lime will be the primary rectification measure.

In line dosing of fines lines/ channels and return water must be contemplated – refer Section 5.8.4.

5.8.3 Contingency Measures – groundwater

Contingency measures for variances in groundwater chemistry that indicates potential excursion of parameters associated with acid sulfate soils are presented in Table 5-8.

In accordance with considerations of the In line dosing of feed in, return and fines lines/ channels must be contemplated – refer Section 5.8.4.

Table 5-8 Strategy for contingency plan for groundwater contamination (Shand et al., 2018)

Exceedance detected
Inform relevant authority
Carry out additional testing to confirm
If they still exceed trigger values
Install additional piezometers to assess the extent and severity of contamination
Undertake additional studies to determine the fate and transport of contaminants in groundwater
Remediation measures considered
Groundwater recharge barriers to divert flow
Permeable reactive barriers
Monitored natural attenuation

5.8.4 In Line Dosing (Contingency Measures)

5.8.4.1 Treatment Dosing – Return Water Pipeline to New Dredge Area

Where monitoring parameters suggest risk of acidification of the dredge pond over time, the return water must be dosed to achieve an alkalinity >60 mg/L. The dosing rate for piped rejects (Section 5.8.4.2) in the first instance subject to adjustment on advice from a suitable environmental consultant. may be used for return pipeline.

5.8.4.2 Treatment Dosing – Piped Rejects (Fines)

The fines (rejects) post hydro-cyclone are piped to the existing dredge pond for submerged disposal. The fines are likely to exhibit PASS characteristics. High %S has been reported in the material (e.g. BH8) and resulted in maximum liming rate of 950 kg $CaCO_3$ per tonne of material. This would not represent all fines piped to the pond, and the optimum strategy is to lime at 95% upper confidence limit of all liming rates obtained (Table A-1) unless operational data suggest a different treatment rate (and after consideration by a suitable environmental consultant)

The contingency dosing for piped returns is 40 kg/m^3 of material (0.04 kg/L of liquid).

Operational testing of in line pipe should comprise collection of samples for net acidity testing (use chromium reducible sulfur suite) and adjust liming rate accordingly.

5.9 Refine management options by evaluating and fine tuning predictions and management objectives.

In accordance with and required contingency actions, a full review of this plan including actions, and potential risk profile must be undertaken and any management options by evaluating and fine tuning predictions and management objectives.

5.10 Reporting

In order to facilitate an ultimate closure plan, detailed records must be kept covering (but not limited to):

1. total final volumes and dimensions of disturbed ASS;
2. details of soil management strategies undertaken at the site (including evidence of specific management measures such as waste tracking, photographic evidence of neutralisation and of bunded treatment pads);
3. location of any offsite treatment and/or disposal of ASS and evidence of treatment off site;
4. summary of verification testing results for material treated either on or off site;
5. location and maps of areas used for burial of fines from sluicing; and
6. location and maps of areas used for strategic burial of potential ASS, depth below finished surface and details of safety margin below the permanent water table.

Also detailed information relating specifically to general impacts must include:

7. where dewatering was involved, final location, extent and duration of dewatering and details of groundwater management strategies applied;
8. details of water management strategies undertaken at the site;
9. summary of monitoring results for surface water and groundwater (with an emphasis on trends in water quality).
10. total final volumes and dimensions of disturbed ASS.

In additional, a closure report will require:

- appendices that contain full results of monitoring and verification testing regimes;
- a discussion of the effectiveness of management strategies employed at the site;
- details of any incidence of nonconformity with the environmental management plan and corrective actions taken;
- a discussion of any potential risks to the environment or human health;
- proposed future monitoring and/or reporting programs;

- proposed remediation measures if needed (for example handover testing); and
- if handover testing is required as part of a closure report for an ‘extra high’ level disturbance, summarise and discuss handover testing results, referring to any failures and corrective actions.

Note that NSW EPA (2022) also requires the following records must be kept for a period of four years for any sampling and analysis required by or under environment protection legislation, including by a notice or environment protection licence issued under that legislation, and must be provided to the EPA, if and when requested or required:

- site identification, including a map showing sampling locations with GPS coordinates (if applicable)
- number of samples collected and analysed
- sampling methods used, including pattern; depth; locations; sampling containers, devices, and procedures; and, whenever possible, photographs of the sample locations and sample(s)
- list of field quality-control samples (if applicable)
- chain-of-custody forms
- analytical reports, including the QA/QC data
- a statement regarding whether a modified method (including a minor modification) or alternative method was used – stating what the modification was and the reason for the modification
- a copy of EPA approval where a significantly modified or alternative method was used or the required justification where a minor modification was used any reports associated with the request for approval.

6 AUDITING, REVIEWS AND COMPLAINTS

6.1 AUDITING AND REVIEWS

Regular reviews of environmental monitoring data and management strategies will be undertaken to ensure the ASSMP meets its objectives. This will include formal and informal checks as follows:

- Ad-hoc review of alerts from fixed monitoring equipment in response to pre-configured trigger values.
- Monthly internal review of water monitoring data by the Environmental Officer.
- Annual Review completed by the Environmental Officer following the end of each financial year (reporting period).
- Independent Environmental Audits conducted on a three-yearly basis.

6.1.1 Ad-hoc Reviews

The fixed automatic monitoring infrastructure installed in each dredge pond and in Blue Angle Creek will be configured to send an alert to the Production Manager and Environmental Officer in the event the objective levels are exceeded. On receipt of an alert, the Environmental Officer will investigate and if required implement corrective actions in accordance with this plan.

6.1.2 Monthly Internal Review

The Environmental Officer will review all incoming water monitoring data on a monthly basis. This will include a review of all water monitoring data received against the objective levels, and to informally assess any unexpected changes to water quality or levels.

6.1.3 Annual Review

The Annual Review will be prepared by the Environmental Officer within two months of the end of the reporting year (July to June) and will:

- describe the works carried out in the last 12 months and the works planned for the next 12 months;
- include a summary of the water monitoring results for the Project during the past year;
- include a comprehensive review of the monitoring results over the previous year, which includes a comparison of these results against the relevant:
  - impact assessment criteria and objectives;
  - monitoring results from previous years;
  - requirements of this ASSMP; and
  - predictions in the environmental assessment (EA);
- identify any non-compliance during the previous year and describe what actions were (or are being) taken to rectify the non-compliance and avoid recurrence;
- identify any trends in the monitoring results over the life of the Project;

- identify any discrepancies between the predicted and actual impacts of the Project, and analyse the potential cause of any significant discrepancies;
- describe any measures that will be implemented over the next year to improve the environmental performance of the project; and
- review the suitability of the ASSMP.

An electronic copy of the Annual Review will be provided to the DPE and members of the Community Consultative Committee, as well as uploaded to the Cleary Bros website.

6.1.4 Independent Environmental Audit

Every three years, Cleary Bros will engage a suitable qualified, experienced, and independent person(s) to undertake an independent environmental audit. The audit will be conducted in accordance with Schedule 5 Condition 5 of the Development Consent, with the auditor approved by the Planning Secretary.

7 REFERENCES

Ahern, CR, Ahern, MR & Powell, B 1998, Guidelines for Sampling and Analysis of Lowland Acid Sulfate Soils (ASS) in Queensland 1998, Queensland Acid Sulfate Soils Investigation Team (QASSIT), Report DNRQ980124, Department of Natural Resources, Indooroopilly, Queensland.

Ahern, CR, McElnea, AE & Sullivan, LA 2004, Acid Sulfate Soils Laboratory Methods Guidelines. Queensland Department of Natural Resources, Mines, and Energy. Indooroopilly, Queensland.

AINA 2008, Waste management for dredgings operations – a good practice guide for navigation authorities, Association of Inland Navigation Authorities (AINA), <www.aina.org.uk/>.

Aller, JY, Woodin, SA, Aller, RC & Belle, W 2001, Organism-sediment interactions, Baruch Institute for Marine Biology, Coastal Research (eds), The Belle W. Baruch library in marine science, published for the Belle W. Baruch Institute for Marine Biology.

ANZECC/ARMCANZ 2000, Australian and New Zealand Guidelines for Fresh and Marine Water Quality, Australian and New Zealand Environment and Conservation Council/Agriculture and Resource Management Council of Australia and New Zealand, Canberra, Australian Capital Territory.

Australian Standard 2008, Analysis of acid sulfate soil—Dried samples—Methods of test, AS 4969.0—2008, Standards Australia, Sydney, New South Wales.

Dear, S-E, Ahern, CR, O'Brien, LE, Dobos, SK, McElnea, AE, Moore, NG & Watling, KM 2014, Queensland Acid Sulfate Soil Technical Manual: Soil Management Guidelines, Brisbane: Department of Science, Information Technology, Innovation and the Arts, Brisbane, Queensland

DER (2015) Treatment and management of soil and water in acid sulfate soil landscapes – Department of Environment Regulation Western Australia (June 2015)

DES (2021). Using monitoring data to assess groundwater quality and potential environmental impacts. Version 2. Department of Environment and Science (DES), Queensland Government, Brisbane.

Douglas Partners 2018, Acid Sulfate Soil Management Plan, Proposed Sand Quarry Extension

Douglas Partners 2019, Updated Report on Modification 1 (MP 05_0099) Environmental Assessment. Groundwater Issues

Shand, P, Appleyard, S, Simpson, SL, Degens, B, Mosley, LM 2018, National Acid Sulfate Soils Guidance: Guidance for the dewatering of acid sulfate soils in shallow groundwater environments, Department of Agriculture and Water Resources, Canberra, ACT. CC BY 4.0

Simpson, SL, Mosley, L, Batley, GE and Shand, P (2018). National Acid sulfate soils guidance: Guidelines for the dredging of acid sulfate soil sediments and associated dredge spoil management, Department of Agriculture and Water Resources, Canberra, ACT. CC BY 4.0

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

Tulau, M.J. (2007). Acid Sulfate Soils Remediation Guidelines for Coastal Floodplains in New South Wales. Department of Environment and Climate Change.

Water Quality Australia (WQA – 2018) National Acid Sulfate Soil Guidelines – Guidelines for the dredging of acid sulfate soil sediments and associated dredge spoil management

Water Quality Australia (WQA – 2018) National Acid Sulfate Soil Guidelines – National guidance for dewatering of acid sulfate soils in shallow groundwater environments

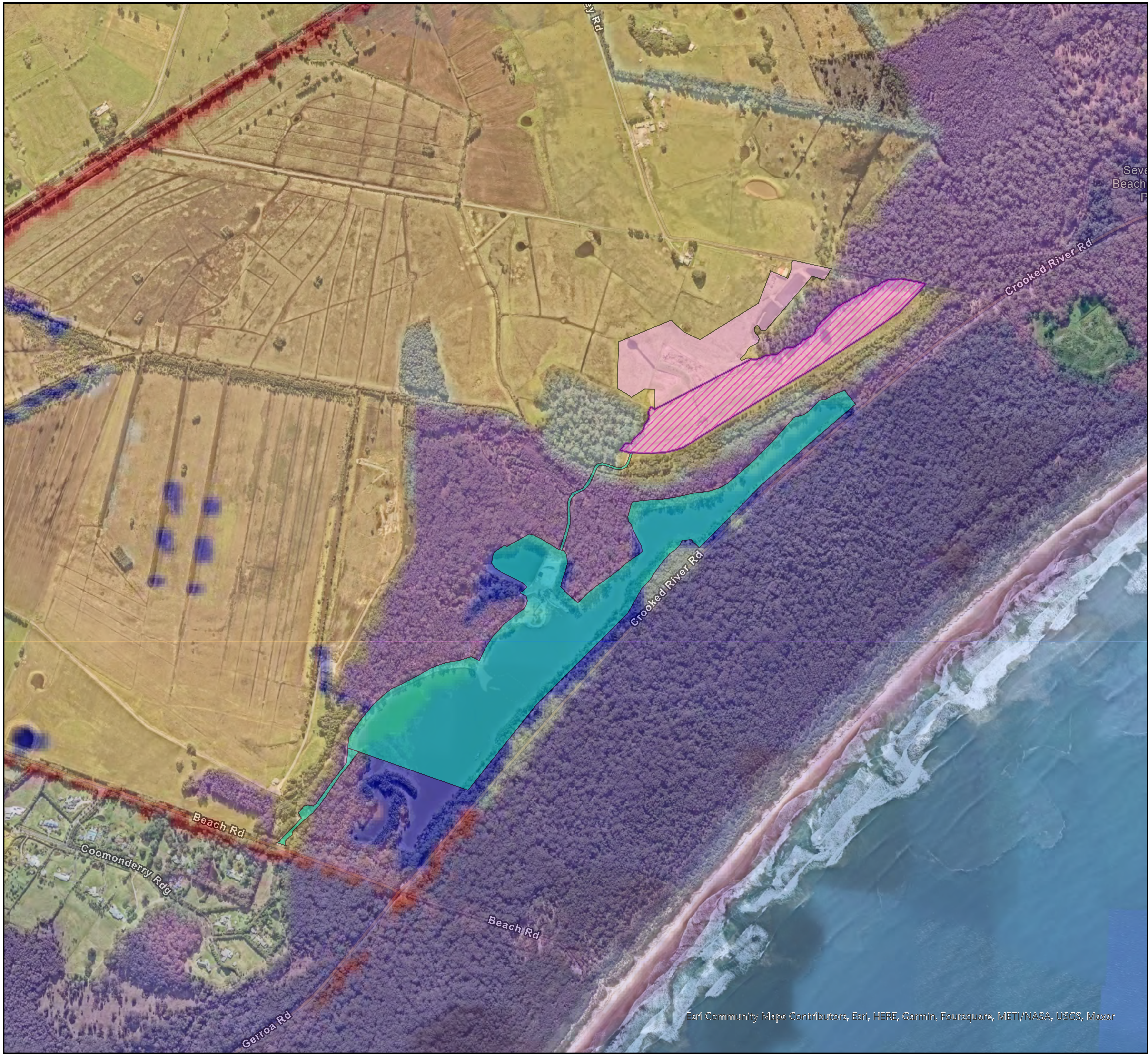
8 LIMITATIONS

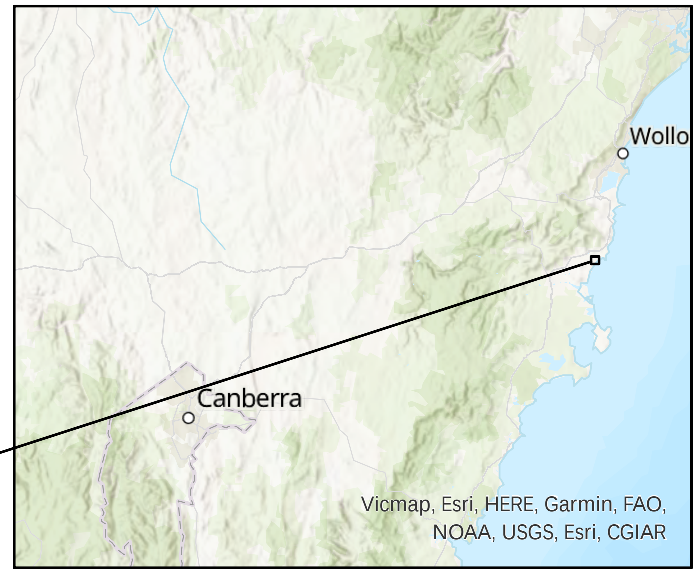
Your attention is drawn to the Statement of Limitations which is presented as Appendix B. The statements presented in this document are intended to advise you of what your realistic expectations of this report should be, and to present you with recommendations on how to minimise the risks associated with the ASS management for the Project. The purpose of the Statement of Limitations is to ensure that all parties that rely on this ASSMP are aware of the responsibilities each assumes in so doing.

LWC
Land and Water Consulting

FIGURES

Land & Water Consulting
Email: enquiries@lwconsulting.com.au
Web: www.lwconsulting.com.au

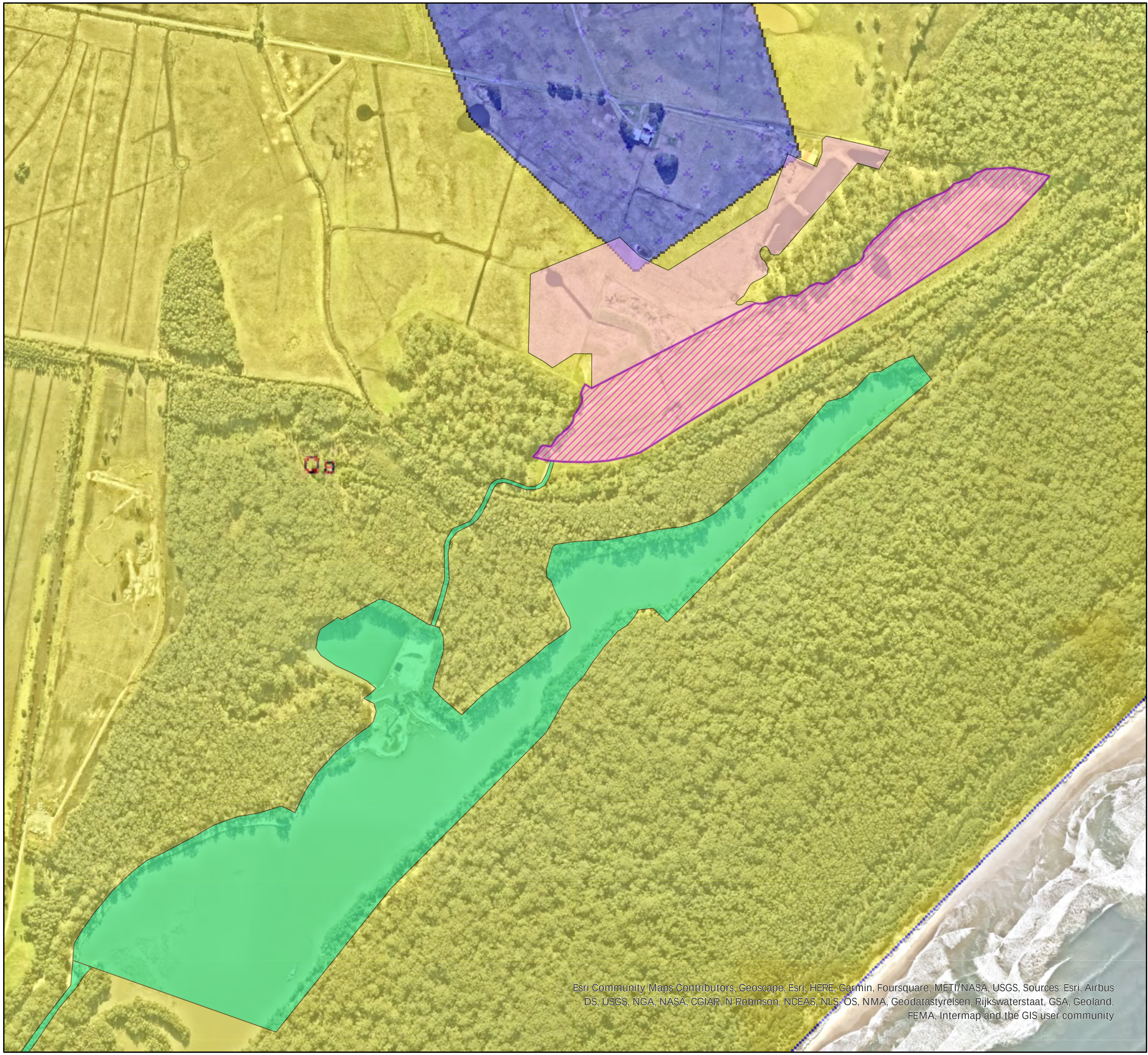




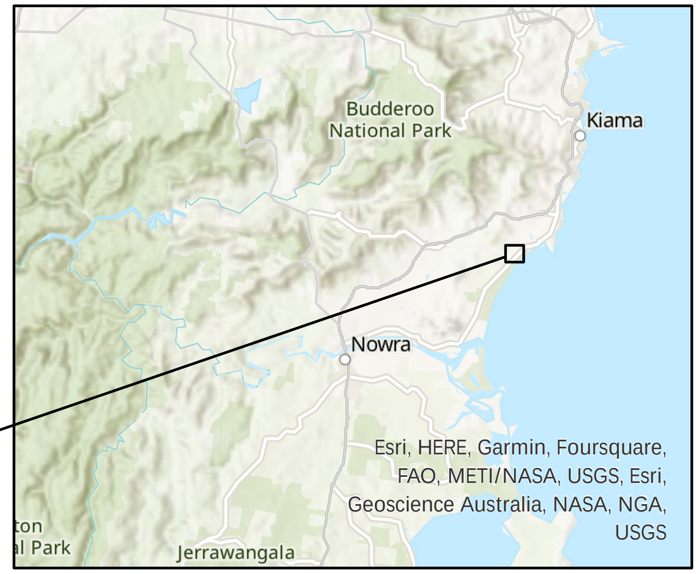
PROJECT: Gerroa Quarry Extension		
FIGURE TITLE: Site Locality		
Site Address: Crooked River Rd Gerroa, NSW 2534	FIGURE 1	Date: 13/10/2022
		Projection: GDA2020 Z54
Figure in set: 1 of 12	Revision A	Scale: 1:11,799

0 0.1 0.2 0.4 0.6 0.8
Kilometres

Legend
- Dredge extent subject to ASS characterisaton
- Proposed Quarry Extension Region
- Existng Quarry
- Grazing Pasture
- Nature Conservaton
- Water Body



Land & Water Consulting
Email: enquiries@lwconsulting.com.au
Web: www.lwconsulting.com.au



PROJECT: Gerroa Quarry Extension		
FIGURE TITLE: Surface Geology of Site		
Site Address: Crooked River Rd Gerroa, NSW 2534	FIGURE 2	Date: 13/10/2022
		Projection: GDA2020 Z54
Figure in set: 2 of 12	Revision A	Scale: 1:6,973

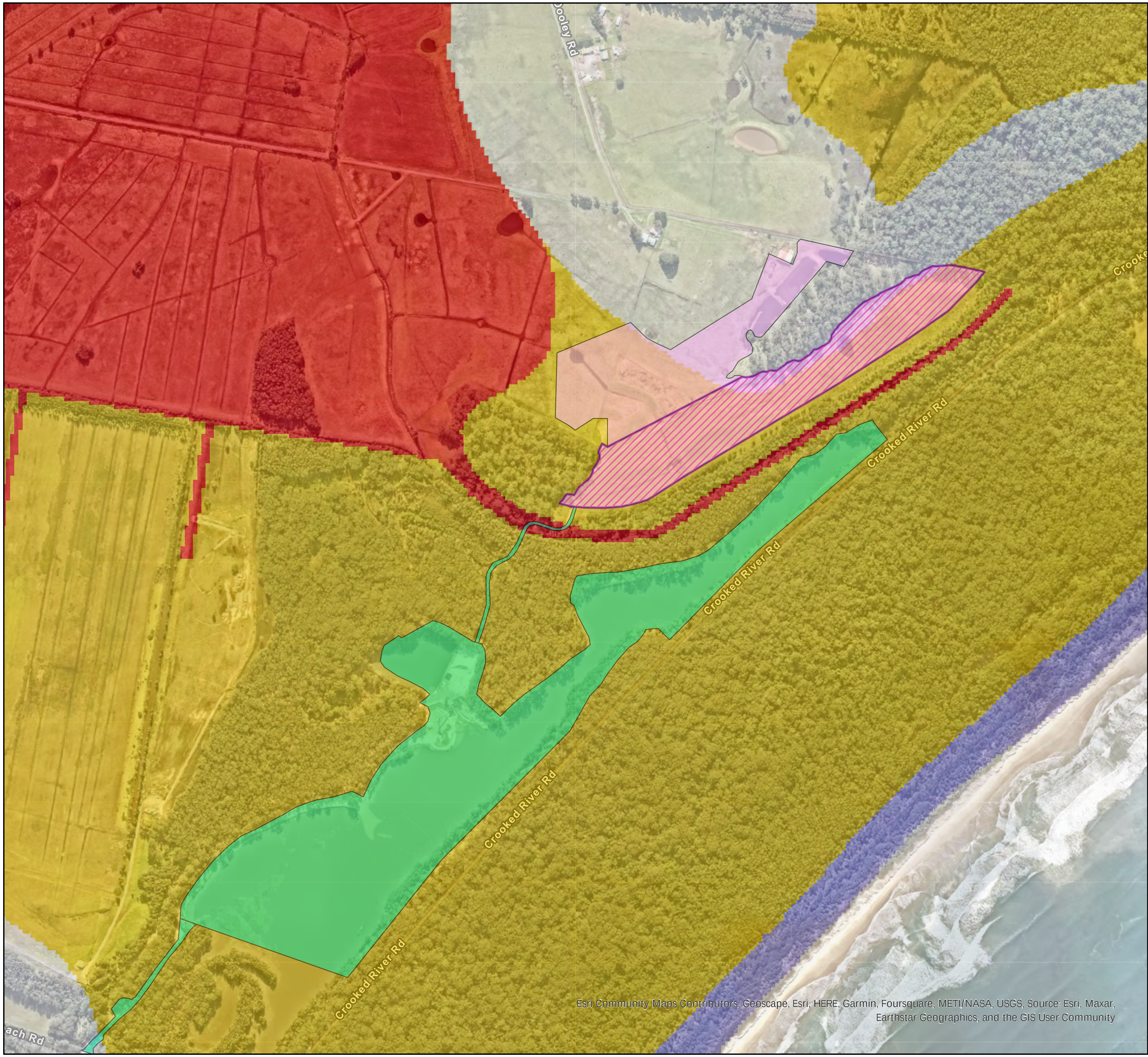
0 0.05 0.1 0.2 0.3 0.4
Kilometres

Legend

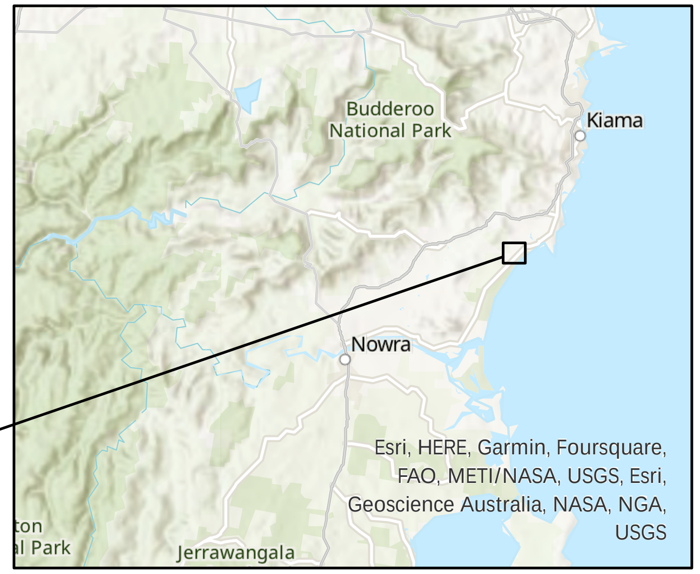
- Dredge extent subject to ASS characterisa ton
- Proposed Quarry Extension Region
- Exist ng Quarry

Lithologies

- Qa- Quaternary alluvial deposits
- Pvu- Permian silic to intermediate volcanic and volcaniclast c rocks



Land & Water Consulting
Email: enquiries@lwconsulting.com.au
Web: www.lwconsulting.com.au



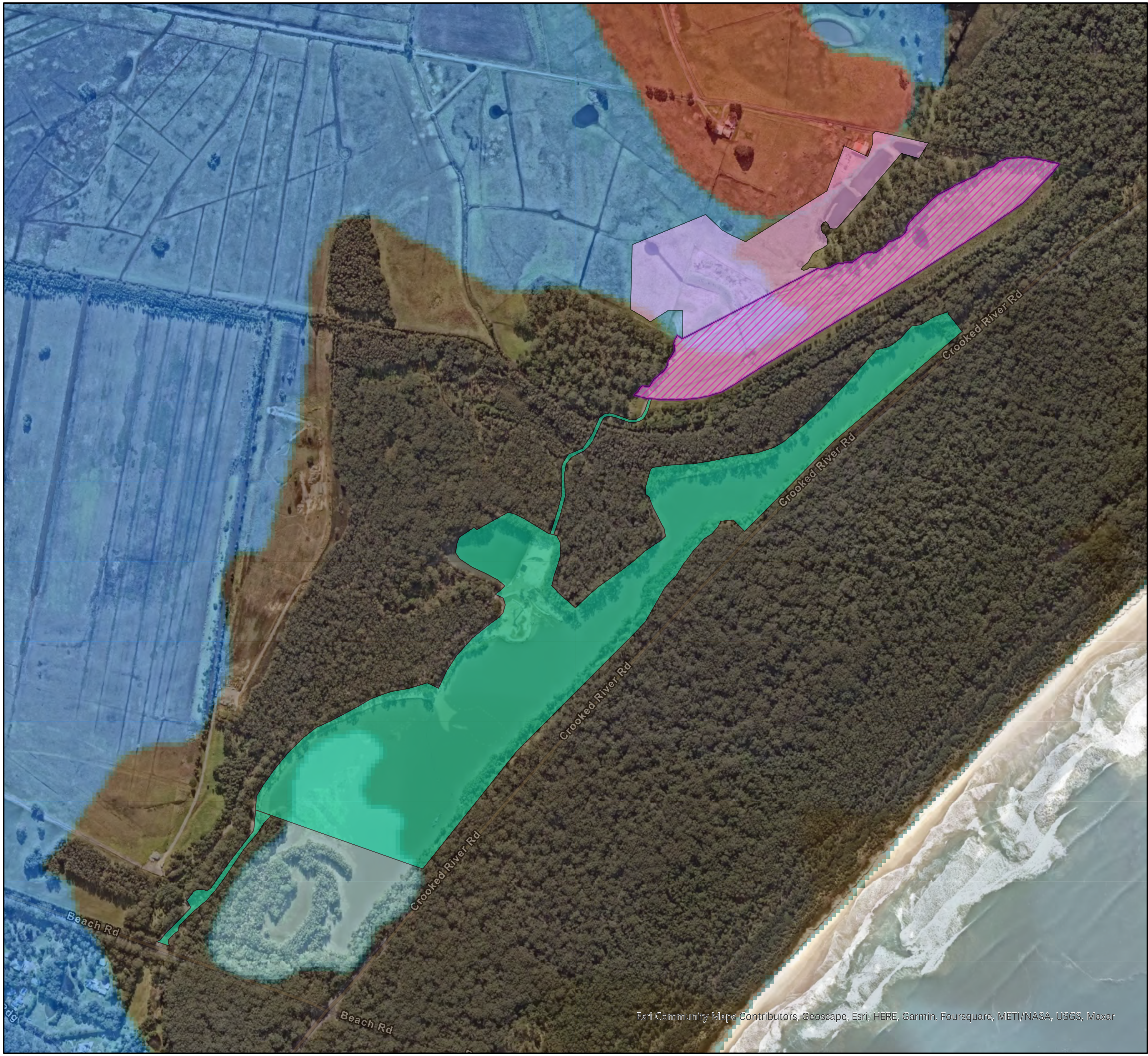
PROJECT: Gerroa Quarry Extension		
FIGURE TITLE: Acid Sulfate Risk in Soil		
Site Address: Crooked River Rd Gerroa, NSW 2534	FIGURE 3	Date: 13/10/2022
		Projection: GDA2020 Z54
Figure in set: 3 of 12	Revision A	Scale: 1:8,477

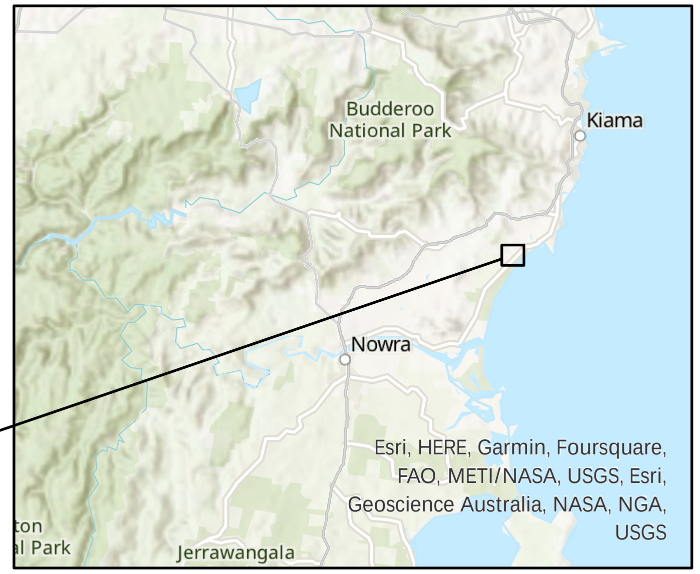
0 0.07 0.15 0.3 0.45 0.6
Kilometres

Legend
- Dredge extent subject to ASS characterisat on
- Proposed Quarry Extension Region
- Exist ng Quarry

Acid Sulfate Risk
- High probability of occurrence
- Low probability of occurrence
- No known occurrence
- Not assessed

Land & Water Consulting
Email: enquiries@lwconsulting.com.au
Web: www.lwconsulting.com.au





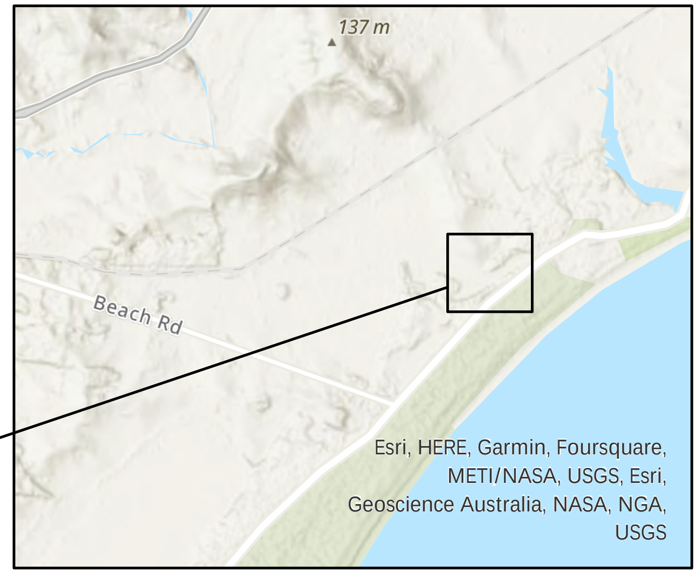
PROJECT: Gerroa Quarry Extension		
FIGURE TITLE: Surface Soil Lithology of Site		
Site Address: Crooked River Rd Gerroa, NSW 2534	FIGURE 4	Date: 13/10/2022
		Projection: GDA2020 Z54
Figure in set: 4 of 12	Revision A	Scale: 1:8,477

0 0.07 0.15 0.3 0.45 0.6
Kilometres

Legend
- Dredge extent subject to ASS characterisa t on
- Proposed Quarry Extension Region
- Exist ng Quarry

Soil Lithology
- Rudosols
- Dermosols
- Ferrosols
- Not assessed

Land & Water Consulting
Email: enquiries@lwconsulting.com.au
Web: www.lwconsulting.com.au



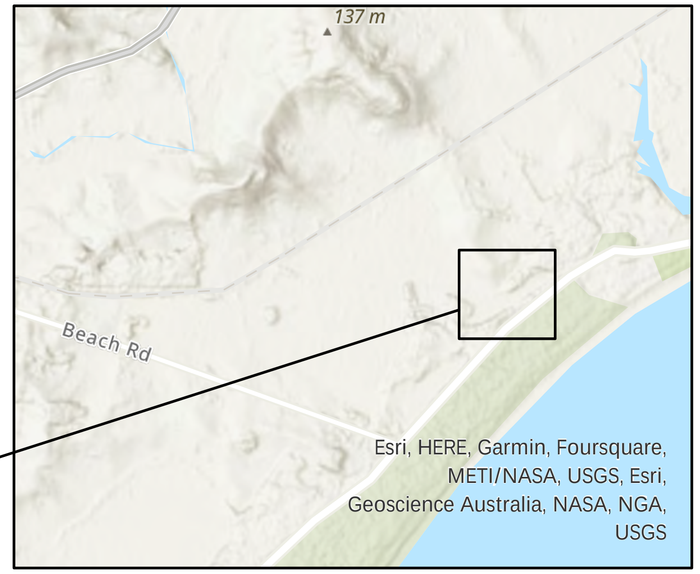
PROJECT: Gerroa Quarry Extension		
FIGURE TITLE: ASS pH for depth of 0.4 m - 1 m		
Site Address: Crooked River Rd Gerroa, NSW 2534	FIGURE 5	Date: 13/10/2022
		Projection: GDA2020 Z54
Figure in set: 5 of 12	Revision A	Scale: 1:3,472

0 0.03 0.06 0.12 0.18 0.24
Kilometres

Legend
- Gerroa Access Tracks
- Gerroa Project Area
- Dredge extent subject to ASS characterisation

pHFOX - pHF
- <0.4
- >0.4 - 0.6
- >0.6 - 0.7
- >0.7 - 0.8

Land & Water Consulting
Email: enquiries@lwconsulting.com.au
Web: www.lwconsulting.com.au



PROJECT: Gerroa Quarry Extension		
FIGURE TITLE: ASS pH for depth of 1 m - 2 m		
Site Address: Crooked River Rd Gerroa, NSW 2534	FIGURE 6	Date: 13/10/2022
		Projection: GDA2020 Z54
Figure in set: 6 of 12	Revision A	Scale: 1:3,472

0 0.03 0.06 0.12 0.18 0.24
Kilometres

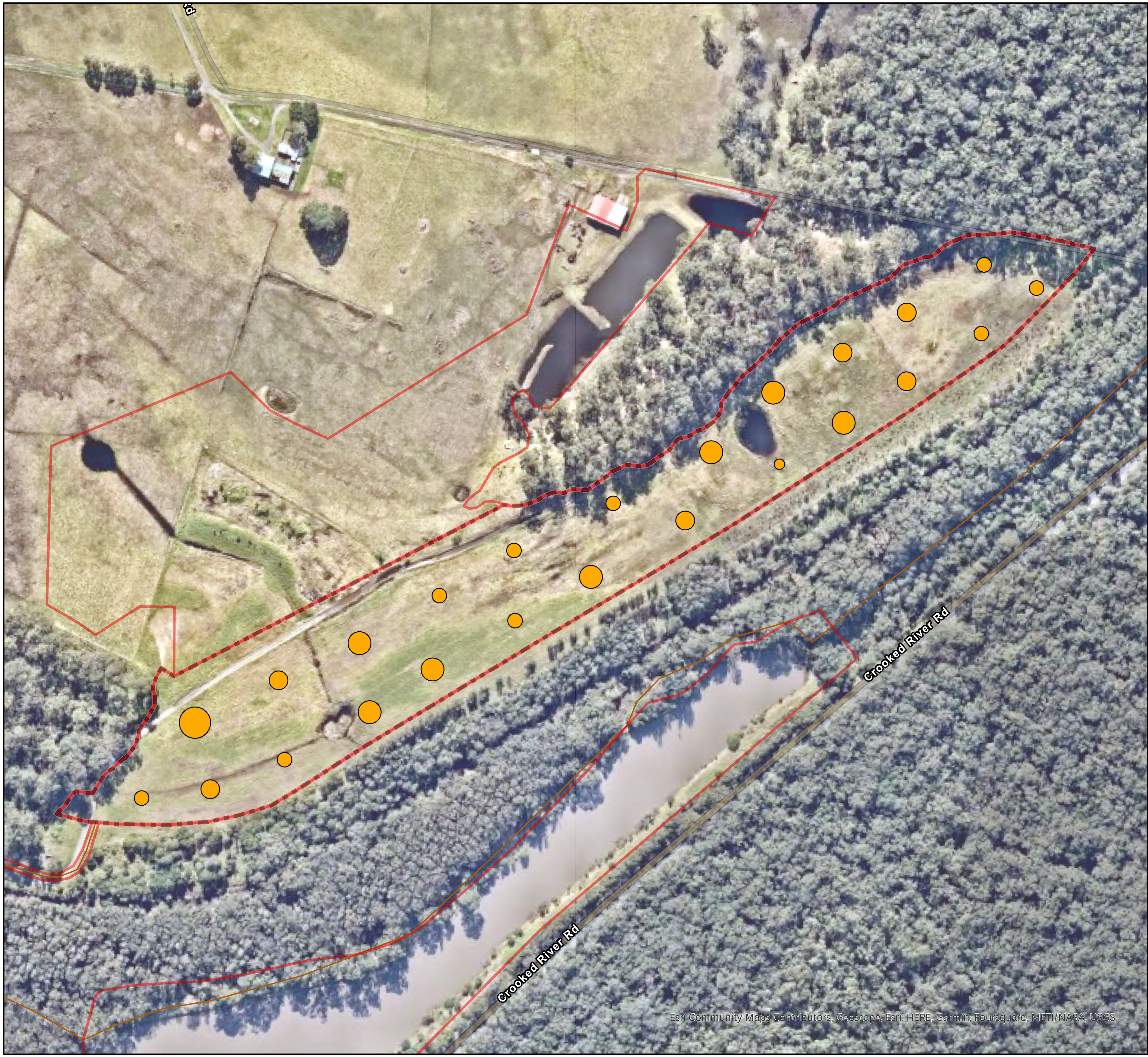
Legend

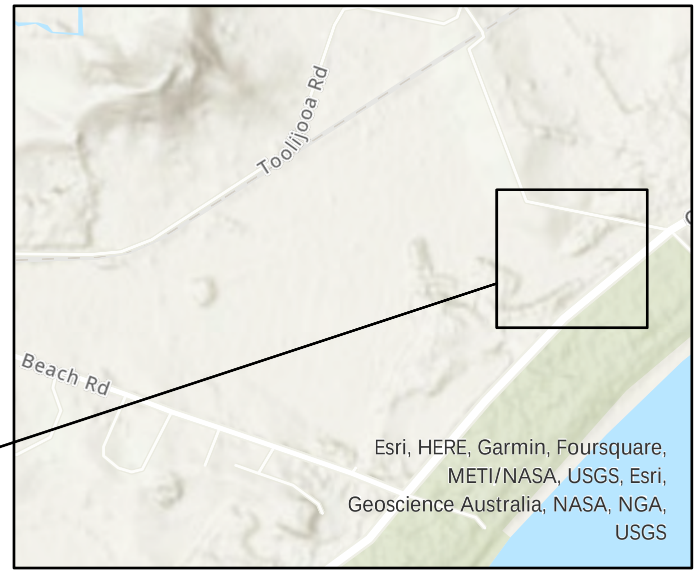
- Gerroa Access Tracks
- Gerroa Project Area
- Dredge extent subject to ASS characterisation

pHFOX - pHF

- <2.3- 2.5
- >2.5- 2.7
- >2.7- 3.2
- >3.2- 3.6
- >3.6- 4.3

Land & Water Consulting
Email: enquiries@lwconsulting.com.au
Web: www.lwconsulting.com.au



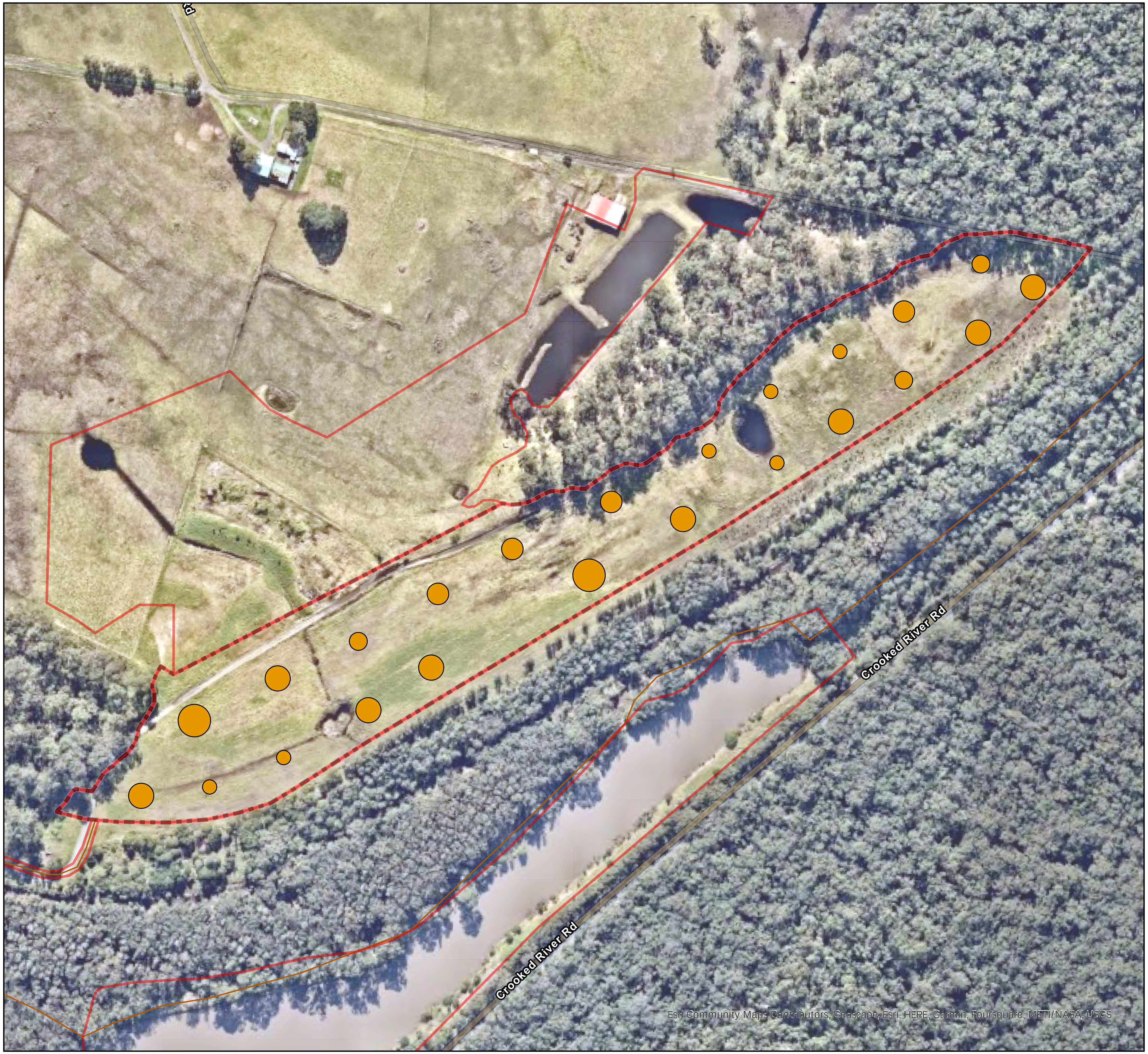


PROJECT: Gerroa Quarry Extension		
FIGURE TITLE: ASS pH for depth of 2 m - 3 m		
Site Address: Crooked River Rd Gerroa, NSW 2534	FIGURE 7	Date: 13/10/2022 Projection: GDA2020 Z54
Figure in set: 7 of 12	Revision A	Scale: 1:3,472

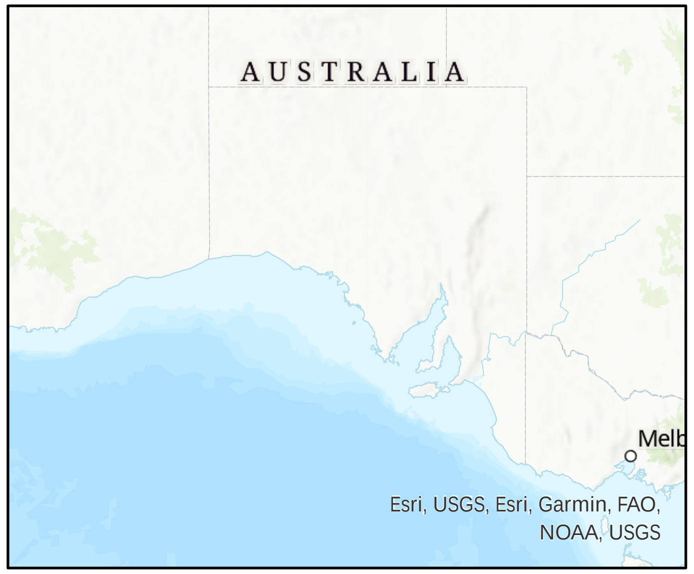
0 0.03 0.06 0.12 0.18 0.24
Kilometres

Legend
- Gerroa Access Tracks
- Gerroa Project Area
- Dredge extent subject to ASS characterisat on

pHFOX - pHF
- <1.6
- >1.6 - 3.1
- >3.1 - 3.5
- >3.5 - 4.1
- >4.1 - 4.8



Land & Water Consulting
Email: enquiries@lwconsulting.com.au
Web: www.lwconsulting.com.au



PROJECT: Gerroa Quarry Extension		
FIGURE TITLE: ASS pH for depth of 3 m - 4 m		
Site Address: Crooked River Rd Gerroa, NSW 2534	FIGURE 8	Date: 13/10/2022
		Projection: GDA2020 Z54
Figure in set: 8 of 12	Revision A	Scale: 1:3,472

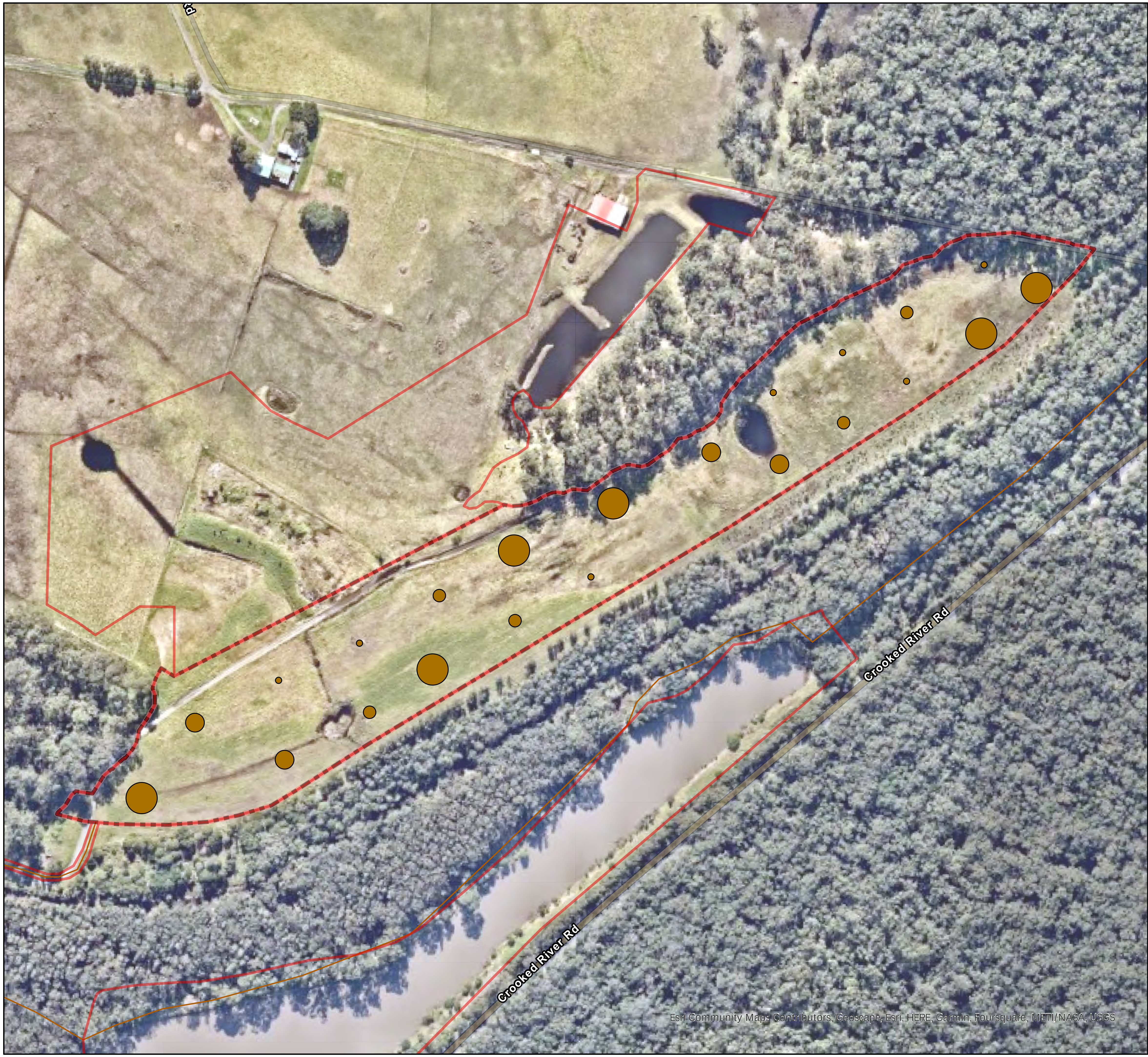
0 0.03 0.06 0.12 0.18 0.24
Kilometres

Legend

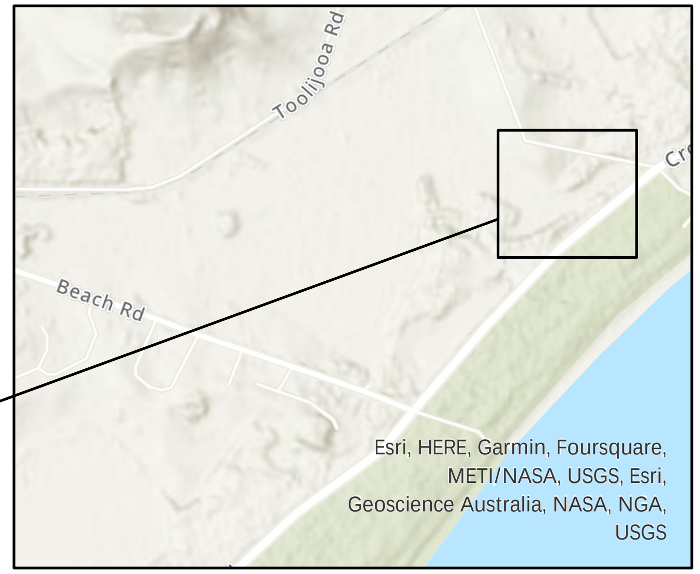
- Gerroa Access Tracks
- Gerroa Project Area
- Dredge extent subject to ASS characterisation

pHFOX - pHF

- >1.5- 2.2
- >2.2- 2.9
- >2.9- 3.4
- >3.4- 4.1
- >4.1- 4.9



Land & Water Consulting
Email: enquiries@lwconsulting.com.au
Web: www.lwconsulting.com.au



PROJECT:
Gerroa Quarry Extension

FIGURE TITLE:
ASS pH for depth of 4 m - 5m

Site Address: Street Name Suburb, State Postcode	FIGURE 9	Date: 13/10/2022
		Projection: GDA2020 Z54
Figure in set: 9 of 12	Revision A	Scale: 1:3,472

0 0.03 0.06 0.12 0.18 0.24
Kilometres

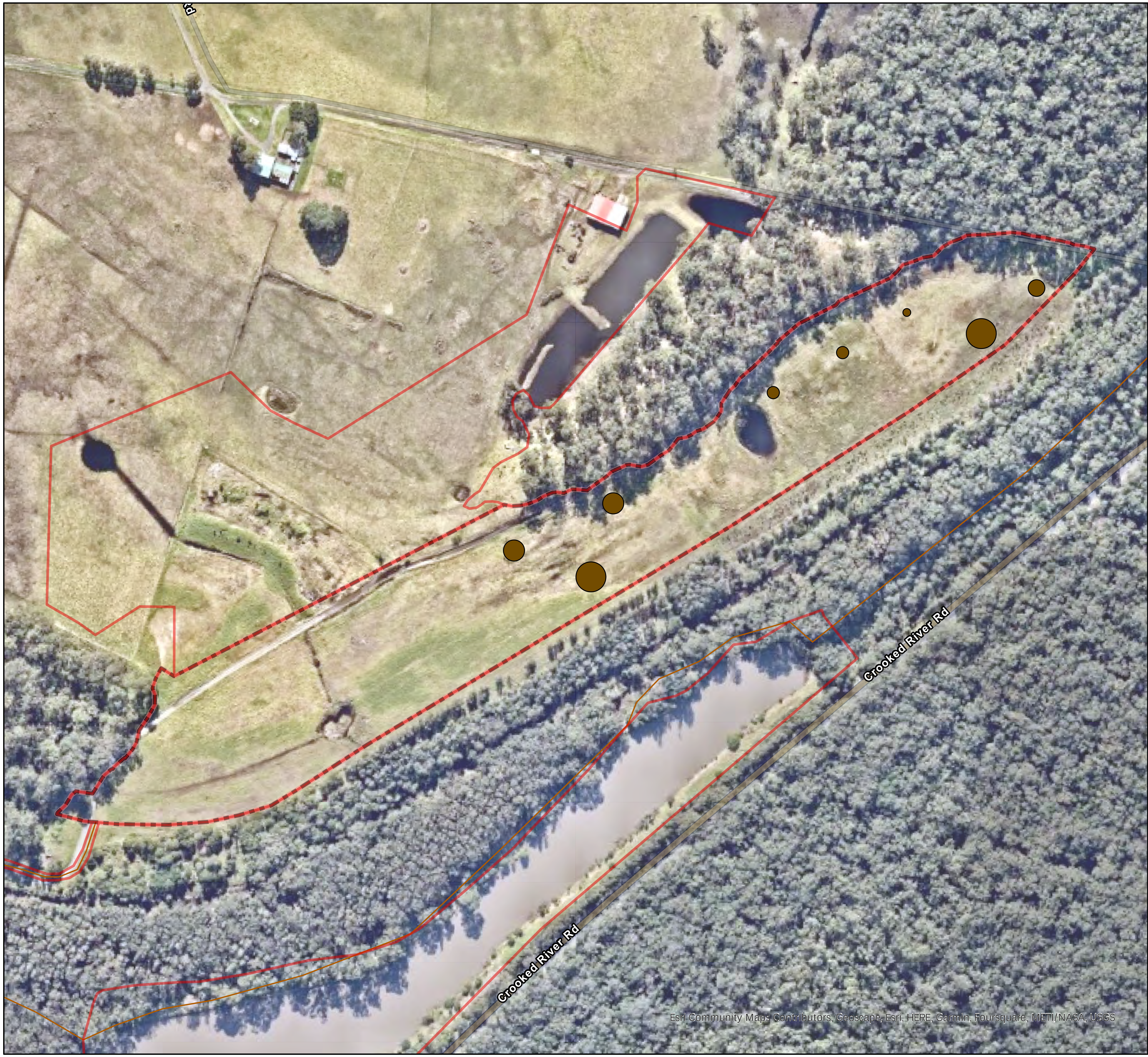
Legend

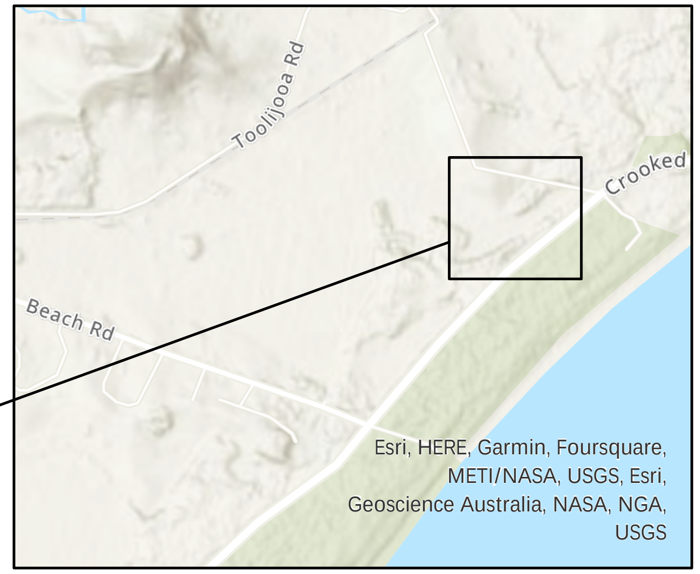
- Gerroa Access Tracks
- Gerroa Project Area
- Dredge extent subject to ASS characterisation

pHFOX - pHF

- <0.1
- >0.1 - 2.1
- >2.1 - 2.7
- >2.7 - 3.6
- >3.6 - 4.8

Land & Water Consulting
Email: enquiries@lwconsulting.com.au
Web: www.lwconsulting.com.au



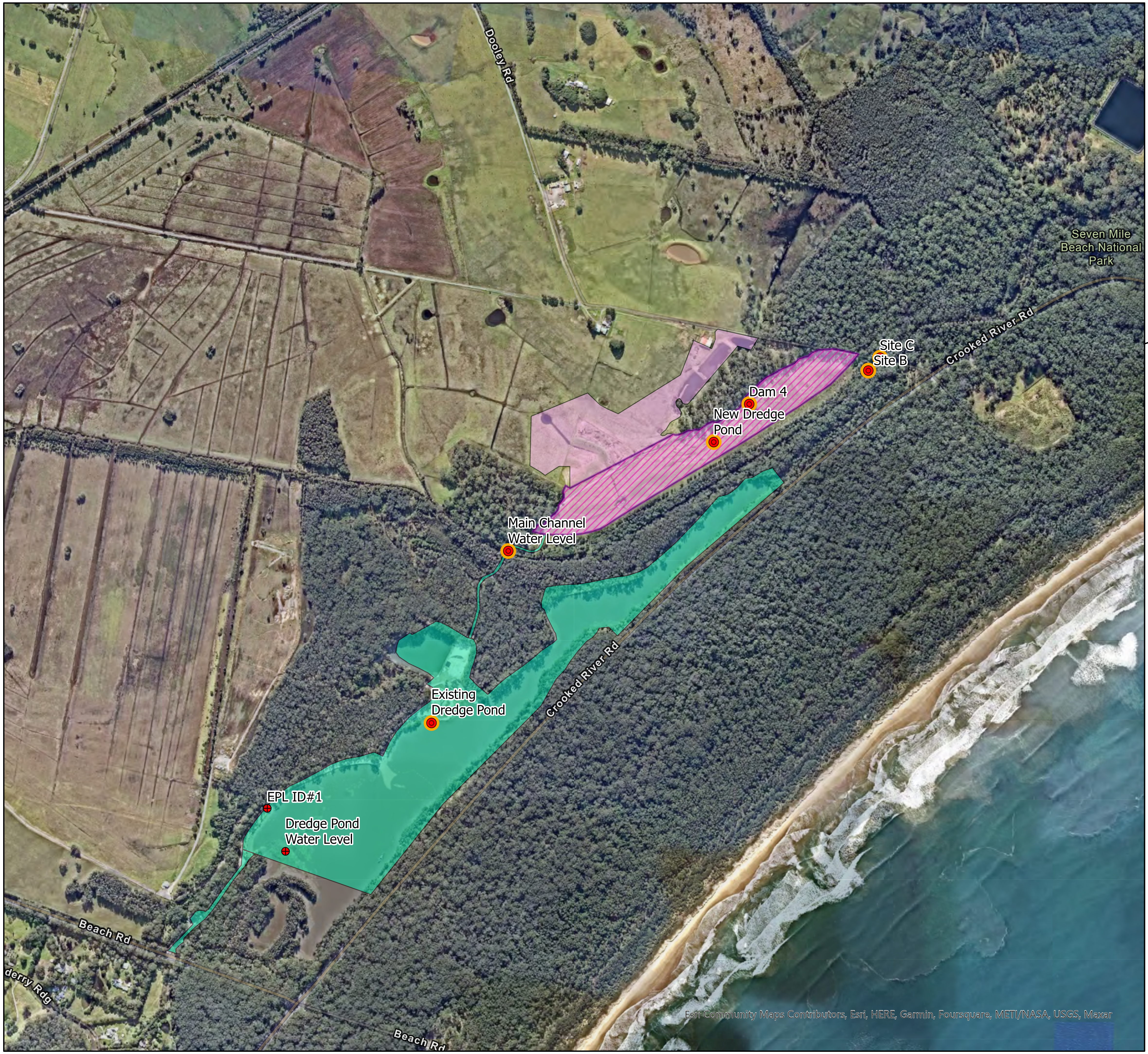


PROJECT: Gerroa Quarry Extension		
FIGURE TITLE: ASS pH for depth of 5 m - 6 m		
Site Address: Crooked River Rd Gerroa, NSW 2534	FIGURE 10	Date: 13/10/2022
		Projection: GDA2020 Z54
Figure in set: 10 of 12	Revision A	Scale: 1:3,472

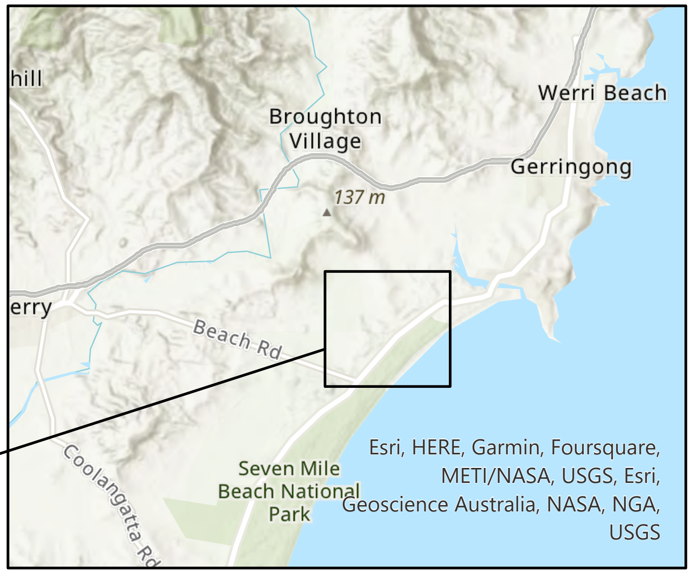
0 0.03 0.06 0.12 0.18 0.24
Kilometres

Legend
- Gerroa Access Tracks
- Gerroa Project Area
- Dredge extent subject to ASS characterisation

pHFOX - pHF
- <1.2
- >1.2- 2.0
- >2.0- 2.3
- >2.3- 4.0
- >4.0- 4.6



Land & Water Consulting
Email: enquiries@lwconsulting.com.au
Web: www.lwconsulting.com.au



PROJECT:
Gerroa Quarry Extension

FIGURE TITLE:
Surface Water Bore Location Plan

Site Address: Crooked River Rd Gerroa, NSW 2534	FIGURE **11**	Date: 19/10/2022
		Projection: GDA2020 Z54
Figure in set: 11 of 12	Revision A	Scale: 1:11,038

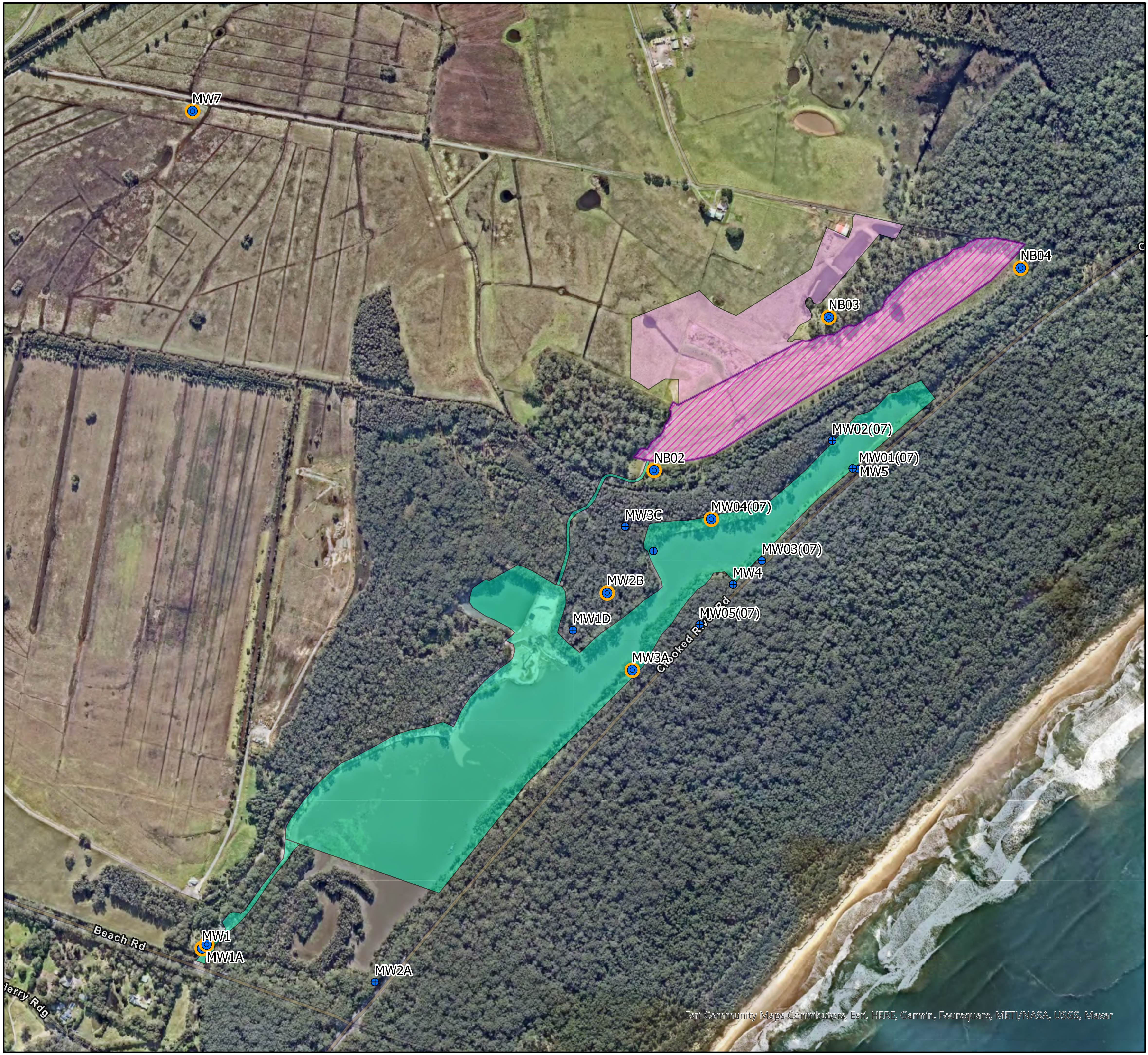
N

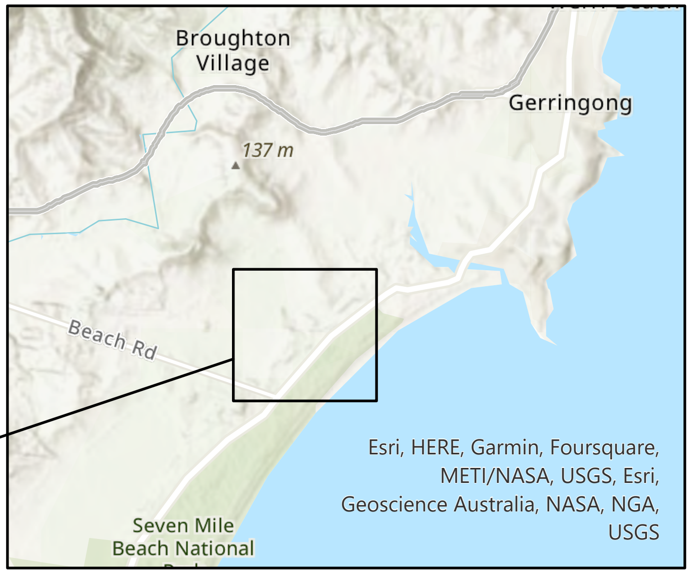
0 0.1 0.2 0.4 0.6 0.8
Kilometres

Legend

- Proposed Quarry Extension Region
- Existing Quarry
- Dredge extent subject to ASS characterisation
- Proposed surface water monitoring points
- Existing surface water monitoring points

Land & Water Consulting
Email: enquiries@lwconsulting.com.au
Web: www.lwconsulting.com.au





PROJECT: Gerroa Quarry Extension		
FIGURE TITLE: Groundwater Bore Location Plan		
Site Address: Crooked River Rd Gerroa, NSW 2534	FIGURE **12**	Date: 19/10/2022
		Projection: GDA2020 Z54
Figure in set: 12 of 12	Revision A	Scale: 1:9,198

N

0 0.07 0.15 0.3 0.45 0.6
Kilometres

Legend

Type

- Proposed Quarry Extension Region
- Existing Quarry
- Dredge extent subject to ASS characterisation
- Proposed Groundwater monitoring points
- Existing Groundwater monitoring points

APPENDIX A
TESTING RESULTS

A-1 Tabulated Soil Sampling Results

Table A-1 Acid Sulfate Soil Data

#	Sample #	Test Location	Depth: MAX. (mbgl)	Depth: MIN. (mbgl)	Depth RL: MIN. (m AHD)	Depth RL: MAX. (m AHD)	Groundwater Level (mbgl)	Groundwater Level (m AHD)	Material Description	pH_F	pH_{FOX}	$pH_F - pH_{FOX}$	Field Screening Tests: Reaction Strength (N, Sl, M, St, E)	HCl (FIZZ) Test (Y=yes;N=No)	AASS	PASS (Preliminary Risk Rating): High	Medium	Low	CRS Suite: pH_{KCl}	s-TAA	(%S)	S_{NAS} (%S)	(if pH ≤ 4.5)	ANCe (%S)		CRS (%S)		Acid Base Accounting*: Potential Acidity (%S)	Actual Acidity (%S)	Retained Acidity (%S)	Net Acidity (exc. ANC) (%S)	Management: Is This AASS	Is This PASS	Liming Rate for PASS Net Acidity (kg/m3)	Liming Rate for AASS Net Acidity (kg/m3)
																															0.3		Average	27	
																																	kg/tonne	33	
																																	2 SF	67	
#		location		depth																											5.1		Maximum	386	
																																	kg/tonne	475	
																																	2 SF	950	
96		BH01		0.4					Sand (mf), light brown/grey	5.31	4.84	0.47	No reaction to slight																						
1	EB2123140002	BH01		1.3					Sand (md), light brown/grey, trace gravel (fn)	4.88	1.68	3.2	extreme			x			5.8	<	0.02						0.162	0.16	0.00	0.00	0.16	No	YES	12.26	NA
2	EB2123140003	BH01		2.2					Sand (fm), light brown	4.87	1.92	2.95	Strong			x			5.9	<	0.02						0.093	0.09	0.00	0.00	0.09	No	YES	7.04	NA
97		BH01		3					Sand (fm), light brown	4.82	1.59	3.23	extreme			x																			
98		BH01		3.5					Sand (fm), light brown	5.06	1.91	3.15	extreme			x																			
99		BH01		3.9					Sand (mc), light brown	6.62	2	4.62	extreme			x																			
100		BH01		4.6					Sandy clay (fn), trace silt.	6.53	2.08	4.45	extreme			x																			
101		BH01		5					Sandy clay (fm), trace silt. Single cobble (WR 70mm)	7.02	2.86	4.16	extreme			x																			
102		BH01		5.4					Silty clay, hard, dark brown	6.95	4.66	2.29	Strong					x																	
3	EB2123140010	BH02		0.20					Silty Sand (fm) dark brown/grey	5.93	4.9	1.03	Moderate					x	6	<	0.02						0.013	0.01	0.00	0.00	0.01	No	No	NA	NA
70	EB2125980001	BH02		0.40					Sand (fm), tan, orange brown	5.21	4.61	0.6	No reaction to slight					x	5.6	<	0.02						0.016	0.02	0.00	0.00	0.02	No	No	NA	NA
71	EB2125980002	BH02		0.70					Sand (fm), yellow brown, trace fine gravel	5.18	4.97	0.21	No reaction to slight					x	6	<	0.02						0.012	0.01	0.00	0.00	0.01	No	No	NA	NA
4	EB2123140013	BH02		1.35					Sand (fm), yellow brown, trace fine gravel	4.51	2.14	2.37	Strong		x				5.8	<	0.02						0.108	0.11	0.00	0.00	0.11	No	YES	8.17	NA
5	EB2123140014	BH02		1.73					Sand (fm), yellow brown, trace fine gravel	4.8	2.12	2.68	Strong				x		5.8	<	0.02						0.061	0.06	0.00	0.00	0.06	No	YES	4.62	NA
6	EB2123140015	BH02		2.45					Sand (mc), single cobble	4.99	2.21	2.78	Strong				x		5.9	<	0.02						0.088	0.09	0.00	0.00	0.09	No	YES	6.66	NA
90	EB2125980021	BH02		2.45					Sand (mc), single cobble	4.99	2.21	2.78	Strong				x		5.4	<	0.02						0.218	0.22	0.00	0.00	0.22	No	YES	16.50	NA
72	EB2125980003	BH02		2.95					Sand (mc)	4.85	2.08	2.77	Strong				x		6	<	0.02						0.129	0.13	0.00	0.00	0.13	No	YES	9.76	NA
73	EB2125980004	BH02		3.68					Sand (mc)	4.85	2.08	2.77	Strong				x		6	<	0.02						0.074	0.07	0.00	0.00	0.07	No	YES	5.60	NA
74	EB2125980005	BH02		4.33					Sand (mc)	5.55	2.9	2.65	Moderate					x	6.2	<	0.02						0.027	0.03	0.00	0.00	0.03	No	No	NA	NA
103		BH03		0.2					Silty sand (fm), drk brown/grey	4.96	4.29	0.67	No reaction to slight					x																	
104		BH03		0.7					Sand (mc), yellow/cream	5.13	4.95	0.18	No reaction to slight					x																	
7	EB2123140021	BH03		1.31					silty sand (md), brown, ~30% organic matter	4.93	1.42	3.51	extreme			x			5.5	<	0.02						0.219	0.22	0.00	0.00	0.22	No	YES	16.58	NA
8	EB2123140022	BH03		1.93					Sand (mc), grey	4.64	1.8	2.84	Strong				x		5.8	<	0.02						0.135	0.14	0.00	0.00	0.14	No	YES	10.22	NA
9	EB2123140023	BH03		2.31					Sand (mc), light grey, fine gravel	4.68	1.97	2.71	Strong				x		5.9	<	0.02						0.074	0.07	0.00	0.00	0.07	No	YES	5.60	NA
105		BH03		2.95					Sand (mc), light grey, fine gravel	4.66	1.97	2.69	Strong				x																		
106		BH03		3.51					Sand (mc), light grey, fine gravel	5.36	1.78	3.58	extreme			x																			
107		BH03		4.08					Clay and sand (fm), drk brown, stiff	6.63	1.78	4.85	extreme			x																			
108		BH03		4.61					Clay, stiff	6.87	2.07	4.8	extreme			x																			
109		BH03		5.13					Clay, stiff	6.49	1.89	4.6	extreme			x																			
110		BH04		0.3					silty sand (md), dark brown	5.17	4.58	0.59	No reaction to slight					x																	
111		BH04		0.6					silty sand (mf), orange/dark brown	5.18	4.57	0.61	No reaction to slight					x																	
112		BH04		0.9					sand (md), yellow	5.02	4.66	0.36	No reaction to slight					x																	
10	EB2123140032	BH04		1.30					sand (md), yellow	4.84	1.5	3.34	extreme			x			5.7	<	0.02						0.1	0.10	0.00	0.00	0.10	No	YES	7.57	NA
11	EB2123140033	BH04		2.20					sand (md), yellow	4.72	1.46	3.26	extreme			x			5.8	<	0.02						0.121	0.12	0.00	0.00	0.12	No	YES	9.16	NA
113		BH04		3.1					Sand (fm)	4.7	1.78	2.92	Strong				x																		
75	EB2125980006	BH04		3.85					Sand (fm)	4.87	1.7	3.17	extreme			x			5.9	<	0.02						0.321	0.32	0.00	0.00	0.32	No	YES	24.30	NA
114		BH04		4.25					Stiff clay / coffee rock	6.3	2.88	3.42	extreme			x																			
115		BH04		4.6					sand (cc) and clay	6.5	5.13	1.37	Moderate					x																	
116		BH04		5.05					Clay and sand (10% fm)	6.79	5.57	1.22	Moderate					x																	
117		BH04		5.25					Silty and Sand (fm), 10% organic matter	6.75	5.5	1.25	Moderate					x																	
12	EB2123140040	BH05		0.20					Silty sand(fm), black	5.32	4.15	1.17	Moderate					x	5.5	<	0.02						0.012	0.01	0.00	0.00	0.01	No	No	NA	NA
118		BH05		0.6					Sand (md), yellow/cream, silt peds	4.72	4.47	0.25	No reaction to slight					x																	
13	EB2123140042	BH05		1.20					sand (fm), light brown, trace organic	5.05	1.56	3.49	extreme			x			5.6	<	0.02						0.214	0.21	0.00	0.00	0.21	No	YES	16.20	NA
14	EB2123140043	BH05		1.70					sand (fm), light brown, trace organic	4.45	1.65	2.8	Strong		x	x			5.7	<	0.02						0.221	0.22	0.00	0.00	0.22	No	YES	16.73	NA
15	EB2123140044	BH05		2.20					sand (fm), light brown, trace organic	4.84	1.76	3.08	extreme			x			5.9	<	0.02						0.118	0.12	0.00	0.00	0.12	No	YES	8.93	NA
119		BH05		2.7					sand (fm), light brown, trace organic	5.3	1.77	3.53	extreme			x																			
120		BH05		3.1					Sand (mc), trace shell/organic matter	6.13	1.96	4.17	extreme			x																			
121		BH05		4					Sand (mc), trace shell/organic matter	6.85	5.3	1.55	Moderate					x																	
76	EB2125980007	BH05		4.50					Sandy clay (cc)	7.07	3.43	3.64	extreme				x		6.3	<	0.02						0.108	0.11	0.00	0.00	0.11	No	YES	8.17	NA
77	EB2125980008	BH05		4.90					Sandy clay (md), grey	7.06	5.9	1.16	Moderate					x	6.4	<	0.02						0.065	0.07	0.00	0.00	0.07	No	YES	4.92	NA
122		BH06		0.3					Silty sand(fm), black	5.21	4.27	0.94	No reaction to slight					x																	
123		BH06		0.7					Sand (md), yellow/cream, silt peds	5.07	4.68	0.39	No reaction to slight					x																	
16	EB2123140052	BH06		1.36					Sand (md), yellow/cream	4.54	1.61	2.93	Strong		x	x			5.5	<	0.02						0.242	0.242	0	0	0.242	No	YES	18.32	NA
17	EB2123140053	BH06		1.91					sand (mc), trace gravel (fn)	4.8	1.79	3.01	extreme			x			5.7	<	0.02						0.32	0.32	0	0	0.32	No	YES	24.22	NA
18	EB2123140054	BH06		2.4					sand (mc), trace gravel (fn)	4.98	1.75	3.23	extreme			x			5.8	<	0.02						0.341	0.341	0	0	0.341	No	YES	25.81	NA
124		BH06		2.82					Silty sand (fn), grey low plasticity	5.25	1.68	3.57	extreme			x																			
125		BH06		3.31					Sandy clay (fn)	5.95	4.56	1.39	Moderate					x																	
126		BH06		3.75					Sand (mc), trace silt, trace gravel	6.3	4.21	2.09	Strong					x																	
127		BH06		4.42					Sand (mc), trace silt, trace gravel	6.71	5.41	1.3	Moderate					x																	
128		BH06		4.84					Sand (mc), trace silt, trace gravel	7.05	5.25	1.8	Moderate					x																	
129		BH06		5.57					Sand (mc), trace silt, trace gravel	7.22	5.24	1.98	Moderate					x																	
19	EB2123140061	BH07		0.20					Silty sand(fm), black	5.2	4.17	1.03	Moderate					x	5.3	<	0.02						0.025	0.03	0.00	0.00	0.03	No	No	NA	NA
130		BH07		0.6					Sand (md), yellow/cream, silt peds	4.9	4.53	0.37	No reaction to slight					x																	
20	EB2123140063	BH07		1.45					Sand (md), yellow/cream	6.54	1.73	4.81	extreme			x			5.7	<	0.02						0.244	0.24	0.00	0.00	0.24	No	YES	18.47	NA
131		BH07		1.62					Sand (md), yellow/cream	4.95	1.64	3.31	extreme			x																			
21	EB2123140065	BH07		2.12					Sand (md), yellow/cream	5.11	1.4	3.71	extreme			x			5.8	<	0.02						0.225	0.23	0.00	0.00	0.23	No	YES	17.03	NA
132		BH07		2.3					Sand (md), yellow/cream	5.18	1.64	3.54	extreme			x																			
133		BH07		2.84					Sand (cc), single gravel (WR 25mm)	5.3	1.64	3.66	extreme			x																			
134		BH07		3.43					Sand (cc)	5.32	1.71	3.61	extreme			x																			
135		BH07		3.83					Sand (cc)	6.1	2.49	3.61	extreme			x																			
22	EB2123140070	BH08		0.20					Silty sand(fm), black	4.99	3.3	1.69	Moderate					x	4.6		0.05						0.013	0.01	0.05	0.00	0.06	YES	No	NA	4.5
136		BH08		0.7					Sand (md), yellow/cream, silt peds	4.84	4.05	0.79	No reaction to slight					x																	
23	EB2123140072	BH08		1.46					Sand (md), yellow/cream ~10% organic matter	4.45	1.38	3.07	extreme		x	x			5.8	<	0.02						0.211	0.21	0.00	0.00	0.21	No	YES	15.97	NA
78	EB2125980009	BH08		1.63					Clay, stiff, high organic, trace sand (fn)	5.15	1.36	3.79	extreme			x			6	<	0.02						0.199	0.20	0.00	0.00	0.20	No	YES	15.06	NA
24	EB2123141002	BH08		1.81					Clay, stiff, high organic, trace sand (fn)	5.75	1.64	4.11	extreme			x			5.2		0.05						5.05	5.05	0.05	0.00	5.10	No	YES	386.00	NA
79	EB2125980010	BH08		1.97					Sandy clay (fm)	6.03	3.33	2.7	Strong					x	5.9	<	0.02						0.319	0.32	0.00	0.00	0.32	No	YES	24.14	NA
92	EB2127300001	BH08		2.18					Sandy clay (md)	6.32	1.81	4.51	extreme			x			6.2	<	0.02						0.22	0.22	0.00	0.00	0.22	No	YES	16.65	NA
25	EB2123141005	BH08		2.44					Sandy clay (mc)	6.4	1.64	4.76	extreme			x			6	<	0.02						0.353	0.35	0.00	0.00	0.35	No	YES	26.72	NA
137		BH08		2.8					Sandy clay (mc)	6.35	4.03	2.32	Strong					x																	
80	EB2125980011	BH08		3.61					Sand (fm), light grey/grey, trace silt	6.38	4.97	1.41	Moderate					x	6.3	<	0.02						0.015	0.02	0.00	0.00	0.02	No	No	NA	NA
138		BH08		3.9					Sand (fm), light grey/grey, trace silt	6.94	5.12	1.82	Moderate					x																	
139		BH08		5.44					Sandy Clay (md), brown, moderate plasticity	7.2	5.48	1.72	Moderate					x																	
26	EB2123141010	BH09		0.20					Silty sand(fm), black	5.07	2.99	2.08	Strong				x		5.7	<	0.02						0.01	0.01	0.00	0.00	0.01	No	No	NA	NA
27	EB2123141011	BH09		0.70					Sand (md), yellow/cream, silt peds	4.88	3.85	1.03	Moderate					x	5.6	<	0.02						0.012	0.01	0.00	0.00	0.01	No	No	NA	NA
28	EB2123141012	BH09		1.34					Sand (fn) with trace organics	4.53	1.45	3.08	extreme		x	x			5.7	<	0.02						0.25	0.25	0.00	0.00	0.25	No	YES	18.92	NA
29	EB2123141013	BH09		1.89					Sand (fm). 2x gravel (WR ~30mm)	4.49	2.22	2.27	Strong		x	x			6	<	0.02						0.125	0.13	0.00	0.00	0.13	No	YES	9.46	NA
140		BH09		2.4					Sand (mc)	5.1	3.6	1.5	Moderate					x																	
141		BH09		2.9					Sand (cc)	7.3	5.55	1.75	Moderate					x																	
142		BH09		3.3					Sand (fm) and Silt	7.32	5.19	2.13	Strong					x																	
143		BH10		0.2					Silty sand(fm), black	5.24	4.6	0.64	No reaction to slight					x																	
144		BH10		0.7					Silty sand(fm), orange/brown	5.36	4.65	0.71	No reaction to slight					x																	
145		BH10		1.1					Sand (md), yellow/cream, silt peds	5.19	4.81	0.38	No reaction to slight					x																	
30	EB2123141020	BH10		1.50					Stiff clay w/ trace sand (fm)	5.83	1.24	4.59	extreme			x			5.8	<	0.02						0.159	0.16	0.00	0.00	0.16	No	YES	12.03	NA
31	EB2123141021	BH10		2.10					Sand (md), grey	6.23	1.25	4.98	extreme			x			6	<	0.02						0.093	0.09	0.00	0.00	0.09	No	YES	7.04	NA
146		BH10		2.9					Sand (md), grey	6.49	4.1	2.39	Strong					x																	
147		BH10		3.3					Sand (md) w/ some silt, dark grey	6.69	5.03	1.66	Moderate					x																	
148		BH10		3.6					Sand (md) w/ some silt, dark grey	6.84	5.35	1.49	Moderate					x																	
149		BH11		0.2					Silty sand(fm), black	5.73	4.75	0.98	No reaction to slight					x																	
150		BH11		0.7					Sand (md), yellow/cream, silt peds	5.4	4.8	0.6	No reaction to slight					x																	
32	EB2123141027	BH11		2.00					Sand (fm)	4.77	2.45	2.32	strong				x		5.9	<	0.02						0.042	0.04	0.00	0.00	0.04	No	YES	3.18	NA
151		BH11		2.7					Sand (mc) with trace gravel (WR fc)	4.91	1.48	3.43	extreme			x																			
152		BH11		3.7					Sand (md) w/ some silt, dark grey	5.12	1.36	3.76	extreme			x																			
153		BH11		4.1					Sand (md) w/ some silt, dark grey	5.44	2.96	2.48	Strong				x																		
154		BH12		0.2					Silty sand(fm), black	5.01	4.37	0.64	No reaction to slight					x																	
155		BH12		0.6					Silty sand(fm), orange/brown	5.2	4.75	0.45	No reaction to slight					x																	
156		BH12		0.9					Sand (md), yellow/cream, silt peds	5.37	4.84	0.53	No reaction to slight					x																	
33	EB2123141034	BH12		1.59					Sand (fm)	4.55	1.93	2.62	Strong		x	x			5.8	<	0.02						0.092	0.09	0.00	0.00	0.09	No	YES	6.96	NA
34	EB2123141035	BH12		2.35					Stiff organic rich clay	5.33	2.53	2.8	Strong					x	6	<	0.02						0.19	0.19	0.00	0.00	0.19	No	YES	14.38	NA
157		BH12		3.02					Sandy clay (fm)	5.95	2.29	3.66	extreme			x																			
158		BH12		3.54					Sand (mf)	5.9	2.81	3.09	extreme			x																			
159		BH12		4.71					Silty Sand (mc)	6.57	4.62	1.95	Moderate					x																	
160		BH12		5.75					Silty Sand (mc)	5.67	1.69	3.98	extreme			x																			
161		BH13		0.2					Silty sand(fm), black	5.51	4.82	0.69	No reaction to slight					x																	
162		BH13		0.8					Sand (md), yellow/cream, silt peds	5.2	4.89	0.31	No reaction to slight					x																	
35	EB2123141042	BH13		1.73					Sand (fm)	5.68	1.42	4.26	extreme			x			6	<	0.02						0.094	0.09	0.00	0.00	0.09	No	YES	7.11	NA
163		BH13		2.04					Sand (cc) and gravel (fn)	5.68	1.86	3.82	extreme			x																			
164		BH13		2.9					Sand (cc) and gravel (fn)	5.81	1.81	4	extreme			x																			
165		BH13		3.57					Sand (mc) w/ trace charcoal	5.83	1.37	4.46	extreme			x																			
166		BH13		4.22					Sand (mc) w/ trace charcoal	6.1	2.17	3.93	extreme			x																			
167		BH13		4.53					Silty sand (mc), trace vegetative matter	6.2	3.62	2.58	Strong					x																	
81	EB2125980012	BH13		5.00					Silty sand (mc), trace vegetative matter	6.26	1.86	4.4	extreme			x			6	<	0.02						0.225	0.23	0.00	0.00	0.23	No	YES	17.03	NA
168		BH13		5.85					Silty sand (mc)	6.46	1.92	4.54	extreme			x																			
169		BH14		0.3					Silty sand(fm), black	5.92	5.11	0.81	No reaction to slight					x																	
170		BH14		0.9					Sand (md), yellow/cream, silt peds	5.34	4.82	0.52	No reaction to slight					x																	
36	EB2123141052	BH14		1.86					Sand (fm)	4.73	1.76	2.97	Strong				x		6.1	<	0.02						0.058	0.06	0.00	0.00	0.06	No	YES	4.39	NA
171		BH14		2.82					Sand (fm)	4.66	1.82	2.84	Strong				x																		

Table A-1 Acid Sulfate Soil Data

#	Sample #	Test Location	Depth MAX. (mbgl)	Depth MIN. (mbgl)	Depth RL MIN. (m AHD)	Depth RL MAX. (m AHD)	Groundwater Level (mbgl)	Groundwater Level (m AHD)	Material Description	Field Screening Tests pH_F	pH_{FOX}	pH_F - pH_{FOX}	Reaction Strength (N, Sl, M, St, E)	HCl (FIZZ) Test (Y=yes;N= No)	AASS	PASS (Preliminary Risk Rating) High	Medium	Low	CRS Suite pH_{KCl}	s-TAA	(%S)	S_{NAS} (%S) (if pH ≤ 4.5)		ANCe (%S)		CRS (%S)		Acid Base Accounting* Potential Acidity (%S)	Actual Acidity (%S)	Retained Acidity (%S)	Net Acidity (exc. ANC) (%S)	Management Is This AASS	Is This PASS	Liming Rate for PASS Net Acidity (kg/m3)	Liming Rate for AASS Net Acidity (kg/m3)
																															0.3		Average	27	
																																	kg/tonne	33	
																																	2 SF	67	
#		location		depth																											5.1		Maximum	386	
																																	kg/tonne	475	
																																	2 SF	950	
172		BH14		3.78					Sand (fm)	4.85	1.59	3.26	extreme			x																			
173		BH14		4.3					Sand (fm)	5.09	1.86	3.23	extreme			x																			
174		BH14		4.5					Sand (mc) w/ trace silt	5.29	1.96	3.33	extreme			x																			
175		BH14		4.8					Silty Sand (cc) w/ trace charcoal	5.14	1.8	3.34	extreme			x																			
176		BH14		5.4					Sand (cc) w/ trace silt	5.21	1.75	3.46	extreme			x																			
177		BH14		5.7					Sand (mc) w/ trace silt	5.43	1.71	3.72	extreme			x																			
37	EB2123141060	BH15		0.30					Silty sand(fm), black	4.68	2.42	2.26	Strong				x		5.8	<	0.02						0.01	0.01	0.00	0.00	0.01	No	No	NA	NA
38	EB2123141061	BH15		0.90					Sand (md), yellow/cream, silt peds	4.84	3.69	1.15	Moderate						6	<	0.02						0.005	0.01	0.00	0.00	0.01	No	No	NA	NA
39	EB2123141062	BH15		1.40					Sand (mf)	4.24	1.77	2.47	Strong		x	x			5.6	<	0.02						0.328	0.33	0.00	0.00	0.33	No	YES	24.83	NA
178		BH15		1.77					Sand (mf)	4.8	1.99	2.81	Strong				x																		
45	EB2123141064	BH15		2.22					Sandy clay (mf), soft	5.88	2.08	3.8	extreme			x			5.6	<	0.02						0.335	0.34	0.00	0.00	0.34	No	YES	25.36	NA
179		BH15		2.5					Clay, brown, very stiff	6.41	3.79	2.62	Strong					x																	
40	EB2123141066	BH16		0.10					Silty sand(fm), black	5.99	4.49	1.5	Moderate					x	6.3	<	0.02						0.005	0.01	0.00	0.00	0.01	No	No	NA	NA
41	EB2123141067	BH16		0.60					Sand (md), yellow/cream, silt peds	5.45	4.02	1.43	Moderate					x	6	<	0.02						0.01	0.01	0.00	0.00	0.01	No	No	NA	NA
46	EB2123141068	BH16		1.59					Sand (mf)	4.65	1.56	3.09	extreme				x		6	<	0.02						0.023	0.02	0.00	0.00	0.02	No	No	NA	NA
180		BH16		2.24					Sand (mf)	4.35	1.46	2.89	Strong		x	x																			
181		BH16		2.98					Sand (mc)	5.09	1.91	3.18	extreme			x																			
182		BH16		3.6					Sand (mc), trace silt	5.43	1.65	3.78	extreme			x																			
183		BH16		3.96					Sand (mc), trace silt	5.46	2.8	2.66	Strong				x																		
184		BH16		4.3					Sand (mc), trace silt	5.26	5.53	-0.27	No reaction to slight																						
42	EB2123141074	BH17		0.20					Sand (mf)	4.65	1.56	3.09	strong			x			5.7	<	0.02						0.021	0.02	0.00	0.00	0.02	No	No	NA	NA
43	EB2123141075	BH17		0.70					Sand (md), yellow/cream, silt peds	4.85	3.6	1.25	Moderate						5.8	<	0.02						0.017	0.02	0.00	0.00	0.02	No	No	NA	NA
44	EB2123141076	BH17		1.65					Sand (mf) and trace organic matter	4.68	1.69	2.99	strong				x		5.7	<	0.02						0.297	0.30	0.00	0.00	0.30	No	YES	22.48	NA
47	EB2123141077	BH17		2.28					Sandy clay (mf), soft	5.88	2.08	3.8	extreme			x			5.6	<	0.02						0.431	0.43	0.00	0.00	0.43	No	YES	32.62	NA
185		BH17		2.91					Sandy clay (mf), stiff	5.65	1.47	4.18	extreme			x																			
186		BH17		3.45					Clay and Sand (mf), stiff	6.11	2.03	4.08	extreme			x																			
187		BH17		4.08					Sand (mf)	6.41	2	4.41	extreme			x																			
82	EB2125980013	BH17		4.32					Silty Sand (mf)	6.47	1.55	4.92	extreme			x			6.2	<	0.02						0.076	0.08	0.00	0.00	0.08	No	YES	5.75	NA
188		BH17		4.6					Sand (mc)	6.41	2.48	3.93	extreme			x																			
48	EB2123142004	BH18		0.30					Silty sand(fm), black	4.79	3.77	1.02	Moderate					x	5.6	<	0.02						0.014	0.01	0.00	0.00	0.01	No	No	NA	NA
189		BH18		0.7					Silty sand(fm), orange/brown	4.82	4.34	0.48	No reaction to slight					x																	
83	EB2125980014	BH18		1.10					Sand (md), yellow/cream, silt peds	4.78	4.49	0.29	No reaction to slight					x	6.1	<	0.02						0.016	0.02	0.00	0.00	0.02	No	No	NA	NA
49	EB2123142007	BH18		1.65					Clay and Sand (fm), black, firm	5.92	1.6	4.32	extreme			x			5		0.03						1.72	1.72	0.03	0.00	1.75	No	YES	132.45	NA
50	EB2123142008	BH18		2.16					Sandy Clay (mf)	6.17	1.73	4.44	extreme			x			5.8	<	0.02						0.188	0.19	0.00	0.00	0.19	No	YES	14.23	NA
190		BH18		2.64					Clayey Sand (md)	6.53	2.68	3.85	extreme			x																			
191		BH18		3.22					Clayey Sand (md)	6.6	3.46	3.14	extreme				x																		
192		BH18		3.92					Clayey Sand (fm)	6.79	4.41	2.38	Strong					x																	
84	EB2125980015	BH18		4.53					Sand (mf) w/ trace silt	7.15	5.1	2.05	Strong					x	6.2	<	0.02						0.027	0.03	0.00	0.00	0.03	No	No	NA	NA
51	EB2123142013	BH19		0.20					Silty sand(fm), black	4.84	2.67	2.17	Strong				x		5		0.03						0.033	0.03	0.03	0.00	0.06	No	YES	4.77	NA
52	EB2123142014	BH19		0.50					Sand (md), yellow/cream, silt peds	4.97	3.78	1.19	Moderate					x	5.9	<	0.02						0.012	0.01	0.00	0.00	0.01	No	No	NA	NA
53	EB2123142015	BH19		0.80					Sand (md), green/grey	5.5	1.48	4.02	extreme			x			5.6	<	0.02						0.162	0.16	0.00	0.00	0.16	No	YES	12.26	NA
54	EB2123142016	BH19		1.44					Sand (fm) with trace organics	5.13	1.25	3.88	extreme			x			5.8	<	0.02						0.168	0.17	0.00	0.00	0.17	No	YES	12.72	NA
193		BH19		1.87					Sand (fm) with trace organics	5.13	1.26	3.87	extreme			x																			
194		BH19		2.51					Sand (mc)	4.84	1.23	3.61	extreme			x																			
195		BH19		3.24					Sand (mc)	4.86	1.3	3.56	extreme			x																			
196		BH19		3.8					Sand (mc)	5.09	1.52	3.57	extreme			x																			
197		BH20		0.4					Silty sand(fm), black	5.25	4.43	0.82	No reaction to slight					x																	
198		BH20		0.8					Sand (md), yellow/cream, silt peds	4.97	4.59	0.38	No reaction to slight					x																	
55	EB2123142023	BH20		1.56					Sand (mf)	5.38	2.12	3.26	extreme			x			5.6	<	0.02						0.136	0.14	0.00	0.00	0.14	No	YES	10.29	NA
199		BH20		1.96					Sand (mf)	4.75	2.01	2.74	Strong				x																		
200		BH20		2.53					Sand (mf)	5.43	1.97	3.46	extreme			x																			
201		BH20		3.06					Sandy Clay (fm), black, soft	6	1.99	4.01	extreme			x																			
202		BH20		3.67					Sandy Clay (fm), black, soft	6.81	3.02	3.79	extreme			x																			
203		BH20		4.05					Sand (mc), compacted/hard	7.07	2.36	4.71	extreme			x																			
56	EB2123142029	BH21		0.20					Silty sand(fm), black	4.54	2.31	2.23	Strong		x	x			5.4	<	0.02						0.009	0.01	0.00	0.00	0.01	No	No	NA	NA
204		BH21		0.7					Sand (md), yellow/cream, silt peds	4.3	3.37	0.93	No reaction to slight		x																				
57	EB2123142031	BH21		1.33					Sand (fm)	5	1.86	3.14	extreme			x			5.7	<	0.02						0.177	0.18	0.00	0.00	0.18	No	YES	13.40	NA
85	EB2125980016	BH21		1.72					Sand (fm), trace organics (rootlets)	4.98	1.98	3	Strong			x			5.9	<	0.02						0.184	0.18	0.00	0.00	0.18	No	YES	13.93	NA
58	EB2123142033	BH21		2.12					Clayey sand (fm), black, soft	5.84	1.83	4.01	extreme			x			5.2	<	0.02						0.652	0.65	0.00	0.00	0.65	No	YES	49.35	NA
86	EB2125980017	BH21		2.58					Clayey sand (fm), black, soft	5.57	3.03	2.54	Strong					x	5.5	<	0.02						0.043	0.04	0.00	0.00	0.04	No	YES	3.25	NA
205		BH21		2.99					Clayey sand (fm), black, soft	6.02	3.61	2.41	Strong					x																	
93	EB2127300002	BH21		3.43					Clayey sand (fm), black, soft	6.56	4.36	2.2	Strong					x	6.1	<	0.02						0.246	0.25	0.00	0.00	0.25	No	YES	18.62	NA
206		BH21		3.88					Clayey sand (fm), black, soft	6.82	4.73	2.09	Strong					x																	
207		BH21		4					Clayey sand (fm), black, soft	6.81	4.55	2.26	Strong					x																	
59	EB2123142039	BH22		0.30					Silty sand(fm), black	4.82	2.51	2.31	Strong				x		5.1		0.03						0.019	0.02	0.03	0.00	0.05	No	No	NA	NA
208		BH22		0.8					Sand (md), yellow/cream, silt peds	4.83	4.18	0.65	No reaction to slight					x																	
209		BH22		1.34					Sand (fm)	4.96	1.95	3.01	extreme			x																			
87	EB2125980018	BH22		1.68					Sand (fm)	5.45	2	3.45	extreme			x			5.8	<	0.02						0.184	0.18	0.00	0.00	0.18	No	YES	13.93	NA
60	EB2123142043	BH22		2.00					Sand (fm)	6.34	1.9	4.44	extreme			x			5.8	<	0.02						0.678	0.68	0.00	0.00	0.68	No	YES	51.32	NA
61	EB2123142044	BH22		2.30					Clayey Sand (fm), black soft	6.88	2.21	4.67	extreme			x			5.5	<	0.02						2.36	2.36	0.00	0.00	2.36	No	YES	178.62	NA
88	EB2125980019	BH22		2.76					Clay, black, firm, trace sand (fm)	6.94	2.1	4.84	extreme			x			5.9	<	0.02						0.162	0.16	0.00	0.00	0.16	No	YES	12.26	NA
94	EB2127300003	BH22		3.15					Clayey Sand (fm), black soft	7.1	1.87	5.23	extreme			x			6	<	0.02						0.586	0.59	0.00	0.00	0.59	No	YES	44.35	NA
89	EB2125980020	BH22		3.56					Silty sand (fm)	7.06	1.92	5.14	extreme			x			6	<	0.02						0.482	0.48	0.00	0.00	0.48	No	YES	36.48	NA
210		BH22		3.89					Silty sand (fm)	6.98	2.61	4.37	extreme			x																			
211		BH22		4.4					Sand (mc)	7.16	4.48	2.68	Strong					x																	
62	EB2123142050	BH23		0.30					Silty sand(fm), black	5.35	2.77	2.58	Strong				x		5.2		0.02						0.035	0.04	0.02	0.00	0.06	No	YES	4.16	NA
63	EB2123142051	BH23		0.80					Sand (md), yellow/cream, silt peds	4.99	3.81	1.18	Moderate						5.9	<	0.02						0.015	0.02	0.00	0.00	0.02	No	No	NA	NA
64	EB2123142052	BH23		1.17					Sand (fm), trace organics (rootlets)	4.39	2.04	2.35	Strong		x	x			5.6	<	0.02						0.232	0.23	0.00	0.00	0.23	No	YES	17.56	NA
65	EB2123142053	BH23		1.61					Silty sand (fm)	4.5	2.06	2.44	Strong		x	x			5.8	<	0.02						0.218	0.22	0.00	0.00	0.22	No	YES	16.50	NA
67	EB2123142054	BH23		1.96					Clay, black, firm	4.56	1.98	2.58	Strong		x	x			4.9		0.04						2.98	2.98	0.04	0.00	3.02	No	YES	228.57	NA
212		BH23		2.3					Sandy clay (mf), black, soft	5.93	2.23	3.7	extreme																						
213		BH23		2.59					Clay, black, firm, trace sand (fm)	5.74	2.26	3.48	extreme																						
95	EB2127300004	BH23		2.86					Clay, black stiff	5.59	3.22	2.37	Strong					x	5.8	<	0.02						0.047	0.05	0.00	0.00	0.05	No	YES	3.56	NA
214		BH23		3.2					Clay, black stiff	5.07	3.35	1.72	Moderate					x																	
68	EB2123142059	BH24		0.30					Silty sand(fm), black	5.4	3.8	1.6	Moderate					x	5.8	<	0.02						0.069	0.07	0.00	0.00	0.07	No	YES	5.22	NA
215		BH24		0.8					Sand (md), yellow/cream, silt peds	4.6	4.26	0.34	No reaction to slight					x																	
216		BH24		1.25					Sand (fm), trace organics (rootlets)	4.45	2.07	2.38	Strong		x	x																			
66	EB2123142062	BH24		1.74					Sand (mc), trace organics (rootlets)	4.54	1.71	2.83	Strong		x	x			5.6	<	0.02						0.148	0.15	0.00	0.00	0.15	No	YES	11.20	NA
69	EB2123142063	BH24		2.28					Sand (mc)	4.63	1.58	3.05	extreme			x			5.7	<	0.02						0.172	0.17	0.00	0.00	0.17	No	YES	13.02	NA
217		BH24		2.79					Sand (mc)	4.66	1.6	3.06	extreme			x																			
91	EB2125980022	BH24		3.17					Silty sand (fm), black, soft	5.78	1.44	4.34	extreme			x			6	<	0.02						0.095	0.10	0.00	0.00	0.10	No	YES	7.19	NA
218		BH24		3.62					Sand (cc)	5.83	2.43	3.4	extreme			x																			
219		BH24		4.02					Silty sand (fm), black, soft	6.34	1.98	4.36	extreme			x																			

A-2 Tabulated Groundwater Data

Table A-2 Groundwater Data September 2022

EW2204148
Gerroa Boreholes (Quarterly)

				ALS Sample number:	EW2204148001	EW2204148002	EW2204148003	EW2204148004	EW2204148005	EW2204148007	EW2204148010	EW2204148012	EW2204148006	EW2204148016	EW2204148017	EW2204148018	EW2204148019	EW2204148024
				Sample date:	9/09/2022	9/09/2022	9/09/2022	9/09/2022	9/09/2022	9/09/2022	9/09/2022	9/09/2022	9/09/2022	9/09/2022	9/09/2022	9/09/2022	9/09/2022	9/09/2022
				Client sample ID (Primary):	MW1	MW1A	MW1D	MW2A	MW2B	MW3C	MW02(07)	MW04(07)	MW3A	NB02	NB03	NB04	MW07	NB01
				Client sample ID (Secondary):														
				ANZG 2018 incl HMTV														
EA005FD: Field pH																		
pH		pH Unit	0.1		5	----	7.3	7.6	7	7.6	7.7	7.7	----	5.9	6.7	6.9	----	7.2
Electrical Conductivity (Non Compensated)		ÂµS/cm	1		6820	----	1560	636	1100	1090	510	528	----	173	134	8480	----	837
Total Dissolved Solids @180Â°C		mg/L	10		----	----	1070	308	----	----	308	----	----	195	102	5970	----	494
Salinity		g/L	0.2		3.8	----	0.8	0.3	0.6	0.5	0.2	0.3	----	<0.2	<0.2	4.8	----	0.4
Turbidity		NTU	0.1		----	----	----	----	----	----	----	----	----	----	----	----	----	----
Redox Potential		mV	0.1		----	----	-49	-77.5	----	----	-89.8	----	----	-34.9	-95.7	137	----	114
Hydroxide Alkalinity as CaCO3	DMO-210-001	mg/L	1		<1	----	<1	<1	<1	<1	<1	<1	----	<1	<1	<1	----	<1
Carbonate Alkalinity as CaCO3	3812-32-6	mg/L	1		<1	----	<1	<1	<1	<1	<1	<1	----	<1	<1	<1	----	<1
Bicarbonate Alkalinity as CaCO3	71-52-3	mg/L	1		4	----	262	187	142	202	102	96	----	15	18	100	----	37
Total Alkalinity as CaCO3		mg/L	1		4	----	262	187	142	202	102	96	----	15	18	100	----	37
Acidity as CaCO3		mg/L	1		----	----	14	7	----	----	6	----	----	24	10	13	----	6
Acidity as CaCO3 (pH 3.7)		mg/L	1		----	----	0	<1	----	----	<1	----	----	<1	<1	<1	----	<1
Acidity as CaCO3 (pH 8.3)		mg/L	1		----	----	14	7	----	----	6	----	----	24	10	13	----	6
Acidity as H2SO4		mg/L	1		----	----	14	7	----	----	6	----	----	23	10	12	----	6
Sulfate as SO4 - Turbidimetric	14808-79-8	mg/L	1		686	----	434	16	170	158	45	47	----	<10	<1	394	----	27
Chloride	16887-00-6	mg/L	1		1730	----	119	29	155	120	66	68	----	34	21	2700	----	227
Calcium	7440-70-2	mg/L	1		----	----	200	70	----	----	41	----	----	6	4	171	----	12
Magnesium	7439-95-4	mg/L	1		138	----	37	6	19	19	11	11	----	2	3	159	----	11
Sodium	7440-23-5	mg/L	1		1170	----	85	22	87	79	43	45	----	21	10	1250	----	113
Potassium	7/09/7440	mg/L	1		3	----	6	<1	3	6	4	4	----	3	3	37	----	13
Aluminium	7429-90-5	mg/L	0.01	**0.055**	----	----	0.02	<0.01	----	----	0.03	----	----	**1.91**	**0.14**	<0.01	----	0.07
Arsenic	7440-38-2	mg/L	0.001	**0.024**	----	----	<0.001	0.008	----	----	<0.001	----	----	0.007	<0.001	<0.001	----	<0.001
Beryllium	7440-41-7	mg/L	0.001	**0.0013**	----	----	<0.001	<0.001	----	----	<0.001	----	----	<0.001	<0.001	<0.001	----	<0.001
Barium	7440-39-3	mg/L	0.001	**0.137**	----	----	0.024	0.049	----	----	0.029	----	----	0.104	0.092	0.041	----	0.016
Cadmium	7440-43-9	mg/L	0.0001	**0.002**	----	----	<0.0001	<0.0001	----	----	<0.0001	----	----	<0.0001	<0.0001	<0.0001	----	<0.0001
Chromium	7440-47-3	mg/L	0.001	**0.03**	----	----	0.002	<0.001	----	----	<0.001	----	----	0.003	<0.001	<0.001	----	0.001
Cobalt	7440-48-4	mg/L	0.001	**0.0028**	----	----	<0.001	<0.001	----	----	<0.001	----	----	<0.001	<0.001	<0.001	----	<0.001
Copper	7440-50-8	mg/L	0.001	**0.013**	----	----	<0.001	<0.001	----	----	<0.001	----	----	<0.001	<0.001	<0.001	----	0.002
Lead	7439-92-1	mg/L	0.001	**0.048**	----	----	<0.001	<0.001	----	----	<0.001	----	----	<0.001	<0.001	<0.001	----	<0.001
Manganese	7439-96-5	mg/L	0.001	**1.9**	----	----	0.122	0.176	----	----	0.006	----	----	0.007	0.087	0.239	----	0.004
Nickel	7440-02-0	mg/L	0.001	**0.105**	----	----	<0.001	0.001	----	----	<0.001	----	----	<0.001	0.001	0.002	----	0.001
Selenium	7782-49-2	mg/L	0.01	**0.0011**	----	----	<0.01	<0.01	----	----	<0.01	----	----	<0.01	<0.01	<0.01	----	<0.01
Vanadium	7440-62-2	mg/L	0.01	**0.0012 (low reliability)**	----	----	<0.01	<0.01	----	----	<0.01	----	----	<0.01	<0.01	<0.01	----	<0.01
Zinc	7440-66-6	mg/L	0.005	**0.076**	----	----	**0.086**	0.064	----	----	0.039	----	----	**0.116**	0.042	**0.083**	----	0.014
Boron	7440-42-8	mg/L	0.05	**0.37**	----	----	0.08	<0.05	----	----	<0.05	----	----	0.06	<0.05	0.52	----	0.12
Iron	7439-89-6	mg/L	0.05	**use 95% ile**	1.19	----	9.25	2.77	12.9	5.7	0.13	<0.05	----	0.82	1.32	<0.05	----	0.5
Aluminium - Total	7429-90-5	mg/L	0.01		----	----	0.37	0.51	----	----	0.61	----	----	3.36	0.47	0.04	----	0.82
Iron - Total	7439-89-6	mg/L	0.05		----	----	28.9	51.2	----	----	1.22	----	----	1.6	3.53	18.2	----	5
Mercury	7439-97-6	mg/L	0.0001		----	----	<0.0001	<0.0001	----	----	<0.0001	----	----	<0.0001	<0.0001	<0.0001	----	<0.0001
Ferrous Iron		mg/L	0.05		----	----	10	2.93	----	----	0.16	----	----	0.91	1.42	<0.05	----	0.15
Ferric Iron		mg/L	0.05		----	----	<0.05	<0.05	----	----	<0.05	----	----	<0.05	<0.05	<0.05	----	0.35
Ammonium as N	14798-03-9_N	mg/L	0.01		1.23	----	0.82	0.39	0.29	0.4	0.07	<0.01	----	0.06	0.39	0.04	----	0.03
Ammonia as N	7664-41-7	mg/L	0.01		----	----	0.83	0.4	----	----	0.07	----	----	0.06	0.39	0.04	----	0.03
Nitrite as N	14797-65-0	mg/L	0.01		----	----	<0.01	<0.01	----	----	<0.01	----	----	<0.01	<0.01	<0.01	----	<0.01
Nitrate as N	14797-55-8	mg/L	0.01		----	----	0.04	0.02	----	----	0.01	----	----	0.01	<0.01	0.92	----	1.43
Nitrite + Nitrate as N		mg/L	0.01		0.06	----	0.04	0.02	<0.01	0.01	0.01	0.44	----	0.01	<0.01	0.92	----	1.43
Total Kjeldahl Nitrogen as N		mg/L	0.1		1.4	----	1.1	0.4	1.1	0.9	0.6	0.4	----	1.6	1.1	0.3	----	1.6
Total Nitrogen as N		mg/L	0.1		1.5	----	1.1	0.4	1.1	0.9	0.6	0.8	----	1.6	1.1	1.2	----	3
Total Phosphorus as P		mg/L	0.01		0.04	----	0.1	1.09	0.15	0.18	0.1	0.09	----	0.08	0.74	<0.02	----	0.2
Reactive Phosphorus as P	14265-44-2	mg/L	0.01		----	----	<0.01	<0.01	----	----	0.02	----	----	<0.01	0.21	<0.01	----	0.03
Field Observations		--	0.01		----	Insufficient Sample	----	----	----	----	----	----	No Safe Access	----	----	----	NO SAFE ACCESS	----
Chlorophyll a		mg/mÂ³	1		1	----	<1	<1	<1	<1	<1	<1	----	<1	<1	<1	----	<1
Dissolved Oxygen		mg/L	0.01		----	----	----	----	----	----	----	----	----	4.44	5.16	7.34	----	9.46
Dissolved Oxygen - % Saturation		% saturation	0.1		----	----	----	----	----	----	----	----	----	44.3	50.8	78.9	----	95.2

APPENDIX B SOLUBLE IRON 95THILES

	0	1	2	3	4	5	6	7	8	9	10	11
	MW1	MW1A	MW1D	MW2A	MW2B	MW3A	MW3C	MW4	MW01(07)	MW02(07)	MW03(07)	MW04(07)
1									0.06	0.82	0.07	0.13
2									2.2	18	8.1	1.3
3									0.15	6.8	1.9	0.19
4									0.23	16	0.29	0.57
5									0.41	4.9	0.42	8.5
6									0.53	6.8	1.4	5
7									0.5	3.8	1	2.6
8									0.54	5.6	0.22	4.4
9									0.66	6.4	2.1	16
10									0.34	3.4	0.91	9.4
11									0.46	5.6	0.66	19
12									1.9	3.6	3.2	14
13									0.55	1.7	1.6	7.6
14									1.2	2.7	2.5	9.3
15									0.42	1.7	1.2	26
16	19			15		3.3			0.79	9.9	0.05	2.6
17	10	1.1	19	41	21	22	0.27	0.53	1.3	15	3.3	11
18	11		6.7	12	13	17	0.87			29	20	44
19	17		3.1	26	9.2	9.1	0.58			17		19
20	45.2		13.3	9.21	8.8	2.62	3.93			3.3	2.09	5.55
21	7.57		27.3	13.8	22.5	5.64	8.57	2.99		13.9	5.12	0.77
22	0.57	3.93	2.2	0.96		0.18	1.96	0.1	0.025	13.9	0.11	0.09
23	43.9		2.7	0.025	2.72	3.42	3.33	0.39		1.56	0.34	0.53
24	59.6	1	3.13	4.74	5.7	0.97	1.92			3.56	0.14	1.44
25	50.9	1.4	0.63	0.15	3.14	1.02	1.68			4.09	0.2	0.2
26	0.87		0.43	0.52	0.98	0.65	1.69	0.13		0.55	0.05	0.24
27	65.9	2.71	2.76	16.5	7.83	6.16	3.77	19.5		4.81	1.46	1.94
28	38.8	4.23	0.63	3.09	3.62	4.46	1.23	1.9	0.025	2.96	0.13	0.34
29	48.1	1.26	0.99	12.5	6.06	0.56	1.49	2.96	0.12	5.1	0.32	1.71
30	0.2		3.21	15.1	2.81	1.49	3.8			1.6	0.14	3.14
31			3.58	13.8	3.4	1.84	1.15			1.09		3.63
32	56.9		1.56	8.04	4.21	3.82	0.37			5.65		4.18
33	0.28	1.3	0.86	23.7	4.78	3.59	0.2	1.15		6		2.11
34	55.1	0.46	0.44	24.2	3.94	0.34	0.79	2.79	0.07	2.76	0.18	0.08
35	81.4	1.01	0.96	21	5.4	7	0.52			1.54		0.08
36	83.5		1.84	17.2	2.62	4.07	0.5			1.34		0.025
37	0.32	1.54	0.26	10.8	0.1	2.05	0.17	2.15		0.59		0.025
38	1.12	1.24	0.25	23.3	1.08	15.2	0.36			2.8		0.025
39	33.9		0.9	17.8	4.34	10.1	0.19			1.6		0.025
40	120		0.78	15.7	2.11	6.5	0.45			1.89		0.08
41	3.5	0.96	0.25	17.9	3.58	2.59	0.07			1.26		0.025
42	6.6		0.14	14.7	0.36	0.3	0.15	1.08	0.12	0.36		0.025
43	35	0.49	0.78	18.1	1.56	21.7	0.23	0.89		2.9		0.25
44	63.7	0.65	0.84	11.8	2.88	16.8	1.86	0.83		4.61		0.025
45	0.16	0.58	0.54	19	3.34	4.57	0.09	2.28		2.98		0.23
46	41.6	4.4	0.21	25	1.02	1.12	1.91	0.61				0.025
47	7.46		0.38	10.6	0.74	18.4	0.51					0.06
48	69.1	1.36	0.78	0.14	1.88	6.55	1.62		4.23			0.025
49	40.9	0.53	0.66	24.7	2.11	4.8	1.23		1.78	2.51		0.14
50	0		0	0	0	0	0			0		0
51	0		0	0	0	0	0			0		0
52	0		0	0	0	0	0			0		0
53	0		0	0	0	0	0			0		0.025
54	0		0	0	0	0	0			0		0.025

	12	13	14	15	16	17	18
	MW05(07)	NB2	NB3	NB4	MW07	MW5	MW06(07)
1	0.13						1.9
2	2.8						6.2
3	0.15						10
4	0.33						7.6
5	0.42						4.3
6	0.57						1.4
7	0.64						18
8	0.49						33
9	4.5						19
10	1.1						21
11	1.3						16
12	4.1						20
13	2.2						12
14	2.3						33
15	11						1.2
16							7.1
17							4.9
18							17
19							22
20							51.4
21							21.1
22							0.31
23	0.82						0.51
24							1.77
25							0.53
26	0.27						0.13
27							2.18
28	1.11					0.38	1.17
29	3.49						4.71
30	2.36						
31							
32							
33							
34	5.88						
35							
36							
37							
38							
39							
40							
41	11.7						
42	1.35						
43							
44							
45	2.22						
46	4.36						
47							
48	1.09						
49	1.7						
50							
51							
52							
53							
54							

General Statistics on Uncensored Full Data

Date/Time of Computation	ProUCL 5.2 19/10/2022 12:18:15 PM
User Selected Options	
From File	WorkSheet.xls
Full Precision	OFF

From File: WorkSheet.xls

General Statistics for Uncensored Data Sets

Variable	NumObs	# Missing	Minimum	Maximum	Mean	Geo-Mean	SD	SEM	MAD/0.675	Skewness
MW1	52	17	0	120	21.52	0	29.41	4.078	3.425	1.312
MW1A	22	45	0	4.4	1.37	0	1.298	0.277	0.712	1.428
MW1D	52	17	0	27.3	1.963	0	4.859	0.674	0.645	4.014
MW2A	54	15	0	41	9.038	0	10.05	1.368	9.474	0.842
MW2B	51	18	0	22.5	3.075	0	4.772	0.668	2.313	2.685
MW3A	52	15	0	22	4.037	0	5.933	0.823	1.935	1.835
MW3C	53	16	0	8.57	0.895	0	1.512	0.208	0.341	3.067
MW4	16	30	0.1	19.5	2.518	1.127	4.637	1.159	1.312	3.691
MW01(07)	26	42	0	4.23	0.716	0	0.944	0.185	0.497	2.421
MW02(07)	66	3	0	29	3.847	0	5.492	0.676	2.661	2.408
MW03(07)	31	31	0	20	1.91	0	3.784	0.68	0.875	4.019
MW04(07)	69	0	0	44	3.301	0	7.282	0.877	0.193	3.52
MW05(07)	29	39	0	11.7	2.358	0	2.928	0.544	1.483	2.181
NB2	13	56	0	6.02	2.071	0	1.465	0.406	0.608	1.383
NB3	13	56	0	2.91	1.058	0	0.971	0.269	0.919	0.771
NB4	13	56	0	92.7	45.43	0	35.76	9.917	49.96	0.0509
MW07	9	60	0	109	82.86	0	34.77	11.59	18.68	-2.033
MW5	1	27	0.38	0.38	0.38	0.38	N/A	N/A	0	N/A
MW06(07)	29	0	0.13	51.4	11.7	5.216	12.42	2.307	9.741	1.453

Percentiles for Uncensored Data Sets

Variable	NumObs	# Missing	10%ile	20%ile	25%ile(Q1)	50%ile(Q2)	75%ile(Q3)	80%ile	90%ile	95%ile
MW1	52	17	0	0	0	2.31	42.18	47.52	63.29	74.63
MW1A	22	45	0.046	0.498	0.543	1.055	1.39	1.512	3.808	4.215
MW1D	52	17	0	0	0	0.435	1.133	2.128	3.202	9.67
MW2A	54	15	0	0	0	6.39	16.3	17.84	23.58	24.81
MW2B	51	18	0	0	0	1.56	3.78	4.34	7.83	11.1
MW3A	52	15	0	0	0	1.305	5.01	6.432	14.69	17.63
MW3C	53	16	0	0	0	0.23	1.23	1.656	1.952	3.782
MW4	16	30	0.26	0.53	0.59	1.115	2.408	2.79	2.975	7.118
MW01(07)	26	42	0.025	0.07	0.12	0.44	0.758	1.2	1.84	2.125
MW02(07)	66	3	0	0	0	1.795	4.878	5.6	11.9	15.75
MW03(07)	31	31	0.07	0.14	0.16	0.66	1.995	2.1	3.3	6.61
MW04(07)	69	0	0	0.025	0.025	0.13	2.6	4.268	9.72	17.8
MW05(07)	29	39	0.146	0.384	0.49	1.3	2.8	3.734	4.776	8.952
NB2	13	56	0.31	1.602	1.68	1.96	2.48	2.522	2.742	4.082
NB3	13	56	0.05	0.294	0.36	0.85	1.66	1.72	2.472	2.754
NB4	13	56	0.54	9.38	19.4	33.7	73	80.5	90.94	92.46
MW07	9	60	47.12	73.12	82.6	92.4	105	106.6	109	109
MW5	1	27	0.38	0.38	0.38	0.38	0.38	0.38	0.38	0.38
MW06(07)	29	0	0.526	1.32	1.77	7.1	19	20.4	24.2	33

APPENDIX C SURFACE & GROUNDWATER QUALITY – DISSOLVED METALS CRITERIA

Appendix C-1 - Surface water criteria (interim)

	Calcium	Magnesium	Hardness	TDS	
Existing Works	40	10	141	338	mg/L

Total permanent water hardness is calculated with the following formula:

TOTAL PERMANENT HARDNESS = CALCIUM HARDNESS + MAGNESIUM HARDNESS

The calcium and magnesium hardness is the concentration of calcium and magnesium ions expressed as equivalent of calcium carbonate. The molar mass of $CaCO_3$, Ca^{2+} and Mg^{2+} are respectively 100,1 g/mol, 40,1 g/mol and 24,3 g/mol.

The ratio of the molar masses are:

$$\frac{M_{CaCO_3}}{M_{Ca}} = \frac{100,1}{40,1} = 2,5 \qquad \frac{M_{CaCO_3}}{M_{Mg}} = \frac{100,1}{24,3} = 4,1$$

So total permanent water hardness expressed as equivalent of $CaCO_3$ can be calculated with the following formula:

$$[CaCO_3] = 2,5 \cdot [Ca^{2+}] + 4,1 \cdot [Mg^{2+}]$$

Table 3.4.3 General form of the hardness-dependent algorithms describing guideline values for selected metals in freshwaters

Metal	Hardness-dependent algorithm
Cadmium	$HMTV = TV\ (H/30)^{0.89}$
Chromium(III)	$HMTV = TV\ (H/30)^{0.82}$
Copper	$HMTV = TV(H/30)^{0.85}$
Lead	$HMTV = TV(H/30)^{1.27}$
Nickel	$HMTV = TV(H/30)^{0.85}$
Zinc	$HMTV = TV(H/30)^{0.85}$

HMTV, hardness-modified trigger value (µg/L); TV, trigger value (µg/L) at a hardness of 30 mg/L as $CaCO_3$; H, measured hardness (mg/L as $CaCO_3$) of a fresh surface water (≤2.5‰). From Markich et al (in press).

Table 3.4.4 Approximate factors to apply to soft water trigger values for selected metals in freshwaters of varying water hardness[a]

Hardness category[b] (mg/L as $CaCO_3$)	Water hardness[c] (mg/L as $CaCO_3$)	Cd	Cr(III)	Cu	Pb	Ni	Zn
Soft (0–59)	30	TV	TV	TV	TV	TV	TV
Moderate (60–119)	90	X 2.7	X 2.5	X 2.5	X 4.0	X 2.5	X 2.5
Hard (120–179)	150	X 4.2	X 3.7	X 3.9	X 7.6	X 3.9	X 3.9
Very hard (180–240)	210	X 5.7	X 4.9	X 5.2	X 11.8	X 5.2	X 5.2
Extremely hard (400)	400	X 10.0	X 8.4	X 9.0	X 26.7	X 9.0	X 9.0

a Trigger values from table 3.4.1;

b Range of water hardness (mg/L as $CaCO_3$) for each category as defined by CCREM (1987);

c Mid-range value of each water hardness category. For example, a copper trigger value of 1.4 µg/L (from table 3.4.1) with 95% protection level chosen (e.g. slightly–moderately disturbed system) is applied to a site with very hard water (e.g. 210 mg/L as $CaCO_3$) by multiplying the trigger value by 5.2 to give a site-specific trigger value of 7.3 µg/L. If the hardness is away from the mid-range, it may be preferable to use the algorithm.

95%	TV (ug/L)	H		Factor	HMTV (ug/L)
Cadmium	0.2	141	30	0.89	0.8
Chromium (III)	3.3	141	30	0.82	13
Copper	1.4	141	30	0.85	6
Lead	3.4	141	30	1.27	20
Nickel	11	141	30	0.85	44
Zinc	8	141	30	0.85	32

	FW 95%	mg/L	ug/L	Max GW BK	SD GW BK	TV
Aluminium >pH 6.5	55	<0.01	<10			
Arsenic (III)	24	0.001	1			
Arsenic (V)	13					
Beryllium*	1.3	<0.001	<1			
Barium	No Criteria	0.043	43	104	33	137
Cadmium	0.8	<0.0001	<0.1			
Chromium	13	<0.001	<1			
Cobalt	2.8	<0.001	<1			
Copper	6	<0.001	<1			
Lead	20	<0.001	<1			
Manganese	1900	0.002	2			
Nickel	44	<0.001	<1			
Selenium (total)	11	<0.01	<10			
Vanadium**	12	<0.01	<10			
Zinc	32	0.04	40	116	36	152
Boron	370	<0.05	<50			
Iron	95th%ile	<0.05	<50			

*AF100

**AF10

Appendix C-2 - Groundwater Criteria (Interim)

	Calcium	Magnesium	Hardness	TDS	
Groundwater	72	38	336	1206	mg/L

Total permanent water hardness is calculated with the following formula:

TOTAL PERMANENT HARDNESS = CALCIUM HARDNESS + MAGNESIUM HARDNESS

The calcium and magnesium hardness is the concentration of calcium and magnesium ions expressed as equivalent of calcium carbonate. The molar mass of $CaCO_3$, Ca^{2+} and Mg^{2+} are respectively 100,1 g/mol, 40,1 g/mol and 24,3 g/mol.

The ratio of the molar masses are:

$$\frac{M_{CaCO_3}}{M_{Ca}} = \frac{100{,}1}{40{,}1} = 2{,}5 \qquad \frac{M_{CaCO_3}}{M_{Mg}} = \frac{100{,}1}{24{,}3} = 4{,}1$$

So total permanent water hardness expressed as equivalent of $CaCO_3$ can be calculated with the following formula:

$$[CaCO_3] = 2.5 \cdot [Ca^{2+}] + 4.1 \cdot [Mg^{2+}]$$

Table 3.4.3 General form of the hardness-dependent algorithms describing guideline values for selected metals in freshwaters

Metal	Hardness-dependent algorithm
Cadmium	$HMTV = TV\,(H/30)^{0.89}$
Chromium(III)	$HMTV = TV\,(H/30)^{0.82}$
Copper	$HMTV = TV(H/30)^{0.85}$
Lead	$HMTV = TV(H/30)^{1.27}$
Nickel	$HMTV = TV(H/30)^{0.85}$
Zinc	$HMTV = TV(H/30)^{0.85}$

HMTV, hardness-modified trigger value (µg/L); TV, trigger value (µg/L) at a hardness of 30 mg/L as $CaCO_3$; H, measured hardness (mg/L as $CaCO_3$) of a fresh surface water (≤2.5‰). From Markich et al (in press).

Table 3.4.4 Approximate factors to apply to soft water trigger values for selected metals in freshwaters of varying water hardness[a]

Hardness category[b] (mg/L as $CaCO_3$)	Water hardness[c] (mg/L as $CaCO_3$)	Cd	Cr(III)	Cu	Pb	Ni	Zn
Soft (0–59)	30	TV	TV	TV	TV	TV	TV
Moderate (60–119)	90	X 2.7	X 2.5	X 2.5	X 4.0	X 2.5	X 2.5
Hard (120–179)	150	X 4.2	X 3.7	X 3.9	X 7.6	X 3.9	X 3.9
Very hard (180–240)	210	X 5.7	X 4.9	X 5.2	X 11.8	X 5.2	X 5.2
Extremely hard (400)	400	X 10.0	X 8.4	X 9.0	X 26.7	X 9.0	X 9.0

a Trigger values from table 3.4.1;

b Range of water hardness (mg/L as $CaCO_3$) for each category as defined by CCREM (1987);

c Mid-range value of each water hardness category. For example, a copper trigger value of 1.4 µg/L (from table 3.4.1) with 95% protection level chosen (e.g. slightly–moderately disturbed system) is applied to a site with very hard water (e.g. 210 mg/L as $CaCO_3$) by multiplying the trigger value by 5.2 to give a site-specific trigger value of 7.3 µg/L. If the hardness is away from the mid-range, it may be preferable to use the algorithm.

95%	TV (ug/L)	H		Factor	HMTV (ug/L)
Cadmium	0.2	336	30	0.89	2.0
Chromium (III)	3.3	336	30	0.82	30
Copper	1.4	336	30	0.85	13
Lead	3.4	336	30	1.27	48
Nickel	11	336	30	0.85	105
Zinc	8	336	30	0.85	76

	FW 95%	Max GW BK	SD GW BK	Interim Review Value
	µg/L	µg/L	µg/L	µg/L
Aluminium >pH 6.5	55	1900	800	2700
Arsenic (III)	24			24
Arsenic (V)	13			13
Beryllium*	1.3			1.3
Barium	No Criteria	104	33	137
Cadmium	2.0			2.0
Chromium	30			30
Cobalt	2.8			2.8
Copper	13			13
Lead	48			48
Manganese	1900			1900
Nickel	105			105
Selenium (total)	11			11
Vanadium**	12			12
Zinc	76	116	36	152
Boron	370			370
Iron	95th%ile			95th%ile

*AF100

**AF10

	A–E	F	G–K	L
1	UCL Statistics for Uncensored Full Data Sets			
2				
3	User Selected Options			
4	Date/Time of Computation	ProUCL 5.2 31/10/2022 10:55:24 AM		
5	From File	WorkSheet.xls		
6	Full Precision	OFF		
7	Confidence Coefficient	95%		
8	Number of Bootstrap Operations	2000		
9				
10				
11	zinc			
12				
13	General Statistics			
14	Total Number of Observations	10	Number of Distinct Observations	9
15			Number of Missing Observations	14
16	Minimum	0.009	Mean	0.0507
17	Maximum	0.116	Median	0.041
18	SD	0.0357	Std. Error of Mean	0.0113
19	Coefficient of Variation	0.705	Skewness	0.559
20				
21	Normal GOF Test			
22	Shapiro Wilk Test Statistic	0.924	Shapiro Wilk GOF Test	
23	1% Shapiro Wilk Critical Value	0.781	Data appear Normal at 1% Significance Level	
24	Lilliefors Test Statistic	0.196	Lilliefors GOF Test	
25	1% Lilliefors Critical Value	0.304	Data appear Normal at 1% Significance Level	
26	Data appear Normal at 1% Significance Level			
27				
28	Assuming Normal Distribution			
29	95% Normal UCL		95% UCLs (Adjusted for Skewness)	
30	95% Student's-t UCL	0.0714	95% Adjusted-CLT UCL (Chen-1995)	0.0714
31			95% Modified-t UCL (Johnson-1978)	0.0717
32				
33	Gamma GOF Test			
34	A-D Test Statistic	0.354	Anderson-Darling Gamma GOF Test	
35	5% A-D Critical Value	0.737	Detected data appear Gamma Distributed at 5% Significance Level	
36	K-S Test Statistic	0.182	Kolmogorov-Smirnov Gamma GOF Test	
37	5% K-S Critical Value	0.27	Detected data appear Gamma Distributed at 5% Significance Level	
38	Detected data appear Gamma Distributed at 5% Significance Level			
39				
40	Gamma Statistics			
41	k hat (MLE)	1.869	k star (bias corrected MLE)	1.375
42	Theta hat (MLE)	0.0271	Theta star (bias corrected MLE)	0.0369
43	nu hat (MLE)	37.37	nu star (bias corrected)	27.5
44	MLE Mean (bias corrected)	0.0507	MLE Sd (bias corrected)	0.0432
45			Approximate Chi Square Value (0.05)	16.54
46	Adjusted Level of Significance	0.0267	Adjusted Chi Square Value	15.08
47				
48	Assuming Gamma Distribution			
49	95% Approximate Gamma UCL	0.0843	95% Adjusted Gamma UCL	0.0925
50				
51	Lognormal GOF Test			
52	Shapiro Wilk Test Statistic	0.915	Shapiro Wilk Lognormal GOF Test	
53	10% Shapiro Wilk Critical Value	0.869	Data appear Lognormal at 10% Significance Level	
54	Lilliefors Test Statistic	0.213	Lilliefors Lognormal GOF Test	
55	10% Lilliefors Critical Value	0.241	Data appear Lognormal at 10% Significance Level	
56	Data appear Lognormal at 10% Significance Level			
57				
58	Lognormal Statistics			
59	Minimum of Logged Data	-4.711	Mean of logged Data	-3.273
60	Maximum of Logged Data	-2.154	SD of logged Data	0.874
61				
62	Assuming Lognormal Distribution			
63	95% H-UCL	0.127	90% Chebyshev (MVUE) UCL	0.0987
64	95% Chebyshev (MVUE) UCL	0.119	97.5% Chebyshev (MVUE) UCL	0.148
65	99% Chebyshev (MVUE) UCL	0.205		
66				
67	Nonparametric Distribution Free UCL Statistics			
68	Data appear to follow a Discernible Distribution			
69				
70	Nonparametric Distribution Free UCLs			
71	95% CLT UCL	0.0693	95% BCA Bootstrap UCL	0.0701
72	95% Standard Bootstrap UCL	0.0683	95% Bootstrap-t UCL	0.0774
73	95% Hall's Bootstrap UCL	0.0723	95% Percentile Bootstrap UCL	0.0681
74	90% Chebyshev(Mean, Sd) UCL	0.0846	95% Chebyshev(Mean, Sd) UCL	0.1
75	97.5% Chebyshev(Mean, Sd) UCL	0.121	99% Chebyshev(Mean, Sd) UCL	0.163
76				
77	Suggested UCL to Use			
78	95% Student's-t UCL	0.0714		
79				
80	Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL			
81	Recommendations are based upon data size, data distribution, and skewness using results from simulation studies			
82	However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician			
83				
84				
85	BARIUM			
86				
87	General Statistics			

Total Number of Observations	10	Number of Distinct Observations	10
		Number of Missing Observations	14
Minimum	0.007	Mean	0.0416
Maximum	0.104	Median	0.035
SD	0.0329	Std. Error of Mean	0.0104
Coefficient of Variation	0.791	Skewness	1.08
Normal GOF Test			
Shapiro Wilk Test Statistic	0.872	**Shapiro Wilk GOF Test**	
1% Shapiro Wilk Critical Value	0.781	Data appear Normal at 1% Significance Level	
Lilliefors Test Statistic	0.211	**Lilliefors GOF Test**	
1% Lilliefors Critical Value	0.304	Data appear Normal at 1% Significance Level	
Data appear Normal at 1% Significance Level			
Assuming Normal Distribution			
95% Normal UCL		**95% UCLs (Adjusted for Skewness)**	
95% Student's-t UCL	0.0607	95% Adjusted-CLT UCL (Chen-1995)	0.0625
		95% Modified-t UCL (Johnson-1978)	0.0613
Gamma GOF Test			
A-D Test Statistic	0.205	**Anderson-Darling Gamma GOF Test**	
5% A-D Critical Value	0.737	Detected data appear Gamma Distributed at 5% Significance Level	
K-S Test Statistic	0.127	**Kolmogorov-Smirnov Gamma GOF Test**	
5% K-S Critical Value	0.27	Detected data appear Gamma Distributed at 5% Significance Level	
Detected data appear Gamma Distributed at 5% Significance Level			
Gamma Statistics			
k hat (MLE)	1.768	k star (bias corrected MLE)	1.305
Theta hat (MLE)	0.0235	Theta star (bias corrected MLE)	0.0319
nu hat (MLE)	35.37	nu star (bias corrected)	26.09
MLE Mean (bias corrected)	0.0416	MLE Sd (bias corrected)	0.0364
		Approximate Chi Square Value (0.05)	15.45
Adjusted Level of Significance	0.0267	Adjusted Chi Square Value	14.04
Assuming Gamma Distribution			
95% Approximate Gamma UCL	0.0703	95% Adjusted Gamma UCL	0.0773
Lognormal GOF Test			
Shapiro Wilk Test Statistic	0.968	**Shapiro Wilk Lognormal GOF Test**	
10% Shapiro Wilk Critical Value	0.869	Data appear Lognormal at 10% Significance Level	
Lilliefors Test Statistic	0.132	**Lilliefors Lognormal GOF Test**	
10% Lilliefors Critical Value	0.241	Data appear Lognormal at 10% Significance Level	
Data appear Lognormal at 10% Significance Level			
Lognormal Statistics			
Minimum of Logged Data	-4.962	Mean of logged Data	-3.488
Maximum of Logged Data	-2.263	SD of logged Data	0.872
Assuming Lognormal Distribution			
95% H-UCL	0.102	90% Chebyshev (MVUE) UCL	0.0793
95% Chebyshev (MVUE) UCL	0.0959	97.5% Chebyshev (MVUE) UCL	0.119
99% Chebyshev (MVUE) UCL	0.164		
Nonparametric Distribution Free UCL Statistics			
Data appear to follow a Discernible Distribution			
Nonparametric Distribution Free UCLs			
95% CLT UCL	0.0587	95% BCA Bootstrap UCL	0.0616
95% Standard Bootstrap UCL	0.0578	95% Bootstrap-t UCL	0.0746
95% Hall's Bootstrap UCL	0.107	95% Percentile Bootstrap UCL	0.0584
90% Chebyshev(Mean, Sd) UCL	0.0728	95% Chebyshev(Mean, Sd) UCL	0.087
97.5% Chebyshev(Mean, Sd) UCL	0.107	99% Chebyshev(Mean, Sd) UCL	0.145
Suggested UCL to Use			
95% Student's-t UCL	0.0607		
Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL			
Recommendations are based upon data size, data distribution, and skewness using results from simulation studies			
However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician			
ALUMINIUM			
General Statistics			
Total Number of Observations	5	Number of Distinct Observations	5
		Number of Missing Observations	11
Minimum	0.02	Mean	0.434
Maximum	1.91	Median	0.07
SD	0.826	Std. Error of Mean	0.37
Coefficient of Variation	1.904	Skewness	2.218
Note: Sample size is small (e.g., <10), if data are collected using incremental sampling methodology (ISM) approach,			
refer also to ITRC Tech Reg Guide on ISM (ITRC 2020 and ITRC 2012) for additional guidance,			
but note that ITRC may recommend the t-UCL or the Chebyshev UCL for small sample sizes (n < 7).			
The Chebyshev UCL often results in gross overestimates of the mean.			
Refer to the ProUCL 5.2 Technical Guide for a discussion of the Chebyshev UCL.			

Normal GOF Test			
Shapiro Wilk Test Statistic	0.602	**Shapiro Wilk GOF Test**	
1% Shapiro Wilk Critical Value	0.686	Data Not Normal at 1% Significance Level	
Lilliefors Test Statistic	0.439	**Lilliefors GOF Test**	
1% Lilliefors Critical Value	0.396	Data Not Normal at 1% Significance Level	
Data Not Normal at 1% Significance Level			
Assuming Normal Distribution			
95% Normal UCL		**95% UCLs (Adjusted for Skewness)**	
95% Student's-t UCL	1.222	95% Adjusted-CLT UCL (Chen-1995)	1.434
		95% Modified-t UCL (Johnson-1978)	1.283
Gamma GOF Test			
A-D Test Statistic	0.641	**Anderson-Darling Gamma GOF Test**	
5% A-D Critical Value	0.718	Detected data appear Gamma Distributed at 5% Significance Level	
K-S Test Statistic	0.345	**Kolmogorov-Smirnov Gamma GOF Test**	
5% K-S Critical Value	0.374	Detected data appear Gamma Distributed at 5% Significance Level	
Detected data appear Gamma Distributed at 5% Significance Level			
Note GOF tests may be unreliable for small sample sizes			
Gamma Statistics			
k hat (MLE)	0.447	k star (bias corrected MLE)	0.312
Theta hat (MLE)	0.97	Theta star (bias corrected MLE)	1.39
nu hat (MLE)	4.474	nu star (bias corrected)	3.123
MLE Mean (bias corrected)	0.434	MLE Sd (bias corrected)	0.777
		Approximate Chi Square Value (0.05)	0.41
Adjusted Level of Significance	0.0086	Adjusted Chi Square Value	0.154
Assuming Gamma Distribution			
95% Approximate Gamma UCL	3.308	95% Adjusted Gamma UCL	8.815
Lognormal GOF Test			
Shapiro Wilk Test Statistic	0.892	**Shapiro Wilk Lognormal GOF Test**	
10% Shapiro Wilk Critical Value	0.806	Data appear Lognormal at 10% Significance Level	
Lilliefors Test Statistic	0.231	**Lilliefors Lognormal GOF Test**	
10% Lilliefors Critical Value	0.319	Data appear Lognormal at 10% Significance Level	
Data appear Lognormal at 10% Significance Level			
Note GOF tests may be unreliable for small sample sizes			
Lognormal Statistics			
Minimum of Logged Data	-3.912	Mean of logged Data	-2.279
Maximum of Logged Data	0.647	SD of logged Data	1.801
Assuming Lognormal Distribution			
95% H-UCL	1078	90% Chebyshev (MVUE) UCL	0.942
95% Chebyshev (MVUE) UCL	1.229	97.5% Chebyshev (MVUE) UCL	1.629
99% Chebyshev (MVUE) UCL	2.413		
Nonparametric Distribution Free UCL Statistics			
Data appear to follow a Discernible Distribution			
Nonparametric Distribution Free UCLs			
95% CLT UCL	1.042	95% BCA Bootstrap UCL	1.18
95% Standard Bootstrap UCL	0.974	95% Bootstrap-t UCL	14.26
95% Hall's Bootstrap UCL	9.29	95% Percentile Bootstrap UCL	1.156
90% Chebyshev(Mean, Sd) UCL	1.543	95% Chebyshev(Mean, Sd) UCL	2.045
97.5% Chebyshev(Mean, Sd) UCL	2.742	99% Chebyshev(Mean, Sd) UCL	4.111
Suggested UCL to Use			
Recommendation cannot be provided			
Recommendations are not available due to the sample size and skew of the input data.			
Consult with a statistician to evaluate the adequacy of your data to support your objectives or explore alternative estimation methods.			

The calculated UCLs are based on assumptions that the data were collected in a random and unbiased manner.
Please verify the data were collected from random locations.
If the data were collected using judgmental or other non-random methods,
then contact a statistician to correctly calculate UCLs.

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL
Recommendations are based upon data size, data distribution, and skewness using results from simulation studies
However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician

APPENDIX D ENRS ACID SULFATE SOILS

ACID SULFATE SOIL INVESTIGATION

PROPOSED SAND QUARRY EXTENSION
CROOKED RIVER ROAD, GERROA, NSW 2534

Prepared For:	**Cleary Bros (Bombo) Pty Ltd**
Project Number:	**ENRS1947**
Date:	**November 2021**

ENVIRONMENT & NATURAL RESOURCE SOLUTIONS
ENRS PTY LTD ABN 68 600 154 596
T 02 4448 5729 F 02 9037 4708
E: projects@enrs.com.au www.enrs.com.au

Author and Document Control

Written/Submitted by:	Reviewed / Approved by:
Matt Lemcke (Grad. Dip, BSc.) *Hydrogeologist & Environmental Scientist* *SafeWork NSW LAA001357*	Rohan Last (MSc., BSc.) *Hydrogeologist & Environmental Scientist* *SafeWork NSW LAA000166*

Record of Distribution

Copies	Report No. & File Name	Status	Date	Prepared for:
1 x PDF	ENRS1947_CB Gerroa Extention ASS Investigation	Rev.1	23/11/2021	Cleary Bros (Bombo) Pty Ltd

TABLE OF CONTENTS

LIST OF TABLES, FIGURES & APPENDICES

TABLES

FIGURES

APPENDICES

INTRODUCTION

Environment & Natural Resource Solutions (ENRS Pty Ltd) were commissioned as independent environmental consultants in July 2021 by *Cleary Bros (Bombo) Pty Ltd* (the client) to conduct an Investigation for Potential Acid Sulfate Soils (PASS) within the proposed dredging footprint of the Sand Quarry Extension located at Crooked River Road, Gerroa, NSW, 2534 (*herein referred to as the Site*).

It is understood that the modification of the Project Approval (Sand Quarry Extension) for the site will include:

- Extension of the sand quarrying operations by dredge and mobile plant extraction of material from within an approximately 35.8 ha area located to the north and northwest of the current dredge pond and processing facility within the current Gerroa Sand Quarry;
- Transporting the extracted material in a hydraulic slurry via a 250 mm pipe system for processing and stockpiling of the extracted sand product at the existing facility;
- Deposition of material not suitable for concrete manufacture into the current dredge pond for underwater disposal under controlled conditions and eventual profiling as rehabilitation of that site.

1.1 OBJECTIVES

The aim of the project was to undertake penetrative investigations throughout the proposed extension area to provide a detailed characterisation of ASS and PASS distribution to inform potential environmental management requirements as outlined in the Site specific Acid Sulfate Soil Management Plan (Douglas Partners 2018).

1.2 SCOPE OF WORK

The scope of work for the project comprised the following tasks:

- Review of available background data;
- Preparation of a Health, Safety and Environment (HSE) Plan and Sampling Analysis Plan (SAP);
- Undertake site inspection and investigation including test pits, subsurface drilling and sampling (9-12/08/2021);
- Review of laboratory analytical data; and
- Document investigation results and development of recommendations.

2.0 SITE DESCRIPTION

2.1 SITE IDENTIFICATION

The Site is located on the western side of Crooked River Road adjacent Seven Mile Beach, approximately 40km south of Wollong, as shown in **Figure 1**. The key features required to identify the Site are presented in **Table 1** below.

Table 1: Site Identification

SITE	DESCRIPTION
Street Address	358 Crooked River Road, Gerroa, NSW, 2534
Lot / Deposited Plan	2 / 1111012
Easting / Northing	GDA 2020 – Zone 56H 297412 / 6149367 (~centre of investigation area)
Local Government Area	Kiama Municipal Council

Figure 1: Site Location Map

Source: www.maps.six.nsw.gov.au(cited 8/10/2021)

2.2 SITE HISTORY AND BACKGROUND DATA

Douglas Partners (DP Project Number 37673.09 - November 2018) produced a report detailing the Acid Sulfate Soil Management Plan (ASSMP) for the proposed sand quarry extension. The ASSMP (DP, 2018) provides a comprehensive characterisation of the Site geological/hydrogeological setting and a summary of all historic acid sulfate soil information pertaining to the Site area in addition to management systems and procedures for identified ASS and PASS materials.

The reader if referred to this report for this information.

3.0 SITE INVESTIGATION

3.1 METHOD OF INVESTIGATION

The site inspection and intrusive ground investigations were carried out between 9th and 12th August 2021 by ENRS. The distribution of the intrusive investigation points was selected in general accordance with ASSMAC (1998) recommendations to deliver adequate information on representative site conditions and provide suitable land-based access to excavator/vibrocore and support vehicles. All exploratory location points were identified and recorded by ENRS surveyed using a hand-held GPS to an accuracy of approximately ±5.0 m.

3.2 PUBLIC UTILITY AND PLANT

A search of underground utilities was undertaken with Dial Before You Dig (DBYD) before mobilisation. No services were identified within or proximal to the proposed investigation area.

The Cleary Bros Project Manager further confirmed through the company internal ground disturbance permitting system that the investigation area was free for buried services and utilities.

3.3 TEST PIT INVESTIGATIONS

The investigation test pits were installed using 1.8 tonne excavator with a 1.2m wide mud type bucket. Test pits were advanced to a depth of approximately 0.2m into the saturated zone as to allow for further advancement by vibrocore borehole.

Test pits depths ranged from 0.8 m below ground level (mBGL) at BH01 to 1.3 mBGL at BH18. ENRS site inspections were programmed to provide preliminary information on ASS characteristics in the observed profiles. ENRS supervised the fieldwork and logged the test pits, noting changes in consistency, density, plasticity fines, moisture content, odours, and colour of the encountered strata.

Representative samples were collected from each stratum throughout the profile for PASSA field screening and later laboratory analysis, if triggered.

3.4 BOREHOLE INVESTIGATIONS

Test pits were further advanced by method of vibrocore borehole to collect representative and continuous soil cores throughout the profile. A total of twenty four (24) boreholes (BH01 – BH24) were drilled to depths between 2.6 mBGL and 6.1 mBGL below the existing surface level as part of this investigation. As with test pit investigations, boreholes were logged, noting changes in consistency, density, plasticity fines, moisture content, odours, and colour of the encountered strata.

Representative samples were collected from each stratum throughout the profile for PASSA field screening and later laboratory analysis, if triggered.

Investigation logs are provided in **Appendix A**. A summary of investigation locations is detailed in **Table 2** with the investigation layout plan presented in **Figure 2**.

Table 2: Site investigation location summary

LOCATION ID	SPATIAL POSITION (MGA94 ZONE 56H)		TERMINATION / REFUSAL DEPTH IN METRES (BGL)
	EASTING	NORTHING	
BH01	297727	6149572	5.4
BH02	297686	6149589	5.25
BH03	297685	6149536	5.8
BH04	297627	6149551	5.7
BH05	297628	6149498	5.0
BH06	297578	6149519	5.8
BH07	297580	6149465	4.4
BH08	297525	6149487	5.5
BH09	297531	6149432	4.5
BH10	297478	6149440	5.3
BH11	297459	6149387	4.5
BH12	297403	6149399	6.1
BH13	297387	6149342	5.7
BH14	297327	6149361	5.5
BH15	297329	6149307	2.6
BH16	297270	6149325	4.3
BH17	297266	6149268	4.6
BH18	297209	6149287	4.7
BH19	297218	6149234	4.4
BH20	297147	6149257	4.3
BH21	297153	6149196	4.0
BH22	297083	6149223	4.9

LOCATION ID	SPATIAL POSITION (MGA94 ZONE 56H)		TERMINATION / REFUSAL DEPTH IN METRES (BGL)
	EASTING	NORTHING	
BH23	297096	6149172	3.6
BH24	297043	6149164	4.5

3.5 FIELD SCREENING AND LABORATORY ANALYSIS SAMPLING

Representative soil samples were collected by ENRS during site investigations. Samples were collected at regular depth intervals and/or at changes in material type at all test locations. A minimum of 200 g was collected for each sample, with samples labelled and wrapped in a 200 µm plastic bag to expel air and immediately sealed. A smaller ~30 g subsample was collected at each location for PASSA field screening.

All samples were collected with new disposable sampling and protective equipment. Following collection, samples were immediately placed into chests with ice and dispatched under Chain of Custody to the NATA accredited laboratory (ALS) for Chromium Reducible Sulfur (CrS). All laboratory test certificates and quality control results are provided in **Appendix B**.

In summary, field screening during logging was undertaken on two hundred and eighteen (218) samples, with laboratory CrS analysis undertaken on ninety-five (95) samples.

4.0 ADOPTED ASSESSMENT CRITERIA-+

4.1 FIELD SCREEN ANALYSIS

Field screen testing with pH field (pH_F) and pH field oxidised (pH_{FOX}) was conducted as a preliminary and qualitative screening analysis on all representative samples using the peroxide oxidation method set out in AS4969. Field screening test results are assessed by these pre and post oxidation pH levels to indicate the presence of Actual ASS (AASS) and Potential ASS (PASS). The interpretations generally placed on these qualitative indicator pH levels and reactions include:

4.1.1 pH field (pHF)

- <4 – Inferred as oxidised acid sulfate soil
- <4.5 – Inferred as extremely acidic soil, possibly due to pyrite oxidation or can be due to the soil being highly organic or from prolonged fertiliser use
- 4.5-5.5 – Inferred as highly acidic soil, however it is not conclusive that low pH is due to pyrite oxidation
- >6 – No actual acidity

4.1.2 pH oxidised (pHFOX)

- <3 – Strongly inferred as PASS
- 3-4 – Inferred PASS, lab analysis would be required to confirm presence of sulfides
- 4-5 – Inferred level of sulfides present, or the sample might be poorly reactive or fine carbonates are present
- >5 – With a minimal difference to pHF, this is unlikely to be PASS unless carbonates are present in the sample.

Field screen analysis also included a reaction rating observation of between 1 to 4 to classify the level samples reacted to the peroxide that includes:

1. No reaction to slight
2. Moderate reaction
3. Strong reaction with persistent froth
4. Extreme reaction.

Field screen analysis is a preliminary test method with limitations that provides qualitative indicators to undertake further analysis using the CrS suite.

5.0 LABORATORY RESULTS AND ANALYSIS

5.1 ACID SULFATE SOILS ANALYSIS

Representative samples throughout the investigation area were analysed for CrS. Representative samples were selected to:

- Determine the association between field screening parameters and sulfur;
- Characterise ASS/PASS risk for material types;
- Characterise ASS/PASS distribution within the investigation area; and
- Characterise ASS/PASS risk within the excavation footprint of the initial dredge area.

Field screen results in the profile indicate that pH field levels range between 4.2 to 7.3 with field oxidised pH level ranging between 1.23 to 5.9. Reaction ratings were recorded to range for none to extreme, however organics that were observed during investigations and responsive materials such as calcium carbonate (recorded as ANC) can influence these results. Results indicate generally mildly acidic conditions in the representative materials tested, with additional laboratory testing required to confirm and the nature and quantum of acidity.

An action criterion of 18 mol H+/tonne (0.03% S) with a sum of existing and potential acidity is recommended when applying texture-based ASS measures from Queensland Guidelines (2014) for excavation works and disturbances of material greater than 1,000 tonnes. Laboratory results indicate:

- Titratable actual acidity was recorded between <2 mol H+/t (limit of reporting) and 33 mol H+/t;

- All oxidisable inorganic sulfur (SCR) was below the level of reporting (0.02% S) in all but eight (8) samples. Of these, six (6) were ≥ 0.03% demonstrating that pyritic materials were present and above the action criteria indicating PASS;
- Chromium reducible sulfur was reported at ≥ 0.03% S in seventy one (71) of the samples analysed; and
- Laboratory calculated liming rates ranged from <1 kg $CaCO_3$/t to 239 $CaCO_3$/t.

A summary of field screen test results is provided in **Table 3**. Results of chromium reducible sulfur suite laboratory testing are summarised in **Table 4**.

Treatment action criteria and methodology is outlined in **Section 10** of the Acid Sulfate Soil Management Plan (DP, 2018).

Table 3: Field Screening testing results summary

TEST LOCATION / DEPTH	pH_F	pH_{FOX}	REACTION RATING	REACTION
BH1/0.4	5.31	4.84	1	No reaction to slight
BH1/1.3	4.88	1.68	4	extreme
BH1/2.2	4.87	1.92	3	Strong
BH1/3	4.82	1.59	4	extreme
BH1/3.5	5.06	1.91	4	extreme
BH1/3.9	6.62	2	4	extreme
BH1/4.6	6.53	2.08	4	extreme
BH1/5	7.02	2.86	4	extreme
BH1/5.4	6.95	4.66	3	Strong
BH2/0.2	5.93	4.9	2	Moderate
BH2/0.4	5.21	4.61	1	No reaction to slight
BH2/0.7	5.18	4.97	1	No reaction to slight
BH2/1.35	4.51	2.14	3	Strong
BH2/1.73	4.8	2.12	3	Strong
BH2/2.45	4.99	2.21	3	Strong
BH2/2.95	4.85	2.08	3	Strong
BH2/3.68	5.55	2.9	3	Strong
BH2/4.33	5.53	3.67	2	Moderate
BH3/0.2	4.96	4.29	1	No reaction to slight
BH3/0.7	5.13	4.95	1	No reaction to slight
BH3/1.31	4.93	1.42	4	extreme
BH3/1.93	4.64	1.8	3	Strong
BH3/2.31	4.68	1.97	3	Strong
BH3/2.95	4.66	1.97	3	Strong
BH3/3.51	5.36	1.78	4	extreme
BH3/4.08	6.63	1.78	4	extreme

TEST LOCATION / DEPTH	pH_F	pH_{FOX}	REACTION RATING	REACTION
BH3/4.61	6.87	2.07	4	extreme
BH3/5.13	6.49	1.89	4	extreme
BH4/0.3	5.17	4.58	1	No reaction to slight
BH4/0.6	5.18	4.57	1	No reaction to slight
BH4/0.9	5.02	4.66	1	No reaction to slight
BH4/1.3	4.84	1.5	4	extreme
BH4/2.2	4.72	1.46	4	extreme
BH4/3.1	4.7	1.78	3	Strong
BH4/3.85	4.87	1.7	4	extreme
BH4/4.25	6.3	2.88	4	extreme
BH4/4.6	6.5	5.13	2	Moderate
BH4/5.05	6.79	5.57	2	Moderate
BH4/5.25	6.75	5.5	2	Moderate
BH5/0.2	5.32	4.15	2	Moderate
BH5/0.6	4.72	4.47	1	No reaction to slight
BH5/1.2	5.05	1.56	4	extreme
BH5/1.7	4.45	1.65	3	Strong
BH5/2.2	4.84	1.76	4	extreme
BH5/2.7	5.3	1.77	4	extreme
BH5/3.1	6.13	1.96	4	extreme
BH5/4	6.85	5.3	2	Moderate
BH5/4.5	7.07	3.43	4	extreme
BH5/4.9	7.06	5.9	2	Moderate
BH6/0.3	5.21	4.27	1	No reaction to slight
BH6/0.7	5.07	4.68	1	No reaction to slight
BH6/1.36	4.54	1.61	3	Strong
BH6/1.91	4.8	1.79	4	extreme
BH6/2.4	4.98	1.75	4	extreme
BH6/2.82	5.25	1.68	4	extreme
BH6/3.31	5.95	4.56	2	Moderate
BH6/3.75	6.3	4.21	3	Strong
BH6/4.42	6.71	5.41	2	Moderate
BH6/4.84	7.05	5.25	2	Moderate
BH6/5.57	7.22	5.24	2	Moderate
BH7/0.2	5.2	4.17	2	Moderate
BH7/0.6	4.9	4.53	1	No reaction to slight
BH7/1.45	6.54	1.73	4	extreme

TEST LOCATION / DEPTH	pH_F	pH_{FOX}	REACTION RATING	REACTION
BH7/1.62	4.95	1.64	4	extreme
BH7/2.12	5.11	1.4	4	extreme
BH7/2.3	5.18	1.64	4	extreme
BH7/2.84	5.3	1.64	4	extreme
BH7/3.43	5.32	1.71	4	extreme
BH7/3.83	6.1	2.49	4	extreme
BH8/0.2	4.99	3.3	2	Moderate
BH8/0.7	4.84	4.05	1	No reaction to slight
BH8/1.46	4.45	1.38	4	extreme
BH8/1.63	5.15	1.36	4	extreme
BH8/1.81	5.75	1.64	4	extreme
BH8/1.97	6.03	3.33	3	Strong
BH8/2.18	6.32	1.81	4	extreme
BH8/2.44	6.4	1.64	4	extreme
BH8/2.8	6.35	4.03	3	Strong
BH8/3.61	6.38	4.97	2	Moderate
BH8/3.9	6.94	5.12	2	Moderate
BH8/5.44	7.2	5.48	2	Moderate
BH9/0.2	5.07	2.99	3	Strong
BH9/0.7	4.88	3.85	2	Moderate
BH9/1.34	4.53	1.45	4	extreme
BH9/1.89	4.49	2.22	3	Strong
BH9/2.4	5.1	3.6	2	Moderate
BH9/2.9	7.3	5.55	2	Moderate
BH9/3.3	7.32	5.19	3	Strong
BH10/0.2	5.24	4.6	1	No reaction to slight
BH10/0.7	5.36	4.65	1	No reaction to slight
BH10/1.1	5.19	4.81	1	No reaction to slight
BH10/1.5	5.83	1.24	4	extreme
BH10/2.1	6.23	1.25	4	extreme
BH10/2.9	6.49	4.1	3	Strong
BH10/3.3	6.69	5.03	2	Moderate
BH10/3.6	6.84	5.35	2	Moderate
BH11/0.2	5.73	4.75	1	No reaction to slight
BH11/0.7	5.4	4.8	1	No reaction to slight
BH11/2	4.77	2.45	3	Strong
BH11/2.7	4.91	1.48	4	extreme

TEST LOCATION / DEPTH	pH_F	pH_{FOX}	REACTION RATING	REACTION
BH11/3.7	5.12	1.36	4	extreme
BH11/4.1	5.44	2.96	3	Strong
BH12/0.2	5.01	4.37	1	No reaction to slight
BH12/0.6	5.2	4.75	1	No reaction to slight
BH12/0.9	5.37	4.84	1	No reaction to slight
BH12/1.59	4.55	1.93	3	Strong
BH12/2.35	5.33	2.53	3	Strong
BH12/3.02	5.95	2.29	4	extreme
BH12/3.54	5.9	2.81	4	extreme
BH12/4.71	6.57	4.62	2	Moderate
BH12/5.75	5.67	1.69	4	extreme
BH13/0.2	5.51	4.82	1	No reaction to slight
BH13/0.8	5.2	4.89	1	No reaction to slight
BH13/1.73	5.68	1.42	4	extreme
BH13/2.04	5.68	1.86	4	extreme
BH13/2.9	5.81	1.81	4	extreme
BH13/3.57	5.83	1.37	4	extreme
BH13/4.22	6.1	2.17	4	extreme
BH13/4.53	6.2	3.62	3	Strong
BH13/5	6.26	1.86	4	extreme
BH13/5.85	6.46	1.92	4	extreme
BH14/0.3	5.92	5.11	1	No reaction to slight
BH14/0.9	5.34	4.82	1	No reaction to slight
BH14/1.86	4.73	1.76	3	Strong
BH14/2.82	4.66	1.82	3	Strong
BH14/3.78	4.85	1.59	4	extreme
BH14/4.3	5.09	1.86	4	extreme
BH14/4.5	5.29	1.96	4	extreme
BH14/4.8	5.14	1.8	4	extreme
BH14/5.4	5.21	1.75	4	extreme
BH14/5.7	5.43	1.71	4	extreme
BH15/0.3	4.68	2.42	3	Strong
BH15/0.9	4.84	3.69	2	Moderate
BH15/1.4	4.24	1.77	3	Strong
BH15/1.77	4.8	1.99	3	Strong
BH15/2.22	5.75	2.71	4	extreme
BH15/2.5	6.41	3.79	3	Strong

TEST LOCATION / DEPTH	pH_F	pH_{FOX}	REACTION RATING	REACTION
BH16/0.1	5.99	4.49	2	Moderate
BH16/0.6	5.45	4.02	2	Moderate
BH16/1.59	4.65	1.56	4	extreme
BH16/2.24	4.35	1.46	3	Strong
BH16/2.98	5.09	1.91	4	extreme
BH16/3.6	5.43	1.65	4	extreme
BH16/3.96	5.46	2.8	3	Strong
BH16/4.3	5.26	5.53	1	No reaction to slight
BH17/0.2	5.38	3.26	3	Strong
BH17/0.7	4.85	3.6	2	Moderate
BH17/1.65	4.68	1.69	3	Strong
BH17/2.28	5.88	2.08	4	extreme
BH17/2.91	5.65	1.47	4	extreme
BH17/3.45	6.11	2.03	4	extreme
BH17/4.08	6.41	2	4	extreme
BH17/4.32	6.47	1.55	4	extreme
BH17/4.6	6.41	2.48	4	extreme
BH18/0.3	4.79	3.77	2	Moderate
BH18/0.7	4.82	4.34	1	No reaction to slight
BH18/1.1	4.78	4.49	1	No reaction to slight
BH18/1.65	5.92	1.6	4	extreme
BH18/2.16	6.17	1.73	4	extreme
BH18/2.64	6.53	2.68	4	extreme
BH18/3.22	6.6	3.46	4	extreme
BH18/3.92	6.79	4.41	3	Strong
BH18/4.53	7.15	5.1	3	Strong
BH19/0.2	4.84	2.67	3	Strong
BH19/0.5	4.97	3.78	2	Moderate
BH19/0.8	5.5	1.48	4	extreme
BH19/1.44	5.13	1.25	4	extreme
BH19/1.87	5.13	1.26	4	extreme
BH19/2.51	4.84	1.23	4	extreme
BH19/3.24	4.86	1.3	4	extreme
BH19/3.8	5.09	1.52	4	extreme
BH20/0.4	5.25	4.43	1	No reaction to slight
BH20/0.8	4.97	4.59	1	No reaction to slight
BH20/1.56	5.38	2.12	4	extreme

TEST LOCATION / DEPTH	pH_F	pH_{FOX}	REACTION RATING	REACTION
BH20/1.96	4.75	2.01	3	Strong
BH20/2.53	5.43	1.97	4	extreme
BH20/3.06	6	1.99	4	extreme
BH20/3.67	6.81	3.02	4	extreme
BH20/4.05	7.07	2.36	4	extreme
BH21/0.2	4.54	2.31	3	Strong
BH21/0.7	4.3	3.37	1	No reaction to slight
BH21/1.33	5	1.86	4	extreme
BH21/1.72	4.98	1.98	3	Strong
BH21/2.12	5.84	1.83	4	extreme
BH21/2.58	5.57	3.03	3	Strong
BH21/2.99	6.02	3.61	3	Strong
BH21/3.43	6.56	4.36	3	Strong
BH21/3.88	6.82	4.73	3	Strong
BH21/4	6.81	4.55	3	Strong
BH22/0.3	4.82	2.51	3	Strong
BH22/0.8	4.83	4.18	1	No reaction to slight
BH22/1.34	4.96	1.95	4	extreme
BH22/1.68	5.45	2	4	extreme
BH22/2	6.34	1.9	4	extreme
BH22/2.3	6.88	2.21	4	extreme
BH22/2.76	6.94	2.1	4	extreme
BH22/3.15	7.1	1.87	4	extreme
BH22/3.56	7.06	1.92	4	extreme
BH22/3.89	6.98	2.61	4	extreme
BH22/4.4	7.16	4.48	3	Strong
BH23/0.3	5.35	2.77	3	Strong
BH23/0.8	4.99	3.81	2	Moderate
BH23/1.17	4.39	2.04	3	Strong
BH23/1.61	4.5	2.06	3	Strong
BH23/1.96	4.56	1.98	3	Strong
BH23/2.3	5.93	2.23	4	extreme
BH23/2.59	5.74	2.26	4	extreme
BH23/2.86	5.59	3.22	3	Strong
BH23/3.2	5.07	3.35	2	Moderate
BH24/0.3	5.4	3.8	2	Moderate
BH24/0.8	4.6	4.26	1	No reaction to slight

TEST LOCATION / DEPTH	pH_F	pH_{FOX}	REACTION RATING	REACTION
BH24/1.25	4.45	2.07	3	Strong
BH24/1.74	4.54	1.71	3	Strong
BH24/2.28	4.63	1.58	4	extreme
BH24/2.79	4.66	1.6	4	extreme
BH24/3.17	5.78	1.44	4	extreme
BH24/3.62	5.83	2.43	4	extreme
BH24/4.02	6.34	1.98	4	extreme

Table 4: Chromium Reducible Sulfur Suite (CrS) Analytical Summary

TEST LOCATION / DEPTH	pH KCL (pH Units)	TITRATABLE ACTUAL ACIDITY (mole H^+ / t)	SULFIDIC - TITRATABLE ACTUAL ACIDITY (% pyrite S)	CHROMIUM REDUCABLE SULFUR (% S)	LIMING RATE (kg $CaCO_3$/t)
BH1/1.3	5.8	<2	<0.02	0.162	8
BH1/2.2	5.9	<2	<0.02	0.093	4
BH2/.02	6	<2	<0.02	0.013	<1
BH2/0.4	5.6	10	<0.02	0.016	1
BH2/0.7	6	3	<0.02	0.012	<1
BH2/1.35	5.8	<2	<0.02	0.108	5
BH2/1.73	5.8	<2	<0.02	0.061	3
BH2/2.45	5.9	<2	<0.02	0.088	4
BH2/2.95	6	2	<0.02	0.129	6
BH2/3.68	6	<2	<0.02	0.074	3
BH2/4.33	6.2	<2	<0.02	0.027	1
BH3/1.31	5.5	3	<0.02	0.219	10
BH3/1.93	5.8	<2	<0.02	0.135	6
BH3/2.31	5.9	<2	<0.02	0.074	3
BH4/1.3	5.7	2	<0.02	0.1	5
BH4/2.2	5.8	<2	<0.02	0.121	6
BH4/3.85	5.9	3	<0.02	0.321	15
BH5/0.2	5.5	3	<0.02	0.012	<1
BH5/1.7	5.7	2	<0.02	0.221	10
BH5/2.2	5.9	<2	<0.02	0.118	6
BH5/4.5	6.3	<2	<0.02	0.108	5
BH5/4.9	6.4	<2	<0.02	0.065	3

TEST LOCATION / DEPTH	pH KCL (pH Units)	TITRATABLE ACTUAL ACIDITY (mole H^+ / t)	SULFIDIC - TITRATABLE ACTUAL ACIDITY (% pyrite S)	CHROMIUM REDUCABLE SULFUR (% S)	LIMING RATE (kg $CaCO_3$/t)
BH5/5/1.2	5.6	2	<0.02	0.214	10
BH6/1.36	5.5	3	<0.02	0.242	12
BH6/1.91	5.7	3	<0.02	0.32	15
BH6/2.4	5.8	2	<0.02	0.341	16
BH7/0.2	5.3	7	<0.02	0.025	2
BH7/1.45	5.7	<2	<0.02	0.244	11
BH7/2.12	5.8	<2	<0.02	0.225	10
BH8/0.2	4.6	32	0.05	0.013	3
BH8/1.46	5.8	<2	<0.02	0.211	10
BH8/1.63	6	<2	<0.02	0.199	9
BH8/1.81	5.2	33	0.05	5.05	239
BH8/1.97	5.9	7	<0.02	0.319	15
BH8/2.18	6.2	4	<0.02	0.22	10
BH8/2.44	6	<2	<0.02	0.353	16
BH8/3.61	6.3	<2	<0.02	0.015	<1
BH9/0.2	5.7	5	<0.02	0.01	<1
BH9/0.7	5.6	6	<0.02	0.012	1
BH9/1.34	5.7	4	<0.02	0.25	12
BH9/1.89	6	<2	<0.02	0.125	6
BH10/1.5	5.8	<2	<0.02	0.159	7
BH10/2.1	6	<2	<0.02	0.093	4
BH11/2	5.9	<2	<0.02	0.042	2
BH12/1.59	5.8	2	<0.02	0.092	4
BH12/2.35	6	2	<0.02	0.19	9
BH13/1.73	6	<2	<0.02	0.094	4
BH13/5	6	<2	<0.02	0.225	10
BH14/1.86	6.1	<2	<0.02	0.058	3
BH15/0.3	5.8	4	<0.02	0.01	<1
BH15/0.9	6	<2	<0.02	0.005	<1
BH15/1.4	5.6	6	<0.02	0.328	16
BH15/2.22	5.6	8	<0.02	0.335	16
BH16/0.1	6.3	<2	<0.02	0.005	<1
BH16/0.6	6	<2	<0.02	0.01	<1
BH16/1.59	6	<2	<0.02	0.023	1
BH17/0.2	5.7	4	<0.02	0.021	1

TEST LOCATION / DEPTH	pH KCL (pH Units)	TITRATABLE ACTUAL ACIDITY (mole H^+ / t)	SULFIDIC - TITRATABLE ACTUAL ACIDITY (% pyrite S)	CHROMIUM REDUCABLE SULFUR (% S)	LIMING RATE (kg $CaCO_3$/t)
BH17/0.7	5.8	<2	<0.02	0.017	<1
BH17/1.65	5.7	2	<0.02	0.297	14
BH17/2.28	5.6	5	<0.02	0.431	20
BH17/4.32	6.2	<2	<0.02	0.076	4
BH18/0.3	5.6	2	<0.02	0.014	<1
BH18/1.1	6.1	<2	<0.02	0.016	<1
BH18/1.65	5	19	0.03	1.72	82
BH18/2.16	5.8	2	<0.02	0.188	9
BH18/4.53	6.2	<2	<0.02	0.027	1
BH19/0.2	5	20	0.03	0.033	3
BH19/0.5	5.9	<2	<0.02	0.012	<1
BH19/0.8	5.6	3	<0.02	0.162	8
BH19/1.44	5.8	<2	<0.02	0.168	8
BH20/1.56	5.6	2	<0.02	0.136	6
BH21/0.2	5.4	5	<0.02	0.009	<1
BH21/1.33	5.7	4	<0.02	0.177	8
BH21/1.72	5.9	4	<0.02	0.184	9
BH21/2.12	5.2	8	<0.02	0.652	31
BH21/2.58	5.5	8	<0.02	0.043	3
BH21/3.43	6.1	8	<0.02	0.246	12
BH22/0.3	5.1	17	0.03	0.019	2
BH22/1.68	5.8	4	<0.02	0.184	9
BH22/2	5.8	3	<0.02	0.678	32
BH22/2.3	5.5	5	<0.02	2.36	111
BH22/2.76	5.9	<2	<0.02	0.162	8
BH22/3.15	6	8	<0.02	0.586	28
BH22/3.56	6	<2	<0.02	0.482	22
BH23/0.3	5.2	13	0.02	0.035	3
BH23/0.8	5.9	<2	<0.02	0.015	<1
BH23/1.17	5.6	2	<0.02	0.232	11
BH23/1.61	5.8	<2	<0.02	0.218	10
BH23/1.96	4.9	28	0.04	2.98	141
BH23/2.3	5.4	6	<0.02	0.218	11
BH23/2.86	5.8	12	<0.02	0.047	3
BH24/0.3	5.8	<2	<0.02	0.069	3

TEST LOCATION / DEPTH	pH KCL (pH Units)	TITRATABLE ACTUAL ACIDITY (mole H^+ / t)	SULFIDIC - TITRATABLE ACTUAL ACIDITY (% pyrite S)	CHROMIUM REDUCABLE SULFUR (% S)	LIMING RATE (kg $CaCO_3$/t)
BH24/1.74	5.6	2	<0.02	0.148	7
BH24/2.28	5.7	<2	<0.02	0.172	8
BH24/3.17	6	<2	<0.02	0.095	4

5.2 OCCURRENCE AND DISTRIBUTION

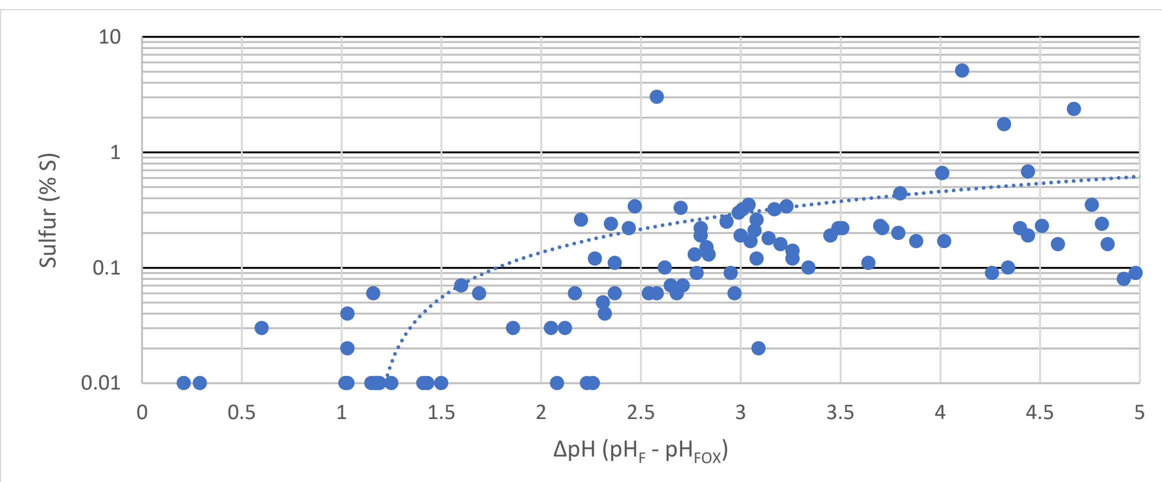
Further analysis of laboratory results was undertaken to understand:

- The relationship between field screening pH change and sulfur (%);
- Patterns of sulfur (%) and distribution with depth in the upper profile (<3 mBGL); and
- The relationship between material type sulfur (%).

5.2.1 Field screening pH change VS sulfur (%)

A comparison of percent sulfur vs the measured field screening pH change was undertaken to determine a potential correlation between field screening test results from this investigation and to inform future field testing programs undertaken for site management. Where CrS analysis was undertaken, a field screening pH change (ΔpH) of >3 is generally indicative of a sulfur content of approximately 0.1% or greater. **Chart 1** presents laboratory reported S% vs field screening pH change.

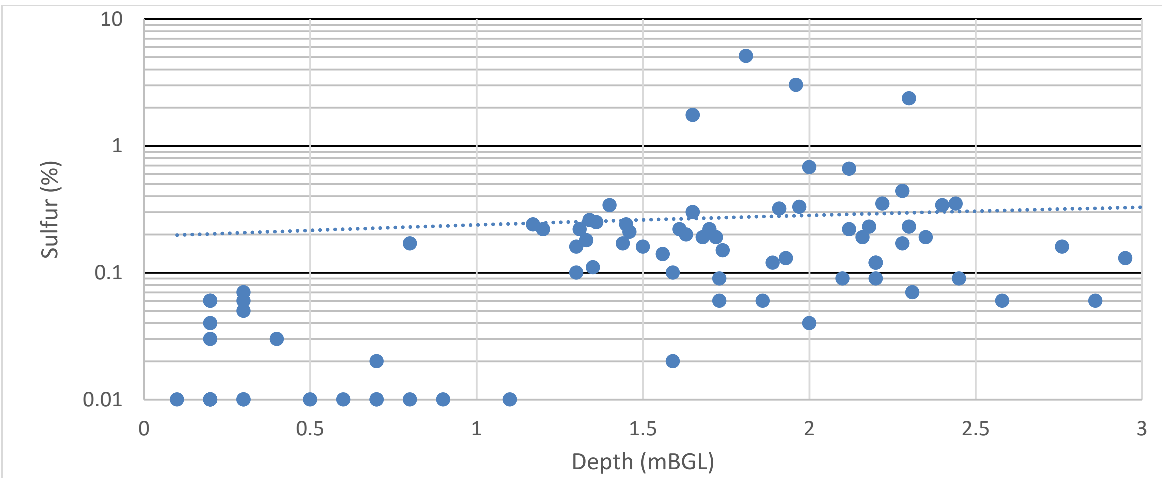
Chart 1: Sulfur (%) by pH Field Test Change



5.2.2 Sulfur (%) distribution within the upper profile (<3 mBGL)

To characterise the risk posed by ASS/PASS material within the bater of the proposed dredge pond a comparison of the laboratory reported percent sulfur vs the sample depth was undertaken. A depth of 3 mBGL was selected as this is beyond the anticipated maximum water level within the dredge pond during operations. It is further noted that the groundwater level throughout the investigation area was approximately 1 mBGL at the time of investigation. **Chart 2** presents a plot of Sulfur (%) within 3mBGL. **Figure 3** and **Figure 4** illustrate the distribution of percentage sulfur (where analysed) and the calculated liming rate for material residing within the upper 3m of the ground profile.

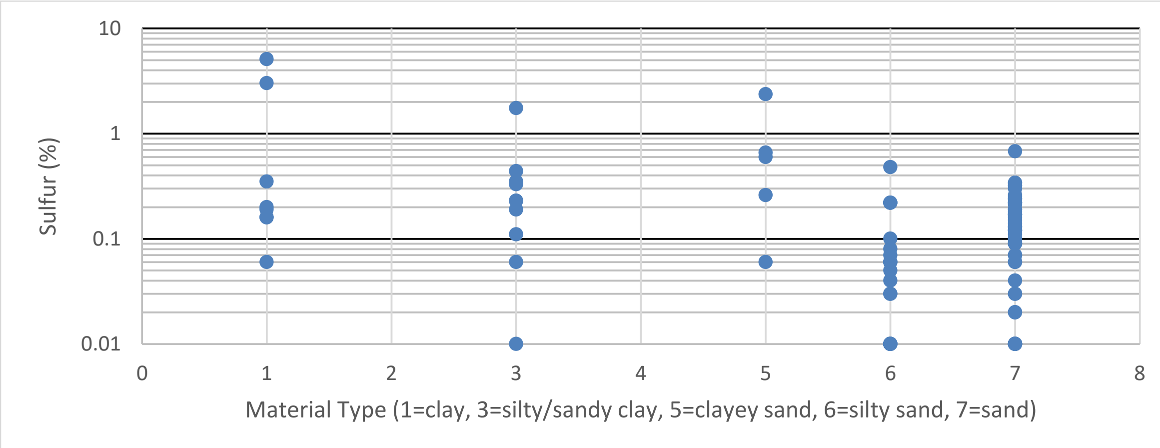
Chart 2: Sulfur (%) within 3mBGL



5.2.3 Sulfur (%) occurrence and material type

The laboratory results of percent sulfur (where analysed) were tallied for each broad material type to determine the correlation between sulfur (%) and material grainsize. **Chart 3** indicates that the presence of clay & silt sized particles may result in an increased likelihood of materials having a sulfur content >1%. It is further noted that sulfur content reported within units comprising predominantly of sand is highly variably and as such using material type as a sole indicator of PASS risk may not be appropriate. Detailed materials descriptions are presented in **Appendix A**.

Chart 3: Sulfur (%) by Material Type



5.3 AREAS OF POTENTIALLY ELEVATED RISK

Based on dredge pond batter design and potential fluctuations in dredge pond water levels, the near surface (within 3 m depth of the current ground surface) presents the greatest potential of disturbance and dewatering. As such focus was given to characterising PASS risk within the near surface.

From review of borehole logs, field screening and the results of laboratory analysis the materials presenting the highest PASS risk within the upper ground profile (<3 mBGL depth) are those primarily comprising of black clay/silt. During this investigation this material type was encountered in the upper ground profile in several of the boreholes installed for this program. Whilst field screening results of this material were predominately characterised by a vigorous/violent reaction and pH change of >3, laboratory reported sulfur (%) and corresponding liming rates were highly variable. From review of the results it is inferred that there is a higher prevalence of this near surface high risk unit in the south western portion of the investigation area (Figure 4).

Through the deeper profile (>3 mBGL depth) to the maximum investigation depth CrS results were variable, however, materials primarily comprising of or with accessory black clay/silt were noted to generally be correlated with increased laboratory reported sulfur (%).

Field screening supported by laboratory analysis of samples from BH2 report maximum sulfur (%) of 0.129% within 3 mBGL. As such this area has been assessed to be of low risk for incidence of near surface PASS. It is understood that the quarry design will see the initial mechanical excavation of the dredge pond commenced in this area.

6.0 CONCLUSIONS AND RECOMMENDATIONS

Based on the information reviewed during the scope of works the following conclusions and recommendations are provided:

6.1 CONLCUSIONS

- This Acid Sulfate Soil (ASS) Investigation of the Gerroa Sand Quarry Extension area comprised of field inspections, test pits and boreholes undertaken between the 9th and 12th August 2021;
- Twenty-four (24) soil cores were collected during the scope of work terminating at depths ranging from 2.6 - 6.1 m below the ground level at the time of investigation. Soil cores were logged with representative samples collected for field screening and further laboratory analysis (chromium reducible sulfur suite method) where required to determine the potential presence of PASS materials;
- Field screening during logging was undertaken on two hundred and eighteen (218) samples, with laboratory CrS analysis undertaken on ninety-five (95) samples;
- Field screen results in the profile indicate that pH field levels range between 4.2 to 7.3 with field oxidised pH level ranging between 1.23 to 5.9;
- Titratable actual acidity was recorded between <2 mol H+/t (limit of reporting) and 33 mol H+/t;
- All oxidisable inorganic sulfur (SCR) was below the level of reporting (0.02% S) in all but eight (8) samples. Of these, six (6) were ≥ 0.03% demonstrating that pyritic materials were present and above the action criteria indicating PASS;
- Chromium reducible sulfur was reported at ≥ 0.03% S in seventy one (71) of the samples analysed; and
- Laboratory calculated liming rates ranged from <1 kg $CaCO_3$/t to 239 $CaCO_3$/t.

6.2 RECOMMENDATIONS

- It is recommended that all identified ASS and PASS materials are managed in accordance with the Site specific Acid Sulfate Soil Management Plan (DP 2018);
- Where a high risk material type requires excavation and dewatering or has potential for oxidisation within the dredge pond batter it is recommended that a conservative liming rate is applied to account for heterogeneity. **Figure 3** and **Figure 4** illustrate the distribution of percentage sulfur (where analysed) and the calculated liming rate for material residing within the upper 3m of the ground profile;
- The area proximal to BH2 has been assessed to be of low risk for incidence of near surface PASS and it is a suitable location for the initial mechanical excavation of the dredge pond;
- Should any change in Site conditions or excavation of a material type not previously characterised occur which may result in a potential environmental impact, a suitably qualified environmental professional should be engaged to further assess the Site and consider requirements for any additional assessment; and
- This report must be read in conjunction with the attached Statement of Limitations.

7.0 REFERENCES

Ahern, C. R., McElnea, A. E. & Sullivan L.A. (2004). Acid Sulfate Soils Laboratory Methods Guidelines in Queensland Acid Sulphate Soils Manual 2004, Department of Natural Resources, Mines and Energy, Indooroopilly, June 2004.

Australian Standard (1999) AS4482.2–1999: Guide to the investigation and sampling of sites with potentially contaminated soil – Volatile substances.

Australian Standard (2005) AS4482.1–2005: Guide to the investigation and sampling of sites with potentially contaminated soil – Non-volatile and semi-volatile compounds.

ANZECC and ARMCANZ, 2000. Australian and New Zealand Guidelines for Fresh and Marine Water Quality, Artarmon: Australian Water Association.

ANZG, 2018. Australian and New Zealand Guidelines for Fresh and Marine Water Quality

Safe Work Australia (2020). Excavation Work Code of Practice.

Dear, S E., Ahern, C. R., O'Brien, L. E., Dobos, S. K., McElnea, A. E., Moore, N. G. & Watling, K. M., (2014). Queensland Acid Sulfate Soil Technical Manual: Soil Management Guidelines. Brisbane:

Department of Science, Information Technology, Innovation and the Arts, Queensland Government.

Dear, S E., Ahern, C. R. & Moore, N. G., (2000). Acid Sulfate Soil Management Plans for Queensland, in Acid Sulfate Soils: Environmental Issues, Assessment & Management, Technical Papers, Brisbane, June 2000.

Douglas Partners (2018). Acid Sulfate Management Plan: Proposed Sand Quarry Extension Crooked River Road, Gerroa, Prepared for Cleary Bros (Bombo) Pty Ltd.

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

8.0 LIMITATIONS

This report and the associated services performed by ENRS are in accordance with the scope of services set out in the contract between ENRS and the Client. The scope of services was defined by the requests of the Client, by the time and budgetary constraints imposed by the Client, and by the availability of access to Site.

ENRS derived the data in this report primarily from visual inspections, and, limited sample collection and analysis made on the dates indicated. In preparing this report, ENRS has relied upon, and presumed accurate, certain information provided by government authorities, the Client and others identified herein. The report has been prepared on the basis that while ENRS believes all the information in it is deemed reliable and accurate at the time of preparing the report, it does not warrant its accuracy or completeness and to the full extent allowed by law excludes liability in contract, tort or otherwise, for any loss or damage sustained by the Client arising from or in connection with the supply or use of the whole or any part of the information in the report through any cause whatsoever.

Limitations also apply to analytical methods used in the identification of substances (or parameters). These limitations may be due to non-homogenous material being sampled (i.e. the sample to be analysed may not be representative), low concentrations, the presence of 'masking' agents and the restrictions of the approved analytical technique. As such, non-statistically significant sampling results can only be interpreted as 'indicative' and not used for quantitative assessments.

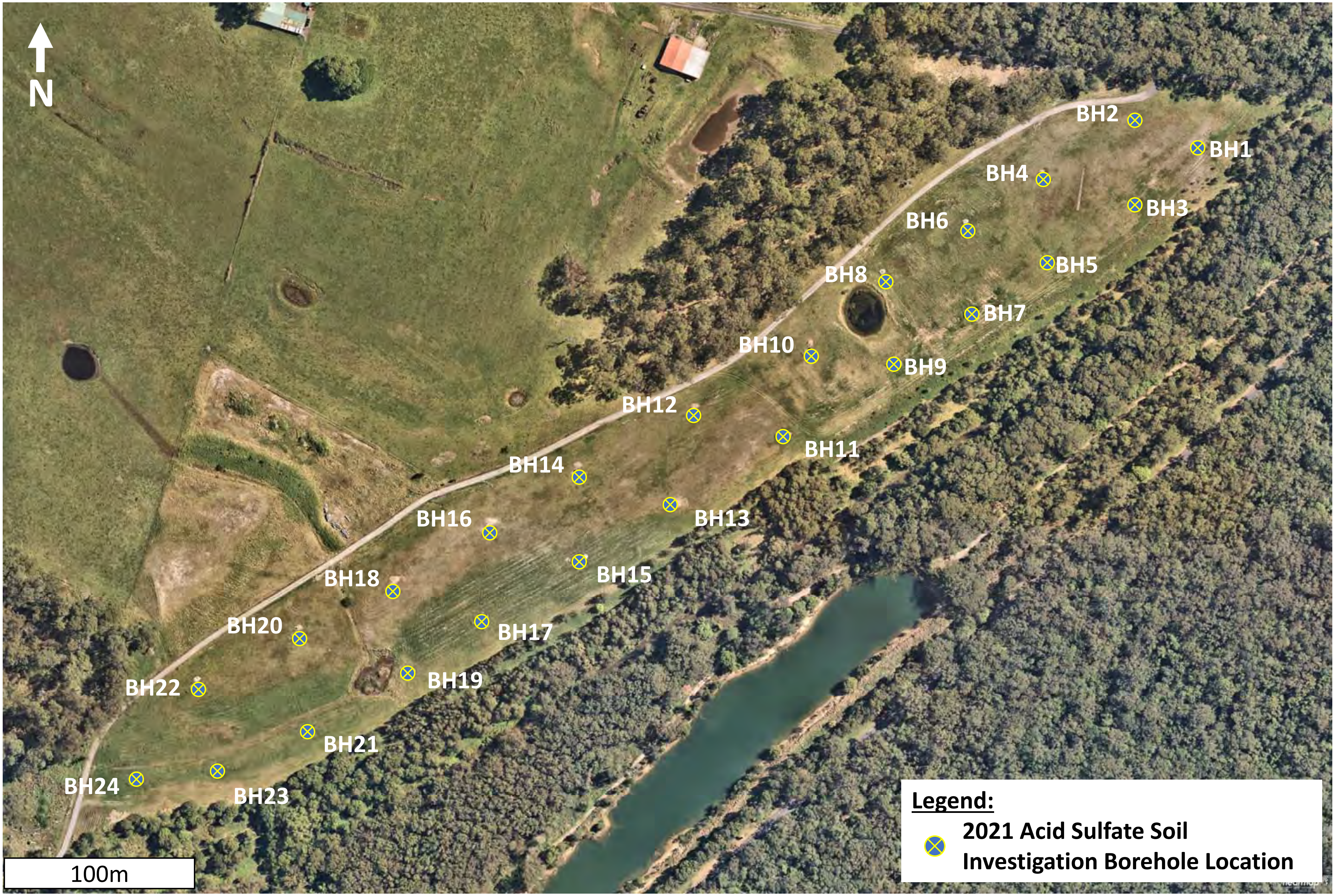
The data, findings, observations, conclusions and recommendations in the report are based solely upon the state of Site at the time of the investigation. The passage of time, manifestation of latent conditions or impacts of future events (e.g. changes in legislation, scientific knowledge, land uses, etc) may render the report inaccurate. In those circumstances, ENRS shall not be liable for any loss or damage that may be occasioned directly or indirectly through the use of, or reliance on, the contents of the report.

This report has been prepared on behalf of and for the exclusive use of the Client, and is subject to and issued in connection with the provisions of the agreement between ENRS and the Client. ENRS accepts no liability or responsibility whatsoever and expressly disclaims any responsibility for or in respect of any use of or reliance upon this report by any third party or parties.

This report is to be independently reviewed by NSW Site Auditor Brad May of *Epic Environmental* prior to issuing to the local authority.

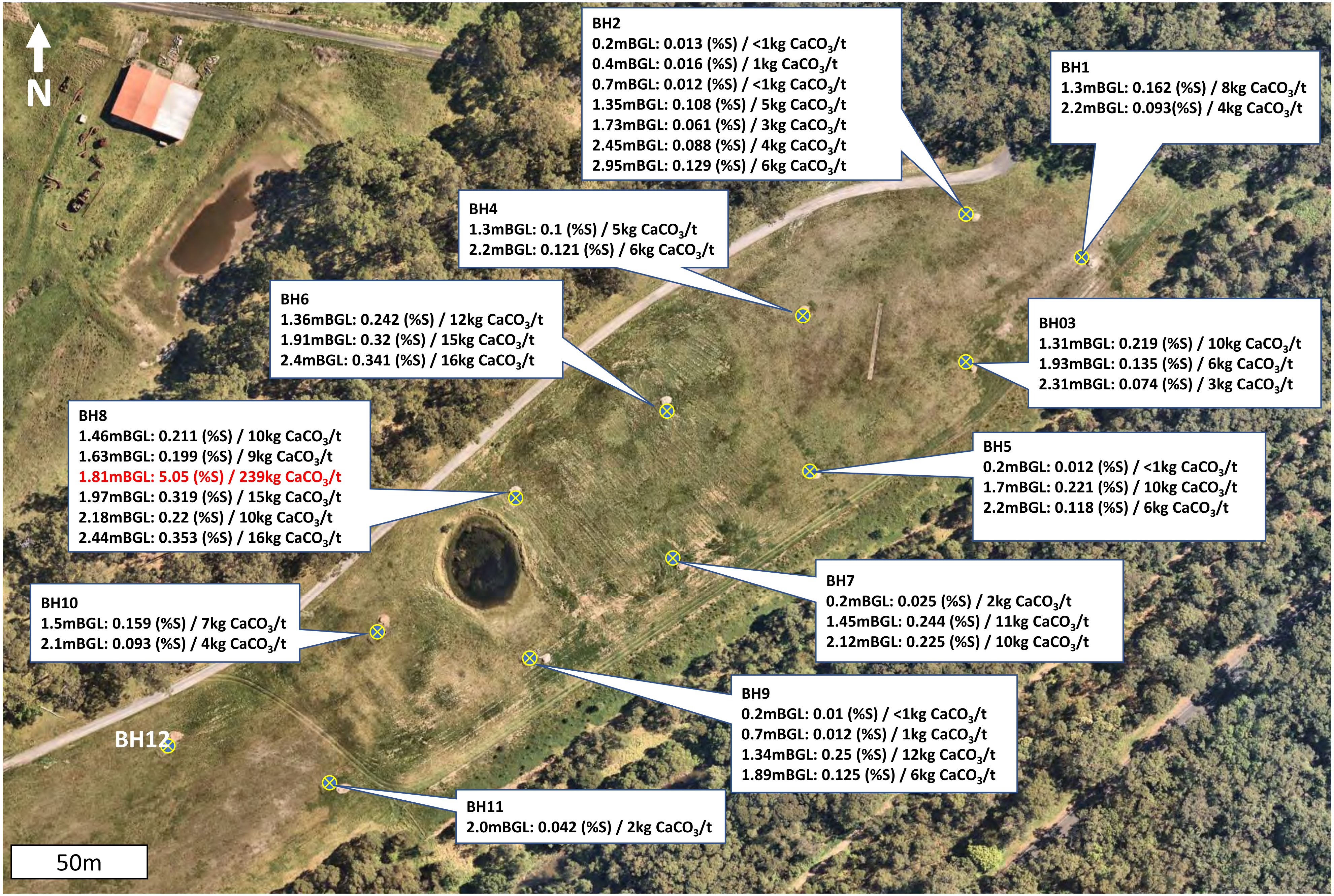
It is the responsibility of the Client to accept if the Client so chooses any recommendations contained within and implement them in an appropriate, suitable and timely manner.

Figures



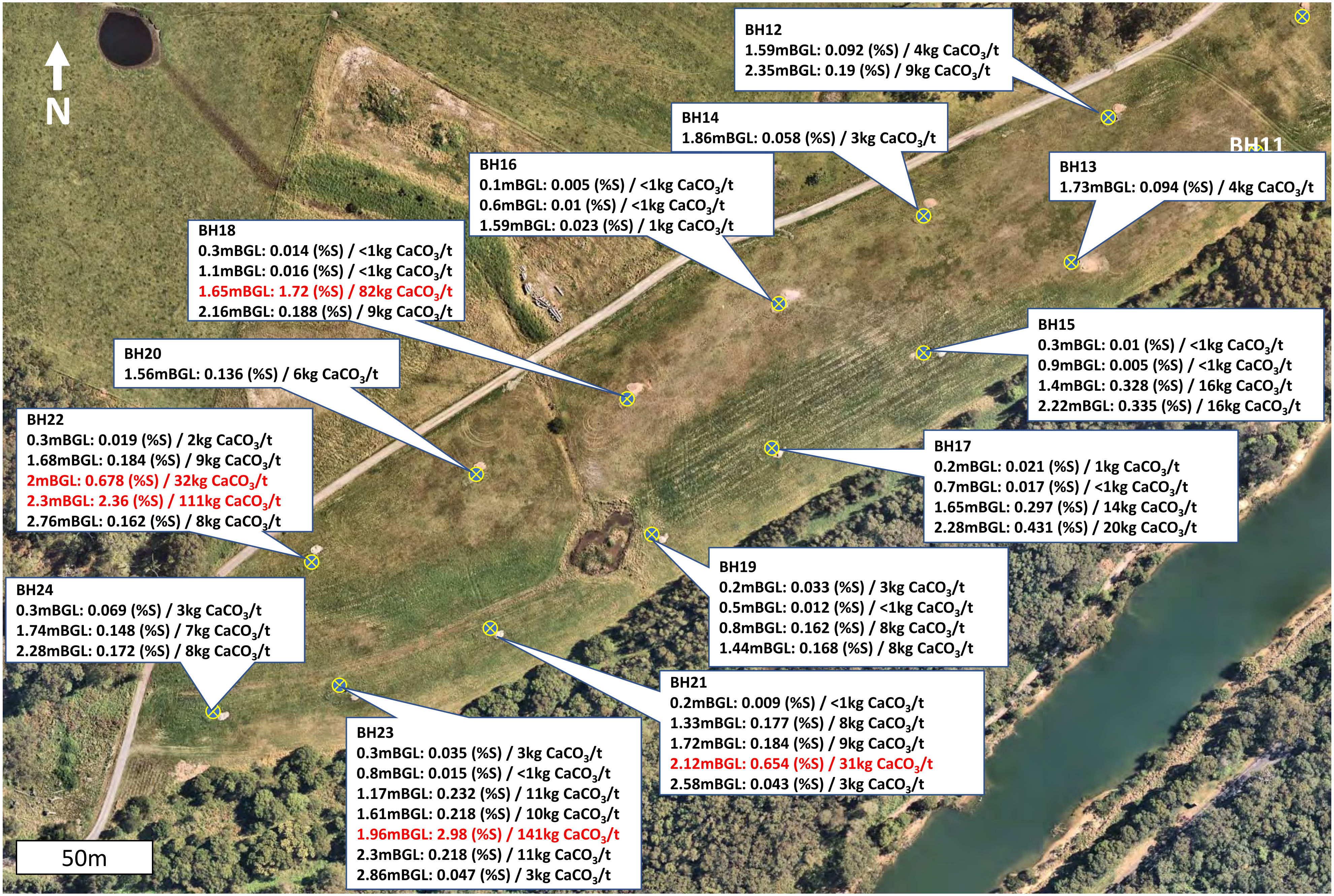
ENRS
Environment & Natural Resource Solutions
108 Jerry Bailey Road, Shoalhaven Heads, NSW, 2535
Tel: 02 4448 5490 Fax: 02 90374708 projects@enrs.com.au
www.enrs.com.au

Client:	Cleary Bros (Bombo) Pty Ltd	Drawn:	ML	Figure:	2
Project:	ENRS1947	Source:	NearMap	Date:	11/11/21
Location:	Gerroa Sand Mine Extension	Scale:	Map	Title:	Investigation Locations
		Status:	Rev 1		



ENRS
Environment & Natural Resource Solutions
108 Jerry Bailey Road, Shoalhaven Heads, NSW, 2535
Tel: 02 4448 5490 Fax: 02 90374708 projects@enrs.com.au
www.enrs.com.au

Client:	Cleary Bros (Bombo) Pty Ltd	Drawn:	ML	Figure:	3
Project:	ENRS1947	Source:	NearMap	Date:	11/11/21
Location:	Gerroa Sand Mine Extension	Scale:	Map	Title:	Sulfur (%) and liming rates within upper soil profile
		Status:	Rev 1		



ENRS
Environment & Natural Resource Solutions
108 Jerry Bailey Road, Shoalhaven Heads, NSW, 2535
Tel: 02 4448 5490 Fax: 02 90374708 projects@enrs.com.au
www.enrs.com.au

Client:	Cleary Bros (Bombo) Pty Ltd	Drawn:	ML	Figure:	4
Project:	ENRS1947	Source:	NearMap	Date:	11/11/21
Location:	Gerroa Sand Mine Extension	Scale:	Map	Title:	Sulfur (%) and liming rates within upper soil profile
		Status:	Rev 1		

APPENDICES

Appendix A

Investigation Logs

ENVIRONMENTAL INVESTIGATION LOG

ENRS
ENVIRONMENT & NATURAL RESOURCE SOLUTIONS
108 JERRY BAILEY ROAD ABN: 68 600 154 596
SHOALHAVEN HEADS NSW 2535
t: 02 4448 5490 e: projects@enrs.com.au

TP/BH ID: BH01

PROJECT No:	ENRS1947	**DATE:**	9/08/2021 - 10/08/2021
LOCATION:	CB Gerroa	**LOGGED BY:**	JF / ML / GD
CLIENT:	Cleary Brothers	**EXCAVATED BY:**	CB / Quaternary Resources
SURFACE RL:		**METHOD:**	TP / Vibracore
EASTING:	297727	**LENGTH/WIDTH:**	TP: 2.3 / 2.2 Core: 82mm
NORTHING:	6149572	**DEPTH:**	TP: 0.8 Core: 5.4 Total Depth: 5.4

Depth (m)	(Interval m-m) Description (Soil TYPE, colour, consistency, grainsize, moisture, remarks)	pH (field)	pH (FOX)	Δ pH	Lab Sample ID
	0.0 - 2.4: SAND, md, light brown, grey, no visable shell.				
0.25					
TP		5.31	4.84	0.47	BH01 / 0.40
0.50					
0.75					
0.80					
VIBRACORE					
1.00					
1.25		4.88	4.68	0.20	BH01 / 1.30
1.50					
1.75					
2.00					
		4.87	1.92	2.95	BH01 / 2.20
2.25					
	2.4 - 2.9: SAND, mc, light brown, traces fine gravel (rounded)				
2.50					
2.75					
	2.9 - 5.1: CLAY, with sand & silt, black, single coble (well rounded, ~70mm diameter).	4.82	1.59	3.23	BH01 / 3.00
3.00					
3.25					
		5.06	1.91	3.15	BH01 / 3.50
3.50					
3.75					
		6.62	2.00	4.62	BH01 / 3.90
4.00					
4.25					
4.50		6.53	2.08	4.45	BH01 / 4.60
4.75					
		7.02	2.86	4.16	BH01 / 5.00
5.00	5.1 - 5.4: Silty CLAY, black, stiff.				
5.25					
	5.4: End of BH01 due to refusal.	6.95	4.66	2.29	BH01 / 5.40
5.50					
5.75					
6.00					

Notes:

Descriptions are based on observations and hand testing of grab samples.
Mechanical Tests were not performed unless otherwise stated

ENVIRONMENT & NATURAL RESOURCE SOLUTIONS
108 JERRY BAILEY ROAD ABN: 68 600 154 596
SHOALHAVEN HEADS NSW 2535
t: 02 4448 5490 e: projects@enrs.com.au

ENVIRONMENTAL INVESTIGATION LOG

TP/BH ID: BH02

PROJECT No:	ENRS1947	**DATE:**	9/08/2021 & 10/08/2021
LOCATION:	CB Gerroa	**LOGGED BY:**	JF / ML / GD
CLIENT:	Cleary Brothers	**EXCAVATED BY:**	CB / Quaternary Resources
SURFACE RL:		**METHOD:**	TP / Vibracore
EASTING:	297686	**LENGTH/WIDTH:**	TP: 2.0 / 1.7 Core: 82mm
NORTHING:	6149589	**DEPTH:**	TP: 1.1 Core: 4.15 Total Depth: 5.25

Depth (m)	(Interval m-m) Description (Soil TYPE, colour, consistency, grainsize, moisture, remarks)	pH (field)	pH (FOX)	Δ pH	Lab Sample ID
TP	0.0 - 0.3: Silty SAND, mf, dark brown, grey, no visable shell.	5.93	4.90	1.03	BH02 / 0.20
0.25	0.3-0.5: SAND, mf, tan, orange brown, no visable shell.				
0.50		5.21	4.61	0.60	BH02 / 0.40
	0.5 - 2.6: SAND, mf, yellow to cream, upward fining, small well rounded gravel and rootlets.	5.18	4.97	0.21	BH02 / 0.70
0.75					
1.00					
1.10 (VIBRACORE)					
1.25		4.51	2.12	2.39	BH02 / 1.35
1.50					
1.75		4.80	2.12	2.68	BH02 / 1.73
2.00					
2.25					
2.50		4.99	2.21	2.78	BH02 / 2.45
	2.6 - 4.01: SAND, mc, two (2) cobbles (110mm & 60mm) well rounded at 3.4m.				
2.75					
3.00		4.85	2.08	2.77	BH02 / 2.96
3.25					
3.50		5.55	2.90	2.65	BH02 / 3.68
3.75					
4.00	4.01 - 5.25: SAND, with silt, mc.				
4.25		5.53	3.67	1.86	BH02 / 4.33
4.50					
4.75					
5.00					
5.25	5.25: End of BH02 due to refusal.				
5.50					
5.75					
6.00					

Notes:

Descriptions are based on observations and hand testing of grab samples.
Mechanical Tests were not performed unless otherwise stated

ENVIRONMENT & NATURAL RESOURCE SOLUTIONS

108 JERRY BAILEY ROAD ABN: 68 600 154 596
SHOALHAVEN HEADS NSW 2535
t: 02 4448 5490 e: projects@enrs.com.au

ENVIRONMENTAL INVESTIGATION LOG

TP/BH ID: BH03

PROJECT No:	ENRS1947	**DATE:**	9/08/2021 & 10/08/2021
LOCATION:	CB Gerroa	**LOGGED BY:**	JF / ML / GD
CLIENT:	Cleary Brothers	**EXCAVATED BY:**	CB / Quaternary Resources
SURFACE RL:		**METHOD:**	TP / Vibracore
EASTING:	297685	**LENGTH/WIDTH:**	TP: 2.1 / 1.8 Core: 82mm
NORTHING:	6149536	**DEPTH:**	TP: 0.9 Core: 4.9 Total Depth: 5.8

Depth (m)	(Interval m-m) Description (Soil TYPE, colour, consistency, grainsize, moisture, remarks)	pH (field)	pH (FOX)	Δ pH	Lab Sample ID
0.25 (TP)	0.0 - 0.4: Silty SAND, mf, dark brown, grey, no visable shell.	4.96	4.29	0.67	BH03 / 0.20
0.50 (TP)	0.4 - 1.0: SAND, mf, yellow to cream.				
0.75 (TP)		5.13	4.95	0.18	BH03 / 0.70
1.00 (VIBRACORE)	1.0 - 2.01: Silty SAND, mm, brown, high organic content (wood, reeds, & rootlets).				
1.25		4.93	1.42	3.51	BH03 / 1.31
1.50					
1.75		4.64	1.80	2.84	BH03 / 1.93
2.00	2.01 - 2.5: SAND, mc, grey.				
2.25		4.68	1.97	2.71	BH03 / 2.31
2.50	2.5 - 3.96: SAND, mc, light grey, fine gravel.				
2.75	3.96 - 4.53: CLAY & SAND, dark brown, moderate stiffness.	4.66	1.97	2.69	BH03 / 2.95
3.00					
3.25					
3.50		5.36	1.78	3.58	BH03 / 3.51
3.75					
4.00	4.0: COFFEE ROCK, 0.1m thick.	6.63	1.78	4.85	BH03 / 4.08
4.25					
4.50	4.53 - 5.8: CLAY, stiff	6.87	2.07	4.80	BH03 / 4.61
4.75					
5.00		6.49	1.89	4.60	BH03 / 5.13
5.25					
5.50					
5.75	5.8: End of BH03 due to refusal.				
6.00					

Notes:

Descriptions are based on observations and hand testing of grab samples.
Mechanical Tests were not performed unless otherwise stated

ENVIRONMENT & NATURAL RESOURCE SOLUTIONS

108 JERRY BAILEY ROAD ABN: 68 600 154 596
SHOALHAVEN HEADS NSW 2535
t: 02 4448 5490 e: projects@enrs.com.au

ENVIRONMENTAL INVESTIGATION LOG

TP/BH ID: BH04

PROJECT No:	ENRS1947	**DATE:**	9/08/2021 & 10/08/2021
LOCATION:	CB Gerroa	**LOGGED BY:**	JF / ML / GD
CLIENT:	Cleary Brothers	**EXCAVATED BY:**	CB / Quaternary Resources
SURFACE RL:		**METHOD:**	TP / Vibracore
EASTING:	297627	**LENGTH/WIDTH:**	TP: 2.2 / 2.1 Core: 82mm
NORTHING:	6149551	**DEPTH:**	TP: 1.15 Core: 4.55 Total Depth: 5.7

Depth (m)		(Interval m-m) Description (Soil TYPE, colour, consistency, grainsize, moisture, remarks)	pH (field)	pH (FOX)	Δ pH	Lab Sample ID
0.25	TP	0.0 - 0.5: Silty SAND, mf, dark brown, grey, no visable shell.	5.17	4.58	0.59	BH04 / 0.30
0.50		0.5 - 0.8: Silty SAND, mf, orange brown, dark brown, tan.	5.18	4.57	0.61	BH04 / 0.60
0.75		0.8 - 2.8: SAND, mm, yellow to cream.	5.08	4.66	0.42	BH04 / 0.90
1.00						
1.15	VIBRACORE					
1.25			4.84	1.50	3.34	BH04 / 1.30
1.50						
1.75						
2.00						
2.25			4.72	1.46	3.26	BH04 / 2.20
2.50						
2.75		2.8 - 3.2: SAND, mf.				
3.00			4.70	1.78	2.92	BH04 / 3.10
3.25		3.2 - 4.1: SAND, mc, light brown, white.				
3.50						
3.75						
4.00		4.01 - 4.18: CLAY, stiff. Underlain by coffee rock.	4.87	1.70	3.17	BH04 / 3.85
4.25		4.18 - 4.4: SAND & CLAY, cc, dark brown.	6.30	2.88	3.42	BH04 / 4.25
4.50		4.4 - 5.25: CLAY, ~10% sand, moderate plasticity.	6.50	5.13	1.37	BH04 / 4.6
4.75						
5.00			6.79	5.57	1.22	BH04 / 5.05
5.25		5.25 - 5.7: SILT & SAND, dark brown, high organics.	6.75	5.50	1.25	BH04 / 5.25
5.50						
5.75		5.7: End of BH04 due to refusal.				
6.00						

Notes:

Descriptions are based on observations and hand testing of grab samples.
Mechanical Tests were not performed unless otherwise stated

ENRS
ENVIRONMENT & NATURAL RESOURCE SOLUTIONS
108 JERRY BAILEY ROAD ABN: 68 600 154 596
SHOALHAVEN HEADS NSW 2535
t: 02 4448 5490 e: projects@enrs.com.au

ENVIRONMENTAL INVESTIGATION LOG

TP/BH ID: BH05

PROJECT No:	ENRS1947	**DATE:**	9/08/2021 & 10/08/2021
LOCATION:	CB Gerroa	**LOGGED BY:**	JF / ML / GD
CLIENT:	Cleary Brothers	**EXCAVATED BY:**	CB / Quaternary Resources
SURFACE RL:		**METHOD:**	TP / Vibracore
EASTING:	297628	**LENGTH/WIDTH:**	TP: 2.5 / 1.8 Core: 82mm
NORTHING:	6149498	**DEPTH:**	TP: 0.9 Core: 4.1 Total Depth: 5.0

Depth (m)	(Interval m-m) Description (Soil TYPE, colour, consistency, grainsize, moisture, remarks)	pH (field)	pH (FOX)	Δ pH	Lab Sample ID
0.25 (TP)	0.0 - 0.3: Silty SAND, mf, black, no visable shell.				BH05 / 0.20
0.50	0.3 - 1.1: SAND, mf, yellow to cream, silt peds, no visable shell.				BH05 / 0.60
0.75					
0.90					
1.00 (VIBRACORE)					
1.25	1.1 - 2.95: SAND, fm, light brown, trace organic.				BH05 / 1.20
1.50					
1.75					BH05 / 1.70
2.00					
2.25					BH05 / 2.20
2.50					
2.75					BH05 / 2.70
3.00	2.95 - 4.2: SAND, mc, trace shell, organic matter.				BH05 / 3.10
3.25					
3.50					
3.75					
4.00					BH05 / 4.00
4.25	4.2 - 4.75: Sandy CLAY, cc.				
4.50					BH05 / 4.50
4.75	4.75 - 5.0- Sandy CLAY, mm, grey.				BH05 / 4.90
5.00	5.0: End of BH05 due to refusal.				
5.25					
5.50					
5.75					
6.00					

Notes:

Descriptions are based on observations and hand testing of grab samples.
Mechanical Tests were not performed unless otherwise stated

ENRS
ENVIRONMENT & NATURAL RESOURCE SOLUTIONS
108 JERRY BAILEY ROAD ABN: 68 600 154 596
SHOALHAVEN HEADS NSW 2535
t: 02 4448 5490 e: projects@enrs.com.au

ENVIRONMENTAL INVESTIGATION LOG

TP/BH ID: BH06

PROJECT No:	ENRS1947	**DATE:**	9/08/2021 & 10/08/2021
LOCATION:	CB Gerroa	**LOGGED BY:**	JF / ML / GD
CLIENT:	Cleary Brothers	**EXCAVATED BY:**	CB / Quaternary Resources
SURFACE RL:		**METHOD:**	TP / Vibracore
EASTING:	297578	**LENGTH/WIDTH:**	TP: 2.5 / 1.8 Core: 82mm
NORTHING:	6149519	**DEPTH:**	TP: 1.1 Core: 4.7 Total Depth:5.8

Depth (m)	(Interval m-m) Description (Soil TYPE, colour, consistency, grainsize, moisture, remarks)	pH (field)	pH (FOX)	Δ pH	Lab Sample ID
0.25 (TP)	0.0 - 0.5: Silty SAND, mf, dark brown, black, no visable shell.	5.21	4.27	0.94	BH06 / 0.30
0.50 – 0.75 (TP)	0.5 - 2.14: SAND, mf, yellow to cream, silt peds, no visable shell, downward fining.	5.07	4.68	0.39	BH06 / 0.70
1.00					
1.10 (VIBRACORE)					
1.25 – 1.50		4.54	1.61	2.93	BH06 / 1.36
1.75 – 2.00		4.80	1.79	3.01	BH06 / 1.91
2.00 – 2.25	2.14 - 3.18: SAND, mc, trace gravel (fn).				
2.25 – 2.50		4.98	1.75	3.23	BH06 / 2.40
2.75 – 3.00		5.25	1.68	3.57	BH06 / 2.82
3.00 – 3.25	3.18 - 3.44: Silty SAND, fn, grey, low plasticity.	5.95	4.56	1.39	BH06 / 3.31
3.25 – 3.50	3.44 - 4.03: Sandy CLAY, fn.				
3.75		6.30	4.21	2.09	BH06 / 3.75
4.00	4.03 - 5.8: SAND, mc, trace silt & gravel.				
4.25 – 4.50		6.71	5.41	1.30	BH06 / 4.42
4.75		7.05	5.25	1.80	BH06 / 4.84
5.00 – 5.25					
5.50		7.22	5.24	1.98	BH06 / 5.57
5.75	5.8: End of BH06 due to refusal.				
6.00					

Notes:

Descriptions are based on observations and hand testing of grab samples.
Mechanical Tests were not performed unless otherwise stated

ENVIRONMENT & NATURAL RESOURCE SOLUTIONS

108 JERRY BAILEY ROAD ABN: 68 600 154 596
SHOALHAVEN HEADS NSW 2535
t: 02 4448 5490 e: projects@enrs.com.au

ENVIRONMENTAL INVESTIGATION LOG

TP/BH ID: BH07

PROJECT No:	ENRS1947	**DATE:**	9/08/2021 & 11/08/2021
LOCATION:	CB Gerroa	**LOGGED BY:**	JF / ML / GD
CLIENT:	Cleary Brothers	**EXCAVATED BY:**	CB / Quaternary Resources
SURFACE RL:		**METHOD:**	TP / Vibracore
EASTING:	297580	**LENGTH/WIDTH:**	TP: 2.5 / 1.8 Core: 82mm
NORTHING:	6149465	**DEPTH:**	TP: 0.9 Core: 3.5 Total Depth: 4.4

Depth (m)	(Interval m-m) Description (Soil TYPE, colour, consistency, grainsize, moisture, remarks)	pH (field)	pH (FOX)	Δ pH	Lab Sample ID
TP (0.00–0.90)	0.0 - 0.4: Silty SAND, fm, dark brown, black, no visable shell.	5.20	4.17	1.03	BH07 / 0.20
	0.4 - 2.4: SAND, mf, yellow to cream, tan mottling.				
		4.90	4.53	0.37	BH07 / 0.60
VIBRACORE (0.90–4.40)		6.54	1.73	4.81	BH07 / 1.45
		4.95	1.64	3.31	BH07 / 1.62
		5.11	1.40	3.71	BH07 / 2.12
	2.4 - 2.9: SAND, mc.	5.18	1.64	3.54	BH07 / 2.30
	2.9 - 3.1: SAND, cc, single gravel (wr 25).	5.30	1.64	3.66	BH07 / 2.84
	3.1 - 4.4: SAND, cc.				
		5.32	1.71	3.61	BH07 / 3.43
		6.10	2.49	3.61	BH07 / 3.83
	4.4: End of BH07 due to refusal.				

Depth scale: 0.25, 0.50, 0.75, 0.90, 1.00, 1.25, 1.50, 1.75, 2.00, 2.25, 2.50, 2.75, 3.00, 3.25, 3.50, 3.75, 4.00, 4.25, 4.50, 4.75, 5.00, 5.25, 5.50, 5.75, 6.00

Notes:

Descriptions are based on observations and hand testing of grab samples.
Mechanical Tests were not performed unless otherwise stated

ENVIRONMENT & NATURAL RESOURCE SOLUTIONS

108 JERRY BAILEY ROAD ABN: 68 600 154 596
SHOALHAVEN HEADS NSW 2535
t: 02 4448 5490 e: projects@enrs.com.au

ENVIRONMENTAL INVESTIGATION LOG

TP/BH ID: BH08

PROJECT No:	ENRS1947	**DATE:**	9/08/2021 & 11/08/2021
LOCATION:	CB Gerroa	**LOGGED BY:**	JF / ML / GD
CLIENT:	Cleary Brothers	**EXCAVATED BY:**	CB / Quaternary Resources
SURFACE RL:		**METHOD:**	TP / Vibracore
EASTING:	297525	**LENGTH/WIDTH:**	TP: 2.5 / 1.8 Core: 82mm
NORTHING:	6149487	**DEPTH:**	TP: 1.1 Core: 4.4 Total Depth: 5.5

Depth (m)	(Interval m-m) Description (Soil TYPE, colour, consistency, grainsize, moisture, remarks)	pH (field)	pH (FOX)	Δ pH	Lab Sample ID
TP (0–1.10)	0.0 - 0.4: Silty SAND, mf, dark brown, black, no visable shell.	4.99	3.30	1.69	BH08 / 0.20
	0.4 - 1.2: SAND, mf, yellow to cream.				
		4.84	4.05	0.79	BH08 / 0.70
VIBRACORE	1.2 - 1.35: SAND, mm, yellow to cream, organic matter.				
	1.35 - 1.98: SAND, mm, light grey, fine gravel.	4.45	1.38	3.07	BH08 / 1.46
		5.15	1.36	3.79	BH08 / 1.63
		5.75	1.64	4.11	BH08 / 1.81
	1.98 - 2.55: CLAY, stiff, high organics, trace fn sand.	6.03	3.33	2.70	BH08 / 1.97
		6.32	1.81	4.51	BH08 / 2.18
		6.40	1.64	4.76	BH08 / 2.44
	2.55 - 3.42: Sandy CLAY, mc, upward fining.				
		6.35	4.03	2.32	BH08 / 2.80
	3.42 - 5.44: SAND, fm, light grey, grey, trace silt.				
		6.38	4.97	1.41	BH08 / 3.61
		6.94	5.12	1.82	BH08 / 3.90
	5.44 - 5.5: Sandy CLAY, mm, brown.	7.20	5.48	1.72	BH08 / 5.44
	5.5: End of BH08 due to refusal.				

Depth scale (m): 0.25, 0.50, 0.75, 1.00, 1.10, 1.25, 1.50, 1.75, 2.00, 2.25, 2.50, 2.75, 3.00, 3.25, 3.50, 3.75, 4.00, 4.25, 4.50, 4.75, 5.00, 5.25, 5.50, 5.75, 6.00

Notes:

Descriptions are based on observations and hand testing of grab samples.
Mechanical Tests were not performed unless otherwise stated

ENVIRONMENT & NATURAL RESOURCE SOLUTIONS

108 JERRY BAILEY ROAD ABN: 68 600 154 596
SHOALHAVEN HEADS NSW 2535
t: 02 4448 5490 e: projects@enrs.com.au

ENVIRONMENTAL INVESTIGATION LOG

TP/BH ID: BH09

PROJECT No:	ENRS1947	**DATE:**	9/08/2021 & 11/08/2021
LOCATION:	CB Gerroa	**LOGGED BY:**	JF / ML / GD
CLIENT:	Cleary Brothers	**EXCAVATED BY:**	CB / Quaternary Resources
SURFACE RL:		**METHOD:**	TP / Vibracore
EASTING:	297531	**LENGTH/WIDTH:**	TP: 2.5 / 1.8 Core: 82mm
NORTHING:	6149432	**DEPTH:**	TP: 0.9 Core: 3.6 Total Depth: 4.5

Depth (m)	(Interval m-m) Description (Soil TYPE, colour, consistency, grainsize, moisture, remarks)	pH (field)	pH (FOX)	Δ pH	Lab Sample ID
TP (0.0–0.90)	0.0 - 0.4: Silty SAND, mf, dark brown, grey, no visable shell.	5.07	2.99	2.08	BH09 / 0.20
	0.4 - 1.1: SAND, mf, yellow to cream.	4.88	3.85	1.03	BH09 / 0.70
VIBRACORE	1.1 - 1.34: SAND, organics (grass).	4.53	1.45	3.08	BH09 / 1.34
	1.34 - 3.31: SAND, fm to mc, upwards fining.	4.49	2.22	2.27	BH09 / 1.89
		5.10	3.60	1.50	BH09 / 2.40
		7.30	5.55	1.75	BH09 / 2.90
		7.32	5.19	2.13	BH09 / 3.30
	3.31 - 3.53: SAND, cc, with fine gravel.				
	3.53 - 4.5: SAND, fm, traces silt.				
	3.78: Two (2) drop stones (30mm).				
	4.5: End of BH09 due to refusal.				

Depth scale: 0.25, 0.50, 0.75, 0.90, 1.00, 1.25, 1.50, 1.75, 2.00, 2.25, 2.50, 2.75, 3.00, 3.25, 3.50, 3.75, 4.00, 4.25, 4.50, 4.75, 5.00, 5.25, 5.50, 5.75, 6.00

Notes:

Descriptions are based on observations and hand testing of grab samples.
Mechanical Tests were not performed unless otherwise stated

ENVIRONMENT & NATURAL RESOURCE SOLUTIONS

108 JERRY BAILEY ROAD ABN: 68 600 154 596
SHOALHAVEN HEADS NSW 2535
t: 02 4448 5490 e: projects@enrs.com.au

ENVIRONMENTAL INVESTIGATION LOG

TP/BH ID: BH10

PROJECT No:	ENRS1947	**DATE:**	9/08/2021 & 11/08/2021
LOCATION:	CB Gerroa	**LOGGED BY:**	JF / ML / GD
CLIENT:	Cleary Brothers	**EXCAVATED BY:**	CB / Quaternary Resources
SURFACE RL:		**METHOD:**	TP / Vibracore
EASTING:	297478	**LENGTH/WIDTH:**	TP: 2.6 / 1.9 Core: 82mm
NORTHING:	6149440	**DEPTH:**	TP: 1.3 Core: 4.0 Total Depth: 5.3

Depth (m)	Method	(Interval m-m) Description (Soil TYPE, colour, consistency, grainsize, moisture, remarks)	pH (field)	pH (FOX)	Δ pH	Lab Sample ID
	TP	0.0 - 0.4: Silty SAND, mf, dark brown, grey, no visable shell.	5.24	4.60	0.64	BH10 / 0.20
0.25		0.4 - 1.0: SAND, mf, tan, orange brown, no visable shell.				
0.50			5.36	4.65	0.71	BH10 / 0.70
0.75						
1.00		1.0 - 1.5: SAND, mf, yellow to cream.	5.19	4.81	0.38	BH10 / 1.10
1.25						
1.30	VIBRACORE					
1.50		1.5 - 3.24: CLAY (hard), with sand (mf) ~10%.	5.83	1.24	4.59	BH10 / 1.50
1.75						
2.00			6.23	1.25	4.98	BH10 / 2.10
2.25						
2.50						
2.75			6.49	4.10	2.39	BH10 / 2.90
3.00		3.24 - 4.5: SAND, mm.				
3.25			6.69	5.03	1.66	BH10 / 3.30
3.50			6.84	5.35	1.49	BH10 / 3.60
3.75						
4.00						
4.25						
4.50		4.5 - 5.3: Silty SAND, mm.				
4.75						
5.00						
5.25		5.3: End of BH10 due to refusal.				
5.50						
5.75						
6.00						

Notes:

Descriptions are based on observations and hand testing of grab samples.
Mechanical Tests were not performed unless otherwise stated

ENVIRONMENT & NATURAL RESOURCE SOLUTIONS

108 JERRY BAILEY ROAD ABN: 68 600 154 596
SHOALHAVEN HEADS NSW 2535
t: 02 4448 5490 e: projects@enrs.com.au

ENVIRONMENTAL INVESTIGATION LOG

TP/BH ID: BH11

PROJECT No:	ENRS1947	**DATE:**	9/08/2021 &11/08/2021
LOCATION:	CB Gerroa	**LOGGED BY:**	JF / ML / GD
CLIENT:	Cleary Brothers	**EXCAVATED BY:**	CB / Quaternary Resources
SURFACE RL:		**METHOD:**	TP / Vibracore
EASTING:	297459	**LENGTH/WIDTH:**	TP: 2.5 / 1.9 Core: 82mm
NORTHING:	6149387	**DEPTH:**	TP: 1.1 Core: 3.4 Total Depth: 4.5

Depth (m)	(Interval m-m) Description (Soil TYPE, colour, consistency, grainsize, moisture, remarks)	pH (field)	pH (FOX)	Δ pH	Lab Sample ID
0.25 (TP)	0.0 - 0.4: Silty SAND, mf, dark brown, grey, no visable shell.	5.73	4.75	0.98	BH11 / 0.20
0.50 (TP)	0.5 - 2.5: SAND, mf, yellow to cream, upward fining, small well rounded gravel and rootlets.				
0.75 (TP)		5.40	4.80	0.60	BH11 / 0.70
1.00 (TP)					
1.10					
1.25					
1.50					
1.75					
2.00 (VIBRACORE)		4.77	2.45	2.32	BH11 / 2.0
2.25					
2.50	2.5 - 3.9: SAND, mc. 2.55: Cobbles, fm, well rounded.	4.91	1.48	3.43	BH11 / 2.70
2.75					
3.00					
3.25					
3.50		5.12	1.36	3.76	BH11 / 3.70
3.75	3.9 - 4.5, SAND, mc, with silt (~10%).				
4.00		5.44	2.96	2.48	BH11 / 4.10
4.25					
4.50	4.5: End of BH11 due to refusal.				
4.75					
5.00					
5.25					
5.50					
5.75					
6.00					

Notes:

Descriptions are based on observations and hand testing of grab samples.
Mechanical Tests were not performed unless otherwise stated

ENVIRONMENT & NATURAL RESOURCE SOLUTIONS
108 JERRY BAILEY ROAD ABN: 68 600 154 596
SHOALHAVEN HEADS NSW 2535
t: 02 4448 5490 e: projects@enrs.com.au

ENVIRONMENTAL INVESTIGATION LOG

TP/BH ID: BH12

PROJECT No:	ENRS1947	**DATE:**	9/08/2021 & 11/08/2021
LOCATION:	CB Gerroa	**LOGGED BY:**	JF / ML / GD
CLIENT:	Cleary Brothers	**EXCAVATED BY:**	CB / Quaternary Resources
SURFACE RL:		**METHOD:**	TP / Vibracore
EASTING:	297403	**LENGTH/WIDTH:**	TP: 2.6 / 1.8 Core: 82mm
NORTHING:	6149399	**DEPTH:**	TP: 1.1 Core: 5.0 Total Depth: 6.1

Depth (m)	(Interval m-m) Description (Soil TYPE, colour, consistency, grainsize, moisture, remarks)	pH (field)	pH (FOX)	Δ pH	Lab Sample ID
TP (0–1.10)	0.0 - 0.5: Silty SAND, mf, dark brown, grey, no visable shell.	5.01	4.37	0.64	BH12 / 0.20
	0.5-0.7: SAND, mf, tan, orange brown, no visable shell.	5.20	4.75	0.45	BH12 / 0.60
	0.7 - 1.73: SAND, mf, yellow to cream, upward fining.				
		5.37	4.84	0.53	BH12 / 0.90
VIBRACORE (1.10–6.1)		4.55	1.93	2.62	BH12 / 1.59
	1.73 - 2.5: CLAY, with organic matter.				
		5.33	2.53	2.80	BH12 / 2.35
	2.5 - 3.2: Clayey SAND, mf.				
		5.95	2.29	3.66	BH12 / 3.02
	3.2 - 3.8: Clayey SAND (mf), clay hard.				
		5.90	2.81	3.09	BH12 / 3.54
	3.8 - 5.6: SAND, mf.				
		6.57	4.62	1.95	BH12 / 4.71
	5.6 - 6.1: SAND (mf), with silt (~10%).				
		5.67	1.69	3.98	BH12 / 5.75
	6.1: TDR.				

Depth scale: 0.25, 0.50, 0.75, 1.00, 1.10, 1.25, 1.50, 1.75, 2.00, 2.25, 2.50, 2.75, 3.00, 3.25, 3.50, 3.75, 4.00, 4.25, 4.50, 4.75, 5.00, 5.25, 5.50, 5.75, 6.00

Notes:

Descriptions are based on observations and hand testing of grab samples.
Mechanical Tests were not performed unless otherwise stated

ENVIRONMENT & NATURAL RESOURCE SOLUTIONS

108 JERRY BAILEY ROAD ABN: 68 600 154 596
SHOALHAVEN HEADS NSW 2535
t: 02 4448 5490 e: projects@enrs.com.au

ENVIRONMENTAL INVESTIGATION LOG

TP/BH ID: BH13

PROJECT No:	ENRS1947	**DATE:**	9/08/2021 & 11/08/2021
LOCATION:	CB Gerroa	**LOGGED BY:**	JF / ML / GD
CLIENT:	Cleary Brothers	**EXCAVATED BY:**	CB / Quaternary Resources
SURFACE RL:		**METHOD:**	TP / Vibracore
EASTING:	297387	**LENGTH/WIDTH:**	TP: 2.5 / 1.8 Core: 82mm
NORTHING:	6149342	**DEPTH:**	TP: 1.0 Core: 4.7 Total Depth: 5.7

Depth (m)	(Interval m-m) Description (Soil TYPE, colour, consistency, grainsize, moisture, remarks)	pH (field)	pH (FOX)	Δ pH	Lab Sample ID
TP	0.0 - 0.5: Silty SAND, mf, dark brown, grey, no visable shell.				
0.25		5.51	4.82	0.69	BH13 / 0.30
0.50	0.5 - 1.9: SAND, mf, yellow to cream.				
0.75		5.20	4.89	0.31	BH13 / 0.80
1.00 (VIBRACORE)					
1.25					
1.50					
1.75		5.68	1.42	4.26	BH13 / 1.73
2.00	1.9 - 2.5: SAND, mc.	5.68	1.80	3.88	BH13 / 2.04
2.25					
2.50	2.5 - 3.1: Gravelly SAND, cc, gravel up 5mm.				
2.75					
3.00		5.81	1.81	4.00	BH13 / 2.90
3.00	3.1 - 4.4: SAND, mc, traces of charcoal.				
3.25					
3.50		5.83	1.37	4.46	BH13 / 3.57
3.75					
4.00					
4.25		6.10	2.14	3.96	BH13 / 4.22
4.50	4.4 - 5.4: Silty SAND, traces of organic matter (twigs).	6.20	3.62	2.58	BH13 / 4.53
4.75					
5.00		6.26	1.86	4.40	BH13 / 5.00
5.25					
5.50	5.4 - 5.7: SAND, ms, with silt (~10%).				
5.75	5.7: End of BH13 due to refusal..	6.46	1.92	4.54	BH13 / 5.85
6.00					

Notes:

Descriptions are based on observations and hand testing of grab samples.
Mechanical Tests were not performed unless otherwise stated

ENVIRONMENT & NATURAL RESOURCE SOLUTIONS
108 JERRY BAILEY ROAD ABN: 68 600 154 596
SHOALHAVEN HEADS NSW 2535
t: 02 4448 5490 e: projects@enrs.com.au

ENVIRONMENTAL INVESTIGATION LOG

TP/BH ID: BH14

PROJECT No:	ENRS1947	**DATE:**	9/08/2021 & 11/08/2021
LOCATION:	CB Gerroa	**LOGGED BY:**	JF / ML / GD
CLIENT:	Cleary Brothers	**EXCAVATED BY:**	CB / Quaternary Resources
SURFACE RL:		**METHOD:**	TP / Vibracore
EASTING:	297327	**LENGTH/WIDTH:**	TP: 2.5 / 2.0 Core: 82mm
NORTHING:	6149361	**DEPTH:**	TP: 1.2 Core: 4.3 Total Depth: 5.5

Depth (m)	(Interval m-m) Description (Soil TYPE, colour, consistency, grainsize, moisture, remarks)	pH (field)	pH (FOX)	Δ pH	Lab Sample ID
TP (0.25)	0.0 - 0.5: Silty SAND, mf, dark brown, grey, no visable shell.	5.92	5.11	0.81	BH14 / 0.30
0.50	0.5 - 4.5: SAND, mf, yellow to cream.				
0.90		5.34	4.82	0.52	BH14 / 0.90
1.20					
VIBRACORE (1.86)		4.73	1.76	2.97	BH14 / 1.86
2.82		4.66	1.82	2.84	BH14 / 2.82
3.78		4.85	1.59	3.26	BH14 / 3.78
4.30	4.5 - 4.8: SAND (mc), with silt (10%), traces of charcoal.	5.09	1.86	3.23	BH14 / 4.30
4.50		5.29	1.96	3.33	BH14 / 4.50
4.80	4.8 - 5.4: SAND (cc), with silt, traces of charcoal.	5.14	1.80	3.34	BH14 / 4.80
5.40	5.4 - 5.5: Silty SAND, cc.	5.21	1.75	3.46	BH14 / 5.40
5.50	5.5: End of BH14 due to refusal.	5.43	1.71	3.72	BH14 / 5.50

Notes:

Descriptions are based on observations and hand testing of grab samples.
Mechanical Tests were not performed unless otherwise stated

ENRS
ENVIRONMENT & NATURAL RESOURCE SOLUTIONS

108 JERRY BAILEY ROAD ABN: 68 600 154 596
SHOALHAVEN HEADS NSW 2535
t: 02 4448 5490 e: projects@enrs.com.au

ENVIRONMENTAL INVESTIGATION LOG

TP/BH ID: BH15

PROJECT No:	ENRS1947	**DATE:**	9/08/2021 & 11/08/2021
LOCATION:	CB Gerroa	**LOGGED BY:**	JF / ML / GD
CLIENT:	Cleary Brothers	**EXCAVATED BY:**	CB / Quaternary Resources
SURFACE RL:		**METHOD:**	TP / Vibracore
EASTING:	297329	**LENGTH/WIDTH:**	TP: 2.5 / 1.8 Core: 82mm
NORTHING:	6149307	**DEPTH:**	TP: 1.2 Core: 1.4 Total Depth: 2.6

Depth (m)	(Interval m-m) Description (Soil TYPE, colour, consistency, grainsize, moisture, remarks)	pH (field)	pH (FOX)	Δ pH	Lab Sample ID
0.25 (TP)	0.0 - 0.5: Silty SAND, mf, dark brown, grey, no visable shell.	4.68	2.42	2.26	BH15 / 0.30
0.50	0.5 - 2.0: SAND, mf, yellow to cream.				
0.75					
1.00		4.84	3.69	1.15	BH15 / 0.90
1.10 (VIBRACORE)					
1.25					
1.50		4.24	1.77	2.47	BH15 / 1.40
1.75		4.80	1.99	2.81	BH15 / 1.77
2.00	2.0 - 2.5: CLAY, very stiff.				
2.25		5.75	2.71	3.04	BH15 / 2.22
2.50	2.5 - 2.6: CLAY, hard. 2.6: End of BH15 due to refusal.	6.41	3.79	2.62	BH15 / 2.50
2.75					
3.00					
3.25					
3.50					
3.75					
4.00					
4.25					
4.50					
4.75					
5.00					
5.25					
5.50					
5.75					
6.00					

Notes:

Descriptions are based on observations and hand testing of grab samples.
Mechanical Tests were not performed unless otherwise stated

ENRS
ENVIRONMENT & NATURAL RESOURCE SOLUTIONS
108 JERRY BAILEY ROAD ABN: 68 600 154 596
SHOALHAVEN HEADS NSW 2535
t: 02 4448 5490 e: projects@enrs.com.au

ENVIRONMENTAL INVESTIGATION LOG

TP/BH ID: BH16

PROJECT No:	ENRS1947	**DATE:**	9/08/2021 & 11/08/2021
LOCATION:	CB Gerroa	**LOGGED BY:**	JF / ML / GD
CLIENT:	Cleary Brothers	**EXCAVATED BY:**	CB / Quaternary Resources
SURFACE RL:		**METHOD:**	TP / Vibracore
EASTING:	297270	**LENGTH/WIDTH:**	TP: 2.5 / 1.8 Core: 82mm
NORTHING:	6149325	**DEPTH:**	TP: 1.2 Core: 3.1 Total Depth: 4.3

Depth (m)	(Interval m-m) Description (Soil TYPE, colour, consistency, grainsize, moisture, remarks)	pH (field)	pH (FOX)	Δ pH	Lab Sample ID
TP (0–1.10)	0.0 - 0.2: Silty SAND, mf, dark brown, grey, no visable shell.	5.99	4.49	1.50	BH16 / 0.10
	0.2 - 2.5: SAND, md, yellow to cream, silt peds.				
		5.45	4.02	1.43	BH16 / 0.60
VIBRACORE (1.10–)		4.65	1.56	3.09	BH16 / 1.59
		4.35	1.46	2.89	BH16 / 2.24
	2.5 - 3.3: SAND, mc.				
		5.09	1.91	3.18	BH16 / 2.98
	3.3 - 4.3: SAND (mc), with silt (10%).				
		5.43	1.65	3.78	BH16 / 3.60
		5.46	2.80	2.66	BH16 / 3.96
	4.3: End of BH16 due to refusal.	5.26	5.53	-0.27	BH16 / 4.30

Depth scale: 0.25, 0.50, 0.75, 1.00, 1.10, 1.25, 1.50, 1.75, 2.00, 2.25, 2.50, 2.75, 3.00, 3.25, 3.50, 3.75, 4.00, 4.25, 4.50, 4.75, 5.00, 5.25, 5.50, 5.75, 6.00

Notes:

Descriptions are based on observations and hand testing of grab samples.
Mechanical Tests were not performed unless otherwise stated

ENVIRONMENT & NATURAL RESOURCE SOLUTIONS

108 JERRY BAILEY ROAD ABN: 68 600 154 596
SHOALHAVEN HEADS NSW 2535
t: 02 4448 5490 e: projects@enrs.com.au

ENVIRONMENTAL INVESTIGATION LOG

TP/BH ID: BH17

PROJECT No:	ENRS1947	**DATE:**	9/08/2021 & 11/08/2021		
LOCATION:	CB Gerroa	**LOGGED BY:**	JF / ML / GD		
CLIENT:	Cleary Brothers	**EXCAVATED BY:**	CB / Quaternary Resources		
SURFACE RL:		**METHOD:**	TP / Vibracore		
EASTING:	297266	**LENGTH/WIDTH:**	TP: 2.5 / 1.8	Core: 82mm	
NORTHING:	6149268	**DEPTH:**	TP: 1.2	Core: 3.4	Total Depth: 4.6

Depth (m)	(Interval m-m) Description (Soil TYPE, colour, consistency, grainsize, moisture, remarks)	pH (field)	pH (FOX)	Δ pH	Lab Sample ID
0.25 (TP)	0.0 - 0.4: Silty SAND, mf, dark brown, grey, no visable shell.	5.38	3.26	2.12	BH17 / 0.20
0.50	0.4 - 1.7: SAND, md, yellow to cream, silt peds.				
0.75		4.85	3.60	1.25	BH17 / 0.70
1.00					
1.20 (VIBRACORE)					
1.25					
1.50		4.68	1.69	2.99	BH17 / 1.65
1.75	1.7 - 2.5: Sandy CLAY, sand mf.				
2.00					
2.25		5.88	2.08	3.80	BH17 / 2.28
2.50	2.5 - 4.1: Sandy CLAY, hard, sand mf.				
2.75					
3.00		5.65	1.47	4.18	BH17 / 2.91
3.25					
3.50		6.11	2.03	4.08	BH17 / 3.45
3.75					
4.00	4.1 - 4.4: SAND (mf), with silt.	6.41	2.00	4.41	BH17 / 4.08
4.25		6.47	1.55	4.92	BH17 / 4.35
4.50	4.4 - 4.6: SAND, mc.				
4.75	4.6: End of BH17 due to refusal.	6.41	2.48	3.93	BH17 / 4.60
5.00					
5.25					
5.50					
5.75					
6.00					

Notes:

Descriptions are based on observations and hand testing of grab samples.
Mechanical Tests were not performed unless otherwise stated

ENRS
ENVIRONMENT & NATURAL RESOURCE SOLUTIONS

108 JERRY BAILEY ROAD ABN: 68 600 154 596
SHOALHAVEN HEADS NSW 2535
t: 02 4448 5490 e: projects@enrs.com.au

ENVIRONMENTAL INVESTIGATION LOG

TP/BH ID: BH18

PROJECT No:	ENRS1947	**DATE:**	9/08/2021 & 11/08/2021
LOCATION:	CB Gerroa	**LOGGED BY:**	JF / ML / GD
CLIENT:	Cleary Brothers	**EXCAVATED BY:**	CB / Quaternary Resources
SURFACE RL:		**METHOD:**	TP / Vibracore
EASTING:	297209	**LENGTH/WIDTH:**	TP: 2.5 / 1.8 Core: 82mm
NORTHING:	6149287	**DEPTH:**	TP: 1.3 Core: 3.4 Total Depth: 4.7

Depth (m)	(Interval m-m) Description (Soil TYPE, colour, consistency, grainsize, moisture, remarks)	pH (field)	pH (FOX)	Δ pH	Lab Sample ID
0.25 (TP)	0.0 - 0.5: Silty SAND, mf, dark brown, grey, no visable shell.	4.79	3.77	1.02	BH18 / 0.30
0.50	0.5-0.9: SAND, mf, tan, orange brown, no visable shell.	4.82	4.34	0.48	BH18 / 0.70
0.75					
1.00	0.9 - 1.3: SAND, md, yellow to cream, silt peds.	4.78	4.49	0.29	BH18 / 1.10
1.25					
1.30 (VIBRACORE)	1.3 - 1.8: Sandy CLAY, black, sand mf (50%).				
1.50		5.92	1.60	4.32	BH18 / 1.65
1.75	1.8 - 2.3: Sandy Clay, hard clay, sand mf (30%).				
2.00		6.17	1.73	4.44	BH18 / 2.16
2.25	2.3 - 2.8: Clayey SAND, sand mc (70%).				
2.50		6.53	2.68	3.85	BH18 / 64
2.75	2.8 - 3.5: Clayey SAND, sand mc (60%).				
3.00					
3.25		6.60	3.46	3.14	BH18 / 3.22
3.50	3.5 - 4.2: Clayey SAND, mf, yellow.				
3.75					
4.00		6.79	4.41	2.38	BH18 / 3.92
4.25	4.2 - 4.7: SAND (mf), with silt (10%).				
4.50		7.15	5.10	2.05	BH18/ 4.53
4.75	4.7: End of BH18 due to refusal.				
5.00					
5.25					
5.50					
5.75					
6.00					

Notes:

Descriptions are based on observations and hand testing of grab samples.
Mechanical Tests were not performed unless otherwise stated

ENVIRONMENT & NATURAL RESOURCE SOLUTIONS
108 JERRY BAILEY ROAD ABN: 68 600 154 596
SHOALHAVEN HEADS NSW 2535
t: 02 4448 5490 e: projects@enrs.com.au

ENVIRONMENTAL INVESTIGATION LOG

TP/BH ID: BH19

PROJECT No:	ENRS1947	**DATE:**	9/08/2021 & 12/08/2021
LOCATION:	CB Gerroa	**LOGGED BY:**	JF / ML / GD
CLIENT:	Cleary Brothers	**EXCAVATED BY:**	CB / Quaternary Resources
SURFACE RL:		**METHOD:**	TP / Vibracore
EASTING:	297218	**LENGTH/WIDTH:**	TP: 2.5 / 1.8 Core: 82mm
NORTHING:	6149234	**DEPTH:**	TP: 1.0 Core: 4.4

Depth (m)	Method	(Interval m-m) Description (Soil TYPE, colour, consistency, grainsize, moisture, remarks)	pH (field)	pH (FOX)	Δ pH	Lab Sample ID
0.25	TP	0.0 - 0.3: Silty SAND, mf, dark brown, grey, no visable shell.	4.84	2.67	2.17	BH19 / 0.20
		0.3 - 0.7: SAND, md, yellow to cream.				
0.50			4.97	3.78	1.19	BH19 / 0.50
		0.7 - 1.1: SAND, mf, greeny grey.				
0.75			5.50	1.48	4.02	BH19 / 0.80
1.00	VIBRACORE	1.1 - 1.6: SAND, mf, with organic matter (grass).				
1.25						
			5.13	1.25	3.88	BH19 / 1.44
1.50		1.6 - 2.1: SAND, mf, with organic matter (grass).				
1.75			5.13	1.26	3.87	BH19 / 1.87
2.00		2.1 - 4.1: SAND, mc.				
2.25						
2.50			4.84	1.23	3.61	BH19 / 2.51
2.75						
3.00						
3.25			4.86	1.30	3.56	BH19 / 3.24
3.50						
3.75			5.09	1.52	3.57	BH19 / 3.8
4.00		4.1: End of BH19 due to refusal.				
4.25						
4.50						
4.75						
5.00						
5.25						
5.50						
5.75						
6.00						

Notes:

Descriptions are based on observations and hand testing of grab samples.
Mechanical Tests were not performed unless otherwise stated

ENVIRONMENT & NATURAL RESOURCE SOLUTIONS
108 JERRY BAILEY ROAD ABN: 68 600 154 596
SHOALHAVEN HEADS NSW 2535
t: 02 4448 5490 e: projects@enrs.com.au

ENVIRONMENTAL INVESTIGATION LOG

TP/BH ID: BH20

PROJECT No:	ENRS1947	**DATE:**	9/08/2021 & 12/08/2021
LOCATION:	CB Gerroa	**LOGGED BY:**	JF / ML / GD
CLIENT:	Cleary Brothers	**EXCAVATED BY:**	CB / Quaternary Resources
SURFACE RL:		**METHOD:**	TP / Vibracore
EASTING:	297147	**LENGTH/WIDTH:**	TP: 2.5 / 1.8 Core: 82mm
NORTHING:	6149257	**DEPTH:**	TP: 1.2 Core: 4.3

Depth (m)	(Interval m-m) Description (Soil TYPE, colour, consistency, grainsize, moisture, remarks)	pH (field)	pH (FOX)	Δ pH	Lab Sample ID
TP	0.0 - 0.5: Silty SAND, mf, dark brown, grey, no visable shell.				
0.25		5.25	4.43	0.82	BH20 / 0.40
0.50	0.5 - 1.3: SAND, mf, yellow to cream.				
0.75		4.97	4.59	0.38	BH20 / 0.80
1.00					
1.20					
VIBRACORE 1.25	1.3 - 2.8: SAND, mf, upwards fining.				
1.50		5.38	2.12	3.26	BH20 / 1.56
1.75		4.75	2.01	2.74	BH20 / 1.96
2.00					
2.25					
2.50		5.43	1.97	3.46	BH20 / 2.53
2.75	2.8 - 4.05: Clayey SAND, fm, black.				
3.00		6.00	1.99	4.01	BH20 / 3.06
3.25					
3.50		6.81	3.02	3.79	BH20 / 3.67
3.75					
4.00	4.05 - 4.3: SAND, mc.	7.07	2.36	4.71	BH20 / 4.05
4.25	4.3: End of BH20 due to refusal.				
4.50					
4.75					
5.00					
5.25					
5.50					
5.75					
6.00					

Notes:

Descriptions are based on observations and hand testing of grab samples.
Mechanical Tests were not performed unless otherwise stated

ENVIRONMENT & NATURAL RESOURCE SOLUTIONS

108 JERRY BAILEY ROAD ABN: 68 600 154 596
SHOALHAVEN HEADS NSW 2535
t: 02 4448 5490 e: projects@enrs.com.au

ENVIRONMENTAL INVESTIGATION LOG

TP/BH ID: BH21

PROJECT No:	ENRS1947	**DATE:**	9/08/2021 & 12/08/2021
LOCATION:	CB Gerroa	**LOGGED BY:**	JF / ML / GD
CLIENT:	Cleary Brothers	**EXCAVATED BY:**	CB / Quaternary Resources
SURFACE RL:		**METHOD:**	TP / Vibracore
EASTING:	297153	**LENGTH/WIDTH:**	TP: 2.5 / 1.8 Core: 82mm
NORTHING:	6149196	**DEPTH:**	TP: 1.1 Core: 4.0

Depth (m)	(Interval m-m) Description (Soil TYPE, colour, consistency, grainsize, moisture, remarks)	pH (field)	pH (FOX)	Δ pH	Lab Sample ID
TP (0.00–1.10)	0.0 - 0.3: Silty SAND, mf, dark brown, grey, no visable shell.	4.54	2.31	2.23	BH21 / 0.20
	0.3 - 1.1: SAND, md, yellow to cream, silt peds.				
		4.30	3.37	0.93	BH21 / 0.70
VIBRACORE (1.10–)	1.1 - 1.8: SAND, mf, traces of organic matter (grass & rootlets).				
		5.00	1.86	3.14	BH21 / 1.33
	1.8 - 4.0: Sandy CLAY, black, mf, soft..	4.98	1.98	3.00	BH21 / 1.72
		5.84	1.83	4.01	BH21 / 2.12
		5.57	3.03	2.54	BH21 / 2.58
		6.02	3.61	2.41	BH21 / 2.99
		6.56	4.36	2.20	BH21 / 3.43
		6.82	4.73	2.09	BH21 / 3.88
	4.0: End of BH21 due to refusal.	6.81	4.55	2.26	BH21 / 4.00

Depth scale: 0.25, 0.50, 0.75, 1.00, 1.10, 1.25, 1.50, 1.75, 2.00, 2.25, 2.50, 2.75, 3.00, 3.25, 3.50, 3.75, 4.00, 4.25, 4.50, 4.75, 5.00, 5.25, 5.50, 5.75, 6.00

Notes:

Descriptions are based on observations and hand testing of grab samples.
Mechanical Tests were not performed unless otherwise stated

ENVIRONMENT & NATURAL RESOURCE SOLUTIONS
108 JERRY BAILEY ROAD ABN: 68 600 154 596
SHOALHAVEN HEADS NSW 2535
t: 02 4448 5490 e: projects@enrs.com.au

ENVIRONMENTAL INVESTIGATION LOG

TP/BH ID: BH22

PROJECT No:	ENRS1947	**DATE:**	9/08/2021 & 12/08/2021
LOCATION:	CB Gerroa	**LOGGED BY:**	JF / ML / GD
CLIENT:	Cleary Brothers	**EXCAVATED BY:**	CB / Quaternary Resources
SURFACE RL:		**METHOD:**	TP / Vibracore
EASTING:	297083	**LENGTH/WIDTH:**	TP: 2.4 / 1.8 Core: 82mm
NORTHING:	6149223	**DEPTH:**	TP: 1.2 Core: 4.9

Depth (m)	(Interval m-m) Description (Soil TYPE, colour, consistency, grainsize, moisture, remarks)	pH (field)	pH (FOX)	Δ pH	Lab Sample ID
TP	0.0 - 0.5: Silty SAND, mf, dark brown, grey, no visable shell.				
0.25		4.82	2.51		BH22 / 0.30
0.50	0.5 - 2.10: SAND, mf, yellow to cream, upward fining.				
0.75		4.83	4.18		BH22 / 0.80
1.00					
1.20 (VIBRACORE)					
1.25		4.96	1.95		BH22 / 1.34
1.50					
1.75		5.45	2.00		BH22 / 1.68
2.00		6.34	1.90		BH22 / 2.0
	2.1 - 2.2: Sandy CLAY, black, mf, soft.				
	2.2 - 2.5: CLAY, black, firm, traces of sand (mf).				
2.25		6.88	2.21		BH22 / 2.30
2.50	2.5 - 3.0: Sandy CLAY, black, mf, soft.				
2.75		6.94	2.10		BH22 / 2.76
3.00	3.0 - 4.0: Silty SAND, mf, black.	7.10	1.87		BH22 / 3.15
3.25					
3.50		7.06	1.92		BH22 / 3.56
3.75		6.98	2.61		BH22 / 3.89
4.00	4.0 - 4.9: SAND, mc.				
4.25		7.16	4.48		BH22 / 4.40
4.50					
4.75	4.9: End of BH22 due to refusal.				
5.00					
5.25					
5.50					
5.75					
6.00					

Notes:

Descriptions are based on observations and hand testing of grab samples.
Mechanical Tests were not performed unless otherwise stated

ENVIRONMENT & NATURAL RESOURCE SOLUTIONS
108 JERRY BAILEY ROAD ABN: 68 600 154 596
SHOALHAVEN HEADS NSW 2535
t: 02 4448 5490 e: projects@enrs.com.au

ENVIRONMENTAL INVESTIGATION LOG

TP/BH ID: BH23

PROJECT No:	ENRS1947	**DATE:**	9/08/2021 & 12/08/2021
LOCATION:	CB Gerroa	**LOGGED BY:**	JF / ML / GD
CLIENT:	Cleary Brothers	**EXCAVATED BY:**	CB / Quaternary Resources
SURFACE RL:		**METHOD:**	TP / Vibracore
EASTING:	297096	**LENGTH/WIDTH:**	TP: 2.4 / 1.8 Core: 82mm
NORTHING:	6149172	**DEPTH:**	TP: 1.0 Core: 3.6

Depth (m)	(Interval m-m) Description (Soil TYPE, colour, consistency, grainsize, moisture, remarks)	pH (field)	pH (FOX)	Δ pH	Lab Sample ID
TP	0.0 - 0.4: Silty SAND, mf, dark brown, grey, no visable shell.				
0.25		5.35	2.77		BH23 / 0.30
	0.5 - 1.7: SAND, mf, yellow to cream, upward fining.				
0.50					
0.75		4.99	3.81		BH23 / 0.80
VIBRACORE 1.00					
1.25		4.39	2.04		BH23 / 1.17
1.50		4.50	2.06		BH23 1.61
1.75	1.7 - 2.1: CLAY, black, firm, traces of organic matter (roots).				
		4.56	1.98		BH23 / 1.96
2.00	2.1 - 2.2: CLAY, black, soft, traces of sand (mf).				
	2.2 - 2.5: CLAY, black, very soft, with sand (mf).				
2.25		5.93	2.23		BH23 / 2.30
2.50	2.5 - 2.7: CLAY, black, firm, traces of sand (mf).	5.74	2.26		BH23 / 2.59
2.75	2.7 - 3.6: CLAY, black, stiff.				
3.00		5.59	3.22		BH23 / 2.86
3.25		5.07	3.35		BH23 / 3.20
3.50	3.6: End of BH23 due to refusal.				
3.75					
4.00					
4.25					
4.50					
4.75					
5.00					
5.25					
5.50					
5.75					
6.00					

Notes:

Descriptions are based on observations and hand testing of grab samples.
Mechanical Tests were not performed unless otherwise stated

ENVIRONMENT & NATURAL RESOURCE SOLUTIONS
108 JERRY BAILEY ROAD ABN: 68 600 154 596
SHOALHAVEN HEADS NSW 2535
t: 02 4448 5490 e: projects@enrs.com.au

ENVIRONMENTAL INVESTIGATION LOG

TP/BH ID: BH24

PROJECT No:	ENRS1947	**DATE:**	9/08/2021 & 12/08/2021
LOCATION:	CB Gerroa	**LOGGED BY:**	JF / ML / GD
CLIENT:	Cleary Brothers	**EXCAVATED BY:**	CB / Quaternary Resources
SURFACE RL:		**METHOD:**	TP / Vibracore
EASTING:	297043	**LENGTH/WIDTH:**	TP: 2.6 / 1.7 Core: 82mm
NORTHING:	6149164	**DEPTH:**	TP: 1.1 Core: 4.5

Depth (m)	(Interval m-m) Description (Soil TYPE, colour, consistency, grainsize, moisture, remarks)	pH (field)	pH (FOX)	Δ pH	Lab Sample ID
0.25 (TP)	0.0 - 0.6: Silty SAND, mf, dark brown, grey, no visable shell.	5.40	3.80	1.60	BH24 / 0.30
0.50	0.6 - 1.5: SAND, mf, yellow to cream, upward fining.				
0.75		4.60	4.26	0.34	BH24 / 0.80
1.00 / 1.10		4.45	2.07	2.38	BH24 / 1.25
1.25 (VIBRACORE)					
1.50	1.5 - 2.0: SAND, mc, traces of organic matter (grass).				
1.75		4.54	1.71	2.83	BH24 / 1.74
2.00	2.0 - 2.5: SAND, mc, with gravel (10-25mm), well rounded				
2.25		4.63	1.58	3.05	BH24 / 2.28
2.50	2.5 - 3.0: SAND, mc.				
2.75		4.66	1.60	3.06	BH24 / 2.79
3.00	3.0 - 4.0: Silty SAND, mf, black.	5.78	1.44	4.34	BH24 / 3.17
3.25					
3.50		5.83	2.43	3.40	BH24 / 3.62
3.75					
4.00	4.0 - 4.5: Silty SAND, cc, black.	6.34	1.98	4.36	BH24 / 4.02
4.25					
4.50	4.5: End of BH24 due to refusal.				
4.75					
5.00					
5.25					
5.50					
5.75					
6.00					

Notes:
Descriptions are based on observations and hand testing of grab samples.
Mechanical Tests were not performed unless otherwise stated

Appendix B

Laboratory Certificates of Analysis

CERTIFICATE OF ANALYSIS

Work Order	: **EB2123140**	Page	: 1 of 7
Client	: **ENVIRONMENT & NATURAL RESOURCE SOLUTIONS**	Laboratory	: Environmental Division Brisbane
Contact	: Mr Matt Lemcke	Contact	: Customer Services EB
Address	: 25 River Rd Shoalhaven Heads 2535	Address	: 2 Byth Street Stafford QLD Australia 4053
Telephone	: 02 9037 4708	Telephone	: +61-7-3243 7222
Project	: ENRS1947	Date Samples Received	: 13-Aug-2021 19:00
Order number	: ----	Date Analysis Commenced	: 26-Aug-2021
C-O-C number	: ----	Issue Date	: 26-Aug-2021 14:35
Sampler	: Matt Lemcke		
Site	: CB Gerroa		
Quote number	: WO/001/21		
No. of samples received	: 72		
No. of samples analysed	: 23		

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*
Ben Felgendrejeris	Senior Acid Sulfate Soil Chemist	Brisbane Acid Sulphate Soils, Stafford, QLD

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.

- ASS: EA033 (CRS Suite):Retained Acidity not required because pH KCl greater than or equal to 4.5
- ASS: EA033 (CRS Suite): ANC not required because pH KCl less than 6.5
- ASS: EA033 (CRS Suite): Liming rate is calculated and reported on a dry weight basis assuming use of fine agricultural lime (CaCO3) and using a safety factor of 1.5 to allow for non-homogeneous mixing and poor reactivity of lime. For conversion of Liming Rate from 'kg/t dry weight' to 'kg/m3 in-situ soil', multiply 'reported results' x 'wet bulk density of soil in t/m3'.

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Sample ID	BH1/1.3	BH1/2.2	BH2/.02	BH2/1.35	BH2/1.73
			Sampling date / time	10-Aug-2021 00:00	10-Aug-2021 00:00	09-Aug-2021 00:00	10-Aug-2021 00:00	10-Aug-2021 00:00
Compound	CAS Number	LOR	Unit	EB2123140-002	EB2123140-003	EB2123140-010	EB2123140-013	EB2123140-014
				Result	Result	Result	Result	Result
EA033-A: Actual Acidity								
pH KCl (23A)	----	0.1	pH Unit	**5.8**	**5.9**	**6.0**	**5.8**	**5.8**
Titratable Actual Acidity (23F)	----	2	mole H+ / t	<2	<2	<2	<2	<2
sulfidic - Titratable Actual Acidity (s-23F)	----	0.02	% pyrite S	<0.02	<0.02	<0.02	<0.02	<0.02
EA033-B: Potential Acidity								
Chromium Reducible Sulfur (22B)	----	0.005	% S	**0.162**	**0.093**	**0.013**	**0.108**	**0.061**
acidity - Chromium Reducible Sulfur (a-22B)	----	10	mole H+ / t	**101**	**58**	<10	**67**	**38**
EA033-E: Acid Base Accounting								
ANC Fineness Factor	----	0.5	-	**1.5**	**1.5**	**1.5**	**1.5**	**1.5**
Net Acidity (sulfur units)	----	0.02	% S	**0.16**	**0.09**	<0.02	**0.11**	**0.06**
Net Acidity (acidity units)	----	10	mole H+ / t	**101**	**58**	<10	**67**	**38**
Liming Rate	----	1	kg CaCO3/t	**8**	**4**	<1	**5**	**3**
Net Acidity excluding ANC (sulfur units)	----	0.02	% S	**0.16**	**0.09**	<0.02	**0.11**	**0.06**
Net Acidity excluding ANC (acidity units)	----	10	mole H+ / t	**101**	**58**	<10	**67**	**38**
Liming Rate excluding ANC	----	1	kg CaCO3/t	**8**	**4**	<1	**5**	**3**

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Sample ID	BH2/2.45	BH3/1.31	BH3/1.93	BH3/2.31	BH4/1.3
			Sampling date / time	10-Aug-2021 00:00	10-Aug-2021 00:00	10-Aug-2021 00:00	10-Aug-2021 00:00	10-Aug-2021 00:00
Compound	CAS Number	LOR	Unit	EB2123140-015	EB2123140-021	EB2123140-022	EB2123140-023	EB2123140-032
				Result	Result	Result	Result	Result
EA033-A: Actual Acidity								
pH KCl (23A)	----	0.1	pH Unit	5.9	5.5	5.8	5.9	5.7
Titratable Actual Acidity (23F)	----	2	mole H+ / t	<2	3	<2	<2	2
sulfidic - Titratable Actual Acidity (s-23F)	----	0.02	% pyrite S	<0.02	<0.02	<0.02	<0.02	<0.02
EA033-B: Potential Acidity								
Chromium Reducible Sulfur (22B)	----	0.005	% S	0.088	0.219	0.135	0.074	0.100
acidity - Chromium Reducible Sulfur (a-22B)	----	10	mole H+ / t	55	137	84	46	62
EA033-E: Acid Base Accounting								
ANC Fineness Factor	----	0.5	-	1.5	1.5	1.5	1.5	1.5
Net Acidity (sulfur units)	----	0.02	% S	0.09	0.22	0.13	0.07	0.10
Net Acidity (acidity units)	----	10	mole H+ / t	55	140	84	46	65
Liming Rate	----	1	kg CaCO3/t	4	10	6	3	5
Net Acidity excluding ANC (sulfur units)	----	0.02	% S	0.09	0.22	0.13	0.07	0.10
Net Acidity excluding ANC (acidity units)	----	10	mole H+ / t	55	140	84	46	65
Liming Rate excluding ANC	----	1	kg CaCO3/t	4	10	6	3	5

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			*Sample ID*	BH4/2.2	BH5/0.2	BH5/5/1.2	BH5/1.7	BH5/2.2
			Sampling date / time	10-Aug-2021 00:00	09-Aug-2021 00:00	10-Aug-2021 00:00	10-Aug-2021 00:00	10-Aug-2021 00:00
Compound	*CAS Number*	*LOR*	*Unit*	**EB2123140-033**	**EB2123140-040**	**EB2123140-042**	**EB2123140-043**	**EB2123140-044**
				Result	Result	Result	Result	Result
EA033-A: Actual Acidity								
pH KCl (23A)	----	0.1	pH Unit	**5.8**	**5.5**	**5.6**	**5.7**	**5.9**
Titratable Actual Acidity (23F)	----	2	mole H+ / t	<2	**3**	**2**	**2**	<2
sulfidic - Titratable Actual Acidity (s-23F)	----	0.02	% pyrite S	<0.02	<0.02	<0.02	<0.02	<0.02
EA033-B: Potential Acidity								
Chromium Reducible Sulfur (22B)	----	0.005	% S	**0.121**	**0.012**	**0.214**	**0.221**	**0.118**
acidity - Chromium Reducible Sulfur (a-22B)	----	10	mole H+ / t	**76**	<10	**133**	**138**	**74**
EA033-E: Acid Base Accounting								
ANC Fineness Factor	----	0.5	-	**1.5**	**1.5**	**1.5**	**1.5**	**1.5**
Net Acidity (sulfur units)	----	0.02	% S	**0.12**	<0.02	**0.22**	**0.22**	**0.12**
Net Acidity (acidity units)	----	10	mole H+ / t	**76**	**11**	**135**	**140**	**74**
Liming Rate	----	1	kg CaCO3/t	**6**	<1	**10**	**10**	**6**
Net Acidity excluding ANC (sulfur units)	----	0.02	% S	**0.12**	<0.02	**0.22**	**0.22**	**0.12**
Net Acidity excluding ANC (acidity units)	----	10	mole H+ / t	**76**	**11**	**135**	**140**	**74**
Liming Rate excluding ANC	----	1	kg CaCO3/t	**6**	<1	**10**	**10**	**6**

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Sample ID	BH6/1.36	BH6/1.91	BH6/2.4	BH7/0.2	BH7/1.45
			Sampling date / time	10-Aug-2021 00:00	10-Aug-2021 00:00	10-Aug-2021 00:00	09-Aug-2021 00:00	10-Aug-2021 00:00
Compound	CAS Number	LOR	Unit	EB2123140-052	EB2123140-053	EB2123140-054	EB2123140-061	EB2123140-063
				Result	Result	Result	Result	Result
EA033-A: Actual Acidity								
pH KCl (23A)	----	0.1	pH Unit	5.5	5.7	5.8	5.3	5.7
Titratable Actual Acidity (23F)	----	2	mole H+ / t	3	3	2	7	<2
sulfidic - Titratable Actual Acidity (s-23F)	----	0.02	% pyrite S	<0.02	<0.02	<0.02	<0.02	<0.02
EA033-B: Potential Acidity								
Chromium Reducible Sulfur (22B)	----	0.005	% S	0.242	0.320	0.341	0.025	0.244
acidity - Chromium Reducible Sulfur (a-22B)	----	10	mole H+ / t	151	199	213	16	152
EA033-E: Acid Base Accounting								
ANC Fineness Factor	----	0.5	-	1.5	1.5	1.5	1.5	1.5
Net Acidity (sulfur units)	----	0.02	% S	0.25	0.32	0.34	0.04	0.24
Net Acidity (acidity units)	----	10	mole H+ / t	154	202	215	23	152
Liming Rate	----	1	kg CaCO3/t	12	15	16	2	11
Net Acidity excluding ANC (sulfur units)	----	0.02	% S	0.25	0.32	0.34	0.04	0.24
Net Acidity excluding ANC (acidity units)	----	10	mole H+ / t	154	202	215	23	152
Liming Rate excluding ANC	----	1	kg CaCO3/t	12	15	16	2	11

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Sample ID	BH7/2.12	BH8/0.2	BH8/1.46	----	----
			Sampling date / time	10-Aug-2021 00:00	09-Aug-2021 00:00	11-Aug-2021 00:00	----	----
Compound	CAS Number	LOR	Unit	EB2123140-065	EB2123140-070	EB2123140-072	--------	--------
				Result	Result	Result	----	----
EA033-A: Actual Acidity								
pH KCl (23A)	----	0.1	pH Unit	5.8	4.6	5.8	----	----
Titratable Actual Acidity (23F)	----	2	mole H+ / t	<2	32	<2	----	----
sulfidic - Titratable Actual Acidity (s-23F)	----	0.02	% pyrite S	<0.02	0.05	<0.02	----	----
EA033-B: Potential Acidity								
Chromium Reducible Sulfur (22B)	----	0.005	% S	0.225	0.013	0.211	----	----
acidity - Chromium Reducible Sulfur (a-22B)	----	10	mole H+ / t	140	<10	131	----	----
EA033-E: Acid Base Accounting								
ANC Fineness Factor	----	0.5	-	1.5	1.5	1.5	----	----
Net Acidity (sulfur units)	----	0.02	% S	0.22	0.06	0.21	----	----
Net Acidity (acidity units)	----	10	mole H+ / t	140	40	131	----	----
Liming Rate	----	1	kg CaCO3/t	10	3	10	----	----
Net Acidity excluding ANC (sulfur units)	----	0.02	% S	0.22	0.06	0.21	----	----
Net Acidity excluding ANC (acidity units)	----	10	mole H+ / t	140	40	131	----	----
Liming Rate excluding ANC	----	1	kg CaCO3/t	10	3	10	----	----

CERTIFICATE OF ANALYSIS

Work Order	: **EB2123141**	Page	: 1 of 7
Client	: **ENVIRONMENT & NATURAL RESOURCE SOLUTIONS**	Laboratory	: Environmental Division Brisbane
Contact	: Mr Matt Lemcke	Contact	: Customer Services EB
Address	: 25 River Rd Shoalhaven Heads 2535	Address	: 2 Byth Street Stafford QLD Australia 4053
Telephone	: 02 9037 4708	Telephone	: +61-7-3243 7222
Project	: ENRS1947	Date Samples Received	: 13-Aug-2021 19:00
Order number	: ----	Date Analysis Commenced	: 24-Aug-2021
C-O-C number	: ----	Issue Date	: 27-Aug-2021 11:02
Sampler	: Matt Lemcke		
Site	: CB Gerroa		
Quote number	: WO/001/21		
No. of samples received	: 79		
No. of samples analysed	: 24		

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*
Ben Felgendrejeris	Senior Acid Sulfate Soil Chemist	Brisbane Acid Sulphate Soils, Stafford, QLD

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.

- ASS: EA033 (CRS Suite):Retained Acidity not required because pH KCl greater than or equal to 4.5
- ASS: EA033 (CRS Suite): ANC not required because pH KCl less than 6.5
- ASS: EA033 (CRS Suite): Liming rate is calculated and reported on a dry weight basis assuming use of fine agricultural lime ($CaCO_3$) and using a safety factor of 1.5 to allow for non-homogeneous mixing and poor reactivity of lime. For conversion of Liming Rate from 'kg/t dry weight' to 'kg/m3 in-situ soil', multiply 'reported results' x 'wet bulk density of soil in t/m3'.

Analytical Results

Sub-Matrix: **SOIL** (Matrix: **SOIL**)			*Sample ID*	**BH8/1.81**	**BH8/2.44**	**BH9/0.2**	**BH9/0.7**	**BH9/1.34**
			Sampling date / time	11-Aug-2021 00:00	11-Aug-2021 00:00	09-Aug-2021 00:00	09-Aug-2021 00:00	11-Aug-2021 00:00
Compound	*CAS Number*	*LOR*	*Unit*	**EB2123141-002**	**EB2123141-005**	**EB2123141-010**	**EB2123141-011**	**EB2123141-012**
				Result	Result	Result	Result	Result
EA033-A: Actual Acidity								
pH KCl (23A)	----	0.1	pH Unit	**5.2**	**6.0**	**5.7**	**5.6**	**5.7**
Titratable Actual Acidity (23F)	----	2	mole H+ / t	**33**	<2	**5**	**6**	**4**
sulfidic - Titratable Actual Acidity (s-23F)	----	0.02	% pyrite S	**0.05**	<0.02	<0.02	<0.02	<0.02
EA033-B: Potential Acidity								
Chromium Reducible Sulfur (22B)	----	0.005	% S	**5.05**	**0.353**	**0.010**	**0.012**	**0.250**
acidity - Chromium Reducible Sulfur (a-22B)	----	10	mole H+ / t	**3150**	**220**	<10	<10	**156**
EA033-E: Acid Base Accounting								
ANC Fineness Factor	----	0.5	-	**1.5**	**1.5**	**1.5**	**1.5**	**1.5**
Net Acidity (sulfur units)	----	0.02	% S	**5.10**	**0.35**	<0.02	**0.02**	**0.26**
Net Acidity (acidity units)	----	10	mole H+ / t	**3180**	**220**	**11**	**14**	**160**
Liming Rate	----	1	kg CaCO3/t	**239**	**16**	<1	**1**	**12**
Net Acidity excluding ANC (sulfur units)	----	0.02	% S	**5.10**	**0.35**	<0.02	**0.02**	**0.26**
Net Acidity excluding ANC (acidity units)	----	10	mole H+ / t	**3180**	**220**	**11**	**14**	**160**
Liming Rate excluding ANC	----	1	kg CaCO3/t	**239**	**16**	<1	**1**	**12**

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Sample ID	BH9/1.89	BH10/1.5	BH10/2.1	BH11/2	BH12/1.59
			Sampling date / time	11-Aug-2021 00:00	11-Aug-2021 00:00	11-Aug-2021 00:00	11-Aug-2021 00:00	11-Aug-2021 00:00
Compound	CAS Number	LOR	Unit	EB2123141-013	EB2123141-020	EB2123141-021	EB2123141-027	EB2123141-034
				Result	Result	Result	Result	Result
EA033-A: Actual Acidity								
pH KCl (23A)	----	0.1	pH Unit	6.0	5.8	6.0	5.9	5.8
Titratable Actual Acidity (23F)	----	2	mole H+ / t	<2	<2	<2	<2	2
sulfidic - Titratable Actual Acidity (s-23F)	----	0.02	% pyrite S	<0.02	<0.02	<0.02	<0.02	<0.02
EA033-B: Potential Acidity								
Chromium Reducible Sulfur (22B)	----	0.005	% S	0.125	0.159	0.093	0.042	0.092
acidity - Chromium Reducible Sulfur (a-22B)	----	10	mole H+ / t	78	99	58	26	57
EA033-E: Acid Base Accounting								
ANC Fineness Factor	----	0.5	-	1.5	1.5	1.5	1.5	1.5
Net Acidity (sulfur units)	----	0.02	% S	0.12	0.16	0.09	0.04	0.10
Net Acidity (acidity units)	----	10	mole H+ / t	78	99	58	26	60
Liming Rate	----	1	kg CaCO3/t	6	7	4	2	4
Net Acidity excluding ANC (sulfur units)	----	0.02	% S	0.12	0.16	0.09	0.04	0.10
Net Acidity excluding ANC (acidity units)	----	10	mole H+ / t	78	99	58	26	60
Liming Rate excluding ANC	----	1	kg CaCO3/t	6	7	4	2	4

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Sample ID	BH12/2.35	BH13/1.73	BH14/1.86	BH15/0.3	BH15/0.9
			Sampling date / time	11-Aug-2021 00:00	11-Aug-2021 00:00	11-Aug-2021 00:00	09-Aug-2021 00:00	09-Aug-2021 00:00
Compound	CAS Number	LOR	Unit	EB2123141-035	EB2123141-042	EB2123141-052	EB2123141-060	EB2123141-061
				Result	Result	Result	Result	Result
EA033-A: Actual Acidity								
pH KCl (23A)	----	0.1	pH Unit	6.0	6.0	6.1	5.8	6.0
Titratable Actual Acidity (23F)	----	2	mole H+ / t	2	<2	<2	4	<2
sulfidic - Titratable Actual Acidity (s-23F)	----	0.02	% pyrite S	<0.02	<0.02	<0.02	<0.02	<0.02
EA033-B: Potential Acidity								
Chromium Reducible Sulfur (22B)	----	0.005	% S	0.190	0.094	0.058	0.010	0.005
acidity - Chromium Reducible Sulfur (a-22B)	----	10	mole H+ / t	119	58	36	<10	<10
EA033-E: Acid Base Accounting								
ANC Fineness Factor	----	0.5	-	1.5	1.5	1.5	1.5	1.5
Net Acidity (sulfur units)	----	0.02	% S	0.19	0.09	0.06	<0.02	<0.02
Net Acidity (acidity units)	----	10	mole H+ / t	121	58	36	<10	<10
Liming Rate	----	1	kg CaCO3/t	9	4	3	<1	<1
Net Acidity excluding ANC (sulfur units)	----	0.02	% S	0.19	0.09	0.06	<0.02	<0.02
Net Acidity excluding ANC (acidity units)	----	10	mole H+ / t	121	58	36	<10	<10
Liming Rate excluding ANC	----	1	kg CaCO3/t	9	4	3	<1	<1

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Sample ID	BH15/1.4	BH15/2.22	BH16/0.1	BH16/0.6	BH16/1.59
			Sampling date / time	11-Aug-2021 00:00	11-Aug-2021 00:00	09-Aug-2021 00:00	09-Aug-2021 00:00	11-Aug-2021 00:00
Compound	CAS Number	LOR	Unit	EB2123141-062	EB2123141-064	EB2123141-066	EB2123141-067	EB2123141-068
				Result	Result	Result	Result	Result
EA033-A: Actual Acidity								
pH KCl (23A)	----	0.1	pH Unit	**5.6**	**5.6**	**6.3**	**6.0**	**6.0**
Titratable Actual Acidity (23F)	----	2	mole H+ / t	**6**	**8**	<2	<2	<2
sulfidic - Titratable Actual Acidity (s-23F)	----	0.02	% pyrite S	<0.02	<0.02	<0.02	<0.02	<0.02
EA033-B: Potential Acidity								
Chromium Reducible Sulfur (22B)	----	0.005	% S	**0.328**	**0.335**	**0.005**	**0.010**	**0.023**
acidity - Chromium Reducible Sulfur (a-22B)	----	10	mole H+ / t	**204**	**209**	<10	<10	**15**
EA033-E: Acid Base Accounting								
ANC Fineness Factor	----	0.5	-	**1.5**	**1.5**	**1.5**	**1.5**	**1.5**
Net Acidity (sulfur units)	----	0.02	% S	**0.34**	**0.35**	<0.02	<0.02	**0.02**
Net Acidity (acidity units)	----	10	mole H+ / t	**210**	**217**	<10	<10	**15**
Liming Rate	----	1	kg CaCO3/t	**16**	**16**	<1	<1	**1**
Net Acidity excluding ANC (sulfur units)	----	0.02	% S	**0.34**	**0.35**	<0.02	<0.02	**0.02**
Net Acidity excluding ANC (acidity units)	----	10	mole H+ / t	**210**	**217**	<10	<10	**15**
Liming Rate excluding ANC	----	1	kg CaCO3/t	**16**	**16**	<1	<1	**1**

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Sample ID	BH17/0.2	BH17/0.7	BH17/1.65	BH17/2.28	----
			Sampling date / time	09-Aug-2021 00:00	09-Aug-2021 00:00	11-Aug-2021 00:00	11-Aug-2021 00:00	----
Compound	CAS Number	LOR	Unit	EB2123141-074	EB2123141-075	EB2123141-076	EB2123141-077	--------
				Result	Result	Result	Result	----
EA033-A: Actual Acidity								
pH KCl (23A)	----	0.1	pH Unit	5.7	5.8	5.7	5.6	----
Titratable Actual Acidity (23F)	----	2	mole H+ / t	4	<2	2	5	----
sulfidic - Titratable Actual Acidity (s-23F)	----	0.02	% pyrite S	<0.02	<0.02	<0.02	<0.02	----
EA033-B: Potential Acidity								
Chromium Reducible Sulfur (22B)	----	0.005	% S	0.021	0.017	0.297	0.431	----
acidity - Chromium Reducible Sulfur (a-22B)	----	10	mole H+ / t	13	11	185	269	----
EA033-E: Acid Base Accounting								
ANC Fineness Factor	----	0.5	-	1.5	1.5	1.5	1.5	----
Net Acidity (sulfur units)	----	0.02	% S	0.03	<0.02	0.30	0.44	----
Net Acidity (acidity units)	----	10	mole H+ / t	17	11	188	274	----
Liming Rate	----	1	kg CaCO3/t	1	<1	14	20	----
Net Acidity excluding ANC (sulfur units)	----	0.02	% S	0.03	<0.02	0.30	0.44	----
Net Acidity excluding ANC (acidity units)	----	10	mole H+ / t	17	11	188	274	----
Liming Rate excluding ANC	----	1	kg CaCO3/t	1	<1	14	20	----

CERTIFICATE OF ANALYSIS

Work Order	: **EB2123142**	Page	: 1 of 7
Client	: **ENVIRONMENT & NATURAL RESOURCE SOLUTIONS**	Laboratory	: Environmental Division Brisbane
Contact	: Mr Matt Lemcke	Contact	: Customer Services EB
Address	: 25 River Rd Shoalhaven Heads 2535	Address	: 2 Byth Street Stafford QLD Australia 4053
Telephone	: 02 9037 4708	Telephone	: +61-7-3243 7222
Project	: ENRS1947	Date Samples Received	: 13-Aug-2021 19:00
Order number	: ----	Date Analysis Commenced	: 27-Aug-2021
C-O-C number	: ----	Issue Date	: 01-Sep-2021 16:35
Sampler	: Matt Lemcke		
Site	: CB Gerroa		
Quote number	: WO/001/21		
No. of samples received	: 67		
No. of samples analysed	: 22		

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*
Ben Felgendrejeris	Senior Acid Sulfate Soil Chemist	Brisbane Acid Sulphate Soils, Stafford, QLD

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.

- ASS: EA033 (CRS Suite):Retained Acidity not required because pH KCl greater than or equal to 4.5
- ASS: EA033 (CRS Suite): ANC not required because pH KCl less than 6.5
- ASS: EA033 (CRS Suite): Liming rate is calculated and reported on a dry weight basis assuming use of fine agricultural lime (CaCO3) and using a safety factor of 1.5 to allow for non-homogeneous mixing and poor reactivity of lime. For conversion of Liming Rate from 'kg/t dry weight' to 'kg/m3 in-situ soil', multiply 'reported results' x 'wet bulk density of soil in t/m3'.

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Sample ID	BH18/0.3	BH18/1.65	BH18/2.16	BH19/0.2	BH19/0.5
			Sampling date / time	09-Aug-2021 00:00	11-Aug-2021 00:00	11-Aug-2021 00:00	09-Aug-2021 00:00	09-Aug-2021 00:00
Compound	CAS Number	LOR	Unit	EB2123142-004	EB2123142-007	EB2123142-008	EB2123142-013	EB2123142-014
				Result	Result	Result	Result	Result
EA033-A: Actual Acidity								
pH KCl (23A)	----	0.1	pH Unit	**5.6**	**5.0**	**5.8**	**5.0**	**5.9**
Titratable Actual Acidity (23F)	----	2	mole H+ / t	**2**	**19**	**2**	**20**	<2
sulfidic - Titratable Actual Acidity (s-23F)	----	0.02	% pyrite S	<0.02	**0.03**	<0.02	**0.03**	<0.02
EA033-B: Potential Acidity								
Chromium Reducible Sulfur (22B)	----	0.005	% S	**0.014**	**1.72**	**0.188**	**0.033**	**0.012**
acidity - Chromium Reducible Sulfur (a-22B)	----	10	mole H+ / t	<10	**1070**	**117**	**21**	<10
EA033-E: Acid Base Accounting								
ANC Fineness Factor	----	0.5	-	**1.5**	**1.5**	**1.5**	**1.5**	**1.5**
Net Acidity (sulfur units)	----	0.02	% S	<0.02	**1.75**	**0.19**	**0.06**	<0.02
Net Acidity (acidity units)	----	10	mole H+ / t	**11**	**1090**	**120**	**40**	<10
Liming Rate	----	1	kg CaCO3/t	<1	**82**	**9**	**3**	<1
Net Acidity excluding ANC (sulfur units)	----	0.02	% S	<0.02	**1.75**	**0.19**	**0.06**	<0.02
Net Acidity excluding ANC (acidity units)	----	10	mole H+ / t	**11**	**1090**	**120**	**40**	<10
Liming Rate excluding ANC	----	1	kg CaCO3/t	<1	**82**	**9**	**3**	<1

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Sample ID	BH19/0.8	BH19/1.44	BH20/1.56	BH21/0.2	BH21/1.33
			Sampling date / time	09-Aug-2021 00:00	12-Aug-2021 00:00	12-Aug-2021 00:00	09-Aug-2021 00:00	12-Aug-2021 00:00
Compound	CAS Number	LOR	Unit	EB2123142-015	EB2123142-016	EB2123142-023	EB2123142-029	EB2123142-031
				Result	Result	Result	Result	Result
EA033-A: Actual Acidity								
pH KCl (23A)	----	0.1	pH Unit	5.6	5.8	5.6	5.4	5.7
Titratable Actual Acidity (23F)	----	2	mole H+ / t	3	<2	2	5	4
sulfidic - Titratable Actual Acidity (s-23F)	----	0.02	% pyrite S	<0.02	<0.02	<0.02	<0.02	<0.02
EA033-B: Potential Acidity								
Chromium Reducible Sulfur (22B)	----	0.005	% S	0.162	0.168	0.136	0.009	0.177
acidity - Chromium Reducible Sulfur (a-22B)	----	10	mole H+ / t	101	105	84	<10	110
EA033-E: Acid Base Accounting								
ANC Fineness Factor	----	0.5	-	1.5	1.5	1.5	1.5	1.5
Net Acidity (sulfur units)	----	0.02	% S	0.17	0.17	0.14	<0.02	0.18
Net Acidity (acidity units)	----	10	mole H+ / t	104	105	87	11	114
Liming Rate	----	1	kg CaCO3/t	8	8	6	<1	8
Net Acidity excluding ANC (sulfur units)	----	0.02	% S	0.17	0.17	0.14	<0.02	0.18
Net Acidity excluding ANC (acidity units)	----	10	mole H+ / t	104	105	87	11	114
Liming Rate excluding ANC	----	1	kg CaCO3/t	8	8	6	<1	8

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Sample ID	BH21/2.12	BH22/0.3	BH22/2	BH22/2.3	BH23/0.3
			Sampling date / time	12-Aug-2021 00:00	09-Aug-2021 00:00	12-Aug-2021 00:00	12-Aug-2021 00:00	09-Aug-2021 00:00
Compound	*CAS Number*	*LOR*	*Unit*	EB2123142-033	EB2123142-039	EB2123142-043	EB2123142-044	EB2123142-050
				Result	Result	Result	Result	Result
EA033-A: Actual Acidity								
pH KCl (23A)	----	0.1	pH Unit	5.2	5.1	5.8	5.5	5.2
Titratable Actual Acidity (23F)	----	2	mole H+ / t	8	17	3	5	13
sulfidic - Titratable Actual Acidity (s-23F)	----	0.02	% pyrite S	<0.02	0.03	<0.02	<0.02	0.02
EA033-B: Potential Acidity								
Chromium Reducible Sulfur (22B)	----	0.005	% S	0.652	0.019	0.678	2.36	0.035
acidity - Chromium Reducible Sulfur (a-22B)	----	10	mole H+ / t	406	12	423	1470	22
EA033-E: Acid Base Accounting								
ANC Fineness Factor	----	0.5	-	1.5	1.5	1.5	1.5	1.5
Net Acidity (sulfur units)	----	0.02	% S	0.66	0.05	0.68	2.37	0.06
Net Acidity (acidity units)	----	10	mole H+ / t	415	29	426	1480	35
Liming Rate	----	1	kg CaCO3/t	31	2	32	111	3
Net Acidity excluding ANC (sulfur units)	----	0.02	% S	0.66	0.05	0.68	2.37	0.06
Net Acidity excluding ANC (acidity units)	----	10	mole H+ / t	415	29	426	1480	35
Liming Rate excluding ANC	----	1	kg CaCO3/t	31	2	32	111	3

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Sample ID	BH23/0.8	BH23/1.17	BH23/1.61	BH23/1.96	BH24/0.3
			Sampling date / time	09-Aug-2021 00:00	12-Aug-2021 00:00	12-Aug-2021 00:00	12-Aug-2021 00:00	09-Aug-2021 00:00
Compound	CAS Number	LOR	Unit	EB2123142-051	EB2123142-052	EB2123142-053	EB2123142-054	EB2123142-059
				Result	Result	Result	Result	Result
EA033-A: Actual Acidity								
pH KCl (23A)	----	0.1	pH Unit	**5.9**	**5.6**	**5.8**	**4.9**	**5.8**
Titratable Actual Acidity (23F)	----	2	mole H+ / t	<2	**2**	<2	**28**	<2
sulfidic - Titratable Actual Acidity (s-23F)	----	0.02	% pyrite S	<0.02	<0.02	<0.02	**0.04**	<0.02
EA033-B: Potential Acidity								
Chromium Reducible Sulfur (22B)	----	0.005	% S	**0.015**	**0.232**	**0.218**	**2.98**	**0.069**
acidity - Chromium Reducible Sulfur (a-22B)	----	10	mole H+ / t	<10	**145**	**136**	**1860**	**43**
EA033-E: Acid Base Accounting								
ANC Fineness Factor	----	0.5	-	**1.5**	**1.5**	**1.5**	**1.5**	**1.5**
Net Acidity (sulfur units)	----	0.02	% S	<0.02	**0.24**	**0.22**	**3.02**	**0.07**
Net Acidity (acidity units)	----	10	mole H+ / t	<10	**147**	**136**	**1880**	**43**
Liming Rate	----	1	kg CaCO3/t	<1	**11**	**10**	**141**	**3**
Net Acidity excluding ANC (sulfur units)	----	0.02	% S	<0.02	**0.24**	**0.22**	**3.02**	**0.07**
Net Acidity excluding ANC (acidity units)	----	10	mole H+ / t	<10	**147**	**136**	**1880**	**43**
Liming Rate excluding ANC	----	1	kg CaCO3/t	<1	**11**	**10**	**141**	**3**

Analytical Results

Sub-Matrix: **SOIL** (Matrix: **SOIL**)			Sample ID	**BH24/1.74**	**BH24/2.28**	**----**	**----**	**----**
			Sampling date / time	12-Aug-2021 00:00	12-Aug-2021 00:00	----	----	----
Compound	CAS Number	LOR	Unit	**EB2123142-062**	**EB2123142-063**	--------	--------	--------
				Result	Result	----	----	----
EA033-A: Actual Acidity								
pH KCl (23A)	----	0.1	pH Unit	**5.6**	**5.7**	----	----	----
Titratable Actual Acidity (23F)	----	2	mole H+ / t	**2**	<2	----	----	----
sulfidic - Titratable Actual Acidity (s-23F)	----	0.02	% pyrite S	<0.02	<0.02	----	----	----
EA033-B: Potential Acidity								
Chromium Reducible Sulfur (22B)	----	0.005	% S	**0.148**	**0.172**	----	----	----
acidity - Chromium Reducible Sulfur (a-22B)	----	10	mole H+ / t	**92**	**108**	----	----	----
EA033-E: Acid Base Accounting								
ANC Fineness Factor	----	0.5	-	**1.5**	**1.5**	----	----	----
Net Acidity (sulfur units)	----	0.02	% S	**0.15**	**0.17**	----	----	----
Net Acidity (acidity units)	----	10	mole H+ / t	**94**	**108**	----	----	----
Liming Rate	----	1	kg CaCO3/t	**7**	**8**	----	----	----
Net Acidity excluding ANC (sulfur units)	----	0.02	% S	**0.15**	**0.17**	----	----	----
Net Acidity excluding ANC (acidity units)	----	10	mole H+ / t	**94**	**108**	----	----	----
Liming Rate excluding ANC	----	1	kg CaCO3/t	**7**	**8**	----	----	----

ALS Environmental

CERTIFICATE OF ANALYSIS

Work Order	: **EB2125980**	Page	: 1 of 7
Client	: **ENVIRONMENT & NATURAL RESOURCE SOLUTIONS**	Laboratory	: Environmental Division Brisbane
Contact	: Mr Matt Lemcke	Contact	: Customer Services EB
Address	: 25 River Rd Shoalhaven Heads 2535	Address	: 2 Byth Street Stafford QLD Australia 4053
Telephone	: 02 9037 4708	Telephone	: +61-7-3243 7222
Project	: ENRS1947	Date Samples Received	: 13-Sep-2021 13:23
Order number	: ----	Date Analysis Commenced	: 17-Sep-2021
C-O-C number	: ----	Issue Date	: 17-Sep-2021 14:28
Sampler	: Matt Lemcke		
Site	: CB Gerroa		
Quote number	: WO/001/21		
No. of samples received	: 22		
No. of samples analysed	: 22		

ilac-MRA

NATA

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*
Ben Felgendrejeris	Senior Acid Sulfate Soil Chemist	Brisbane Acid Sulphate Soils, Stafford, QLD

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.

- ASS: EA033 (CRS Suite):Retained Acidity not required because pH KCl greater than or equal to 4.5
- ASS: EA033 (CRS Suite): ANC not required because pH KCl less than 6.5
- ASS: EA033 (CRS Suite): Liming rate is calculated and reported on a dry weight basis assuming use of fine agricultural lime ($CaCO_3$) and using a safety factor of 1.5 to allow for non-homogeneous mixing and poor reactivity of lime. For conversion of Liming Rate from 'kg/t dry weight' to 'kg/m3 in-situ soil', multiply 'reported results' x 'wet bulk density of soil in t/m3'.

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Sample ID	BH2/0.4 EB2123140 011	BH2/0.7 EB2123140 012	BH2/2.95 EB2123140 016	BH2/3.68 EB2123140 017	BH2/4.33 EB2123140 018
			Sampling date / time	09-Aug-2021 00:00	09-Aug-2021 00:00	10-Aug-2021 00:00	10-Aug-2021 00:00	10-Aug-2021 00:00
Compound	CAS Number	LOR	Unit	EB2125980-001	EB2125980-002	EB2125980-003	EB2125980-004	EB2125980-005
				Result	Result	Result	Result	Result
EA033-A: Actual Acidity								
pH KCl (23A)	----	0.1	pH Unit	**5.6**	**6.0**	**6.0**	**6.0**	**6.2**
Titratable Actual Acidity (23F)	----	2	mole H+ / t	**10**	**3**	**2**	<2	<2
sulfidic - Titratable Actual Acidity (s-23F)	----	0.02	% pyrite S	<0.02	<0.02	<0.02	<0.02	<0.02
EA033-B: Potential Acidity								
Chromium Reducible Sulfur (22B)	----	0.005	% S	**0.016**	**0.012**	**0.129**	**0.074**	**0.027**
acidity - Chromium Reducible Sulfur (a-22B)	----	10	mole H+ / t	<10	<10	**80**	**46**	**17**
EA033-E: Acid Base Accounting								
ANC Fineness Factor	----	0.5	-	**1.5**	**1.5**	**1.5**	**1.5**	**1.5**
Net Acidity (sulfur units)	----	0.02	% S	**0.03**	<0.02	**0.13**	**0.07**	**0.03**
Net Acidity (acidity units)	----	10	mole H+ / t	**20**	**11**	**83**	**46**	**17**
Liming Rate	----	1	kg CaCO3/t	**1**	<1	**6**	**3**	**1**
Net Acidity excluding ANC (sulfur units)	----	0.02	% S	**0.03**	<0.02	**0.13**	**0.07**	**0.03**
Net Acidity excluding ANC (acidity units)	----	10	mole H+ / t	**20**	**11**	**83**	**46**	**17**
Liming Rate excluding ANC	----	1	kg CaCO3/t	**1**	<1	**6**	**3**	**1**

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Sample ID	BH4/3.85 EB2123140 035	BH5/4.5 EB2123140 048	BH5/4.9 EB2123140 049	BH8/1.63 EB2123141 001	BH8/1.97 EB2123141 003
			Sampling date / time	10-Sep-2021 00:00	10-Sep-2021 00:00	10-Sep-2021 00:00	11-Aug-2021 00:00	11-Aug-2021 00:00
Compound	CAS Number	LOR	Unit	EB2125980-006	EB2125980-007	EB2125980-008	EB2125980-009	EB2125980-010
				Result	Result	Result	Result	Result
EA033-A: Actual Acidity								
pH KCl (23A)	----	0.1	pH Unit	**5.9**	**6.3**	**6.4**	**6.0**	**5.9**
Titratable Actual Acidity (23F)	----	2	mole H+ / t	**3**	<2	<2	<2	**7**
sulfidic - Titratable Actual Acidity (s-23F)	----	0.02	% pyrite S	<0.02	<0.02	<0.02	<0.02	<0.02
EA033-B: Potential Acidity								
Chromium Reducible Sulfur (22B)	----	0.005	% S	**0.321**	**0.108**	**0.065**	**0.199**	**0.319**
acidity - Chromium Reducible Sulfur (a-22B)	----	10	mole H+ / t	**200**	**68**	**41**	**124**	**199**
EA033-E: Acid Base Accounting								
ANC Fineness Factor	----	0.5	-	**1.5**	**1.5**	**1.5**	**1.5**	**1.5**
Net Acidity (sulfur units)	----	0.02	% S	**0.32**	**0.11**	**0.06**	**0.20**	**0.33**
Net Acidity (acidity units)	----	10	mole H+ / t	**203**	**68**	**41**	**124**	**206**
Liming Rate	----	1	kg CaCO3/t	**15**	**5**	**3**	**9**	**15**
Net Acidity excluding ANC (sulfur units)	----	0.02	% S	**0.32**	**0.11**	**0.06**	**0.20**	**0.33**
Net Acidity excluding ANC (acidity units)	----	10	mole H+ / t	**203**	**68**	**41**	**124**	**206**
Liming Rate excluding ANC	----	1	kg CaCO3/t	**15**	**5**	**3**	**9**	**15**

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Sample ID	BH8/3.61 EB2123141 007	BH13/5 EB2123141 048	BH17/4.32 EB2123142 002	BH18/1.1 EB2123142 006	BH18/4.53 EB2123142 012
			Sampling date / time	11-Aug-2021 00:00	11-Aug-2021 00:00	11-Aug-2021 00:00	09-Aug-2021 00:00	11-Aug-2021 00:00
Compound	CAS Number	LOR	Unit	EB2125980-011	EB2125980-012	EB2125980-013	EB2125980-014	EB2125980-015
				Result	Result	Result	Result	Result
EA033-A: Actual Acidity								
pH KCl (23A)	----	0.1	pH Unit	6.3	6.0	6.2	6.1	6.2
Titratable Actual Acidity (23F)	----	2	mole H+ / t	<2	<2	<2	<2	<2
sulfidic - Titratable Actual Acidity (s-23F)	----	0.02	% pyrite S	<0.02	<0.02	<0.02	<0.02	<0.02
EA033-B: Potential Acidity								
Chromium Reducible Sulfur (22B)	----	0.005	% S	0.015	0.225	0.076	0.016	0.027
acidity - Chromium Reducible Sulfur (a-22B)	----	10	mole H+ / t	<10	141	47	<10	17
EA033-E: Acid Base Accounting								
ANC Fineness Factor	----	0.5	-	1.5	1.5	1.5	1.5	1.5
Net Acidity (sulfur units)	----	0.02	% S	<0.02	0.22	0.08	<0.02	0.03
Net Acidity (acidity units)	----	10	mole H+ / t	<10	141	47	<10	17
Liming Rate	----	1	kg CaCO3/t	<1	10	4	<1	1
Net Acidity excluding ANC (sulfur units)	----	0.02	% S	<0.02	0.22	0.08	<0.02	0.03
Net Acidity excluding ANC (acidity units)	----	10	mole H+ / t	<10	141	47	<10	17
Liming Rate excluding ANC	----	1	kg CaCO3/t	<1	10	4	<1	1

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Sample ID	BH21/1.72 EB2123142 032	BH21/2.58 EB2123142 034	BH22/1.68 EB2123142 042	BH22/2.76 EB2123142 045	BH22/3.56 EB2123142 047
			Sampling date / time	12-Aug-2021 00:00	12-Aug-2021 00:00	12-Aug-2021 00:00	12-Aug-2021 00:00	12-Aug-2021 00:00
Compound	CAS Number	LOR	Unit	EB2125980-016	EB2125980-017	EB2125980-018	EB2125980-019	EB2125980-020
				Result	Result	Result	Result	Result
EA033-A: Actual Acidity								
pH KCl (23A)	----	0.1	pH Unit	5.9	5.5	5.8	5.9	6.0
Titratable Actual Acidity (23F)	----	2	mole H+ / t	4	8	4	<2	<2
sulfidic - Titratable Actual Acidity (s-23F)	----	0.02	% pyrite S	<0.02	<0.02	<0.02	<0.02	<0.02
EA033-B: Potential Acidity								
Chromium Reducible Sulfur (22B)	----	0.005	% S	0.184	0.043	0.184	0.162	0.482
acidity - Chromium Reducible Sulfur (a-22B)	----	10	mole H+ / t	115	27	115	101	301
EA033-E: Acid Base Accounting								
ANC Fineness Factor	----	0.5	-	1.5	1.5	1.5	1.5	1.5
Net Acidity (sulfur units)	----	0.02	% S	0.19	0.06	0.19	0.16	0.48
Net Acidity (acidity units)	----	10	mole H+ / t	118	35	119	101	301
Liming Rate	----	1	kg CaCO3/t	9	3	9	8	22
Net Acidity excluding ANC (sulfur units)	----	0.02	% S	0.19	0.06	0.19	0.16	0.48
Net Acidity excluding ANC (acidity units)	----	10	mole H+ / t	118	35	119	101	301
Liming Rate excluding ANC	----	1	kg CaCO3/t	9	3	9	8	22

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Sample ID	BH23/2.3 EB2123142 055	BH24/3.17 EB2123142 065	----	----	----
			Sampling date / time	12-Aug-2021 00:00	12-Aug-2021 00:00	----	----	----
Compound	CAS Number	LOR	Unit	EB2125980-021	EB2125980-022	--------	--------	--------
				Result	Result	----	----	----
EA033-A: Actual Acidity								
pH KCl (23A)	----	0.1	pH Unit	**5.4**	**6.0**	----	----	----
Titratable Actual Acidity (23F)	----	2	mole H+ / t	**6**	<2	----	----	----
sulfidic - Titratable Actual Acidity (s-23F)	----	0.02	% pyrite S	<0.02	<0.02	----	----	----
EA033-B: Potential Acidity								
Chromium Reducible Sulfur (22B)	----	0.005	% S	**0.218**	**0.095**	----	----	----
acidity - Chromium Reducible Sulfur (a-22B)	----	10	mole H+ / t	**136**	**59**	----	----	----
EA033-E: Acid Base Accounting								
ANC Fineness Factor	----	0.5	-	**1.5**	**1.5**	----	----	----
Net Acidity (sulfur units)	----	0.02	% S	**0.23**	**0.10**	----	----	----
Net Acidity (acidity units)	----	10	mole H+ / t	**142**	**59**	----	----	----
Liming Rate	----	1	kg CaCO3/t	**11**	**4**	----	----	----
Net Acidity excluding ANC (sulfur units)	----	0.02	% S	**0.23**	**0.10**	----	----	----
Net Acidity excluding ANC (acidity units)	----	10	mole H+ / t	**142**	**59**	----	----	----
Liming Rate excluding ANC	----	1	kg CaCO3/t	**11**	**4**	----	----	----

CERTIFICATE OF ANALYSIS

Work Order	: **EB2127300**	Page	: 1 of 3
Client	: **ENVIRONMENT & NATURAL RESOURCE SOLUTIONS**	Laboratory	: Environmental Division Brisbane
Contact	: Mr Matt Lemcke	Contact	: Customer Services EB
Address	: 25 River Rd Shoalhaven Heads 2535	Address	: 2 Byth Street Stafford QLD Australia 4053
Telephone	: 02 9037 4708	Telephone	: +61-7-3243 7222
Project	: ENRS1947	Date Samples Received	: 22-Sep-2021 10:35
Order number	: ----	Date Analysis Commenced	: 29-Sep-2021
C-O-C number	: ----	Issue Date	: 29-Sep-2021 13:17
Sampler	: Matt Lemcke		
Site	: CB Gerroa		
Quote number	: WO/001/21		
No. of samples received	: 4		
No. of samples analysed	: 4		

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*
Ben Felgendrejeris	Senior Acid Sulfate Soil Chemist	Brisbane Acid Sulphate Soils, Stafford, QLD

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.

- ASS: EA033 (CRS Suite):Retained Acidity not required because pH KCl greater than or equal to 4.5
- ASS: EA033 (CRS Suite): ANC not required because pH KCl less than 6.5
- ASS: EA033 (CRS Suite): Liming rate is calculated and reported on a dry weight basis assuming use of fine agricultural lime (CaCO3) and using a safety factor of 1.5 to allow for non-homogeneous mixing and poor reactivity of lime. For conversion of Liming Rate from 'kg/t dry weight' to 'kg/m3 in-situ soil', multiply 'reported results' x 'wet bulk density of soil in t/m3'.

Analytical Results

Sub-Matrix: **SOIL** (Matrix: **SOIL**)			Sample ID	**BH8/2.18**	**BH21/3.43**	**BH22/3.15**	**BH23/2.86**	**----**
			Sampling date / time	11-Aug-2021 00:00	12-Aug-2021 00:00	12-Aug-2021 00:00	12-Aug-2021 00:00	----
Compound	CAS Number	LOR	Unit	**EB2127300-001**	**EB2127300-002**	**EB2127300-003**	**EB2127300-004**	**--------**
				Result	Result	Result	Result	----
EA033-A: Actual Acidity								
pH KCl (23A)	----	0.1	pH Unit	**6.2**	**6.1**	**6.0**	**5.8**	----
Titratable Actual Acidity (23F)	----	2	mole H+ / t	**4**	**8**	**8**	**12**	----
sulfidic - Titratable Actual Acidity (s-23F)	----	0.02	% pyrite S	<0.02	<0.02	<0.02	<0.02	----
EA033-B: Potential Acidity								
Chromium Reducible Sulfur (22B)	----	0.005	% S	**0.220**	**0.246**	**0.586**	**0.047**	----
acidity - Chromium Reducible Sulfur (a-22B)	----	10	mole H+ / t	**137**	**153**	**365**	**29**	----
EA033-E: Acid Base Accounting								
ANC Fineness Factor	----	0.5	-	**1.5**	**1.5**	**1.5**	**1.5**	----
Net Acidity (sulfur units)	----	0.02	% S	**0.23**	**0.26**	**0.60**	**0.06**	----
Net Acidity (acidity units)	----	10	mole H+ / t	**141**	**162**	**373**	**41**	----
Liming Rate	----	1	kg CaCO3/t	**10**	**12**	**28**	**3**	----
Net Acidity excluding ANC (sulfur units)	----	0.02	% S	**0.23**	**0.26**	**0.60**	**0.06**	----
Net Acidity excluding ANC (acidity units)	----	10	mole H+ / t	**141**	**162**	**373**	**41**	----
Liming Rate excluding ANC	----	1	kg CaCO3/t	**10**	**12**	**28**	**3**	----

ALS Environmental

QUALITY CONTROL REPORT

Work Order	: **EB2123140**		Page	: 1 of 4
Client	: **ENVIRONMENT & NATURAL RESOURCE SOLUTIONS**		Laboratory	: Environmental Division Brisbane
Contact	: Mr Matt Lemcke		Contact	: Customer Services EB
Address	: 25 River Rd Shoalhaven Heads 2535		Address	: 2 Byth Street Stafford QLD Australia 4053
Telephone	: 02 9037 4708		Telephone	: +61-7-3243 7222
Project	: ENRS1947		Date Samples Received	: 13-Aug-2021
Order number	: ----		Date Analysis Commenced	: 26-Aug-2021
C-O-C number	: ----		Issue Date	: 26-Aug-2021
Sampler	: Matt Lemcke			
Site	: CB Gerroa			
Quote number	: WO/001/21			
No. of samples received	: 72			
No. of samples analysed	: 23			

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*
Ben Felgendrejeris	Senior Acid Sulfate Soil Chemist	Brisbane Acid Sulphate Soils, Stafford, QLD

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 (%)*
EA033-A: Actual Acidity (QC Lot: 3865275)									
EB2123140-002	BH1/1.3	EA033: sulfidic - Titratable Actual Acidity (s-23F)	----	0.02	% pyrite S	<0.02	<0.02	0.0	No Limit
		EA033: Titratable Actual Acidity (23F)	----	2	mole H+ / t	<2	<2	0.0	No Limit
		EA033: pH KCl (23A)	----	0.1	pH Unit	5.8	5.7	0.0	0% - 20%
EB2123140-033	BH4/2.2	EA033: sulfidic - Titratable Actual Acidity (s-23F)	----	0.02	% pyrite S	<0.02	<0.02	0.0	No Limit
		EA033: Titratable Actual Acidity (23F)	----	2	mole H+ / t	<2	<2	0.0	No Limit
		EA033: pH KCl (23A)	----	0.1	pH Unit	5.8	5.8	0.0	0% - 20%
EA033-A: Actual Acidity (QC Lot: 3865276)									
EB2123140-065	BH7/2.12	EA033: sulfidic - Titratable Actual Acidity (s-23F)	----	0.02	% pyrite S	<0.02	<0.02	0.0	No Limit
		EA033: Titratable Actual Acidity (23F)	----	2	mole H+ / t	<2	<2	0.0	No Limit
		EA033: pH KCl (23A)	----	0.1	pH Unit	5.8	5.9	0.0	0% - 20%
EB2123667-005	Anonymous	EA033: sulfidic - Titratable Actual Acidity (s-23F)	----	0.02	% pyrite S	<0.02	<0.02	0.0	No Limit
		EA033: Titratable Actual Acidity (23F)	----	2	mole H+ / t	6	6	0.0	No Limit
		EA033: pH KCl (23A)	----	0.1	pH Unit	4.8	4.8	0.0	0% - 20%
EA033-B: Potential Acidity (QC Lot: 3865275)									
EB2123140-002	BH1/1.3	EA033: Chromium Reducible Sulfur (22B)	----	0.005	% S	0.162	0.158	2.7	0% - 20%
		EA033: acidity - Chromium Reducible Sulfur (a-22B)	----	10	mole H+ / t	101	99	2.7	0% - 50%
EB2123140-033	BH4/2.2	EA033: Chromium Reducible Sulfur (22B)	----	0.005	% S	0.121	0.123	1.3	0% - 20%
		EA033: acidity - Chromium Reducible Sulfur (a-22B)	----	10	mole H+ / t	76	76	0.0	No Limit
EA033-B: Potential Acidity (QC Lot: 3865276)									
EB2123140-065	BH7/2.12	EA033: Chromium Reducible Sulfur (22B)	----	0.005	% S	0.225	0.230	2.5	0% - 20%
		EA033: acidity - Chromium Reducible Sulfur (a-22B)	----	10	mole H+ / t	140	144	2.5	0% - 50%

Sub-Matrix: **SOIL**

Laboratory sample ID	Sample ID	Method: Compound	CAS Number	LOR	Unit	Original Result	Duplicate Result	RPD (%)	Acceptable RPD (%)
				Laboratory Duplicate (DUP) Report					
EA033-B: Potential Acidity (QC Lot: 3865276) - continued									
EB2123667-005	Anonymous	EA033: Chromium Reducible Sulfur (22B)	----	0.005	% S	0.015	0.012	17.3	No Limit
		EA033: acidity - Chromium Reducible Sulfur (a-22B)	----	10	mole H+ / t	<10	<10	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
EA033-A: Actual Acidity (QCLot: 3865275)								
EA033: pH KCl (23A)	----	----	pH Unit	----	4.4 pH Unit	101	91.0	107
EA033: Titratable Actual Acidity (23F)	----	2	mole H+ / t	<2	15 mole H+ / t	88.3	70.0	124
EA033: sulfidic - Titratable Actual Acidity (s-23F)	----	0.02	% pyrite S	<0.02	----	----	----	----
EA033-A: Actual Acidity (QCLot: 3865276)								
EA033: pH KCl (23A)	----	----	pH Unit	----	4.4 pH Unit	99.6	91.0	107
EA033: Titratable Actual Acidity (23F)	----	2	mole H+ / t	<2	15 mole H+ / t	92.3	70.0	124
EA033: sulfidic - Titratable Actual Acidity (s-23F)	----	0.02	% pyrite S	<0.02	----	----	----	----
EA033-B: Potential Acidity (QCLot: 3865275)								
EA033: Chromium Reducible Sulfur (22B)	----	0.005	% S	<0.005	0.246 % S	104	77.0	121
EA033: acidity - Chromium Reducible Sulfur (a-22B)	----	10	mole H+ / t	<10	----	----	----	----
EA033-B: Potential Acidity (QCLot: 3865276)								
EA033: Chromium Reducible Sulfur (22B)	----	0.005	% S	<0.005	0.246 % S	107	77.0	121
EA033: acidity - Chromium Reducible Sulfur (a-22B)	----	10	mole H+ / t	<10	----	----	----	----

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

QUALITY CONTROL REPORT

Work Order	: **EB2123141**		Page	: 1 of 4
Client	: **ENVIRONMENT & NATURAL RESOURCE SOLUTIONS**		Laboratory	: Environmental Division Brisbane
Contact	: Mr Matt Lemcke		Contact	: Customer Services EB
Address	: 25 River Rd Shoalhaven Heads 2535		Address	: 2 Byth Street Stafford QLD Australia 4053
Telephone	: 02 9037 4708		Telephone	: +61-7-3243 7222
Project	: ENRS1947		Date Samples Received	: 13-Aug-2021
Order number	: ----		Date Analysis Commenced	: 24-Aug-2021
C-O-C number	: ----		Issue Date	: 27-Aug-2021
Sampler	: Matt Lemcke			
Site	: CB Gerroa			
Quote number	: WO/001/21			
No. of samples received	: 79			
No. of samples analysed	: 24			

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

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*
Ben Felgendrejeris	Senior Acid Sulfate Soil Chemist	Brisbane Acid Sulphate Soils, Stafford, QLD

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 (%)*
EA033-A: Actual Acidity (QC Lot: 3863214)									
EB2123141-002	BH8/1.81	EA033: sulfidic - Titratable Actual Acidity (s-23F)	----	0.02	% pyrite S	0.05	0.04	25.9	No Limit
		EA033: Titratable Actual Acidity (23F)	----	2	mole H+ / t	33	25	25.9	0% - 50%
		EA033: pH KCl (23A)	----	0.1	pH Unit	5.2	5.2	0.0	0% - 20%
EB2123141-035	BH12/2.35	EA033: sulfidic - Titratable Actual Acidity (s-23F)	----	0.02	% pyrite S	<0.02	<0.02	0.0	No Limit
		EA033: Titratable Actual Acidity (23F)	----	2	mole H+ / t	2	<2	0.0	No Limit
		EA033: pH KCl (23A)	----	0.1	pH Unit	6.0	6.0	0.0	0% - 20%
EA033-A: Actual Acidity (QC Lot: 3863215)									
EB2123141-074	BH17/0.2	EA033: sulfidic - Titratable Actual Acidity (s-23F)	----	0.02	% pyrite S	<0.02	<0.02	0.0	No Limit
		EA033: Titratable Actual Acidity (23F)	----	2	mole H+ / t	4	4	0.0	No Limit
		EA033: pH KCl (23A)	----	0.1	pH Unit	5.7	5.7	0.0	0% - 20%
EB2123446-007	Anonymous	EA033: sulfidic - Titratable Actual Acidity (s-23F)	----	0.02	% pyrite S	<0.02	<0.02	0.0	No Limit
		EA033: Titratable Actual Acidity (23F)	----	2	mole H+ / t	<2	<2	0.0	No Limit
		EA033: pH KCl (23A)	----	0.1	pH Unit	8.4	8.4	0.0	0% - 20%
EA033-B: Potential Acidity (QC Lot: 3863214)									
EB2123141-002	BH8/1.81	EA033: Chromium Reducible Sulfur (22B)	----	0.005	% S	5.05	5.26	4.0	0% - 20%
		EA033: acidity - Chromium Reducible Sulfur (a-22B)	----	10	mole H+ / t	3150	3280	4.0	0% - 20%
EB2123141-035	BH12/2.35	EA033: Chromium Reducible Sulfur (22B)	----	0.005	% S	0.190	0.180	5.7	0% - 20%
		EA033: acidity - Chromium Reducible Sulfur (a-22B)	----	10	mole H+ / t	119	112	5.7	0% - 50%
EA033-B: Potential Acidity (QC Lot: 3863215)									
EB2123141-074	BH17/0.2	EA033: Chromium Reducible Sulfur (22B)	----	0.005	% S	0.021	0.020	0.0	No Limit
		EA033: acidity - Chromium Reducible Sulfur (a-22B)	----	10	mole H+ / t	13	12	0.0	No Limit

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 (%)
EA033-B: Potential Acidity (QC Lot: 3863215) - continued									
EB2123446-007	Anonymous	EA033: Chromium Reducible Sulfur (22B)	----	0.005	% S	0.015	0.015	0.0	No Limit
		EA033: acidity - Chromium Reducible Sulfur (a-22B)	----	10	mole H+ / t	<10	<10	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
EA033-A: Actual Acidity (QCLot: 3863214)								
EA033: pH KCl (23A)	----	----	pH Unit	----	4.4 pH Unit	102	91.0	107
EA033: Titratable Actual Acidity (23F)	----	2	mole H+ / t	<2	15 mole H+ / t	91.3	70.0	124
EA033: sulfidic - Titratable Actual Acidity (s-23F)	----	0.02	% pyrite S	<0.02	----	----	----	----
EA033-A: Actual Acidity (QCLot: 3863215)								
EA033: pH KCl (23A)	----	----	pH Unit	----	4.4 pH Unit	102	91.0	107
EA033: Titratable Actual Acidity (23F)	----	2	mole H+ / t	<2	15 mole H+ / t	83.8	70.0	124
EA033: sulfidic - Titratable Actual Acidity (s-23F)	----	0.02	% pyrite S	<0.02	----	----	----	----
EA033-B: Potential Acidity (QCLot: 3863214)								
EA033: Chromium Reducible Sulfur (22B)	----	0.005	% S	<0.005	0.246 % S	109	77.0	121
EA033: acidity - Chromium Reducible Sulfur (a-22B)	----	10	mole H+ / t	<10	----	----	----	----
EA033-B: Potential Acidity (QCLot: 3863215)								
EA033: Chromium Reducible Sulfur (22B)	----	0.005	% S	<0.005	0.246 % S	106	77.0	121
EA033: acidity - Chromium Reducible Sulfur (a-22B)	----	10	mole H+ / t	<10	----	----	----	----

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.**

QUALITY CONTROL REPORT

Work Order	: **EB2123142**	Page	: 1 of 4
Client	: **ENVIRONMENT & NATURAL RESOURCE SOLUTIONS**	Laboratory	: Environmental Division Brisbane
Contact	: Mr Matt Lemcke	Contact	: Customer Services EB
Address	: 25 River Rd Shoalhaven Heads 2535	Address	: 2 Byth Street Stafford QLD Australia 4053
Telephone	: 02 9037 4708	Telephone	: +61-7-3243 7222
Project	: ENRS1947	Date Samples Received	: 13-Aug-2021
Order number	: ----	Date Analysis Commenced	: 27-Aug-2021
C-O-C number	: ----	Issue Date	: 01-Sep-2021
Sampler	: Matt Lemcke		
Site	: CB Gerroa		
Quote number	: WO/001/21		
No. of samples received	: 67		
No. of samples analysed	: 22		

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*
Ben Felgendrejeris	Senior Acid Sulfate Soil Chemist	Brisbane Acid Sulphate Soils, Stafford, QLD

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 (%)*
EA033-A: Actual Acidity (QC Lot: 3867700)									
EB2123142-004	BH18/0.3	EA033: sulfidic - Titratable Actual Acidity (s-23F)	----	0.02	% pyrite S	<0.02	<0.02	0.0	No Limit
		EA033: Titratable Actual Acidity (23F)	----	2	mole H+ / t	2	2	0.0	No Limit
		EA033: pH KCl (23A)	----	0.1	pH Unit	5.6	5.6	0.0	0% - 20%
EB2123142-033	BH21/2.12	EA033: sulfidic - Titratable Actual Acidity (s-23F)	----	0.02	% pyrite S	<0.02	<0.02	0.0	No Limit
		EA033: Titratable Actual Acidity (23F)	----	2	mole H+ / t	8	8	0.0	No Limit
		EA033: pH KCl (23A)	----	0.1	pH Unit	5.2	5.3	0.0	0% - 20%
EA033-A: Actual Acidity (QC Lot: 3867701)									
EB2123142-062	BH24/1.74	EA033: sulfidic - Titratable Actual Acidity (s-23F)	----	0.02	% pyrite S	<0.02	<0.02	0.0	No Limit
		EA033: Titratable Actual Acidity (23F)	----	2	mole H+ / t	2	2	0.0	No Limit
		EA033: pH KCl (23A)	----	0.1	pH Unit	5.6	5.6	0.0	0% - 20%
EB2123954-004	Anonymous	EA033: sulfidic - Titratable Actual Acidity (s-23F)	----	0.02	% pyrite S	<0.02	<0.02	0.0	No Limit
		EA033: Titratable Actual Acidity (23F)	----	2	mole H+ / t	<2	<2	0.0	No Limit
		EA033: pH KCl (23A)	----	0.1	pH Unit	6.1	6.2	2.2	0% - 20%
EA033-B: Potential Acidity (QC Lot: 3867700)									
EB2123142-004	BH18/0.3	EA033: Chromium Reducible Sulfur (22B)	----	0.005	% S	0.014	0.015	0.0	No Limit
		EA033: acidity - Chromium Reducible Sulfur (a-22B)	----	10	mole H+ / t	<10	<10	0.0	No Limit
EB2123142-033	BH21/2.12	EA033: Chromium Reducible Sulfur (22B)	----	0.005	% S	0.652	0.741	12.8	0% - 20%
		EA033: acidity - Chromium Reducible Sulfur (a-22B)	----	10	mole H+ / t	406	462	12.8	0% - 20%
EA033-B: Potential Acidity (QC Lot: 3867701)									
EB2123142-062	BH24/1.74	EA033: Chromium Reducible Sulfur (22B)	----	0.005	% S	0.148	0.145	1.6	0% - 20%
		EA033: acidity - Chromium Reducible Sulfur (a-22B)	----	10	mole H+ / t	92	90	1.6	No Limit

Sub-Matrix: **SOIL**

Laboratory sample ID	Sample ID	Method: Compound	CAS Number	LOR	Unit	Original Result	Duplicate Result	RPD (%)	Acceptable RPD (%)
				Laboratory Duplicate (DUP) Report					
EA033-B: Potential Acidity (QC Lot: 3867701) - continued									
EB2123954-004	Anonymous	EA033: Chromium Reducible Sulfur (22B)	----	0.005	% S	0.012	0.009	28.6	No Limit
		EA033: acidity - Chromium Reducible Sulfur (a-22B)	----	10	mole H+ / t	<10	<10	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: Compound	CAS Number	LOR	Unit	Method Blank (MB) Report	Laboratory Control Spike (LCS) Report			
					Spike	Spike Recovery (%)	Acceptable Limits (%)	
				Result	Concentration	LCS	Low	High
EA033-A: Actual Acidity (QCLot: 3867700)								
EA033: pH KCl (23A)	----	----	pH Unit	----	4.4 pH Unit	100	91.0	107
EA033: Titratable Actual Acidity (23F)	----	2	mole H+ / t	<2	15 mole H+ / t	84.2	70.0	124
EA033: sulfidic - Titratable Actual Acidity (s-23F)	----	0.02	% pyrite S	<0.02	----	----	----	----
EA033-A: Actual Acidity (QCLot: 3867701)								
EA033: pH KCl (23A)	----	----	pH Unit	----	4.4 pH Unit	100.0	91.0	107
EA033: Titratable Actual Acidity (23F)	----	2	mole H+ / t	<2	15 mole H+ / t	88.0	70.0	124
EA033: sulfidic - Titratable Actual Acidity (s-23F)	----	0.02	% pyrite S	<0.02	----	----	----	----
EA033-B: Potential Acidity (QCLot: 3867700)								
EA033: Chromium Reducible Sulfur (22B)	----	0.005	% S	<0.005	0.246 % S	93.2	77.0	121
EA033: acidity - Chromium Reducible Sulfur (a-22B)	----	10	mole H+ / t	<10	----	----	----	----
EA033-B: Potential Acidity (QCLot: 3867701)								
EA033: Chromium Reducible Sulfur (22B)	----	0.005	% S	<0.005	0.246 % S	110	77.0	121
EA033: acidity - Chromium Reducible Sulfur (a-22B)	----	10	mole H+ / t	<10	----	----	----	----

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.**

QUALITY CONTROL REPORT

Work Order	: **EB2125980**	Page	: 1 of 4
Client	: **ENVIRONMENT & NATURAL RESOURCE SOLUTIONS**	Laboratory	: Environmental Division Brisbane
Contact	: Mr Matt Lemcke	Contact	: Customer Services EB
Address	: 25 River Rd Shoalhaven Heads 2535	Address	: 2 Byth Street Stafford QLD Australia 4053
Telephone	: 02 9037 4708	Telephone	: +61-7-3243 7222
Project	: ENRS1947	Date Samples Received	: 13-Sep-2021
Order number	: ----	Date Analysis Commenced	: 17-Sep-2021
C-O-C number	: ----	Issue Date	: 17-Sep-2021
Sampler	: Matt Lemcke		
Site	: CB Gerroa		
Quote number	: WO/001/21		
No. of samples received	: 22		
No. of samples analysed	: 22		

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*
Ben Felgendrejeris	Senior Acid Sulfate Soil Chemist	Brisbane Acid Sulphate Soils, Stafford, QLD

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 (%)*
EA033-A: Actual Acidity (QC Lot: 3905872)									
EB2125893-007	Anonymous	EA033: sulfidic - Titratable Actual Acidity (s-23F)	----	0.02	% pyrite S	<0.02	<0.02	0.0	No Limit
		EA033: Titratable Actual Acidity (23F)	----	2	mole H+ / t	6	6	0.0	No Limit
		EA033: pH KCl (23A)	----	0.1	pH Unit	5.4	5.3	0.0	0% - 20%
EB2125947-010	Anonymous	EA033: sulfidic - Titratable Actual Acidity (s-23F)	----	0.02	% pyrite S	<0.02	<0.02	0.0	No Limit
		EA033: Titratable Actual Acidity (23F)	----	2	mole H+ / t	<2	<2	0.0	No Limit
		EA033: pH KCl (23A)	----	0.1	pH Unit	8.7	8.8	0.0	0% - 20%
EA033-A: Actual Acidity (QC Lot: 3905873)									
EB2125980-005	BH2/4.33 EB2123140 018	EA033: sulfidic - Titratable Actual Acidity (s-23F)	----	0.02	% pyrite S	<0.02	<0.02	0.0	No Limit
		EA033: Titratable Actual Acidity (23F)	----	2	mole H+ / t	<2	<2	0.0	No Limit
		EA033: pH KCl (23A)	----	0.1	pH Unit	6.2	6.2	0.0	0% - 20%
EB2125980-015	BH18/4.53 EB2123142 012	EA033: sulfidic - Titratable Actual Acidity (s-23F)	----	0.02	% pyrite S	<0.02	<0.02	0.0	No Limit
		EA033: Titratable Actual Acidity (23F)	----	2	mole H+ / t	<2	<2	0.0	No Limit
		EA033: pH KCl (23A)	----	0.1	pH Unit	6.2	6.3	0.0	0% - 20%
EA033-B: Potential Acidity (QC Lot: 3905872)									
EB2125893-007	Anonymous	EA033: Chromium Reducible Sulfur (22B)	----	0.005	% S	0.015	0.013	16.4	No Limit
		EA033: acidity - Chromium Reducible Sulfur (a-22B)	----	10	mole H+ / t	<10	<10	0.0	No Limit
EB2125947-010	Anonymous	EA033: Chromium Reducible Sulfur (22B)	----	0.005	% S	0.579	0.584	0.8	0% - 20%
		EA033: acidity - Chromium Reducible Sulfur (a-22B)	----	10	mole H+ / t	361	364	0.8	0% - 20%
EA033-B: Potential Acidity (QC Lot: 3905873)									
EB2125980-005	BH2/4.33 EB2123140 018	EA033: Chromium Reducible Sulfur (22B)	----	0.005	% S	0.027	0.029	5.8	No Limit
		EA033: acidity - Chromium Reducible Sulfur (a-22B)	----	10	mole H+ / t	17	18	5.8	No Limit

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 (%)
EA033-B: Potential Acidity (QC Lot: 3905873) - continued									
EB2125980-015	BH18/4.53 EB2123142 012	EA033: Chromium Reducible Sulfur (22B)	----	0.005	% S	0.027	0.025	9.2	No Limit
		EA033: acidity - Chromium Reducible Sulfur (a-22B)	----	10	mole H+ / t	17	16	9.2	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
EA033-A: Actual Acidity (QCLot: 3905872)								
EA033: pH KCl (23A)	----	----	pH Unit	----	4.4 pH Unit	102	91.0	107
EA033: Titratable Actual Acidity (23F)	----	2	mole H+ / t	<2	15 mole H+ / t	85.7	70.0	124
EA033: sulfidic - Titratable Actual Acidity (s-23F)	----	0.02	% pyrite S	<0.02	----	----	----	----
EA033-A: Actual Acidity (QCLot: 3905873)								
EA033: pH KCl (23A)	----	----	pH Unit	----	4.4 pH Unit	102	91.0	107
EA033: Titratable Actual Acidity (23F)	----	2	mole H+ / t	<2	15 mole H+ / t	83.2	70.0	124
EA033: sulfidic - Titratable Actual Acidity (s-23F)	----	0.02	% pyrite S	<0.02	----	----	----	----
EA033-B: Potential Acidity (QCLot: 3905872)								
EA033: Chromium Reducible Sulfur (22B)	----	0.005	% S	<0.005	0.246 % S	108	77.0	121
EA033: acidity - Chromium Reducible Sulfur (a-22B)	----	10	mole H+ / t	<10	----	----	----	----
EA033-B: Potential Acidity (QCLot: 3905873)								
EA033: Chromium Reducible Sulfur (22B)	----	0.005	% S	<0.005	0.246 % S	100	77.0	121
EA033: acidity - Chromium Reducible Sulfur (a-22B)	----	10	mole H+ / t	<10	----	----	----	----

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.**

QUALITY CONTROL REPORT

Work Order	: **EB2127300**	Page	: 1 of 3
Client	: **ENVIRONMENT & NATURAL RESOURCE SOLUTIONS**	Laboratory	: Environmental Division Brisbane
Contact	: Mr Matt Lemcke	Contact	: Customer Services EB
Address	: 25 River Rd Shoalhaven Heads 2535	Address	: 2 Byth Street Stafford QLD Australia 4053
Telephone	: 02 9037 4708	Telephone	: +61-7-3243 7222
Project	: ENRS1947	Date Samples Received	: 22-Sep-2021
Order number	: ----	Date Analysis Commenced	: 29-Sep-2021
C-O-C number	: ----	Issue Date	: 29-Sep-2021
Sampler	: Matt Lemcke		
Site	: CB Gerroa		
Quote number	: WO/001/21		
No. of samples received	: 4		
No. of samples analysed	: 4		

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*
Ben Felgendrejeris	Senior Acid Sulfate Soil Chemist	Brisbane Acid Sulphate Soils, Stafford, QLD

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 (%)*
EA033-A: Actual Acidity (QC Lot: 3926365)									
EB2127300-001	BH8/2.18	EA033: sulfidic - Titratable Actual Acidity (s-23F)	----	0.02	% pyrite S	<0.02	<0.02	0.0	No Limit
		EA033: Titratable Actual Acidity (23F)	----	2	mole H+ / t	4	4	0.0	No Limit
		EA033: pH KCl (23A)	----	0.1	pH Unit	6.2	6.2	0.0	0% - 20%
ES2134221-001	Anonymous	EA033: sulfidic - Titratable Actual Acidity (s-23F)	----	0.02	% pyrite S	<0.02	<0.02	0.0	No Limit
		EA033: Titratable Actual Acidity (23F)	----	2	mole H+ / t	<2	<2	0.0	No Limit
		EA033: pH KCl (23A)	----	0.1	pH Unit	6.4	6.4	0.0	0% - 20%
EA033-B: Potential Acidity (QC Lot: 3926365)									
EB2127300-001	BH8/2.18	EA033: Chromium Reducible Sulfur (22B)	----	0.005	% S	0.220	0.222	1.2	0% - 20%
		EA033: acidity - Chromium Reducible Sulfur (a-22B)	----	10	mole H+ / t	137	139	1.2	0% - 50%
ES2134221-001	Anonymous	EA033: Chromium Reducible Sulfur (22B)	----	0.005	% S	0.012	0.012	0.0	No Limit
		EA033: acidity - Chromium Reducible Sulfur (a-22B)	----	10	mole H+ / t	<10	<10	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
EA033-A: Actual Acidity (QCLot: 3926365)								
EA033: pH KCl (23A)	----	----	pH Unit	----	4.4 pH Unit	101	91.0	107
EA033: Titratable Actual Acidity (23F)	----	2	mole H+ / t	<2	19 mole H+ / t	97.0	70.0	124
EA033: sulfidic - Titratable Actual Acidity (s-23F)	----	0.02	% pyrite S	<0.02	----	----	----	----
EA033-B: Potential Acidity (QCLot: 3926365)								
EA033: Chromium Reducible Sulfur (22B)	----	0.005	% S	<0.005	0.246 % S	103	77.0	121
EA033: acidity - Chromium Reducible Sulfur (a-22B)	----	10	mole H+ / t	<10	----	----	----	----

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.**

Appendix C

Photographic Record of Site Conditions

Photograph 1: TP2/BH2 upper profile

Photograph 2: TP2/BH2 Soil Core

Photograph 3: TP8/BH8 upper profile

Photograph 4: TP8/BH8 soil core

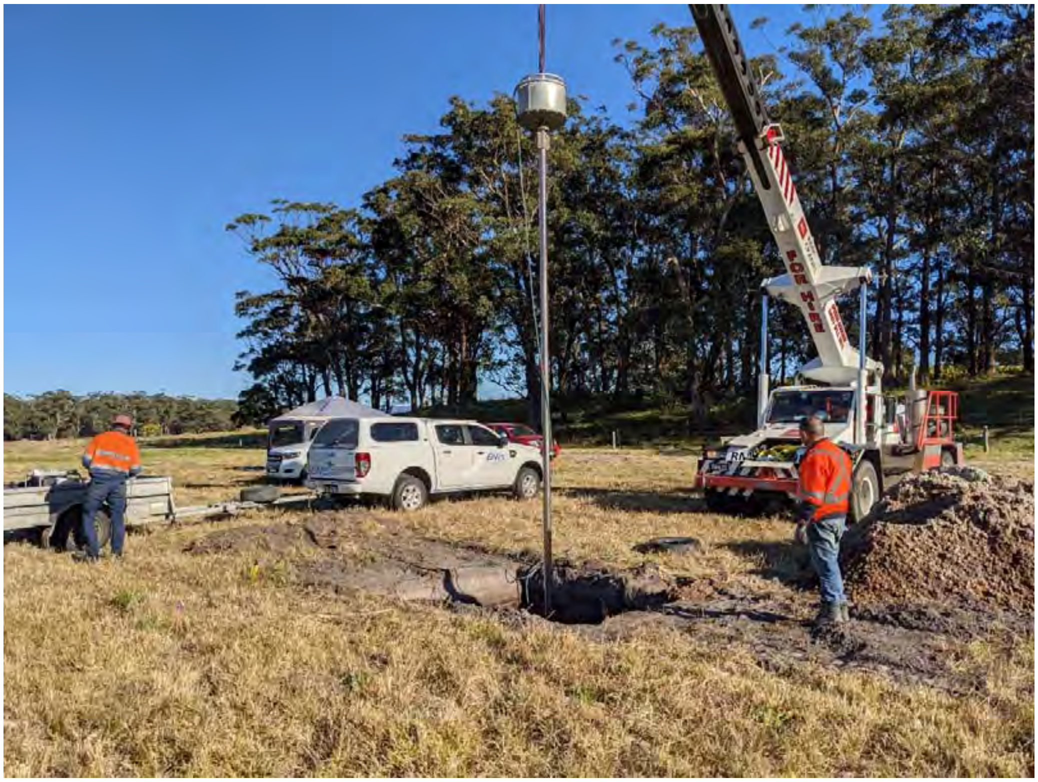
Photograph 5: TP18/BH18 shallow profile

Photograph 6: TP18/BH18 soil core

Photograph 7: TP22/BH22 shallow profile

Photograph 8: TP22/BH22 soil core

Photograph 9: Vibrocore deployment from crane



Photograph 10: Vibrocore penetrating base of test pit

Photograph 11: Sample retained in core catcher

Photograph 12: Investigation area

LWC
Land and Water Consulting

APPENDIX E
STATEMENT OF LIMITATIONS

STATEMENT OF LIMITATIONS & IMPORTANT INFORMATION REGARDING YOUR REPORT

INTRODUCTION

This report has been prepared by Land & Water Consulting for you, as Land & Water Consulting's client, in accordance with our agreed purpose, scope, schedule and budget.

The report has been prepared using accepted procedures and practices of the consulting profession at the time it was prepared, and the opinions, recommendations and conclusions set out in the report are made in accordance with generally accepted principles and practices of that profession.

The report is based on information gained from environmental conditions (including assessment of some or all of soil, groundwater, vapour and surface water) and supplemented by reported data of the local area and professional experience. Assessment has been scoped with consideration to industry standards, regulations, guidelines and your specific requirements, including budget and timing. The characterisation of site conditions is an interpretation of information collected during assessment, in accordance with industry practice.

This interpretation is not a complete description of all material on or in the vicinity of the site, due to the inherent variation in spatial and temporal patterns of contaminant presence and impact in the natural environment. Land & Water Consulting may have also relied on data and other information provided by you and other qualified individuals in preparing this report. Land & Water Consulting has not verified the accuracy or completeness of such data or information except as otherwise stated in the report. For these reasons the report must be regarded as interpretative, in accordance with industry standards and practice, rather than being a definitive record.

No warranty or guarantee of the site conditions is intended.

This report was prepared for the sole use of you, the Client and may not contain sufficient information for purposes of other parties or for other uses. Any reliance on this report by third parties shall be at such parties sole risk. This report shall only be presented in full and may not be used to support any other objectives than those set out in the report, except where written approval with comments are provided by Land & Water Consulting.

The report does not include the evaluation or assessment of potential geotechnical engineering constraints of the site.

LIMITATIONS OF THE REPORT

The scope of works undertaken and the report prepared to complete the assessment was in accordance with the information provided by the client and the specifications for works required under the contract. As such, works undertaken and statements made are based on those specifications (such as levels of risks and significance of any contamination) and should be considered and interpreted within this context. The analyses, evaluations, opinions and conclusions presented in this report are based on that purpose and scope, requirements, data or information, and they could change if such requirements or data are inaccurate or incomplete.

Your environmental report should not be used without reference to Land & Water Consulting in the first instance:

- When the nature of the proposed development is changed, for example if a residential development is proposed instead of a commercial one;
- When the size or configuration of the proposed development is altered;
- When the location or orientation of the proposed structures are modified;
- When there is a change in ownership;
- For application to an adjacent site.

In addition, advancements in professional practice regarding contaminated land and changes in applicable statues and/or guidelines may affect the validity of this report. Consequently, the currency of conclusions and recommendations in this report should be verified if you propose to use this report more than 6 months after its date of issue.

ENVIRONMENTAL ASSESSMENT "FINDINGS" ARE PROFESSIONAL ESTIMATES

The information in this report is considered to be accurate with respect to conditions encountered at the site at the time of investigation and considering the inherent limitations associated with extrapolating information from a sample set. Note however that site assessment identifies actual subsurface conditions only at those specific points where samples are taken, when they are taken. Environmental data derived through sampling and analysis are interpreted by consultants who then render an opinion about overall subsurface conditions, the nature and extent of contamination and potential impacts on the use of the land. Actual conditions may differ from those inferred to exist as no professional and no subsurface assessment program can reveal every detail within the ground across a site. Subsurface conditions can vary across a particular site and no practical degree of sampling can ever eliminate the possibility that conditions may be present at a site that have not been represented though sampling.

SUBSURFACE CONDITIONS CAN CHANGE

This report is valid as of the date of preparation. The condition of the site (including subsurface conditions) and extent or nature of contamination or other environmental hazards can change over time, as a result of either natural processes or human influence. Land & Water Consulting should be kept appraised of any such events and should be consulted for further investigations if any changes are noted, particularly during construction activities where excavations often reveal subsurface conditions. Since subsurface conditions (including contamination concentrations) can change within a limited period of time and space, this inherent limitation to the representation of site conditions provided by this report should always be taken into consideration particularly if the report is used after a delay in time.

DATA SHOULD NOT BE SEPARATED FROM THE REPORT

The report as a whole presents the findings of the site assessment and the report should not be copied in part or altered in any way. Logs, figures, laboratory data, drawings, etc. are customarily included in our reports and are developed by scientists or engineers based on their interpretation of field logs, field testing and laboratory evaluation of samples. This information should not under any circumstances be redrawn for inclusion in other documents or separated from the report in any way.

This report should be reproduced in full. No responsibility is accepted for use of any part of this report in any other context or for any other purpose or by third parties.

RESPONSIBILITY

Environmental reporting relies on interpretation of factual information using professional judgement and opinion and has a level of uncertainty attached to it, which is much less exact than other design disciplines. As noted earlier, the recommendations and findings set out in this report should only be regarded as interpretive and should not be taken as accurate and complete information about all environmental media at all depths and locations across the site.