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Dunmore Lakes Sand Extraction Project | Modification 2

ENVIRONMENTAL ASSESSMENT

Prepared for Dunmore Sand & Soil Pty Ltd | April 2019

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DOCUMENT CONTROL

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Executive Summary

Introduction

Stage 1 of the Dunmore Lakes Sand Project (the 'approved project') was issued development consent from the Minister for Planning in 1999. Stage 1 was on Swamp Road, Dunmore, and encompassed sand extraction by dredging of up to 500,000 tonnes per annum (tpa) for 10 years.

The application for stages 2 to 4 was lodged in 2004, and development consent was received from the Minister for Planning in June 2005. Extraction of up to 800,000 tpa of sand was approved for 25 years. Boral Resources (NSW) Pty Ltd (hereafter 'Boral') purchased Dunmore Sand & Soil Pty Ltd (DSS), including the Dunmore Lakes Sand Project in mid-2005.

Dredging commenced for stages 2 to 4 in June 2007. Since then, due to the high demand for sand in the Sydney market, the majority of sand in Stage 2 has been extracted with dredging recently moving into Stage 3. Given recent high demand, the sand resource in Stage 3 is expected to be exhausted in eight to twelve months. The last extraction stage (Stage 4) encompasses an area containing the road access and private rail line to the approved project, supporting infrastructure for stages 2 to 4 and Boral's adjacent Dunmore Hard Rock Quarry. Given this, Stage 4 cannot be extracted until these activities are relocated. This has led DSS to investigate other local sources of sand to continue operations beyond Stage 3.

DSS has been investigating a fine sand resource on an adjoining private property to the south of the former Stage 1 extraction area (referred to as Stage 5). Investigative drilling has confirmed that there is sufficient sand resource to support three to four more years of extraction from two areas (stages 5A and 5B).

As such, DSS is seeking to modify the current Project Approval (DA 195-8-2004) under Section 75W of the NSW *Environmental Planning and Assessment Act 1979* (EP&A Act), to provide for an additional extraction area (Stage 5) on adjoining private land, encompassing two separate extraction areas, Stage 5A and Stage 5B (hereafter referred to as the 'proposed modification'). The land on which the proposed modification is to be carried out is hereafter referred to as the 'modification site'.

This will be Modification 2 to the Project Approval. The Minister for Planning is the consent authority for the proposed modification.

This environmental assessment (EA) has been prepared by Element Environment Pty Ltd (Element) on behalf of DSS to assess the potential environmental and social impacts of Modification 2 to the current Project Approval, and to support a development application (DA) to be lodged with NSW Department of Planning & Environment (DP&E).

Site description

The approved project (the existing site) is near Dunmore, approximately 3 kilometres (km) south-south west of Shellharbour and 7 km north of Kiama, in the Illawarra region of New South Wales. The existing site covers approximately 88 hectares (ha) and is immediately west of the Princes Highway near Tabbita Road, Dunmore. The site is in the Shellharbour Local Government Area (LGA).

The modification site is approximately 1.1 km south-south east of the existing site, covers approximately 38 ha and is on an alluvial coastal flood plain, adjacent to the tidal reaches of the

Minnamurra River. The northern portion of the extraction area has been partially cleared and has historically been used for grazing.

The modification site is bound by Riverside Drive to the north and Princes Highway to the west.

The modification site is characterised by agricultural land that has been mostly cleared of native vegetation for the grazing of livestock. Land use surrounding the modification site comprises:

- commercial and industrial development, including Dunmore Hard Rock Quarry and concrete batching plant to the north west and Dunmore Resource and Recycling Facility to the north;
- residential development, including Dunmore Lakes Estate to the south west and Minnamurra to the east;
- infrastructure development, including the Princes Highway to the west, and the South Coast Rail Line to the north east; and
- Minnamurra River and associated wetland (protected under State Environmental Planning Policy (Coastal Management) 2018) (Coastal SEPP) is located adjacent to the south of the modification.

The modification site will be accessed via Riverside Drive, Fig Hill Lane and an internal road network consisting of several unsealed access roads.

The closest residential dwellings to the Stage 5 extraction areas are:

- 69 Fig Hill Lane, which is on lot 51 DP 1012246, and is approximately 130 m to the north of the Stage 5B extraction area;
- 71 Fig Hill Lane, which is approximately 290 m north east of the Stage 5B extraction area. The dwelling at this address is derelict and is uninhabited. There is no valid development approval for this house;
- 471 Riverside Drive (Dunmore House), which is located on Lot 501 DP 1174897, and is approximately 175 m to the south of the Stage 5A extraction area, 250 m to the east of the proposed internal access road between the two extraction areas, and 750m north-north east of the Stage 5B extraction area; and
- 431 Riverside Drive, which is located approximately 345 m south of the Stage 5A extraction area.

To the south-west of the modification site is the residential Dunmore Lakes Estate. The main access for these properties is via Riverside Road and Swamp Road. These properties are separated from the modification site by the Princes Highway, with the closest approximately 495 m from the access road linking the Stage 5A and 5B extraction areas. The township of Minnamurra is approximately 865 m east of the Stage 5A extraction area.

Refer to **Figure E-1** for the location of the approved project and proposed modification.

Figure E.1
Local context

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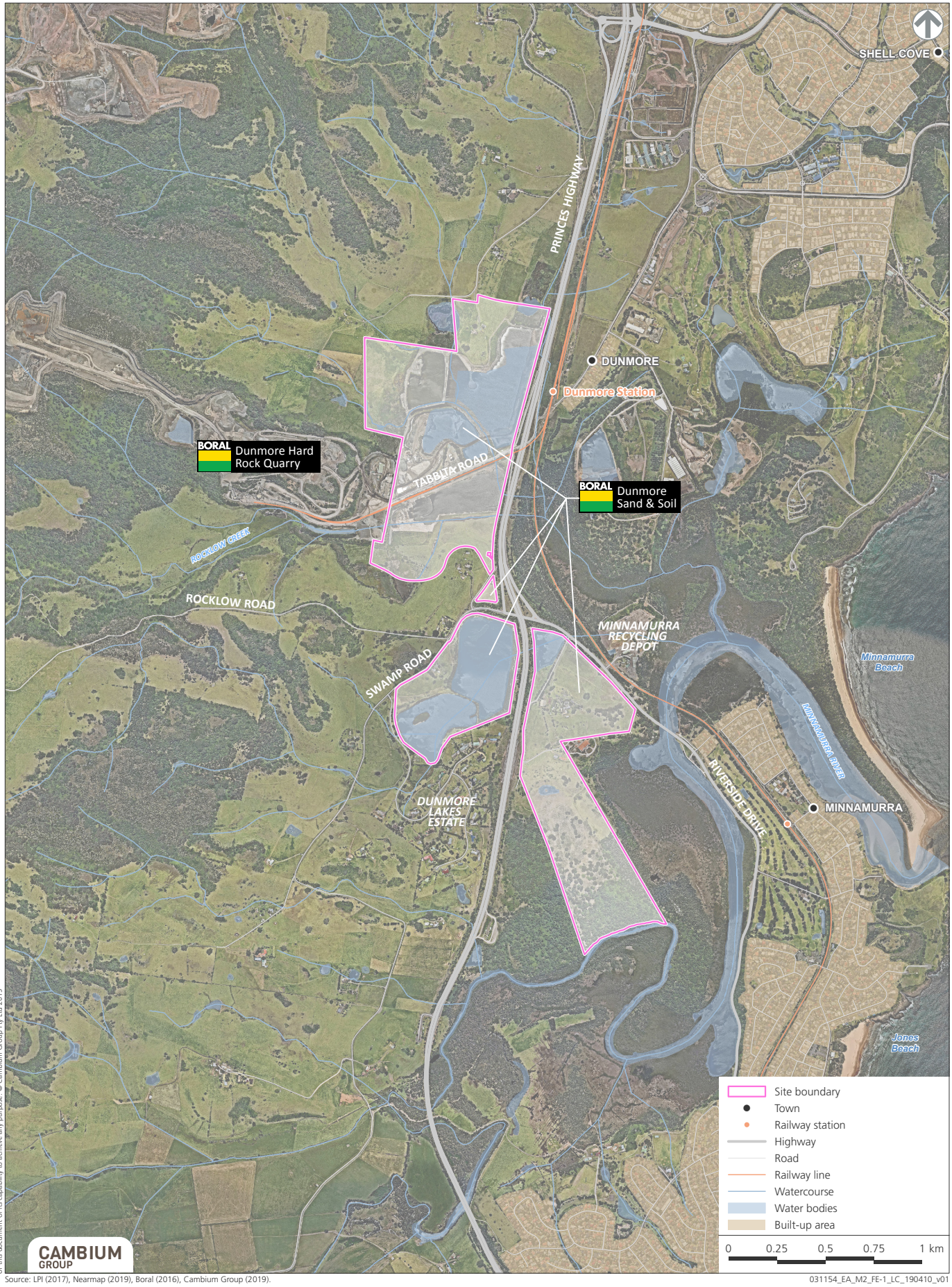

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Proposed modification

The modification to the approved project seeks to establish additional extraction areas (Stage 5) on adjoining private property which is to be leased by DSS. Extraction is proposed in two separate extraction areas, namely Stage 5A (immediately south of Riverside Drive), and Stage 5B (to the north of Minnamurra River). The sand resource to be extracted from Stage 5A is estimated at 234,000 t and approximately 1,123,000 t from Stage 5B. These resource volumes are the estimated sand resource only, and additional tonnage of soil material (known as overburden) will be extracted in addition to the sand resource.

Mobile plant and equipment will be operated across both extraction areas. Extraction methods will be identical to those in Stages 2 and 3.

Refer to **Figure E-2** for an overview of the proposed modification.

Figure E.2
Proposed modification

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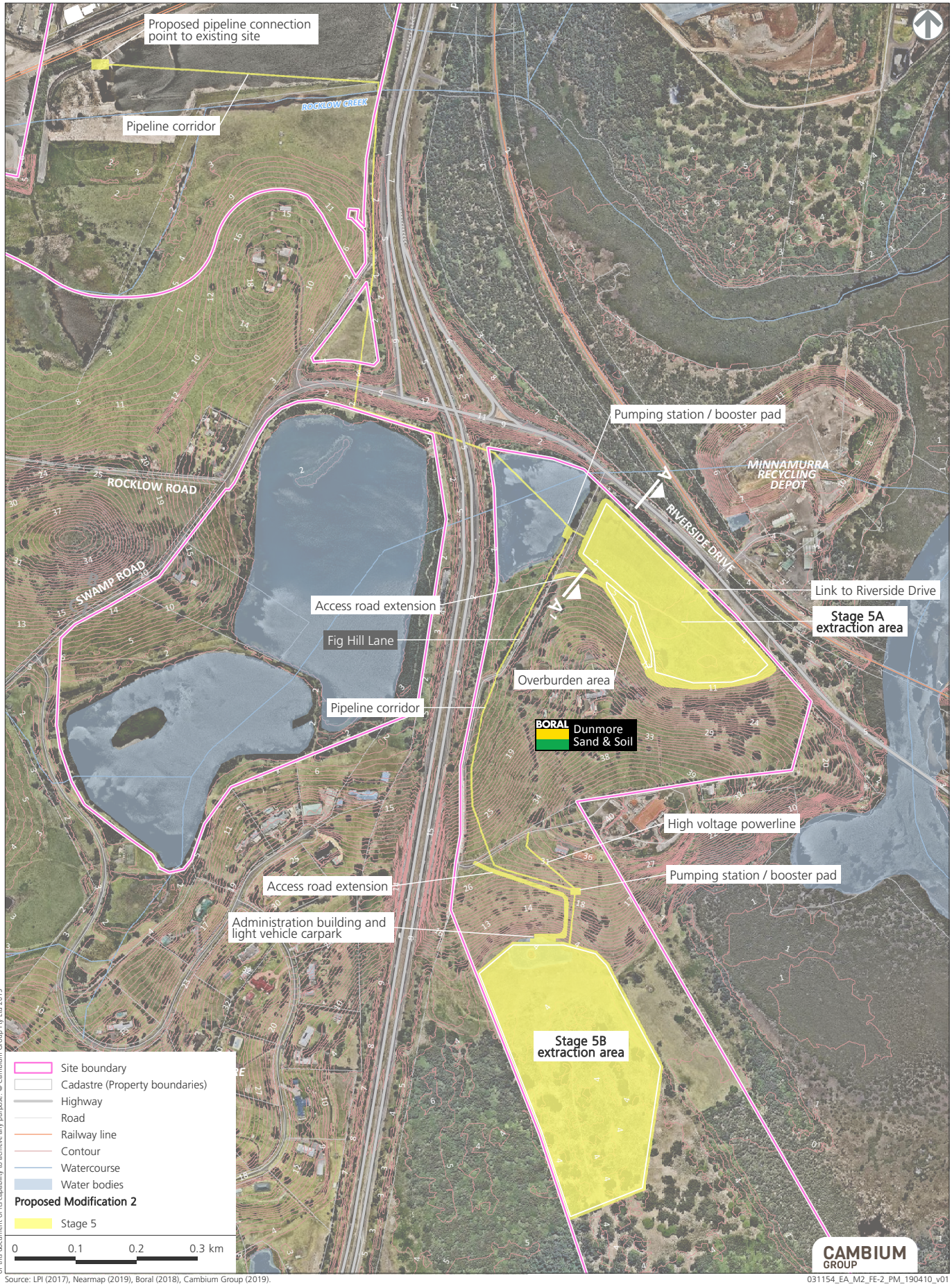

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Stage 5A

Sand extraction in Stage 5A will commence prior to Stage 5B and will involve clearing and grubbing of established groundcover vegetation. Topsoil will be stripped and stockpiled along the southern edge of the extraction area for later re-use in rehabilitation. At the same time, earth mounds will be formed using a dozer to construct the flood protection bunding for the dredge pond.

The sand will initially be extracted from Stage 5A via excavator to create a large enough pond to float a dredge and accommodate fresh water pumping from the dredge via overland pipeline to the processing plant in Stage 2.

Sand will be extracted to a maximum depth of 12 m.

Stage 5B

Stage 5B operations will not commence until approximately two weeks prior to the completion of extraction in Stage 5A. During the two-week transition period, two dredges may be operating in tandem to minimise disruption to operations and ensure the supply of sand is not compromised during the transition between extraction areas. At the same time, earth mounds will be formed using a dozer to construct the flood protection bunding for the dredge pond.

Initially, sand will be excavated in the northern end of the Stage 5B extraction area to create a large enough pond to float a dredge and accommodate fresh water pumping from the dredge via overland pipeline to the processing plant in Stage 2.

Sand will be extracted to a maximum depth of 27m.

Processing and dispatch

An overland transfer pipeline will be established from the Stage 5 extraction areas to the existing Stage 2 processing area. At the Stage 2 processing area, the sand and water will pass over an initial screen to separate oversize organic matter or debris and into a large wash tank to float out any fines. The sand will then be pumped through a cyclone and stockpiled for further dewatering. Water will drain to an existing fines pond and a secondary settling pond before being pumped back to the Stage 5A and Stage 5B dredge ponds.

Dewatered sand will then be loaded with a front-end loader for dispatch by road and rail.

Water pumped from the Stage 5 extraction areas will be returned to these extraction areas via the pumping pipeline.

Sand processing and dispatch at the Stage 2 processing plant will be in accordance with the approved project. The proposed modification does not involve any changes to the approved processing and dispatch activities.

Access roads

The Stage 5 extraction areas are accessed via Fig Hill Lane. This access route is unsafe for haul vehicles as it is too close to the Princes Highway/Riverside Drive intersection. Therefore, a new access road will be constructed to the Stage 5 extraction area from Riverside Drive, opposite Saltwater Creek Road.

The access road will join a 3.5 m wide unsealed road around the perimeter of the Stage 5A extraction area, which will then join the existing Fig Hill Lane, a sealed road that heads southwards towards the Stage 5B extraction area. A new 240 m long and 3.5 m wide unsealed access track will need to be constructed down the slope from the end of Fig Hill Lane to the northern end of the Stage 5B extraction area and will require cut and fill earthworks.

A 3.5 m wide unsealed road will also be constructed around the perimeter of the Stage 5B extraction area to enable maintenance vehicle access.

All existing access arrangements for residents along Fig Hill Lane and Riverside Drive will be maintained during the Stage 5 operations.

Site office and parking

A portable site office and associated parking area for 10 light vehicles will be established in the north western corner of the Stage 5B extraction area.

Utilities and infrastructure

Pipeline

Two approximately 2.1 km long pipes will be laid from the Stage 5 extraction areas to the Stage 2 processing area. The pipeline will be removed on completion of dredging in the Stage 5 extraction area.

The proposed pipeline route starts at the edge of the Stage 5B extraction area and travels over the hill to the Stage 5A extraction area (adjacent to the existing Fig Hill Lane for the majority). The pipeline will then run across the former Stage 1 dredge pond to the north of Stage 5A and through existing culverts beneath the Princes Highway and Swamp Road.

The pipeline will require a crossing of Rocklow Creek adjacent to the south of the existing Stage 2 processing area. A gangway structure is proposed to ensure the pipeline does not disturb the bed of the creek, nor impede potential fish passage.

Booster pump

A booster pump station will be constructed to pump the water and sand through the pipeline from the Stage 5B extraction area to the processing plant located in the Stage 2 area adjacent to Tabbita Road. The water and sand will be pumped from the Stage 5B extraction area over the hill immediately north and will gravity feed to the Stage 2 processing plant. A second booster pump will also be required at the junction of the Stage 5A and Stage 5B pipelines to ensure sufficient pressure to transfer the water and sand to the Stage 2 processing area.

An overhead high voltage power line will also be constructed from the existing powerline at 69 Fig Hill Lane (Lot 51 DP 1012246) to the booster pump station to the north of Stage 5B. The overhead power line will require installation of power poles.

Importation of fill material

DSS proposes to import up to 325,000 tpa of virgin excavated natural material (VENM) by road to the Stage 5 extraction area.

The VENM fill is required to:

- construct flood protection bunding and access roads in the Stage 5A extraction area;
- backfill the Stage 5A extraction area to natural ground level; and
- stabilise the edges of the Stage 5B dredge pond and the upper portions of the natural batters that form underwater, to allow safe access for vehicles, plant and equipment around the pond's perimeter.

Refer to **Figure E-3** for the proposed haulage route of VENM to the modification site.

Figure E.3
Haulage route

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Source: Boral (2019)

Rehabilitation

DSS has successfully backfilled and rehabilitated dredge ponds with VENM at previous stages of the operation. This experience and knowledge will be used in planning final rehabilitation of the Stage 5 extraction area.

Topsoil will be stripped prior to extraction in the Stage 5A area and stockpiled for use in rehabilitation.

Upon completion, the Stage 5A extraction area will be backfilled with VENM, topsoil spread and groundcover vegetation planted to return the land to pasture at the request of the landowner. The Stage 5B extraction area will be left as a freshwater pond.

Comparison against approved project

No changes to the approved production volumes or operational hours are proposed. The existing sand production facilities will process material extracted from the Stage 5 extraction areas, with no processing taking place in the modification site.

The proposed modification will not increase the current hourly or daily traffic volumes associated with dispatch of processed sand products given that the production limit of the approved project will not be altered. However, there will be additional heavy vehicles along the Princes Highway and Riverside Drive associated with importation of fill to the Stage 5 extraction area.

A summary of the proposed modification in comparison to the approved project is provided in **Table E-1** below.

Table E-1: Comparison against the approved project

Aspect	Approved project	Proposed modification
Operations		
Land use	Extractive industry.	No change.
Hours of operation	Refer to Section 2.3.	No change to hours of operation of existing site. All activities associated with the proposed modification, except for dredging operations, would occur between 7 am to 6 pm Monday to Friday.
Consent period	25 years from commencement.	No change.
Production and transport limits	Up to 800,000 tpa of product per year from the site.	No change.
Extraction method	Extraction by excavator and dredge.	No change.
Site infrastructure and plant	Mobile screening plant, fine and coarse sand washing plants and material blending.	No change.
Product transport	Truck via established access road network.	No change to dispatch method. Additional transfer pipelines to be provided to connect Stage 5 extraction area to the existing Stage 2 processing plant.

Aspect	Approved project	Proposed modification
Environmental impacts		
Traffic	Dispatch limit of 800,000 tpa.	No change in traffic volumes. The proposed modification does not require amendment to the product, dispatch limit of 800,000 tpa. VENM importation to Stage 5 extraction area to be limited to 325,000 tpa.
Noise and vibration	Condition 13 of the existing development consent imposes operational noise limits.	No changes to extraction/processing methods, or hours of operations at existing site. Additional noise impacts associated with the proposed modification are outlined in Section 7.6.
Rehabilitation/stabilisation	In accordance with existing Rehabilitation Plan.	No change to existing sites. Revised rehabilitation plans to be prepared subsequent to approval.
Waste Management	In accordance with existing Waste Management Plan.	No changes.

Need, justification and alternatives

With the significant increase in approved housing and infrastructure projects in Sydney and other parts of NSW, the leading suppliers of natural sand (including Boral) are under pressure to meet this increased demand as natural sand has unique structural characteristics to manufactured sand and is essential to meet design specifications on many infrastructure and associated development projects.

Given recent high demand, the sand resource in Stage 3 of the approved project is expected to be exhausted in approximately three to five months. The last extraction stage, Stage 4, contains the existing site's road access and private rail line and infrastructure for the approved project and Boral's neighbouring Dunmore hard rock quarry. As such, sand extraction cannot commence in this area until this infrastructure is relocated in future (not subject to this modification).

As the approved project is one of Boral's few remaining natural sand quarries, DSS, on behalf of Boral, proposes to meet part of this increased demand in natural sand by establishing the additional Stage 5 extraction area on land adjoining its current operations.

The expanded operations at the modification site will provide:

- supply of essential natural sand to major infrastructure and associated development projects;
- continued employment of 10 full time employees and truck/transportation drivers, with further jobs created through flow-on effects;
- optimal use of a regionally-significant resource; and
- economic benefits to the local community through the purchase of goods and services and local expenditure both directly and indirectly through employee wages.

DSS' operations provide substantial economic benefits at Commonwealth, State and local levels while being committed to maintaining a good working relationship with the local community and implementing best practice environmental management across the site.

Alternatives

Do nothing

If the proposed extraction of additional sand is not approved, the DSS operations will likely cease in late 2019 to early 2020, and possibly earlier due to current extraction rates. The closure of DSS operations will result in loss of employment, reduced revenue to local service providers, sterilisation of a valuable resource and shortages of raw materials for essential NSW infrastructure and associated development projects.

Alternative locations

The DSS site is one of Boral's few remaining natural sand quarries. With the demand for natural sand ongoing, all of Boral's natural sand quarries are operating at full capacity and quickly running out of resource.

The modification site is optimally positioned with regard to the proximity to the South Coast and Sydney supply markets. Thereby Boral considered it reasonable to look for opportunities which will maintain their competitiveness and ability to supply the region, rather than exploring regions which would be unfeasible or ineffectively positioned. Investigations around the region at other sites were eliminated due to these reasons, as well as the need to establish new infrastructure to process the resource, the shifting of jobs from the site elsewhere, and the nature of the sand resource available.

The current DSS site has the advantage of an existing rail line, which is utilised to distribute the sand resource to the greater metropolitan Sydney area; thereby reducing Boral's reliance on road-based transport methods. Alternative locations would not have the benefit of this specifically developed infrastructure, which is the most effective means of providing mass transit of sand resource across long distances.

Given the DSS site is fully established, inclusive of supporting infrastructure, it was considered more responsible from an economic, social and environmental perspective to expand operations at the existing site rather than establish a new development at an alternative location. The proposed modification will also secure the continued employment of staff at the site, and retain indirect benefits of the operation within the region.

The isolated position of the proposed Stage 5A and 5B extraction areas will also result in benefits associated with minimisation of potential adverse impacts to the local community. Similarly, establishment of the transfer pipeline overland will eliminate the need for heavy vehicle movements along the local and regional road network, which would otherwise be required to transport the sand extracted from Stage 5 further north to the Stage 2 processing area along Tabbita Road. This methodology also eliminates the need for additional vegetation clearing and bulk ground disturbance to occur, as would be required to establish new infrastructure at any alternative site.

Environmental impact assessment

Specialist technical investigations were undertaken to assess key environmental issues associated with the proposed modification that were identified by a preliminary environmental risk assessment and a thorough government agency and community consultation process. Environmental issues identified as low risk were not further assessed as the proposed modification will not result in any additional impacts on these issues than the impacts previously assessed under the approved project.

A broad overview of the key outcomes of the environmental impact assessment is provided below.

Groundwater

A hydrogeological impact assessment (HIA) report assessed the potential impacts on groundwater resources from the proposed modification and provides mitigation and management measures to minimise any resultant impacts.

The HIA included a review of existing data for the local aquifer system, and development of a water balance for the aquifer, and subsequent assessment of the potential impacts from proposed works under varying climatic conditions.

The review of existing data was supplemented by a field investigation of the modification site comprising:

- installation of a groundwater monitoring bore network at the Stage 5 extraction area;
- physical aquifer testing on installed bores to determine aquifer parameters; and
- implementation of a groundwater monitoring program to assess changes in groundwater levels and chemistry over time under varying climatic conditions, including installation of permanent groundwater pressure transducer loggers in select bores to assess groundwater level responses to climatic conditions.

The HIA determined that as groundwater movement accounts for less than 0.21% of catchment drainage, excavation of the aquifer sediments should have no discernible effect on catchment hydrology other than increasing the area available for water storage on the modification site, particularly in the Stage 5B extraction area. Subsequent reinstatement of excavated areas of the Stage 5A extraction area will simply reduce this temporarily increased storage volume back to near pre-excavation levels.

The HIA concludes that all physical impacts to the aquifer beneath the modification site will be minor to negligible. This is primarily because the modification site makes such a small contribution to the overall catchment water balance, and that there are no potential receptors to groundwater discharge down-gradient of the modification site other than the ecosystems of Rocklow Creek and the Minnamurra River.

The major risk of chemical impact is likely to be as a result of oxidation of natural *in-situ* or imported reduced sulphides within imported VENM.

Whilst it is proposed to backfill the Stage 5A extraction area with VENM, depending on the condition and origin of the soil, it has the potential to be PASS. This will be managed through appropriate certifications to ensure only non-PASS material is handled within Stage 5.

Lowering of the water-table during excavation of *in-situ* sediments could expose PASS around the pond perimeter of Stage 5A (estimated to be close to 500 m in length). Hence, it has been estimated that approximately 600 m^3 of PASS could be oxidised, which has potential to produce over 19 tonnes of acid.

The consequence of chemical impacts to groundwater during rehabilitation of the proposed modification will be low, as any acidification at this stage is expected to be limited to the upper portion of the water table surface.

Management recommendations outlined in the HIA will be formalised in an update to the existing groundwater monitoring and management plan (GMMP) for the approved project to encompass the Stage 5 extraction area. The GMMP forms a sub-plan to the water management plan (WMP) prepared in accordance with the Project Approval.

Aboriginal heritage

Potential impacts on Aboriginal cultural heritage from the proposed modification were assessed in accordance with OEH's:

- *Aboriginal Cultural Heritage Consultation Requirements for Proponents 2010* (2010);
- *Guide to investigating, assessing and reporting on Aboriginal cultural heritage in NSW* (2011); and
- *Code of practice for archaeological investigation of Aboriginal objects in NSW* (2010).

The Aboriginal cultural values of the modification site were determined in consultation with 19 Aboriginal groups or individuals who registered their interest in the proposed modification.

The modification site was surveyed, which focussed on the areas predicted to contain evidence of previous Aboriginal occupation.

Forty-five test pits were excavated in the modification site to characterise the sub-surface archaeology and test predictions and the survey results. Three Aboriginal sites were identified within the modification site, in which a total of 1,292 artefacts were discovered. Most of the artefacts were flakes or broken flakes, with some stone tools also discovered.

All the Aboriginal sites in the modification site will be lost due to creation of the dredge ponds and associated sand extraction.

While Aboriginal archaeological sites and associated objects within the disturbance footprint of the proposed modification will be lost, impacts will be mitigated through collection and relocation of artefacts prior to the commencement of works.

All artefacts identified in the salvage effort will be collected by an archaeologist and members of the Aboriginal community and will be subject to attribute analysis to understand manufacturing technology, site function and to compare the assemblage to studies completed in the wider region.

Biodiversity

Potential biodiversity impacts from construction and operation of the proposed modification were assessed in accordance with the Office of Environment and Heritage's (OEH) (2017) *Biodiversity Assessment Method* (BAM). Ecosystem and species credits were calculated for proposed vegetation clearing in accordance with the BAM.

Public databases, vegetation mapping and the BAM Calculator were used to predict the threatened flora and fauna species, and threatened ecological communities, which could exist in or frequent the modification site. Results of these searches were:

- according to the databases 20 threatened flora species could occur in the modification site, though the likelihood was low;
- the BAM Calculator predicted that 41 threatened fauna species could occur in the modification site; and
- mapping indicated three plant community types in the modification site:
    - Bangalay - Old-man Banksia open forest on coastal sands, Sydney Basin Bioregion and South East Corner Bioregion;
    - Swamp Oak Floodplain Forest; and
    - cleared land (exotic pasture).

The Bangalay - Old-man Banksia open forest on coastal sands, Sydney Basin Bioregion and South East Corner Bioregion is listed as an endangered ecological community (EEC) under the NSW *Biodiversity Conservation Act 2016* (BC Act) and is not listed under the Commonwealth

Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act). The Swamp Oak Floodplain Forest is listed as an EEC under the BC Act and the EPBC Act.

Field surveys confirmed the existence of the vegetation communities. No threatened flora species were observed, however a total of seven threatened fauna species (species credit fauna) were recorded during the survey.

The following direct impacts would result from the proposed modification:

- clearing of native vegetation and associated habitat, conservatively estimated to be 7.5 ha, including 4.53 ha of Bangalay - Old-man Banksia open forest on coastal sands, Sydney Basin Bioregion and South East Corner Bioregion TEC;
- clearing of approximately 4.04 ha of exotic grassland vegetation; and
- clearing of associated species credit fauna habitat, including hollow bearing trees and logs.

A total of 12 Bangalay trees containing hollows will require removal for the proposed modification.

The existing *Dunmore Sand and Soil Quarry Flora and Fauna Management Plan* (Arcadis, 2017) (FFMP) will be updated to include the additional management activities associated with the Stage 5 extraction areas in order to minimise potential adverse impacts on biodiversity.

Additionally, a strategy will be developed to offset the vegetation clearing impacts on biodiversity, which will be based on the following credit requirements:

- Ecosystem credit requirements:
    - Bangalay - Old-man Banksia open forest on coastal sands, Sydney Basin Bioregion and South East Corner Bioregion TEC – 30 credits for the good condition vegetation and 41 credits for the moderate condition vegetation.
- Species credit requirements:
    - Southern Myotis (*Myotis Macropus)* – 19 credits;
    - Barking Owl (*Ninox connivens*) – 30 credits; and
    - Masked Owl (*Tyto novaehollandiae*) – 30 credits.

Historic heritage

A search of relevant public heritage databases and registers was conducted and identified four registered heritage items within and adjacent to the modification site, including four local significant heritage items listed under the Shellharbour Local Environment Plan 2013. The heritage listings are identified as:

- ‘Dunmore House Complex, Dry Stone Walls and Trees’ (located on the modification site);
- ‘Minnamurra Vegetation Area’ (located on the modification site);
- ‘Anglesboro and Trees’ (located on the modification site); and
- ‘Rocklow Road Dry Stone Wall’ (located adjacent to the modification site).

The modification site was inspected to identify and assess potential impacts of the proposed modification on heritage items, including impacts to potential archaeological deposits in the modification site, and historic views and vistas.

No evidence of archaeological remains were identified during the field survey.

The statement of heritage impact (SoHI) report identified that the proposed modification would result in moderate direct and visual impacts to the ‘Dunmore House Complex, Dry Stone Walls and Trees’ and ‘Minnamurra Vegetation Area’ heritage listings.

The potential for locally significant archaeology to be located within the modification site has been assessed as nil-low, therefore the proposed modification is not considered to result in an archaeological impact.

Mitigation and management measures have been recommended to assist in minimising the potential impact of the proposed modification on nearby heritage items and the wider Shellharbour cultural landscape.

Air Quality

Potential air quality impacts from construction and operation of the proposed modification on nearby sensitive receivers were assessed in accordance with the EPA's (2017) *Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales*. Total suspended particulates, deposited dust, PM_{10} and $PM_{2.5}$ (particulate matter with an aerodynamic diameter of 10µm and 2.5µm or less) will be the primary emissions from the proposed modification.

The majority of dust emissions from the proposed modification will occur during the initial preparation stages, which are for a limited duration, and ongoing operational activities will generate minimal dust emissions. As the proposed modification will not increase the maximum total approved sand production rate, it will not generate additional dust beyond that occurring under the approved project.

There is a low to medium risk that importation of fill will generate dust. This risk will be reduced with implementation of the management measures outlined in the Air Quality Assessment report, which will be incorporated into the revised Environmental Management Strategy for the approved project.

Noise

Potential noise impacts from construction and operation of the proposed modification on nearby sensitive receivers were assessed in accordance with the NSW Environment Protection Authority's (EPA) (2017) *Noise Policy for Industry* (NPI) and EPA (2009) *Interim Construction Noise Guideline* (ICNG). Application of the NPI required the determination of 'trigger levels' (criteria) for the proposed modification.

Noise generation during the daytime (7 am to 6 pm) and night (6 am to 7 am) operating periods were estimated for the worst-case operating scenarios in each extraction area.

The assessment incorporated worst case weather conditions as it was determined that given the proposed modification will involve commencement of dredging operations at 6 am which is the morning shoulder of the night period, the modification will be subject to temperature inversions, which occur during the night time, as well as prevailing winds which occur during the evening and night periods.

All construction activities associated with the proposed modification would comply with criteria established by the ICNG.

The predicted noise levels for proposed day time and night time operations comply with the operational noise trigger levels and Project Approval criteria at all locations. The highest noise level event which could interrupt sleep at the nearest receiver was estimated to be less than the maximum noise event screening criterion.

The residual noise impact is the exceedance of the proposed modification noise trigger level after all feasible and reasonable mitigation measures have been considered. No residual impacts are predicted at any privately-owned receivers and, therefore, receiver-based treatments or controls are not required.

Notwithstanding, DSS will continue its noise compliance monitoring and community consultation activities, and will implement measures if an exceedance is detected or a complaint is received from a member of the community.

As new project noise trigger levels have been developed for the proposed modification, it will be necessary to incorporate these into the Project Approval and Environment Protection Licence (EPL). The *Dunmore Lakes Sand Project Noise Management Plan* (DSS, 2017) will be amended to include the Stage 5 extraction area, together with the new trigger levels once the proposed modification is approved.

Surface Water Management

Surface water is managed in accordance with the *Dunmore Sand & Soil Environmental Management Pla*n (R.W. Corkery & Co. Limited, 2006), which includes a water management plan and surface water monitoring program.

Management and monitoring of surface water quality is also a requirement of EPL 11147.

The Stage 5A extraction area lies within flood prone land associated with the Rocklow Creek catchment, while the Stage 5B extraction area lies within the floodplain of Minnamurra River.

The proposed modification would result in ground disturbance which has the potential to expose ground surfaces to erosion and result in sedimentation of local watercourses and ultimately Rocklow Creek and Minnamurra River, and associated coastal wetland.

The Stage 5A and Stage 5B dredge ponds will be bunded to prevent impounded water interacting with surface flows and floodwaters. These bunds will function as sediment basins for the localised catchment of each extraction area.

In addition to the isolation of the dredge ponds from surrounding surface and river flows, the flooding protection bunds will provide significant freeboard of up to 2 m to 3 m from the normal operating water level (likely to be close to local groundwater surface levels of around 1 m AHD). The freeboard will reduce the possibility of basin overflows in flood and high rainfall events and allow the ponds to act as sediment basins through the provision of detention storage.

As a comparison, sediment basin sizing using the *Managing Urban Stormwater Soils and Construction Volume 1* was applied in the surface water assessment. Assuming 5 day, 95th percentile rainfall capture, as recommended in DECC's (2008) *Managing Urban Stormwater: soils and construction, Volume 2E: Mines and Quarries*, the calculated sediment basin storage within the dredge ponds will exceed the recommended sediment basin volumes for the catchments draining to them.

The proposed pipeline route from the Stage 5 extraction area to the processing plant in Stage 2 will traverse across the former Stage 1 dredge pond to the north of Stage 5A and through existing culverts beneath the Princes Highway and Swamp Road. The pipeline will be secured to the side wall of culverts at water crossings with brackets and will sit well above the water column to mitigate against potential flooding and allow for inspections and maintenance to be completed.

The pipeline will require a crossing of Rocklow Creek adjacent to the south of the existing Stage 2 processing area. A gangway structure is proposed to ensure the pipeline does not disturb the bed of the creek, nor impede potential fish passage.

The existing water use for a production level of 450,000 tpa is 74 megalitres per year (ML/y), which includes water extracted for dust suppression as well as captured within moisture content in exported sand products. Currently, DSS has a Water Access Licence (WAL) and associated water supply work (WSW) under the *Water Management Act 2000* for 65 ML/y from the Sydney Basin South Groundwater source.

DSS also has a WAL for an additional 15 ML/y from the Metropolitan Coastal Sands Groundwater source, however are yet to obtain a WSW for this allocation. Once a WSW is nominated (likely over the modification site) and approved, DSS will have a total of 80 ML/y available for extraction across the approved project. It is anticipated that this would cover the current operations together with the proposed modification.

In the event production rates increase in future beyond the current rate of extraction, and are likely to exceed the allocated water extraction permitted by all relevant WAL and WSW, DSS would carry out a revised site water balance and seek any necessary licence amendments or seek additional licensing with NSW Department of Industry.

The *Dunmore Sand & Soil Environmental Management Pla*n (R.W. Corkery & Co. Limited, 2006) will be revised to incorporate the proposed modification.

Additional mitigation and management measures recommended in the surface water assessment would be implemented to ensure best practice surface water management at the modification site. Such management measures include an additional four monitoring points to the current water monitoring program and EPL.

Visual

Visual amenity at the modification site and surrounds is characterised by a rural landscape. The modification site is adjacent to a major road (Princes Highway), and is near residential, commercial and industrial receivers. The modification site is in the topographically lower rural lands in the Dunmore area, with a backdrop of rising hills and vegetated valleys.

The landscape around the modification site has an open character due to extensive vegetation clearing and low topographic relief. The surrounding terrain generally comprises rounded hills and gentle slopes with some steeper gully areas which merge into low-lying rural flats, floodplains and estuarine wetlands. The principal land uses in the Dunmore area are grazing and extractive industries, both of which form an important component of the visual landscape.

There will be minor residual impacts to Dunmore House, 431 Riverside Drive, 69 Fig Hill Lane, Riverside Drive and the Princes Highway. Some impacts will be temporary, with infrastructure removed at the end of sand extraction and disturbed surface progressively rehabilitated. Permanent visual impacts could be positive, with the addition of a freshwater pond and landscape plantings in the viewscape.

The modification site will be rehabilitated in accordance with *Dunmore Sand and Soil Project Rehabilitation Management Plan* (Arcadis, 2017), which will be updated to include progressive rehabilitation of disturbed surfaces with groundcover vegetation

Traffic and Transport

Potential impacts on traffic and road safety along Riverside Drive and the Princes Highway from the modification site were assessed in accordance with NSW Roads and Maritime Service's (2002) *Guide to Traffic Generating Developments*.

The proposed modification will not increase existing heavy vehicle moments associated with exportation of outgoing sand products currently consented by the approved project.

DSS propose to import up to 325,000 tonnes of VENM by road per annum to the Stage 5 extraction area. This activity will require heavy vehicle movements along the Princes Highway and Riverside Drive to access the modification site.

Therefore, the proposed modification has the potential to impact on the capacity of Riverside Drive, the Princes Highway and other main heavy vehicle transport routes and associated intersections.

Use of the existing access to the modification site along Fig Hill Lane will be unsafe, so a new intersection and access road will be constructed to the east of the Stage 5A extraction area and provide a link to Riverside Drive.

Peak hour traffic volumes at the proposed new intersection were predicted to determine its level of service (LoS). The proposed intersection will have a good LoS (B) in the near term, which will change to an afternoon peak hour LoS D in ten years' time coupled with growth in the region.

Upgrades to the road network in the area will not be required, other than reconfiguration of lanes along Riverside Drive during construction of the proposed intersection.

Conclusion

As outlined in this environmental assessment, the proposed modification is unlikely to result in any significant impacts on either the biophysical or social environment with the implementation of:

- environmental management and mitigation measures outlined in:
  - the Project Approval;
  - the approved environmental management strategy and supporting management plans;
  - **Chapter 7** of this document;
- biodiversity offsetting requirements; and
- requirements of EPL 11147.

The environmental management strategy and associated management plans will need to be reviewed, revised and amended to include operations at the Stage 5 extraction area (as required) and submitted to the DP&E for approval, prior to commencing operations in the Stage 5 extraction areas.

As required by Schedule 5, Condition 4 of the Project Approval, amendments to management plans would be undertaken within three months of a notice of approval and submitted to DP&E for endorsement.

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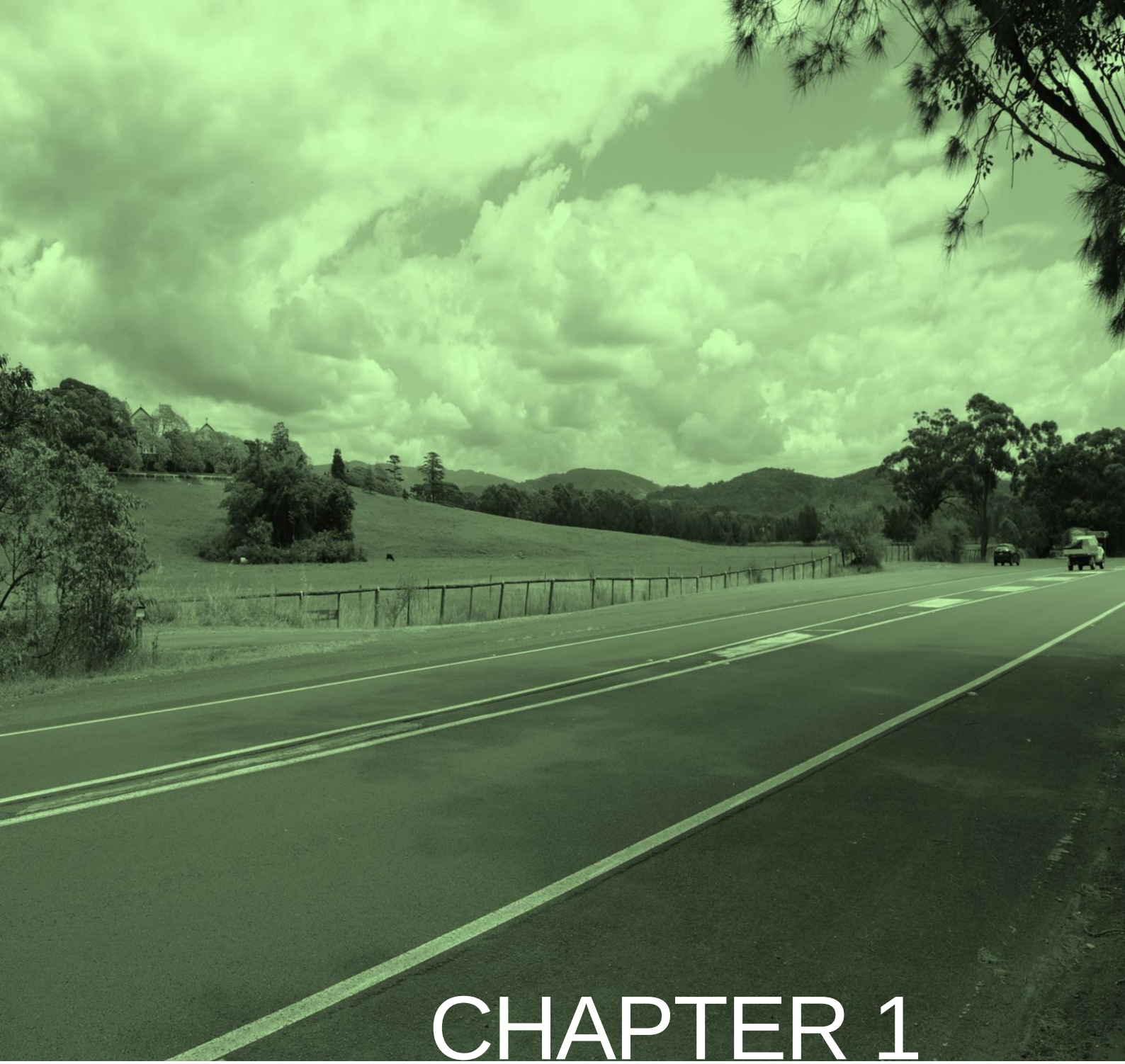

CHAPTER 1

INTRODUCTION

1 INTRODUCTION

1.1 Overview

Stage 1 of the Dunmore Lakes Sand Project (the 'approved project') was issued development consent from the Minister for Planning in 1999. Stage 1 was on Swamp Road, Dunmore, and encompassed sand extraction by dredging of up to 500,000 tonnes per annum (tpa) for 10 years. The Stage 1 consent included conditions requiring the proponent to lodge a further application for the remaining identified development stages of the Dunmore sand resource (being stages 2 to 4).

The application for stages 2 to 4 was lodged in 2004, and development consent was received from the Minister for Planning in June 2005. Extraction of up to 800,000 tpa of sand was approved for 25 years. Boral Resources (NSW) Pty Ltd (hereafter 'Boral') purchased Dunmore Sand & Soil Pty Ltd (DSS), including the Dunmore Lakes Sand Project in mid-2005. The Stage 1 consent has since lapsed following successful extraction of the approved sand resource and rehabilitation of the site in 2010.

Dredging commenced for Stages 2 to 4 in June 2007. Since then, due to the high demand for sand in the Sydney market, the majority of sand in Stage 2 has been extracted with dredging recently moving into Stage 3. Given recent high demand, the sand resource in Stage 3 is expected to be exhausted in eight to twelve months. The last extraction stage (Stage 4) encompasses an area containing the road access and private rail line to the approved project, supporting infrastructure for stages 2 to 4 and Boral's adjacent Dunmore Hard Rock Quarry. Given this, Stage 4 cannot be extracted until these activities are relocated. This has led DSS to investigate other local sources of sand to continue operations beyond Stage 3.

DSS has been investigating a fine sand resource on an adjoining private property to the south of the former Stage 1 extraction area (referred to as Stage 5). Investigative drilling has confirmed that there is sufficient sand resource to support three to four more years of extraction from two areas (stages 5A and 5B).

As such, DSS is seeking to modify the current Project Approval (DA 195-8-2004) under Section 75W of the NSW *Environmental Planning and Assessment Act 1979* (EP&A Act), to provide for an additional extraction area (Stage 5) on adjoining private land, encompassing two separate extraction areas, Stage 5A and Stage 5B (hereafter referred to as the 'proposed modification'). The land on which the proposed modification is to be carried out is hereafter referred to as the 'modification site'.

This will be Modification 2 to the Project Approval. The Minister for Planning is the consent authority for the proposed modification.

This environmental assessment (EA) has been prepared by Element Environment Pty Ltd (Element) on behalf of DSS to assess the potential environmental and social impacts of Modification 2 to the current Project Approval, and to support a development application (DA) to be lodged with NSW Department of Planning & Environment (DP&E).

1.2 The applicant

Dunmore Sand & Soil Pty Ltd is a wholly owned subsidiary of Boral Limited (Boral) and is the applicant for the proposed modification. Boral is an international building and construction materials group, headquartered in North Sydney, Australia. Boral's competitive position is underpinned by being a market leader in cement and construction materials in Australasia, Plasterboard in Australia and Asia and Cladding and Roof Tiles in the USA.

The Boral Australia division employs over 5,000 people in its quarry, concrete, asphalt, concrete placing and cement operations. The business is a major supplier of products to the residential, commercial construction, and roads and engineering markets.

Boral operates over 110 quarries producing products such as concrete aggregates, crushed rock, asphalt and sealing aggregates, road base materials, sand and gravels for the Australian construction materials industry.

1.3 Site description

1.3.1 Site location

Existing site

The approved project (the existing site) is near Dunmore, approximately 3 kilometres (km) south-south west of Shellharbour and 7 km north of Kiama, in the Illawarra region of New South Wales. The existing site covers approximately 88 hectares (ha) and is immediately west of the Princes Highway near Tabbita Road, Dunmore. The site is in the Shellharbour Local Government Area (LGA).

Stage 2 of the approved project covers an area of 37 ha and adjoins the northern boundary of Tabbita Road. The area encompasses a large area of cleared and disturbed grassland and the footprint of existing sand extraction activities, which are nearing completion. Stage 2 also contains the sand processing infrastructure, which will continue to be utilised during sand extraction activities in Stages 3, 4 and eventually Stage 5.

Stage 3 of the approved project, which covers an area of 21 ha, adjoins the southern boundary of Tabbita Road. Rocklow Creek transects Stage 3, which flows into the Coastal SEPP wetland located to the east of the Princes Highway, conveyed by a culvert beneath the Highway.

Stage 4 of the approved project, covering five hectares, encompasses the Tabbita Road corridor, which includes the current road and rail access to Dunmore Hard Rock Quarry, located to the west of the site.

Modification site

The modification site is approximately 1.1 km south-south east of the existing site.

The modification site covers approximately 38 ha and is on an alluvial coastal flood plain, adjacent to the tidal reaches of the Minnamurra River. The northern portion of the extraction area has been partially cleared and has historically been used for grazing.

The modification site is bound by Riverside Drive to the north and Princes Highway to the west.

The regional context of the site is shown in **Figure 1.1**.

1.3.2 Land use and ownership

Existing site

Land holdings in the stages 2 to 4 areas comprise:

- part Lot 6 DP 611159 (Stage 2);
- part lots 3, 4 and 5 DP 1030504 (stages 2 and 4);
- part Lot 6 DP 1001931 (Stage 3); and

- Lot 1 DP 213575 (Stage 4).

The existing site is characterised by sand extraction activities (i.e. stages 2 and 3) and agricultural land that has been mostly cleared of native vegetation for the grazing of livestock. Land use in the surrounding locality comprises:

- agricultural land to the north and south, primarily livestock grazing;
- commercial and industrial development, including Dunmore Hard Rock Quarry and concrete batching plant immediately to the west and Dunmore Resource and Recycling Facility to the east;
- residential development, including Dunmore Lakes Estate to the south, Shell Cove and Shellharbour to the north east;
- infrastructure development, including the Princes Highway and the South Coast Rail Line to the east; and
- a wetland (protected under State Environmental Planning Policy (Coastal Management) 2018) (Coastal SEPP) is on the eastern side of the Princes Highway, with the north western edge of the wetland approximately 350 m downstream of the site.

Access to the existing site is via the Princes Highway and Tabbita Road. The internal road network consists of several unsealed haul roads.

Modification site

The proposed Stage 5A extraction area is on Lot 501 DP 1174897 and the proposed Stage 5B extraction area is on the adjoining Lot 51 DP 1012246.

The modification site is also characterised by agricultural land that has been mostly cleared of native vegetation for the grazing of livestock. Land use surrounding the modification site comprises:

- commercial and industrial development, including Dunmore Hard Rock Quarry and concrete batching plant to the north west and Dunmore Resource and Recycling Facility to the north;
- residential development, including Dunmore Lakes Estate to the south west and Minnamurra to the east;
- infrastructure development, including the Princes Highway to the west, and the South Coast Rail Line to the north east; and
- Minnamurra River and associated wetland (protected under State Environmental Planning Policy (Coastal Management) 2018) (Coastal SEPP) is located adjacent to the south of the modification.

The modification site will be accessed via Riverside Drive, Fig Hill Lane and the internal road network consisting of several unsealed access roads.

DSS has an access and extraction agreement with the land owner.

The closest residential dwellings to the Stage 5 extraction areas are:

- 69 Fig Hill Lane, which is on lot 51 DP 1012246, and is approximately 130 m to the north of the Stage 5B extraction area;
- 71 Fig Hill Lane, which is approximately 290 m north east of the Stage 5B extraction area. The dwelling at this address is derelict and is uninhabited. There is no valid development approval for this house;
- 471 Riverside Drive (Dunmore House), which is located on Lot 501 DP 1174897, and is approximately 175 m to the south of the Stage 5A extraction area, 250 m to the east of the proposed internal access road between the two extraction areas, and 750m north-north east of the Stage 5B extraction area; and

- 431 Riverside Drive, which is located approximately 345 m south of the Stage 5A extraction area.

It should be noted that DSS has entered into an access and extraction agreement with the owners of the residences at 69 Fig Hill Lane and 471 Riverside Drive, and hence there are negotiated agreements in place regarding noise, air quality and other environmental impacts.

To the south-west of the modification site is the residential Dunmore Lakes Estate. The main access for these properties is via Riverside Road and Swamp Road. These properties are separated from the modification site by the Princes Highway, with the closest approximately 495 m from the access road linking the Stage 5A and 5B extraction areas. The township of Minnamurra is approximately 865 m east of the Stage 5A extraction area. Sensitive receivers are shown in **Figure 1.2**.

1.3.3 Zoning

The majority of the modification site is zoned RU2 – Rural Landscape zone under the Shellharbour Local Environmental Plan 2013 (LEP). The southern portion of Stage 5B extraction area is zoned E3 – Environmental Management.

Land to the east and south of the modification site is zoned E2 – Environmental Conservation and E3 – Environmental Management, and this land is associated with environmental conservation areas of Minnamurra River and associated Coastal SEPP wetland.

The E2 zoning also runs along the northern fringe of Riverside Drive opposite the Stage 5A extraction area, whilst Riverside Drive and the Princes Highway are zoned as SP2 – Infrastructure.

Refer to **Figure 1.3** for land use zoning in and adjacent to the modification site.

1.3.4 Topography and hydrology

Existing site

The existing site is in the Illawarra Coastal Plains and is characterised by flat to gently inclined low-lying alluvial land (Cumberland Ecology, 2010). Surrounding topography is generally less than 20 m Australian Height Datum (AHD) and slopes are generally less than 30%. The entire site is low lying at approximately 1.5-2 m AHD (R.W. Corkery & Co, 2004).

The existing site is in the catchment of Rocklow Creek, a tributary of the Minnamurra River. The confluence of Rocklow Creek and the Minnamurra River is approximately 1 km downstream of the site. The site is subject to periodic inundation by flooding of Rocklow Creek and Minnamurra River (Cumberland Ecology, 2010).

Rocklow Creek is highly modified, mostly comprising man-made channels. In some areas, the creek has been re-directed for agricultural activities. Rocklow Creek flows from west to east through the southern portion of Stage 3 to a culvert in the south-eastern portion of the site, which channels the creek under the Princes Highway and railway line to the Coastal SEPP wetland (Cumberland Ecology, 2010). The tidal influence of the wetland extends a short distance upstream of the Princes Highway into the Stage 3 area. Tidal inundation to Stage 3 only occurs during above average high tides (R.W. Corkery & Co, 2004).

Modification site

The Stage 5A extraction area comprises an area of approximately 4 ha and is located on the northern side of a hill with relief from approximately 9 m AHD to about 1.3 m AHD close to the driveway entrance to Dunmore House. The majority of the Stage 5A extraction area is currently low lying, with current ground surface generally below 3 m AHD. The extraction area is influenced by three main surface flow behaviours; namely surface flows from the adjacent hillside, runoff associated with the catchment to the west, and backwater flooding associated with Rocklow Creek and ultimately the Minnamurra River.

Local flows from the small hillside catchment to the south (approximately 6 ha) drain to the proposed Stage 5A extraction area. Currently, runoff from this local catchment traces existing low points and a constructed drainage channel along the southern boundary of Riverside Drive, making its way to the twin 900 mm culverts beneath Fig Hill Lane in the northern corner to the adjacent pond, then beneath Riverside Drive via three 2.7 m wide by 2.4 m high culverts to Rocklow Creek, and ultimately Minnamurra River.

The former Stage 1 dredge pond immediately to the west of the Stage 5A extraction area drains a catchment of approximately 315 ha, extending west approximately 3 km. The catchment is a mixture of cleared farmland and forested areas over the steeper slopes, with a relatively incised and steep sided watercourse through the mid-catchment, opening out into pond areas in the lower catchment created as part of the previous dredging operations.

The Stage 5B extraction area is located on a flat area at the southern base of a hill with elevations ranging from 2.5 m – 4 m AHD. The area is located on the floodplain within a large meander of the Minnamurra River, with the channel approximately 265 m to the south and 700 m to the north east of the extraction area.

Local drainage, including the small catchment on the hillside to the north, flows to a sequence of ephemeral drainage lines which drain to the Minnamurra River estuary to the east.

The Minnamurra River catchment covers approximately 96 km^2, extending approximately 13 km west to the Illawarra Range escarpment. The catchment is a mixture of steeper forested areas in the upper to mid-catchment, with undulating cleared rural land trending to cleared agricultural floodplains in the lower catchment.

Within the lower alluvial plains of the catchment, known as the Terragong Swamp, the Minnamurra River and floodplain have been drained and the River straightened to improve agricultural productivity. From approximately the Princes Highway east, the River becomes more estuarine as it meanders to the north and east where it meets the ocean at Minnamurra Point.

1.3.5 Geology and soils

Existing site

The local geology has been described in the Kiama 1:50 000 Geological series sheet 9028 (Reference 6) as comprising Quaternary aged (up to 2 - 3 million years old) alluvium overlying Permian aged (about 250 million years old) volcanics of the Bumbo Latite member. The geology around the perimeter of the existing site forms the sides of a valley as a result of Bumbo Latite outcropping along the edge of a ‘drowned’ river valley. The valley is in-filled with unconsolidated sediments being Quaternary aged and consisting of gravels, swamp deposits and sand dunes (R.W. Corkery & Co, 2004).

The soil of the area is formed from alluvial, colluvial or aeolian deposition of medium to fine well-sorted sands. Siliceous sands that were deposited mainly during the Recent or Holocene period

(0 - 10,000 years ago) may have been laid down over potentially sulfidic marine sediments deposited during sea-level fluctuations over the last three million years (R.W. Corkery & Co, 2004).

The soil within the existing site is described in the Soil landscapes of the Kiama 1:100 000 sheet as belonging to the Killalea Soil Landscape (Reference 16). A soil landscape is an area of land that has recognisable and specifiable topographies and soils. This soil landscape describes soils with moderate to deep (50 - 150 centimetres) Prairie Soils occurring on drainage plains, Alluvial Soils occurring on the alluvial plains, and Humic Gleys in swamps and low-lying areas (R.W. Corkery & Co, 2004).

The Department of Land & Water Conservation (DLWC) 1:25 000 Albion Park acid sulfate soil (ASS) risk map (Reference 7) describes the sediments on the investigation area as being 'high probability' in terms of ASS risk. This map has classified much of the existing site as being predominantly an alluvial plain, while Rocklow Creek and surrounds running through the property to the south eastern boundary has been classified as an estuarine plain (R.W. Corkery & Co, 2004).

Modification site

Preliminary geotechnical investigations of the Stage 5A and Stage 5B extraction areas found the general geological profile of the modification site comprises sandy topsoil and weathered sand soil profiles overlying fresh (unweathered) tsunami deposits of medium and fine sand of varying shell content. These deposits are frequently found above fluvial sand deposits, separated by a small weathered clay deposit.

The underlying bedrock consisted of latite. However, large latitic clay deposits sit above the fresh rock, and were used to identify the base of the sand deposits.

The Stage 5A extraction area is lower lying and boreholes encountered fresh sand after only approximately 2 m of topsoil and weathered sand.

Boreholes drilled closest to the base of the hill toward the centre of the allotment, displayed the smallest quantity of resource return as the latite sits closer to the surface. The fine-medium sand ranges from 2.5-7 m thickness. Some fresh sand was noted in the boreholes drilled in the north section of Stage 5A varying from 1–5 m in thickness.

The proposed Stage 5A and a portion of the proposed Stage 5B extraction area are mapped as Class 2 acid sulfate soil (ASS) risk on the LEP map. There is a potential for the sediments of the modification site to form acid upon oxidation, through water table lowering or bulk excavation. Acid sulfate soil risks have been assessed as summarised in **Section 7.10.2**.

1.3.6 Hydrogeology

Existing site

The existing site forms the north western and western extent of an unconfined aquifer system. This system extends along the course of Rocklow Creek and the Minnamurra River, to the Pacific Ocean between Dunmore and Minnamurra (R.W. Corkery & Co, 2004).

Groundwater bores are frequently constructed on the Quaternary sediments of the catchment. This is due to high production rates and low salinity making these waters excellent for domestic, industrial or agricultural use. The aquifer is predominantly unconfined and is present less than 2 m below the surface, hence a number of registered bores are located within the catchment.

Rainfall recharge is estimated to be rapid, with infiltration estimated at between 75 to 90%. Despite this, moderate to high intensity rainfall events that are regular occurrences in the area rapidly fully charge the aquifer, resulting in 100% run-off (zero recharge or infiltration) in such situations (R.W. Corkery & Co, 2004).

The alluvial sands which dominate the geological setting within which the existing site is situated, and the low-lying topography, have combined to create an unconfined aquifer system overlying bedrock (with some associated silt and clay) to a reported depth exceeding 12 m below the surface. The area is recharged from hills to the northwest and west, as also evident in the surface water catchment.

The unconfined aquifer on the existing site exhibits only slight hydraulic conductivity variations across the site (R.W. Corkery & Co, 2004).

Groundwater investigations undertaken during March 2001 in the Stage 2 extraction area revealed that at that time, the average depth from the ground surface to the top of the aquifer was approximately 0.6 m (ranging from 0.1 m to 1.6 m) and the average thickness of the sand aquifer was 8.6 m. The groundwater investigations undertaken during August 2003 in the Stage 3 extraction area revealed that the average depth from the ground surface to the top of the aquifer was approximately 0.7 m (ranging from 0.3 m to 1.5 m) and the average thickness of the sand aquifer was 9.15 m (R.W. Corkery & Co, 2004).

The sediments comprising the aquifer are moderately permeable with relatively high hydraulic conductivity (3.0-3.5 metres per day (m/day)) and transmissivity (25.0-29.6 m^2/day). However, this potential is not realised due to the low-lying nature of the existing site, minimal hydraulic gradient and location of the piezometric surface at an average depth of between 0.6 and 0.7 m below the ground surface across the existing site. These factors result in minimal to negligible water movement through the aquifer, calculated at between 0.36 m/year and 0.42 m/year (R.W. Corkery & Co, 2004).

Groundwater flow across the existing site is influenced by topography and regional recharge and discharge zones, with the hydraulic gradient across the site generally towards the south east, where discharge is expected into Rocklow Creek, the Minnamurra River and the Tasman Sea (R.W. Corkery & Co, 2004).

It is noteworthy that the direction of groundwater flow from the existing site does not coincide with the surface water flow.

Groundwater flow is principally influenced by flow off bedrock to the north and west of the existing site and is likely to be confined to the upper one to two metres of the aquifer. In contrast, groundwater flow at deeper levels within the aquifer (e.g. centre of the existing site) is expected to be low or negligible (R.W. Corkery & Co, 2004).

Recharge of the aquifer beneath the existing site is expected to occur by infiltration of water generated as surface flow from further up the catchment and through direct infiltration from the surface of the site and surrounding area (R.W. Corkery & Co, 2004).

Modification site

The hydrogeological impact assessment of the proposed modification (refer to **Section 7.1**) found that the modification site is in the southern extent of an unconfined aquifer system that is likely connected to the Minnamurra River in the Stage 5B extraction area. The modification site may partially interact with both the Rocklow Creek Catchment (Stage 5A) and the Minnamurra River Catchment (Stage 5B).

The alluvial sands which dominate the geological setting of the modification site, coupled with low-lying topography, have combined to create an unconfined aquifer system overlying bedrock

(with some associated silt and clay) to 18 m or more below the surface. The aquifer system is recharged from hills to the west, whilst the presence of the hill outcrop between the Stage 5A and Stage 5B extraction areas is likely to have a recharge point to the north and south.

Rainfall recharge is likely to be rapid, with infiltration estimated at between 75-90%. Despite this, regular moderate to high intensity rainfall will rapidly fully recharge the aquifer, resulting in 100% surface run-off (zero recharge or infiltration).

The general concept for groundwater occurrence below the modification site is that alluvial groundwater is unconfined and relatively shallow and fresh, as the water table responds rapidly to recharge via rainfall. Groundwater flows towards the Minnumarra River which flows around the south and east of the modification site in a north easterly direction.

The aquifer is likely to be recharged directly by rainfall from creek and low-lying swales, particularly when the water table is depressed following dry weather.

Sands and gravels in the alluvium are the primary aquifers, with weathered latite bedrock comprising finer grained silts and clays acting as aquitards. The alluvial aquifer at the modification site is underlain by an aquitard / aquiclude of clay overlying latite bedrock.

Groundwater flow is influenced by topography and regional recharge / discharge zones. As a result, the hydraulic gradient is typically to the north east for both Stage 5A and Stage 5B extraction areas towards the Minnumarra River, eventually feeding into the Pacific Ocean. The outcrop of latite bedrock to the north of the Stage 5B extraction area is likely to behave as a no-flow boundary.

The position of the piezometric surface close to ground level, particularly in the northern areas of the Stage 5A and Stage 5B extraction areas, means very little groundwater movement is likely to occur. Only the upper one to two metres of the aquifer are likely to experience groundwater movement. Deep groundwater below this depth is unlikely to move significantly. Therefore, there will be very little groundwater in the central area of the Stage 5B extraction area, where the aquifer is deepest.

Overall, the water table surface is a subdued form of the topography, which is typical of all local and regional groundwater flow systems. Depths to groundwater are greatest in areas of groundwater recharge and shallowest in areas of groundwater discharge.

1.3.7 Climate

Long-term climatic data from the Bureau of Meteorology (BoM) weather station at Albion Park (Wollongong Airport) Automatic Weather Station (AWS) (Site No. 068241), which is approximately 7 km north west of the modification site, was used in the air quality impact assessment (**Appendix H**) to characterise the local climate.

Climate statistics from the AWS are summarised in **Table 1.1**.

Table 1.1 Monthly climate statistics summary.

Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann.
Temperature													
Mean max. temperature (ºC)	27.0	26.3	25.3	23.1	20.6	18.1	17.6	18.8	21.4	23.1	24.0	25.6	22.6
Mean min. temperature (ºC)	16.9	17.1	15.6	12.2	8.8	7.2	6.3	6.5	8.5	10.8	13.4	15.3	11.5
Rainfall													
Rainfall (mm)	72.9	140.5	122.3	76.9	58.1	94.5	51.4	55.3	42.7	64.5	83.1	67.0	925.6

Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann.
Mean No. of rain days (≥1mm)	7.8	8.6	7.9	7.3	4.8	6.3	4.8	4.5	5.1	6.4	8.2	8.1	79.8
9am conditions													
Mean temperature (ºC)	22.5	22.0	20.2	19.2	15.8	13.0	12.5	14.0	17.1	19.0	19.7	21.4	18.0
Mean relative humidity (%)	68	74	76	68	69	73	68	61	57	58	67	66	67
Mean wind speed (km/h)	11.6	9.8	8.1	10.7	12.4	13.6	14.4	15.0	15.3	14.4	12.9	12.7	12.6
3pm conditions													
Mean temperature (ºC)	24.8	24.5	23.5	21.3	18.8	16.7	16.2	17.3	19.3	20.4	21.6	23.5	20.7
Mean relative humidity (%)	63	67	64	61	58	57	54	49	53	58	63	61	59
Mean wind speed (km/h)	21.6	20.0	18.9	17.7	17.1	17.6	18.1	21.8	22.6	20.9	20.9	21.5	19.9

Source: Bureau of Meteorology, 2018

The data indicates that January is typically the warmest month, with a mean maximum temperature of 27.0 degrees Celsius (ºC) while July is typically the coolest month, with a mean minimum temperature of 6.3ºC.

Rainfall peaks during the first half of the year and declines during the latter, with an annual average rainfall of 925.6 mm over 79.8 days. The data indicates that February is the wettest month with an average rainfall of 140.5 mm over 8.6 days and September is the driest month with an average rainfall of 42.7 mm over 5.1 days.

There is little variation in humidity levels and seasonal flux across the year. Mean 9 am humidity levels range from 57% in September to 76% in March. The mean 3 pm humidity levels vary from 53% in September to 67% in February.

The mean 9 am wind speeds range from 8.1 km/h in March to 15.3 km/h in September. The mean 3 pm wind speeds range from 17.1 km/h in May and June to 22.6 km/h in September.

There will be a 0-5% decrease in precipitation between 2020 and 2039, and 5-10% increase between 2060 and 2079 (OEH, 2018).

Figure 1.1
Regional context

DUNMORE LAKES SAND EXTRACTION PROJECT | MODIFICATION 2
ENVIRONMENTAL ASSESSMENT

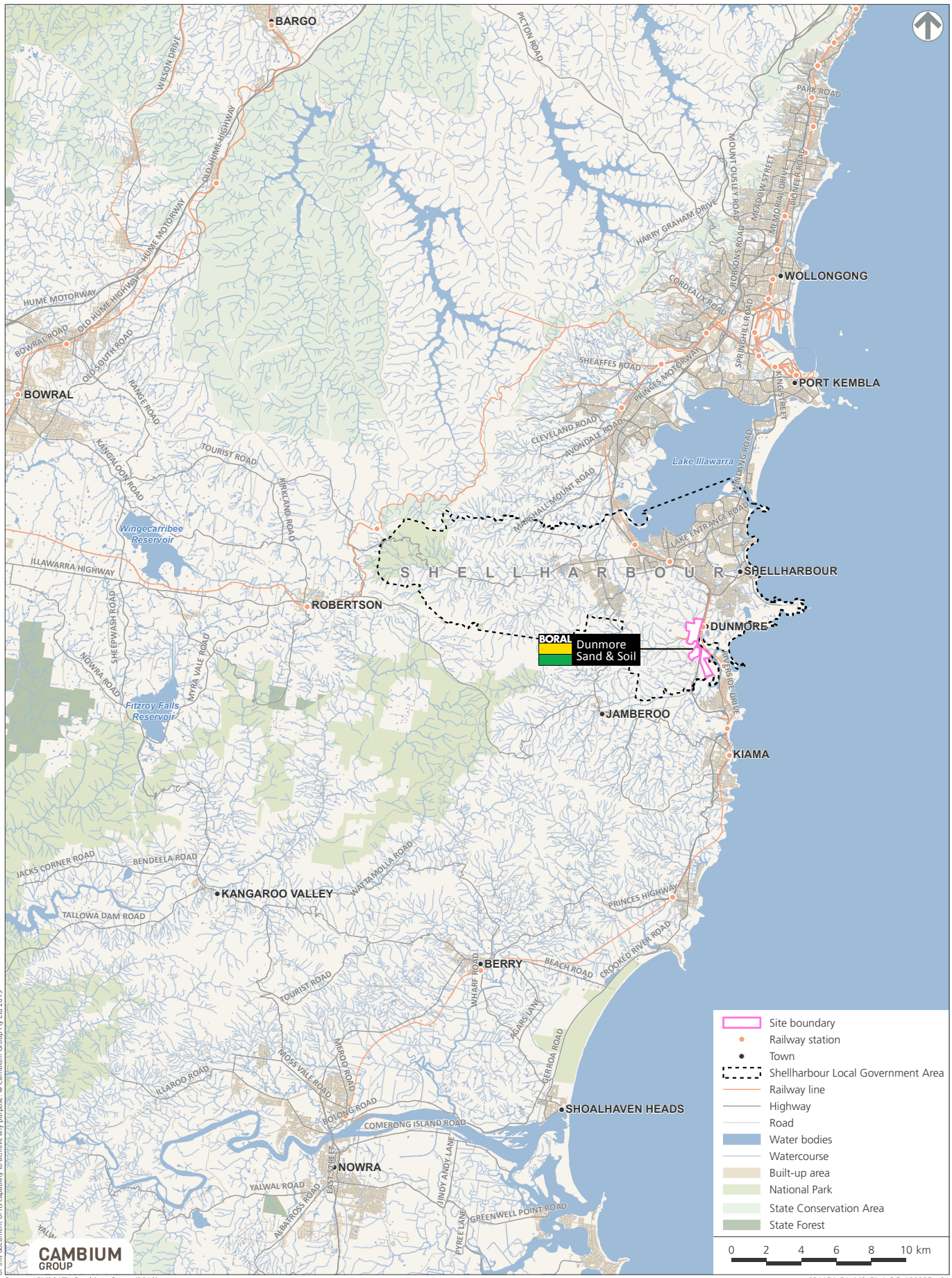

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Figure 1.2
Local context

DUNMORE LAKES SAND EXTRACTION PROJECT | MODIFICATION 2
ENVIRONMENTAL ASSESSMENT

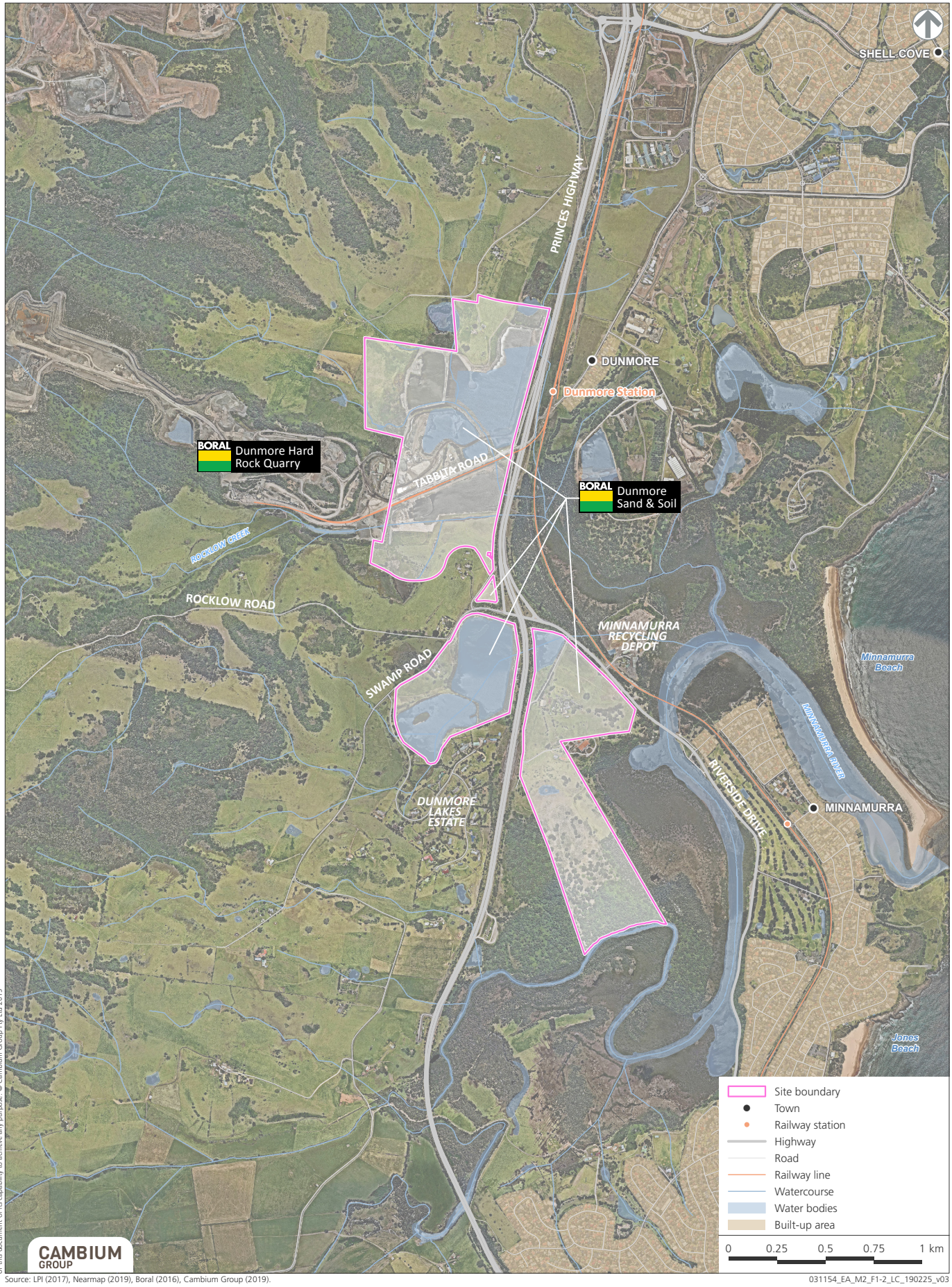

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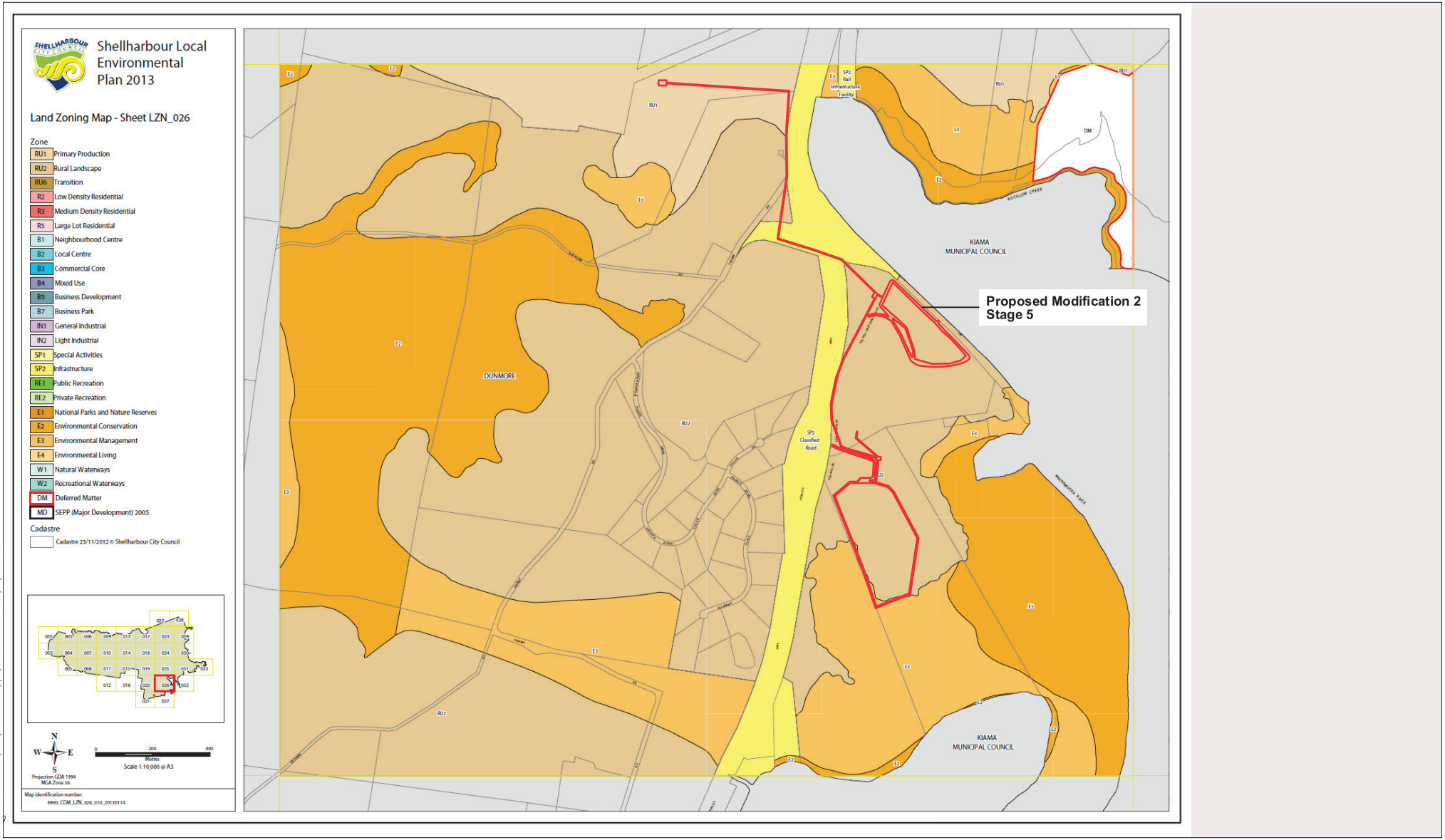
Figure 1.3
Zoning



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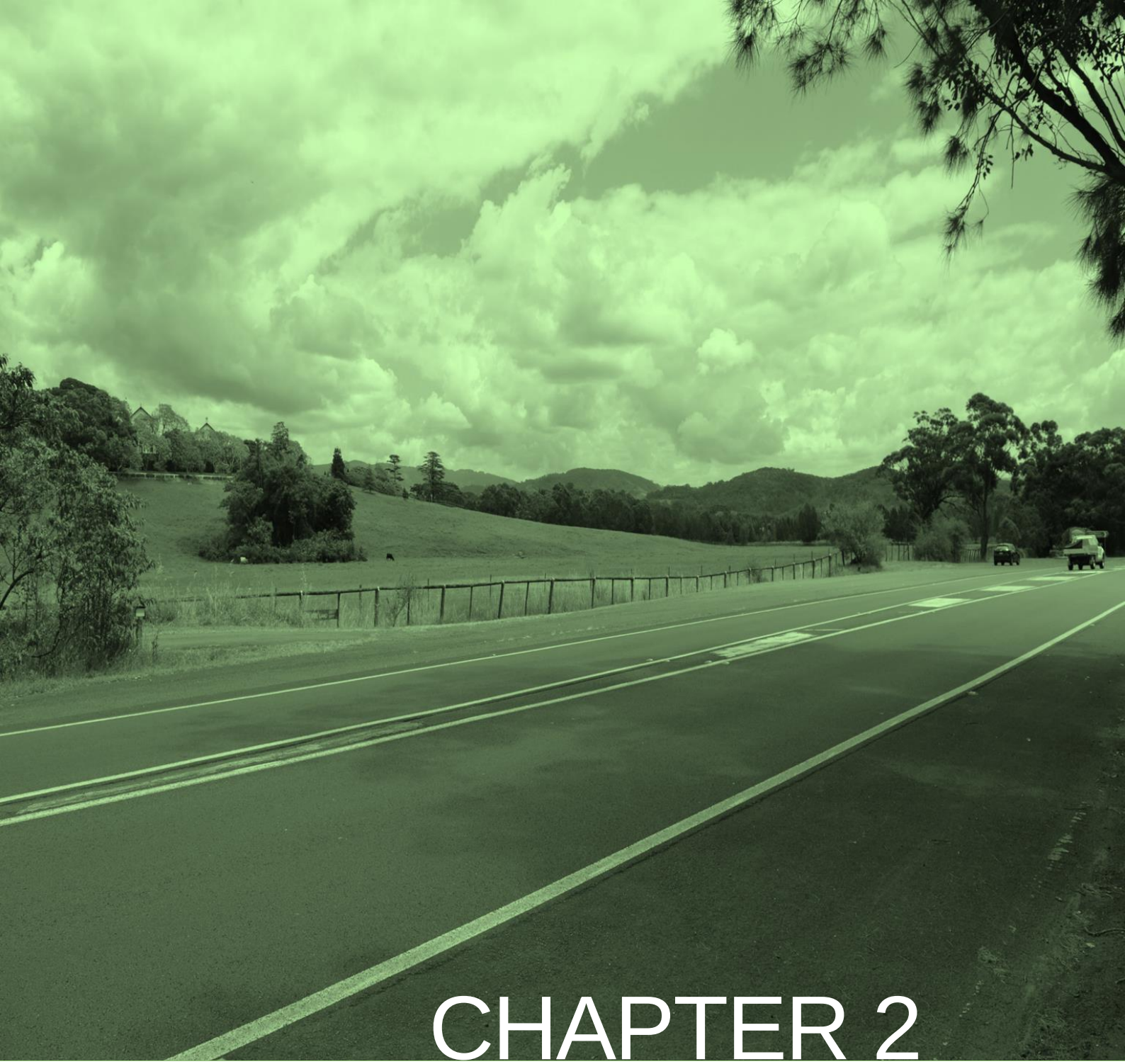
Source: Shellharbour LEP (2013)



CHAPTER 2

EXISTING OPERATIONS

2 EXISTING OPERATIONS

2.1 Approved Project

The approved operations include extraction and transportation of up to 800,000 t of sand products per annum from stages 2 to 4 over a period of 25 years.

The primary components of the Approved Project are outlined below:

- Stage 2: excavation of 0.5 Mt of soil and extraction of approximately 3.6 Mt of sand from a 5 ha area around the margins of the Stage 2 area, and dredging from a 32 ha area of land in the Stage 2 area.
- Stage 3: excavation of approximately 0.3 Mt of soil and extraction of approximately 2.2 Mt of sand from a 2 ha area around the margins and dredging from a 16 ha area of land in the Stage 3 area.
- Stage 4B: excavation of approximately 0.1 Mt of soil and dredging of 1.1 Mt of sand from a 3.1 ha area of land in the Stage 4 area. A further 0.3 Mt of sand would be recovered from Stage 4 as some boundary profile materials in stages 2 and 3 would be extracted.
- Processing of the dredged sand.
- Processing of imported quarry fines and blending with washed fine sand and fine blue metal to yield coarse sand products for concrete manufacture and other applications.
- Processing and sale of other quarry products, and when required, blending with proprietary materials to meet customers' individual specifications.
- Blending of a range of natural materials with washed or unwashed sand to meet customers' individual specifications.
- Progressive backfilling of pre-determined areas to create up to 16 ha of useable, landscaped and mostly flood-free land. Approximately 16 ha of the area extracted would be backfilled to a level comparable with existing levels.
- Progressive rehabilitation and landscaping of the lake foreshores and adjoining land in the stage 2 and 3 areas to create a picturesque lake setting. The lake setting would comprise some wetland shallows and at least one near-shore bird nesting island.
- Transportation of soil, sand, blended and other products from the site and backfill materials and product component materials to the site.

Refer to **Figure 2.1** for an overview of the approved project.

2.1.1 Extraction activities

Existing operations involve the sequential dredging and excavation of approximately 8 Mt of sand and soil from stages 2, 3 and 4. Sand and soil are extracted by excavator and dredging, followed by washing, processing and material blending. The final product is then stockpiled on site until transported to local and regional markets via road and rail.

The general extraction process is summarised below.

Topsoil removal

Topsoil and underlying sand to a maximum depth of 1 m is removed by excavator with either direct loading into trucks or into draining stockpiles prior to loading.

The topsoil is either removed directly from site, stored in the processing area or placed on areas for use in site rehabilitation and/or in bund wall construction.

Excavator extraction

Sand is extracted by excavator on a campaign basis, where a perimeter of the nominated stage is extracted ahead of the associated dredging.

Extraction via excavator generally only occurs where site conditions mean that the dredge cannot be utilised immediately following removal of topsoil.

Dredging extraction

The dredge moves progressively through the resource area generally following the nominated stages. In most cases, the sand in each extraction stage is fully extracted unless constraints are encountered.

The dredge moves backwards and forwards across the active dredge pond, cutting away against the underwater sand face. The sand / water mix is pumped directly from the dredge via a pontoon-mounted pipeline to either an initial storage area or the fine sand washing plant in the processing and stockpile area at Stage 2. The pipe route changes constantly but is positioned to minimise impacts on natural vegetation and the banks of man-made channels. The dredges manoeuvre around the ponds and their position is stabilised by ‘spud’ bars or tie ropes connected to the banks around the active pond.

2.1.2 Processing, blending and stockpiling

The screening and blending plants are in the Stage 2 portion of the site and are mobile units comprising a hopper, conveyor belts, screens and delivery chute. The components for all blends are fed into the units by a front-end loader in their required proportions and a product stockpile created. It is normal for at least ten different blended product stockpiles to be present at any one time.

Each plant has a capacity to blend products ranging from 20-200 t per hour (tph).

Coarse sand plant

This plant produces the coarse sand products from a blend of the washed fine-grained sand and the quarry fines generated at the nearby Dunmore Hard Rock Quarry. The plant has a capacity to produce coarse sand components at a rate of up to 150 tph.

Fine sand plant

The fine sand plant has a capacity of approximately 200 tph. This plant is fitted with twin cyclones and can feed two draining stockpiles.

2.1.3 Sand products

The bulk of the sand that is extracted by dredge from stages 2, 3 and 4 is processed to yield washed fine sand for direct sale or use in other products.

The fine sand is ideally suited as a raw material for a wide range of sand-based products, including concrete sand and similar products either as a fine concrete sand or as a component of coarse sand blends. It is expected that between 30-50% of the fine washed sand will be used in the manufacture of the coarse sand blends. The grading of the coarse sands is designed to meet the customers’ individual requirements.

2.2 Planning approval history

Stage 1 of the approved project was issued development consent from the then Minister for Planning in 1999. Stage 1 was on Swamp Road, Dunmore, and encompassed sand extraction by dredging of up to 500,000 tpa for a period of 10 years. The Stage 1 consent included conditions requiring the proponent to lodge a further application for the remaining identified Stages of the Dunmore sand resource (being Stages 2 to 4).

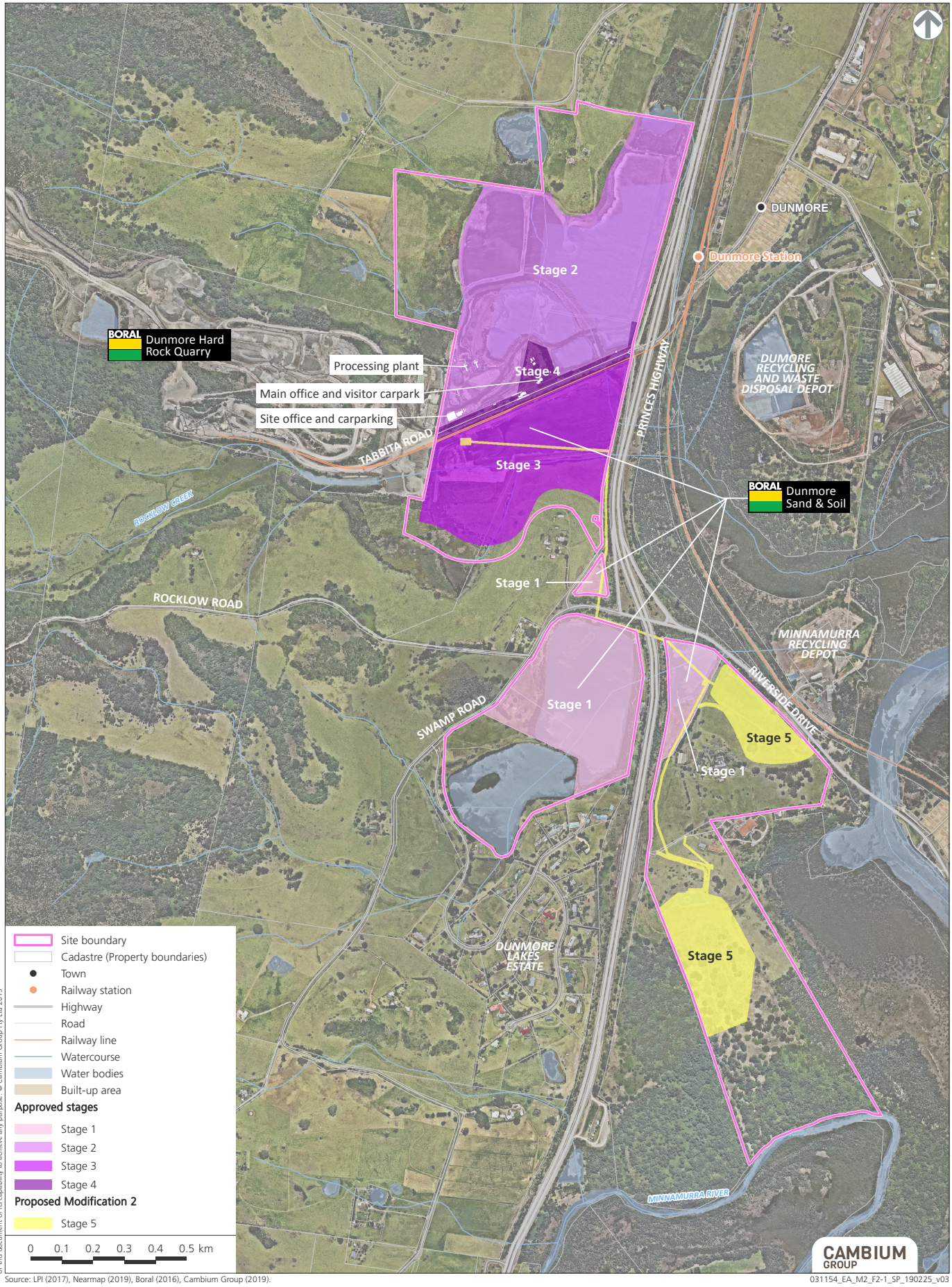
The application for Stages 2 to 4 was lodged in 2004, and development consent was received from the Minister for Planning in June 2005. The consent approves extraction of up to 800,000 tpa of sand for a period of 25 years. Boral purchased DSS, including the Dunmore Lakes Sand Project in mid-2005. The Stage 1 consent has since lapsed following successful extraction of the approved sand resource and rehabilitation of the site in 2010.

Stages 2 to 4 commenced dredging in June 2007.

An application to modify the Project Approval under Section 75W of the EP&A Act (Modification 1) was sought in April 2016 to modify a condition of consent relating to the re-alignment of Rocklow Creek. The modification was subsequently approved in June 2016.

Figure 2.1
Staging plan

DUNMORE LAKES SAND EXTRACTION PROJECT | MODIFICATION 2
ENVIRONMENTAL ASSESSMENT



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Source: LPI (2017), Nearmap (2019), Boral (2016), Cambium Group (2019).

2.3 Operating hours

The operating hours for the approved project are in **Table 2.1**.

Table 2.1: Approved operating hours

Activity	Day	Time
Dredging and processing	Monday-Saturday	6:00 am to 6:00 pm
	Sunday and public holidays	8:00 am to 4:00 pm
Excavator extraction	Monday-Saturday	6:30 am to 6:00 pm
	Sunday and public holidays	None
Delivery, distribution and maintenance	Monday-Friday	5:00 am to Midnight
	Saturday	6:00 am to 6:00 pm
	Sunday and public holidays	8:00 am to 4:00 pm
Delivery and distribution via Shellharbour Road	Monday-Friday	7:00 am to 10:00 pm
	Saturday	7:00 am to 6:00 pm
	Sunday and public holidays	8:00 am to 4:00 pm
Maintenance (if inaudible at neighbouring residences)	Any time	Any time

2.4 Environment protection licence

The NSW *Protection of the Environment Operations Act 1997* provides for an integrated system of licensing and contains a core list of activities requiring environment protection licences (EPL) from the NSW Environment Protection Authority (EPA). The activities are called 'scheduled activities' and are listed in Schedule 1 of the Act.

The approved project currently operates under EPL No. 11147, for the scheduled activities of crushing, grinding and separating, and extractive activities.

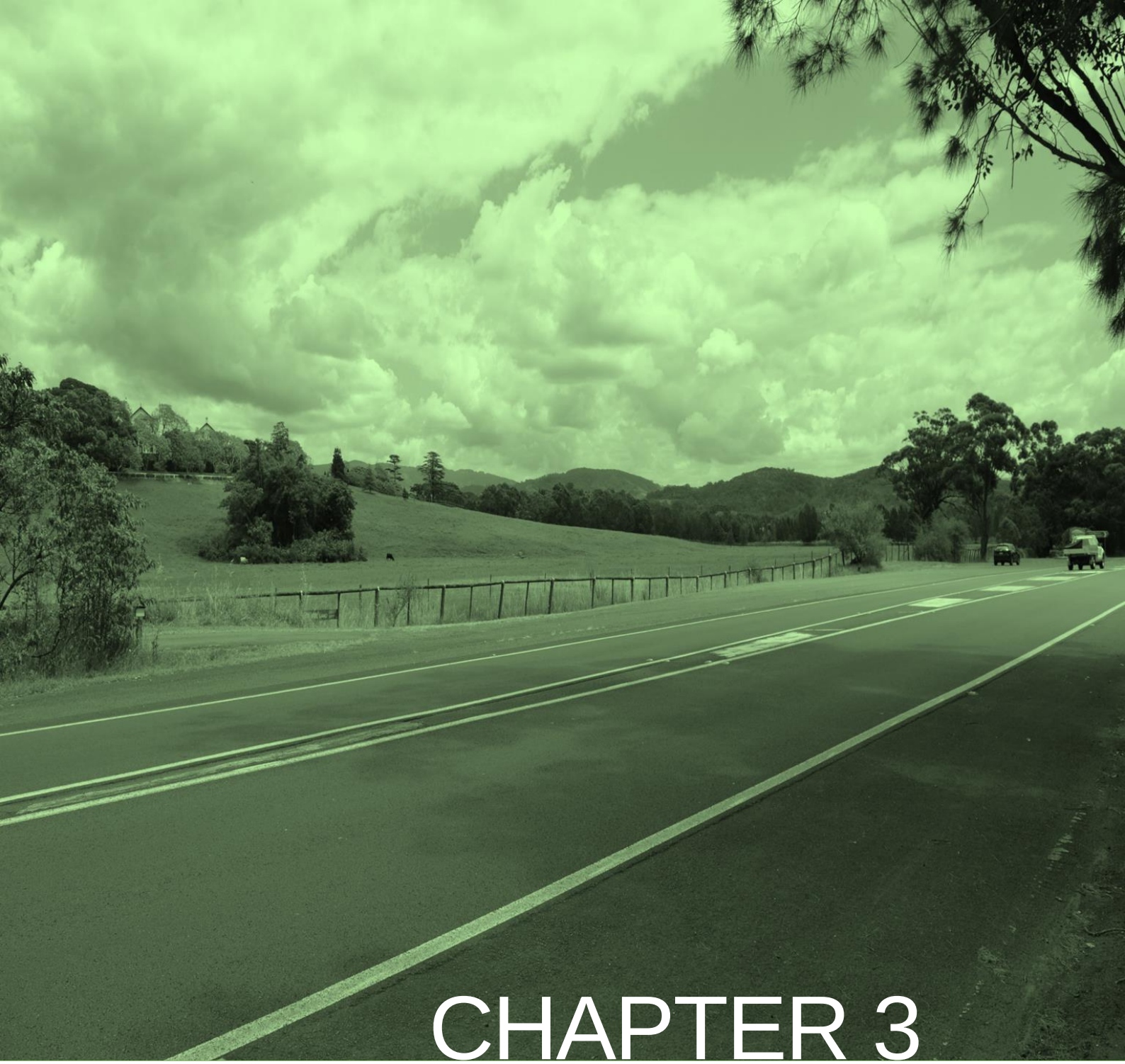
2.5 Environmental management

An environmental management strategy and the following associated management plans were prepared in accordance with the Project Approval:

- environmental management strategy;
- noise management plan;
- air quality management plan;
- flora and fauna management plan;
- water management plan which includes:
  - site water balance;
  - surface water monitoring program; and
  - ground water monitoring program.
- waste management plan; and

- rehabilitation management plan.

The Environmental Management Strategy and associated management plans will be updated to take into account the proposed modification. As required by Schedule 5, Condition 4 of the Project Approval, amendments to management plans would be undertaken within three months of a notice of approval and submitted to DP&E for endorsement.



CHAPTER 3

PROPOSED MODIFICATION

3 PROPOSED MODIFICATION

3.1 Additional Stage 5 extraction areas

The modification to the approved project seeks to establish additional extraction areas (Stage 5) on adjoining private property which is to be leased by DSS. Extraction is proposed in two separate extraction areas, namely Stage 5A (immediately south of Riverside Drive), and Stage 5B (to the north of Minnamurra River). The sand resource to be extracted from Stage 5A is estimated at 234,000 t and approximately 1,123,000 t from Stage 5B. These resource volumes are the estimated sand resource only, and additional tonnage of soil material (known as overburden) will be extracted in addition to the sand resource.

Mobile plant and equipment will be operated across both extraction areas. Extraction methods will be identical to those in Stages 2 and 3.

3.1.1 Stage 5A

Sand extraction in Stage 5A will commence prior to Stage 5B and will involve clearing and grubbing of established groundcover vegetation. Topsoil will be stripped and stockpiled along the southern edge of the extraction area for later re-use in rehabilitation. At the same time, earth mounds will be formed using a dozer to construct the flood protection bunding for the dredge pond.

The sand will initially be extracted from Stage 5A via excavator to create a large enough pond to float a dredge and accommodate fresh water pumping from the dredge via overland pipeline to the processing plant in Stage 2.

The dredge will then progressively extract sand in an easterly direction.

Sand will be extracted to a maximum depth of 12 m.

3.1.2 Stage 5B

Stage 5B operations will not commence until approximately two weeks prior to the completion of extraction in Stage 5A. During the two-week transition period, two dredges may be operating in tandem to minimise disruption to operations and ensure the supply of sand is not compromised during the transition between extraction areas. At the same time, earth mounds will be formed using a dozer to construct the flood protection bunding for the dredge pond.

Initially, sand will be excavated in the northern end of the Stage 5B extraction area to create a large enough pond to float a dredge and accommodate fresh water pumping from the dredge via overland pipeline to the processing plant in Stage 2.

The dredge will then progressively extract sand in a southerly direction.

Sand will be extracted to a maximum depth of 27m.

3.2 Processing and dispatch

An overland transfer pipeline will be established from the Stage 5 extraction areas to the existing Stage 2 processing area and will comprise two parallel 355 mm black polyethylene pipelines.

At the Stage 2 processing area, the sand and water will pass over an initial screen to separate oversize organic matter or debris and into a large wash tank to float out any fines (<7 µm). The sand will then be pumped through a cyclone and stockpiled for further dewatering. Water will drain to an existing fines pond and a secondary settling pond before being pumped back to the Stage 5A and Stage 5B dredge ponds.

Dewatered sand will then be loaded with a front-end loader for dispatch by road and rail.

Water pumped from the Stage 5 extraction areas will be returned to these extraction areas via the pumping pipeline.

Sand processing and dispatch at the Stage 2 processing plant will be in accordance with the approved project. The proposed modification does not involve any changes to the approved processing and dispatch activities.

3.3 Importation of fill material

DSS proposes to import up to 325,000 tpa of virgin excavated natural material (VENM) by road to the Stage 5 extraction area.

The VENM fill is required to:

- construct flood protection bunding and access roads in the Stage 5A extraction area;
- backfill the Stage 5A extraction area to natural ground level; and
- stabilise the edges of the Stage 5B dredge pond and the upper portions of the natural batters that form underwater, to allow safe access for vehicles, plant and equipment around the pond's perimeter.

VENM will be transported to the site by road truck/truck and dog and will be tipped directly into the respective extraction areas and spread with a dozer.

3.4 Access roads

The Stage 5 extraction areas are accessed via Fig Hill Lane. This access route is unsafe for haul vehicles as it is too close to the Princes Highway/Riverside Drive intersection. Therefore, a new access road will be constructed to the Stage 5 extraction area from Riverside Drive, opposite Saltwater Creek Road.

The access road will join a 3.5 m wide unsealed road around the perimeter of the Stage 5A extraction area, which will then join the existing Fig Hill Lane, a sealed road that heads southwards towards the Stage 5B extraction area. A new 240 m long and 3.5 m wide unsealed access track will need to be constructed down the slope from the end of Fig Hill Lane to the northern end of the Stage 5B extraction area and will require cut and fill earthworks.

A 3.5 m wide unsealed road will also be constructed around the perimeter of the Stage 5B extraction area to enable maintenance vehicle access.

The new access roads will be used by light vehicles accessing the site office and parking area adjacent to the Stage 5B extraction area and heavy vehicles delivering VENM fill to the site.

All existing access arrangements for residents along Fig Hill Lane and Riverside Drive will be maintained during the Stage 5 operations.

3.5 Site office and parking

A portable site office and associated parking area for 10 light vehicles will be established in the north western corner of the Stage 5B extraction area.

3.6 Utilities and infrastructure

3.6.1 Pipeline

Two approximately 2.1 km long 355 mm black polyethylene pipes will be laid from the Stage 5 extraction areas to the Stage 2 processing area along the shortest possible route avoiding existing infrastructure, vegetation, creeks and land ownership restrictions (refer to **Figure 3.1**). The pipeline will be removed on completion of dredging in the Stage 5 extraction area.

The proposed pipeline route starts at the edge of the Stage 5B extraction area and travels over the hill to the Stage 5A extraction area (adjacent to the existing Fig Hill Lane for the majority). The pipeline will then run across the former Stage 1 dredge pond to the north of Stage 5A and through existing culverts beneath the Princes Highway and Swamp Road.

The culverts beneath the Princes Highway are 4 m long, 2.7 m wide and 2.4 m high box culverts which connect the upstream catchment of about 205 ha to downstream. The 1% Annual Exceedance Probability (AEP) flood level in these culverts is estimated at 2.9 m AHD, with the invert of the culvert at approximately 1.7 m AHD.

The Swamp Road culvert is a single 2.7 m wide by 2.4 m high box culvert primarily installed to incorporate infrastructure that led to the previous wash plant located to the north of Swamp Road, and to provide a hydraulic connection to this area.

The pipeline will be secured to the side wall of culverts at water crossings with brackets and will sit well above the water column to mitigate against potential flooding and allow for inspections and maintenance to be completed.

The pipeline will require a crossing of Rocklow Creek adjacent to the south of the existing Stage 2 processing area. A gangway structure is proposed to ensure the pipeline does not disturb the bed of the creek, nor impede potential fish passage.

A flat bed truck with hi-ab crane will unload the 12 m pipe segments into position. A small excavator may be required to position the pipe segments prior to welding of the segments together. The pipeline will be secured with star pickets and/or emplacement of fill over the pipelines. Any fill material used to secure the pipelines will be stabilised with groundcover vegetation to minimise the potential for erosion and sedimentation. The pipeline will be placed under Fig Hill Lane to ensure access is not obstructed.

3.6.2 Booster pump

A booster pump station will be constructed to pump the water and sand through the pipeline from the Stage 5B extraction area to the processing plant located in the Stage 2 area adjacent to Tabbita Road. The water and sand will be pumped from the Stage 5B extraction area over the hill immediately north and will gravity feed to the Stage 2 processing plant. A second booster pump will also be required at the junction of the Stage 5A and Stage 5B pipelines to ensure sufficient pressure to transfer the water and sand to the Stage 2 processing area.

The pump stations will have metal cladding for noise attenuation and sit on an approximately 5 m by 5 m aggregate pad. The pump stations will be approximately 3.5 m long, 3 m wide and 2.5 m high.

An overhead high voltage power line will also be constructed from the existing powerline at 69 Fig Hill Lane (Lot 51 DP 1012246) to the booster pump station to the north of Stage 5B. The overhead power line will require installation of power poles.

3.7 Rehabilitation

DSS has successfully backfilled and rehabilitated dredge ponds with VENM at previous stages of the operation. This experience and knowledge will be used in planning final rehabilitation of the Stage 5 extraction area.

Topsoil will be stripped prior to extraction in the Stage 5A area and stockpiled for use in rehabilitation.

Upon completion, the Stage 5A extraction area will be backfilled with VENM, topsoil spread and groundcover vegetation planted to return the land to pasture at the request of the landowner. The Stage 5B extraction area will be left as a freshwater pond.

Rehabilitation will be in accordance with the approved *Dunmore Sand and Soil Project Rehabilitation Management Plan* (Arcadis, 2017). The rehabilitation management plan will be updated to include the Stage 5 extraction area.

Detailed rehabilitation information relating to rehabilitation of the project is provided in **Section 7.10.3**.

3.8 Comparison against approved project

No changes to the approved production volumes or operational hours are proposed. The existing sand production facilities will process material extracted from the Stage 5 extraction areas, with no processing taking place in the modification site.

The proposed modification will not increase the current hourly or daily traffic volumes associated with dispatch of processed sand products given that the production limit of the approved project will not be altered. However, there will be additional heavy vehicles along the Princes Highway and Riverside Drive associated with importation of fill to the Stage 5 extraction area.

A summary of the proposed modification in comparison to the approved project is provided in **Table 3.1** below.

Table 3.1: Comparison against the approved project.

Aspect	Approved project	Proposed modification
Operations		
Land use	Extractive industry.	No change.
Hours of operation	Refer to Section 2.3.	No change to hours of operation of existing site. All activities associated with the proposed modification, except for dredging operations, would occur between 7 am to 6 pm Monday to Friday.
Consent period	25 years from commencement.	No change.

Aspect	Approved project	Proposed modification
Production and transport limits	Up to 800,000 tpa of product per year from the site.	No change.
Extraction method	Extraction by excavator and dredge.	No change.
Site infrastructure and plant	Mobile screening plant, fine and coarse sand washing plants and material blending.	No change.
Product transport	Truck via established access road network.	No change to dispatch method. Additional transfer pipelines to be provided to connect Stage 5 extraction area to the Stage 2 processing plant.
Environmental impacts		
Traffic	Dispatch limit of 800,000 tpa.	No change in traffic volumes. The proposed modification does not require amendment to the product, dispatch limit of 800,000 tpa. VENM importation to Stage 5 extraction area to be limited to 325,000 tpa.
Noise and vibration	Condition 13 of the existing development consent imposes operational noise limits.	No changes to extraction/processing methods, or hours of operations at existing site. Additional noise impacts associated with the proposed modification are outlined in Section 7.6.
Rehabilitation/stabilisation	In accordance with existing Rehabilitation Plan.	No change to existing sites. Revised rehabilitation plans to be prepared subsequent to approval.
Waste Management	In accordance with existing Waste Management Plan.	No changes.

3.9 Need, justification and alternatives

3.9.1 Need and justification

Boral is a leading producer and supplier of building and construction materials in the country. Accordingly, a significant amount of development in NSW, including many of the state's best known structures, are underpinned by Boral-supplied concrete, cement, asphalt and construction materials such as natural sand.

With the significant increase in approved housing and infrastructure projects in Sydney and other parts of NSW, the leading suppliers of natural sand are under pressure to meet this increased demand as natural sand has unique structural characteristics to manufactured sand and is essential to meet design specifications on many infrastructure and associated development projects.

Given recent high demand, the sand resource in Stage 3 of the approved project is expected to be exhausted in approximately three to five months. The last extraction stage, Stage 4, contains the existing site's road access and private rail line and infrastructure for the approved project and Boral's neighbouring Dunmore hard rock quarry. As such, sand extraction cannot commence in this area until this infrastructure is relocated in future (not subject to this modification).

As the approved project is one of Boral's few remaining natural sand quarries, DSS, on behalf of Boral, proposes to meet part of this increased demand in natural sand by establishing the additional Stage 5 extraction area on land adjoining its current operations.

The expanded operations at the modification site will provide:

- supply of essential natural sand to major infrastructure and associated development projects;
- continued employment of 10 full time employees and truck/transportation drivers, with further jobs created through flow-on effects;
- optimal use of a regionally-significant resource; and
- economic benefits to the local community through the purchase of goods and services and local expenditure both directly and indirectly through employee wages.

DSS' operations provide substantial economic benefits at Commonwealth, State and local levels while being committed to maintaining a good working relationship with the local community and implementing best practice environmental management across the site.

3.9.2 Alternatives

Do nothing

If the proposed extraction of additional sand is not approved, the DSS operations will likely cease in late 2019 to early 2020, and possibly earlier due to current extraction rates. The closure of DSS operations will result in loss of employment, reduced revenue to local service providers, sterilisation of a valuable resource and shortages of raw materials for essential NSW infrastructure and associated development projects.

Alternative locations

The DSS site is one of Boral's few remaining natural sand quarries. With the demand for natural sand ongoing, all of Boral's natural sand quarries are operating at full capacity and quickly running out of resource.

The modification site is optimally positioned with regard to the proximity to the South Coast and Sydney supply markets. Thereby Boral considered it reasonable to look for opportunities which will maintain their competitiveness and ability to supply the region, rather than exploring regions which would be unfeasible or ineffectively positioned. Investigations around the region at other sites were eliminated due to these reasons, as well as the need to establish new infrastructure to process the resource, the shifting of jobs from the site elsewhere, and the nature of the sand resource available.

The current DSS site has the advantage of an existing rail line, which is utilised to distribute the sand resource to the greater metropolitan Sydney area; thereby reducing Boral's reliance on

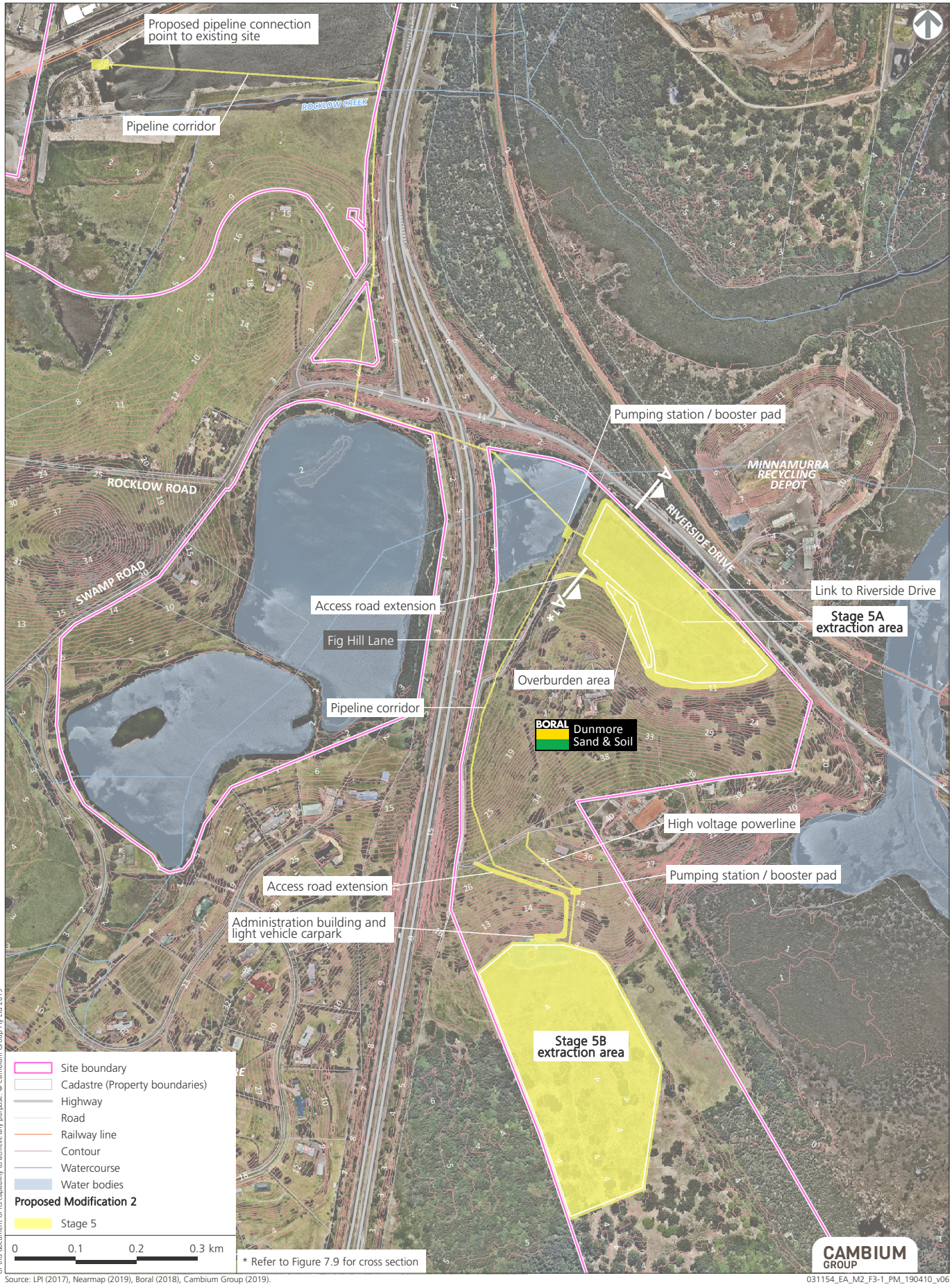
road-based transport methods. Alternative locations would not have the benefit of this specifically developed infrastructure, which is the most effective means of providing mass transit of sand resource across long distances.

Given the DSS site is fully established, inclusive of supporting infrastructure, it was considered more responsible from an economic, social and environmental perspective to expand operations at the existing site rather than establish a new development at an alternative location. The proposed modification will also secure the continued employment of staff at the site, and retain indirect benefits of the operation within the region.

The isolated position of the proposed Stage 5A and 5B extraction areas will also result in benefits associated with minimisation of potential adverse impacts to the local community. Similarly, establishment of the transfer pipeline overland will eliminate the need for heavy vehicle movements along the local and regional road network, which would otherwise be required to transport the sand extracted from Stage 5 further north to the Stage 2 processing area along Tabbita Road. This methodology also eliminates the need for additional vegetation clearing and bulk ground disturbance to occur, as would be required to establish new infrastructure at any alternative site.

Figure 3.1
Proposed modification

DUNMORE LAKES SAND EXTRACTION PROJECT | MODIFICATION 2
ENVIRONMENTAL ASSESSMENT



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Source: LPI (2017), Nearmap (2019), Boral (2018), Cambium Group (2019).

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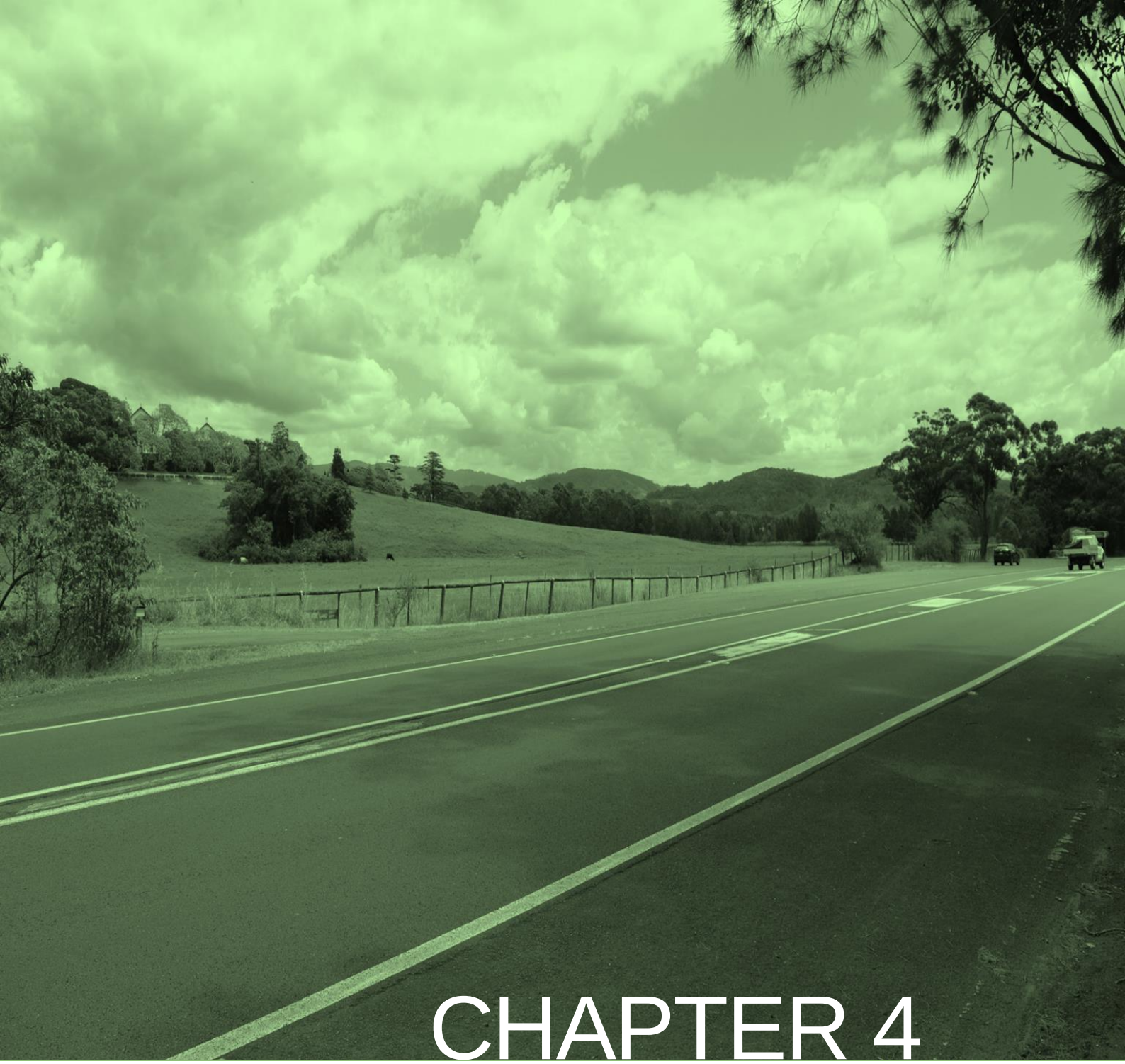


CHAPTER 4

LEGISLATIVE PLANNING CONSIDERATIONS

4 LEGISLATIVE PLANNING CONSIDERATIONS

Boral seeks to modify the Project Approval, as described in **Section 3**, under Section 75W of the EP&A Act.

The following section identifies the applicable Commonwealth and State environment and planning legislation, local planning instruments, and discusses the relevant planning approval process applicable to the proposed modification.

4.1 Commonwealth legislation

4.1.1 Environment Protection and Biodiversity Conservation Act 1999

The Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) is the primary Commonwealth environmental legislation. The EPBC Act is administered by the Commonwealth Department of the Environment and Energy (DoEE) and provides a legal framework to protect and manage national and international important flora, fauna, ecological communities and heritage places, defined under the EPBC Act as matters of national environmental significance (MNES). The EPBC Act also confers jurisdiction over actions that have a significant impact on the environment where the actions affect, or are taken on, Commonwealth land.

An action that "*has, will have or is likely to have a significant impact on a matter of National Environmental Significance*" may not be undertaken without approval from the Commonwealth Minister for the Environment and Energy, as provided under Part 9 of the EPBC Act. Approval under the EPBC Act is also required where actions are proposed on, or will affect, Commonwealth land and its environment.

The Protected Matters Search Tool is managed by DoEE and is used to identify MNES near a project. The tool was searched in December 2018 to find protected matters recorded within 10 km of the modification site (**Appendix B**). Results of this search are presented in **Table 4.1**. This data, together with other local knowledge and records was used to assess whether the project will have, or is likely to have, a significant impact upon a MNES or on Commonwealth land.

Table 4.1: Matters of national environmental significance considered in the EPBC Act

Matters of national environmental significance	Commentary
World heritage properties	There are no world heritage properties (including buffer zones) within 10 km of the modification site.
National heritage places	There are no national heritage properties (including buffer zones) within 10 km of the modification site.
Wetlands of international importance (listed under the Ramsar Convention)	There are no wetlands of national importance within 10km of the modification site.
Listed threatened species and ecological communities	There are four threatened ecological communities and 79 threatened species recorded within 10 km of the modification site (refer **Appendix B**). Remnant native vegetation in the modification site is isolated from dense vegetation on the Illawarra escarpment and foothills and other large areas of woodland or forest vegetation along the coastal

Matters of national environmental significance	Commentary
	margin. Nevertheless, given the moderate size of the remaining woodland, the modification site offers potential habitat to a range of native fauna. The Grey-headed Flying-fox could be impacted by the proposed modification, and as such an assessment of significance was undertaken as part of the biodiversity assessment (refer to **Section 7.3**). The assessment concluded that there will be no significant impact on the species, therefore a referral under the EPBC Act is not required.
Migratory species protected under international agreements	70 migratory species have been recorded within 10 km of the modification site. Although migratory bird species are listed under the EPBC Act as occurring within 10km of the site, due to the highly modified nature of the modification site and absence of breeding habitat, it is unlikely that the proposal will significantly impact any migratory species.
Commonwealth marine area	There are no Commonwealth marine areas that will be impacted by the proposed modification.
The Great Barrier Reef Marine Park	The Great Barrier Reef Marine Park is not near the modification site.
Nuclear actions (including uranium)	There are no nuclear actions near the modification site.
A water resource, in relation to coal seam gas development and large coal mining development	This is not applicable to the proposed modification.
Other protected matters: The Environment, where actions proposed are on, or will affect Commonwealth land and the environment The environment, where Commonwealth agencies are proposing to take an action	This is not applicable to the proposed modification.

4.1.2 Native Title Act 1993

The Commonwealth *Native Title Act 1993* recognises that Aboriginal people have rights and interests to land and waters which derive from their traditional laws and customs. Native title may be recognised in places where Indigenous people continue to follow their traditional laws and customs and have maintained a link with their traditional country. It can be negotiated through a native title claim, an Indigenous land use agreement or future act agreements.

The National Native Title Register, Register of Native Title Claims, Unregistered Claimant Applications Register, and Register of Indigenous Land Use Agreements were searched in December 2018 for reported native title claimants in the LGA.

A search of the Register of Native Title Claims indicates that a claim was lodged by the 'South Coast People' in August 2017 which covers all lands and waters between the southern shore of Botany Bay and the Towamba River at Eden (Tribunal File Number NC2017/003). Despite the claim for native title, the potential for the proposed modification to impact culturally significant values has been assessed as detailed in **Section 7.2**.

There were no other results for native title in the LGA.

4.1.3 National Greenhouse and Energy Reporting Act 2007

The Commonwealth *National Greenhouse and Energy Reporting Act 2007* (NGER Act) provides a single national framework for the reporting and dissemination of information about the greenhouse gas emissions, greenhouse gas projects, and energy use and production of corporations. It makes registration and reporting mandatory for corporations whose energy production, energy use or greenhouse gas emissions meet specified thresholds.

Boral triggers the threshold for reporting under the NGER Act, and reports energy use and greenhouse gas emissions from its operations, including the approved project.

Boral will be required to monitor and report energy use and greenhouse gas emissions associated with the proposed modification under its obligations under the NGER Act.

4.2 Key NSW legislation

4.2.1 Environmental Planning and Assessment Act 1979

Under (the now repealed) clause 8J(8) of the NSW Environmental Planning and Assessment Regulation 2000 (EPA Regulation), a development consent relating to State significant development (SSD) that was granted by the Minister under Part 4 of the EP&A Act before 1 August 2005 is taken to be an approval under Part 3A of the EP&A Act, for the purposes of modification only, and Section 75W of the EP&A Act applies to any modification of such a consent.

The development consent for the approved project was issued on 29 June 2005, and Section 75W is therefore the appropriate planning pathway for the proposed modification.

Part 3A was repealed by the NSW *Environmental Planning and Assessment Amendment (Part 3A Repeal) Act 2011* (Part 3A Repeal Act), which commenced on 1 October 2011. Under the Part 3A Repeal Act, projects deemed to be 'transitional Part 3A projects' will continue to be subject to Part 3A of the EP&A Act (as in force immediately before the repeal and as modified by the Part 3A Repeal Act). Transitional Part 3A projects include certain projects that were the subject of an existing approval under Part 3A.

As the approved project has a Project Approval that is taken to be approved under Part 3A of the EP&A Act (by virtue of clause 8J(8) of the EPA Regulation), it is a transitional Part 3A project. The provisions of Part 3A (as in force immediately prior to its repeal) continue to be applicable to the approved project, subject to the discretion of DP&E. Therefore, following confirmation with DP&E, the proposed modification will be assessed under Section 75W of the repealed Part 3A.

The transitional arrangements in the EP&A Act were repealed by the Environmental Planning and assessment Bill 2017. This moved transitional Part 3A projects to the current State SSD and State significant infrastructure (SSI) pathways, and applications to modify such projects will no longer be made under Section 75W. This modification application has been made within the

transitional timeframe specified by DP&E and is therefore not affected by the above arrangements.

Although there would be an increase in the disturbance footprint of the approved project, and inclusion of additional land, there will be no changes to the annual production limit or consent life (consent lapses on 29 June 2030). A comparison of the proposed modification in relation to the Approved Project, within the context of legislative permissibility under Section 75W, is summarised in Table 4-2.

Table 4.2: Comparison of the proposed modification in relation to the approved project.

Factor	Approved Project	Proposed Modification	Difference (%)
Extraction area (ha)	37.6 (Stage 2) 21.3 (Stage 3) 4.8 (Stage 4)	3.32 (Stage 5A) 7.85 (Stage 5B)	17
Resource (million tonnes)	4.1 (Stage 2) 2.7 (Stage 3) 1.2 (Stage 4)	0.23 (Stage 5A) 1.12 (Stage 5B)	17
Quarry life	25 years	No change	Nil
Production output (annual)	800,000 tpa	No change	Nil

The proposed modification is reasonable for assessment as a Section 75W modification, as the proposed modification will have 'limited environmental consequences'. The test attributed to determining whether the proposed modification will have 'limited environmental consequences', is achieved by considering whether the disturbance footprint, production, and quarry life exceeds 30% of what was proposed by the original approved project.

The proposed modification would result in a 17% increase in extraction area, and a 17% increase in resource availability. Noting that the Stage 5A extraction area will be returned to its current condition, subsequent to extraction being completed and rehabilitation fully implemented on the area, the overall long-term impact would be 12%, which would be more appropriately regarded as the long term consequence of the modification.

Based on other extractive industry Section 75W modifications (Lynwood Quarry Modification 4 (30% increase in disturbance)), establishing precedent for such scales of proposals, and other case law establishing modifications can involve an expansion onto neighboring land, the proposed modification would have limited environmental consequences and would not constitute a radical transformation.

4.3 Other legislation and policies

A summary of the other State environment and planning legislation potentially relevant to the proposed modification is provided in **Table 4.3**.

Table 4.3 : Summary of State legislation and relevance to the proposed modification.

Planning provision	Comments	Further approvals and requirements
NSW Protection of the Environment Operations Act 1997 (POEO Act)	The POEO Act is administered by the EPA and requires licences for environmental protection including waste, air, water and noise pollution control. The EPL No. 11147 provides for crushing, grinding and separation activities between 100,000 to 500,000 tonnes per annum, and water based extractive activities with a production rate of between 100,000 and 500,000 cubic metres per annum. The proposed modification will not trigger additional scheduled activities under the POEO Act. However, variation to the EPL will be required as a result of the proposed modification in order to include the Stage 5 extraction area within the scheduled premises boundary. The requirement to vary the EPL will be confirmed by DSS via liaison with the EPA following the receipt of the notice of approval.	Yes
NSW Water Management Act 2000 (WM Act)	The WM Act is intended to ensure that water resources are conserved and properly managed for sustainable use benefitting both present and future generations. Water sharing plans prepared in accordance with the WM Act include rules for protecting the environment and administrating water licencing and trading. The proposed modification will use a combination of potable water from the urban reticulated supply and captured stormwater and wastewater from the existing site. The site is in the 'Illawarra Rivers' water source under the Water Sharing Plan for the Greater Metropolitan Region Unregulated River Water Sources. Water is currently extracted from the dredge ponds for dust suppression. Additionally, water is extracted from the ponds via moisture content in the outgoing sand product and evapotranspiration to the atmosphere. This practice will continue for the newly formed Stage 5 dredge ponds. The approved project has a water access licence (WAL) (WAL24477) issued under the WM Act. The licence permits the taking of 65 megalitres (ML) per annum of water from the Sydney Basin South Groundwater Source and is subject to a number of conditions. The proposed modification will require additional extraction of water from the dredge ponds associated	Yes

Planning provision	Comments	Further approvals and requirements
	with dust suppression and will lose water to evapotranspiration and outgoing moisture content of sand products. The proposed modification will thereby require extraction of groundwater given the dredge ponds are an exposed aquifer. Given the proposed modification is a transitional Part 3A project, by virtue of section 75U(1) of the EP&A Act, the provisions of the WM Act in regard to water use approvals under Section 89, a water management work approval under Section 90 or an activity approval under Section 91 are not applicable to the development. Currently, DSS has a Water Access Licence (WAL) and associated Water Supply Work (WSW) approval for 65 megalitres per year (ML/y) from the Sydney Basin South Groundwater source. DSS also has a WAL for an additional 15 ML/y from the Metropolitan Coastal Sands Groundwater source, however are yet to obtain a WSW for this allocation. Once a WSW is nominated (likely over the modification site) and approved, DSS will have a total of 80 ML/y available for extraction across the approved project. It is anticipated that this would cover the current operations together with the proposed modification. A further allocation of 20 ML has also been secured by DSS from the Metropolitan Coastal Sands Groundwater source, however both a WAL and WSW are pending for this allocation.	
NSW National Parks and Wildlife Act 1974 (NPW Act)	The NPW Act is the primary piece of legislation for the protection of Aboriginal cultural heritage in New South Wales. The Office of Environment and Heritage (OEH) administers the NPW Act. The NPW Act provides statutory protection for Aboriginal objects by making it illegal to harm Aboriginal objects and Aboriginal places. Under Section 86 of the NPW Act, a person must not harm or desecrate an Aboriginal object or place. In cases where harm to Aboriginal objects or places cannot be avoided, an Aboriginal heritage impact permit (AHIP) may be sought under Section 90 of the Act. An AHIP is not required for Part 3A approvals in accordance with the repealed Section 75U of the EP&A Act and therefore no further approvals are required for the proposed modification under the NPW Act. Potential impacts to Aboriginal heritage were assessed (refer to **Section 7.2**).	No
NSW Biodiversity	The BC Act aims to protect biological diversity of	Yes

Planning provision	Comments	Further approvals and requirements
Conservation Act 2016 (BC Act)	NSW and lists threatened or endangered flora and fauna species and ecological communities. Under the EP&A Act, impacts on threatened species listed under the BC Act are required to be assessed. Potential impacts to biodiversity were assessed, which identified that approximately 4.53 ha of Bangalay Sand Forest of the Sydney Basin and South East Corner bioregions endangered ecological community (EEC) will be impacted by the proposed modification. Additionally, six threatened fauna species listed under the BC Act could be impacted by the proposed modification via loss of habitat. 71 ecosystem credits and 19 species credits will be required to offset the impacts of clearing native vegetation for the proposed modification. A biodiversity offset strategy will be formulated in accordance with the requirements of the Biodiversity Assessment Method (2017) (BAM).	
NSW Heritage Act 1977 (Heritage Act)	The purpose of this Act is to conserve environmental heritage which includes places, buildings, work, relics, movable objects and precincts of State or local heritage significance. Potential impacts to historic heritage were assessed, as detailed in **Section 7.4**. Despite the presence of registered heritage items in the modification site, the proposed modification will not result in significant impacts to historic heritage and no further approvals are required under the Heritage Act.	No
NSW Roads Act 1993 (Roads Act)	Under Section 138 of the Roads Act, consent is required to erect a structure or carry out work in, on or over a public road. It is proposed to construct an intersection on Riverside Drive to facilitate access to the new Stage 5 extraction areas. As such, consent will be sought from the road authority under Section 138 of the Act to construct the intersection.	Yes
NSW Contaminated Land Management Act, 1997 (CLM Act)	This Act establishes a process for investigating, and where required remediating contaminated lands, that pose a risk to human health and the environment. The EPA Contaminated Land Record was searched in January 2019. There are no contaminated sites near the modification site.	No

Planning provision	Comments	Further approvals and requirements
	If previously unidentified contaminated materials are located during construction and operation of the proposed modification, relevant statutory requirements, including potential soil testing and waste classification, will need to be complied with, and the material managed and disposed of appropriately. No further assessment of contaminated land is therefore required.	
NSW *Waste Avoidance and Resource Recovery Act 2001* (WARR Act)	The purpose of the WARR Act is to encourage the most efficient use of resources and to reduce environmental harm in accordance with the principles of ecological sustainable development. This Act provides for the making of policies and strategies to achieve these ends. This Act promotes a hierarchy of avoidance of unnecessary resource consumption; resource recovery (including reuse, reprocessing, recycling and energy recovery), and disposal (as a last resort). The construction and operation of the proposed modification will assist in achieving the actions and goals for the management of waste in accordance with this Act by: ▪ re-using infrastructure at the approved project site where feasible; ▪ purchasing recycled products where appropriate; ▪ developing and implementing waste management procedures to minimise the generation of waste and where unavoidable, re-use waste on-site; ▪ recycling as many wastes as practically possible through appropriate handling, separation, storage, and collection; and ▪ where waste cannot be re-used or recycled, transportation and disposal of waste off-site at an appropriately licensed facility.	No
NSW Coastal Management Act 2016 (CM Act)	The objectives of the CM Act are to manage the coastal environment of NSW in a manner consistent with the principles of ecologically sustainable development for the social, cultural and economic well-being of the people of the State. The CM Act defines the coastal zone, comprising four coastal management areas: 1. coastal wetlands and littoral rainforests area; 2. coastal vulnerability area; 3. coastal environment area; and 4. coastal use area. The CM Act establishes management objectives	No

Planning provision	Comments	Further approvals and requirements
	specific to each of these management areas, reflecting their different values to coastal communities. The CM Act is supported by State Environmental Planning Policy (Coastal Management) 2018, which maps coastal zones within NSW, and provides obligations for development applications. The modification site is within a mapped coastal environment area as further detailed in **Section 4.3.1**.	
NSW Fisheries Management Act 1994 (FM Act)	The objectives of this Act are to conserve, develop and share the fisheries resources of NSW for the benefit of present and future generations. Various permits are required for certain activities that have the potential to impact waterways and associated fishery resources. The Stage 5A extraction area is located within the 'proximity area for coastal wetlands' defined under the Coastal Management SEPP and within approximately 150 m of mangrove areas within the Minnamurra River and 250 m of mangrove areas within Rocklow Creek. The Stage 5B extraction area is also located approximately 160 m from saltmarsh and mangrove areas on the tidal flats of the Minnamurra River. The above adjacent aquatic areas are considered 'Type 1 – Highly sensitive key fish habitat' due to their coastal wetland characterisation and the presence of mangrove, saltmarsh and seagrass communities. Given the proposed modification is a transitional Part 3A project, by virtue of section 75U(1) of the EP&A Act, the provisions of the FM Act in regard to approvals under Section 201 (dredging and reclamation), 205 (marine vegetation) or 219 (fish passage) are not applicable to the development. Nevertheless, key objectives of the FM Act have been considered in the design of the proposed modification and recommended management measures summarized in **Section 7.7**.	No

4.3.1 State environmental planning policies

The relevant State environmental planning policies (SEPP) which need to be considered in relation to the proposed modification are outlined below.

State Environmental Planning Policy (Mining, Petroleum Production and Extractive Industries) 2007

This SEPP regulates the permissibility of mining, extractive industries and related development and specifies matters that must be considered in assessing extractive industry developments requiring consent under the EP&A Act.

The proposed modification is not exempt or complying development under the SEPP and therefore requires consent. Accordingly, the Minister for Planning is the consent authority under Section 75W of the EP&A Act.

Part 3 of the SEPP identifies matters for consideration by the consent authority in determining an application for consent for the purposes of mining, petroleum production or extractive industries.

The following sections outline the compatibility of activities associated with the proposed modification with clauses 12 to 17 of Part 3 of the SEPP.

Clause 12

Clause 12 of the SEPP requires consideration of the compatibility of the development with other land uses in the vicinity. Potential impacts of the proposed modification on surrounding land uses have been considered in this EA. The EA has demonstrated that the proposed modification will not result in a significant impact on existing or adjacent land uses. Environmental control measures will be implemented to avoid or minimise identified impacts.

As highlighted in **Chapter 5**, neighbouring landowners have been informed of the proposed modification and consulted to identify potential impacts on existing uses. DSS also holds regular Community Consultative Committee meetings which allow the community to raise any incompatibility issues between the approved operations and existing land uses and allows DSS to work with the community to resolve these issues.

Clause 12A of the SEPP requires consent authorities to consider any applicable provisions of the NSW Government's (2014) *Voluntary Land Acquisition and Mitigation Policy* before determining an application for consent for the purposes of mining, petroleum production or extractive industry.

The provisions of the Voluntary Land Acquisition and Mitigation Policy have been considered in the noise and air quality impact assessments and it was concluded that the policy is not applicable to the proposed modification.

Clause 13

Clause 13 of the SEPP requires a consent authority, prior to determining a development application, to consider whether the proposed development is likely to:

- have a significant impact on current or future extraction or recovery of extractive materials (including by limiting access to those resources); and
- be incompatible with any existing or approved mine or extractive industry in the vicinity.

The proposed modification will not result in the long-term sterilisation of extractive resources associated with the approved project, nor sterilise any mineral resources or result in any negative impacts on the operations of the approved project.

Clause 14

Clause 14 of the SEPP requires that the consent authority must consider whether or not the consent should be issued subject to conditions aimed at ensuring that the development is undertaken in an environmentally responsible manner, including conditions to ensure the following:

- impacts on significant water resources, including surface and groundwater resources, are avoided, or are minimised to the greatest extent practicable;
- impacts on threatened species and biodiversity, are avoided, or are minimised to the greatest extent practicable; and
- greenhouse gas emissions are minimised to the greatest extent practicable.

The potential impacts of the proposed modification on groundwater and surface water resources are discussed in **Section 7.1** and **7.7** respectively, including management measures that will be implemented to minimise potential impacts.

The potential impacts of the proposed modification on threatened species and biodiversity are described in **Section 7.3** and include management and mitigation measures to be implemented in order to minimise potential impacts.

The potential for impacts associated with greenhouse gas emissions are considered in **Section 7.10.4**.

Clause 15

Clause 15 of the SEPP requires the consent authority to consider the efficiency of the development in terms of resource recovery and the minimisation of waste associated with the extraction, recovery or processing of extractive materials.

The proposed modification will be near the approved project and sand will be transferred to the Stage 2 processing area via a pipeline, which will eliminate the necessity to haul sand on public roads.

The transfer of extracted sand via a closed pipeline directly to the processing area in Stage 2 will also eliminate the potential for waste material to be generated such as spillages of sand material during road transportation to the processing area, as well as reduce greenhouse gas emissions.

As outlined in **Section 7.10.7**, the proposal will continue to manage waste in accordance with the waste hierarchy in the WARR Act.

Clause 16

Clause 16 of the SEPP requires the consent authority to consider the implications of transporting extractive materials from the development on public roads.

The proposed pipeline will convey dredged sand from the Stage 5 extraction area to the Stage 2 processing plant. Transferring the sand via pipeline will eliminate the requirement for haulage of sand on public roads.

Following processing, sand will be transported from the approved project site via road in accordance with the existing Project Approval and in line with current practices.

Clause 17

Clause 17 of the SEPP requires the consent authority to consider whether consent should be issued subject to conditions regarding rehabilitation of the modification site.

The Stage 5A extraction area will be landscaped and rehabilitated in accordance with Boral's (2017) *Dunmore Sand and Soil Project Rehabilitation Management Plan*, which was prepared as a condition of the approved project. The management plan will be updated to include the new Stage 5 extraction area.

The proposed Stage 5B extraction area will be left as a waterbody upon completion of the works at the request of the landowner.

State Environmental Planning Policy (Coastal Management) 2018

The aim of the Coastal SEPP is to promote an integrated and co-ordinated approach to land use planning in the coastal zone in a manner consistent with the objects of the CM Act.

The modification site is in a 'coastal environment area'. The proposed Stage 5A extraction area is on land identified as a 'proximity area for coastal wetlands' and the Stage 5B extraction area is adjacent to land identified as a 'proximity area for coastal wetlands'.

In accordance with clause 11 of the Coastal SEPP, prior to granting consent to a proposed development, a consent authority must be satisfied that the proposed development will not have a significant impact upon:

(a) the biophysical, hydrological or ecological integrity of the adjacent coastal wetland or littoral rainforest, or

(b) the quantity and quality of surface and ground water flows to and from the adjacent coastal wetland or littoral rainforest.

As identified in **Section 7.1, 7.3** and **7.7**, potential indirect impacts from the modification can be managed so that there will not be significant impacts on the biophysical, hydrological or ecological integrity of the Minnamurra River coastal wetland, nor compromise the quantity and quality of surface and groundwater flows to and from the wetland.

In accordance with Clause 13 of the Coastal SEPP, prior to granting consent to a proposed development, a consent authority must be satisfied that the proposed development will not have an adverse impact upon:

(a) the integrity and resilience of the biophysical, hydrological (surface and groundwater) and ecological environment,

(b) coastal environmental values and natural coastal processes,

(c) the water quality of the marine estate (within the meaning of the Marine Estate Management Act 2014), in particular, the cumulative impacts of the proposed development on any of the sensitive coastal lakes identified in Schedule 1,

(d) marine vegetation, native vegetation and fauna and their habitats, undeveloped headlands and rock platforms,

(e) existing public open space and safe access to and along the foreshore, beach, headland or rock platform for members of the public, including persons with a disability,

(f) Aboriginal cultural heritage, practices and places,

(g) the use of the surf zone.

Development consent must not be granted unless the consent authority is satisfied that:

(a) the development is designed, sited and will be managed to avoid an adverse impact referred to in subclause (1), or

(b) if that impact cannot be reasonably avoided—the development is designed, sited and will be managed to minimise that impact, or

(c) if that impact cannot be minimised—the development will be managed to mitigate that impact.

If not appropriately mitigated and managed, the proposed modification has the potential to adversely impact upon biodiversity and Aboriginal cultural heritage values, and have potential to

adversely impact upon hydrological regimes. The proposed modification will not adversely impact upon other attributes listed in Clause 13 of the Coastal Management SEPP.

The modification was developed in consideration of the Coastal SEPP. The initial footprint of the Stage 5B extraction area was reduced to avoid or minimise impacts on ecologically significant vegetation and the proximity area for the coastal wetland.

Management measures will be implemented to reduce impacts to biodiversity, Aboriginal cultural heritage and hydrological regimes.

State Environmental Planning Policy No. 33 – Hazardous and Offensive Development

SEPP No. 33 requires the consent authority to consider whether a development proposal is a potentially hazardous industry or a potentially offensive industry.

The proposed modification will require the use of hazardous materials and has the potential to constitute an offensive development.

As outlined in **Section 7.10.6** of this EA, the project is not classified as hazardous or offensive industry under SEPP No. 33. As such, no further assessment in the form of a preliminary hazard analysis (PHA), required under Clause 12 of the SEPP, is warranted.

4.4 Local environmental planning instruments

4.4.1 Shellharbour Local Environment Plan 2013

Local environmental plans are environmental planning instruments that guide planning decisions for local government areas and allow councils to manage the way in which land is used through zoning and development consents.

The majority of the proposed modification site is zoned RU2 – Rural Landscape zone under the Shellharbour Local Environmental Plan (LEP) 2013. The southern portion of Stage 5B extraction area is zoned E3 – Environmental Management. Extractive industries are not permitted within these zones, however agricultural land uses are permitted with consent. By virtue of Section 7, Clause 3 (a) of State Environmental Planning Policy (Mining, Petroleum Production and Extractive Industries) 2007, extractive industries are permitted with consent on land where development for the purposes of agriculture or industry is permitted.

Land to the east and south of the modification site is zoned E2 – Environmental Conservation and E3 – Environmental Management, and this land is associated with environmental conservation areas of Minnamurra River and associated Coastal SEPP wetland.

The E2 zoning also runs along the northern fringe of Riverside Drive opposite the Stage 5A extraction area, generally within the road reserve area of Riverside Drive, whilst the balance of Riverside Drive and the Princes Highway are zoned as SP2 – Infrastructure.

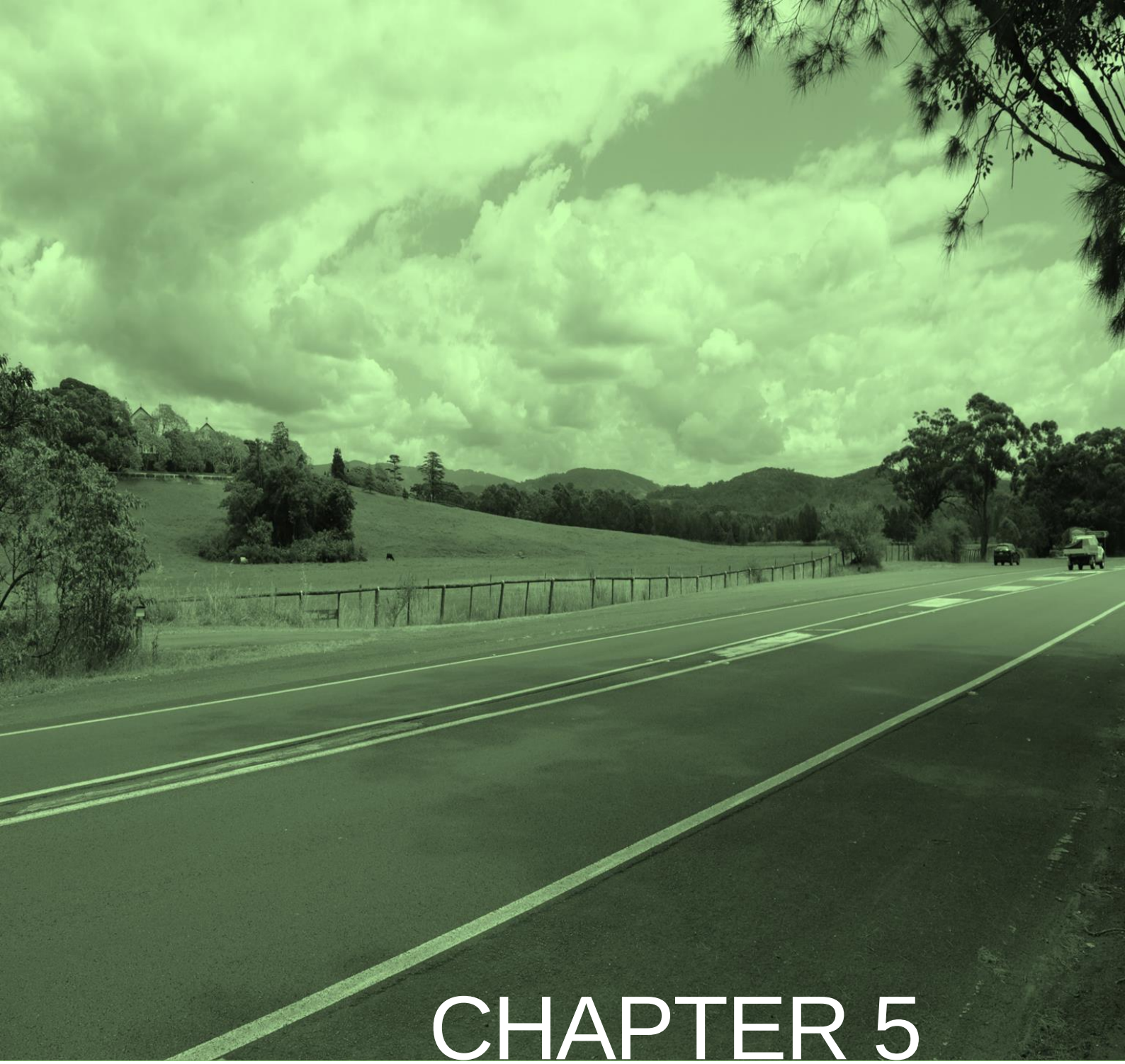
The RU2 zone objectives are:

- to encourage sustainable primary industry production by maintaining and enhancing the natural resource base;
- to maintain the rural landscape character of the land; and
- to provide for a range of compatible land uses, including extensive agriculture.

The E3 zone objectives are:

- to protect, manage and restore areas with special ecological, scientific, cultural or aesthetic values;
- to provide for a limited range of development that does not have an adverse effect on those values; and
- to retain and enhance the visual and scenic qualities of the Illawarra Escarpment.

This EA demonstrates that the proposed modification, if implemented in accordance with the additional environmental controls, mitigation and monitoring measures proposed in this EA and the biodiversity offset strategy to be formulated, can be carried out in a manner which upholds the objectives of the respective zones and is consistent with other objectives of the Shellharbour LEP.



CHAPTER 5

STAKEHOLDER CONSULTATION

5 STAKEHOLDER CONSULTATION

Preparation of the EA involved consultation with DP&E, Shellharbour City Council, key government agencies and the local community.

Comments obtained through the consultation process assisted in identifying all environmental and social issues associated with the proposed modification and have been considered in:

- the assessment of impacts associated with the proposed modification;
- selecting the location of and preparing the concept design for the proposed extraction areas and supporting infrastructure; and
- developing appropriate safeguards and environmental management measures.

Table 5.1 provides a summary of the issues that have been raised during stakeholder and community consultation and provides reference to the section of the EA in which these issues have been addressed.

All relevant government stakeholders, Aboriginal stakeholders and the local community will be advised of the public exhibition of the EA. A copy of the EA will be made available for review on DP&E's website, and at the Shellharbour City Council office.

Once the EA has been exhibited, DSS will prepare a response to submissions report, if required, summarising the issues and concerns raised in written submissions, prior to determination of the modification application.

Table 5.1: Summary of stakeholder consultation

Stakeholder	Consultation details	Comments	Response/EA section reference
DP&E	Initial notification of the proposed modification submitted to DP&E on 15 November 2016. Email correspondence was provided to DP&E on 1 November 2018 to confirm the relevant planning pathway for the application.	A letter was received from DP&E on 21 December 2018 confirming that the Department would consider the proposal under Section 75W of the EP&A Act providing the Environmental Assessment was provided to the Department by no later than 28 February 2018.	Refer to letter correspondence from DP&E in **Appendix C**.
Shellharbour City Council	Shellharbour City Council was issued a letter introducing the proposed modification on 3 December 2018. The letter advised that the EA was currently being prepared and Council was invited to discuss the modification, advise if they required any considerations in the EA, or state whether they had no comments and would like to await exhibition of the EA.	A letter was received from Council on 24 January 2019 stating that they would discuss the matter and provide a response in near future. A subsequent response was also received from the Senior Development Officer at Council on 5 February 2019. Council noted that the modification application should consider the provisions of clause 7(3) of the State Environmental Planning Policy (Mining, Petroleum Production and Extractive Industries) 2007. Council also noted the modification site is located within an area covered by the State Environmental Planning Policy (Coastal Management) 2018, is located within the curtilage of local heritage listings and contains potential for Aboriginal heritage items. Council requested a Statement of Heritage Impact be prepared along with a supporting Aboriginal assessment. Council recommended that extensive community consultation be undertaken prior to lodgement of the application. It is considered that all comments provided by Council have been addressed in full by this EA and the respective specialist assessments.	Refer to letter correspondence from Council in **Appendix C**. Statement of Heritage Impact: **Appendix G** and **Section 7.4**. Aboriginal cultural heritage assessment: **Appendix E** and **Section 7.2**.

Stakeholder	Consultation details	Comments	Response/EA section reference
NSW Department of Industry (Water)	The DoI (contact Wayne Conners) was issued a letter introducing the proposed modification on 3 December 2018. The letter advised that the EA was currently being prepared and DoI was invited to discuss the modification, advise if they required any considerations in the EA, or state whether they had no comments and would like to await exhibition of the EA.	Water NSW (contact Martin Holland) responded via email on 22 January 2019 advising they would review the project and provide a response. Water NSW were invited to inspect the site on 29 January 2019 however had to decline due to other workload arrangements. Water NSW responded on 30 January 2019 advising that Boral should contact the Natural Resources Access Regulator (NRAR) regarding the modification, who would advise on the need for Water NSW involvement. The NRAR was contacted on 5 February 2018 and were invited to discuss the modification, advise if they required any considerations in the EA, or state whether they had no comments and would like to await exhibition of the EA. NRAR advised that due to resourcing constraints, they would review the documents once submitted to the DP&E.	Surface water assessment: **Appendix J** and **Section 7.7**.
Office of Environment and Heritage (OEH)	The OEH (contact Calvin Houlison) was issued a letter introducing the proposed modification on 3 December 2018. The letter advised that the EA was currently being prepared and OEH was invited to discuss the modification, advise if they required any considerations in the EA, or state whether they had no comments and would like to await exhibition of the EA.	A response was received from OEH on 4 December 2018, and made the following comments: ▪ the proposed extraction areas at Stages 5A and 5B appear to result in the clearing of scattered trees, and are adjacent to areas of Illawarra Lowlands Grassy Woodland and Bangalay Sand Forest threatened ecological communities. Direct and indirect impacts upon biodiversity should be assessed in accordance with the *NSW Biodiversity Conservation Act 2016* and documented in a Biodiversity Development Assessment Report (BDAR). The extent of the EECs should be ground truthed in accordance with OEH survey guidelines, and	Refer to letter correspondence from OEH in **Appendix C**. Aboriginal heritage assessment: **Appendix E** and **Section 7.2**. Surface water assessment: **Appendix J** and **Section 7.7**. Groundwater assessment: **Appendix D** and **Section 7.1**.

Stakeholder	Consultation details	Comments	Response/EA section reference
		the proposal's impacts upon these EECs should be quantified in the EA. OEH recommended that impacts upon biodiversity are avoided or mitigated wherever possible, with any residual impacts to be offset in accordance with the Biodiversity Assessment Method (BAM); ▪ the site is located within a landscape of high Aboriginal cultural heritage sensitivity, and a number of AHIMS-listed sites are located within the surrounds. OEH recommended an Aboriginal Cultural Heritage Assessment Report (ACHAR) be carried out in accordance with relevant OEH guidelines, namely the *Code of Practice for Archaeological Investigation of Aboriginal Objects in NSW* (2010) and the *Guide to investigating, assessing and reporting on Aboriginal cultural heritage in NSW* (2011). Consultation should be undertaken and documented in accordance with the *Aboriginal cultural heritage consultation requirements for proponents* (2010). Given the landscape sensitivity, OEH would welcome the opportunity for further early consultation regarding the proposed investigations including any test excavations that may be required; and ▪ the EA should demonstrate how the proposal is consistent with the SEPP (Coastal Management) 2018 and contributes to maintaining water quality objectives in sensitive receiving waters of the nearby Minnamurra River estuary. Surface and groundwater assessments should be undertaken as part of the EA to quantify the proposal's impact on water quality.	

Stakeholder	Consultation details	Comments	Response/EA section reference
		OEH requested the opportunity to review and comment on the EA once exhibited. It is considered that all comments provided by OEH have been addressed in full by this EA and the respective specialist assessments.	
Environment Protection Authority (EPA)	The EPA (contact Matthew Fuller) was issued a letter introducing the proposed modification on 3 December 2018. The letter advised that the EA was currently being prepared and EPA was invited to discuss the modification, advise if they required any considerations in the EA, or state whether they had no comments and would like to await exhibition of the EA.	No response was received from the EPA. Follow up consultation was made on 10 January 2019 and 30 January 2019 however no response was received.	N/A
NSW Department of Primary Industries (Fisheries)	DPI (contact Scott Carter) was issued a letter introducing the proposed modification on 3 December 2018. The letter advised that the EA was currently being prepared and DPI was invited to discuss the modification, advise if they required any considerations in the EA, or state whether they had no comments and would like to await exhibition of the EA.	A response was received from DPI on 19 December 2018, and made the following comments: ▪ the proposed expansion areas are situated adjacent to Minnamurra River and land identified as “coastal wetland”. Parts of the proposal areas are located within land identified as “proximity zone for coastal wetlands” Coastal Wetlands and the Minnamurra River are considered to be Type 1 (highly sensitive), Class 1 (Major) Key Fish Habitats. The Coastal Management SEPP 2018 aims to protect, and where possible enhance the biophysical, hydrological and ecological integrity of these sensitive areas. ▪ the potential impact of the development upon the aquatic habitats and fish communities in the adjacent wetland and waterway from discharge of sediment laden waters, particularly during high rainfall events, as well as groundwater drawdown is of particular interest to this	Refer to email correspondence from DPI in **Appendix C**. Biodiversity assessment: **Appendix F** and **Section 7.3**. Surface water assessment: **Appendix J** and **Section 7.7**. Groundwater assessment: **Appendix D** and **Section 7.1**.

Stakeholder	Consultation details	Comments	Response/EA section reference
		Department. DPI Fisheries advised that the following requirements should be addressed in the environmental assessment: ▪ description of aquatic environments (watercourses, wetlands) located on the site or adjacent to the site and their regional significance; ▪ predictions of any impacts of the development upon riparian or aquatic environments, both at the site and downstream (both temporary and permanent, including groundwater drawdown). ▪ Predictions of any impacts upon water quality and aquatic threatened species, populations and ecological communities listed under the *Fisheries Management Act 1994*. ▪ Safeguards to mitigate any impacts upon aquatic environments and riparian habitats (e.g. full details of proposed riparian buffer zones and any riparian rehabilitation and revegetation plans). ▪ Safeguards to mitigate any impacts upon water quality and any threatened species, including impacts from drawdown. In particular, - details of proposed erosion and sediment control during construction (to be incorporated into a Construction Environmental Management Plan – CEMP); - proposed water quality monitoring downstream of the development site.	

Stakeholder	Consultation details	Comments	Response/EA section reference
		▪ Details of any proposed waterway crossings or possible obstruction of fish passage. DPI Fisheries recommends the inclusion of riparian corridors wherever possible to provide a buffer between the development areas and adjacent waterways or natural drainage lines to provide protection to riparian and aquatic habitats. The DPI Fisheries policy is that the width of the riparian buffer zone adjacent to Type 1 habitats should be at least 100 metres as measured from the top of the bank. Where the riparian zone is degraded or disturbed due to past use or development works, rehabilitation of the zone is recommended including planting of endemic riparian vegetation. Retention and replanting of native riparian vegetation will help to protect receiving waters from erosion and runoff and benefit fish habitat. DPI Fisheries requested the opportunity to review and comment on the EA once exhibited. It is considered that all comments provided by DPI Fisheries have been addressed in full by this EA and the respective specialist assessments.	
NSW Roads and Maritime Services (RMS)	A meeting was held between representative of Boral and RMS on 19 November 2018 to discuss the possibility of placing the pipeline alignment within RMS land. RMS (contact Rachel Carocci) was issued a follow up letter introducing the proposed modification on 3 December 2018. The letter advised that the EA was currently being prepared and RMS was invited to discuss the	A letter response was received from RMS on 17 December 2018 and advised that the following requirements should be addressed in the environmental assessment: ▪ a traffic impact study (TIS) is required. As a guide Table 2.1 of the RTA Guide to Traffic Generating Developments outlines the key issues that may be considered in preparing a TIS. In addition, the TIS must also address the	Refer to email correspondence from RMS in **Appendix C**. Traffic impact assessment: **Appendix K** and **Section 7.9**.

Stakeholder	Consultation details	Comments	Response/EA section reference
	modification, advise if they required any considerations in the EA, or state whether they had no comments and would like to await exhibition of the EA.	following: - details on road transport routes to be used to provide access to/from the site, including a comparison of the routes used under current operations compared to the proposed. - details of existing movements along the road network and likely additional movements to and from the development site onto the Princes Highway, including the types of vehicles, peak hour movements and maximum daily movements. - the existing traffic volumes (based on survey) using the junction of the Princes Highway and Riverside Drive. The traffic study needs to consider the likely impact of the additional traffic associated with the proposed development including the suitability of the existing junctions against Austroads standards, the associated need for upgrades and interruptions to traffic flow on the Princes Highway; and - the identification of any suitable infrastructure required to ameliorate any traffic impacts and safety impacts associated with the development including the provision of supporting plans. ▪ intersection modelling using SIDRA needs to be undertaken for the intersections of the Princes Highway and Riverside Drive to demonstrate that an acceptable level of service is maintained and assist in determining if upgrade works are required to facilitate the	

Stakeholder	Consultation details	Comments	Response/EA section reference
		proposed development. The intersection modelling needs to give consideration to the following: - full development of the site. - AM and PM peaks volumes. - existing traffic volumes with and without development and 10 year projected volumes with and without the development. - the base SIDRA models must be calibrated with on-site observations in the AM and PM peak. This can be done by measuring existing queue lengths and delays. - electronic copies of all SIDRA files needs to be provided to RMS for review It is considered that all comments provided by RMS have been addressed in full by this EA and the traffic impact assessment **(Appendix K**).	
Aboriginal Community Consultation	Thorough consultation was undertaken with Aboriginal parties in accordance with *OEH Aboriginal Cultural Heritage Consultation Requirements for Proponents 2010* (OEH, 2010). Nineteen Aboriginal groups or individuals registered their interest in the proposed modification and contributed cultural knowledge and archaeological expertise to the Aboriginal heritage assessment process.	The registered Aboriginal parties were invited to make comment on the draft Aboriginal Cultural Heritage Assessment on 24 January 2018.	Aboriginal heritage assessment: **Appendix E** and **Section 7.2**.
Neighbouring residences and community	An overview of the proposed modification and other ongoing activities was provided to Dunmore Community Consultative Committee on 20 February 2019; there are two committees, one for each consent. The two CCC's consider not only Dunmore Hard Rock Quarry activities,	No comments or concerns received to date.	N/A

Stakeholder	Consultation details	Comments	Response/EA section reference
	but also activities relating to DSS. Engagement was also completed with the Minnamurra Progress Association, in order to provide an update as to the progress of the modification application, due to consultation being completed with the Association in the past. Presentations were made at the meeting held on 5 March 2019. Further consultation with the community was completed through the Kiama North Precinct Community Meeting, where Boral representatives made presentations and answered questions at the 13 March 2019 meeting. Approximately 30 people attended this meeting, including one Kiama Councillor and the Convenor of the equivalent Central Precinct Committee. With regard to electronic communications, the Boral Dunmore website has been updated, which was then circulated through the community via a targeted Facebook post, ensuring information about the project has been circulated to followers in the community. An approximate 'potential reach' of this campaign resulted in some 4000 localised users being engaged. Contact was been made via mail to the adjoining landowner at 431 Riverside Drive, as well as the Minnamurra Recycling Depot, with contact details provided to them in order to be able to reach out to Boral with regard to any queries/concerns they may have. A meeting was held with this resident and other residents		

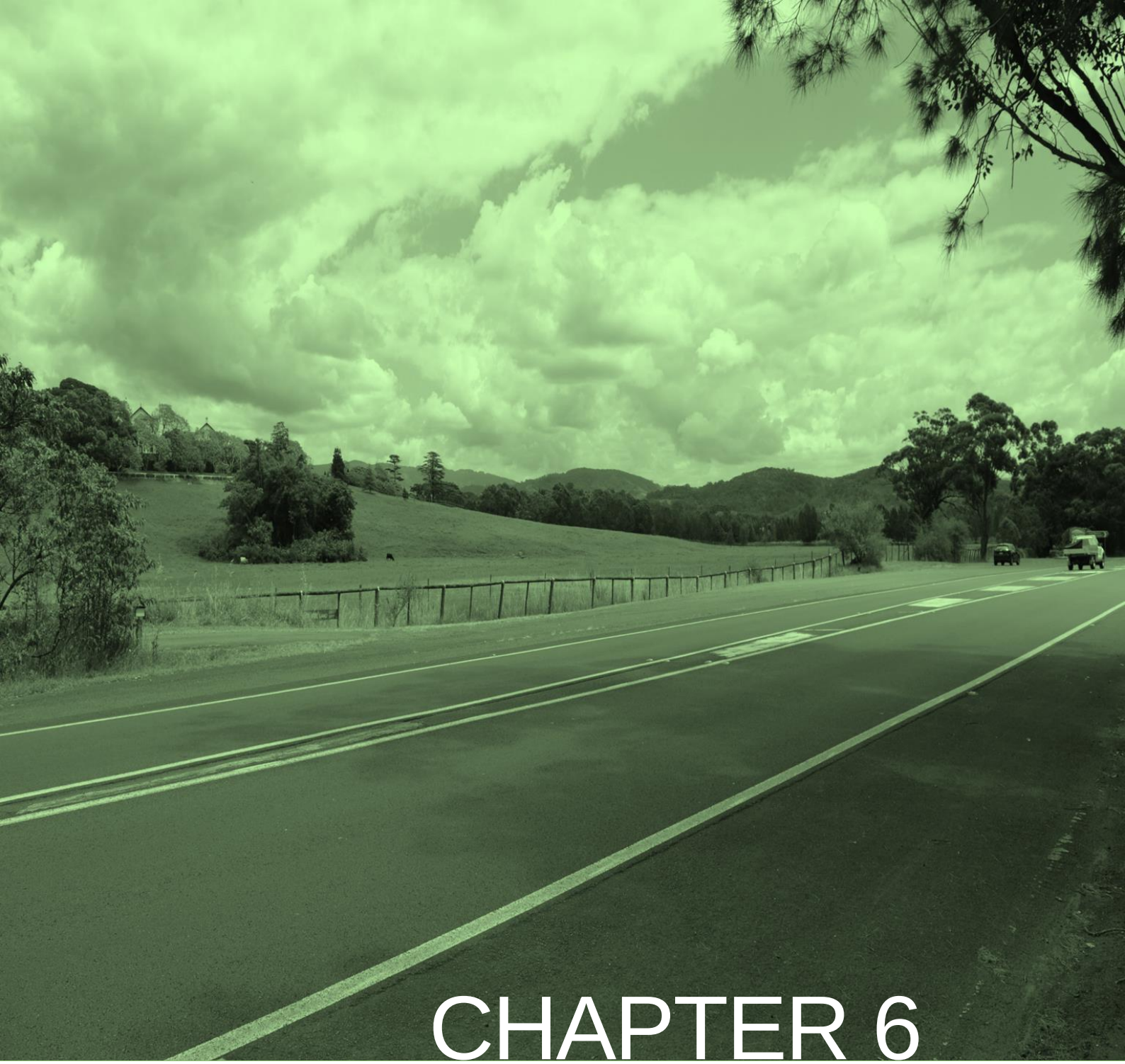
Stakeholder	Consultation details	Comments	Response/EA section reference
	in the region to go through the proposed modification, at the site's offices on 10 April 2019. A total of 9 individuals attended the meeting where the modification more generally was discussed, as well has ecological and water related matters. On the same evening, consultation was completed with the North Kiama Precinct meeting, where approximately 15 people were in attendance.		

As demonstrated in **Table 5.1**, all issues raised by stakeholders and the community have been considered in this EA and during the preparation of technical specialist assessments.

DSS is committed to the timely, orderly, consistent and credible dissemination of appropriate information within the constraints of legal and regulatory requirements to all interested stakeholders and the community.

Consultation with stakeholders will continue through the life of the modification of the approved project to:

- maintain strong and effective relationships with the community;
- ensure the community remains informed of the progress of the modification to the approved project; and
- disseminate the outcomes of the EA assessment process for the modification to the approved project.



CHAPTER 6

ENVIRONMENTAL RISK ASSESSMENT

6 ENVIRONMENTAL RISK ASSESSMENT

6.1 Identification of potential environmental impact

Environmental risks were assessed **prior** to preparation of the EA to identify the key potential environmental issues or impacts associated with the proposed modification.

Each environmental factor has been ranked based on the likelihood of occurrence and the perceived consequence of effects if left unmanaged. It **did not** consider the potential outcomes of specialist technical assessments and the application of mitigation measures to manage the environmental factor. These specialist technical studies have subsequently demonstrated that suitable mitigation measures are likely to minimise any potential adverse impacts.

6.2 Risk rating assessment criteria

The allocation of risk is based on the considerations in **Table 6.1**, **Table 6.2** and **Table 6.3**.

Table 6.1: Allocation of risk based on likelihood of occurrence

Definition	Likelihood of occurrence Risk rating
High probability of occurring	High
Potential to occur	Medium
Unlikely to occur	Low

Table 6.2: Allocation of risk based on consequence of unmanaged effects

Definition	Consequence of unmanaged effects Risk rating
Adverse environmental change; inter-regional implications; serious or long-term cumulative impacts, offsets not readily available.	High
Moderate adverse environmental change; regional implications; modest or medium-term cumulative impacts; offsets available, scientific value possible.	Medium
Minor environmental change; localised implications; imperceptible or short-term cumulative impacts; offsets readily available.	Low

Table 6.3: Environmental factors priority matrix

	Consequence of unmanaged effects		
Likelihood of occurrence	3 High	2 Medium	1 Low
1 Low	4 (Medium)	3 (Low)	2 (Low)
2 Medium	5 (High)	4 (Medium)	3 (Low)
3 High	5 (High)	5 (High)	4 (Medium)

6.3 Risk analysis for the proposed modification

The key environmental aspects (high or medium risk rating) warranting detailed technical assessment have been identified through:

- the existing environmental context of the proposed modification and the surrounding locality (sensitive receivers, physical environment and management practices);
- consultation with stakeholders (government agencies and the community);
- preliminary environmental risk analysis outcomes (high or medium risk rating);
- technical specialist assessments; and
- the legislative framework that underpins the development.

For those environmental aspects that achieved a low risk rating in the preliminary environmental risk analysis, further specialist technical investigations were not considered necessary given the low risk they represent. Risk ratings outlined in **Table 8** are prior to mitigation measures being employed. With the implementation of mitigation measures identified in this EA, the risk rating for each environmental factor would anticipated to be 'low'.

Table 9 provides a summary of all the environmental and social aspects that have been considered in the EA and provides reference to the section of the EA in which these aspects have been addressed.

Table 6.4: Risk rating for environmental factors

Environmental factor	Risk rating	Potential impacts	EA reference	Resultant Risk Rating
Groundwater	Medium	The proposed modification will intercept groundwater and will require sand to be predominantly extracted by dredging. Therefore, the modification has the potential to impact on groundwater volume, hydraulic gradients and quality.	Refer to **Section 7.1** and **Appendix D**.	Low Appropriate mitigation measures, as detailed in the **Section 7.1** will be implemented to minimise the potential risk.

Environmental factor	Risk rating	Potential impacts	EA reference	Resultant Risk Rating
Aboriginal heritage	Medium	The proposed modification will be on land that has not been previously assessed for Aboriginal heritage values. Despite this area being subject to a history of surface disturbance associated with livestock grazing and agricultural land use, given the soil profile and position of the modification site in proximity to Rocklow Creek and Minnumurra River, the modification site has the potential to support Aboriginal artefacts and other cultural heritage values.	Refer to **Section 7.2** and **Appendix E**.	Low Appropriate mitigation measures, as detailed in the **Section 7.2** will be implemented to minimise the potential risk.
Biodiversity	Medium	The proposed modification will require the clearing of native vegetation to allow for the new extraction areas and supporting infrastructure. This activity has the potential to impact on threatened species (flora and fauna) and endangered ecological communities.	Refer to **Section 7.3** and **Appendix F**.	Low Appropriate mitigation measures, as detailed in the **Section 7.3** will be implemented to minimise the potential risk.
Historic heritage	Medium	The proposed modification will be in the curtilage of local heritage items and without adequate management, the works could adversely impact the heritage significance of the items.	Refer to **Section 7.4** and **Appendix G**.	Low Appropriate mitigation measures, as detailed in the **Section 7.4** will be implemented to minimise the potential risk.

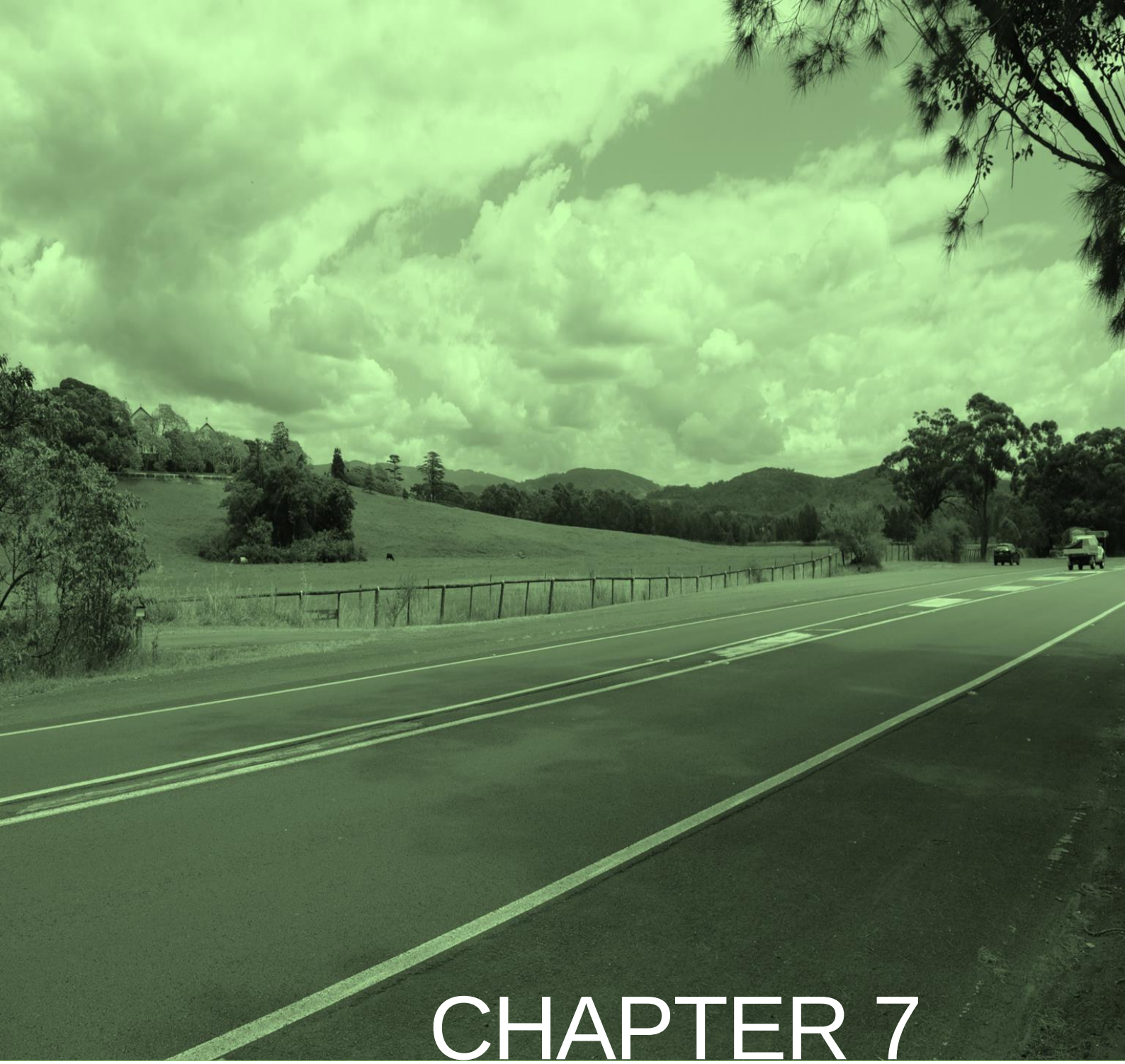
Environmental factor	Risk rating	Potential impacts	EA reference	Resultant Risk Rating
Air quality	Medium	The proposed modification combined with air emissions from the approved project and other extractive industries and agricultural uses in the area has the potential to result in cumulative air quality impacts at sensitive receivers. As the proposed modification is largely a wet process, involving the dredging of sand, dust emissions are not predicted to be significant.	Refer to **Section 7.5** and **Appendix H**.	Low Appropriate mitigation measures, as detailed in the **Section 7.5** will be implemented to minimise the potential risk.
Noise	Medium	The proposed modification combined with noise emissions from the approved project, other extractive industries in the area and road traffic along Riverside Drive and the Princes Highway has the potential to result in cumulative noise impacts at sensitive receivers. However, due to the distance to the nearest sensitive residential receivers, and the Princes Highway traffic being the dominant noise in the local area, noise emissions from the proposed modification are not predicted to be significant.	Refer to **Section 7.6** and **Appendix I**.	Low Appropriate mitigation measures, as detailed in the **Section 7.6** will be implemented to minimise the potential risk.

Environmental factor	Risk rating	Potential impacts	EA reference	Resultant Risk Rating
Surface water	Medium	Dredging will be in extremely porous sands. As a result, rainfall that lands in the catchment of the extraction areas will percolate into the soil quickly due to the downward pressure gradient to the underlying aquifer and not result in overflows from the dredging ponds other than during extreme rainfall events. Uncontrolled surface water runoff from the proposed modification has the potential to impact on the quality and quantity of water discharged to Rocklow Creek and the Minnamurra River and associated coastal wetland.	Refer to **Section 7.7** and **Appendix J**.	Low Appropriate mitigation measures, as detailed in the **Section 7.7** will be implemented to minimise the potential risk.
Visual amenity	Medium	The proposed modification will result in temporary and permanent changes to views of adjoining residents, as well as passing motorists along the Princes Highway and Riverside Drive.	Refer to **Section 7.8**.	Low Appropriate mitigation measures, as detailed in the **Section 7.8** will be implemented to minimise the potential risk.

Environmental factor	Risk rating	Potential impacts	EA reference	Resultant Risk Rating
Traffic and transport	Medium	The proposed modification will not increase existing heavy vehicle moments associated with exportation of outgoing sand products currently consented by the approved project. DSS propose to import up to 325,000 tonnes of VENM by road per annum to the Stage 5 extraction area. This activity will require heavy vehicle movements along the Princes Highway and Riverside Drive to access the modification site. Therefore, the proposed modification has the potential to impact on the capacity of Riverside Drive, the Princes Highway and other main heavy vehicle transport routes and associated intersections.	Refer to **Section 7.9** and **Appendix K**.	Low Appropriate mitigation measures, as detailed in the **Section 7.9** will be implemented to minimise the potential risk.
Land contamination	Low	There is potential to discover or disturb known or unexpected contamination in soil and groundwater at the site given its position within an area of historical agricultural land use.	Refer to **Section 7.10.1**.	Low

Environmental factor	Risk rating	Potential impacts	EA reference	Resultant Risk Rating
Acid sulfate soils	Low	The proposed modification is positioned within an area with mapped risk of ASS. As the proposed dredging activities will be below the water table and potentially expose sandy soils to oxygen, assessment of potential ASS constraints at the site is required.	Refer to **Section 7.10.2** and **Appendix L**.	Low
Rehabilitation	Low	Disturbed areas will need to be rehabilitated to prevent air quality, erosion and sedimentation impacts from unstabilised surfaces. Rehabilitation will also be required to reduce long term visual impacts to adjacent residents and passing motorists.	Refer to **Section 7.10.3**.	Low
Greenhouse gas	Low	The proposed modification will not result in an increase in total production volumes for the approved project or the means of finished product transportation by road network. Minor quantities of greenhouse gas emissions will result from operation of plant and machinery such as the dredge and heavy vehicles importing VENM to the modification site.	Refer to **Section 7.10.4**.	Low

Environmental factor	Risk rating	Potential impacts	EA reference	Resultant Risk Rating
Socio-economic	Low	The proposed modification will not change the types of activities at the approved project. As a result, the previous socio-economic considerations described in the EIS are still applicable to the development and will not be altered or diminished by the proposed modification.	Refer to **Section 7.10.5**.	Low
Hazard and risk	Low	The position and nature of the modification site presents several hazards and risks, including fire, storage and management of hazardous substances and dangerous goods. If not managed appropriately, these hazards and risks have the potential to result in adverse impacts to public safety, health and the environment.	Refer to **Section 7.10.6**.	Low
Waste	Low	The project is unlikely to generate large volumes of waste or additional waste streams which cannot be adequately managed.	Refer to **Section 7.10.7**.	Low
Sustainability	Low	The project can be undertaken in an ecologically sustainable manner as it is unlikely to result in any additional significant impacts to the natural environment or surrounding community beyond that generated by the approved project.	Refer to **Section 7.10.8.**	Low



CHAPTER 7
ENVIRONMENTAL ASSESSMENT

7 ENVIRONMENTAL ASSESSMENT

This chapter examines the change in the potential impacts of the proposed modification as compared to the approved project. It recommends, where required, mitigation and monitoring measures to manage potential impacts.

7.1 Groundwater

This section summarises the hydrogeological impact assessment (HIA) report, which is in **Appendix D**. It describes the potential impacts on groundwater resources from the proposed modification and provides mitigation and management measures to minimise any resultant impacts.

A summary of the hydrogeological setting of the modification site is outlined in **Section 1.3.6**.

7.1.1 Field investigation

The HIA included a review of existing data for the local aquifer system, and development of a water balance for the aquifer, and subsequent assessment of the potential impacts from proposed works under varying climatic conditions.

The review of existing data was supplemented by a field investigation of the modification site comprising:

- installation of a groundwater monitoring bore network at the Stage 5 extraction area;
- physical aquifer testing on installed bores to determine aquifer parameters; and
- implementation of a groundwater monitoring program to assess changes in groundwater levels and chemistry over time under varying climatic conditions, including installation of permanent groundwater pressure transducer loggers in select bores to assess groundwater level responses to climatic conditions.

A groundwater monitoring bore network comprising seven bores in the proposed Stage 5 extraction areas and one bore to the south of Stage 5B extraction area was installed in July 2018 to provide baseline groundwater data.

Groundwater was encountered in all bores at shallow depths between 0.90-3.31 m below ground level (bgl), with the shallowest depth recorded at bore MW5A3 in the Stage 5A extraction area.

The bores were sampled on three separate occasions between November 2018 and January 2019. The standing water levels (SWL) in all bores remained consistent over the three-month sampling period, ranging between 0.90 m and 3.31 m bgl. During the first monitoring visit in October 2018, submersible data loggers were installed in four bores to provide continuous monitoring data of groundwater levels across the site.

Water samples were obtained from four bores and analysed in the field for:

- oxidation reduction potential (ORP);
- pH;
- dissolved oxygen (DO);
- electrical conductivity (EC); and
- temperature.

Groundwater samples collected were then sent to a National Association of Testing Authorities (NATA) accredited laboratory and analysed for the following parameters:

- full ionic balance suite – pH, total dissolved solids (TDS), cations (Na, Ca, Mg, K), anions (Cl, SO4, HCO3, PO4, F) and nutrients (NH3, NO3 and NO2); and
- dissolved metals / metalloids including aluminium (Al), arsenic (As), cadmium (Cd), chromium (Cr), copper (Cu), iron (Fe), lead (Pb), manganese (Mn), mercury (Hg), nickel (Ni) and zinc (Zn).

Hydraulic parameter testing

As part of the groundwater monitoring program, 'slug-tests' (or falling head tests) were undertaken at four locations (bores MW5A1, MW5A3, MW5B2s and MW5B2d) in October 2018. Slug tests require piezometers to have the screens fully submerged beneath the piezometric surface. This method was used to determine the *in situ* hydraulic conductivity (K).

The tests involve causing an instantaneous change in water level in a section of the piezometer by introducing a known volume (i.e. a 'slug') and then measuring the recovery of the water level over time.

Using the data obtained from these tests, values for hydraulic conductivity, transmissivity and groundwater velocity were determined for the unconfined aquifer. The slug-tests were performed across the modification site in order to determine the change in hydraulic properties of the water bearing sediments beneath the modification site.

7.1.2 Results

Recharge rates and water balance

The aquifer is recharged by infiltration of water generated as surface flow from upgradient in the catchment, and through direct infiltration from the surface. The catchment area for drainage into the modification site is limited due to its low altitude and percolating unconfined groundwater is likely to be sourced from an area up to 3 km to the west of the modification site.

The contours in **Figures 4a to 4c** indicate movement of groundwater predominantly to the north east. This is consistent with regional and site surface topography, and the location of down-gradient discharge zones (namely Minnamurra River and Pacific Ocean) to the east of the modification site.

Based on the total modification site area of close to 12 ha, the HIA estimated that an average of 125 ML of rainfall falls on the modification site per annum, 30% of which (37 ML) recharges the aquifer and the remainder (88 ML) discharges as surface flow. Evapotranspiration is approximately 70% of recharge, and the extracted sand will contain approximately 8% moisture and be removed at the current production rate of 450,000 tonnes per annum. A water balance, based on these calculations, is summarised in **Table 7.1**.

Table 7.1: Site water balance

Parameter	Inflow (m^3/day)	Outflow (m^3/day)
Recharge	100	-
Groundwater inflow	675	-
Evapotranspiration	-	70
Sand Extraction	-	60

Parameter	Inflow (m^3/day)	Outflow (m^3/day)
Groundwater outflow	-	675
Total	775	761

As the entire 120 km^2 Minnamurra River catchment (including the modification site) accumulates and discharges approximately 120,000 ML in an average rainfall year, the groundwater component of total catchment discharge for the modification site is minimal (<0.21% of total catchment discharge).

Groundwater chemistry

Results of the field chemical assessment are provided in Appendix C of the HIA and correlate well with field observations.

Ionic balance

The ORP reported in Appendix C of the HIA indicates a generally reducing and oxygen depleted aquifer, with negative values recorded in most locations. The exception to this was bore MW5A1 which has consistently recorded positive ORP values. This may be attributed to the low-lying nature of the area which was noted to be very reactive to rainfall and became easily waterlogged.

The highly negative ORP values observed elsewhere across the modification site compares well with DO readings, which were minimal. The highly negative ORP readings (as well as low DO and grey sand colour) support the physical assessment that there is very little groundwater movement through the modification site, particularly percolation of oxygenated surface recharge water.

The ionic balance of the groundwater samples analysed is consistent with natural uncontaminated waters within the aquifer on the modification site. Groundwater beneath the modification site was found to range in pH from 6.0 to 7.7. The neutral to slightly acidic nature of the groundwater is likely to be due to the large amount of bicarbonate (HCO_3) present within the soil matrix, particularly in the Stage 5B extraction area, and is likely associated with shell fragments within the alluvial sediments. The HCO_3^- (in addition to Ca^{2+}, Mg^{2+} and SO_4^{2-}), when dissolved into the aquifer, will act to buffer any organic acids present in the system.

The aquifer can be described as having predominantly fresh water within the Stage 5 extraction areas (TDS <500 mg/L other than at bores MW5A3 and MW5B5 (1090 mg/L and 650 mg/L respectively in January 2019). The bore MW5A3 is close to the former Stage 1 dredge pond to the north of Fig Hill Lane and it is anticipated that the northern corner of the Stage 5A extraction area may be hydraulically impacted by the associated drainage channel adjacent to Riverside Drive, which links the Stage 5A extraction area to Minnamurra River. Similarly, the elevated TDS levels in bore MW5B5 are expected to be a reflection of the proximity to the Minnamurra River, of which the aquifer is in hydraulic connectivity.

Previous data collected for groundwater from surrounding sites (including the approved project) correlates well with the results obtained in the HIA. This provides confidence in the conclusion that groundwater underlying the modification site is chemically similar with the natural groundwater of the Dunmore area.

Comparison to water quality criteria

The groundwater samples collected from the unconfined aquifer were also analysed for 11 heavy metals. Manganese (Mn) exceeded the guidelines for drinking (aesthetic only) and

irrigation in bores MW5A2 and MW5A3, while phosphate (PO_4) also exceeded the irrigation criteria at these locations. All dissolved metal concentrations are therefore suitable for all uses other than irrigation at bores MW5A2 and MW5A3. Nitrate (NO_3) narrowly exceeded the ecosystem criteria at bore MW5B1, and all other exceedances were aesthetic only.

The groundwater quality results are generally considered to be representative of baseline groundwater quality in the modification site and will provide a good basis for comparison against results for monitoring throughout the life of the proposed modification and into closure.

Groundwater usage and receptors

The WAL permits the extraction of 65ML of water from the Sydney Basin South Groundwater Source and is subject to a number of conditions. Associated 'work approvals' include 10WA106713 and 10WA106714.

The continued limited use of groundwater for dust suppression is proposed, however, the groundwater resource beneath the modification site is of relatively useful yield and quality, and is therefore suitable for a number of potential beneficial uses.

Potential beneficial uses of an aquifer are directly associated with potential yield (sustainable or otherwise) and quality. All groundwater, regardless of yield or quality, is required to be protective of the natural ecosystem within which it resides and in particular discharges to, including any groundwater dependent ecosystems (GDEs). There are no GDEs within the modification site, however terrestrial GDEs are located adjacent to the south and east of the Stage 5B extraction area, as well as to the north of the Stage 5A Extraction area. These GDEs correlate to the coastal wetlands afforded protection under the Coastal Management SEPP.

The HIA has determined that the relevant beneficial users of groundwater (in order of priority and importance) are:

- the freshwater and marine ecosystems of local surface water features (Minnamurra River in particular) and nearby ephemeral creek systems;
- stock watering;
- recreational, direct contact and aesthetic use; and
- possible irrigation.

The local groundwater is not considered to have potential beneficial use as drinking water, whilst use for irrigation is not currently occurring and is considered unlikely.

7.1.3 Potential impacts

The nature of the groundwater flow system (i.e. a local flow system discharging to the Minnamurra River and local creeks) means that all potential impacts of the proposed modification are locally constrained.

Physical impacts

Once vegetation is cleared from the modification site there will be increased opportunity for direct recharge of rainfall to the water table, and a coincident increase in the potential for infiltration to and run off from the modification site. This increased surface water movement could increase erosion rates, and as such it will be important to ensure erosion and sedimentation controls are in place prior to vegetation removal.

The implementation of erosion and sedimentation controls will improve the mechanism for water table recharge (i.e. direct infiltration of ponded surface water) which, along with reduced evapotranspiration following vegetation removal, may result in localised water table elevations beneath the modification site. The consequence of such an impact will be minor to negligible

and may even be beneficial by increasing groundwater flow rates from the modification site to Minnamurra River.

Chemical impacts

Due to the reduction of evapotranspiration rates following the removal of vegetation and the potential resultant localised water table elevations beneath the modification site, chemical impact from the proposed modification is expected to be limited to potential increases in fresh water recharge to the aquifer. Any chemical alteration is therefore likely to be beneficial.

Dredging operations

Physical impacts

The removal of alluvial sediments by excavation is likely to have very little physical impact on the groundwater resource. This is because the disturbance footprint of the Stage 5 extraction areas (11.54 ha) makes up a small proportion (0.1%) of the overall 11,730 ha (117.3 km^2) Minnamurra River catchment.

Whilst the likelihood of any change in water table levels as a result of dredging and consequent alteration of recharge and discharge mechanisms for groundwater at the modification site is possible, the consequence is minor. This is because changes in the water table level (within the ranges predicted below) in the vicinity of the dredge ponds will not have a physical consequence for the aquifer or its potential receptors.

Mechanisms for lowering the water table will be limited to increased evaporation rates in the area of the dredge ponds once the water table is exposed to the atmosphere and reduced run-on to the pond areas.

Based on rainfall and evaporation rates in the area, the difference between rainfall recharge to and evaporation from the dredge ponds will vary from a deficit of 67 m^3/day in November to an average accumulation of 55 m^3/day in June. Overall, based on evaporation of the open dredge ponds and average rainfall in the catchment, the proposed modification will result in a slight net deficit in rainfall recharge of 219 m^3 per annum.

Chemical impacts

The removal of alluvial sediments by dredging has the potential to chemically impact on the groundwater resource by reducing the water table and exposing reduced inorganic sulfides to oxygen, which may generate acid.

As highlighted in **Section 7.10.2**, sulfides may be encountered in the Stage 5A extraction area between 1.25 m – 4 m bgl, and as such the maintenance of water table levels in the Stage 5A extraction area is an important consideration for the proposed modification.

The water table will not drop by any significant degree as a result of the proposed modification. As such, a reduction in water table level does have a very minor potential to expose soil sulfides around the perimeter of the Stage 5A extraction area, and monitoring of water table and pond levels (as well as management procedures to mitigate any acid production) will be necessary throughout the duration of the proposed modification and into closure.

Rehabilitation

Physical impacts

The reinstatement of the Stage 5A extraction area with VENM is likely to result in the physical impact of decreasing bulk porosity of the aquifer matrix, due to the expected finer texture of VENM compared to *in situ* sand dominated alluvial sediments. Despite the likely occurrence, it is considered such impacts will be minor.

Of the two rehabilitation options, the rehabilitation of the Stage 5B extraction area as a wetland is considered to have a slightly lower level of overall risk to the rehabilitation proposed for Stage 5A, as the wetland is expected to facilitate water table recharge and return to natural conditions. However, both options have a negligible consequence of any physical impact, and hence overall minor risk.

Chemical impacts

The proposed modification has the potential chemical impacts of allowing acid to be produced by permanently lowering the water table in the Stage 5A footprint, thereby allowing opportunity for *in situ* PASS material to be oxidised.

The wetland rehabilitation proposed for the Stage 5B extraction area is considered to have a slightly lower level of overall risk to the rehabilitation proposed in Stage 5A as the wetland would be expected to facilitate water table recharge and return to natural conditions, without a change to the chemical composition of the groundwater.

Summary of potential impacts

As detailed above, all consequences associated with potential physical impacts will be minor to negligible. This is primarily because the modification site makes such a small contribution to the overall catchment water balance, and that there are no potential receptors to groundwater discharge down-gradient of the modification site other than the ecosystems of Rocklow Creek and the Minnamurra River.

The major risk of chemical impact is likely to be as a result of oxidation of natural *in-situ* or imported reduced sulphides within imported VENM.

Whilst it is proposed to backfill the Stage 5A extraction area with VENM, depending on the condition and origin of the soil, it has the potential to be PASS. This will be managed through appropriate certifications to ensure only non-PASS material is handled within Stage 5.

Lowering of the water-table during excavation of *in-situ* sediments could expose PASS around the pond perimeter of Stage 5A (estimated to be close to 500 m in length). Hence, it has been estimated that approximately 600 m^3 of PASS could be oxidised, which has potential to produce over 19 tonnes of acid.

The consequence of chemical impacts to groundwater during rehabilitation of the proposed modification will be low, as any acidification at this stage is expected to be limited to the upper portion of the water table surface.

7.1.4 Mitigation and management measures

Soil management and monitoring

All material to be used in the rehabilitation of the proposed modification is to be non-PASS VENM. Receival protocols will be implemented in accordance with those specified in the approved Waste Management Plan (Boral 2017) for the approved project, which is to be reviewed and updated to include the Stage 5 extraction area.

Groundwater monitoring

The following recommendations will be formalised in an update to the existing groundwater monitoring and management plan (GMMP) for the approved project to encompass the Stage 5 extraction area. The GMMP forms a sub-plan to the water management plan (WMP) prepared in

accordance with Schedule 3(34) for Development Consent DA 195-8-2004 (2004) for Stages 2, 3 & 4.

Monitoring network

Due to dredging operations, bores MW5A1 to MW5A3, MW5B1 and MW5B2 may be destroyed. When this occurs, three additional bores will be installed surrounding the proposed dredge pond in the Stage 5A extraction area (one to the north; one to the east; and one to the south of the dredge pond). A further bore will be installed to the north of the Stage 5B dredging pond. New bores will be installed to a depth of at least 6 m.

All bores will need to be surveyed for relative height to AHD with at least 0.001 m accuracy, so that relative groundwater levels can be compared. In addition, the dredge pond surface will need to be surveyed so that the relative height of water in the dredge pond over time can be accurately measured.

Physical assessment of groundwater and dredge pond levels

Standing groundwater levels (SWL) and pond water level AHD heights will be measured weekly via data loggers during dredging works, reinstatement works, and during rehabilitation works (bores only).

Following rehabilitation, all seven bores (existing and proposed) will be incorporated into the existing quarterly groundwater monitoring program for the approved project.

Chemical assessment of groundwater and surface water

During dredging works and rehabilitation, in additional to SWL and pond water level measurement, all seven bores and the dredge pond will be tested for pH on a monthly basis. It is recommended that pH measurement be performed in the field with a hand-held electronic meter that is 2-point calibrated.

In addition to the above recommended measurement for pH, all bores from both Stage 5A and Stage 5B will be incorporated into the pre-existing GMMP, which will be updated following approval of the proposed modification.

Groundwater bores will be sampled on a monthly basis for SWL and pH, and tested quarterly for the following analytical suite:

Field measurement of:

- pH, EC, ORP, SWL, DO and temperature.

Laboratory analysis for:

- full ionic balance suite pH, TDS, cations (Na, Ca, Mg, K), anions (Cl, SO_4, HCO_3, PO_4, F) and nutrients (NH_4, NO_3, NO_2, Total N); and
- dissolved iron (Fe).

7.2 Aboriginal heritage

This chapter summarises the Aboriginal cultural heritage assessment (ACHA) report, which is in **Appendix E**. It describes the cultural context of the modification site, consultation with the Aboriginal community, study methods, items discovered during surveys, the significance of the items, potential impacts and mitigation measures where impacts are unavoidable.

7.2.1 Overview of assessment methods

The following assessment methods were used during the ACHA:

Desktop study

The Aboriginal Heritage Information Management System (AHIMS) database was searched (April 2018) to identify any registered Aboriginal sites or places in the modification site or surrounds.

Environmental features which could influence historic Aboriginal occupation of the locality were characterised, for example landscape, drainage, geology, soils, vegetation, fauna and climate.

Literature such as previous heritage assessments of the region and local area were reviewed to understand historical Aboriginal use of the area and customs.

Information gathered from the desktop study was used to develop a predictive model of what types of Aboriginal sites are likely to occur in the modification site and the landforms they may be associated with.

Aboriginal consultation

Aboriginal parties were consulted in accordance with OEH's (2010) *Aboriginal Cultural Heritage Consultation Requirements for Proponents 2010*. Nineteen Aboriginal groups or individuals registered their interest (registered Aboriginal parties – RAPs) in the proposed modification and contributed cultural knowledge and archaeological expertise to the Aboriginal heritage assessment process.

Archaeological survey

The modification site was surveyed by an archaeologist, targeting ground exposures on land near watercourses, hill spurs and crests. All mature trees and rock outcrops along the survey transects were inspected for evidence of cultural modifications on trees and grinding grooves or engravings on rocks.

Potential Aboriginal sites were photographed, and their locations recorded using global positioning system units.

Test excavation

Areas that were identified by the desktop study and survey as potentially containing Aboriginal items were excavated over five days in November 2018 by archaeologists and representatives of the RAPs. The aim of the excavation was to characterise the subsurface archaeological deposit and test the predictive model and survey results.

Forty-five sites were excavated by hand to a maximum depth of 1.2 m. Excavated material was sieved and artefacts were washed and bagged for future recording.

7.2.2 Results

Desktop study

The geology, soil and landforms of the modification site influence the presence of Aboriginal archaeological features. Coastal and estuarine environments within the vicinity of the modification site would have been favourable for past Aboriginal occupation.

Estuarine, swamp/wetland and littoral and marine resources of the coast were all available, along with fresh water from smaller streams. The variety of habitats would also have encouraged a diverse population of fauna. Raw materials suitable for tool-making are available

from surrounding geologies and may have been sourced directly from outcrops or as stream and river cobbles transported to the coast from deposits further inland. The soils derived from the volcanic geology of the modification site also supported varied native vegetation which was utilised by past Aboriginal people as a resource.

The adjacent catchment areas of Frazers Creek and Rocklow Creek would also have offered important resources. These would have differed significantly during the Holocene period when the flood plains and eastern portion of Rocklow Creek formed an estuary. Topographically, elevated and well-drained portions of the modification site would have been a preferable camping place surrounded by a variety of resources.

There are no AHIMS sites in the modification area. There are four AHIMS sites within 200 m of the modification site. Three of the sites (52-5-0526, 52-5-0253 and 52-5-0819) were recorded in tidal flats and saline swampy environments, which were subject to active, recent cycles of erosion and deposition processes. Therefore, any items are unlikely to be in their primary context and it is highly unlikely that deep stratified deposits occur in these conditions.

One AHIMS site (52-5-0117) has been recorded 100 m south of the modification site and is in the same beach ridge landform as the Stage 5B location. This site had stratified deposits of shell and artefacts. Another site (52-5-0159) was recorded in the same landform approximately 500 m south-west of the modification site.

The location of these sites near, and in similar landforms, to the modification site indicates there may be Aboriginal items in the modification area.

The northern portion of the Stage 5A extraction area has moderate potential to contain scattered cultural material that would not be in its primary context. The southern section has a high potential to contain Aboriginal objects.

The Stage 5B extraction area has a high potential to contain deep stratified cultural deposits relating to Aboriginal activities on this specific landform. Areas of archaeological potential would be dependent on the levels of previous disturbance, including natural processes and recent land modifications.

A review of previous archaeological assessments and the distribution of recorded archaeological sites across the landscape surrounding the modification site indicate a strong relationship between site type and geological, topographic and geographic factors.

Additionally, environmental factors contribute directly to the survivability of archaeological sites in the landscape. Elevated sand bodies above the former estuarine environments in the modification site are the most archaeologically sensitive landform. Aboriginal archaeological sites associated with these landscape features would have the potential to contribute significantly to the understanding of Aboriginal use of these unique environmental contexts.

Archaeological survey

Visual inspection of the modification site confirmed the potential for Aboriginal objects based on:

- stable and intact soil profiles;
- topographically favourable features related to elevated level ground and vistas; and
- proximity to known archaeological sites and presence of surface Aboriginal objects within the eroded areas.

The pipeline and access roads to the west and north of the Stage 5A extraction area are substantially disturbed by previous construction and crossed mostly lower sensitivity tidal flat areas in association with Rocklow Creek and the Minnamurra River. Visibility was on average good with areas of exposure located around the existing former Stage 1 dredge pond and within

access tracks. The entire low-lying area has been significantly disturbed due to past land use, with no areas of archaeological potential identified.

There was dense grass cover and a lack of exposure areas in the Stage 5A extraction area. No Aboriginal objects were identified during the field inspection of the Stage 5A area.

The southern portion of the Stage 5A extraction area contains high potential for subsurface Aboriginal objects to be present given its environmental setting, low degree of previous disturbance, intact sandy soil conditions and previously recorded sites in similar conditions.

The tidal flat in the northern section of the Stage 5A extraction area has moderate potential to contain cultural material that would be in a secondary (disturbed geomorphic) context.

Ground surface visibility in the Stage 5B extraction area varied from high to low with some exposures limited to tracks, around trees and on the banks of the existing farm dam in the northern portion of the proposed dredge pond. An artefact scatter site was discovered in a beach ridge landform. Therefore, the potential for subsurface deposits in Stage 5B was assessed as high.

Therefore, further detailed investigation (test excavation) was recommended to determine the nature, extent and significance of any archaeological sites and potential archaeological deposits in the modification site.

Test excavation

One of the most suitable ways to further investigate the desktop predictions and the results of the survey is through test excavation which provides valuable data on the subsurface archaeological character of the modification site.

The test excavation of the modification site identified three Aboriginal archaeological sites, namely:

- DLS Boral AFT 1;
- DLS Boral AFT 2; and
- DLS Boral AFT 3.

Test excavations averaged 80 cm to 1 m in depth, with two test excavations extending to 1.2 m. The two tested areas were in different landforms, but were part of the same coastal barrier land system with similar geomorphological deposition processes.

Soils across the modification site contain deep sandy deposits that extended beyond the limit of test excavation, however all identified deposits demonstrated a trend of minimal archaeology below 1 m.

Artefact distribution was characterised by high density deposits. There were some patchy, low density deposits towards the margins of the sand bodies. The highest artefact density was in the central, most elevated parts of the sand beach ridge and back barrier flat.

DLS Boral AFT 1 did not reveal evidence of significant previous ground disturbance that could have impacted on subsurface archaeological deposits. The only previous disturbance was evident within very shallow surface soils due to repeated natural fire events and land clearing. These land use practices and natural events would cause some horizontal and shallow vertical movement of archaeological deposit, but would not remove it in its entirety. In addition, these disturbances were patchy and not identified in all test excavation units.

The majority of the modification site is within very stable intact sandy deposits. DLS Boral AFT 2 had some areas that revealed imported fill deposits up to 35 cm depth. These were limited to

the southern and western sections of the sand body. Natural sandy deposits are still present under fill material containing high to low density Aboriginal cultural material.

Flaked artefacts recovered were made of a diverse range of stone raw materials. Sources of these raw materials are known in the immediate vicinity of the test excavation areas, within Shellharbour and Bass Point, located approximately 5 km from the modification site. The predominantly small size of artefacts and evidence of artefact recycling indicate that the materials were brought to the area from elsewhere (perhaps from sources along the nearby Minnamurra River). Some knapping (shaping of stone) was also likely occurring at dispersed locations and most likely different times throughout the modification site. The presence of backed artefacts indicates particular and selective activities.

The results of the test excavation program demonstrate that DLS Boral AFT 1 and DLS Boral AFT 2 have moderate-high archaeological research potential due to the high number and diversity of raw material and tool types, relatively intact nature of the subsurface deposit at these locations and their proximity to estuarine environments. DLS Boral AFT 3 has low archaeological research potential due to the low density of artefacts recovered and the disturbed nature of the site.

Summary of findings

Aboriginal cultural heritage assessment, including review of previous archaeological investigations, Aboriginal community consultation, site survey and test excavation has identified three Aboriginal archaeological sites within the modification site (refer to **Figure 7-1**).

DLS Boral AFT 1

Site DLS Boral AFT 1 was located within a beach ridge landform within the proposed Stage 5B extraction area, to the immediate south of the existing farm dam and associated small drainage line. Test excavations determined that the site extends throughout the entire landform and contains relatively intact high-density archaeological deposits. A total of 828 artefacts were recovered from 28 test excavations.

Artefact distribution was characterised by high density deposits with a localised low-density deposit towards the margins of the sand body. The majority of the artefacts were recovered between 40 and 70 cm depth. They were preserved within sandy subsoils that represent relatively stable soils, most likely intact and not related to geomorphic processes. Results of test excavation indicate that the area contains evidence of dispersed and varied occupation activities that occurred during a prolonged period of time, and on repeated occasions.

DLS Boral AFT 2

Site DLS Boral AFT 2 was located within a back-barrier sand body within the Stage 5A extraction area, adjacent to the tidal flat in association with the estuary of the Minnamurra River. Test excavation determined that the site retained an intact, high density archaeological deposit located across the entire remnant sand body. A total of 461 artefacts were recovered from 12 test excavations.

Artefact density within the test excavation area was similar to that within DLS Boral AFT 1, characterised by a moderate to high artefact density across all excavated test units. Localised low-density deposits were recorded along the margins of the landform that indicate the site boundary. The highest artefact density was recorded within the central elevated section of the sand body. Some surface fill material was identified within the first 35 cm that did not impact on integrity of deeper sandy archaeological deposits. The assemblage contained a small quantity of cores and formalised tools indicating that the creation of stone tools occurred at the site, but was secondary to the maintenance and use of stone tools.

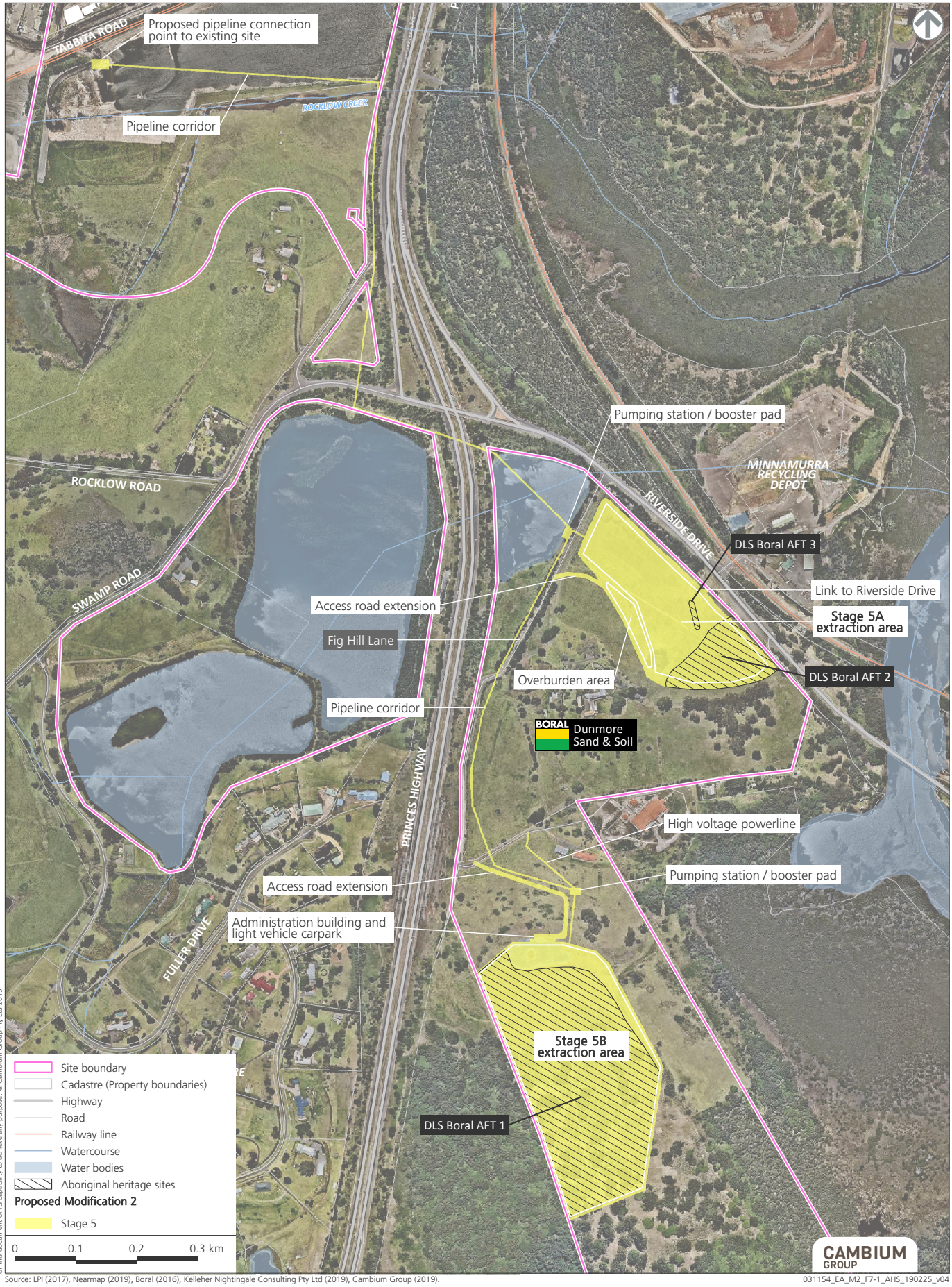
DLS Boral AFT 3

Site DLS Boral AFT 3 was located within the artificially raised area to the immediate west of Riverside Drive. It is located between the tidal flat and back barrier flat landforms. Test excavations determined that the raised area is made of fill material. This fill was most likely brought into the area during the construction of the road and the modification of a small drainage channel that runs parallel to Riverside Drive. A total of three artefacts were recovered from three test excavations.

The recovered artefacts consisted of two quartz angular fragments, and one quartz retouched flake. It is possible that they were imported to the site with the fill material, or they represent dispersed and isolated cultural material from the local area. No further cultural material was identified, and the entire raised area was considered to have very low archaeological potential for intact deposits.

Figure 7.1
Aboriginal heritage sites

DUNMORE LAKES SAND EXTRACTION PROJECT | MODIFICATION 2
ENVIRONMENTAL ASSESSMENT



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Source: LPI (2017), Nearmap (2019), Boral (2016), Kelleher Nightingale Consulting Pty Ltd (2019), Cambium Group (2019).

7.2.3 Significance assessment

Overview

The values held by communities for heritage is an important management consideration, with the values collectively called ‘cultural significance’. The ACHA assessed potential impacts of the proposed modification as outlined in Section 8.1 of the ACHA.

Statements of significance

The modification site has cultural value for the local Aboriginal community. The identified cultural value is a feeling of attachment and responsibility for the land. These values become tangible when tied to identified Aboriginal objects found at the archaeological sites. In this way, the Aboriginal objects can be seen as exhibiting both scientific information and cultural meaning, knowledge about the past tied with social values and belief systems.

The modification site contained three identified Aboriginal archaeological sites. The significance assessment was based on consideration of the research value, representativeness, intactness and rarity of the sites in a local and regional context as outlined below.

DLS Boral AFT 1

Site DLS Boral AFT 1 includes a high-density artefact scatter located within the remnant beach ridge landform adjacent to the Minnamurra River estuary. The site has been subject to limited human disturbance and the results from the test excavation suggest that movement within the deposit was also limited. The site represents a commonly occurring site type in the coastal region, however recorded intact (coastal) sites are becoming less common as the majority of landforms in similar environmental settings are increasingly impacted by contemporary land use practices.

The range of raw material and artefact types found at the site and stratified context adjacent to an estuarine environment is less common. The site demonstrated moderate-high scientific value and it is likely that further investigation will contribute to the understanding of Aboriginal landscape use within coastal areas and assist in understanding the management of coastal sites and identification/conservation of future sites based on geomorphic features (beach ridge).

Based on the intactness, representativeness, and research potential of the site, DLS Boral AFT 1 was determined to have moderate-high archaeological significance.

DLS Boral AFT 2

Site DLS Boral AFT 2 includes a high-density artefact scatter located within the remnant back barrier flat landform adjacent to the Minnamurra River estuary. The site has been subject to some recent land modifications and the results from the test excavation suggest that limited areas have experienced importing of some fill material. Generally, this did not impact on the majority of the artefact-bearing sandy deposits. The site represents a commonly occurring site type in the region, however the majority of landforms in similar environmental settings have been significantly impacted by recent land use practices. The range of raw material and artefact types found at the site and stratified context adjacent to the estuarine environment is less common. The site demonstrated moderate-high scientific value and it is likely that further investigation will contribute to the understanding of Aboriginal landscape use within coastal areas and assist in understanding the management of coastal sites and identification/conservation of future sites based on geomorphic features (back barrier sands).

Based on the intactness, representativeness, and research potential of the site, DLS Boral AFT 2 was determined to have moderate-high archaeological significance.

DLS Boral AFT 3

Site DLS Boral AFT 3 includes a low-density artefact scatter situated with a highly disturbed area. The site is located within fill material with an absence of natural soils. The site represents a commonly occurring site type in the region. The site demonstrated no scientific value due to the disturbed nature and low density of the archaeological deposit. Further investigation will not contribute to the understanding of Aboriginal landscape use in the region.

Based on the intactness, representativeness and research potential of the site, DLS Boral AFT 3 is determined to have low archaeological significance.

7.2.4 Impact assessment

Ground disturbing activities associated with the proposed modification, in particular the creation of the dredging ponds will impact known and unknown Aboriginal sites and objects.

Aboriginal sites and objects may be impacted to the following degrees:

- partial disturbance, for example minor displacement of an object via compaction of soils;
- total disturbance, for example an object may be permanently covered in water within the dredge pond;
- partial loss, for example the loss of part of a site through excavation; and
- total loss, for example the total loss of a site through excavation.

Loss entails the loss of a site's elements, and may include salvage, where items are collected and stored or later returned to the site, as the context is irretrievably lost.

The three identified Aboriginal sites will be impacted as summarised in **Table 7.2**.

Table 7.2: Aboriginal heritage impacts

Site Name	Type of harm	Degree of harm	Consequence of harm	Significance of harm	Mitigation Required
DLS Boral AFT 1	Direct	Total loss	Total loss of value	High	Yes
DLS Boral AFT 2	Direct	Total loss	Total loss of value	High	Yes
DLS Boral AFT 3	Direct	Total loss	Total loss of value	Low	No

The three Aboriginal archaeological sites identified within the modification site have been considered by DSS in relation to the disturbance area of the proposed Stage 5A and Stage 5B extraction areas. While conservation is the best approach when considering Aboriginal heritage, impact to the three sites is unfortunately unavoidable due to the nature of the proposed modification. The most significant sites are situated within the areas of proposed impact.

The scientific value of archaeological sites is linked to the physical information the sites contain. Site DLS Boral AFT 3 has low archaeological significance and does not warrant further archaeological investigation, however measures for mitigating harm to Aboriginal objects (salvage excavation) are recommended for DLS Boral AFT 1 and DLS Boral AFT 2.

The loss of intrinsic Aboriginal cultural value of impacted sites cannot be offset, however the salvaged information will increase scientific understanding, strengthen interpretations and improve ongoing and future management of Aboriginal heritage in the surrounding area. The presence of archaeological deposits and activities related to Aboriginal occupation within

coastal barrier landform contexts in association with estuaries is little known due to limited large excavation data, and the levels of previous disturbance in these environmental conditions within the Illawarra Coastal Plain. In this light, the proposed modification offers a unique opportunity to significantly advance the interpretation and management of Aboriginal heritage of the surrounding area by providing a foundation for future heritage assessments.

7.2.5 Management & mitigation measures

While Aboriginal archaeological sites and associated objects within the disturbance footprint of the proposed modification will be lost, impacts will be mitigated through collection and relocation of artefacts prior to the commencement of works.

The archaeological sites DLS Boral AFT 1 and DLS Boral AFT 2, and surrounding area of moderate-high archaeological sensitivity will be subject to salvage excavation, which will aim to retrieve the most significant portions of the sites and involve a two-stage process of sampling followed by open area excavation. The salvaged artefacts will be subject to attribute analysis to understand manufacturing technology, site function and to compare the assemblage to studies completed in the wider region.

Salvage excavation will be completed prior to any activities which may harm Aboriginal objects at the aforementioned locations. Salvage excavation activities will be undertaken in accordance with the methodology specified in Appendix E of the ACHA. All artefacts identified in the salvage area will be collected by an archaeologist and members of the Aboriginal community. Collected Aboriginal objects will be retained and transported to a nominated temporary storage facility.

No mitigation is required for the archaeological site DLS Boral AFT 3.

An unexpected human remains procedure will be implemented during the proposed modification as summarised in Section 11.3 of the ACHA.

7.3 Biodiversity

This section summarises the biodiversity development assessment report (BDAR), which is in Appendix F. It summarises the potential impacts from the proposed modification on flora and fauna, which were assessed in accordance with the BAM.

Ecosystem and species credits were calculated for proposed vegetation clearing in accordance with the BAM.

7.3.1 Overview of assessment methods

Biodiversity impacts were assessed in accordance with OEH's BAM using the BAM Calculator, which comprises two stages:

- Stage 1 – biodiversity assessment, involving assessment of:
  - landscape features;
  - native vegetation; and
  - threatened species and populations.
- Stage 2 – impact assessment, involving consideration of:
  - how to avoid and minimise impacts on biodiversity values;
  - impact and offset thresholds; and
  - offset requirements.

Landscape assessment

The habitat value of the landscape is determined by comparing the current state of the landscape with the state of the landscape should the proposed modification proceed, and considers:

- native vegetation cover;
- rivers, streams and estuaries;
- areas of geological significance; and
- habitat connectivity.

Native vegetation and flora

Previous records of threatened flora within a 10 km radius of the modification site were retrieved from the NSW Bionet Atlas and the EPBC Act Protected Matters Search Tool.

The plant community type (PCT) mapping in OEH's Vegetation Information System was used to determine potential biodiversity constraints on the proposed modification. The PCTs were validated with fieldwork between April and May 2018, and again in January 2019 using the BAM. The assessment involved observing vegetation attributes in the modification site using vegetation quadrats, transects and 'walking meanders' to identify flora species and confirm the PCTs and their condition. High threat and priority weeds were also recorded during the fieldwork.

The validated PCTs were mapped and it was determined if any threatened ecological communities (TEC) were present in the modification site.

The BAM Calculator was used to predict the presence of threatened flora in the modification site, which were targeted during the fieldwork. The list of potential threatened flora was refined after the fieldwork based on previous records within the search radius, observed PCTs, their condition and habitat features. Then a determination was made on the likelihood of threatened flora occurring in the modification site.

Native fauna and habitat

The NSW Bionet Atlas and EPBC Act Protected Matters Search Tool were also searched for records of threatened fauna within a 10 km radius of the modification site. The results were considered during fieldwork planning and the likelihood of occurrence analysis.

Fauna and habitat fieldwork focussed on threatened species (species credit fauna) and comprised:

- survey of the modification site between April and May 2018 and again in January 2019, comprising spotlighting, call playback, habitat-based assessment, bird surveys and Anabat analysis;
- targeted fauna survey during January 2019, comprising camera trapping, spotlighting, and habitat assessment; and
- amphibian and habitat survey along drainage lines within the modification site in January 2019.

The habitat assessment recorded:

- slope, aspect and landscape position;
- geology and soil type;
- dominant vegetation communities including their composition, structure and condition;
- form, quality and location of water sources;

- presence, size, number and condition of habitat features such as tree hollows; and
- level of disturbance.

Impacts

Direct, indirect and cumulative impacts to native vegetation and habitat were assessed. Serious and irreversible impacts were assessed in accordance with the BAM, which provides criteria to determine if a project will have serious and irreversible impacts on biodiversity. Biodiversity which will be seriously and irreversibly impacted by a project requires offsetting, which is determined by using the Biodiversity Credit Calculator to calculate ecosystem and species offset credits. The credits are retired by establishing a biodiversity stewardship site or payment into the Biodiversity Conservation Trust Fund (BCT).

7.3.2 Results

Native vegetation and flora

Plant community types

The PCTs validated during fieldwork and their TEC status are summarised in **Table** 7.3 **7.3** and presented in **Figure 7.2**. One native and one non-native vegetation type were described. The native vegetation had different condition classes as there were obvious differences in structure and quality within areas of the PCTs.

The Bangalay - Old-man Banksia open forest on coastal sands, Sydney Basin Bioregion and South East Corner Bioregion (PCT 659) is listed as an EEC under the BC Act.

Table 7.3: Summary of PCTs in modification site

PCT	TEC	% cleared	Condition	Stage 5A Area (ha)	Stage 5B Area (ha)
PCT 659 Bangalay - Old-man Banksia open forest on coastal sands, Sydney Basin Bioregion and South East Corner Bioregion	EEC under BC Act Not listed under EPBC Act	50	Good	-	1.42
			Moderate	-	3.11
			Poor (Derived Native Grassland)	-	2.97
Cleared land (exotic pasture)	-		-	3.43	0.63
			Total		**11.54**
			Total native vegetation		**7.5**

High threat and priority weeds

The following high threat weeds listed under the NSW *Biosecurity Act 2015* were recorded during the fieldwork:

- Sheep's sorrel (*Acetosella vulgaris*);
- Cape Ivy (*Delairea odorata*);
- Lantana (*Lantana camara*);
- Panic veldtgrass (*Ehrharta erecta*);
- Sprenger's asparagus (*Asparagus aethiopicus*);
- Balloon Vine (*Cardiospermum grandiflorum*);
- Rhodes grass (*Chloris gayana*);

- African boxthorn (*Lycium ferocissimum*);
- St. Augustine grass (*Stenotaphrum secundatum*); and
- Dallis grass (*Paspalum dilatatum*).

African boxthorn and Lantana are listed as priority weed species for the South East bioregion.

Threatened flora

The BAM calculator predicted the 20 threatened flora species in Appendix 4 of **Appendix F** could occur in the modification site. This list was refined following initial field survey, with no threatened flora species observed or recorded in the modification site.

Figure 7.2
Threatened ecological communities

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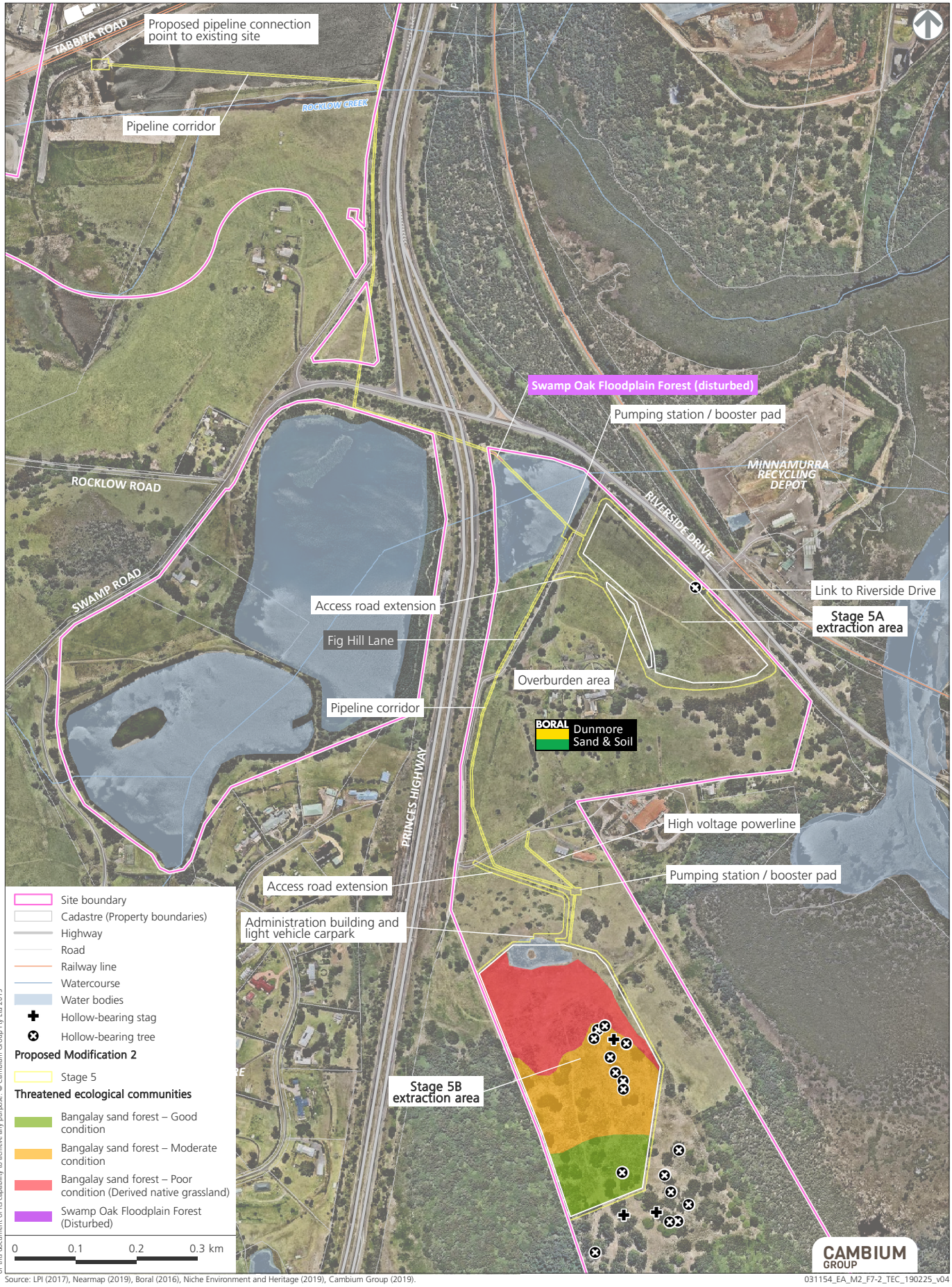

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Fauna and habitat

Fauna habitat

The following general habitat types occur in the modification site:

- exotic grasslands;
- dry sclerophyll forests with a shrubby/grass understorey;
- watercourses (creeks, drainage lines, farm dams and nearby wetland); and
- hollows, tree stags and logs.

The modification site is in and adjacent to remnant floodplain vegetation associated with the Minnamurra River. This native vegetation is predominantly associated with low-lying areas subject to inundation and thus relatively historically protected from development.

Within the broader landscape, the vegetation is isolated from dense vegetation of the Illawarra escarpment and foothills and other large areas of woodland or forest vegetation along the coastal margin. Notwithstanding, given the moderate size of the forest patch remaining, the modification site offers habitat to a range of native fauna.

Fauna habitat over the modification site varies, with the northern portion having been historically cleared or thinned. While much of the understorey and mid-storey components have been removed, some large remnant Bangalay (*Eucalyptus botryoides*) trees remain and contain a large number of hollows.

Habitat connectivity

Adjacent patches of intact vegetation provide the main connectivity pathways to and around the modification site.

The Stage 5A extraction area is cleared and disconnected from remnant vegetation areas and thus does not contribute to local or regional connectivity.

The Stage 5B extraction area is adjacent to consolidated patches of vegetation which provide local connectivity and contribute to regional connectivity. The Stage 5B disturbance footprint has been designed to minimise clearing of consolidated vegetation, therefore reducing potential impacts on connectivity.

Threatened fauna

The BAM Calculator predicted the 41 threatened fauna species in Table 5 of **Appendix F** could occur in the search radius, with 21 of these 'candidate' fauna species (i.e. species credit species). The list of candidate species was reduced to the Southern Myotis (*Myotis macropus*), Barking Owl (*Ninox connivens)* and Masked Owl (*Tyto novaehollandiae)* after the fieldwork.

The 74 species listed in Appendix 6 of **Appendix F** were recorded during surveys of the proposed disturbance areas and other areas in and adjacent to the modification site. Results comprised two reptile, 17 mammal, 51 bird and 4 frog species.

Of these species, six threatened species were observed or recorded during fieldwork, including:

- Dusky Woodswallow (*Artamus cyanopterus cyanopterus*);
- Varied Sittella (*Daphoenositta chrysoptera*);
- Southern Myotis (*Myotis macropus*);
- Eastern Bentwing-bat (*Miniopterus schreibersii oceansis*);
- Eastern Freetail-bat (*Mormopterus norfolkensis*); and
- White-bellied Sea Eagle (*Haliaeetus leucogaster*).

The locations of the threatened species recorded at the modification site are shown on **Figure 7.3**.

The Southern Myotis and Eastern Bentwing-bat are 'species credit' fauna which require biodiversity offsetting if their habitat is present and/or habitat will be impacted by the proposed modification. The Eastern Bentwing-bat is a 'dual credit' species with the species credit component only triggered if breeding habitat is present. The remainder of the species are 'ecosystem credit' species, which are assumed to have habitat in the vegetation types of the modification site.

No breeding habitat was detected for the Eastern Bentwing-bat in the modification site.

Despite no obvious breeding habitat for the Barking Owl (*Ninox connivens)* and Masked Owl (*Tyto novaehollandiae)* field work was not conducted within the breeding season for these species and as such they could not be ruled out from existing in the modification site.

Migratory species

Two migratory species listed under the EPBC Act (White-bellied Sea-Eagle and Cattle Egret (*Ardea ibis*)) were observed adjacent to or in the modification site. The White-bellied Sea Eagle would not use the modification site frequently, nor nest or breed in the modification site and thus will be minimally impacted by the proposed modification given the extent of proposed clearing.

The Cattle Egret is widespread in the locality, as is available foraging habitat within farm paddocks.

The remainder of the species identified as potentially occurring are associated with potential flooding of the modification site, offering infrequent opportunistic foraging habitat. While the area of flooding may be altered slightly from the proposed modification (in response to minor changes in flood patterns), the overall area of opportunistic foraging habitat available to migratory birds is not expected to change and impacts from the proposed modification on these species are likely to be negligible, being confined to opportunistic foraging habitat.

Expansion in the area of permanent ponds in the locality via the creation of a permanent pond in the Stage 5B extraction area may result in some increased habitat being supplied for particular migratory species and consequent positive impacts.

Aquatic habitat

A review of protected habitat mapping and potentially occurring threatened species listed under the *Fisheries Management Act 1994* was undertaken as part of the BDAR.

No areas of protected aquatic habitat or threatened aquatic species are present in the modification site. Areas of protected habitat comprising mangroves, saltmarsh and seagrass occur to the east of the modification site, with the closest mapped areas 150 m to the east of the Stage 5B extraction area.

Key fish habitat is also present in all major rivers and large tributaries in the area including the Minnamurra River and Rocklow Creek. The Black Rockcod (*Epinephelus daemelii*) could inhabit the Minnamurra River estuary.

Figure 7.3
Recorded threatened species

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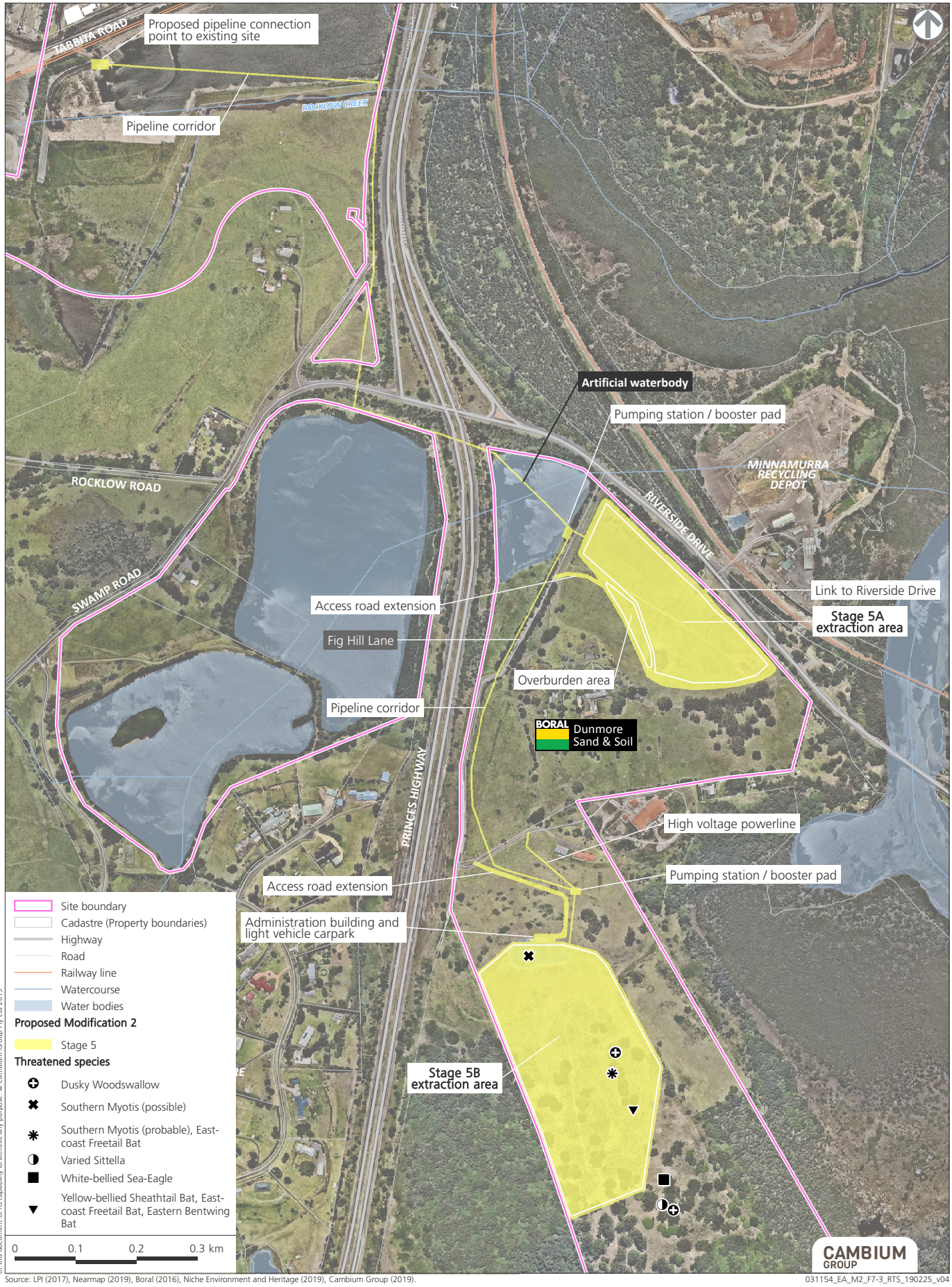

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7.3.3 Impact assessment

Avoidance and minimisation

DSS has aimed to avoid and minimise environmental impacts from the proposed modification during the design process. A preliminary environmental constraints assessment for the Stage 5B extraction area was conducted, which included consideration of constraints such as threatened vegetation communities, threatened species habitat and other identified ecological constraints.

After further ecological survey (described within the BDAR) there has been substantial re-design of the Stage 5B extraction area including reducing the disturbance footprint of the Stage 5B dredge pond, and positioning supporting infrastructure to avoid and mitigate impacts to biodiversity, with a particular emphasis on avoiding the following features:

- threatened ecological communities (i.e. Bangalay Sand Forest (particularly areas in good condition), Swamp Oak Floodplain Forest and Littoral Rainforest) and other intact native vegetation;
- coastal wetlands (including wetlands listed in the Coastal SEPP); and
- hollow bearing trees.

In addition to avoidance measures incorporated into design, planning for the proposed modification has avoided or minimised impacts on biodiversity by:

- relocation of infrastructure to areas that avoid clearing of native vegetation, which enabled avoidance of 11 hollow bearing trees; and
- avoidance of direct impacts within the 'proximity area for coastal wetlands' located immediately east of the Stage 5B extraction area.

Direct impacts

The proposed modification will directly impact biodiversity during construction and operation. Most impacts on biodiversity will occur during establishment of the two extraction areas, associated with clearing of native vegetation and removal of habitat.

The following direct impacts will result from the proposed modification:

- clearing of native vegetation and associated habitat, conservatively estimated to be 7.5 ha, including 4.53 ha of Bangalay - Old-man Banksia open forest on coastal sands, Sydney Basin Bioregion and South East Corner Bioregion TEC;
- clearing of approximately 4.04 ha of exotic grassland vegetation; and
- clearing of associated species credit fauna habitat, including hollow bearing trees and logs.

12 Bangalay trees containing hollows will require removal for the proposed modification. The locations of the hollow bearing trees are shown on **Figure 7.2**.

With the exception of areas of good and moderate condition TEC, most of the vegetation likely to be affected by the proposed modification has been subject to historic clearing, grazing and other agricultural activities and is therefore thinned, fragmented and predominantly consists of exotic pasture grasses.

The Grey-headed Flying-fox is listed under the EPBC Act and could be impacted by the proposed modification via removal of potential habitat, and as such an assessment of significance was undertaken for the species (refer to Appendix 9 of **Appendix F**). The assessment of significance concluded the proposed modification will not result in a significant impact to the species and no referral to the Commonwealth government is required.

Indirect impacts

Indirect impacts will mostly occur during the construction phase of the proposed modification and will be short term and largely confined to the modification site and immediate surrounds.

The primary indirect impacts will be:

- increased noise and dust from the construction and operation of the proposed modification;
- increased edge-effects for surrounding vegetated areas;
- erosion and sedimentation in areas adjoining construction and operational activities; and
- spread of weed propagules, which could lead to invasion of native vegetation by weeds.

Impacts to coastal wetlands

There will be no direct impacts to the mapped coastal wetland areas as a result of the proposed modification. There is some risk of indirect impacts to coastal wetlands via alterations to both groundwater and surface water flow regimes. No other measurable adverse indirect ecological impacts are expected to occur from the proposed modification.

In regard to groundwater changes the hydrogeological impact assessment (EES, 2019) states:

'The findings of this report have determined that as groundwater movement accounts for less than 0.21 per cent of catchment drainage, excavation of the aquifer sediments should have no discernible effect on catchment hydrology other than increasing the area available for water storage on the Site'.

The surface water assessment (Southeast, 2019) highlights potential impacts on coastal wetland areas via flooding of dredge ponds and subsequent transportation of sediments to coastal wetland areas. It is considered that should a moderately large proportion of dredge-pond sediment be transported to coastal wetlands there would be potential to have significant impacts on these areas. However, separation of floodwaters from dredge waters via the proposed flood protection bunding will significantly lower this risk.

Residual risks to aquatic habitats have also been outlined within the surface water assessment including erosion of exposed areas post-clearing of vegetation and during flood protection bund construction. These risks also apply to coastal wetland areas. The key management tool to reduce these risks would be development and implementation of an appropriate Soil and Water Management Plan.

The key risks to coastal wetlands have been examined within the hydrogeological impact assessment and surface water assessment for the proposed modification. Provided that the avoidance and mitigation measures stated within these assessments are successfully achieved, it is considered unlikely that significant impacts would occur for mapped coastal wetland areas.

7.3.4 Mitigation and management measures

Flora and fauna management plan

The existing *Dunmore Sand and Soil Quarry Flora and Fauna Management Plan* (Arcadis, 2017) (FFMP) will be updated to include the additional management activities associated with the Stage 5 extraction area provided in Section 3 of the BDAR, and summarised below:

- establishment of fenced buffer areas around the modification site where native vegetation is adjacent to protect trees and other vegetation outside of the modification site, with fencing maintained throughout the construction and operational phases of the proposed modification;

- pre-clearing inspections of hollow bearing trees to be removed to ensure the absence of roosting/breeding threatened species with the potential to occur. Any native vertebrate fauna present within hollow trees will be managed to minimise the risk of mortality or injury. Tree clearing will be undertaken in accordance with best practise principles;
- clearing of hollow bearing trees should not be undertaken during the breeding season for the majority of hollow-dwelling fauna (spring);
- installation of nest boxes to the south of the Stage 5B extraction area. The number and size of nest boxes will be at least equal to that of the existing number of hollows that are to be removed by the proposed modification as determined via a final survey of hollow trees. Establishment and documentation of a nest box management plan would be included within the FFMP;
- existing protocols for monitoring of weeds and their management would be incorporated into the FFMP, with relevant practices adopted within vegetated areas adjacent to the Stage 5B extraction area. The purpose would be to ensure no increased weed incursions from a result of the proposed modification occurring within adjacent vegetation. As the adjacent area to the west presently has a high density of weeds, this would likely result in overall weed reduction;
- ensuring vehicles remain on designated roads and tracks whenever possible through use of signposting and driver education during the induction process and in ongoing project discussions;
- establishment and regular maintenance of erosion and sediment controls during construction and until exposed surfaces areas are stabilised;
- management and removal of all waste from the site;
- the *Dunmore Sand and Soil Project Rehabilitation Management Pla*n (Arcadis, 2017) would be updated to include the Stage 5 extraction area and any additional management strategies to ensure temporary stabilisation of exposed surfaces, permanent stabilisation strategies, progressive rehabilitation of exposed surfaces with groundcover vegetation during dredging operations, and final rehabilitation as soon as practical after exhaustion of the sand resource in each extraction area.

7.3.5 Residual impacts

The proposed modification will not have 'serious and irreversible impacts' (as defined by the BAM) on any threatened species.

The proposed modification will impact on PCTs, with a total of 4.53 ha of TEC to be cleared as summarised in **Section 7.3.2**. These impacts will require offsetting under the BC Act.

The ecosystem credits required to offset vegetation and habitat impacts are summarised in **Table 7.4**.

Table 7.4: Ecosystem credit requirements

PCT	Required credits
PCT 659 Bangalay - Old-man Banksia open forest on coastal sands, Sydney Basin Bioregion and South East Corner Bioregion (Good condition)	30
PCT 659 Bangalay - Old-man Banksia open forest on coastal sands, Sydney Basin Bioregion and South East Corner Bioregion (Moderate condition)	41
Total	**71**

The species credits required to offset impacts on threatened fauna are summarised in **Table 7.5**.

Table 7.5: Species credit requirements

Species credit species	Required credits
Southern Myotis	19
Masked Owl	30
Barking Owl	30

Under the BAM, an offset strategy is not required to be submitted with the BDAR, as the credits are to be formally retired with the establishment of a stewardship site, or payment into the BCT.

7.4 Historic heritage

This chapter summarises the statement of heritage impact (SoHI) report, which is in **Appendix G**. It describes the non-Aboriginal cultural context of the modification site, heritage listings identified during desktop review and field survey, the significance of the items, and potential impacts and mitigation measures where impacts are unavoidable.

7.4.1 Existing environment

Desktop searches

The Commonwealth Heritage List, National Heritage List, NSW State Heritage Register and Shellharbour LEP 2013 were searched in December 2018.

There are heritage items in the modification site and surrounds, which are summarised in **Table 7.6** and shown on **Figure 7.4**.

Table 7.6: Heritage listings within the modification site and surrounds

Item Name	Item/Listing Number	Address	Significance
Dunmore House Complex, Dry Stone Walls and Trees	Shellharbour LEP 2013 I027	471 Riverside Drive, Dunmore	Local
Anglesboro and Trees	Shellharbour LEP 2013 I028	4 Swamp Road, Dunmore	Local
Minnamurra Vegetation Area	Shellharbour LEP 2013 I358	Dunmore	Local
Rocklow Road Dry Stone Wall	Shellharbour LEP 2013 I253	Rocklow Road, Dunmore	Local

Figure 7.4
Historic heritage items

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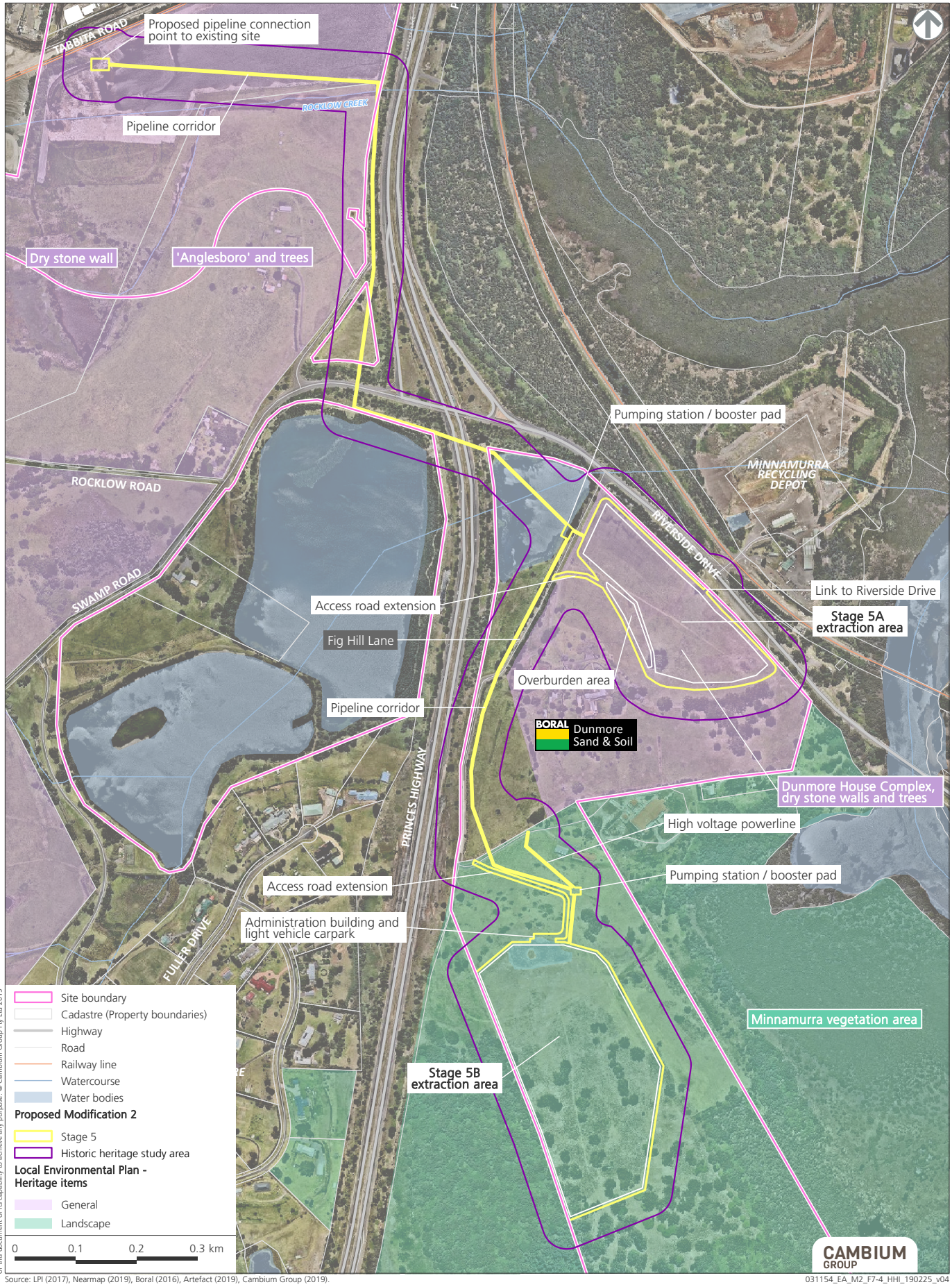

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Field survey

The modification site was inspected on 17 December 2018 to identify and assess potential impacts of the proposed modification on heritage items, including impacts to potential archaeological deposits in the modification site, and historic views and vistas.

Assessment of significance

The significance of a heritage item must be determined before potential impacts on that item's significance can be assessed. In NSW, an item's heritage significance is assessed based on the Burra Charter and considers a combination of its:

- importance to State or local cultural or natural history (historical significance);
- association with the life works of a person or group of importance to State or local cultural or natural history (associative significance);
- demonstration of aesthetic characteristics and/or a high degree of creative or technical achievement (aesthetic significance);
- association with a cultural or community group for social, spiritual or cultural reasons (social significance);
- potential to contribute information about State or local cultural or natural history (research significance);
- possession of uncommon, rare or endangered components (rarity);
- demonstration of the principle characteristics of a class of cultural or natural place or environment (representativeness).

The statements of significance for each item are summarised in Chapter 5 of the SoHI.

Archaeological assessment

No evidence of archaeological remains were identified during the field survey.

The potential archaeological resources in the modification site have been divided into four time periods based on historical activity.

The potential archaeological resources in the modification site that have potential to meet the local significance threshold include:

- Period 1 (early land use grants 1810-1865): evidence of early land grants to D'Arcy Wentworth including the Peterborough Estate. Potential remains are likely to reach the threshold for local significance for historical, social, rarity and research potential; and
- Period 2 (early subdivision and Dunmore House 1865-1880s): evidence of subdivision of the Peterborough Estate and establishment of Dunmore House. Potential archaeological remains dating to the 1860s could include brick footings, outbuildings, evidence of sheds, postholes, rubbish deposits, yard scatters and artefact deposits associated with Dunmore House. These remains would be likely to reach the threshold for local significance for their social value.

Potential archaeological remains in the modification site that could meet the local significance threshold include those associated with:

- Period 3: evidence of 1880s development of the modification site and continued development until the 1960s. Evidence of land use during this phase could include former access ways, fence lines, and evidence of farming practices; and
- Period 4: late 20th century development of the modification site.

The modification site has no to low potential to contain locally significant archaeological remains associated with the earliest European development of the modification site and wider Shellharbour region under Phase 1, and low potential to contain locally significant archaeological remains associated with the subsequent development of the study area under Phase 2.

If archaeological deposits such as wells or rubbish dumps are encountered during operations, they would reach the local significance threshold through their ability to provide information regarding the previous occupants of the site, and potentially contribute to knowledge of the early historical development of Dunmore and wider Shellharbour region.

7.4.2 Potential impacts

Heritage impact assessment

Dunmore House Complex, Dry Stone Walls & Trees

Physical impact

The proposed modification will involve a range of works that will result in direct physical impact within a large area of the heritage curtilage of the Dunmore House Complex, Dry Stone Walls and Trees. The proposed Stage 5A extraction area will be in the northern portion of the heritage item. It is noted that this portion of the heritage item primarily comprises undeveloped land that has undergone previous impact by way of clearing and agricultural grazing.

A small area comprising bamboo, exotic plantings and stone rubble is located within the site of the proposed dredge pond, which are remnants of a Japanese style pond that was established circa 1960. A modern concrete livestock trough is also located within the site of the proposed dredge pond. The establishment of the proposed Stage 5A extraction area will necessitate removal of these features, although these landscape elements are not considered to represent original or significant fabric within the Dunmore House Complex.

The temporary access road from the Stage 5A extraction area connecting to Riverside Drive will result in localised impact to remove a portion of the existing timber post and rail fence located along the northern boundary of the item's heritage curtilage. This modern fence, while sympathetic to the aesthetic qualities of the rural property, does not constitute significant or original fabric within the homestead complex. It is understood that following the completion of the project, the affected portion of fencing will be reinstated. Establishment of the proposed access road will also necessitate removal of one large tree located on the northern boundary of the site. While this mature native tree is not a planting that will constitute a significant heritage component within the homestead complex, the tree supports the setting and context of the historic property and its removal will represent an adverse physical impact.

Establishment of an overburden area adjoining the site of the dredge pond, along with requirement for an earth bund for flooding protection comprising an embankment around the perimeter of the pond, will be temporary and are not considered to result in any additional adverse heritage impact. A short length of a proposed pipeline connecting to the Stage 5A dredge pond and leading north will also be located within the northern extent of the heritage curtilage of the property. It is understood this section of the proposed pipeline, the path of which travels across the existing entry drive and Fig Hill Lane, will be underground. The existing entry drive is not the original driveway to the property, with the original driveway having been formerly located to the east of the homestead complex. Private access to the property via the entry driveway and Fig Hill Lane will not be compromised by the proposed modification.

Following completion of the Stage 5A extraction area, the dredge pond will be infilled to the natural ground level and the land rehabilitated and reverted back for use as agricultural pasture,

which will continue the historical use of this part of the historic property. As such, physical impact from the dredge pond and associated infrastructure will be temporary in nature. The proposed modification will involve construction activities in the vicinity of the heritage item, although these will be more than 75 m away from the nearest built element within the heritage item, and as such indirect physical impact by way of vibration is not anticipated.

The proposed modification will involve ground disturbing activities within the curtilage of Dunmore House Complex, Dry Stone Walls and Trees heritage item within an area that has been identified as having no to low potential for locally significant archaeological remains, therefore archaeological impact is unlikely. It is also noted that no works are proposed within the homestead complex itself, which is likely to contain higher archaeological potential.

The proposed modification will therefore result in a moderate physical impact to the Dunmore House Complex, Dry Stone Walls and Trees heritage item.

Visual impact

The proposed modification will involve establishment of the Stage 5A dredge pond, access roads, installation of a pipeline and associated works within the Dunmore House Complex, Dry Stone Walls and Trees heritage item. These works are associated with a range of visual changes and impacts that will occur within the item's heritage curtilage.

The proposed dredge pond will be located within the primary view catchment of the historic homestead, which is oriented north and north east. Dunmore House itself is prominently sited on a hill, and retains significant views of the surrounding floodplains and distant landscape setting. The dredge pond will be located to the north and north east of the homestead on the low-lying floodplain within the property. It is noted that while the dredge pond will likely be visible from glimpsed views within the homestead and surrounding garden on the hill, the pond will be largely screened by existing vegetation and plantings surrounding the house.

The proposed Stage 5A dredge pond will be partially visible in views looking towards Dunmore House from surrounding vantage points in the public domain, in particular for motorists travelling along the nearby Riverside Drive. The proposed dredge pond and associated infrastructure will detract from these existing views towards the landmark property, although this impact will be temporary in nature and affected views will be reinstated upon completion of the extraction area following rehabilitation of the dredge pond back to existing ground level for grazing. It is also noted that the proposed flooding bund comprising an earth embankment around the pond will partially screen the extraction area from view for motorists travelling along Riverside Drive and from surrounding publicly accessible vantage points.

The proposed pipeline will be located within the north-eastern corner of the item's heritage curtilage leading from the Stage 5A dredge pond. Due to the unobtrusive location of the pipeline beneath the ridgeline and the low-rise profile of the pipes, it is anticipated that any visual changes will be minor and will not diminish the significant rural character and setting of the historic property.

Establishment of the access road from Riverside Drive to the Stage 5A extraction area will necessitate removal of a mature native tree located on the northern boundary of the site. This tree currently enhances the significant semi-rural setting and context of the historic property and its removal will therefore represent an adverse visual impact.

The visual impact of the proposed modification, mainly relating to the proposed Stage 5A dredge pond, and associated flooding bund and overburden area will be temporary in nature. The site of the Stage 5A dredge pond will be infilled and the land reverted back for use as agricultural pasture, which will reinstate the existing rural character and appearance of this part of the property.

The modification will therefore result in a moderate visual impact to the Dunmore House Complex, Dry Stone Walls and Trees heritage item.

Minnamurra Vegetation Area

Physical impact

The proposed modification will involve a range of works that will result in direct physical impact within a large portion of the heritage curtilage of the Minnamurra Vegetation Area. Establishment of the Stage 5B dredge pond will require removal of all vegetation within this footprint and will affect the entirety of this part of the ecological item. It is noted that while this portion of the landscape heritage item has been subject to previous impact by way of clearing and agricultural grazing and an existing agricultural dam, the large trees in the southern portion of the Stage 5B extraction area are contributing elements that support the overall integrity of the surrounding vegetation area.

The proposed modification will also require establishment of a temporary access road and installation of an above ground pipeline with pumping station connecting to the Stage 5B extraction area and running north within the northern extent of the heritage curtilage. It is understood the proposed route of the access road and pipeline will not require removal of any vegetation, and the pipeline will be installed above ground for the duration of the Stage 5B extraction area. Establishment of the access road, carpark and site offices within the northern extent of the heritage curtilage of the Minnamurra Vegetation Area will require localised ground disturbances, although this is largely cleared and is used as agricultural grazing land. Establishment of a flooding bund around the perimeter of the pond is not considered to result in any additional physical impact.

Following completion of the Stage 5B extraction area, the dredge pond will remain in place and adjoining pipeline and associated infrastructure decommissioned. The removal of vegetation and trees within the Minnamurra Vegetation Area for the Stage 5B dredge pond will represent a permanent physical impact to this heritage item that will potentially compromise its identified significant ecological value.

The potential direct and indirect impacts of the proposed modification associated with biodiversity values have been assessed in **Section 7.3**.

It was concluded that despite the presence of threatened ecological communities and fauna habitat at the site, the removal of native vegetation and potential fauna habitat will be unlikely to have significant impacts on the ecological values of the locality and region. A biodiversity offset strategy will be prepared to offset impacts to biodiversity in accordance with the NSW Biodiversity Offset Policy for Major Projects (NSW Office of Environment and Heritage, 2014).

The Minnamurra Vegetation Area comprises a landscape item devoid of any built elements or features, and as such any indirect impact by way of vibrations during construction and operational activities are not anticipated. As physical impacts within the heritage curtilage of the item will be able to be partially mitigated, the impact of the proposed modification will be moderate in nature.

The proposed modification will therefore result in a moderate physical impact to the Minnamurra Vegetation Area heritage item.

Visual impact

The establishment of the Stage 5B dredge pond and associated removal of trees and vegetation will result in permanent visual changes to the existing landscape qualities of the Minnamurra Vegetation Area. While it is noted that the landscape item is mainly of identified significance for its ecological value associated with its rarity, representativeness and research potential, the extent of visual changes within the heritage item and removal of vegetation will still

diminish its integrity and intactness. Visual changes associated with the dredge pond and temporary infrastructure will be localised within the overall context of the heritage item, although they will still be discernible from surrounding properties including from distant views within the adjoining Dunmore House Complex, Dry Stone Wall and Trees heritage item.

The proposed modification will therefore result in a moderate visual impact to the Minnamurra Vegetation Area heritage item.

Anglesboro and trees

Physical impact

While adjacent to the 'Anglesboro' and Trees heritage item, the proposed modification will not involve any works that will result in direct impacts within the heritage curtilage of the historic homestead complex. Construction activities will be required within the vicinity of the heritage item, such as installation of the pipeline, although as these will be more than 75 m away from the nearest built element within the heritage item, indirect physical impact by way of vibrations is not anticipated.

The proposed modification will therefore result in a neutral physical impact to the 'Anglesboro' and Trees heritage item.

Visual impact

The proposed modification will involve installation of an above ground pipeline and associated works adjacent to the 'Anglesboro' and Trees heritage item. The proposed pipeline will be located beyond the existing timber post and rail fence along the item's front (eastern) boundary. Due to the unobtrusive location of the pipeline beneath the ridgeline and the low-rise profile of the proposed pipeline, it is anticipated that any visual changes will be minor and will not diminish the significant rural character and setting of the historic property. The existing fence will further screen any glimpsed views of the pipeline from the cottage.

It is understood the establishment of the proposed pipeline will not require removal of any vegetation immediately adjacent to the item's eastern boundary, which will further maintain the visual character of the heritage item and ensure that views out from the property are not obstructed or diminished.

It is noted that the proposed pipeline will be decommissioned and removed upon completion of the Stage 5 extraction area, and as such any minor visual impacts in the locality will be temporary in nature.

The proposed modification will therefore result in a negligible (temporary) visual impact to the 'Anglesboro' and Trees heritage item.

Rocklow Road Dry Stone Wall

Physical impact

The proposed modification will not involve any works that will result in direct impacts within the heritage curtilage of this heritage item. The significant fabric of the heritage item, comprising the stone wall that borders the northern side of Rocklow Road, is located a considerable distance from the proposed works location. As the pipeline alignment will be more than 75 m away from the stone wall, indirect physical impact by way of vibration is not anticipated.

The proposed modification will therefore result in a neutral physical impact to the Rocklow Road Dry Stone Wall heritage item.

Visual impact

The proposed modification, including establishment of a pipeline on the western side of Princes Highway, will be located a considerable distance from significant fabric within the Rocklow Road

Dry Stone Wall, the heritage curtilage of which appears to be mapped off the boundary of the lot. The stone wall itself is located over 75 m from the proposed pipeline. The pipeline will be low-rise in profile and screened by existing vegetation and development, and as such no visual impact is anticipated.

The modification will therefore result in a neutral visual impact to the Rocklow Road Dry Stone Wall heritage item.

Archaeological impacts

Activities with the potential to impact on archaeological resources will include excavations required for the Stage 5A and 5B dredge ponds and associated infrastructure comprising access roads, carpark, site office, power poles and any localised earth works required for the pipelines, although most of the length of the pipeline will sit above ground.

The potential for locally significant archaeology to be located within the modification site has been assessed as nil-low, therefore the proposed modification is not considered to result in an archaeological impact.

Summary of heritage impacts

A summary of impacts to the historic heritage items in the vicinity of the modification site is provided in **Table 7.7**.

Table 7.7: Summary of heritage impacts.

Item Name	Direct (physical) impact	Visual impact	Indirect impact
Dunmore House Complex, Dry Stone Walls and Trees	Moderate	Moderate	Neutral
Minnamurra Vegetation Area	Moderate	Moderate	Neutral
Anglesboro and Trees	Neutral	Negligible	Neutral
Rocklow Road Dry Stone Wall	Neutral	Neutral	Neutral

7.4.3 Mitigation and management measures

The following mitigation and management measures will assist in minimising the potential impact of the proposed modification on nearby heritage items and the wider Shellharbour cultural landscape:

- any unexpected archaeological remains within the modification site remain protected by the *Heritage Act 1977*. If a potential relic is uncovered in the course of the works, work in the vicinity should cease, and the Heritage Division of OEH should be contacted for advice; and
- a heritage induction should be presented to workers before commencement of works in the vicinity of heritage items within the modification site. The induction should include the heritage values of the place, avoidance procedures, and contacts for reporting unexpected archaeological finds or inadvertent impacts to heritage items.

7.5 Air quality

This section summarises the air quality impact assessment (AQIA) report, which is in Appendix H. It summarises the potential air quality impacts to sensitive receivers during establishment and operation of the proposed modification, and mitigation measures to be implemented to minimise potential impacts.

7.5.1 Objectives and method

The objective of the air quality impact assessment (AQIA) was to identify and assess the potential for adverse operational air quality impacts which may result from the proposed modification.

The AQIA involved:

- a review of the existing meteorological and air quality environment surrounding the modification site;
- quantification of the potential dust emissions generated from the construction and operation of the proposed modification; and,
- a qualitative assessment of potential air quality impacts associated with the proposed modification.

The AQIA was prepared in accordance with EPA's (2017) *Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales*, and key findings of this assessment are summarised in the following sections.

The following atmospheric pollutants are likely to be generated by the proposed modification:

- deposited dust;
- total suspended particulate (TSP) matter, which is nominally taken to be less than 30 micrometres (µm) in diameter and refers to all suspended particles in the air;
- PM_{10}, which is a subset of TSP and has a diameter of 10 µm or less;
- $PM_{2.5}$, which is a subset of TSP and has a diameter of 2.5 µm or less; and
- pollutants generated through the combustion of fuel in vehicle engines (NOx, SO_2, volatile organic compounds, CO, PM_{10} and $PM_{2.5}$).

Pollutants from the exhaust emissions of petrol and diesel powered equipment were considered to be too small, too infrequent or too widely distributed to generate any significant off-site pollutant concentrations. Therefore, these pollutants were not assessed further in the AQIA.

7.5.2 Assessment criteria

Potential emissions from the proposed modification were assessed against the air quality criteria in EPA's (2017) *Approved Methods for the Modelling and Assessment of Air Pollutants in NSW*, which are summarised in **Table 7.8**.

Table 7.8: Project specific air quality criteria

Particulate matter	Averaging time	Criterion
TSP	Annual	90 µg/m³
PM_{10}	24-hour maximum	50 µg/m³

Particulate matter	Averaging time	Criterion
	Annual	25 µg/m³
$PM_{2.5}$	24-hour maximum	25 µg/m³
	Annual	8 µg/m³
Deposited dust	Annual	Maximum Incremental (project only) increase of 2 g/m² /month Maximum total (project and other sources) of 4 g/m² /month

7.5.3 Existing environment

The region's climate characteristics are summarised in **Section 1.3.7**.

Local air quality

The main sources of air pollution in the region are anthropogenic activities such as motor vehicle exhaust, urban activity and various commercial and industrial activities.

Background levels for the modification site were estimated using data from air monitoring locations at the existing site (inclusive of a high volume air sampler (HVAS) measuring PM_{10} and five dust deposition gauges) and the OEH's Wollongong, Kembla Grange and Albion Park South monitoring stations (approximately 22 km, 15 km to 6 km from the site respectively).

The ambient air quality monitoring data indicated that:

- Annual average PM_{10} levels were below the criterion of 25 µg/m³ at the existing site and regional OEH monitoring stations, and 24-hour average results were occasionally above the criterion of 50 µg/m³ in 2017 at the existing site, and in each of the years between 2013 and 2017 at the OEH monitoring locations.
- Annual average $PM_{2.5}$ levels were below the advisory reporting standard of 8 µg/m³, whilst the maximum 24-hour average $PM_{2.5}$ concentrations recorded at the regional OEH monitoring stations exceeded the criterion of 25µg/m³ in each year between 2013 and 2017.
- The 24-hour PM_{10} and $PM_{2.5}$ levels are relatively constant throughout the year, with some periods of elevated levels most likely associated with bushfires.
- Dust deposition was monitored at the existing site during the 2013 to 2017 financial years. The annual average dust deposition levels at each gauge were below the criterion of 4 g/m²/month with the exception of gauge DD2 and DD8 in 2013, and gauge DD8 in 2015.

It is likely these exceedances in depositional dust are associated with the positioning of the gauges adjacent to agricultural land uses and an unsealed road. Additionally, samples are often contaminated with bird droppings and insects, which can increase the insoluble solid content.

It is noted that in the time since the exceedances were recorded, no additional exceedances have occurred.

7.5.4 Potential impacts

Sand extraction

The following activities will generate particulates during operation of the modification:

- handling and transport of topsoil in the initial stages;
- wind erosion from stockpiles;
- vehicle movements on unsealed roads; and
- diesel exhaust from vehicles and plant.

The sand dredging will be a wet process and will not generate significant particulate emissions. There will not be any particulate emissions from sand transportation as it will be conveyed to the processing area via enclosed pipes.

Dust emissions from the proposed modification were estimated applying the United States EPA's emissions factors to the above dust generating activities (Table 5.1 in the AQIA). This demonstrated that most of the emissions associated with the modification will be generated during stripping and stockpiling of the topsoil prior to sand extraction, which will be temporary activities.

As these activities will substitute the existing activities at the approved project, and no additional extraction is proposed, the emissions profile of the proposed modification will be similar to approved activities.

The estimated emissions were compared to the total particulate emissions from the most significant emission source in the surrounding area, namely the Dunmore Hard Rock Quarry to the north west of the modification site.

The *Dunmore Quarry Air Quality Impact Assessment – Modification 9* (Ramboll, 2016) estimated a maximum annual TSP emission rate of 409,600 kg/year. In comparison, the maximum estimated TSP emission rate for the proposed modification equates to approximately 1% of this level. This is considered to be minor in comparison, and would be difficult to discern beyond the existing background level.

It is noted that the existing air quality levels near the modification site indicate annual average PM_{10} levels well below the relevant impact assessment criterion and, given the scale of emissions from the proposed modification relative to existing approved operations and other nearby operations, it is unlikely particulate emissions from the proposal will impact air quality. Therefore, the assessment did not include air dispersion modelling.

Importation of fill material

The activities which have potential to generate dust impacts during importation of fill are:

- earthworks associated with the emplacement and shaping of VENM material imported to the site for construction of the flooding protection bunds, stabilisation of the dredge ponds, the backfill of Stage 5A dredge pond and rehabilitation; and
- potential tracking of sediment from unpaved roads onto public roads.

The following dust impacts may arise from the above dust generating activities:

- annoyance due to dust deposition;
- harm to ecological receptors, referring to direct impacts on vegetation or aquatic ecosystems, from dust deposition; and
- the risk of health effects due to a significant increase in exposure to PM_{10}.

Potential impacts were subject to a risk-based assessment, which considered the scale and nature of the works and the proximity to sensitive receptors. There is a low to medium risk that importation of VENM would result in the above dust impacts, based on the level and area of activity and proximity to surrounding receptors.

Provided the dust management measures in **Section 7.5.5** are implemented, dust impacts will be minimised and potential impacts associated with the importation of fill material will be managed effectively.

7.5.5 Mitigation and management measures

The majority of dust emissions from the proposed modification will occur during the initial preparation stages, which are for a limited duration, and ongoing operational activities will generate minimal dust emissions. As the proposed modification will not increase the maximum total approved sand production rate, it will not generate additional dust beyond that occurring under the approved project.

There is a low to medium risk that importation of fill will generate dust. This risk will be reduced with implementation of the management measures outlined in Section 6 of the AQIA report, which will be incorporated into the revised Environmental Management Plan for the approved project.

7.6 Noise

This section summarises the noise impact assessment (NIA) report, which is in **Appendix I**. It describes the noise assessment criteria which apply to the Project, potential noise emission sources, modelling method and results, potential impacts and mitigation measures where impacts are unavoidable.

7.6.1 Objectives and method

Operational noise emissions from the proposed modification were predicted at sensitive receivers using the 'CadnaA' noise prediction software (refer to Section 6.2 of **Appendix I** for detailed operational noise modelling methods). The predictions were compared to the noise criteria in the EPA's (2017) *Noise Policy for Industry* (NPI). Impacts will occur if the predicted noise levels exceed relevant criteria at any sensitive receivers.

Vibration impacts were not assessed given the separation distance between proposed activities and sensitive receivers. Noise emissions from project related traffic were not assessed as vehicles will not pass near any sensitive receivers.

7.6.2 Existing environment

Noise sources

The modification site is in a semi-rural area which has the following background noise sources:

- natural (e.g. birdsong, insects, road noise and livestock);
- extractives and waste management (Dunmore Hard Rock Quarry to the north west and Dunmore Resource and Recycling Facility to the north);
- residential (Dunmore Lakes Estate to the south west and Minnamurra to the east); and
- infrastructure (Princes Highway to the west, and the South Coast Rail Line to the north east).

The sensitive receivers that could be impacted by noise from the proposed modification are summarised in **Table 7.9**.

Table 7.9: Sensitive receivers

Receiver Identification	Address	Lot/DP Number
R1	471 Riverside Drive, Dunmore	Lot 501 DP 1174897
R2	69 Fig Hill Lane, Dunmore	Lot 51 DP 1012246
R3	431 Riverside Drive, Dunmore	Lot 1 DP 219199
R4	2 The Village, Minnamurra	Lot 1 DP 225638
R5	1 The Village, Minnamurra	Lot 2 DP 1196150
R6	306 Riverside Drive, Minnamurra	Lot 2 DP 1192433
R7	304 Riverside Drive, Minnamurra	Lot 4 DP 1192433
R8	302 Riverside Drive, Minnamurra	Lot 1 DP 224542
R9	300 Riverside Drive, Minnamurra	Lot 2 DP 224542
R10	298 Riverside Drive, Minnamurra	Lot 3 DP 224542
R11	17 Allawah Place, Dunmore	Lot 32 DP 285417
R12	15 Allawah Place, Dunmore	Lot 33 DP 285417
R13	13 Allawah Place, Dunmore	Lot 18 DP 285417
R14	11 Allawah Place, Dunmore	Lot 19 DP 285417
R15	9 Allawah Place, Dunmore	Lot 20 DP 285417
R16	1 Allawah Place, Dunmore	Lot 21 DP 285417
R17	16 Fuller Drive, Dunmore	Lot 22 DP 285417
R18	18 Fuller Drive, Dunmore	Lot 34 DP 285417
R19	63 Swamp Road, Dunmore	Lot 17 DP 607791
R20	40 Swamp Road, Dunmore	Lot 1 DP 745632

It should be noted that the landowners at receivers R1 and R2 have entered into a negotiated noise agreement with DSS and as such project noise trigger levels do not apply to these receivers. In addition, as R21 is an uninhabited structure without DA approval, noise levels at this receiver were not considered further in the NIA.

Meteorology

Certain meteorological conditions may increase noise levels by focusing soundwave propagation paths at a single point. The refraction of sound waves occurs during temperature inversions (where temperature increases with height above ground level) and can vary from hour to hour during the night period. Other adverse meteorological conditions, such as prevailing winds are also required to be considered where relevant for an industrial activity.

The NPI stipulates default parameters to account for noise enhancing weather conditions and these parameters were considered in the NIA. It has been determined that given the proposed

modification will involve commencement of dredging operations at 6 am which is the morning shoulder of the night period, the modification will be subject to temperature inversions, which occur during the night time. Prevailing winds occur during the evening and night periods.

Noise monitoring

Unattended noise monitoring was conducted between 13 and 24 August 2018 at selected representative locations to establish the existing ambient noise environment at the nearest potentially affected sensitive receivers.

Using the existing ambient noise levels, the rating background levels (RBLs) were determined in accordance with the NPI. The ambient noise levels are in **Table 7.10**.

Table 7.10: Ambient noise levels

Monitoring location	Representative receivers	Time of day[1]	Noise levels (dBA)	
			RBL	L_{Aeq}
R1	R1 - R3, R11 – R18	Morning shoulder (6am)	46	54
		Day	47	55
		Evening	45	54
		Night	35	50
R8	R4 – R10	Morning shoulder (6am)	38	57
		Day	42	64
		Evening	38	61
		Night	37	56
R20	R19	Morning shoulder (6am)	41	52
		Day	42	53
		Evening	43	51
		Night	33	49

[1] Daytime (7.00am-6.00pm); evening (6.00pm-10.00pm); night time (10.00pm-7.00am) (NPI).

7.6.3 Assessment criteria

The noise modelling results were compared to the project specific noise criteria, which were established using the NPI. The NPI stipulates that intrusiveness and amenity criteria must be determined for the daytime (7 am - 6 pm), evening (6 pm - 10 pm) and night time (10 pm - 7 am) periods, as relevant, and apply at the most affected point on or within the receiver property boundary.

The project noise trigger level is the lowest value of the project intrusiveness noise level and project amenity noise level.

Table 7.11 summarises the intrusiveness and amenity criteria for the proposed modification, along with the project noise trigger levels.

Table 7.11: Project noise trigger levels

Receiver	Time of day[1]	Criteria (dBA)		
		Intrusiveness ($L_{Aeq, 15min}$)	Amenity ($L_{Aeq, period}$)	Project Noise Trigger Level ($L_{Aeq, 15min}$)
R3, R11 – R18	Morning shoulder (6am)	51	N/A[2]	51
	Day	52	48	48
	Evening	50	43	43

Receiver	Time of day[1]	Criteria (dBA)		
		Intrusiveness ($L_{Aeq, 15min}$)	Amenity ($L_{Aeq, period}$)	Project Noise Trigger Level ($L_{Aeq, 15min}$)
	Night	40	38	38
R4 – R10	Morning shoulder (6am)	43	N/A[2]	43
	Day	47	48	47
	Evening	43	43	43
	Night	42	38	38
R19	Morning shoulder (6am)	46	N/A[2]	46
	Day	47	48	47
	Evening	47	43	43
	Night	38	38	38

[1]Daytime (7.00am-6.00pm); evening (6.00pm-10.00pm); night time (10.00pm-7.00am) (NPI).
[2]There is no recommended amenity noise levels specified for shoulder periods.

It should be noted that operational noise levels at receiver R20 are stipulated in the Project Approval. These noise levels are set at 49 dBA for the day period, 44 dBA for the evening and 38 dBA for the night period.

Residual noise significance

Residual noise is the predicted noise level minus the Project noise trigger level. The NPI acknowledges the potential for residual noise impacts after reasonable and feasible mitigation has been applied and provides guidance as to the significance of these impacts as outlined in **Table 7.12**.

Table 7.12: Significance of residual noise impacts

Predicted noise level minus trigger level	Cumulative industrial noise level	Significance of residual noise level
<= 2 dBA	Not applicable	Negligible
>=3 but <=5 dBA	< recommended amenity noise level or > recommended amenity noise level, but the increase in total cumulative industrial noise level resulting from the development is less than or equal to 1dB	Marginal
>=3 but <=5 dBA	> recommended amenity noise level and the increase in total cumulative industrial noise level resulting from the development is more than 1dB	Moderate
>5 dBA	=< recommended amenity noise level	Moderate
>5 dBA	> recommended amenity noise level	Significant

The NPI also gives examples of noise mitigation measures or noise treatments that can be applied to address residual noise impacts. The NPI states that where the significance of the residual noise level is ‘negligible’, the exceedance will not be discernible by the average listener and therefore will not warrant receiver-based treatment or controls.

Sleep disturbance screening levels

During the night time, it is possible for operational activities of short duration but high intensity to cause sleep disturbance, without significantly affecting $L_{Aeq, 15min}$ noise levels. The dredge(s) will operate from 6 am and maximum noise level events need to be considered for potential sleep disturbance.

The NPI recommends that, where the night time noise levels incurred by residential receivers exceeds 52 dBA or the RBL plus 15 dBA, whichever is the greater, then a more detailed assessment of potential sleep disturbance impacts is warranted.

As the RBL value plus 15 dBA would be greater than 52 dBA for all sensitive receivers, the maximum noise trigger level (sleep disturbance screening level) established by the NIA is set at 52 dBA.

Construction noise criteria

The EPA's *Interim Construction Noise Guidelines* (ICNG) recommends noise management levels (NML) to reduce the likelihood of noise impacts arising from construction activities. The NML for residential receivers recommended in the ICNG are shown in Table 7-1 of the NVIA.

Based on the RBLs in **Table 7.10** and the ICNG recommendations for establishing NML for residential receivers, the construction NML proposed for the proposed modification are summarised in **Table 7.13**.

Table 7.13: Construction noise management levels at sensitive receivers

Receiver	Noise Affected $L_{Aeq,15min}$ Level (Standard daytime construction hours)	Highly Affected Noise Level (dBA)
R3, R11 – R18	57	75
R4 – R10	52	75
R19 and R20	52	75

7.6.4 Potential impacts

Construction noise

The proposed modification will be constructed during the ICNG standard construction hours of:

- Monday to Friday - 7:00am to 6:00pm;
- Saturdays - 8:00am to 1:00pm; and
- no work on Sundays and Public Holidays.

Construction activities likely to generate noise will be:

- tree removal;
- earthworks;
- installation of supporting infrastructure such as access roads, the pipelines, booster pumping stations, site office and car park; and
- truck movements associated with deliveries and waste removal.

Predicted construction noise levels were based on the worst-case construction scenario assuming all plant and equipment will be operating continuously during the 15-minute assessment period.

The predicted worst case $L_{Aeq, 15min}$ noise levels at nearby receivers during construction works are presented in Table 7-4 of **Appendix I** and comply with the construction noise criteria at all receivers during the identified scenarios.

Operational noise sources

The most significant sources of operational noise from the proposed modification include:

- operation of mobile plant and equipment such as excavator, dozer and heavy vehicles during preparation and rehabilitation of the extraction areas;
- operation of the dredge;
- operation of the two booster pumps; and,
- heavy vehicles importing fill material during rehabilitation of the Stage 5A extraction area.

Noise impacts associated with the operation of the proposed modification will vary as the nature and location of the works change over the life of the works. To present the range of potential noise impacts over the life of the proposed modification, operational activities have been modelled in multiple areas of each extraction area, as follows:

- Stage 5A East;
- Stage 5A West;
- Stage 5B North; and
- Stage 5B South.

In each of these areas overburden removal (OB), sand extraction (SE) and rehabilitation activities have been modelled, as described below:

- Overburden removal –
    - Stage 5A extraction area – stripping and stockpiling of topsoil and overburden, and formation of flood protection mounds, using a dozer.
    - Stage 5B extraction area – removal of topsoil and overburden using an excavator and transportation of material in dump trucks to the Stage 5A extraction area for rehabilitation.
- Sand extraction –
    - Stage 5A extraction area – dredging from west to east and pumping of extracted sand including a booster pump.
    - Stage 5B extraction area – operation of two dredges during the two-week transition from Stage 5A to Stage 5B. Dredging from north to south and pumping of extracted sand including a booster pump. Formation of flood protection bunds using a dozer.
- Rehabilitation – backfilling of the Stage 5A extraction area in parallel with extraction in the Stage 5B extraction area using a dozer with fill imported to site via truck and dog. Stabilisation of the western edge of the Stage 5B extraction area with fill.

Assessment of operational noise impacts

The modelled operational noise levels at the identified sensitive receivers are presented in **Table 7.14** during the day time period.

It should be noted that as negotiated agreements will be in place with the landowners of sensitive receivers R1 (471 Riverside Drive) and R2 (69 Fig Hill Lane), project noise trigger levels will not be applicable for these residents.

Table 7.14: Predicted day time operational noise levels

Receiver	Project Noise Trigger Level	Predicted Noise Level (dBA)											Compliance
		5A West OB	5A West RM	5A East OB	5A East RM	5B North OB	5B North RM	5B South OB	5B South RM	5A Rehab	5B Rehab	5A/5B Transition	
R1	N/A	55	46	57	47	41	28	41	28	56	41	47	**N/A**
R2	N/A	27	19	26	20	56	46	55	44	44	53	49	**N/A**
R3	48	46	32	43	37	33	24	36	26	45	32	38	**Yes**
R4	47	32	22	26	22	30	21	34	24	31	29	30	**Yes**
R5	47	30	20	25	20	32	23	37	28	31	32	33	**Yes**
R6	47	29	<20	24	<20	35	23	37	28	30	32	33	**Yes**
R7	47	29	<20	24	<20	35	23	37	28	30	32	33	**Yes**
R8	47	29	<20	23	<20	35	23	37	28	30	32	33	**Yes**
R9	47	28	<20	23	<20	35	27	37	28	30	32	33	**Yes**
R10	47	27	<20	23	<20	35	27	37	28	30	32	33	**Yes**
R11	48	<20	<20	<20	<20	38	30	40	29	29	39	39	**Yes**
R12	48	<20	<20	<20	<20	41	33	42	31	31	42	42	**Yes**
R13	48	<20	<20	<20	<20	42	34	42	30	30	43	43	**Yes**
R14	48	21	<20	<20	<20	46	39	45	34	34	47	47	**Yes**
R15	48	26	21	<20	<20	45	38	44	33	33	45	45	**Yes**
R16	48	28	22	20	<20	39	27	39	24	25	37	34	**Yes**
R17	48	29	24	22	<20	46	27	46	23	25	43	32	**Yes**
R18	48	29	24	23	<20	48	20	48	<20	23	46	26	**Yes**
R19	44	36	30	25	<20	35	<20	35	<20	27	33	21	**Yes**
R20	49	32	25	27	21	32	<20	32	<20	29	30	22	**Yes**

The predicted operational noise levels will comply with the project noise trigger levels at all sensitive receivers.

The modelled operational noise levels associated with the operation of the dredge in the morning shoulder between 6 am and 7 am are presented in **Table 7.15**.

Table 7.15: Predicted operational noise levels during the morning shoulder

Receiver	Project Noise Triger Level	Predicted Noise Level (dBA)					
		5A West RM	5A East RM	5B North RM	5B South RM	5A/5B Transition	Compliance
R1	N/A	49	49	31	31	49	**N/A**
R2	N/A	44	44	48	45	48	**N/A**
R3	48	36	39	26	29	39	**Yes**
R4	47	26	24	24	28	27	**Yes**
R5	47	23	22	26	32	28	**Yes**
R6	47	22	22	27	32	28	**Yes**
R7	47	22	22	27	32	28	**Yes**
R8	47	22	21	27	32	28	**Yes**
R9	47	21	21	31	32	32	**Yes**
R10	47	21	20	31	32	32	**Yes**
R11	48	21	20	34	33	34	**Yes**
R12	48	22	21	36	35	36	**Yes**
R13	48	24	23	37	34	37	**Yes**
R14	48	25	25	42	37	42	**Yes**
R15	48	27	25	41	36	41	**Yes**
R16	48	26	21	30	27	30	**Yes**
R17	48	27	22	29	26	29	**Yes**
R18	48	27	21	23	20	24	**Yes**
R19	44	34	22	18	18	22	**Yes**
R20	49	29	25	16	16	25	**Yes**

The predicted operational noise levels of the dredge operating in the morning shoulder will comply with the project noise trigger levels at all receivers.

The predicted morning shoulder operational noise levels will comply with the project noise trigger levels at all receivers during noise enhancing meteorological conditions.

Sleep disturbance

As the dredge is a relatively constant noise source limited to the operation of pumps and machinery, there are unlikely to be any maximum noise events with the potential to cause sleep disturbance.

As detailed in **Table 7.15** above and Table 6-11 of the NIA, the predicted noise levels for the operation of the dredges during the morning shoulder period are well below the maximum noise trigger level of 52 dBA. Given this, no further assessment of maximum noise levels is required.

Cumulative noise impacts

Cumulative noise levels from multiple industrial noise sources are implicit in the amenity criteria.

However, it is necessary to consider cumulative impacts from the combined operation of the approved project and the proposed modification.

During a recent operational noise audit for DSS, it was found that noise from the Approved Project was inaudible at 40 Swamp Road (R20) and was estimated to be, at most, 38 dBA ($LA_{eq,15min}$).

As R20 is the closest sensitive receiver to the approved project, it is reasonable to conclude that the existing operational noise levels at sensitive receivers will not be greater than 38 dBA. At receivers in the township of Minnamurra, existing operational noise levels from the approved project will be considerably less than 38 dBA.

Accordingly, the existing operational noise levels from the approved project will be at least 10 dBA below the project noise trigger.

Similarly, the highest predicted operational noise level from the proposed modification at sensitive receiver R20 is 34 dBA and therefore, operational noise levels from the proposed modification at sensitive receivers further to the north of R20 will be less than 34 dBA.

The most stringent day time operational noise limit for the approved project is 46 dBA, which applies to 183 James Road, Dunmore. Therefore, operational noise levels from the proposed modification will be at least 10 dBA below the most stringent noise limits for the approved project and will not contribute to an increase in noise levels at sensitive receivers located near the approved project.

7.6.5 Mitigation and management measures

The residual noise impact is the exceedance of the proposed modification noise trigger level after all feasible and reasonable mitigation measures have been considered. No residual impacts are predicted at any privately-owned receivers and, therefore, receiver-based treatments or controls are not required.

Notwithstanding, DSS will continue its noise compliance monitoring and community consultation activities, and will implement measures if an exceedance is detected or a complaint is received from a member of the community.

As new project noise trigger levels have been developed for the proposed modification, it will be necessary to incorporate these into the Project Approval and EPL. The Dunmore Lakes Sand Project Noise Management Plan (DSS, 2017) will be amended to include the Stage 5 extraction area, together with the new trigger levels once the proposed modification is approved.

Construction noise

The noise levels associated with the worst-case construction activity of the proposed modification will not exceed the established NML. However, all reasonable and feasible measures should be applied to manage noise levels. These measures will be documented in a construction noise management plan (CNMP).

7.7 Surface water

This section summarises the surface water assessment report, which is in **Appendix J**. It summarises the potential impacts from the proposed modification on surface waters in and near the modification site.

Existing modification site hydrology is summarised in **Section 1.3.4**.

7.7.1 Existing environment

Surface water management

Surface water is managed in accordance with the *Dunmore Sand & Soil Environmental Management Pla*n (R.W. Corkery & Co. Limited, 2006), which includes a water management plan and surface water monitoring program.

Management and monitoring of surface water quality is also a requirement of EPL 11147.

Water quality is monitored every month and after rainfall of 20 mm or more within 24 hours in accordance with the Project Approval. Water samples are collected at five EPL monitoring sites and other pond sampling and inflow points to provide background water quality data. There is additional sampling during high flows and floods upstream of normally dry watercourses for upstream and downstream water quality comparison.

Flooding

Rocklow Creek

In addition to backwater flooding from Rocklow Creek, the Stage 5A extraction area experiences inundation during local catchment flooding. Runoff from the catchment to the west drains into the Stage 5A extraction area prior to discharge to Rocklow Creek. This flow is controlled by culverts in Riverside Drive and the south coast railway line embankment.

Flows from this catchment and the smaller catchment upslope from the Stage 5A extraction area were modelled using Australian rainfall and runoff (ARR) rainfall intensity data. The peak flows for each sub-catchment and the entire catchment, were calculated.

A hydraulic model was prepared to estimate local flood levels and velocities, and to compare existing and proposed surface conditions.

The backwater flooding levels for the approved project can be used as proxies for those for Rocklow Creek in the Stage 5A extraction area as the catchment configurations are similar.

Backwater flows from Rocklow Creek into the Stage 5A extraction area are partially controlled by the railway embankment and culverts (estimated invert level (IL) 1 m AHD) and Riverside Drive road surface and culverts (estimated IL 1.3 m AHD).

Most of the Stage 5A extraction area is below 2 m AHD and backwater flooding from Rocklow Creek will inundate almost all of the area in a 1% AEP event, with about 60% of the disturbance footprint inundated in a 10% AEP event. As a significant portion of the Stage 5A extraction area is below 1.5 m AHD, backwater flooding is likely to be below the 50% AEP backwater flood level for Rocklow Creek and inundation is estimated to occur every two years.

Minnamurra River

The risk of flooding along the Minnamurra River was assessed during the impact assessment for the North Kiama Bypass. This comprised simple hydraulic calibration using historical anecdotal flood levels upstream of the Princes Highway and assessed the impact of the proposed North Kiama Bypass crossing on Minnamurra River flooding.

Based on this study, the 1% AEP Minnamurra River flood level around the Stage 5B extraction area ranges from 4.14 m AHD at the southern end to 3.67 m AHD at the eastern side. For the 5% AEP, the flood level ranges from 3.78 m AHD at the southern end to about 3.3 m AHD at the eastern end.

Surface levels over the Stage 5B extraction area range from 4.0-2.2 m AHD along the eastern face. The northern quarter of the extraction area sits between 3-4 m AHD, with the remainder at about 4 m AHD. Therefore, flood depth across the Stage 5B extraction area during the 1% AEP event will be relatively shallow (0.1-0.2 m).

In more frequent floods, the majority of the Stage 5B extraction area will remain flood free, apart from the lower areas (2-3 m AHD) at the base of the hillside at the northern end of the extraction area, which may experience backwater inundation in events as frequent as the 20% to 10% AEP events.

Interface between surface and sub-surface flows

There will be little surface runoff during light to moderate rainfall given the permeable surface soils. During heavier rain, or periods of prolonged rain, the high-water table places a limit on soil storage, and extensive areas of waterlogging and ponding will occur over the low-lying areas. This will be exacerbated by the shallow hydraulic gradients, which limit discharge and prolong surface water retention.

Water quality of receiving environment

Rocklow Creek and the Minnamurra River are the receiving waters for the approved project and the proposed modification.

The Stage 5A extraction area drains to the mangrove wetlands surrounding Rocklow Creek, and the Stage 5B area drains to the mangrove wetlands between the extraction footprint and the Minnamurra River. These wetlands are classified as coastal wetlands in the Coastal Management SEPP and contain Type 1 highly sensitive key fish habitat and Class 1 waterways as defined in the SEPP and guidelines for fish habitat conservation and management (DPI, 2013).

The Coastal Zone Management Plan for the Minnamurra River Estuary (Hydrosphere, 2015) summarises the historical and current estuary conditions, pressures on the estuary and water quality data from the estuary and upstream. Key findings of relevance to the proposed modification are:

- Based on the NSW Natural Resources Monitoring, Evaluation and Reporting (MER) program, the overall condition rating for the Minnamurra River Estuary is ‘Good’ from an average of all scores which ranged from poor for seagrass (due to a loss in area), to very good for turbidity and saltmarsh.
- The key pressures on the estuary are increased sediment and nutrient inputs, with an estimated increase of approximately 500% from natural conditions. The overall pressure score in the MER for the estuary was moderate.
- Median water quality values exceed guideline nutrient levels for total nitrogen and total phosphorus throughout the catchment, including Rocklow Creek close to the modification site. The median turbidity values in Rocklow Creek are above the estuarine guideline level.

In summary, the Minnamurra River is in a good condition, however, there are significant land use pressures that increase the risk of water quality degradation. Water quality values for Rocklow Creek and the Minnamurra estuary exceed the A*ustralian and New Zealand Guidelines for Fresh and Marine Water Quality, National Water Quality Management Strategy, Volume 1* (ANZECC, 2000) trigger values for a range of parameters, and in some periods Rocklow Creek shows highly eutrophic conditions (Hydrosphere, 2015). Eutrophic conditions are an indication of algal blooms resulting from high nutrient availability.

Existing water balance

Water is extracted from the existing Stage 2 dredge pond for dust suppression and by moisture exported in sand products.

In order to accurately estimate the proposed water balance of the proposed modification, the current water demands of the approved project must be understood as these demands will continue within the Stage 5 extraction area.

Dust suppression

DSS estimates that for the current Stage 2 to 4 operations, up to five 30,000 L tanker loads are used on non-rain days.

The number of non-rain days according to BoM data is about 230 per year. Assuming 230 days, this will equate to 34.5 megalitres per year (ML/y) of water required for dust suppression.

Water used in processing and export

Based on DSS records, approximately 19.5 megalitres per day (ML/d) (7.1 gigalitres per year (GL/y)) is used for sand processing, including dredge pumping (10.8 ML/d), pumping to the sand wash bin for dust washing (6.5 ML/d) and water use in the oversize screen sprayers (2.2 ML/d).

The average moisture content of sand leaving the site is around 8%. Based on the 2017 production of 401,582 tonnes, approximately 32.12 ML/y currently leaves the site. The remainder (7.07 GL/y) returns to the surrounding landscape ponds as runoff or as infiltration to groundwater.

7.7.2 Potential impacts

Water management – construction phase

Earthworks will be the main source of sedimentation during the construction phase.

Access roads, site office and parking

Sedimentation from construction of the access roads and site office vehicle parking areas will be managed in accordance with a construction soil and water management plan, which will be prepared in accordance with DECC's (2008) *Managing Urban Stormwater: soils and construction, Volume 1 and Volume 2C: Unsealed roads and 2D: main road construction.*

Additional unsealed and sealed areas will be constructed for a site office at the northern part of the Stage 5B extraction area. These areas will drain to the dredge pond which will act as a sediment basin.

Dredge ponds, stockpile areas and access roads

The Stage 5A and Stage 5B dredge ponds will be bunded to prevent impounded water interacting with surface flows and floodwaters These bunds will function as sediment basins for the localised catchment of each extraction area.

The proposed flood protection bunds will be constructed of imported VENM or soils of adequate structural integrity extracted on the modification site.

Clearing and grubbing of the proposed extraction areas, and construction of water diversion structures and flood protection bunds will generate areas of exposed materials increasing the potential for erosion and transfer of sediment to receiving waters. In particular, the outer batter slopes of the flood protection bunds and diversion drains will be required to be adequately stabilised with vegetation to limit erosion and sediment transport off-site. The principles of

DECC's (2008) *Managing Urban Stormwater: soils and construction, Volume 2E: Mines and Quarries* will be implemented for batter treatment and diversion drain design.

In addition to the isolation of the dredge ponds from surrounding surface and river flows, the flooding protection bunds will provide significant freeboard of up to 2 m to 3 m from the normal operating water level (likely to be close to local groundwater surface levels of around 1 m AHD) (EES, 2019). The freeboard will reduce the possibility of basin overflows in flood and high rainfall events and also allow the ponds to act as sediment basins through the provision of detention storage.

As a comparison, sediment basin sizing using the Managing Urban Stormwater Soils and Construction Volume 1 was applied in the surface water assessment. Assuming 5 day, 95th percentile rainfall capture, as recommended in DECC's (2008) *Managing Urban Stormwater: soils and construction, Volume 2E: Mines and Quarries*, the calculated sediment basin storage within the dredge ponds will exceed the recommended sediment basin volumes for the catchments draining to them.

Pipeline

The transfer pipeline will be placed on the surface and minimal surface preparation will be required. There is likely to be minimal surface impacts from machinery used to lay the transfer pipe, which will be managed in accordance with DECC's (2008) *Managing Urban Stormwater, Soils and Construction, Volume 2A Installation of Services* and DPI Water's (2012b) *Guidelines for Laying Pipes and Cables in Watercourses on Waterfront Land*.

Water management – operational phase

Stage 5 extraction areas

The section of Stage 5A extraction area access road around the dredge pond and stockpile area will drain to the dredge pond.

A section of the Stage 5B extraction area access road, the car-park, office and amenities area and surrounding access road will drain to the dredge pond.

Storage capacities in the dredge ponds will exceed the required sediment basin volumes in DECC's (2008) *Managing Urban Stormwater, Soils and Construction, Volume 2E Mines and Quarries* for sensitive receiving waters.

Processing

Processing will use water during sand pumping and washing and fine sediments will be generated during washing. Water generated during dewatering will drain to an existing fines pond and secondary settling pond prior to being returned to the dredge ponds.

Water extracted from the extraction areas during sand pumping will be returned via the return pipeline.

Protection of aquatic environment

The proposed modification may impact aquatic habitats by:

- erosion of exposed surfaces and sedimentation to local watercourses which drain to Rocklow Creek and Minnamurra River;
- transfer of sediment and fines from inflow and overflow of dredge ponds;
- rupture or failure of the transfer pipelines resulting in sand material entering local watercourses; and
- failure of flooding protection bunds leading to sedimentation entering local watercourses;

A minimum 100 m wide riparian buffer between Rocklow Creek and Minnamurra River waterways and the operations will be implemented to protect these sensitive waterways. No riparian vegetation associated with Rocklow Creek or Minnamurra River would be impacted by the proposed modification.

Mitigation and management measures outlined in **Section 7.7.3** will be implemented to minimise the above risks to the aquatic environment.

The transfer pipeline will be floated over the former Stage 1 dredge pond to the north west of the Stage 5A extraction area and suspended above the water column on the side walls of culverts beneath the Princes Highway and Swamp Road. The pipeline is flexible and can be installed without removal of mature riparian vegetation. However, some clearing of smaller, shrub riparian vegetation may be necessary to allow for machinery access for installation.

A gangway structure will be constructed to support the pipeline above Rocklow Creek. The gangway supports will be on the overbanks of Rocklow Creek and no in-stream excavation will be required.

With the above considered, potential impacts on aquatic habitat or fish passage of Rocklow Creek will be avoided.

There is a risk of pipeline leakage or failure, either through mechanical failure or damage from an external cause. System monitoring and maintenance will be incorporated into operational procedures for the transfer pipeline to limit the possibility of failure, and allow for the swift identification and rectification of failure, should it occur.

Local drainage and flooding

Stage 5A extraction area

Drains will be constructed to divert flows from the hillside catchment to the south around the proposed Stage 5A extraction area.

Flows and flooding from the unnamed watercourse to the west pass through the former Stage 1 dredge pond, prior to discharge though the culverts beneath Riverside Drive. The existing 1% AEP flood level for this local catchment is around 2.45 m AHD over the proposed Stage 5A extraction area and backwater flooding from Rocklow Creek and the Minnamurra River is estimated at 3.6 m AHD. These flood levels cover most of the proposed Stage 5A extraction area.

To limit potential water quality impacts or turbid water from the active Stage 5A extraction area entering Rocklow Creek and ultimately the Minnamurra River during floods, an earth flooding protection bund will be constructed around the Stage 5A extraction area up to the 1% AEP backwater flood level, plus 100 mm freeboard (3.7 m AHD) to isolate dredging activities from the local floodwaters and surface flows.

Bunding of the Stage 5A extraction area will remove the extraction area and associated access roads from floodplain storage. The impact of this on local flood flows has been assessed for the local 1% AEP event by comparing an existing hydraulic model with a model of the modified terrain. There will be very small localised increases in flood depth as a result of the temporary removal of floodplain storage in the order of 1 cm to 5 cm over Riverside Drive for the local 1% AEP event.

Given the temporary nature of the works and the limited impact on local 1% AEP flood levels, the temporary loss of floodplain storage on flood levels is not significant. The impact of minor flood changes is outweighed by the water quality benefits associated with isolating the dredge areas from external flows and potential discharge.

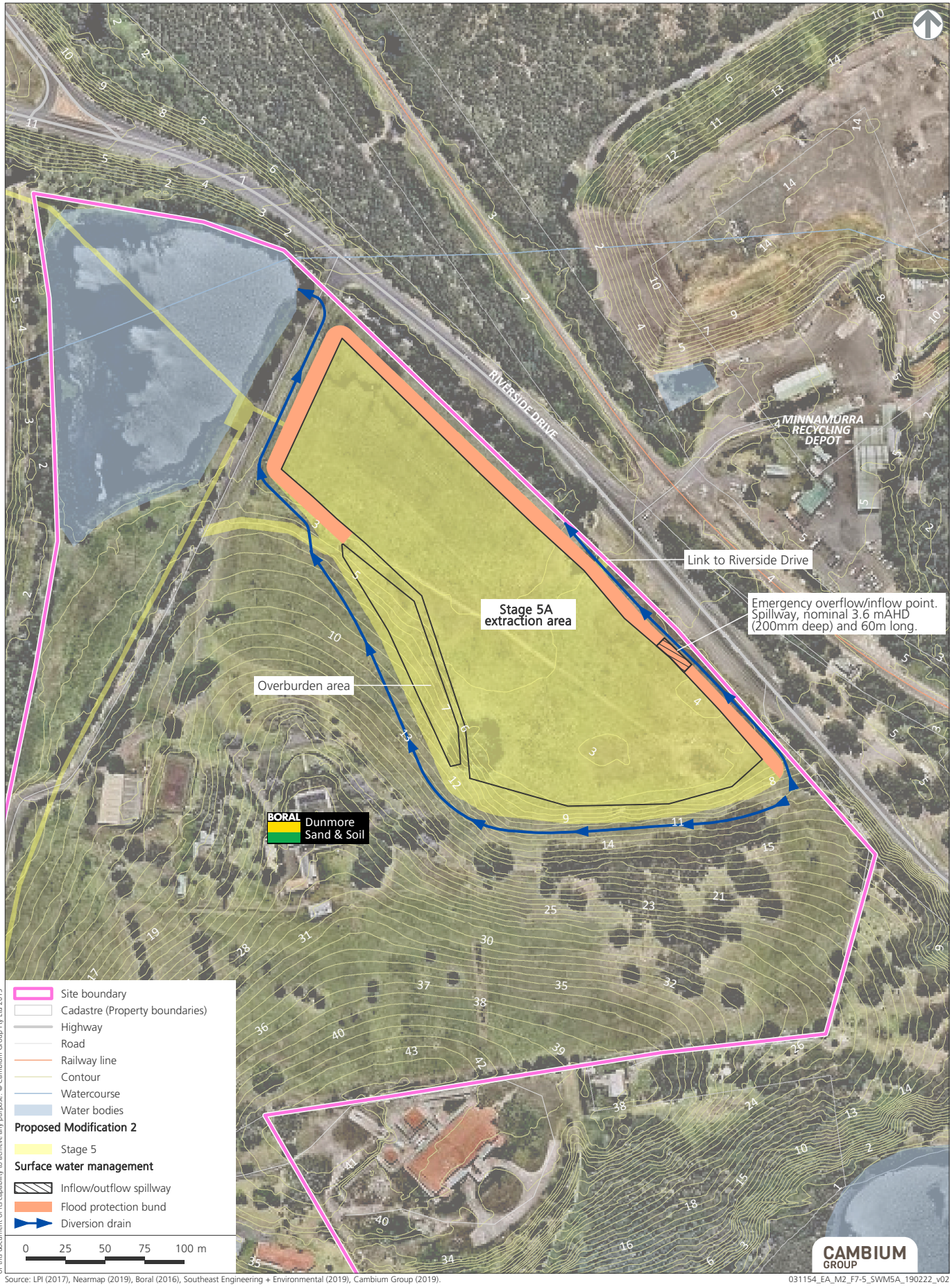
To accommodate the possibility of inundation of the Stage 5A extraction area due to water levels within the extraction area either through rising groundwater levels, local catchment flows draining to the dredge pond, or large flood events in excess of the flooding protection bund level, a preferential flow path into and out of the extraction area will be provided. A 20 m long armoured spillway set 100 mm lower than the bund height (3.6 m AHD) will allow for the dredge pond to drain to the spillway crest over about 1 hour, allowing the upper storage to drain in line with the falling flood wave.

There is the potential for a significant difference in water level inside and outside of the bunded areas of up to 2.5 m in areas. This may occur if surrounding floodwaters have drained, and the dredge pond remains full, or in the opposite case where floodwaters are much higher than water levels within the dredge pond. The design of the flooding protection bund will need to allow for the appropriate hydrostatic pressures, along with the potential for internal erosion through the bund material.

Once resource extraction is complete, reinstatement of floodplain storage shall be undertaken through the removal of the flooding protection bund, backfilling of the Stage 5A extraction area to pre existing ground levels, and associated site rehabilitation.

Figure 7.5
Surface water management - Stage 5A extraction area

DUNMORE LAKES SAND EXTRACTION PROJECT | MODIFICATION 2
ENVIRONMENTAL ASSESSMENT



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Source: LPI (2017), Nearmap (2019), Boral (2016), Southeast Engineering + Environmental (2019), Cambium Group (2019).

Stage 5B extraction area

Surface flows from the hillside to the north will drain down towards the Stage 5B extraction area. The 1% AEP flood levels (4.1 m to 3.7 m AHD) from the Minnamurra River extend over the extraction area at shallow depths of around 100 mm over most of the site, apart from the low-lying parts in the north east corner of the extraction area where flood depths are up to 2 m.

As for Stage 5A, an earth flooding protection bund is to be established around the Stage 5B extraction area up to the estimated 1% AEP flood level (4.1 m AHD) to isolate it from local surface flows and flood flows from the Minnamurra River.

The majority of the Stage 5B extraction area is at or only slightly below the 1% AEP flood level and is in a backwater area of low velocity. The bunded area will either be on what will be classified as the flood fringe, or at most flood storage area, and as such impacts on flood levels are likely to be minimal.

As for Stage 5A, given the temporary nature of the works and the limited impact on local 1% AEP flood levels, the temporary loss of floodplain storage on flood levels is not significant.

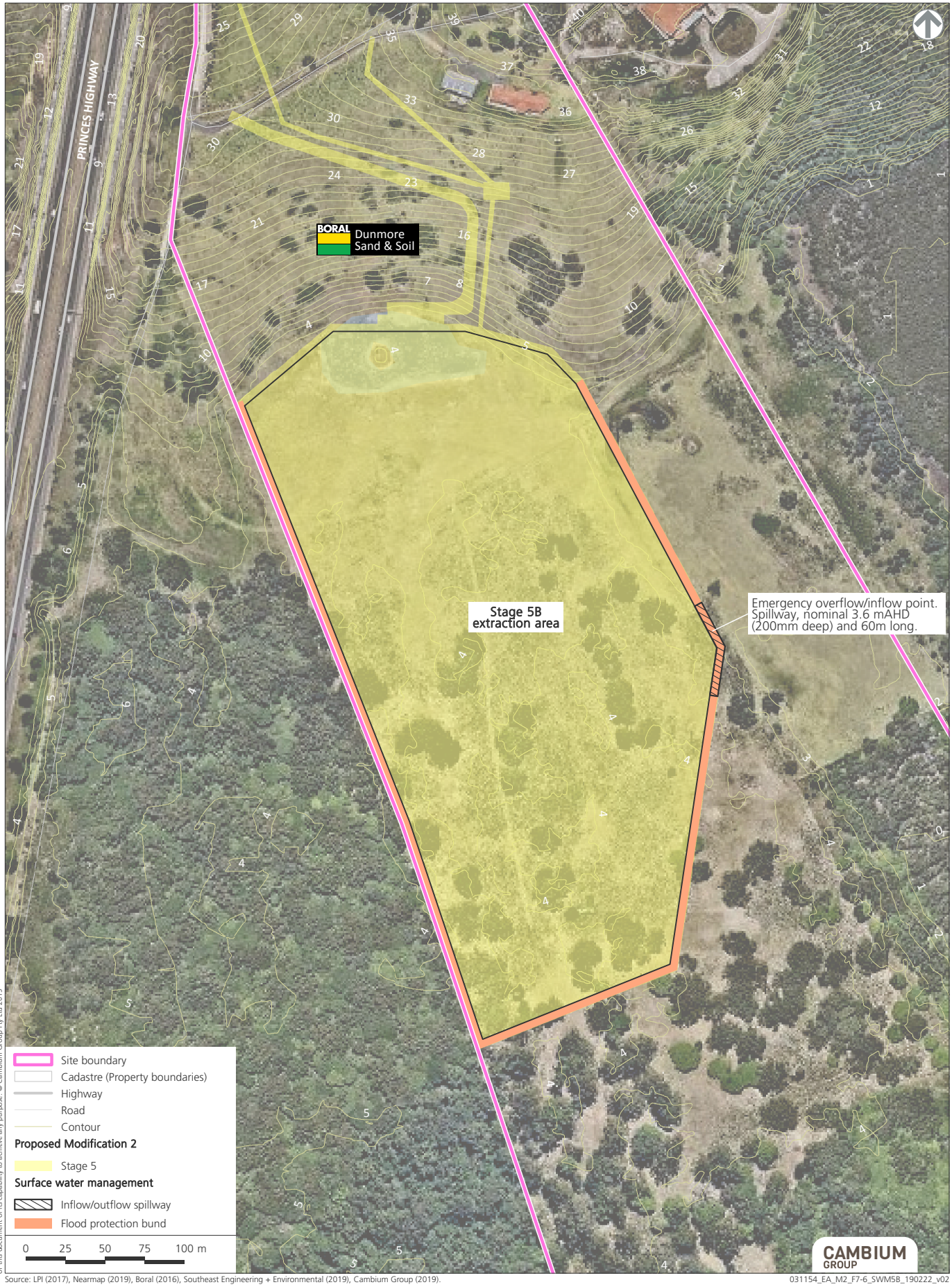
The location of the Stage 5B extraction area within an active part of the floodplain does create the possibility of water levels within the extraction area to exceed the flooding protection bund either through rising groundwater levels, local catchment flows draining to the dredge pond, or large floods in excess of the bund level.

For this reason, an emergency inflow and outflow spillway will be provided. The spillway will provide a preferential armoured flow path for flows in and out of the extraction area in large flood events (approx. 1% AEP and greater). The dimensions of the spillway should be approximately 60 m long and 200 mm deep. This allows for the dredge pond to be drained to the spillway crest over about one hour, and roughly match the falling limb of a flood wave through the Minnamurra River.

On completion of sand extraction, floodplain storage shall be reinstated through the removal of the flooding protection bund, and necessary reshaping and revegetation. The dredge pond will be retained as an open water area.

Figure 7.6
Surface water management - Stage 5B extraction area

DUNMORE LAKES SAND EXTRACTION PROJECT | MODIFICATION 2
ENVIRONMENTAL ASSESSMENT



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Source: LPI (2017), Nearmap (2019), Boral (2016), Southeast Engineering + Environmental (2019), Cambium Group (2019).

Pipeline

The transfer pipeline will be floated across the former Stage 1 dredge pond adjacent to the Stage 5A extraction area. The maximum velocities in a 1% AEP event across this pond are approximately 0.5 metres per second (m/s). The design of the floatation and the fixing system where the pipeline connects back to the pond banks will consider the hydraulic forces associated with flood flows, along with the variation in water levels.

To traverse roadways the transfer pipelines will be attached to the roof or side wall of existing culverts. At the Princes Highway, the existing culverts are 2.7 m wide by 2.4 m high, with invert level at approximately 1.7 m AHD at the upstream end. The culverts provide a flow area of about 26 m^2. The installation of the transfer pipes will require approximately 0.25 m^2 of potential flow area, reducing culvert capacity by about 1%.

Additionally, local 1% AEP flood levels are about 2.9 m AHD, about 1.2 m below the culvert obvert level. As such, backwater flooding from Rocklow Creek may inundate the culverts. Given the small flow area removed and low flow velocity, the hydraulic capacity impacts of the transfer pipeline on the Princes Highway culverts are not considered significant.

The transfer pipelines will also pass through the culvert beneath Swamp Road. This culvert was installed primarily for infrastructure that connected the previous sand extraction area with the previous processing plant. The culvert also allows for the movement of flows from a catchment of about 2 ha. The addition of the transfer pipes to the roof or side wall of this culvert will not have an impact on hydraulic capacity.

To limit riparian and hydraulic impacts on Rocklow Creek, the transfer pipelines will be installed on a gangway approximately 1.5 m above the creek banks and span a length of approximately 12 m. The gangway structure will consist of concrete footings beyond the existing top of bank, with no piers within the watercourse required.

Water balance and licensing

As outlined in **Section 7.7.1**, water leaving the approved project includes water used for dust suppression for roads and stockpile areas as well as water exported from the site as moisture content in the outgoing sand product.

The Project Approval allows for the removal of 800,000 tpa. However, current, and expected extraction averages around 400,000 to 500,000 tpa, and it is expected that this demand will remain in this range during the proposed modification.

Average moisture content of material leaving the site is around 8%. Assuming an average extraction of 450,000 tpa, approximately 36 ML of water will leave the modification site with sand products.

The current dust suppression water use is estimated by DSS at approximately 4.5 ML per hectare, per year, and covers an area of approximately 7.6 ha.

The proposed Stage 5A and 5B access roads and stockpile areas cover approximately 0.7 ha. Applying the same water use rate will increase the current dust suppression water use from approximately 34.2 ML/y to approximately 38 ML/y.

The total water use for a production level of 450,000 tpa is 74 ML/y (36 ML/y as moisture content in exported material and 38 ML/y for dust suppression).

Currently, DSS has a WAL and associated water supply work (WSW) approval for 65 ML/y from the Sydney Basin South Groundwater source.

DSS also has a WAL for an additional 15 ML/y from the Metropolitan Coastal Sands Groundwater source, however are yet to obtain a WSW for this allocation. Once a WSW is

nominated (likely over the modification site) and approved, DSS will have a total of 80 ML/y available for extraction across the approved project. It is anticipated that this would cover the current operations together with the proposed modification.

A further allocation of 20 ML has also been secured by DSS from the Metropolitan Coastal Sands Groundwater source, however both a WAL and WSW are pending for this allocation. In the event production rates increase in future beyond the current rate of extraction, and are likely to exceed the allocated water extraction permitted by all relevant WAL and WSW, DSS would carry out a revised site water balance and seek any necessary licence amendments or seek additional licensing with NSW Department of Industry.

7.7.3 Mitigation and management measures

The *Dunmore Sand & Soil Environmental Management Pla*n (R.W. Corkery & Co. Limited, 2006) will be revised to incorporate the proposed modification.

Additional mitigation and management measures recommended to ensure best practice surface water management at the modification site are summarised below.

Soil and water management plan

Exposed soils generated through the construction of the access roads, site office and parking area will be managed through standard erosion and sediment controls implemented in accordance with DECC's (2008) *Managing Urban Stormwater: soils and construction, Volume 1 and Volume 2C: Unsealed roads and 2D: main road construction*, and will be outlined within a Soil and Water Management Plan (SWMP) prepared for the construction phase of the proposed modification.

Flooding protection bunds

The proposed flood protection bunds will be adequately designed and engineered to ensure their structural integrity.

DECC's (2008) *Managing Urban Stormwater, Soils and Construction, Volume 2E Mines and Quarries* will be implemented for batter treatment and diversion drain design.

Pipeline installation and monitoring

Erosion and sediment controls will be installed where required in accordance with Managing Urban Stormwater, Soils and Construction, Volume 2A Installation of Services (DECC, 2008) as well as Guidelines for Laying Pipes and Cables in Watercourses on Waterfront Land (DPI Water, 2012b).

In order to limit riparian and hydraulic impacts to Rocklow Creek, the transfer pipelines will be installed utilising a gangway approximately 1.5 m above the creek banks and include a span of approximately 12 m. The gangway structure will consist of concrete footings beyond the existing top of bank. No piers within the watercourse are permitted. The design and construction of the gangway structure should be undertaken in compliance with:

- Guidelines for Controlled Activities on Waterfront Land - Riparian Corridors (NRAR, 2018); and
- Guidelines for Instream Works on Waterfront Land (DPI Water, 2012a).

There is a risk of pipeline leakage or failure, either through mechanical failure or damage from an external cause. Risks will be mitigated through the use of a double skinned HDPE pipeline.

System monitoring and maintenance will be incorporated into operational procedures for the transfer pipeline to limit the possibility of failure, and allow for the swift identification of failure, should it occur.

Water quality monitoring

The current water quality and discharge controls for the approved project are outlined in the *Dunmore Sand & Soil Environmental Management Pla*n (R.W. Corkery & Co. Limited, 2006) and include water quality targets for water discharged at licenced discharge points, and water quality objectives for the dredge ponds themselves. It is proposed that the same water quality objectives are applied to the Stage 5A and 5B extraction areas. An increase to the salinity water quality objective of <1500µS/cm should be considered given the potential influence of saline groundwater on the Stage 5 dredge ponds.

The proposed modification will continue to make use of the existing EPL provisions for wastewater (effluent) and discharge from ponds associated with the extraction activities and crushing, grinding and separating activities. No additional discharge points are proposed for the proposed modification, and all processing will be undertaken at the existing facility in the Stage 2 processing area, along with water quality management in the existing fines and settling ponds.

Uncontrolled discharges from the Stage 5A or Stage 5B extraction areas are unlikely as the proposed flooding protection bunds will provide protection of receiving waters by:

- protecting interaction with external flood flows; and
- providing storage (nominally 2 m depth) within the dredge ponds to allow for local rainfall and variations in flow transfer to these ponds.

In the event of overtopping of the flooding protection bunds in a large flood event (>1% AEP), water quality of the dredge ponds is unlikely to be significantly different to water quality within floodwaters themselves, and significant dilution of the dredge pond overflows will also occur.

The current monitoring locations outlined in the EPL should be maintained. In addition, four new monitoring points, along with the new Stage 5A and Stage 5B dredge ponds themselves should be added to the existing water quality monitoring program.

The new monitoring points are recommended to be located upstream and downstream of the extraction areas to allow for comparison. For Stage 5A, an upstream monitoring point should be positioned at the former Stage 1 dredge pond west of the Princess Highway and a downstream monitoring point positioned upstream of the Riverside Drive culvert crossing. Similarly, for the Stage 5B extraction area, water quality monitoring shall be undertaken at sites upstream, and downstream within the Minnamurra River.

Refer to **Figure 7.7** for the indicative locations of proposed water quality monitoring locations.

Monitoring at these four points, along with the Stage 5A and 5B dredge ponds should be carried out in accordance with the current monitoring program.

Figure 7.7
Proposed Stage 5 water quality monitoring network

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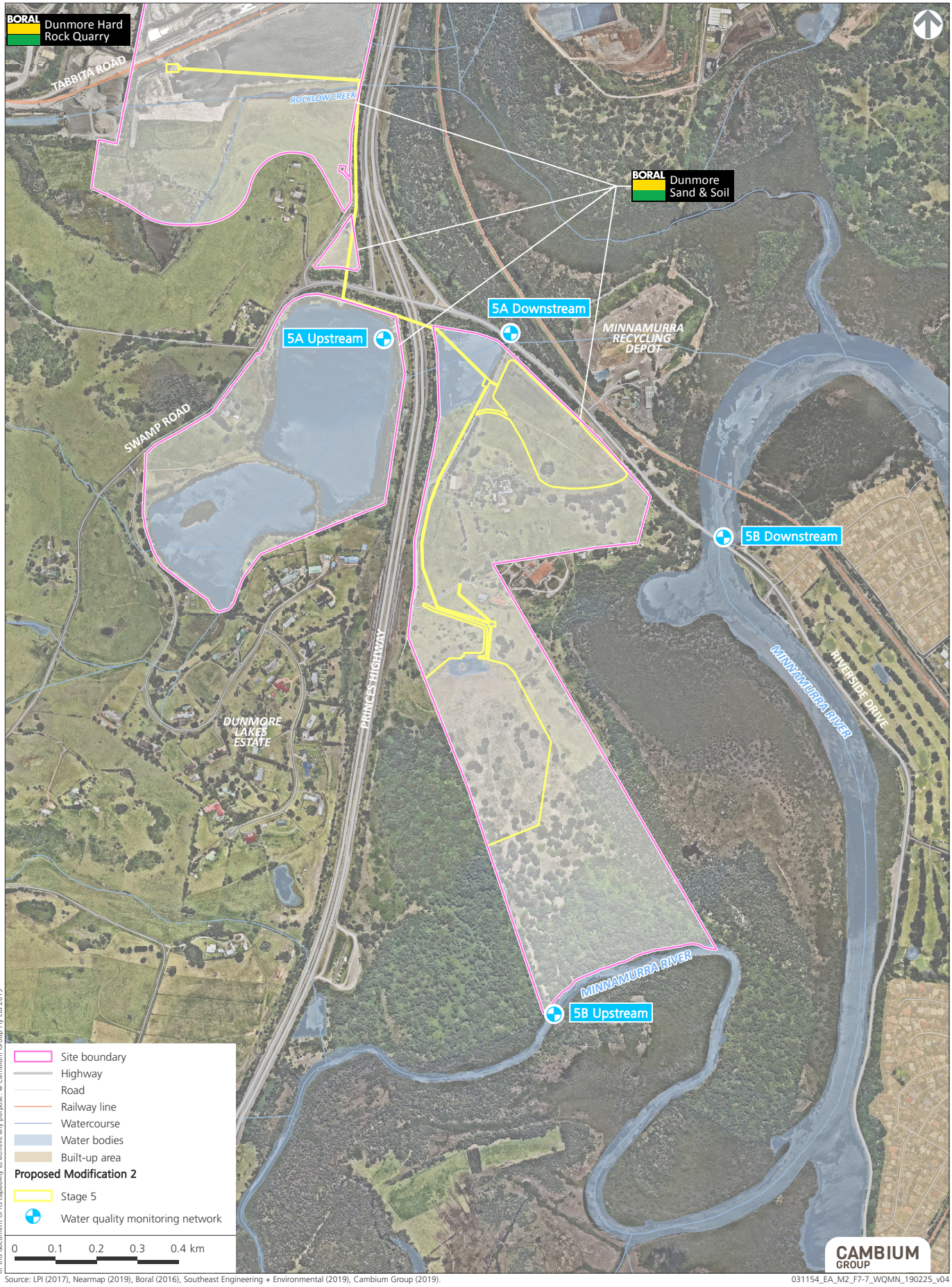

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Rehabilitation

The Stage 5A dredge pond will be backfilled once sand extraction is complete. The flooding protection bunds will be removed, surface levels restored to pre-existing conditions and all exposed surfaces revegetated with ground cover vegetation.

The Stage 5B dredge pond will be retained as an open water area. Water levels in the pond will be driven by groundwater and local catchment flows. The primary connection to the Minnamurra River will be in the north east corner of the pond, where the existing point is at about 2.1 m AHD. When floodwaters exceed this level in the Minnamurra River (approximately 20% AEP event) backwater flows will enter the rehabilitated pond.

Rehabilitation plans for the Stage 5B dredge pond will be prepared and should take into consideration surface flow movements after surface reshaping.

7.8 Visual amenity

7.8.1 Existing environment

Visual amenity at the modification site and surrounds is characterised by a rural landscape. The modification site is adjacent to a major road (Princes Highway), and is near residential, commercial and industrial receivers. The modification site is in the topographically lower rural lands in the Dunmore area, with a backdrop of rising hills and vegetated valleys.

The landscape around the modification site has an open character due to extensive vegetation clearing and low topographic relief. The surrounding terrain generally comprises rounded hills and gentle slopes with some steeper gully areas which merge into low-lying rural flats, floodplains and estuarine wetlands. The principal land uses in the Dunmore area are grazing and extractive industries, both of which form an important component of the visual landscape.

7.8.2 Potential impacts

Stage 5A extraction area

The potential visual impacts on heritage items within and adjacent to the modification site is described in **Section 4.4**.

The proposed dredge pond will be in the primary view catchment of 471 Riverside Drive (Dunmore House). Dunmore House is prominently positioned on a hilltop and retains significant views of the surrounding floodplains and distant landscape. While there will likely be glimpses of the dredge pond from the homestead and surrounding garden on the hill, the pond will be largely screened by existing vegetation and garden plantings surrounding the house. The extraction area will also be visible from the driveway of 431 Riverside Drive, which is on a ridgeline above the extraction area. Given the position on the ridgeline, the Stage 5A and Stage 5B extraction areas would not be visible from the dwelling of 431 Riverside Drive (as illustrated in **Figure 7.8**).

The proposed Stage 5A extraction area will be visible from surrounding vantage points in the public domain, in particular for motorists travelling along Riverside Drive. Existing vegetation along Riverside Drive screens views into the northern portion of the Stage 5A extraction area for southbound motorists of Riverside Drive.

Given the flat topography of the locality, the proposed flooding protection bund will screen views from motorists travelling north and south along Riverside Drive. The bund will largely remove

views of the dredge pond itself, with views from the public domain likely restricted to plant and machinery in the extraction area, and supporting infrastructure such as the access road and intersection with Riverside Drive (refer to **Figure 7.9**). The bund will be stabilised with groundcover vegetation for erosion and sedimentation purposes and once vegetated, the bund will blend with the adjacent landscape and minimise subsequent visual impacts from Riverside Drive.

These minor impacts will be temporary as the dredge pond will be back filled when complete, and flood protection bunding will be removed with disturbed surfaces rehabilitated to grazing land.

The proposed pipeline will be in the north portion of the Dunmore House property and 4 Swamp Road. The pipeline will not be a significant visual feature of the area as it will be beneath the ridgeline, have a low profile and be coloured to contrast well with the ground surface.

A mature native tree will be removed to construct the access road to the Stage 5A extraction area. this will be a permanent visual impact. However, the tree is isolated and impacts will be minimal.

Given the temporary minor visual impacts associated with the Stage 5A extraction area, it is considered that graphical representation of a temporary change to the landscape in the form of photomontages is not required. DSS would instead focus on an ongoing and robust community consultation strategy with potentially affected receivers, in particular the resident located at 431 Riverside Drive and the Minnamurra Recycling Depot opposite the modification site. It is envisaged that ongoing communication with these receivers would minimise the potential for adverse visual impacts which would be temporarily experienced during extraction activities within Stage 5A. To date, no concerns in relation to visual impacts have been raised by adjoining residents in relation to Stage 5A extraction area.

Figure 7.8
Views from private domain adjacent to modification site

View 1 - Looking north east towards Stage 5A extraction area

View 2 - Looking south west towards Stage 5B extraction area

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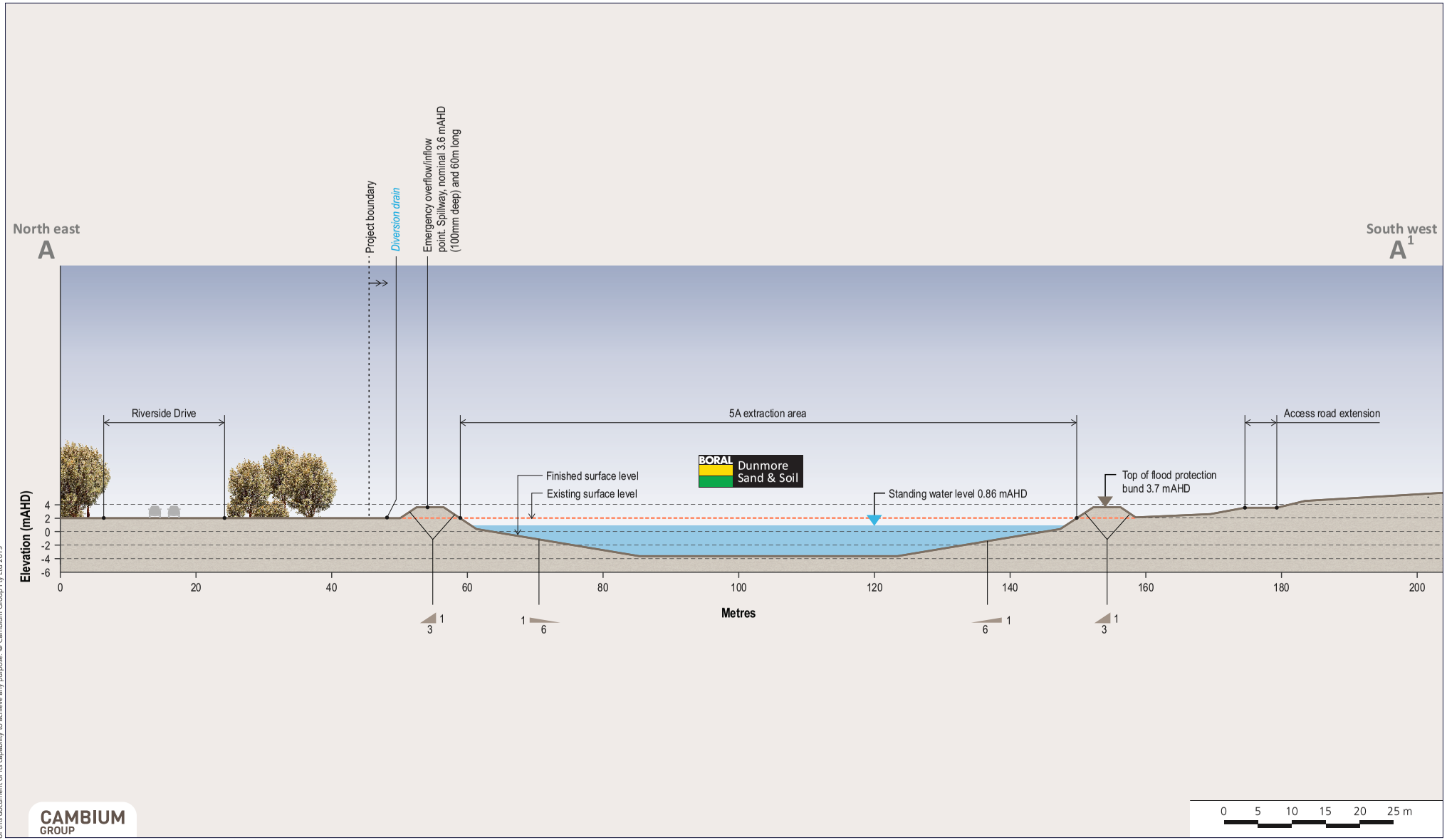
Figure 7.9
Stage 5A extraction area cross section



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Stage 5B extraction area

The establishment of the Stage 5B extraction area and associated removal of existing native and exotic vegetation will result in permanent changes to views from 69 Fig Hill Lane.

The viewscape from 69 Fig Hill Lane and a confined viewpoint on the Princes Highway from vehicles moving at speed will be permanently changed after extraction is complete as the dredge pond will remain at the request of the landowner.

Visual changes associated with the proposed pipeline, flooding protection bund, booster pumping station, site office/car park and access road will be localised in the context of the modification site and will be temporary as infrastructure will be removed at the end of sand extraction and disturbed surfaces rehabilitated to their previous land use.

Once fully rehabilitated, the proposed landscape plantings and pond may result in a positive visual impact.

7.8.3 Management measures and residual impacts

There will be minor residual impacts to Dunmore House, 431 Riverside Drive, 69 Fig Hill Lane, Riverside Drive and the Princes Highway. Some impacts will be temporary, with infrastructure removed at the end of sand extraction and disturbed surface progressively rehabilitated. Permanent visual impacts could be positive, with the addition of a freshwater pond and landscape plantings in the viewscape.

The modification site will be rehabilitated in accordance with *Dunmore Sand and Soil Project Rehabilitation Management Plan* (Arcadis, 2017), which will be updated to include progressive rehabilitation of disturbed surfaces with groundcover vegetation

7.9 Traffic and transport

This section summarises the traffic impact assessment (TIA) report, which is in **Appendix K**. It summarises the potential traffic impacts during construction and operation of the proposed modification on the capacity of the local road network including key intersections between the modification site and arterial roads.

7.9.1 Objectives and method

The objective of the traffic impact assessment was to examine the impact of traffic generated by the proposed modification. The SIDRA traffic modelling program was used to predict impacts on key intersections for the morning (AM) and afternoon (PM) peak hour periods using the existing traffic volumes together with the maximum additional vehicles generated by the proposed modification (worst case scenario).

The best criteria for assessing intersection performance is level of service (LoS), degree of saturation (DS), highest movement delay in seconds (HMD) and average vehicle delay (AVD). **Table 7.16** shows the LoS criteria for intersections in RMS *Guide to Traffic Generating Developments* (October, 2002). The LoS is directly related to the delays experienced by traffic travelling through the intersection. The RMS design criteria for intersections is LoS D or better.

Relevant standards/guidelines adopted and used during the traffic impact assessment were:

- Austroads Guide to Traffic Management;
- Austroads Guide Supplements – Austroads Guide to Traffic Management;
- AS2890.1 (2004) – Parking Facilities. Part 1 Off street car parking; and

- AS2890.2 (2002) – Parking Facilities. Part 2 Off Street Commercial Vehicle facilities.

Table 7.16: LoS criteria for intersections

Level of service	Average delay (seconds per vehicle)	Traffic signals roundabout	Give way & stop signs
A	<14	Good operation	Good operation
B	15 to 28	Good with acceptable delays and spare capacity	Acceptable delays and spare capacity
C	29 to 42	Satisfactory	Satisfactory, but accident study required
D	43 to 56	Operating near capacity	Near capacity and accident study required
E	57 to 70	At capacity; at signals, incidents will cause excessive delays. Roundabouts require other control mode	At capacity, requires other control mode
F	>70	Intersection is oversaturated	Oversaturated, requires other control mode

Source: RMS Guide to Traffic Generating Developments, October 2002

7.9.2 Existing environment

Existing road network

The modification site is accessed by Riverside Drive. Riverside Drive is a two-lane sealed road with a speed limit of 80 km/hr.

Riverside Drive connects Minnamurra and Kiama Downs to the Princes Highway via interchanges at Dunmore (north) and Bombo (south).

The Princes Highway/Riverside Drive intersection at Dunmore comprises north facing ramps. Vehicles travelling south on the Princes Highway can enter Riverside Drive and vehicles can exit Riverside Drive into the Princes Highway northbound lane.

The interchange to the north at the Princes Highway and Shellharbour Road accommodates both northbound and southbound entry and exit movements at the Princes Highway.

Existing traffic conditions

Traffic was observed at different times during the day at the Princes Highway/Riverside interchange. There were no vehicle delays or congestion and only a single vehicle at a time was observed queuing to enter the Prices Highway.

Traffic was counted and classified on Riverside Drive at Fig Hill Lane from 14-21 June 2018, which is summarised in Error! Reference source not found.**7.17.** There were 6,670 vehicles at this point on an average week day. Heavy vehicles comprised 5-6% of total vehicles on Riverside Drive.

Table 7.17: Summary of existing daily traffic volumes

Location	Average Week Day vehicles / day	Weekly average vehicles / day	Percentage heavy vehicles (%)
Riverside Drive (both directions)	6,670	6,349	5.6
Riverside Drive (eastbound)	3,392	3,227	5.4
Riverside Drive (westbound)	3,278	3,122	5.9

The summary indicates a distinctive morning and afternoon peak period of 8 am – 9 am and 4 pm – 5 pm, with westbound peak flows in the morning and eastbound flows peaking in the afternoon period.

7.9.3 Potential impacts

Site access

The modification site is currently accessed via Fig Hill Lane, which is a private property access to 69 Fig Hill Lane.

Fig Hill Lane intersects Riverside Drive approximately 40 m to the east of the end of the merge lane from the Princes Highway exit ramp.

Fig Hill Lane is too close to the end of the merge lane out of the Princes Highway exit ramp to facilitate safe vehicle access to the modification site. It is not practical to upgrade Fig Hill Lane due to its proximity to the merge lane. Therefore, a new access road is proposed to be constructed at the intersection of Riverside Drive and the entrance to the Dunmore Resource and Recycling Centre.

The intersection will comprise a right turn lane from Riverside Drive which will be at a flat grade and have good sight distances from each approach to the intersection. The conceptual design of the intersection is in Appendix A of **Appendix K**.

Once heavy vehicles have entered the Stage 5A extraction area, they will travel along internal access roads across the private driveway of Dunmore House and onto Fig Hill Lane to the Stage 5B extraction area.

No widening of Fig Hill Lane is required to facilitate heavy vehicle access to the Stage 5B extraction area.

Traffic generation

The VENM will be transported to the modification site by heavy vehicles. Importation of VENM will depend on market demand for sand products and will take six months to two years to complete.

The VENM will imported in campaigns and will not be constant. Therefore, it will not occur every day and there will not be any heavy vehicle movements to the project outside of transport campaigns.

Daily and hourly traffic volumes to be generated by the proposed modification will be:

- 5 one-way heavy vehicle trips (i.e. 10 two-way heavy vehicle trips) during a peak hour of operation, and up to 45 one-way heavy vehicle trips (i.e. 90 two-way heavy vehicle trips) on a peak day of operation;

- 3 one-way heavy vehicle trips (i.e. 6 two-way heavy vehicle trips) during an average hour of operation, and up to 27 one-way heavy vehicle trips (i.e. 54 two-way heavy vehicle trips) on an average day of operation; and
- 10 one-way light vehicle trips (i.e. 20 two-way light vehicle trips) per day on average.

The average daily and hourly truck movements will be lower if VENM importation takes more than two years.

It is likely most of the VENM will be sourced from north of the modification site and will enter via the Princes Highway/Riverside Drive interchange and new driveway. Deliveries from south of the modification site will turn around at the Shellharbour Road/Princes Highway interchange then head south to site as per deliveries from the north.

Refer to **Figure 7.10** for the haulage route to and from the modification site.

Figure 7.10
Haulage route

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Source: Boral (2019)

Traffic impacts on the road network

The transport route for the proposed modification is an approved B-Double truck route and is appropriate for use by the DSS fleet.

Maximum traffic impacts will occur during peak VENM delivery to site, which will be 10 two-way heavy vehicle movements per hour. These movements will not impact performance of the Riverside Drive/Prices Highway interchange as it has spare capacity to absorb these movements. Therefore, performance of this interchange was not modelled further.

There is sufficient shoulder width on Riverside Drive for vehicles to safely overtake a standing vehicle waiting to turn right onto the Princes Highway on ramp.

Performance of the proposed intersection on Riverside Drive was modelled using SIDRA software, using existing traffic plus heavy vehicle numbers during peak VENM delivery. The intersection will have LoS B during the AM and PM peak hours, and will have acceptable delays and spare capacity.

The model was repeated with and without the intersection to account for future traffic growth on Riverside Drive (2% per year for ten years).

The results of this are shown in **Table 7.18** and show the intersection will operate at LoS D or better, which is near capacity.

Table 7.18: Cumulative traffic impacts

Scenario	Level of Service (Morning Peak Hour)	Level of Service (Afternoon peak hour)
Without the proposed modification	B	B
With the proposed modification	C	D

Upgrades to the road network in the area will not be required, other than reconfiguration of lanes along Riverside Drive during construction of the proposed intersection.

Construction traffic

Establishment of the proposed modification will take four to six months.

Light and heavy vehicle movements associated with construction will be less than the heavy vehicle movements associated with VENM transport. Construction vehicles will access the site via the Princes Highway, Riversdale Drive and the new site access road. Oversize or over height vehicles will have the appropriate permits.

7.9.4 Mitigation and management measures

Use of the existing access to the modification site will be unsafe, so a new intersection and access road will be constructed. This intersection will have a good LoS (B) in the near term, which will change to a PM peak hour LoS D in ten years. No other road upgrades are required.

DSS will implement driver awareness training for all staff at the modification site, with a focus on the correct protocols when entering and exiting the modification site; minimising compression braking; and legal obligations of covering all truckloads.

7.10 Other environmental considerations

7.10.1 Land contamination

The potential to encounter or disturb areas of contamination at the modification site is low given the historical land use of the proposed extraction areas. Historical land uses comprise clearing of original woodland vegetation to facilitate grazing for livestock. The potential for these land uses to result in contamination of soils is low. DSS are unaware of any potential contaminating activities in the proposed new extraction areas.

The EPA Contaminated Land Record was searched in January 2019 for the Shellharbour LGA. There are no registered contaminated sites near the modification site.

As such, no further assessment of contaminated land or land remediation is required.

Exposure to unexpected contaminated soil and/or materials could pose a health risk to site personnel as well as having a potential wider affect if the contaminant migrates. Contamination entering waterways can pose a threat to aquatic ecology, water quality and the wider community. It is an offence under the POEO Act to cause contamination or spread contaminated material.

If previously unidentified contaminated materials are encountered during construction and operation of the proposed modification, relevant statutory requirements, including potential soil testing and waste classification, will need to be complied with, and the material managed and disposed of appropriately.

Additional impacts are unlikely to occur as a result of the proposed modification. Existing mitigation measures and environmental management practices, as previously required and outlined by the Project Approval conditions, the EPL, and approved environmental management strategy and supporting management plans will continue to be implemented to minimise the potential for adverse impacts associated with unexpected contamination. No additional mitigation measures are required.

7.10.2 Acid sulfate soils

A review of the Shellharbour LEP indicates that the proposed Stage 5A and a portion of the proposed Stage 5B extraction area are mapped as Class 2 ASS risk. There is a potential for the sediments of the site to form acid upon oxidation, through either water table lowering or bulk excavation. The potential for ASS to occur was assessed (**Appendix L**).

A total of seven boreholes were drilled in the proposed sand extraction areas, to depths of 9–13 m below ground level in the Stage 5A area, and 9–18 m below ground level in the Stage 5B area. One soil sample was obtained, and a field pH and peroxide test was undertaken every 0.25 m within the borehole profile.

A total of 49 soil samples were selected for laboratory analysis. The laboratory analysis found there was a moderate to high risk of ASS in two boreholes in the Stage 5A extraction area. The risk for ASS material was identified from the ground surface to approximately 4.0 m to 5.75 m below ground level respectively. No indicators of ASS potential were identified within the Stage 5B extraction area.

As dredging activities will see most of the water drain back into the dredge pond, there is low risk of oxidation of potentially localised instances of Potential Acid Sulfate Soils (PASS). Returning the water to the dredge pond will prevent lowering of the groundwater table and exposing of PASS to air. Furthermore, recharge is rapid in the alluvial lithology, further preventing impacts to the groundwater table in Stage 5 and across the site.

No fine sediments such as clays, silts, or estuarine muds were observed in shallow soil profiles of Stage 5. As sulphides typically reside in the finer grained sediments, this observation further reduces the risk for PASS being oxidised.

The extracted sands will pass through a sluicing device whereby finer grained materials, if present, will drain back into the dredge pond. This reduces the risk of any localised finer grained sediments oxidising into PASS.

An acid sulfate soils management plan will be prepared and implemented in accordance with ASSMAC's (1998) *Acid Sulfate Soils Assessment Guidelines* if PASS may be disturbed by altered hydrogeological conditions from dredging.

7.10.3 Rehabilitation

DSS has successfully backfilled and rehabilitated dredge ponds with VENM at previous stages of the operation, in accordance with the approved Dunmore Sand and Soil Project Rehabilitation Management Plan (Arcadis, 2017). This experience and knowledge will be used in planning final rehabilitation of the Stage 5 extraction area.

Topsoil will be stripped prior to extraction in the Stage 5A extraction area, stockpiled on-site, and is likely be re-used in the rehabilitation process on the surface of the extraction area, once VENM backfilling is completed. Approximately 325,000 tonnes of VENM would be required to backfill the Stage 5A extraction area, through a progressive rehabilitation approach. As such, rehabilitation would be able to occur concurrent to extraction activities, in areas that will not be disturbed by future dredging activities and not required for processing or stockpiling purposes.

Upon completion, the Stage 5A extraction area would be backfilled with VENM, topsoil spread and groundcover vegetation planted to return the land to pasture at the request of the landowner. The objective of the rehabilitation program for the Stage 5A extraction area would be to:

- return the land to its pre-extraction activity land form;
- revegetate the land to prevent soil erosion; and
- appropriately backfill the extraction area in order to ensure that land levels do not change as material settles over time.

Final land form levels are expected to be between 1-3 m AHD, depending on the existing natural slopes in the proposed State 5A extraction area. Revegetation in the extraction area would be completed in consultation with the landowner, to ensure the area can continue to be used for grazing purposes. Weed control would be undertaken in accordance with the Pest and Weed Management Plan (Appendix C of Dunmore Sand and Soil Quarry Flora and Fauna Management Plan (Arcadis, 2016)).

The Stage 5B extraction area will be left as a freshwater pond, in line with existing practices implemented in Stage 2. This includes:

- rehabilitating the lake edge, to provide additional habitat for native fauna;
- plant species planted along the lakes edges will be selected to maximise the bank stability;
- a fringing wetland community will be created along the western and southern boundary, complemented by adjoining tree stands, improving habitat diversity; and
- stabilising re-profiled areas as soon as possible, minimise potential erosion and degradation of areas of exposed topsoil.

Subsequent to approval, and in accordance with any additional approval conditions, the rehabilitation management plan will be updated to include the Stage 5 extraction area as required by Schedule 5, Condition 4 of the Project Approval.

7.10.4 Greenhouse gas

The proposed modification is unlikely to result in significantly greater greenhouse gas emissions than the approved project as it will not result in an increase in approved production volumes, or a change in extraction methodology or the means by which finished product is transported.

The proposed modification will result in vehicular emissions from operating plant such as dozers and the dredge, as well as heavy vehicles importing fill to the modification site. The booster pumps will also require electricity for operation, which will consume energy resources. Despite this, it is considered that such greenhouse emissions would be negligible given the short-term nature of the proposed modification.

DSS will continue to monitor and report greenhouse gas emissions generated by its operations in accordance with obligations under the NGER Act.

7.10.5 Socio-economic

The Stage 2 to 4 EIS (R.W. Corkery & Co, 2004) found that the approved project would have both positive and negative impacts upon the local socio-economic setting. The positive impacts of the approved project included:

- The approved project would continue to employ 10 personnel. Increased direct and indirect employment would occur as the approved project gradually increased production. Up to 15 personnel would be employed once the maximum annual production level was achieved.
- The approved project would spend $5-10 million per year in the local economy, through wages, contractors' charges, fuel, maintenance and other purchases.
- The locally-based employees and contractors would continue to contribute towards the local spending for housing, local produce, services and food.
- The approved project would result in social benefits of sustaining and improving direct and indirect employment.
- The approved project would result in the continued supply of high-quality sand products to the Illawarra region and the opportunity to expand the supply of proprietary blended products to the construction and building industry.
- Local developers and builders would benefit through the continued presence of a local source of sand products.

The EIS found that the continued supply of sand products from the Northern Illawarra area would reduce the quantity of sand products imported to the area, particularly from the Southern Highlands via Macquarie Pass. Less fuel would therefore be used for product distribution and there would be fewer opportunities for motor vehicle accidents on that route involving trucks.

The EIS found that the main negative socio-economic outcome would be the removal of approximately 55 ha of high value agricultural land. It was noted that the groundwater resources and opportunities for ongoing recharge and consideration of the groundwater as a water supply would be forgone if the approved project were to proceed. Rather, the groundwater would be replaced by a freshwater lake providing visual and recreational benefits to the local community.

The proposed modification will not result in a change in the type of activities of the approved project and will seek to extend the lifetime of operations at the existing site. As a result, the socio-economic benefits described in the EIS will remain applicable.

The potential social impacts of the proposed modification relate largely to impacts on general amenity such as noise, air quality (dust), surface water runoff and visual exposure. Such impacts have been adequately assessed in the EA and respective technical studies and resultant impacts are considered minor, temporary and comply with all relevant guidelines and criteria.

Additional socio-economic impacts are unlikely to result provided the potential environmental impacts are managed. Similar to the conclusions of the EIS, the proposed modification will temporarily remove the potential for agricultural land uses on the subject land. However, upon completion of the Stage 5A extraction area, the land will be rehabilitated back to the existing land use and facilitate livestock grazing into the future. The Stage 5B extraction area will be left in place as a freshwater pond and rehabilitated similar to the previous Stages of the approved project. It is anticipated that this freshwater pond will also provide opportunities for positive visual amenity for the local community and passing motorists of the Princes Highway, and provide habitat opportunities for local wildlife.

Existing mitigation measures and environmental management practices, as previously required and outlined by the Project Approval conditions, the EPL, and the approved Environmental Management Strategy and supporting management plans, will continue to be implemented for activities associated with the proposed modification, in addition to those mitigation measures recommended by this EA.

7.10.6 Hazards and risk

Hazardous substance and dangerous goods management

The hazardous substances and dangerous goods required for the proposed modification are likely to include hydrocarbons, such as fuels (diesel), oils and greases.

Diesel

Diesel is classified as a combustible liquid by Australian Standard (AS) 1940:2004 *The Storage and Handling of Flammable and Combustible Liquids* (AS 1940:2004) (Class C1) for the purpose of storage and handling, but is not classified as a dangerous good by the criteria of the Australian Dangerous Goods (ADG) Code (National Transport Commission, 2007).

The proposed modification will require the use of diesel. There are no diesel storage facilities at the existing site and this will continue for the proposed modification. All heavy vehicles will be fuelled off-site, with select plant (such as the dredge, front end loader and excavators) to be re-fuelled on-site as required via a mobile fuel tanker. This mobile fuel tanker will be transported, stored, handled and managed in accordance with relevant regulations and industry standards. The tanker will be parked in a temporary bunded area while re-fuelling, and any spills which occur in the collection areas will be adequately contained, managed in accordance with emergency response procedures, and classified and disposed of in accordance with relevant waste legislation. In terms of re-fuelling of the dredge, a sealed system (i.e. hose) would transfer fuel from the mobile tanker to the dredge.

The use of diesel is not considered potentially hazardous in terms of SEPP 33.

Oils and greases

Oil is classified as a combustible liquid (Class C2) by AS 1940:2004.

DSS may need to store small quantities of hydrocarbons, typically oils and greases for maintaining plant and equipment. These will be stored in accordance with relevant Australian Standards.

In accordance with the above, the use of these materials is not considered potentially hazardous in terms of SEPP 33.

Management and mitigation measures

With regard to hazardous substance storage and handling, the management objectives are to avoid contamination of soil and water, and to minimize risks to health and safety.

A Pollution and Incident Response Management Plan (PIRMP) has been developed by DSS as part of the approved project to manage any potential chemical or hydrocarbon spills. The PIRMP will be updated to incorporate the proposed modification, inclusive of the following management and mitigation measures:

- all personnel will complete awareness training that includes hazardous substance management, emergency response and the use of spill kits;
- appropriately sized and stocked spill response kits will be provided within strategic areas of the site, and within mobile vehicles used to transport hazardous materials to and from the site;
- spill response kits will be maintained, clearly identified and readily accessible on site for use in case of accidental spillages. Key staff will be skilled in their location as well as usage, application and disposal of contaminated material;
- all potential chemical pollutants (e.g. fuels, oils, lubricants, paints, etc.) will be stored in appropriate containers in bunded areas within mobile vehicles, or designated storage areas to minimise the risk of spillages and mobilisation of any pollutants into the soil or stormwater drains;
- equipment will not be used if there are any signs of fuel, oil or hydraulic leaks. Leaks will be repaired immediately, or the equipment will be removed from site and replaced with a leak-free item;
- any contaminated soil resulting from spills will be excavated, classified in accordance with Waste Classification Guidelines, and disposed of at a licensed waste management facility, or remediated on site in accordance with recommendations provided within a contaminated land management action plan developed by a contaminated land specialist.

Application of SEPP 33

SEPP No. 33 requires the consent authority to consider whether a development proposal is a potentially hazardous industry or a potentially offensive industry.

The proposed modification will require the storage and use of hazardous materials.

In context to SEPP No. 33, DP&E has published a guideline on the application of the SEPP to developments. The guideline is entitled *'Hazardous and Offensive Development Application Guidelines: Applying SEPP 33'* (NSW Department of Planning, January 2011).

The guideline states that this EA needs to determine if the proposed modification will constitute a 'potentially hazardous industry'. If the proposed modification is a potentially hazardous industry, then the SEPP applies and the guideline states that a preliminary hazard analysis (PHA) should be undertaken as part of the EA.

A 'hazardous industry' under SEPP 33 is one which, when all locational, technical, operational and organisational safeguards are employed, continues to pose a significant risk. A proposal cannot be considered a hazardous industry unless it is first identified as potentially hazardous industry and subjected to the assessment requirements of SEPP 33.

Potentially hazardous industry

A PHA is required if the screening process described in Applying SEPP 33 indicates the proposal is potentially hazardous.

The screening process involves comparing the type and quantity of hazardous materials or dangerous goods to be used and stored on-site to the distance to public area thresholds in Applying SEPP 33.

As outlined above, no hazardous materials or dangerous goods will be stored at the modification site. All vehicles re-fuel off-site with the exception of a mobile fuel tanker which will

be used to re-fuel plant, including the dredge, front end loaders and excavators on an as required basis. This mobile fuel tanker will be transported, handled and managed in accordance with relevant regulations and industry standards. As such, the proposed modification does not constitute a potentially hazardous industry, and the assessment requirements of the SEPP, including the requirement for a PHA, do not need to be included in this EA.

Potentially offensive industry

Potentially offensive industry is where in the absence of safeguards and controls, the project could 'emit a polluting discharge that could cause a significant level of offence'. Examples of this may include depositional dust, or operational noise impacts on adjacent residents or land uses.

Applying SEPP 33 states that a proposal is potentially offensive if it requires pollution licensing from the EPA. The granting of the licence by the EPA for the existing operations is sufficient to demonstrate that emissions can be effectively managed and, therefore, the proposal is unlikely to be offensive. The approved project constitutes a 'scheduled activity' under the POEO Act and an EPL is in effect for the existing site.

The proposed modification may emit pollutants which in the absence of safeguards could cause offense. However, management measures have been incorporated into relevant models, which have demonstrated that emissions will not exceed relevant criteria. Therefore, the proposed modification is unlikely to qualify as offensive development under SEPP 33.

Bushfire management

The heavily wooded adjacent environmental conservation areas to the south east of Stage 5A and south of Stage 5B, along with the southern portion of the Stage 5B extraction area have been mapped as 'Vegetation Category 1', which is considered to be the highest risk for bush fire. This vegetation category has the highest combustibility and likelihood of forming fully developed fires including heavy ember production.

A bushfire risk management plan was developed in 2016 for the Illawarra region by the Illawarra Bushfire Management Committee. The plan identifies land areas and associated community assets within the Shellharbour LGA at risk of bushfire and recommends measures to reduce these risks. The modification site itself is not listed within the plan.

The bushfire season in the Illawarra region predominantly occurs during the hotter months of the year, between September and March. The prevailing weather conditions associated with the bushfire season are south westerly and north westerly winds accompanied by high day time temperatures and relative low humidity.

The Illawarra region has an average of 760 bush fires per year, with up to five of these fires considered to be major fire events.

The main sources of bushfire ignition within the region include:

- arson;
- car dumping;
- lightning;
- fugitive embers from legal burn off events;
- fugitive embers from illegal burning; and
- arcs from power lines in high winds.

The majority of vegetation within the modification site consists of stands of native woodland vegetation, interspersed with exotic grassland.

The land within the modification site is considered to pose a low to moderate risk of bushfire due to limited available fuel source, and existing vegetation composition interspersed with

disturbed agricultural areas. Undisturbed vegetated areas surrounding the modification site, including environmental conservation areas to the south and south east would represent a high risk of bushfire. These adjoining environmental conservation reserves would experience build-up of high fire fuel sources over time, associated with dense vegetation canopy contributing to leaf litter and tinder on the ground surface.

A combination of relatively low rainfall, dry nature of the landscape, topography, and dense vegetation and high fuel source in the adjacent environmental conservation areas could pose a bushfire risk to the modification site. Bushfires within the reserves will be managed by NSW Rural Fire Service along with the relevant land authority including National Parks & Wildlife Service and/or Shellharbour City Council.

Bushfire risks of proposed development in NSW are assessed in accordance with RFS (2006) *Planning for Bushfire Protection* (PBP). Extractive development is regarded as 'other' development in PBP and must satisfy the aim and objectives of PBP.

In regard to the proposed modification, infrastructure such as the booster pump, site office and car park, above ground pipeline and powerline are proposed within the Stage 5B extraction area. As identified above, sections of this lot contain Category 1 bushfire prone vegetation and the surrounding 100 m buffer. The booster pump, pipeline and powerline will be valuable site infrastructure, and the site office will contain personnel during work hours. These assets could be vulnerable to property destruction, and personnel vulnerable to injury or fatality from a fire event. The booster pump, pipeline and powerline will be located outside the vegetation buffer, however the site office and car park will be inside the buffer.

The assessment of the proposed modification in relation to the aim and objectives of PBP is summarised below.

The aim of PBP is:

To use the NSW development assessment system to provide for the protection of human life (including fire fighters) and to minimise impacts on property from the threat of bushfire, while having due regard to development potential, on-site amenity and protection of the environment.

As demonstrated in the consideration of the PBP objectives below, the proposed modification will present low bushfire risk and the implementation of bushfire protection measures will not impact the environment.

The objectives of PBP are to:

afford occupants of any building adequate protection from exposure to bushfire:

Occupants of the portable site office will be protected from bushfire by the dredge pond and an area previously cleared of remnant woodland vegetation, which will be on land located between the office and bushfire hazard vegetation.

provide for a defendable space to be located around buildings:

The site office will be surrounded by a carpark and a cleared area which will provide defendable space if required.

Provide appropriate separation between a hazard and buildings which, in combination with other measures, prevent direct flame contact and material ignition:

PBP provides for asset protection zones (APZs), which are a buffer area between the bushfire hazard and buildings. The APZ for the site office were determined in accordance with Appendix 2 of PBP as follows:

determine vegetation formations within 140 m of the site:

The bushfire hazard vegetation will be to the south and south west of the site office and comprises the vegetation communities of Bangalay-Old man Banksia open forest on coastal sands, Sydney Basin Bioregion and South-East Corner Bioregion. This corresponds to the 'forests' formation in PBP.

determine slope class of the land under the vegetation and site:

The slope under the bushfire hazard vegetation is class [i] (flat) and the slope between the vegetation and site is 11˚, which corresponds to slope class [iv].

determine appropriate fire weather area:

The site is in the Illawarra/Shoalhaven fire area and has fire danger index (FDI) of 100.

determine appropriate APZ:

this requires reference to one of the tables in Appendix 2, which are based on the FDI of the modification, and compare vegetation formation and slope to provide an APZ width (Table A2.4). The resulting APZ for the site office is 50 m. This APZ will be easily accommodated as there is approximately 80 m distance between the bushfire hazard vegetation and the location of the site office.

ensure that safe operational access and egress for emergency service personnel and residents is available:

The proposed access to the Stage 5B extraction area along Fig Hill Lane to Riverside Drive is positioned outside of bushfire prone land and as such an adequate emergency evacuation route exists in the event of a fire. Similarly, the access road would present suitable access for emergency service personnel and the NSW Rural Fire Service in the event that access for fire fighting is required.

provide for ongoing management and maintenance of bush fire protection measures, including fuel loads in the asset protection zone (APZ):

The APZ will comprise part of the dredge pond and an area previously cleared of woodland vegetation. The APZ will be regularly mowed surrounding the site office and car park during the course of the works.

ensure that utility services are adequate to meet the needs of fire fighters (and others assisting in bush firefighting):

In the event of a fire event, a plentiful supply of water will be stored within the Stage 5B dredge pond and be available to emergency services in the event that fire fighting is required.

The assessment of the proposed modification in relation to the aim and objectives of PBP demonstrates that proposed buildings and other infrastructure will be sufficiently distant from bushfire hazard vegetation such that the risk of bushfire attack is low.

Notwithstanding the above, activities associated with the proposed modification may result in inadvertent bushfire ignition. Such activities may include grass fires sparked by the hot exhaust of vehicles driving or parking in long, dry grassland; fires sparked during hot work activities such as welding; clearing of vegetation; or stockpiling of removed vegetation and timber (prior to reuse in revegetation or rehabilitation) contributing to a fuel source for ignition. This risk will be managed by continued implementation of the site's emergency management plans and hot works protocols.

DSS will continue to work with the NSW Rural Fire Service and respective land authorities to co-ordinate any scheduled burn off events, and monitor and report any fires, suspicious behaviour or hazardous fuel loads within proximity to the modification site boundary.

Soil and water contamination

In the event of a spill of the hydrocarbons used on-site, via human error, or failure or rupture of the storage vessel, potential impacts may include localised contamination of soil and water, as well as impacts on health and safety.

If released to the environment uncontrolled, hydrocarbons may be damaging to soils and aquatic ecosystems, and fires can occur if these materials are ignited.

Potentially hazardous products such as hydrocarbons required for operations will be contained within appropriately bunded areas in accordance with relevant Australian Standards, codes and regulations.

Refuelling and maintenance activities will be restricted to hardstand bunded areas within the site, on flat slope and away from stormwater flow pathways or drainage lines. As such, the risk of soil, surface water and groundwater contamination during the project arising from spills is anticipated to be low. Plant and equipment will also be maintained to minimise the potential for leakages, while appropriately sized and stocked spill response kits will be provided within strategic areas of the site, and within mobile vehicles.

A Pollution and Incident Response Management Plan (PIRMP) has been developed by DSS as part of the approved project to manage any potential chemical or hydrocarbon spills. The PIRMP will be updated to incorporate the proposed modification.

Risk to workers

As with any extractive industry operations, daily operations have inherent risk to workers and contractors and have the potential to result in injury or fatality if workers are ill informed of the hazards involved, or risks associated with plant and machinery are not managed. Examples of activities which could result in injury or fatality include crush injuries by moving plant and equipment, motor accidents or crush by heavy vehicles, exposure to hazardous materials, heat exhaustion, working from heights or confined spaces, and exposure to airborne dust and industrial noise.

DSS has a rigorous workplace health and safety regime, as required by the NSW *Work Health and Safety Act 2011* (WHS Act). All workers, contractors and visitors will be inducted on safety protocols and procedures before entering active parts of the modification site. All personnel working on the modification site will be required to wear personal protective equipment such as hard hats, high visibility clothing and enclosed footwear. Regular communication of safety requirements and initiatives will also be undertaken on a regular basis.

Provided the implementation of workplace health and safety protocols during construction and operation of the proposed modification, as required by the WHS Act and other relevant regulations or standards, the potential for injuries or fatalities to workers, contractors or visitors to the modification site will be minimised.

Designated first aid and emergency response equipment will be available during construction and operation phases of the proposed modification. Appropriately trained personnel will be on site throughout the life of the operations to provide first aid and respond to site emergencies.

Any injuries incurred at the site will be reported and investigated in consultation with SafeWork NSW and other relevant authorities. Any recommendations or findings of investigation reports will be implemented by DSS where feasible and practical.

Public safety

As highlighted previously, risks to public safety may arise where members of the public gain unauthorised access to the modification site. This is particularly hazardous as it could result in potential fatality for members of the public associated with movement of heavy vehicles and moving plant.

To address the risks to public safety, DSS will continuously review and improve security at the site, including new fencing, security cameras, gates and signage.

All visitors to the site will be required to report to the site administration office and register prior to gaining entry to the active areas of the modification site.

With these security initiatives in place, coupled with a regular review and inspection of the integrity and effectiveness of these measures, the potential for members of the public to gain unauthorised access to the modification site will be minimised.

Road safety

Heavy vehicles associated with importation of VENM to the site, along with deliveries of consumables, will frequently travel along Riverside Drive and the Princes Highway on route to and from the modification site. Potential implications to the general public who also utilise these public roadways may occur in the event of a motor vehicle accident, or tip over resulting in the spill of materials across the roadway. Such events could result in injury, fatality, or general inconvenience to the community associated with road closures.

As outlined in **Section 7.9**, the proposed modification is not expected to result in any negative impacts to other road users and the safety of the public road network and DSS will implement driver awareness training for all staff at the modification site, with a focus on the correct protocols when entering and exiting the modification site and driving on public roads.

Cumulative impacts

Despite the proposed modification being located within proximity to other industrial and extractive land uses (including the approved project), there will be no significant cumulative risks as a result of the proximity of the modification to these operations. All technical assessments of the potential impacts of the proposed modification, have where relevant, considered the cumulative impacts of the modification combined with existing activities in the area thereby assessing the cumulative impacts of the modification.

It is assumed that existing operations near the modification site will also experience similar environmental risks, and will also be subject to regulatory requirements in regard to minimising environmental impacts associated with their operations. As such, environmental management practices at these nearby operations will also be to an environmentally and legislatively responsible manner, thereby minimising the potential for cumulative impacts arising from operation of the proposed modification, coupled with these similar industries.

7.10.7 Waste

The proposed modification is unlikely to generate a significant volume of additional waste.

Potential waste sources which may be generated during activities associated with construction and operation of the proposed modification include:

- garden (green) waste, including removed trees and cleared vegetation and groundcover; and

- General Solid Wastes (non-putrescible).

All waste and reusable materials will be removed from the modification site at the conclusion of works and disposed of appropriately. Green wastes such as felled native vegetation may be mulched on-site and used for rehabilitation purposes.

All waste to be removed from site will be classified in accordance with the *Waste Classification Guidelines* (EPA, 2014) and transported and disposed of at an appropriately licenced facility.

Existing waste management practices, as previously required and outlined by the Project Approval conditions, subsequent modification consents, the Environmental Protection Licence, and approved environmental management plans, will continue to be implemented during the proposed modification works to minimise adverse impacts associated with waste generation, management and disposal.

No additional waste management and mitigation measures are required.

7.10.8 Sustainability

The provision of adequate, reliable and affordable resources is essential to meeting the needs of people in both developed and developing countries. A balance is required between the promotion and coordination of the orderly and economic use and development of land, the proper management and development of our resources and the protection of the environment and effective integration of economic, social and environmental considerations as defined by the requirements of ecologically sustainable development (ESD).

ESD describes the principles used to undertake development to maintain and improve the total quality of life, in a way that maintains ecological processes to support current and future generations.

ESD requires a combination of sound planning and an effective and environmentally sensitive approach to design, operations and management of a project. The principles of ESD are defined in Schedule 2 of the EP&A Regulation:

“The reasons justifying the carrying out of the development or activity in the manner proposed, having regard to biophysical, economic and social considerations, including the following principles of ecologically sustainable development:

a) The precautionary principle,
b) Inter-generational equity,
c) Conservation and biological and ecological integrity,
d) Improved valuation, pricing and incentive mechanisms”

Application of the principles of ESD to the proposed modification

DSS is committed to the principles of ESD and understands that social, economic and environmental matters are interdependent. During the feasibility phase of the proposed modification, sustainable development decision making was implemented by placing equal importance on social, environmental and economic considerations. The principles of ESD have been applied in project concept design, planning and assessment through:

- incorporation of a risk assessment at various stages in the modification life-cycle to inform decision-making processes;
- undertaking detailed independent technical assessments of the significant issues, to fully understand the potential impacts associated with the proposed modification and to identify necessary environmental controls and management measures to avoid, minimise or at lease mitigate these impacts;

- various design iterations were considered to where possible, eliminate or minimise impacts on the environment and community;
- conservative baselines and worst-case scenarios adopted when predicting potential impacts; and
- consultation with regulatory and community stakeholders.

The precautionary principle

The precautionary principle reinforces the need to take risk and uncertainty into account, particularly when potential threats of irreversible damage to the environment may be unknown or little understood. In the application of the precautionary principle, Boral has numerous similar extractive operations around Australia, the potential environmental impacts associated with the activity are well understood, and have been effectively managed in a manner which results in little to negligible environmental impact. This has helped inform decision-making when considering how potential environmental impacts for this proposed modification may be eliminated or mitigated to an acceptable level.

This understanding gained from observing and monitoring similar operations has led to the identification of the key issues relating to the proposed modification which pose the greatest risk to the environment. Detailed independent technical assessments were then undertaken to fully understand the key issues associated with the development and to identify necessary environmental controls and management measures to avoid, minimise or at lease mitigate these issues.

The approvals process meets the requirements of the precautionary principle and this EA provides a process for identifying and assessing the potential impacts and environmental consequences of the proposed modification.

Intergenerational equity

Social equity is defined by intergenerational equity, which is centred on the concept that the present generation should ensure that the health, diversity and productivity of the environment are maintained or enhanced for the benefit of future generations.

One of the primary objectives of the proposed modification is to facilitate extractive operations that are conducted in an environmentally and socially responsible manner. The Stage 5A extraction area will be reinstated to natural ground level and existing land use upon completion of sand extraction in this area and as such, the proposed modification will ensure the locality is maintained for future generations. Despite the requirement to leave the Stage 5B dredge pond as a permanent feature at the request of the landowner, the permanent water body is not in conflict with the natural setting of the area which includes open water of the Minnamurra River and estuary and other ponds interspersed with native vegetation, paddocks and rural residential properties. The permanent pond will remove only a small area of grazing land interspersed with some native trees, and replace it with aquatic habitat that is likely to be used by a variety of local native fauna. Leaving the Stage 5B extraction area as a permanent pond will therefore not result in significant environmental impacts that would deprive or impact on future generations.

This EA has addressed the principles of social equity through:

- engagement of suitably qualified and experienced technical specialists to ensure that the environmental assessment phase of the proposed modification has been independently undertaken and is transparent; and
- management strategies, mitigation measures and monitoring programmes to minimise any potential adverse impact upon the local environment and nearby communities.

Conservation of biological diversity and ecological integrity

As the modification site supports areas of high ecological value, the design and alternatives considered, have focused on ensuring:

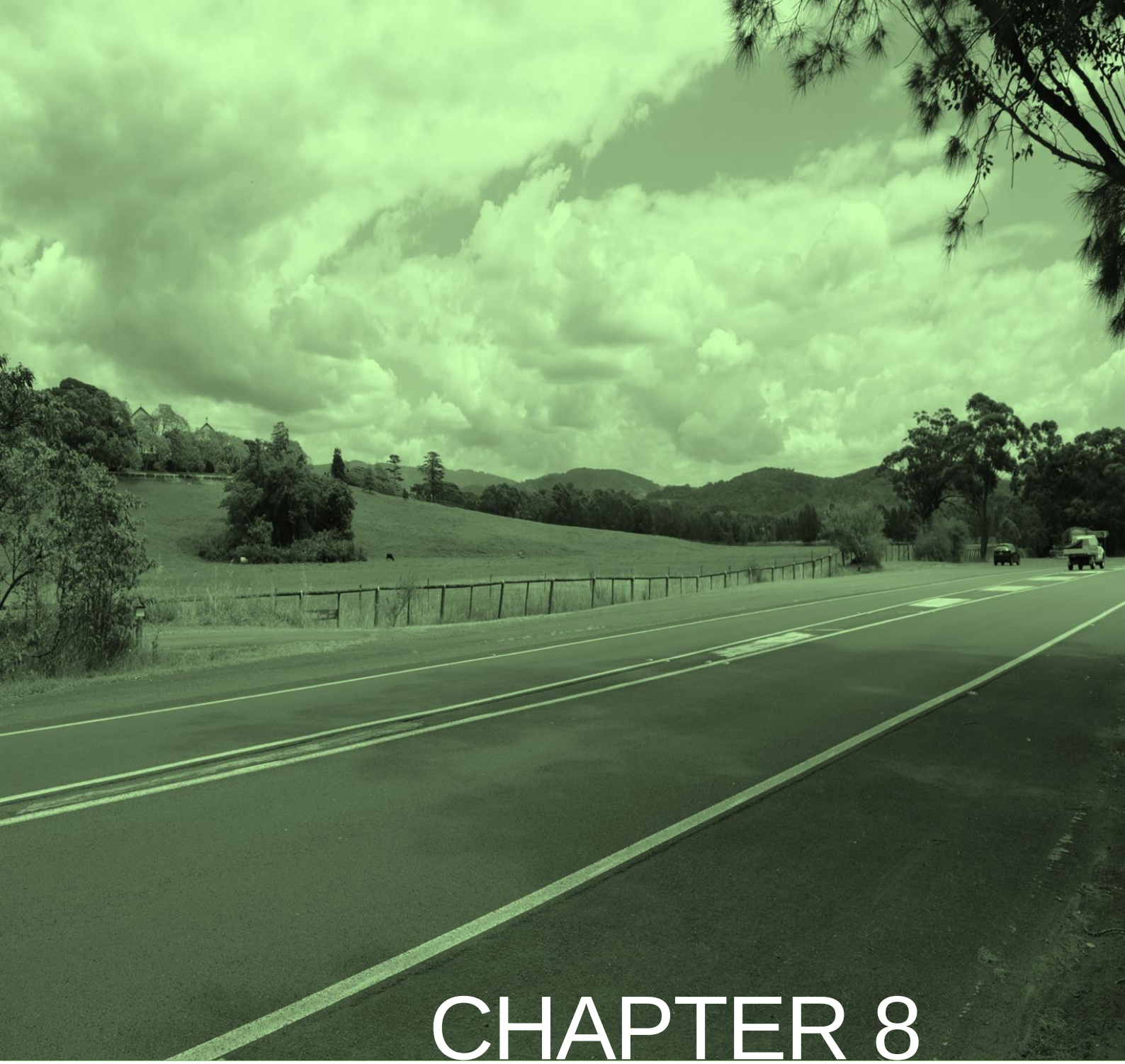
- where possible, remaining native vegetation on the affected land is retained;
- the risk to water quality is minimised as much as is reasonable and feasible; and
- minimal disturbance to potential sub-surface contamination and ASS risks.

In accordance with ESD principles, the proposed modification addresses the conservation of biodiversity and ecological integrity by design iterations to the Stage 5B extraction area that minimises clearing of native vegetation, avoids the coastal wetlands (including wetlands listed in the Coastal SEPP) and the 'proximity area for coastal wetlands' and by proposing environmental mitigation and management recommendations designed to conserve ecological values where practicable. An appropriate biodiversity offset strategy will also be prepared in order to compensate for the native vegetation and fauna habitat that is proposed to be cleared.

Improved valuation and pricing of environmental resource

The principle of improved valuation, pricing and incentive mechanisms deems that environmental factors should be included in the valuation of assets and services, and that those who generate the pollution and waste should bear the cost of containment, avoidance or abatement.

DSS acknowledges and accepts the financial costs associated with all the measures required for the proposed modification to avoid, minimise, mitigate and manage potential environmental and social impacts.



CHAPTER 8

CONCLUSION

8 CONCLUSION

DSS is seeking to modify the current Project Approval (DA 195-8-2004) under Section 75W of the EP&A Act, to provide for an additional extraction area (Stage 5) on adjoining private land, encompassing two separate extraction areas, Stage 5A and Stage 5B, and will constitute Modification 2 to the current Project Approval.

With the significant increase in approved infrastructure projects in Sydney and other parts of NSW, the leading suppliers of natural sand are under pressure to meet this increased demand as natural sand has unique structural characteristics to manufactured sand and is essential to meet design specifications on many infrastructure and associated development projects.

Given recent high demand, the sand resource in Stage 3 of the approved project is expected to be exhausted in approximately eight to twelve months. The last extraction stage, Stage 4, contains the existing site's road access and private rail line and infrastructure for the approved project and Boral's neighbouring Dunmore hard rock quarry. As such, sand extraction cannot commence in this area until this infrastructure is relocated in future.

As Dunmore Lakes Sand Project is one of Boral's few remaining natural sand quarries, DSS, on behalf of Boral, propose to meet part of this increased demand in natural sand by establishing the additional Stage 5 extraction area on land adjoining its current operations.

The expanded operations at the existing site will provide:

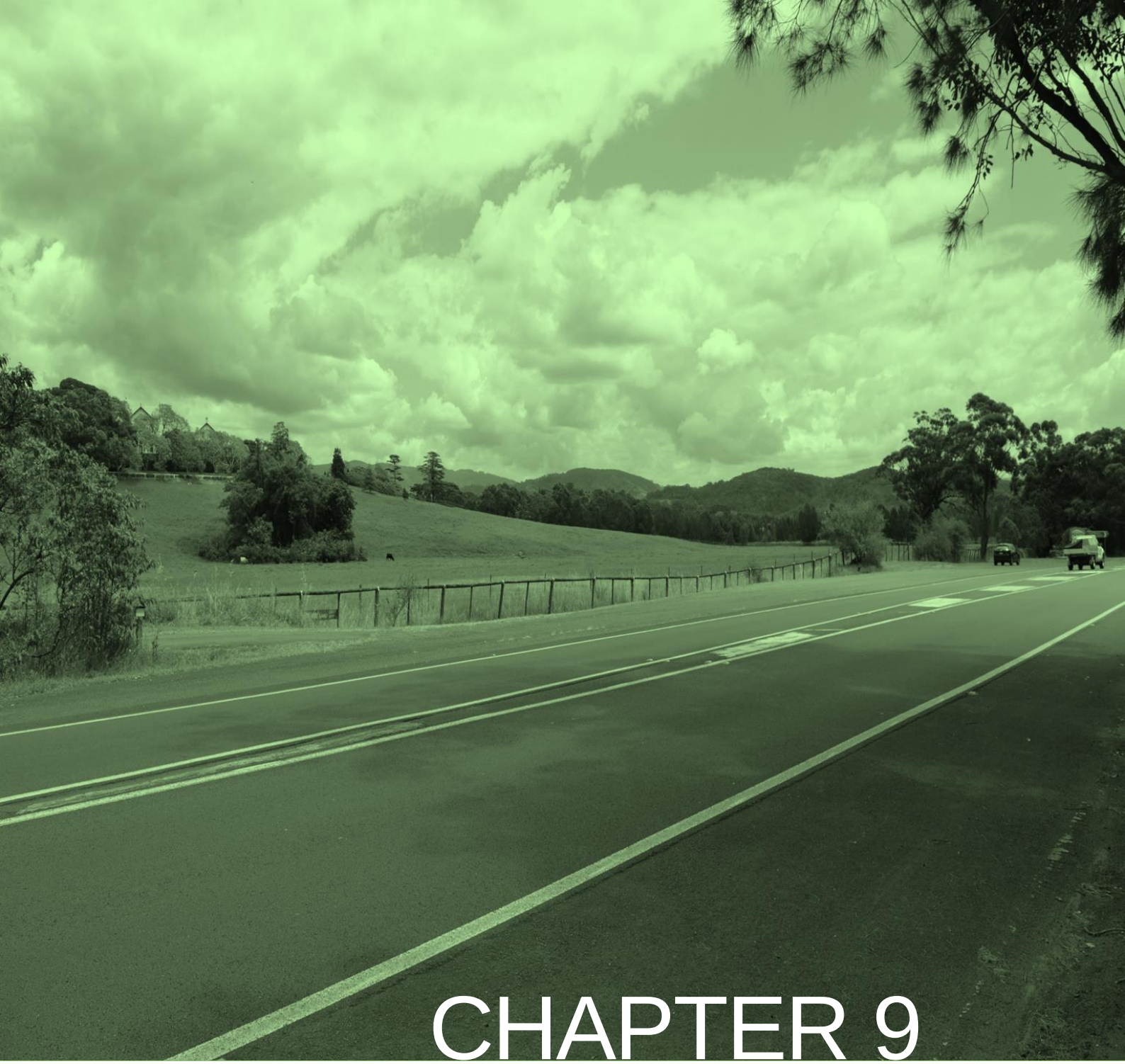
- supply of essential natural sand to major infrastructure and associated development projects;
- continued employment of 10 full time employees and truck/transportation drivers, with further jobs created through flow-on effects;
- optimal use of a regionally-significant resource; and
- economic benefits to the local community through the continued purchase of goods and services and local expenditure both directly and indirectly through employee wages.

Specialist technical investigations were undertaken to assess key environmental issues associated with the proposed modification that were identified by a preliminary environmental risk assessment and a thorough government agency and community consultation process. These investigations concluded that the proposed modification is unlikely to result in any significant impacts on either the biophysical or social environment with the implementation of:

- environmental management and mitigation measures outlined in:
    - the Project Approval;
    - the approved environmental management strategy and supporting management plans;
    - **Chapter 7** of this document;
- biodiversity offsetting requirements; and
- requirements of EPL 11147.

The environmental management strategy and associated management plans will need to be reviewed, revised and amended to include operations at the Stage 5 extraction area (as required) and submitted to the DP&E for approval, prior to commencing operations in the Stage 5 extraction areas.

As required by Schedule 5, Condition 4 of the Project Approval, amendments to management plans would be undertaken within three months of a notice of approval and submitted to DP&E for endorsement.



CHAPTER 9

REFERENCES

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APPENDIX A

EXISTING PROJECT APPROVAL
195-8-2005

Development Consent

Section 80 of the *Environmental Planning & Assessment Act 1979*

I, the Minister for Infrastructure and Planning, approve the Development Application referred to in Schedule 1, subject to the conditions in Schedules 2 to 5.

These conditions are required to:
- prevent, minimise, and/or offset adverse environmental impacts;
- set standards and performance measures for acceptable environmental performance;
- require regular monitoring and reporting; and
- provide for the on-going environmental management of the development.

Craig Knowles, MP
Minister for Infrastructure and Planning
Minister for Natural Resources

Sydney 2005

SCHEDULE 1

Development Application:	DA 195-8-2004.
Applicant:	Dunmore Sand and Soil Pty Limited (ABN: 62 003 497 229).
Consent Authority:	Minister for Infrastructure and Planning.
Land:	Part Lot 6 in DP 611159; Part Lot 3 and Lots 4 & 5 in DP 1030504; Part Lots 5 & 6 in DP1001931; and Lot 1 in DP 213575, Parish of Terragong, County of Camden.
Proposed Development:	Dunmore Lakes Sand Extraction Project (Stages 2, 3 and 4).
State Significant Development:	The proposal is classified as State significant development under section 76A(7)(d) of the *Environmental Planning and Assessment Act 1979*, by virtue of a direction made by the Minister under section 89 of the Act on 11 November 2004.
Integrated Development:	The proposal is classified as integrated development under section 91 of the *Environmental Planning and Assessment Act 1979*, as it requires additional approvals under the: • *Protection of the Environment Operations Act 1997;* • *Water Act 1912; and* • *Rivers and Foreshores Improvement Act 1948.*
Designated Development:	The proposal is classified as designated development under section 77A of the *Environmental Planning & Assessment Act 1979*, as it is for an extractive industry that meets the criteria for designated development in schedule 3 of the *Environmental Planning & Assessment Regulation 2000*.

Note:

- *To find out when this development consent becomes effective, see Section 83 of the Environmental Planning and Assessment Act 1979* (EP&A Act);
- *To find out when this development consent is liable to lapse, see Section 95 of the EP&A Act; and*
- *To find out about appeal rights, see Section 97 of the EP&A Act.*

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Blue type represents June 2016 modification

DEFINITIONS

Annual Review	The review required by condition 9 of Schedule 5
Applicant	Dunmore Sand and Soil Pty Ltd or any other person or persons who rely on this consent to carry out the development that is subject to this consent
ARI	Average Recurrence Interval
BCA	Building Code of Australia
CCC	Community Consultative Committee
Council	Shellharbour City Council
DA	Development Application
Day	Day is defined as the period from 7am to 6pm on Monday to Saturday, and 8am to 6pm on Sundays and Public Holidays
Department	Department of Planning and Environment
Development	The development described in the documents listed in condition 2(a) of Schedule 2
DPI Fisheries	Department of Primary Industries – Fisheries
DPI Water	Department of Primary Industries – Water
DRE	Division of Resources and Energy, within the NSW Department of Industry
EA (MOD 1)	Modification application DA 195-8-2004 MOD 1 and the accompanying Environmental Assessment titled *Dunmore Lakes Sand Project (DA 195-8-2004) – Modification 1* dated 26 April 2016
EIS	Environmental Impact Statement for the *Dunmore Lakes Sand Extraction Proposal, Stages 2, 3 and 4: Environmental Impact Statement, Volumes 1 & 2*, dated August 2004 and supplementary information titled *Dunmore Lakes Sand Extraction Proposal, Stages 2, 3 and 4: Response to EIS Issues*, dated February 2005
EPA	Environment Protection Authority
EP&A Act	*Environmental Planning and Assessment Act 1979*
EP&A Regulation	*Environmental Planning and Assessment Regulation 2000*
Evening	Evening is defined as the period from 6pm to 10pm
GTA	General Term of Approval
Land	As defined in the EP&A Act, except where the term is used in the noise and air quality conditions in Schedules 3 and 4 of this consent, where it is defined as the whole of a lot, or contiguous lots owned by the same landowner, in a current plan registered at the Land Titles Office at the date of this consent.
Minister	Minister for Planning, or delegate
Night	Night is defined as the period from 10pm to 6am on Monday to Saturday, and 10pm to 8am on Sundays and Public Holidays
OEH	Office of Environment and Heritage
Privately-owned land	Land that is not owned by a public agency, a quarrying company or its subsidiary; or where relevant, land that is not covered by a private agreement between the Applicant and the land owner that specifically allows for variances to criteria for environmental performance in this consent
RMS	Roads and Maritime Services
Secretary	Secretary of the Department, or nominee
Shoulder	Time interval from 6am to 7am, Monday to Saturday
Site	Land to which the DA applies
VENM	Virgin Excavated Natural Material, as defined in the *Protection of the Environment Operations Act 1997*

SCHEDULE 2
ADMINISTRATIVE CONDITIONS

Obligation to Minimise Harm to the Environment

1. The Applicant must implement all practicable measures to prevent and/or minimise any harm to the environment that may result from the construction, operation, or rehabilitation of the development.

Terms of Approval

2. The Applicant must carry out the development:
   a) generally in accordance with the EIS, EA (MOD 1) and the Development Layout Plan; and
   b) in accordance with the conditions of this consent.

   Note: The Development Layout Plan is included in Appendix 1.

3. If there is any inconsistency between the documents identified in condition 2(a), the more recent document shall prevail to the extent of the inconsistency. The conditions of this consent shall prevail to the extent of any inconsistency with the documents identified in condition 2(a).

4. The Applicant must comply with any reasonable requirement/s of the Secretary arising from the Department's assessment of:
   a) any strategies, plans, programs, reviews, audits, reports or correspondence that are submitted in accordance with this consent (including any stages of these documents);
   b) any reviews, reports or audits commissioned by the Department regarding compliance with this consent;
   c) the implementation of any actions or measures contained in these documents.

Limits on Approval

5. This consent shall lapse 25 years after the date it commences.

   Note: On-going use of the site for processing and blending activities after this time shall be the subject of a separate application.

6. The Applicant must not produce or transport more than 800,000 tonnes of product per year from the site.

Structural Adequacy

7. The Applicant must ensure that any new buildings and structures, and any alterations or additions to existing buildings and structures, are constructed in accordance with the relevant requirements of the BCA.

   Notes:
   - *Under Part 4A of the EP&A Act, the Applicant is required to obtain construction and occupation certificates for any building works.*
   - *Part 8 of the EP&A Regulation sets out the detailed requirements for the certification of development.*

Demolition

8. The Applicant must ensure that all demolition work is carried out in accordance with *AS 2601-2001: The Demolition of Structures,* or its latest version.

Protection of Public Infrastructure

9. The Applicant must:
   a) repair, or pay the full costs associated with repairing, any public infrastructure that is damaged by the development; and
   b) relocate, or pay the full costs associated with relocating any public infrastructure that needs to be relocated as a result of the development.

Operation of Plant and Equipment

10. The Applicant must ensure that all plant and equipment at the site, or used in connection with the development, are:
    a) maintained in a proper and efficient condition; and
    b) operated in a proper and efficient manner.

SCHEDULE 3
SPECIFIC ENVIRONMENTAL CONDITIONS

GENERAL EXTRACTION AND PROCESSING PROVISIONS

Identification of Boundaries

1. Within 6 months of the date of this consent, the Applicant must:
   a) engage a registered surveyor to mark out the boundaries of the approved limits of extraction;
   b) submit a survey plan of these boundaries to the Secretary; and
   c) ensure that these boundaries are clearly marked at all times in a permanent manner that allows operating staff and inspecting officers to clearly identify those limits.

   Note: The limit of extraction includes the area described in the documents listed in condition 2 of schedule 2 (and shown conceptually on the plan in Appendix 1), as amended by the conditions below.

General Limits on Extraction and Processing

2. The Applicant must not undertake extraction within 3 metres of the project site boundary. Batter slopes from this extraction limit must be no steeper than 1:3 (V:H).

3. The Applicant must not undertake any stockpiling of material in the area marked 'Potential Future Stockpiling Area' on Figure 2.2 of the EIS.

Stage 4 – Tabbita Road Corridor

4. The Applicant must not undertake any extraction in Stage 4 without the prior approval of the Secretary. An application to undertake extraction in Stage 4 must be accompanied by an extraction management plan that must:
   a) detail the proposed realignment and rehabilitation of Tabbita Road and associated infrastructure;
   b) assess the environmental impacts of the proposed realignment; and
   c) include appropriate agreements with affected parties,

   to the satisfaction of the Secretary.

Western, Northern and Eastern Tributaries

Note: The Applicant is required to obtain a Controlled Activity Approval from DPI Water under the Water Management Act 2000 prior to undertaking any works within 40 metres of Rocklow Creek or the Western, Northern and Eastern Tributaries, or any water feature connected to these protected waters.

5. The Applicant must not undertake extraction within 3 metres of the bank of the Eastern Tributary. Batter slopes from this extraction limit must be no steeper than 1:3 (V:H).

6. The Applicant must maintain the integrity of the Northern and Western Tributaries for as long as practicable. In this regard, the Applicant must only extract sand within 3 metres of the bank of the tributaries in accordance with an approved Riparian Area Management Plan (see condition 45). Batter slopes from this extraction limit must be no steeper than 1:2 (V:H).

Southern, North-eastern and North-western Wetlands

7. The Applicant must not undertake extraction within 10 metres of the bank of the southern or north-eastern wetlands. Batter slopes from this extraction limit must be no steeper than 1:2 (V:H).

8. The Applicant must commission a suitably qualified ecologist, whose appointment has been endorsed by the Secretary, to mark out the extraction limit to the southern and north-eastern wetlands.

   Note: The southern and north-eastern wetlands are defined as the area that constitutes Freshwater Wetlands on Coastal Floodplains, an endangered ecological community under the Threatened Species Conservation Act 1995.

9. The Applicant must ensure that extraction within 40m of the southern, north-eastern and north-western wetlands occurs towards the end of dredging when the dredge pond water volume is maximised, and in accordance with an approved Riparian Area Management Plan (see condition 45). The plan must include an assessment by a suitably qualified hydrogeologist justifying the extraction limit referred to in condition 7, based on data obtained from the site.

Rocklow Creek Realignment

10. Prior to the commencement of extraction in Sub-Stage 3C1 (see Appendix 1), the Applicant must complete the realignment and rehabilitation of Rocklow Creek, to the satisfaction of the Secretary. The realignment must be undertaken in accordance with an approved Riparian Area Management Plan (see condition 45). The realigned channel must be designed so as to safely convey, without bed or bank erosion, the 1 in 20 year ARI peak flow.

11. The Applicant must not undertake extraction within 3 metres of the bank of the realigned Rocklow Creek. Batter slopes from this extraction limit must be no steeper than 1:2 (V:H).

12. The Applicant must provide for the ultimate redirection of the realigned Rocklow creek into the lake in Stage 3, unless otherwise approved by the Secretary. The redirection must be undertaken in accordance with an approved Riparian Area Management Plan (see condition 45).

NOISE

Noise Limits

13. [1] The Applicant must ensure that the noise generated by the development does not exceed the criteria specified in Table 1.

Table 1: Noise impact assessment criteria dB(A)

Residential Location	Shoulder $L_{Aeq\ (15\ mins)}$	Day $L_{Aeq\ (15\ mins)}$	Evening $L_{Aeq\ (15\ mins)}$	Night $L_{Aeq\ (15\ mins)}$
Renton	46	46	43	37
Dunmore Village residences	47	49	44	41
Stocker	47	49	44	38

Notes:

a) The criteria above apply to noise emissions under the following weather conditions:
- *wind speeds up to 3 m/s (at a height of 10m); and*
- *Temperature inversions of up to 6^0C/100m and wind speeds up to 2 m/s (at a height of 10m).*

b) The criteria do not apply where the Applicant and the affected landowner have reached a negotiated agreement in regard to noise, and a copy of the agreement has been forwarded to the Secretary and EPA.

c) Noise from the development is to be measured at the most affected point or within the residential boundary, or at the most affected point within 30 metres of a dwelling (rural situations) where the dwelling is more than 30 metres from the boundary, to determine compliance with the $L_{Aeq(15\ minute)}$ noise limits in the above table. Where it can be demonstrated that direct measurement of noise from the development is impractical, EPA may accept alternative means of determining compliance (see Chapter 11 of the NSW Industrial Noise Policy). The modification factors in Section 4 of the NSW Industrial Noise Policy must also be applied to the measured noise levels where applicable.

Operating Hours

14. [2] The Applicant must comply with the operating hours in Table 2:

Table 2: Operating Hours

Activity	Day	Time
Dredging and processing	Monday – Saturday	6:00am to 6:00pm
	Sunday and Public Holidays	8:00am to 4:00pm
Excavator extraction	Monday – Saturday	6:30am to 6:00pm
	Sunday and Public Holidays	Nil
Delivery, distribution and maintenance	Monday – Friday	5:00am to Midnight
	Saturday	6:00am to 6:00pm
	Sunday and Public Holidays	8:00am to 4:00pm
Delivery and distribution via Shellharbour Road	Monday – Friday	7:00am to 10:00pm
	Saturday	7:00am to 6:00pm
	Sunday and Public Holidays	8:00am to 4:00pm

[1] Incorporates EPA GTA
[2] Incorporates EPA GTA

Activity	Day	Time
Maintenance (if inaudible at neighbouring residences)	Anytime	Anytime

15. [3]The following activities may be carried out at the premises outside the hours specified in Table 2:
a) the delivery of materials as requested by Police or other authorities for safety reasons; and
b) emergency work to avoid the loss of lives, property and/or to prevent environmental harm.
In such circumstances the Applicant must notify EPA and affected residents prior to undertaking the works, or within a reasonable period in the case of emergency.

Noise Monitoring Program

16. [4]Within 3 months of the date of this consent, the Applicant must prepare a Noise Monitoring Program for the development, in consultation with EPA, and to the satisfaction of the Secretary. This program must include a noise monitoring protocol for evaluating compliance with the noise impact assessment criteria in this consent.

The Applicant must implement the approved monitoring program as approved from time to time by the Secretary.

Noise Compliance Assessment Report

17. [5]Within 2 months of the date of commencement of extraction of production sand, and annually thereafter unless directed otherwise by the Secretary, the Applicant must:
a) commission a suitably qualified person to assess whether the development is complying with the noise impact assessment criteria in Table 1, in general accordance with the *NSW Industrial Noise Policy* and *Australian Standard (AS) 1055-1997: Description and Measurement of Environmental Noise*; and
b) provide the results of this assessment to EPA and Secretary within a month of commissioning the assessment.

Noise Limit Exceedance Report

18. Within 7 days of detecting any exceedance of the noise limits in Table 1, the Applicant must report the exceedance to EPA and the Secretary. This report must include details of the date and time of the exceedance, the operational cause of the exceedance, the response initiated, and the measures proposed to ensure ongoing compliance with the noise limits.

AIR QUALITY

Impact Assessment Criteria

19. The Applicant must ensure that dust generated by the development does not cause additional exceedances of the criteria listed in Tables 3 to 5 at any residence on, or on more than 25 percent of, any privately-owned land.

Table 3: Long term criteria for particulate matter

Pollutant	Averaging period	Criterion
Total suspended particulate (TSP) matter	Annual	90 µg/m^3
Particulate matter < 10 µm (PM_{10})	Annual	30 µg/m^3

Table 4: Short term criteria for particulate matter

Pollutant	Averaging period	Criterion
Particulate matter < 10 µm (PM_{10})	24 hour	50 µg/m^3

[3] Incorporates EPA GTA
[4] Incorporates EPA GTA
[5] Incorporates EPA GTA

Table 5: Long term impact assessment criteria for deposited dust

Pollutant	Averaging period	Maximum increase in deposited dust level	Maximum total deposited dust level
Deposited dust	Annual	2 g/m^2/month	4 g/m^2/month

Note: Deposited dust is assessed as insoluble solids as defined by Standards Australia, 1991, AS 3580.10.1-1991: Methods for Sampling and Analysis of Ambient Air - Determination of Particulates - Deposited Matter - Gravimetric Method

Air Quality Monitoring Program

20. [6]Within 3 months of the date of this consent, the Applicant must prepare an Air Quality Monitoring Program for the development, in consultation with EPA, and to the satisfaction of the Secretary. This program must include an air monitoring protocol for evaluating compliance with the air quality criteria in this consent.

The Applicant must implement the approved monitoring program as approved from time to time by the Secretary.

Note: Initially, this program should concentrate on monitoring the dust deposition impacts of the development. However, in time, it may be expanded to include other pollutants.

Odour

21. [7] The Applicant must not cause or permit the emission of offensive odour beyond the boundary of the site.

Note: 'Offensive odour' is defined in the Protection of the Environment Operations Act 1997.

SURFACE AND GROUND WATER

Note: Under the Water Act 1912 and/or the Water Management Act 2000, the Applicant is required to obtain the necessary water licences for the development.

Pollution of Waters

22. Except as may be expressly provided by an Environment Protection Licence, the Applicant must comply with section 120 of the *Protection of the Environment Operations Act 1997* during the carrying out of the development.

Water Discharge Limit

23. Except as may be expressly provided by an Environmental Protection Licence, the Applicant must ensure that the discharges from any licenced discharge point/s do not cause additional exceedances of the criteria in Table 6:

Table 6: Water Discharge Pollution Limits

Pollutant	Unit of Measure	100 Percentile Concentration Limit
Total Suspended Solids	mg/L	50
pH	pH	± 1.0

Water Quality Objectives

24. The Applicant must ensure that water quality in the dredge ponds and in groundwater comply with the water quality objectives in Table 7, or other such level as approved by the Secretary:

[6] Incorporates EPA GTA
[7] Incorporates EPA GTA

Table 7: Water Quality Objectives

Pollutant	Unit of Measure	Water Quality Objective
Turbidity	NTU	5-20
pH	pH	6.5 – 8.5
Salinity	µS/cm	<1,500
Dissolved oxygen	mg/L	>6
Total phosphorus	µg/L	5-50
Total nitrogen	µg/L	100-500
Chorophyll-a	µg/L	2-10
Faecal coliforms	Median No./100mL	<1000
Enterococci	Median No./100mL	<230
Algae and blue-green algae	No.cells/mL	<15,000
Sodium	mg/L	400
Potassium ion	mg/L	50
Magnesium ion	mg/L	50
Chloride ion	mg/L	300
Sulphate ion	mg/L	250
Bicarbonate ion	mg/L	750
Soluble Iron ion	mg/L	6
Ammonium ion	mg/L	20

Notes:

- *The objectives for dissolved oxygen, turbidity and algae are relevant to surface water only;*
- *The Department acknowledges that short term exceedances of these objectives may occur during natural events such as heavy rainfall or tidal saline water inflow.*

Stormwater Management

25. [8] The Applicant must ensure that any pond subject to dredging or backfilling, or containing turbid water due to recent dredging or backfilling, must be maintained and operated to prevent discharges of any turbid water (as defined in Tables 6 and 7) from these ponds.

26. [9] The Applicant must cease backfilling activities not less than 12 hours prior to the commencement of overflow from any dredge pond. No backfilling must occur when the dredge ponds are overflowing.

Flood Management

27. The Applicant must ensure that the flood storage capacity of the site is no less than the pre-existing flood storage capacity at all stages of the development. Details of the available flood storage capacity must be reported in the Annual Review.

28. [10]The access road entrance off Tabbita Road, processing and stockpile area, and the fines return pond(s) must be constructed and maintained so as to prevent inundation by floodwaters caused by the 1 in 100 year ARI flood level. Prior to the commissioning of the processing area, the Applicant must provide certification to the Secretary that this condition has been complied with.

29. Following the cessation of dredging and backfilling operations, the Applicant must commission a suitably qualified hydrologist to define the flood-related limits of the final landform. The flood study must be undertaken in consultation with the Department and Shellharbour Council, and to the satisfaction of the Secretary.

[8] Incorporates EPA GTA

[9] Incorporates EPA GTA

[10] Incorporates EPA GTA

Monitoring and Management

30. Within 3 months of the date of this consent, the Applicant must prepare a Water Management Plan for the development, in consultation with DPI Water and the Department, and to the satisfaction of the Secretary. This plan must be prepared by a qualified hydrogeologist/hydrologist and include:
    a) a Water Balance;
    b) an Erosion and Sediment Control Plan;
    c) a Surface Water Monitoring Program;
    d) a Ground Water Monitoring Program; and
    e) a Surface and Ground Water Response Plan, to address any potential adverse impacts associated with the development.

    The Applicant must implement the approved management plan as approved from time to time by the Secretary.

31. The Water Balance must:
    a) include details of all water extracted and used by the development; and
    b) provide for the reporting of annual water extraction and maximum instantaneous pumping rates to the Department in accordance with the licence under the *Water Act 1912*.

32. The Erosion and Sediment Control Plan must:
    a) be consistent with the requirements of the Department of Housing's *Managing Urban Stormwater: Soils and Construction* manual;
    b) identify activities that could cause soil erosion and generate sediment;
    c) describe measures to minimise soil erosion and the potential for the transport of sediment to downstream waters;
    d) describe the location, function, and capacity of erosion and sediment control structures; and
    e) describe what measures would be implemented to maintain the structures over time.

33. The Surface Water Monitoring Program must include:
    a) detailed baseline data on surface water flows and quality in all waterbodies and wetlands within the site;
    b) surface water impact assessment criteria;
    c) a program to monitor surface water flows and quality;
    d) a program to monitor bank and bed stability;
    e) a protocol for the investigation, notification and mitigation of identified exceedances of the surface water impact assessment criteria; and
    f) a program to monitor the effectiveness of the Erosion and Sediment Control Plan.

34. The Ground Water Monitoring Program must include:
    a) detailed baseline data on ground water levels, flows and quality, based on statistical analysis;
    b) ground water impact assessment criteria;
    c) a program to monitor regional ground water levels and quality;
    d) a program to monitor ground water level effects on adjacent wetlands, vegetation, and on ground water supply to adjoining properties; and
    e) a protocol for the investigation, notification and mitigation of identified exceedances of the groundwater impact assessment criteria.

Reporting

35. Each year, the Applicant must:
    a) review the Water Management Plan;
    b) update each sub-plan; and
    c) report the results of this review in the Annual Review, including:
    d) the results of monitoring;
    e) details of the review for each sub-plan;
    f) amendments to the sub-plans; and
    g) details of the measures undertaken/proposed to address any identified issues.

WEATHER MONITORING

36. [11] The Applicant must establish a rainfall monitoring gauge at a location approved by EPA, using the following specified units of measure, averaging period, frequency and sampling method.

Table 8: Weather Monitoring

Parameter	Unit of Measure	Averaging period	Frequency	Sampling method[1]
Rainfall	mm	24 hr	Continuous	AM-4
Siting	-	-	-	AM-1

[1] *NSW EPA, 2001, Approved Methods for the Sampling and Analysis of Air Pollutants in NSW.*

FLORA AND FAUNA

Endangered Ecological Community Compensatory Habitat

37. The Applicant must establish, conserve and maintain at least:
a) 6 ha of Freshwater Wetlands on Coastal Floodplains (which may include areas of associated wetland pondage); and
b) 3 ha of Swamp Oak Floodplain Forest;
in rehabilitation and visual screening plantings on the site, in a manner that integrates the compensatory habitats with existing similar habitats on and near the site.

Flora and Fauna Management Plan

38. Within 12 months of the date of this consent the Applicant must prepare a Flora and Fauna Management Plan for the development to the satisfaction of the Secretary. This plan must be prepared by a suitably qualified ecologist and include:
a) a Vegetation Clearing Protocol;
b) a Compensatory Habitat Management Plan; and
c) a Pest and Weed Management Plan.

The Applicant must implement the approved management plan as approved from time to time by the Secretary.

39. The Vegetation Clearing Protocol must be prepared prior to the commencement of any vegetation clearing works, and must:
a) delineate the areas of vegetation to be cleared; and
b) describe the procedures that would be implemented for;
- pre-clearance surveys;
- progressive clearing;
- fauna management;
- conserving and reusing topsoil;
- collecting seed from the site;
- salvaging and reusing material from the site;
- managing waste vegetation; and
- controlling weeds.

40. The Compensatory Habitat Management Plan must:
a) describe the compensatory habitat proposal;
b) justify why the proposed area(s) is suitable for the compensatory habitat proposal, including how the area will integrate with existing habitat areas on and near the site;
c) establish baseline data for the existing habitat in the proposed area(s);
d) describe how the compensatory habitat proposal would be implemented;
e) set completion criteria for the compensatory habitat proposal; and
f) describe how the performance of the compensatory habitat proposal would be monitored over time.

41. The Pest and Weed Management Plan must be prepared in consultation with Shellharbour Council, OEH and DPI Fisheries, and must:
a) identify potential terrestrial and aquatic pests and weeds that may be expected on the site;
b) describe the measures that would be implemented to prevent and eradicate the occurrence of pests and weeds on the site; and

[11] Incorporates EPA GTA

c) describe how the performance of these measures would be monitored over time.

REHABILITATION

Rehabilitation

42. The Applicant must progressively rehabilitate the site to the satisfaction of the Secretary, in a manner that is generally consistent with the concept final landform in the EIS (see Appendix 2), and in accordance with the conditions of this consent.

Rehabilitation Management Plan

43. Within 12 months of the date of this consent the Applicant must prepare a Rehabilitation Management Plan for the development to the satisfaction of the Secretary: This plan must:
    a) identify the disturbed area at the site;
    b) describe in general the short, medium, and long-term measures that would be implemented to rehabilitate the site;
    c) describe in detail the measures that would be implemented over the next 5 years to rehabilitate the site;
    d) define the final landform based on current backfill estimates;
    e) set completion criteria for the rehabilitation of the site;
    f) describe how the performance of these measures would be monitored over time;
    g) include Riparian Area Management Plan/s for those riparian areas to be disturbed/rehabilitated in the next 5 years; and
    h) include Landscaping Plan/s for the site.

    The Applicant must implement the approved management plan as approved from time to time by the Secretary.

44. The Rehabilitation Management Plan must be prepared:
    a) in consultation with Shellharbour Council, Kiama Council, OEH, DRE, the CCC, and the Department;
    b) by suitably qualified consultants, including a specialist hydrologist, wetlands ecologist and landscape architect, whose appointments have been approved by the Secretary;
    c) in accordance with extant guidelines including the *Constructed Wetlands Manual, Volumes 1 & 2* and the *Shellharbour Visual Management Plan User Manual*,

    to the satisfaction of the Secretary.

45. The Riparian Area Management Plan/s must be prepared in consultation with OEH and the Department, and must:
    a) For works involving disturbance within 3m of an existing riparian area:
        - describe the broader extraction staging and justify the need for extraction in the riparian area at the proposed time;
        - describe in detail the methods and timing for extraction within the riparian area;
        - provide for construction and stabilisation of appropriate diversion channels to divert the waterbody around the disturbance area, unless otherwise approved by OEH and the Department; and
        - describe the methods for rehabilitation of the riparian area and diversion channels.

    b) For works involving construction/rehabilitation of riparian areas:
        - detail proposed channel/bed designs, including scour protection measures;
        - include hydraulic modeling supporting the proposed design;
        - where applicable, include measures to replicate pre-existing tidal-estuarine conditions;
        - include detailed plans for rehabilitation and revegetation of the riparian area using locally endemic species;
        - describe measures for the protection, enhancement and integration with adjacent threatened communities, including *Freshwater Wetlands on Coastal Floodplains* and *Swamp Oak Floodplain Forest.*

46. The Landscaping Plan/s must be prepared in consultation with Shellharbour Council and Kiama Council and must include:
    a) concept design plans for the final landform; and
    b) detailed design plans for the areas to be rehabilitated in the next 5 years.

47. Within 3 years of providing the Rehabilitation Management Plan to the Secretary, and every 4 years thereafter, the Applicant must review and update the Rehabilitation Management Plan in a manner similar to that described in condition 44, to the satisfaction of the Secretary.

Rehabilitation and Conservation Bond

48. Within 12 months of the date of this consent, the Applicant must lodge a rehabilitation and conservation bond for the development with the Secretary. The sum of the bond must be calculated at:
    a) $2.50/m^2 for the total area to be disturbed in each 4 year review period (see condition 49); and
    b) $1.00/m^2 for the total area of land previously disturbed and/or rehabilitated by the development,

    or as otherwise directed by the Secretary.

    Notes:
    - *If the rehabilitation is completed to the satisfaction of the Secretary, the Secretary will release the rehabilitation and conservation bond.*
    - *If the rehabilitation is not completed to the satisfaction of the Secretary, the Secretary will call in all or part of the rehabilitation and conservation bond, and arrange for the satisfactory completion of these works.*

49. Within 3 years of lodging the rehabilitation and conservation bond with the Secretary, and every 4 years thereafter, unless the Secretary directs otherwise, the Applicant must review, and if necessary revise, the sum of the rehabilitation bond to the satisfaction of the Secretary. This review must consider:
    a) the effects of inflation;
    b) any changes to the total area of disturbance; and
    c) the performance of the rehabilitation to date.

LONG TERM MANAGEMENT

Long Term Management Strategy

50. Within 12 months of the date of this consent the Applicant must prepare a Long Term Management Strategy for the site, in consultation with Shellharbour Council, Kiama Council and the CCC, to the satisfaction of the Secretary. The strategy must:
    a) define the objectives and criteria for quarry closure and post-extraction management;
    b) investigate options for the future use of the site;
    c) describe the measures that would be implemented to minimise or manage the ongoing environmental effects of the development; and
    d) describe how the performance of these measures would be monitored over time.

    Note: The Long Term Management Strategy may be prepared as part of the Rehabilitation Management Plan.

51. Within 3 years of providing the Long Term Management Strategy to the Secretary, and every 4 years thereafter, the Applicant must review and update the strategy to the satisfaction of the Secretary.

Long Term Management Trust

52. Within 4 years of the date of this consent the Applicant must establish a trust fund (or other mechanism as agreed by the Secretary), that has available by the end of year 20 a minimum of $300,000 for the long term management of the site, to the satisfaction of the Secretary. Every 4 years following establishment of the trust, the Applicant must review, and if necessary revise, the trust sum to the satisfaction of the Secretary. This review must consider:
    a) the effects of inflation;
    b) any changes to the total area of disturbance; and
    c) the performance of the rehabilitation to date.

TRAFFIC AND TRANSPORT

North Kiama Bypass

53. The Applicant must not undertake any product despatch from the proposal until the completion of the 'Stage 2 – Kiama Bypass' by the RMS.

    Note: 'Stage 2' refers to the north bound traffic carriageway due for completion in late 2005.

Parking

54. The Applicant must provide sufficient parking on-site for all quarry-related traffic, in accordance with Shellharbour Council's parking codes, and to the satisfaction of the Secretary. All vehicular and pedestrian facilities must be in accordance with the RMS's *Guide to Traffic Generating Developments*.

Road Haulage

55. The Applicant must ensure that all loaded vehicles entering or leaving the site are covered.

56. The Applicant must ensure all loaded vehicles leaving the site are cleaned of materials that may fall on the road before they are allowed to leave the site.

Rail Transport

57. The Applicant must maximise the use of rail transport for delivery/despatch outside the Illawarra Region, to the satisfaction of the Secretary. Details of transportation modes and measures to assess and encourage rail transport must be provided in the Annual Review.

VISUAL IMPACT

58. The Applicant must minimise the visual impacts of the development to the satisfaction of the Secretary.

Tree Screens

59. Prior to the commencement of any works, the Applicant must establish and subsequently maintain a tree screen along the eastern boundary (and northeastern and southeastern boundaries), to the satisfaction of the Secretary.

60. Within 2 months of completing construction of the processing area, the Applicant must establish and subsequently maintain a tree screen around the processing area to the satisfaction of the Secretary.

Landscaping Plan

61. The Applicant must establish the tree screens identified in conditions 59 and 60 in accordance with a Landscaping Plan that has been prepared in consultation with Shellharbour Council and Kiama Council, and to the satisfaction of the Secretary. The plan must be prepared by a suitably qualified ecologist/landscape architect and must:
    a) be prepared in accordance with the *Shellharbour Visual Management Plan User Manual*;
    b) comprise a full range of Swamp Oak Floodplain Forest species;
    c) provide for the planting of trees of sufficient maturity that will ensure the prompt screening of the site;
    d) provide for a sufficient planting width and density to ensure that the site will be effectively screened when viewed from the Princes Highway and residential areas.

Lighting Emissions

62. The Applicant must take all practicable measures to prevent and/or minimise any off-site lighting impacts from the development.

63. All external lighting associated with the development must comply with *Australian Standard AS4282 (INT) 1995 – Control of Obtrusive Effects of Outdoor Lighting*.

WASTE MANAGEMENT

Waste Minimisation

64. The Applicant must minimise the amount of waste generated by the development to the satisfaction of the Secretary.

Backfilling Material

65. [12] The Applicant must only use VENM for the purpose of void backfilling.

Note: The definition of VENM may include soil that has been assessed by a certified practicing soil scientist in accordance with the Acid Sulfate Soil Management Advisory Council guidelines and determined to be Potential Acid Sulfate Soil (PASS) and which satisfies all of the requirements for classification as VENM, except that it contains sulfidic soils, that has been approved by EPA for disposal on the site, and that is managed in accordance with the procedures in the Environmental Protection Licence for the development.

[12] Incorporates EPA GTA

66. [13]Backfilling of the voids must be undertaken in a manner, and with material with suitable physical characteristics, so that it does not significantly affect the direction or rate of groundwater flow from the site.

67. [14]All fines separated from the dredged sand must be placed below the permanent water table within 12 hours of processing the dredged sand.

Waste Management Plan

68. [15]Within 12 months of the date of this consent the Applicant must prepare and subsequently implement a Waste Management Plan for the development, in consultation with EPA, and to the satisfaction of the Secretary. The plan must include:
    a) VENM receival and acceptance procedures;
    b) procedures for the management of fines from the processing plant;
    c) procedures for managing potential acid sulfate soils; and
    d) procedures for minimising and managing other wastes generated by the development.

    The Applicant must implement the approved management plan as approved from time to time by the Secretary.

Wastewater Treatment

69. Any on-site wastewater treatment system must comply with the requirements of the *Environment and Health Protection Guidelines – On-site Sewage Management for Single Households* (1998).

EMERGENCY AND HAZARDS MANAGEMENT

Dangerous Goods

70. The Applicant must ensure that the storage, handling, and transport of dangerous goods is conducted in accordance with the relevant Australian Standards, particularly AS1940 and AS1596, and the Dangerous Goods Code.

Safety

71. The Applicant must secure the development to ensure public safety to the satisfaction of the Secretary.

PRODUCTION DATA

72. The Applicant must:
    a) provide annual production data to the DPI using the standard form for that purpose; and
    b) include a copy of this data in the Annual Review.

[13] Incorporates EPA GTA
[14] Incorporates EPA GTA
[15] Incorporates EPA GTA

SCHEDULE 4
ADDITIONAL PROCEDURES

Notification of Landowners

1. As soon as practicable after obtaining monitoring results showing:
   a) an exceedance of any relevant criteria in Schedule 3, the Applicant must notify the affected landowners in writing of the exceedance, and provide regular monitoring results to each affected landowner until the development is again complying with the relevant criteria; and
   b) an exceedance of any relevant air quality criteria in Schedule 3, the Applicant must send a copy of the NSW Health fact sheet entitled "Mine Dust and You" (as may be updated from time to time) to the affected landowners and current tenants of the land (including the tenants of land which is not privately-owned).

Independent Review

2. If an owner of privately-owned land considers the development to be exceeding the relevant criteria in Schedule 3, then he/she may ask the Secretary in writing for an independent review of the impacts of the development on his/her land.

3. If the Secretary is satisfied that an independent review is warranted, then within 2 months of the Secretary's decision the Applicant must:
   a) commission a suitably qualified, experienced and independent person, whose appointment has been approved by the Secretary, to:
      - consult with the landowner to determine his/her concerns;
      - conduct monitoring to determine whether the development is complying with the relevant criteria in Schedule 3; and
      - if the development is not complying with these criteria then identify measures that could be implemented to ensure compliance with the relevant criteria; and
   b) give the Secretary and landowner a copy of the independent review.

SCHEDULE 5
ENVIRONMENTAL MANAGEMENT, REPORTING AND AUDITING

ENVIRONMENTAL MANAGEMENT

Environmental Management Strategy

1. If the Secretary requires, the Applicant must prepare an Environmental Management Strategy for the development to the satisfaction of the Secretary. This strategy must:
   a) be submitted to the Secretary for approval within 6 months of the Secretary requiring preparation of the strategy by notice to the Applicant;
   b) provide the strategic framework for the environmental management of the development;
   c) identify the statutory approvals that apply to the development;
   d) describe the role, responsibility, authority and accountability of all key personnel involved in the environmental management of the development;
   e) describe the procedures that would be implemented to:
      - keep the local community and relevant agencies informed about the operation and environmental performance of the development;
      - receive, handle, respond to, and record complaints;
      - resolve any disputes that may arise during the course of the development;
      - respond to any non-compliance; and
      - respond to emergencies; and
   f) include:
      - copies of any strategies, plans and programs approved under the conditions of this development consent; and
      - a clear plan depicting all the monitoring required to be carried out under the conditions of this consent.

   The Applicant must implement any Environmental Management Strategy as approved from time to time by the Secretary.

Management Plan Requirements

2. The Applicant must ensure that the Management Plans required under this consent are prepared in accordance with any relevant guidelines, and include:
   a) detailed baseline data;
   b) a description of:
      - the relevant statutory requirements (including any relevant approval, licence or lease conditions);
      - any relevant limits or performance measures/criteria; and
      - the specific performance indicators that are proposed to be used to judge the performance of, or guide the implementation of, the development or any management measures;
   c) a description of the measures that would be implemented to comply with the relevant statutory requirements, limits, or performance measures/criteria;
   d) a program to monitor and report on the:
      - impacts and environmental performance of the development; and
      - effectiveness of any management measures (see (c) above);
   e) a contingency plan to manage any unpredicted impacts and their consequences;
   f) a program to investigate and implement ways to improve the environmental performance of the development over time;
   g) a protocol for managing and reporting any:
      - incidents;
      - complaints;
      - non-compliances with statutory requirements; and
      - exceedances of the impact assessment criteria and/or performance criteria; and
   h) a protocol for periodic review of the plan.

   Note: The Secretary may waive some of these requirements if they are unnecessary or unwarranted for particular management plans.

Updating & Staging Submission of Strategies, Plans or Programs

3. To ensure the strategies, plans or programs under this consent are updated on a regular basis, and that they incorporate any appropriate mitigation measures to improve the environmental performance of the development, the Applicant may at any time submit revised strategies, plans or programs to the Secretary for approval. With the agreement of the Secretary, the Applicant may also submit any strategy, plan or program required by this consent on a staged basis.

With the agreement of the Secretary, the Applicant may revise any strategy, plan or program approved under this consent without consulting with all the parties nominated under the applicable conditions of consent.

Notes:

- *While any strategy, plan or program may be submitted on a progressive basis, the Applicant will need to ensure that the existing operations on site are covered by suitable strategies, plans or programs at all times.*
- *If the submission of any strategy, plan or program is to be staged, then the relevant strategy, plan or program must clearly describe the specific stage to which the strategy, plan or program applies, the relationship of this stage to any future stages, and the trigger for updating the strategy, plan or program.*

Revision of Strategies, Plans & Programs

4. Within 3 months of the submission of an:
   a) incident report under condition 7 below;
   b) Annual Review under condition 9 below;
   c) audit report under condition 10 below; and
   d) any modifications to this consent,

   the Applicant must review, and if necessary revise, the strategies, plans, and programs required under this consent, to the satisfaction of the Secretary.

   Note: This is to ensure the strategies, plans and programs are updated on a regular basis, and incorporate any recommended measures to improve the environmental performance of the development.

Adaptive Management

5. The Applicant must assess and manage development-related risks to ensure that there are no exceedances of the criteria and/or performance measures in Schedule 3. Any exceedance of these criteria and/or performance measures constitutes a breach of this consent and may be subject to penalty or offence provisions under the EP&A Act or EP&A Regulation.

   Where any exceedance of these criteria and/or performance measures has occurred, the Applicant must, at the earliest opportunity:
   a) take all reasonable and feasible measures to ensure that the exceedance ceases and does not recur;
   b) consider all reasonable and feasible options for remediation (where relevant) and submit a report to the Department describing those options and any preferred remediation measures or other course of action; and
   c) implement remediation measures as directed by the Secretary,

   to the satisfaction of the Secretary.

COMMUNITY CONSULTATIVE COMMITTEE

6. The Applicant must operate a Community Consultative Committee (CCC) for the development, to the satisfaction of the Secretary. This CCC must be operated in general accordance with the *Guidelines for Establishing and Operating Community Consultative Committees for Mining Projects* (Department of Planning, 2007, or its latest version)

   Notes:

   - *The CCC is an advisory committee. The Department and other relevant agencies are responsible for ensuring that the Applicant complies with this consent.*
   - *In accordance with the guideline, the committee should be comprised of an independent chair and appropriate representation from the Applicant, Council, and the local community.*
   - *The requirement for this CCC may be fulfilled by a regional CCC for any two or more of Boral's quarrying operations in the South Coast area.*

REPORTING

Incident Reporting

7. The Applicant must notify, at the earliest opportunity, the Secretary and any other relevant agencies of any incident that has caused, or threatens to cause, material harm to the environment. For any other incident associated with the development, the Applicant must notify the Secretary and any other relevant agencies as soon as practicable after the Applicant becomes aware of the incident. Within 7 days of the date of the incident, the Applicant must provide the Secretary and any relevant agencies with a detailed report on the incident, and such further reports as may be requested.

Regular Reporting

8. The Applicant must provide regular reporting on the environmental performance of the development on its website, in accordance with the reporting arrangements in any plans or programs approved under the conditions of this consent.

ANNUAL REVIEW

9. By the end of September each year, or other timing as may be agreed by the Secretary, the Applicant must review the environmental performance of the development to the satisfaction of the Secretary. This review must:
   a) describe the development (including rehabilitation) that was carried out in the previous financial year, and the development that is proposed to be carried out over the current financial year;
   b) include a comprehensive review of the monitoring results and complaints records of the development over the previous financial year, which includes a comparison of these results against:
      - the relevant statutory requirements, limits or performance measures/criteria;
      - requirements of any plan or program required under this consent;
      - the monitoring results of previous years; and
      - the relevant predictions in the documents listed in condition 2(a) of Schedule 2;
   c) identify any non-compliance over the last year, and describe what actions were (or are being) taken to ensure compliance;
   d) identify any trends in the monitoring data over the life of the development;
   e) identify any discrepancies between the predicted and actual impacts of the development, and analyse the potential cause of any significant discrepancies; and
   f) describe what measures will be implemented over the current financial year to improve the environmental performance of the development.

   The Applicant must ensure that copies of the Annual Review are submitted to Council and are available to the Community Consultative Committee (see condition 6 of Schedule 5) and any interested person upon request.

INDEPENDENT ENVIRONMENTAL AUDIT

10. By 30 September 2017, and every 3 years thereafter, unless the Secretary directs otherwise, the Applicant must commission and pay the full cost of an Independent Environmental Audit of the development. This audit must:
    a) be conducted by suitably qualified, experienced and independent team of experts whose appointment has been endorsed by the Secretary;
    b) include consultation with the relevant agencies and the CCC;
    c) assess the environmental performance of the development and whether it is complying with the relevant requirements in this consent and any relevant EPL and/or Water Licence (including any assessment, plan or program required under these approvals);
    d) review the adequacy of any approved strategy, plan or program required under the these approvals; and
    e) recommend measures or actions to improve the environmental performance of the development, and/or any assessment, plan or program required under these approvals.

    Note: This audit team must be led by a suitably qualified auditor and include experts in any fields specified by the Secretary.

11. Within 6 weeks of commissioning this audit, or as otherwise agreed by the Secretary, the Applicant must submit a copy of the audit report to the Secretary, Council, EPA and any other NSW agency that requests it, together with its response to any recommendations contained in the audit report.

ACCESS TO INFORMATION

12. By 30 November 2016, unless otherwise agreed by the Secretary, the Applicant must:
    a) make the following information publicly available on its website:
       - the documents listed in condition 2(a) of Schedule 2;
       - current statutory approvals for the development;
       - approved strategies, plans or programs;
       - a summary of the monitoring results of the development, which have been reported in accordance with the various plans and programs approved under the conditions of this consent;
       - a complaints register, which is to be updated on a quarterly basis;
       - the Annual Reviews (over the last 5 years);
       - any independent environmental audit, and the Applicant's response to the recommendations in any audit;
       - any other matter required by the Secretary; and
    b) keep this information up-to-date,

    to the satisfaction of the Secretary.

APPENDIX 1

DEVELOPMENT LAYOUT PLAN

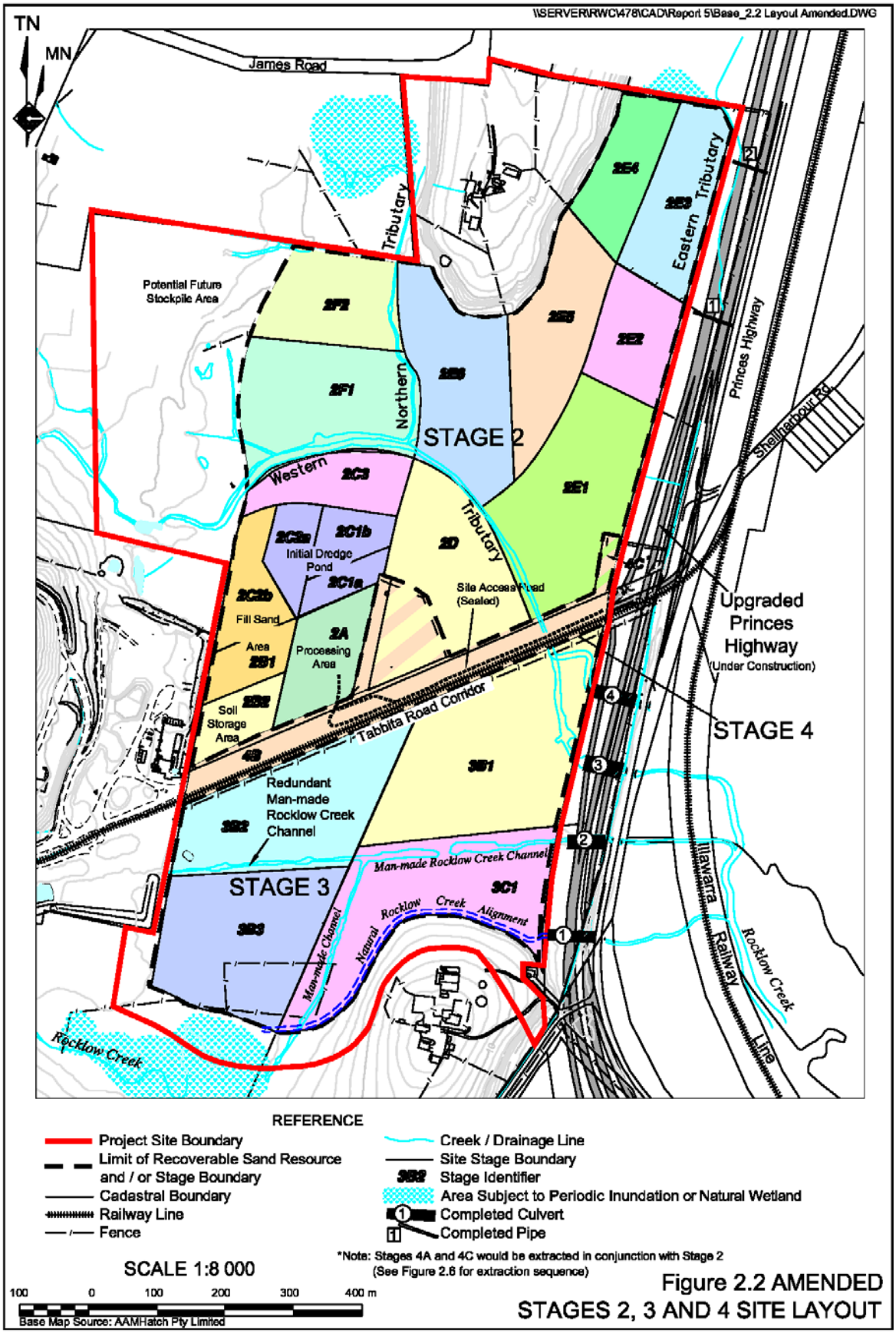


Figure 2.2 AMENDED STAGES 2, 3 AND 4 SITE LAYOUT

APPENDIX 2
CONCEPT FINAL LANDFORM

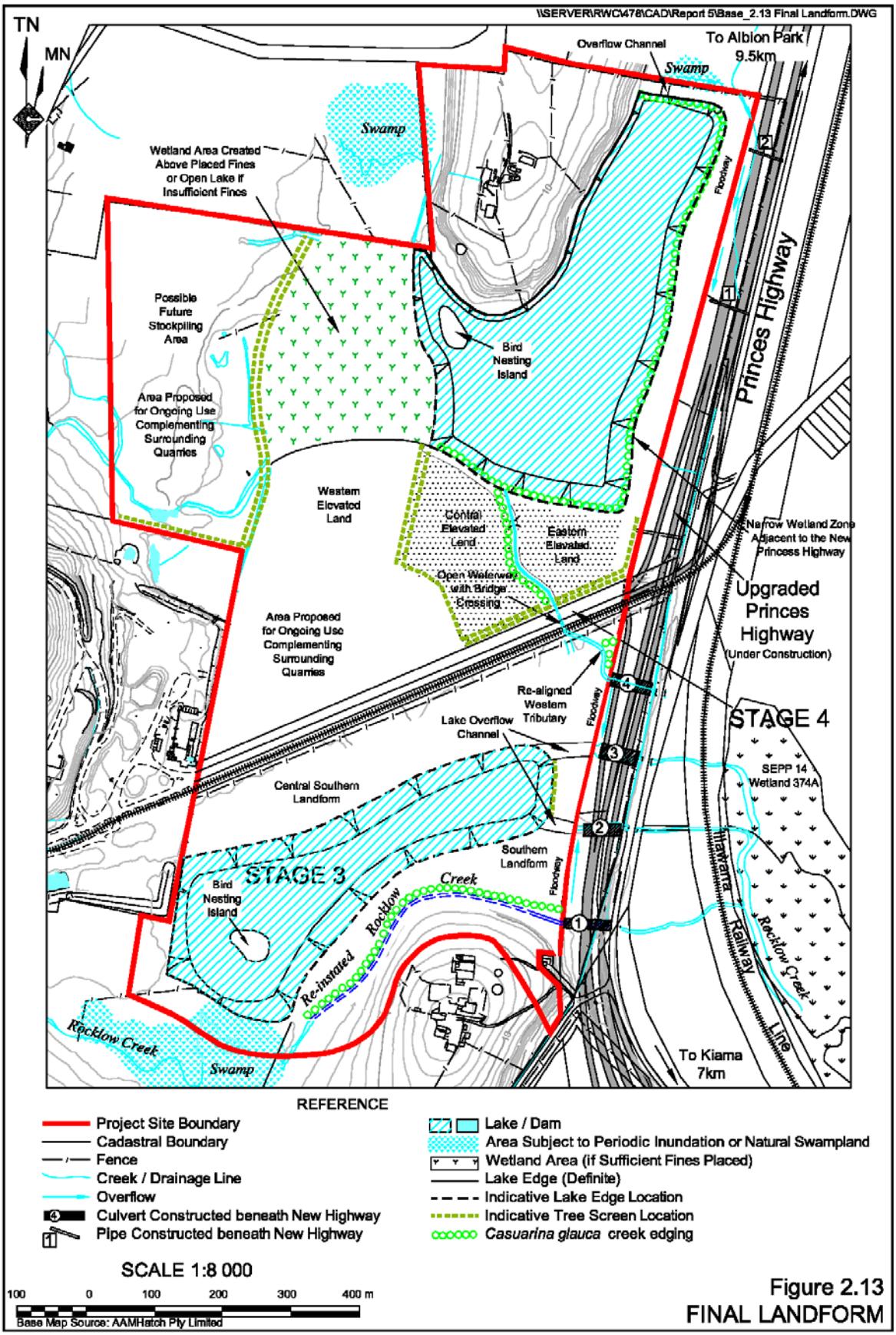


Figure 2.13
FINAL LANDFORM

APPENDIX B

DESKTOP SEARCHES

Australian Government
Department of the Environment and Energy

EPBC Act Protected Matters Report

This report provides general guidance on matters of national environmental significance and other matters protected by the EPBC Act in the area you have selected.

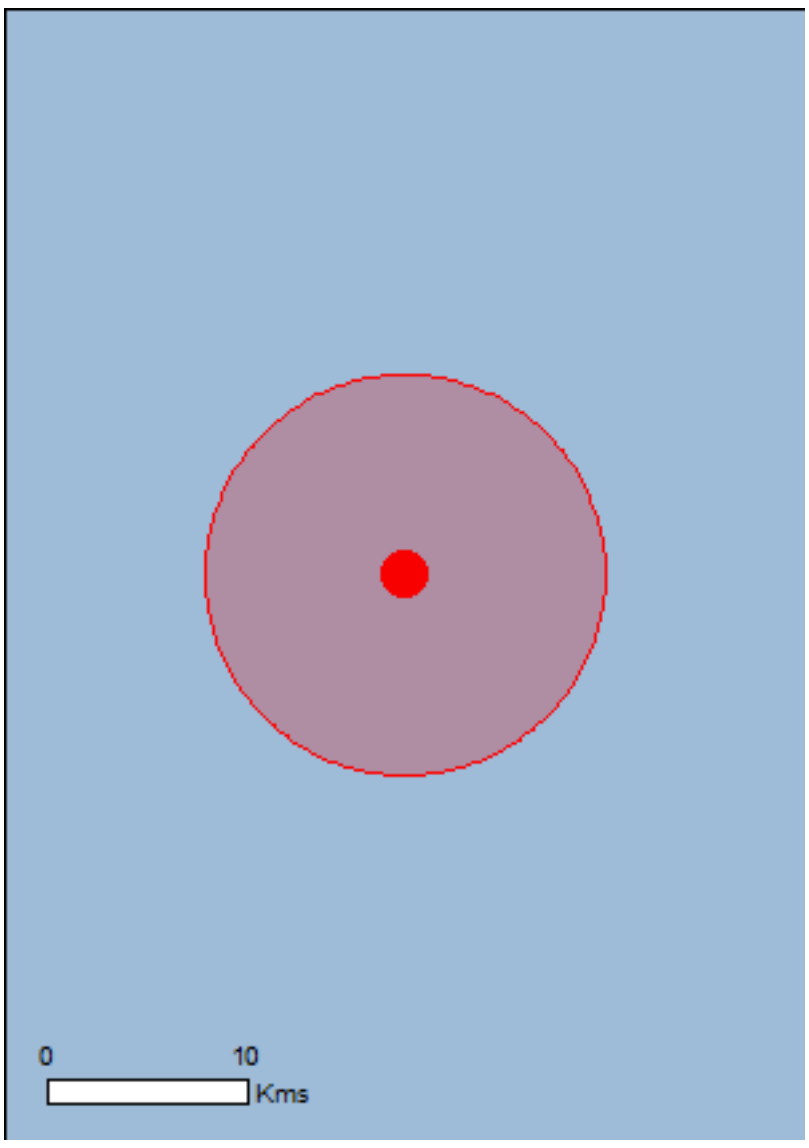
Information on the coverage of this report and qualifications on data supporting this report are contained in the caveat at the end of the report.

Information is available about Environment Assessments and the EPBC Act including significance guidelines, forms and application process details.

Report created: 12/12/18 13:02:50

Summary
Details
- Matters of NES
- Other Matters Protected by the EPBC Act
- Extra Information

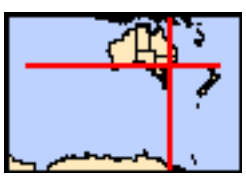
Caveat
Acknowledgements



This map may contain data which are ©Commonwealth of Australia (Geoscience Australia), ©PSMA 2010

Coordinates

Buffer: 10.0Km



Summary

Matters of National Environmental Significance

This part of the report summarises the matters of national environmental significance that may occur in, or may relate to, the area you nominated. Further information is available in the detail part of the report, which can be accessed by scrolling or following the links below. If you are proposing to undertake an activity that may have a significant impact on one or more matters of national environmental significance then you should consider the Administrative Guidelines on Significance.

World Heritage Properties:	None
National Heritage Places:	None
Wetlands of International Importance:	None
Great Barrier Reef Marine Park:	None
Commonwealth Marine Area:	1
Listed Threatened Ecological Communities:	4
Listed Threatened Species:	79
Listed Migratory Species:	70

Other Matters Protected by the EPBC Act

This part of the report summarises other matters protected under the Act that may relate to the area you nominated. Approval may be required for a proposed activity that significantly affects the environment on Commonwealth land, when the action is outside the Commonwealth land, or the environment anywhere when the action is taken on Commonwealth land. Approval may also be required for the Commonwealth or Commonwealth agencies proposing to take an action that is likely to have a significant impact on the environment anywhere.

The EPBC Act protects the environment on Commonwealth land, the environment from the actions taken on Commonwealth land, and the environment from actions taken by Commonwealth agencies. As heritage values of a place are part of the 'environment', these aspects of the EPBC Act protect the Commonwealth Heritage values of a Commonwealth Heritage place. Information on the new heritage laws can be found at http://www.environment.gov.au/heritage

A permit may be required for activities in or on a Commonwealth area that may affect a member of a listed threatened species or ecological community, a member of a listed migratory species, whales and other cetaceans, or a member of a listed marine species.

Commonwealth Land:	7
Commonwealth Heritage Places:	1
Listed Marine Species:	96
Whales and Other Cetaceans:	14
Critical Habitats:	None
Commonwealth Reserves Terrestrial:	None
Australian Marine Parks:	None

Extra Information

This part of the report provides information that may also be relevant to the area you have nominated.

State and Territory Reserves:	None
Regional Forest Agreements:	1
Invasive Species:	50
Nationally Important Wetlands:	3
Key Ecological Features (Marine)	None

Details

Matters of National Environmental Significance

Commonwealth Marine Area [Resource Information]

Approval is required for a proposed activity that is located within the Commonwealth Marine Area which has, will have, or is likely to have a significant impact on the environment. Approval may be required for a proposed action taken outside the Commonwealth Marine Area but which has, may have or is likely to have a significant impact on the environment in the Commonwealth Marine Area. Generally the Commonwealth Marine Area stretches from three nautical miles to two hundred nautical miles from the coast.

Name
EEZ and Territorial Sea

Marine Regions [Resource Information]

If you are planning to undertake action in an area in or close to the Commonwealth Marine Area, and a marine bioregional plan has been prepared for the Commonwealth Marine Area in that area, the marine bioregional plan may inform your decision as to whether to refer your proposed action under the EPBC Act.

Name
Temperate East

Listed Threatened Ecological Communities [Resource Information]

For threatened ecological communities where the distribution is well known, maps are derived from recovery plans, State vegetation maps, remote sensing imagery and other sources. Where threatened ecological community distributions are less well known, existing vegetation maps and point location data are used to produce indicative distribution maps.

Name	Status	Type of Presence
Coastal Swamp Oak (Casuarina glauca) Forest of New South Wales and South East Queensland ecological community	Endangered	Community likely to occur within area
Illawarra and south coast lowland forest and woodland ecological community	Critically Endangered	Community likely to occur within area
Littoral Rainforest and Coastal Vine Thickets of Eastern Australia	Critically Endangered	Community likely to occur within area
Subtropical and Temperate Coastal Saltmarsh	Vulnerable	Community likely to occur within area

Listed Threatened Species [Resource Information]

Name	Status	Type of Presence
Birds		
Anthochaera phrygia Regent Honeyeater [82338]	Critically Endangered	Species or species habitat known to occur within area
Botaurus poiciloptilus Australasian Bittern [1001]	Endangered	Species or species habitat known to occur within area
Calidris canutus Red Knot, Knot [855]	Endangered	Species or species habitat known to occur within area
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat known to occur within area
Calidris tenuirostris Great Knot [862]	Critically Endangered	Roosting known to occur within area
Charadrius leschenaultii Greater Sand Plover, Large Sand Plover [877]	Vulnerable	Roosting known to occur

Name	Status	Type of Presence
		within area
Charadrius mongolus Lesser Sand Plover, Mongolian Plover [879]	Endangered	Roosting known to occur within area
Dasyornis brachypterus Eastern Bristlebird [533]	Endangered	Species or species habitat likely to occur within area
Diomedea antipodensis Antipodean Albatross [64458]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Diomedea antipodensis gibsoni Gibson's Albatross [82270]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Diomedea epomophora Southern Royal Albatross [89221]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Diomedea exulans Wandering Albatross [89223]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Diomedea sanfordi Northern Royal Albatross [64456]	Endangered	Foraging, feeding or related behaviour likely to occur within area
Fregetta grallaria grallaria White-bellied Storm-Petrel (Tasman Sea), White-bellied Storm-Petrel (Australasian) [64438]	Vulnerable	Species or species habitat likely to occur within area
Lathamus discolor Swift Parrot [744]	Critically Endangered	Species or species habitat likely to occur within area
Limosa lapponica baueri Bar-tailed Godwit (baueri), Western Alaskan Bar-tailed Godwit [86380]	Vulnerable	Species or species habitat known to occur within area
Limosa lapponica menzbieri Northern Siberian Bar-tailed Godwit, Bar-tailed Godwit (menzbieri) [86432]	Critically Endangered	Species or species habitat may occur within area
Macronectes giganteus Southern Giant-Petrel, Southern Giant Petrel [1060]	Endangered	Species or species habitat may occur within area
Macronectes halli Northern Giant Petrel [1061]	Vulnerable	Species or species habitat may occur within area
Neophema chrysogaster Orange-bellied Parrot [747]	Critically Endangered	Species or species habitat may occur within area
Numenius madagascariensis Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat known to occur within area
Pachyptila turtur subantarctica Fairy Prion (southern) [64445]	Vulnerable	Species or species habitat known to occur within area
Phoebetria fusca Sooty Albatross [1075]	Vulnerable	Species or species habitat may occur within area
Pterodroma leucoptera leucoptera Gould's Petrel, Australian Gould's Petrel [26033]	Endangered	Species or species habitat may occur within area

Name	Status	Type of Presence
Pterodroma neglecta neglecta		
Kermadec Petrel (western) [64450]	Vulnerable	Foraging, feeding or related behaviour may occur within area
Rostratula australis		
Australian Painted-snipe, Australian Painted Snipe [77037]	Endangered	Species or species habitat likely to occur within area
Sternula nereis nereis		
Australian Fairy Tern [82950]	Vulnerable	Breeding likely to occur within area
Thalassarche bulleri		
Buller's Albatross, Pacific Albatross [64460]	Vulnerable	Species or species habitat may occur within area
Thalassarche bulleri platei		
Northern Buller's Albatross, Pacific Albatross [82273]	Vulnerable	Species or species habitat may occur within area
Thalassarche cauta cauta		
Shy Albatross, Tasmanian Shy Albatross [82345]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Thalassarche cauta steadi		
White-capped Albatross [82344]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Thalassarche eremita		
Chatham Albatross [64457]	Endangered	Foraging, feeding or related behaviour likely to occur within area
Thalassarche impavida		
Campbell Albatross, Campbell Black-browed Albatross [64459]	Vulnerable	Species or species habitat may occur within area
Thalassarche melanophris		
Black-browed Albatross [66472]	Vulnerable	Species or species habitat may occur within area
Thalassarche salvini		
Salvin's Albatross [64463]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Fish		
Epinephelus daemelii		
Black Rockcod, Black Cod, Saddled Rockcod [68449]	Vulnerable	Species or species habitat likely to occur within area
Macquaria australasica		
Macquarie Perch [66632]	Endangered	Species or species habitat may occur within area
Prototroctes maraena		
Australian Grayling [26179]	Vulnerable	Species or species habitat likely to occur within area
Frogs		
Heleioporus australiacus		
Giant Burrowing Frog [1973]	Vulnerable	Species or species habitat likely to occur within area
Litoria aurea		
Green and Golden Bell Frog [1870]	Vulnerable	Species or species habitat known to occur within area
Litoria littlejohni		
Littlejohn's Tree Frog, Heath Frog [64733]	Vulnerable	Species or species habitat likely to occur within area
Mammals		
Balaenoptera borealis		
Sei Whale [34]	Vulnerable	Foraging, feeding or related behaviour likely

Name	Status	Type of Presence
		to occur within area
Balaenoptera musculus Blue Whale [36]	Endangered	Species or species habitat may occur within area
Balaenoptera physalus Fin Whale [37]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Chalinolobus dwyeri Large-eared Pied Bat, Large Pied Bat [183]	Vulnerable	Species or species habitat likely to occur within area
Dasyurus maculatus maculatus (SE mainland population) Spot-tailed Quoll, Spotted-tail Quoll, Tiger Quoll (southeastern mainland population) [75184]	Endangered	Species or species habitat known to occur within area
Eubalaena australis Southern Right Whale [40]	Endangered	Species or species habitat known to occur within area
Isoodon obesulus obesulus Southern Brown Bandicoot (eastern), Southern Brown Bandicoot (south-eastern) [68050]	Endangered	Species or species habitat likely to occur within area
Megaptera novaeangliae Humpback Whale [38]	Vulnerable	Species or species habitat known to occur within area
Petauroides volans Greater Glider [254]	Vulnerable	Species or species habitat likely to occur within area
Phascolarctos cinereus (combined populations of Qld, NSW and the ACT) Koala (combined populations of Queensland, New South Wales and the Australian Capital Territory) [85104]	Vulnerable	Species or species habitat likely to occur within area
Potorous tridactylus tridactylus Long-nosed Potoroo (SE mainland) [66645]	Vulnerable	Species or species habitat likely to occur within area
Pseudomys novaehollandiae New Holland Mouse, Pookila [96]	Vulnerable	Species or species habitat likely to occur within area
Pteropus poliocephalus Grey-headed Flying-fox [186]	Vulnerable	Roosting known to occur within area
Plants		
Acacia bynoeana Bynoe's Wattle, Tiny Wattle [8575]	Vulnerable	Species or species habitat may occur within area
Caladenia tessellata Thick-lipped Spider-orchid, Daddy Long-legs [2119]	Vulnerable	Species or species habitat likely to occur within area
Cryptostylis hunteriana Leafless Tongue-orchid [19533]	Vulnerable	Species or species habitat likely to occur within area
Cynanchum elegans White-flowered Wax Plant [12533]	Endangered	Species or species habitat known to occur within area
Daphnandra johnsonii Illawarra Socketwood [67186]	Endangered	Species or species habitat likely to occur within area
Genoplesium baueri Yellow Gnat-orchid [7528]	Endangered	Species or species habitat likely to occur within area

Name	Status	Type of Presence
Haloragis exalata subsp. exalata Wingless Raspwort, Square Raspwort [24636]	Vulnerable	Species or species habitat known to occur within area
Irenepharsus trypherus Delicate Cress, Illawarra Irene [14664]	Endangered	Species or species habitat known to occur within area
Melaleuca biconvexa Biconvex Paperbark [5583]	Vulnerable	Species or species habitat may occur within area
Persoonia hirsuta Hairy Geebung, Hairy Persoonia [19006]	Endangered	Species or species habitat may occur within area
Pimelea spicata Spiked Rice-flower [20834]	Endangered	Species or species habitat known to occur within area
Prasophyllum affine Jervis Bay Leek Orchid, Culburra Leek-orchid, Kinghorn Point Leek-orchid [2210]	Endangered	Species or species habitat likely to occur within area
Pterostylis gibbosa Illawarra Greenhood, Rufa Greenhood, Pouched Greenhood [4562]	Endangered	Species or species habitat known to occur within area
Syzygium paniculatum Magenta Lilly Pilly, Magenta Cherry, Daguba, Scrub Cherry, Creek Lilly Pilly, Brush Cherry [20307]	Vulnerable	Species or species habitat likely to occur within area
Thesium australe Austral Toadflax, Toadflax [15202]	Vulnerable	Species or species habitat likely to occur within area
Zieria granulata Hill Zieria, Hilly Zieria, Illawarra Zieria [17147]	Endangered	Species or species habitat likely to occur within area
Reptiles		
Caretta caretta Loggerhead Turtle [1763]	Endangered	Breeding likely to occur within area
Chelonia mydas Green Turtle [1765]	Vulnerable	Foraging, feeding or related behaviour known to occur within area
Dermochelys coriacea Leatherback Turtle, Leathery Turtle, Luth [1768]	Endangered	Species or species habitat known to occur within area
Eretmochelys imbricata Hawksbill Turtle [1766]	Vulnerable	Species or species habitat known to occur within area
Hoplocephalus bungaroides Broad-headed Snake [1182]	Vulnerable	Species or species habitat likely to occur within area
Natator depressus Flatback Turtle [59257]	Vulnerable	Foraging, feeding or related behaviour known to occur within area
Sharks		
Carcharias taurus (east coast population) Grey Nurse Shark (east coast population) [68751]	Critically Endangered	Species or species habitat known to occur within area
Carcharodon carcharias White Shark, Great White Shark [64470]	Vulnerable	Species or species habitat known to occur within area

Name	Status	Type of Presence
[Rhincodon typus](#) Whale Shark [66680]	Vulnerable	Species or species habitat may occur within area

Listed Migratory Species [Resource Information]

* Species is listed under a different scientific name on the EPBC Act - Threatened Species list.

Name	Threatened	Type of Presence
Migratory Marine Birds		
[Anous stolidus](#) Common Noddy [825]		Species or species habitat may occur within area
[Apus pacificus](#) Fork-tailed Swift [678]		Species or species habitat likely to occur within area
[Ardenna carneipes](#) Flesh-footed Shearwater, Fleshy-footed Shearwater [82404]		Species or species habitat likely to occur within area
[Ardenna pacifica](#) Wedge-tailed Shearwater [84292]		Breeding known to occur within area
[Calonectris leucomelas](#) Streaked Shearwater [1077]		Species or species habitat known to occur within area
[Diomedea antipodensis](#) Antipodean Albatross [64458]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
[Diomedea epomophora](#) Southern Royal Albatross [89221]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
[Diomedea exulans](#) Wandering Albatross [89223]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
[Diomedea sanfordi](#) Northern Royal Albatross [64456]	Endangered	Foraging, feeding or related behaviour likely to occur within area
[Fregata ariel](#) Lesser Frigatebird, Least Frigatebird [1012]		Species or species habitat likely to occur within area
[Macronectes giganteus](#) Southern Giant-Petrel, Southern Giant Petrel [1060]	Endangered	Species or species habitat may occur within area
[Macronectes halli](#) Northern Giant Petrel [1061]	Vulnerable	Species or species habitat may occur within area
[Phoebetria fusca](#) Sooty Albatross [1075]	Vulnerable	Species or species habitat may occur within area
[Sternula albifrons](#) Little Tern [82849]		Breeding known to occur within area
[Thalassarche bulleri](#) Buller's Albatross, Pacific Albatross [64460]	Vulnerable	Species or species habitat may occur within area
[Thalassarche cauta](#) Tasmanian Shy Albatross [89224]	Vulnerable*	Foraging, feeding or related behaviour likely to occur within area

Name	Threatened	Type of Presence
Thalassarche eremita		
Chatham Albatross [64457]	Endangered	Foraging, feeding or related behaviour likely to occur within area
Thalassarche impavida		
Campbell Albatross, Campbell Black-browed Albatross [64459]	Vulnerable	Species or species habitat may occur within area
Thalassarche melanophris		
Black-browed Albatross [66472]	Vulnerable	Species or species habitat may occur within area
Thalassarche salvini		
Salvin's Albatross [64463]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Thalassarche steadi		
White-capped Albatross [64462]	Vulnerable*	Foraging, feeding or related behaviour likely to occur within area
Migratory Marine Species		
Balaena glacialis australis		
Southern Right Whale [75529]	Endangered*	Species or species habitat known to occur within area
Balaenoptera borealis		
Sei Whale [34]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Balaenoptera edeni		
Bryde's Whale [35]		Species or species habitat may occur within area
Balaenoptera musculus		
Blue Whale [36]	Endangered	Species or species habitat may occur within area
Balaenoptera physalus		
Fin Whale [37]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Caperea marginata		
Pygmy Right Whale [39]		Foraging, feeding or related behaviour may occur within area
Carcharodon carcharias		
White Shark, Great White Shark [64470]	Vulnerable	Species or species habitat known to occur within area
Caretta caretta		
Loggerhead Turtle [1763]	Endangered	Breeding likely to occur within area
Chelonia mydas		
Green Turtle [1765]	Vulnerable	Foraging, feeding or related behaviour known to occur within area
Dermochelys coriacea		
Leatherback Turtle, Leathery Turtle, Luth [1768]	Endangered	Species or species habitat known to occur within area
Eretmochelys imbricata		
Hawksbill Turtle [1766]	Vulnerable	Species or species habitat known to occur within area
Lagenorhynchus obscurus		
Dusky Dolphin [43]		Species or species habitat may occur within area
Lamna nasus		
Porbeagle, Mackerel Shark [83288]		Species or species habitat likely to occur within area

Name	Threatened	Type of Presence
Manta birostris Giant Manta Ray, Chevron Manta Ray, Pacific Manta Ray, Pelagic Manta Ray, Oceanic Manta Ray [84995]		Species or species habitat may occur within area
Megaptera novaeangliae Humpback Whale [38]	Vulnerable	Species or species habitat known to occur within area
Natator depressus Flatback Turtle [59257]	Vulnerable	Foraging, feeding or related behaviour known to occur within area
Orcinus orca Killer Whale, Orca [46]		Species or species habitat likely to occur within area
Rhincodon typus Whale Shark [66680]	Vulnerable	Species or species habitat may occur within area
Migratory Terrestrial Species		
Cuculus optatus Oriental Cuckoo, Horsfield's Cuckoo [86651]		Species or species habitat may occur within area
Hirundapus caudacutus White-throated Needletail [682]		Species or species habitat known to occur within area
Monarcha melanopsis Black-faced Monarch [609]		Species or species habitat known to occur within area
Monarcha trivirgatus Spectacled Monarch [610]		Species or species habitat known to occur within area
Myiagra cyanoleuca Satin Flycatcher [612]		Species or species habitat known to occur within area
Rhipidura rufifrons Rufous Fantail [592]		Species or species habitat known to occur within area
Migratory Wetlands Species		
Actitis hypoleucos Common Sandpiper [59309]		Species or species habitat known to occur within area
Arenaria interpres Ruddy Turnstone [872]		Roosting known to occur within area
Calidris acuminata Sharp-tailed Sandpiper [874]		Roosting known to occur within area
Calidris alba Sanderling [875]		Roosting known to occur within area
Calidris canutus Red Knot, Knot [855]	Endangered	Species or species habitat known to occur within area
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat known to occur within area
Calidris melanotos Pectoral Sandpiper [858]		Species or species habitat known to occur within area
Calidris ruficollis Red-necked Stint [860]		Roosting known to occur

Name	Threatened	Type of Presence
		within area
Calidris tenuirostris Great Knot [862]	Critically Endangered	Roosting known to occur within area
Charadrius bicinctus Double-banded Plover [895]		Roosting known to occur within area
Charadrius leschenaultii Greater Sand Plover, Large Sand Plover [877]	Vulnerable	Roosting known to occur within area
Charadrius mongolus Lesser Sand Plover, Mongolian Plover [879]	Endangered	Roosting known to occur within area
Gallinago hardwickii Latham's Snipe, Japanese Snipe [863]		Roosting may occur within area
Gallinago megala Swinhoe's Snipe [864]		Roosting likely to occur within area
Gallinago stenura Pin-tailed Snipe [841]		Roosting likely to occur within area
Limosa lapponica Bar-tailed Godwit [844]		Species or species habitat known to occur within area
Limosa limosa Black-tailed Godwit [845]		Roosting known to occur within area
Numenius madagascariensis Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat known to occur within area
Numenius minutus Little Curlew, Little Whimbrel [848]		Roosting likely to occur within area
Numenius phaeopus Whimbrel [849]		Roosting known to occur within area
Pandion haliaetus Osprey [952]		Species or species habitat known to occur within area
Pluvialis fulva Pacific Golden Plover [25545]		Roosting known to occur within area
Tringa brevipes Grey-tailed Tattler [851]		Roosting known to occur within area
Tringa nebularia Common Greenshank, Greenshank [832]		Species or species habitat known to occur within area
Tringa stagnatilis Marsh Sandpiper, Little Greenshank [833]		Roosting known to occur within area

Other Matters Protected by the EPBC Act

Commonwealth Land [Resource Information]

The Commonwealth area listed below may indicate the presence of Commonwealth land in this vicinity. Due to the unreliability of the data source, all proposals should be checked as to whether it impacts on a Commonwealth area, before making a definitive decision. Contact the State or Territory government land department for further information.

Name
Commonwealth Land - Australian Academy of Science
Commonwealth Land - Australian Postal Commission
Commonwealth Land - Australian Telecommunications Commission
Commonwealth Land - Commonwealth Trading Bank of Australia
Commonwealth Land - Defence Service Homes Corporation
Commonwealth Land - Director of War Service Homes
Commonwealth Land - Telstra Corporation Limited

Commonwealth Heritage Places [Resource Information]

Name	State	Status
Historic		
Kiama Post Office	NSW	Listed place

Listed Marine Species [Resource Information]

* Species is listed under a different scientific name on the EPBC Act - Threatened Species list.

Name	Threatened	Type of Presence
Birds		
Actitis hypoleucos Common Sandpiper [59309]		Species or species habitat known to occur within area
Anous stolidus Common Noddy [825]		Species or species habitat may occur within area
Apus pacificus Fork-tailed Swift [678]		Species or species habitat likely to occur within area
Ardea alba Great Egret, White Egret [59541]		Species or species habitat known to occur within area
Ardea ibis Cattle Egret [59542]		Species or species habitat may occur within area
Arenaria interpres Ruddy Turnstone [872]		Roosting known to occur within area
Calidris acuminata Sharp-tailed Sandpiper [874]		Roosting known to occur within area
Calidris alba Sanderling [875]		Roosting known to occur within area
Calidris canutus Red Knot, Knot [855]	Endangered	Species or species habitat known to occur within area
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat known to occur within area
Calidris melanotos Pectoral Sandpiper [858]		Species or species habitat known to occur within area
Calidris ruficollis Red-necked Stint [860]		Roosting known to occur within area
Calidris tenuirostris Great Knot [862]	Critically Endangered	Roosting known to occur

Name	Threatened	Type of Presence
		within area
Calonectris leucomelas Streaked Shearwater [1077]		Species or species habitat known to occur within area
Catharacta skua Great Skua [59472]		Species or species habitat may occur within area
Charadrius bicinctus Double-banded Plover [895]		Roosting known to occur within area
Charadrius leschenaultii Greater Sand Plover, Large Sand Plover [877]	Vulnerable	Roosting known to occur within area
Charadrius mongolus Lesser Sand Plover, Mongolian Plover [879]	Endangered	Roosting known to occur within area
Charadrius ruficapillus Red-capped Plover [881]		Roosting known to occur within area
Diomedea antipodensis Antipodean Albatross [64458]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Diomedea epomophora Southern Royal Albatross [89221]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Diomedea exulans Wandering Albatross [89223]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Diomedea gibsoni Gibson's Albatross [64466]	Vulnerable*	Foraging, feeding or related behaviour likely to occur within area
Diomedea sanfordi Northern Royal Albatross [64456]	Endangered	Foraging, feeding or related behaviour likely to occur within area
Fregata ariel Lesser Frigatebird, Least Frigatebird [1012]		Species or species habitat likely to occur within area
Gallinago hardwickii Latham's Snipe, Japanese Snipe [863]		Roosting may occur within area
Gallinago megala Swinhoe's Snipe [864]		Roosting likely to occur within area
Gallinago stenura Pin-tailed Snipe [841]		Roosting likely to occur within area
Haliaeetus leucogaster White-bellied Sea-Eagle [943]		Species or species habitat known to occur within area
Heteroscelus brevipes Grey-tailed Tattler [59311]		Roosting known to occur within area
Himantopus himantopus Pied Stilt, Black-winged Stilt [870]		Roosting known to occur within area
Hirundapus caudacutus White-throated Needletail [682]		Species or species habitat known to occur within area
Lathamus discolor Swift Parrot [744]	Critically Endangered	Species or species habitat likely to occur within area

Name	Threatened	Type of Presence
Limosa lapponica Bar-tailed Godwit [844]		Species or species habitat known to occur within area
Limosa limosa Black-tailed Godwit [845]		Roosting known to occur within area
Macronectes giganteus Southern Giant-Petrel, Southern Giant Petrel [1060]	Endangered	Species or species habitat may occur within area
Macronectes halli Northern Giant Petrel [1061]	Vulnerable	Species or species habitat may occur within area
Merops ornatus Rainbow Bee-eater [670]		Species or species habitat may occur within area
Monarcha melanopsis Black-faced Monarch [609]		Species or species habitat known to occur within area
Monarcha trivirgatus Spectacled Monarch [610]		Species or species habitat known to occur within area
Myiagra cyanoleuca Satin Flycatcher [612]		Species or species habitat known to occur within area
Neophema chrysogaster Orange-bellied Parrot [747]	Critically Endangered	Species or species habitat may occur within area
Numenius madagascariensis Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat known to occur within area
Numenius minutus Little Curlew, Little Whimbrel [848]		Roosting likely to occur within area
Numenius phaeopus Whimbrel [849]		Roosting known to occur within area
Pachyptila turtur Fairy Prion [1066]		Species or species habitat known to occur within area
Pandion haliaetus Osprey [952]		Species or species habitat known to occur within area
Phoebetria fusca Sooty Albatross [1075]	Vulnerable	Species or species habitat may occur within area
Pluvialis fulva Pacific Golden Plover [25545]		Roosting known to occur within area
Puffinus carneipes Flesh-footed Shearwater, Fleshy-footed Shearwater [1043]		Species or species habitat likely to occur within area
Puffinus pacificus Wedge-tailed Shearwater [1027]		Breeding known to occur within area
Rhipidura rufifrons Rufous Fantail [592]		Species or species habitat known to occur within area
Rostratula benghalensis (sensu lato) Painted Snipe [889]	Endangered*	Species or species

Name	Threatened	Type of Presence
		habitat likely to occur within area
[Sterna albifrons](#) Little Tern [813]		Breeding known to occur within area
[Thalassarche bulleri](#) Buller's Albatross, Pacific Albatross [64460]	Vulnerable	Species or species habitat may occur within area
[Thalassarche cauta](#) Tasmanian Shy Albatross [89224]	Vulnerable*	Foraging, feeding or related behaviour likely to occur within area
[Thalassarche eremita](#) Chatham Albatross [64457]	Endangered	Foraging, feeding or related behaviour likely to occur within area
[Thalassarche impavida](#) Campbell Albatross, Campbell Black-browed Albatross [64459]	Vulnerable	Species or species habitat may occur within area
[Thalassarche melanophris](#) Black-browed Albatross [66472]	Vulnerable	Species or species habitat may occur within area
[Thalassarche salvini](#) Salvin's Albatross [64463]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
[Thalassarche sp. nov.](#) Pacific Albatross [66511]	Vulnerable*	Species or species habitat may occur within area
[Thalassarche steadi](#) White-capped Albatross [64462]	Vulnerable*	Foraging, feeding or related behaviour likely to occur within area
[Tringa nebularia](#) Common Greenshank, Greenshank [832]		Species or species habitat known to occur within area
[Tringa stagnatilis](#) Marsh Sandpiper, Little Greenshank [833]		Roosting known to occur within area
Fish		
[Acentronura tentaculata](#) Shortpouch Pygmy Pipehorse [66187]		Species or species habitat may occur within area
[Cosmocampus howensis](#) Lord Howe Pipefish [66208]		Species or species habitat may occur within area
[Festucalex cinctus](#) Girdled Pipefish [66214]		Species or species habitat may occur within area
[Filicampus tigris](#) Tiger Pipefish [66217]		Species or species habitat may occur within area
[Heraldia nocturna](#) Upside-down Pipefish, Eastern Upside-down Pipefish, Eastern Upside-down Pipefish [66227]		Species or species habitat may occur within area
[Hippichthys penicillus](#) Beady Pipefish, Steep-nosed Pipefish [66231]		Species or species habitat may occur within area
[Hippocampus abdominalis](#) Big-belly Seahorse, Eastern Potbelly Seahorse, New Zealand Potbelly Seahorse [66233]		Species or species habitat may occur within area

Name	Threatened	Type of Presence
Hippocampus breviceps Short-head Seahorse, Short-snouted Seahorse [66235]		Species or species habitat may occur within area
Hippocampus whitei White's Seahorse, Crowned Seahorse, Sydney Seahorse [66240]		Species or species habitat likely to occur within area
Histiogamphelus briggsii Crested Pipefish, Briggs' Crested Pipefish, Briggs' Pipefish [66242]		Species or species habitat may occur within area
Kimblaeus bassensis Trawl Pipefish, Bass Strait Pipefish [66247]		Species or species habitat may occur within area
Lissocampus runa Javelin Pipefish [66251]		Species or species habitat may occur within area
Maroubra perserrata Sawtooth Pipefish [66252]		Species or species habitat may occur within area
Notiocampus ruber Red Pipefish [66265]		Species or species habitat may occur within area
Phyllopteryx taeniolatus Common Seadragon, Weedy Seadragon [66268]		Species or species habitat may occur within area
Solegnathus spinosissimus Spiny Pipehorse, Australian Spiny Pipehorse [66275]		Species or species habitat may occur within area
Solenostomus cyanopterus Robust Ghostpipefish, Blue-finned Ghost Pipefish, [66183]		Species or species habitat may occur within area
Solenostomus paradoxus Ornate Ghostpipefish, Harlequin Ghost Pipefish, Ornate Ghost Pipefish [66184]		Species or species habitat may occur within area
Stigmatopora argus Spotted Pipefish, Gulf Pipefish, Peacock Pipefish [66276]		Species or species habitat may occur within area
Stigmatopora nigra Widebody Pipefish, Wide-bodied Pipefish, Black Pipefish [66277]		Species or species habitat may occur within area
Syngnathoides biaculeatus Double-end Pipehorse, Double-ended Pipehorse, Alligator Pipefish [66279]		Species or species habitat may occur within area
Trachyrhamphus bicoarctatus Bentstick Pipefish, Bend Stick Pipefish, Short-tailed Pipefish [66280]		Species or species habitat may occur within area
Urocampus carinirostris Hairy Pipefish [66282]		Species or species habitat may occur within area
Vanacampus margaritifer Mother-of-pearl Pipefish [66283]		Species or species habitat may occur within area
Vanacampus phillipi Port Phillip Pipefish [66284]		Species or species habitat may occur within area
Mammals		

Name	Threatened	Type of Presence
[Arctocephalus forsteri](#) Long-nosed Fur-seal, New Zealand Fur-seal [20]		Species or species habitat may occur within area
[Arctocephalus pusillus](#) Australian Fur-seal, Australo-African Fur-seal [21]		Species or species habitat may occur within area
Reptiles		
[Caretta caretta](#) Loggerhead Turtle [1763]	Endangered	Breeding likely to occur within area
[Chelonia mydas](#) Green Turtle [1765]	Vulnerable	Foraging, feeding or related behaviour known to occur within area
[Dermochelys coriacea](#) Leatherback Turtle, Leathery Turtle, Luth [1768]	Endangered	Species or species habitat known to occur within area
[Eretmochelys imbricata](#) Hawksbill Turtle [1766]	Vulnerable	Species or species habitat known to occur within area
[Natator depressus](#) Flatback Turtle [59257]	Vulnerable	Foraging, feeding or related behaviour known to occur within area

Whales and other Cetaceans [Resource Information]

Name	Status	Type of Presence
Mammals		
[Balaenoptera acutorostrata](#) Minke Whale [33]		Species or species habitat may occur within area
[Balaenoptera borealis](#) Sei Whale [34]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
[Balaenoptera edeni](#) Bryde's Whale [35]		Species or species habitat may occur within area
[Balaenoptera musculus](#) Blue Whale [36]	Endangered	Species or species habitat may occur within area
[Balaenoptera physalus](#) Fin Whale [37]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
[Caperea marginata](#) Pygmy Right Whale [39]		Foraging, feeding or related behaviour may occur within area
[Delphinus delphis](#) Common Dophin, Short-beaked Common Dolphin [60]		Species or species habitat may occur within area
[Eubalaena australis](#) Southern Right Whale [40]	Endangered	Species or species habitat known to occur within area
[Grampus griseus](#) Risso's Dolphin, Grampus [64]		Species or species habitat may occur within area
[Lagenorhynchus obscurus](#) Dusky Dolphin [43]		Species or species habitat may occur within area

Name	Status	Type of Presence
Megaptera novaeangliae		
Humpback Whale [38]	Vulnerable	Species or species habitat known to occur within area
Orcinus orca		
Killer Whale, Orca [46]		Species or species habitat likely to occur within area
Tursiops aduncus		
Indian Ocean Bottlenose Dolphin, Spotted Bottlenose Dolphin [68418]		Species or species habitat likely to occur within area
Tursiops truncatus s. str.		
Bottlenose Dolphin [68417]		Species or species habitat may occur within area

Extra Information

Regional Forest Agreements [Resource Information]

Note that all areas with completed RFAs have been included.

Name	State
Southern RFA	New South Wales

Invasive Species [Resource Information]

Weeds reported here are the 20 species of national significance (WoNS), along with other introduced plants that are considered by the States and Territories to pose a particularly significant threat to biodiversity. The following feral animals are reported: Goat, Red Fox, Cat, Rabbit, Pig, Water Buffalo and Cane Toad. Maps from Landscape Health Project, National Land and Water Resouces Audit, 2001.

Name	Status	Type of Presence
Birds		
Acridotheres tristis		
Common Myna, Indian Myna [387]		Species or species habitat likely to occur within area
Alauda arvensis		
Skylark [656]		Species or species habitat likely to occur within area
Anas platyrhynchos		
Mallard [974]		Species or species habitat likely to occur within area
Carduelis carduelis		
European Goldfinch [403]		Species or species habitat likely to occur within area
Columba livia		
Rock Pigeon, Rock Dove, Domestic Pigeon [803]		Species or species habitat likely to occur within area
Lonchura punctulata		
Nutmeg Mannikin [399]		Species or species habitat likely to occur within area
Passer domesticus		
House Sparrow [405]		Species or species habitat likely to occur within area
Pycnonotus jocosus		
Red-whiskered Bulbul [631]		Species or species habitat likely to occur

Name	Status	Type of Presence
		within area
Streptopelia chinensis Spotted Turtle-Dove [780]		Species or species habitat likely to occur within area
Sturnus vulgaris Common Starling [389]		Species or species habitat likely to occur within area
Turdus merula Common Blackbird, Eurasian Blackbird [596]		Species or species habitat likely to occur within area
Frogs		
Rhinella marina Cane Toad [83218]		Species or species habitat may occur within area
Mammals		
Bos taurus Domestic Cattle [16]		Species or species habitat likely to occur within area
Canis lupus familiaris Domestic Dog [82654]		Species or species habitat likely to occur within area
Capra hircus Goat [2]		Species or species habitat likely to occur within area
Felis catus Cat, House Cat, Domestic Cat [19]		Species or species habitat likely to occur within area
Feral deer Feral deer species in Australia [85733]		Species or species habitat likely to occur within area
Lepus capensis Brown Hare [127]		Species or species habitat likely to occur within area
Mus musculus House Mouse [120]		Species or species habitat likely to occur within area
Oryctolagus cuniculus Rabbit, European Rabbit [128]		Species or species habitat likely to occur within area
Rattus norvegicus Brown Rat, Norway Rat [83]		Species or species habitat likely to occur within area
Rattus rattus Black Rat, Ship Rat [84]		Species or species habitat likely to occur within area
Sus scrofa Pig [6]		Species or species habitat likely to occur within area
Vulpes vulpes Red Fox, Fox [18]		Species or species habitat likely to occur within area
Plants		
Alternanthera philoxeroides Alligator Weed [11620]		Species or species habitat likely to occur within area

Name	Status	Type of Presence
Anredera cordifolia Madeira Vine, Jalap, Lamb's-tail, Mignonette Vine, Anredera, Gulf Madeiravine, Heartleaf Madeiravine, Potato Vine [2643]		Species or species habitat likely to occur within area
Asparagus aethiopicus Asparagus Fern, Ground Asparagus, Basket Fern, Sprengi's Fern, Bushy Asparagus, Emerald Asparagus [62425]		Species or species habitat likely to occur within area
Asparagus asparagoides Bridal Creeper, Bridal Veil Creeper, Smilax, Florist's Smilax, Smilax Asparagus [22473]		Species or species habitat likely to occur within area
Asparagus plumosus Climbing Asparagus-fern [48993]		Species or species habitat likely to occur within area
Asparagus scandens Asparagus Fern, Climbing Asparagus Fern [23255]		Species or species habitat likely to occur within area
Cabomba caroliniana Cabomba, Fanwort, Carolina Watershield, Fish Grass, Washington Grass, Watershield, Carolina Fanwort, Common Cabomba [5171]		Species or species habitat likely to occur within area
Chrysanthemoides monilifera Bitou Bush, Boneseed [18983]		Species or species habitat may occur within area
Chrysanthemoides monilifera subsp. monilifera Boneseed [16905]		Species or species habitat likely to occur within area
Chrysanthemoides monilifera subsp. rotundata Bitou Bush [16332]		Species or species habitat likely to occur within area
Cytisus scoparius Broom, English Broom, Scotch Broom, Common Broom, Scottish Broom, Spanish Broom [5934]		Species or species habitat likely to occur within area
Eichhornia crassipes Water Hyacinth, Water Orchid, Nile Lily [13466]		Species or species habitat likely to occur within area
Genista monspessulana Montpellier Broom, Cape Broom, Canary Broom, Common Broom, French Broom, Soft Broom [20126]		Species or species habitat likely to occur within area
Genista sp. X Genista monspessulana Broom [67538]		Species or species habitat may occur within area
Lantana camara Lantana, Common Lantana, Kamara Lantana, Large-leaf Lantana, Pink Flowered Lantana, Red Flowered Lantana, Red-Flowered Sage, White Sage, Wild Sage [10892]		Species or species habitat likely to occur within area
Lycium ferocissimum African Boxthorn, Boxthorn [19235]		Species or species habitat likely to occur within area
Nassella neesiana Chilean Needle grass [67699]		Species or species habitat likely to occur within area
Nassella trichotoma Serrated Tussock, Yass River Tussock, Yass Tussock, Nassella Tussock (NZ) [18884]		Species or species habitat likely to occur within area
Opuntia spp. Prickly Pears [82753]		Species or species habitat likely to occur within area

Name	Status	Type of Presence
Pinus radiata Radiata Pine Monterey Pine, Insignis Pine, Wilding Pine [20780]		Species or species habitat may occur within area
Rubus fruticosus aggregate Blackberry, European Blackberry [68406]		Species or species habitat likely to occur within area
Sagittaria platyphylla Delta Arrowhead, Arrowhead, Slender Arrowhead [68483]		Species or species habitat likely to occur within area
Salix spp. except S.babylonica, S.x calodendron & S.x reichardtii Willows except Weeping Willow, Pussy Willow and Sterile Pussy Willow [68497]		Species or species habitat likely to occur within area
Salvinia molesta Salvinia, Giant Salvinia, Aquarium Watermoss, Kariba Weed [13665]		Species or species habitat likely to occur within area
Senecio madagascariensis Fireweed, Madagascar Ragwort, Madagascar Groundsel [2624]		Species or species habitat likely to occur within area
Ulex europaeus Gorse, Furze [7693]		Species or species habitat likely to occur within area

Nationally Important Wetlands	[Resource Information]
Name	State
Killalea Lagoon	NSW
Lake Illawarra	NSW
Minnamurra River Estuary	NSW

Caveat

The information presented in this report has been provided by a range of data sources as acknowledged at the end of the report.

This report is designed to assist in identifying the locations of places which may be relevant in determining obligations under the Environment Protection and Biodiversity Conservation Act 1999. It holds mapped locations of World and National Heritage properties, Wetlands of International and National Importance, Commonwealth and State/Territory reserves, listed threatened, migratory and marine species and listed threatened ecological communities. Mapping of Commonwealth land is not complete at this stage. Maps have been collated from a range of sources at various resolutions.

Not all species listed under the EPBC Act have been mapped (see below) and therefore a report is a general guide only. Where available data supports mapping, the type of presence that can be determined from the data is indicated in general terms. People using this information in making a referral may need to consider the qualifications below and may need to seek and consider other information sources.

For threatened ecological communities where the distribution is well known, maps are derived from recovery plans, State vegetation maps, remote sensing imagery and other sources. Where threatened ecological community distributions are less well known, existing vegetation maps and point location data are used to produce indicative distribution maps.

Threatened, migratory and marine species distributions have been derived through a variety of methods. Where distributions are well known and if time permits, maps are derived using either thematic spatial data (i.e. vegetation, soils, geology, elevation, aspect, terrain, etc) together with point locations and described habitat; or environmental modelling (MAXENT or BIOCLIM habitat modelling) using point locations and environmental data layers.

Where very little information is available for species or large number of maps are required in a short time-frame, maps are derived either from 0.04 or 0.02 decimal degree cells; by an automated process using polygon capture techniques (static two kilometre grid cells, alpha-hull and convex hull); or captured manually or by using topographic features (national park boundaries, islands, etc). In the early stages of the distribution mapping process (1999-early 2000s) distributions were defined by degree blocks, 100K or 250K map sheets to rapidly create distribution maps. More reliable distribution mapping methods are used to update these distributions as time permits.

Only selected species covered by the following provisions of the EPBC Act have been mapped:

- migratory and
- marine

The following species and ecological communities have not been mapped and do not appear in reports produced from this database:

- threatened species listed as extinct or considered as vagrants
- some species and ecological communities that have only recently been listed
- some terrestrial species that overfly the Commonwealth marine area
- migratory species that are very widespread, vagrant, or only occur in small numbers

The following groups have been mapped, but may not cover the complete distribution of the species:

- non-threatened seabirds which have only been mapped for recorded breeding sites
- seals which have only been mapped for breeding sites near the Australian continent

Such breeding sites may be important for the protection of the Commonwealth Marine environment.

Coordinates

-34.62669 150.84101

Acknowledgements

This database has been compiled from a range of data sources. The department acknowledges the following custodians who have contributed valuable data and advice:

-Office of Environment and Heritage, New South Wales
-Department of Environment and Primary Industries, Victoria
-Department of Primary Industries, Parks, Water and Environment, Tasmania
-Department of Environment, Water and Natural Resources, South Australia
-Department of Land and Resource Management, Northern Territory
-Department of Environmental and Heritage Protection, Queensland
-Department of Parks and Wildlife, Western Australia
-Environment and Planning Directorate, ACT
-Birdlife Australia
-Australian Bird and Bat Banding Scheme
-Australian National Wildlife Collection
-Natural history museums of Australia
-Museum Victoria
-Australian Museum
-South Australian Museum
-Queensland Museum
-Online Zoological Collections of Australian Museums
-Queensland Herbarium
-National Herbarium of NSW
-Royal Botanic Gardens and National Herbarium of Victoria
-Tasmanian Herbarium
-State Herbarium of South Australia
-Northern Territory Herbarium
-Western Australian Herbarium
-Australian National Herbarium, Canberra
-University of New England
-Ocean Biogeographic Information System
-Australian Government, Department of Defence
Forestry Corporation, NSW
-Geoscience Australia
-CSIRO
-Australian Tropical Herbarium, Cairns
-eBird Australia
-Australian Government – Australian Antarctic Data Centre
-Museum and Art Gallery of the Northern Territory
-Australian Government National Environmental Science Program
-Australian Institute of Marine Science
-Reef Life Survey Australia
-American Museum of Natural History
-Queen Victoria Museum and Art Gallery, Inveresk, Tasmania
-Tasmanian Museum and Art Gallery, Hobart, Tasmania
-Other groups and individuals

The Department is extremely grateful to the many organisations and individuals who provided expert advice and information on numerous draft distributions.

Please feel free to provide feedback via the Contact Us page.

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Canberra ACT 2601 Australia
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APPENDIX C

STAKEHOLDER CONSULTATION

Planning Services
Resource Assessments and Compliance
Contact: Lauren Evans
Phone: 9274 6311
Email: lauren.evans@planning.nsw.gov.au

Mr Adnan Voloder
Boral Land & Property Group
PO Box 6041
North Ryde NSW 2113

Dear Mr Voloder

Dunmore Lakes Sand Extraction Project (DA 195-8-2004)
Modification 2

I refer to the above modification request and to your email dated 1 November 2018 seeking the Department's advice as to the appropriate approval pathway for the proposal.

I have reviewed the information provided and sought advice from the Department's Legal Branch. This advice indicates that there is a degree of risk that Modification 2 would not be considered 'substantially the same' as the development for which consent was originally granted. On this basis, you are advised to seek and carefully consider legal advice before proceeding with the proposal under section 4.55 of the *Environmental Planning and Assessment Act 1979*.

Alternatively, the above modification request may continue under the section 75W approval pathway, provided that a complete Environmental Assessment (EA) is provided to the Department by no later than **28 February 2019**.

On the above date, 12 months will have elapsed since the transitional arrangements for section 75W modification applications were discontinued. The Department considers that this is sufficient time to finalise the EA.

Under clause 3BA(4) of Schedule 2 of the *Environmental Planning and Assessment (Savings, Transitional and Other Provisions) Regulation 2017*, the Secretary may decide not to deal with a modification request made under section 75W at any time after 1 September 2018, if the Secretary is of the opinion that insufficient information has been provided to deal with the request. If a complete EA is not submitted to the Department by 28 February 2019, the Department intends to give immediate notice that Modification 2 will not be dealt with under section 75W.

If you would like to discuss this matter further, please contact Lauren Evans on the details listed above.

Yours sincerely

Howard Reed

Howard Reed 21.12.18
Director
Resource Assessments

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4 December 2018

General Manager - Planning
Shellharbour City Council
Locked Bag 155
Shellharbour City Centre NSW 2529

Dear Sir/Madam,

DUNMORE LAKES SAND AND SOIL OPERATION – MODIFICATION 2 TO EXISTING APPROVAL - NOTICE OF CONSULTATION

Boral Resources (NSW) Pty Ltd (Boral) is proposing to modify the existing approval for the Dunmore Sand & Soil (DSS) operations located in Tabbitta Road, Dunmore, approximately three kilometres south-south west of Shellharbour and seven kilometres north of Kiama.

DSS has investigated a fine sand resource on an adjoining private property (471 Riverside Drive, Dunmore) to the south and confirmed there is sufficient resource to support three to four more years of extraction over two staged areas (5A and 5B).

In order to meet the demand for a consistent and continuous supply of sand to the Sydney market, Boral proposes to develop these two additional extraction areas. Stage 5A is positioned immediately south of Riverside Drive, while Stage 5B is located to the north of the Minnamurra River.

Mobile plant and equipment would be installed to support extraction at both Stage 5A and 5B. Extraction methods would be identical to those currently implemented at the existing DSS operations.

Extraction from the site would be conducted via dredging of the established resource pits, with collected sand material pumped to the existing operations in Tabbitta Road, traversing land owned by DSS, and freeway reservation space controlled by the NSW Roads and Maritime Services (RMS). The pipeline route and construction methodology is still being finalised in consultation with the RMS.

There would be **no** alteration to the existing site's hours of operation associated with the addition of the Stage 5 extraction area. Similarly, the current output limit of 800 000 tonnes per annum would continue following approval of the modification.

The modification would not increase the current hourly or daily traffic volumes associated with dispatch of processed sand products given the production limit of the Approved Project would not be altered.

However, the modification would introduce temporary additional heavy vehicle movements along the Princes Highway and Riverside Drive associated with importation of fill material to the Stage 5A extraction area.

Boral is seeking consent for the modification through the NSW Department of Planning and Environment.

As part of preparing the specialist studies and subsequent application, Boral is seeking to consult relevant stakeholders via this letter. Any response received in return will be taken into consideration as the application is finalised.

If you or your colleagues have any questions, or would like to discuss the proposal in more detail, please feel free to contact me on **0401 897 486** or **adnan.voloder@boral.com.au**.

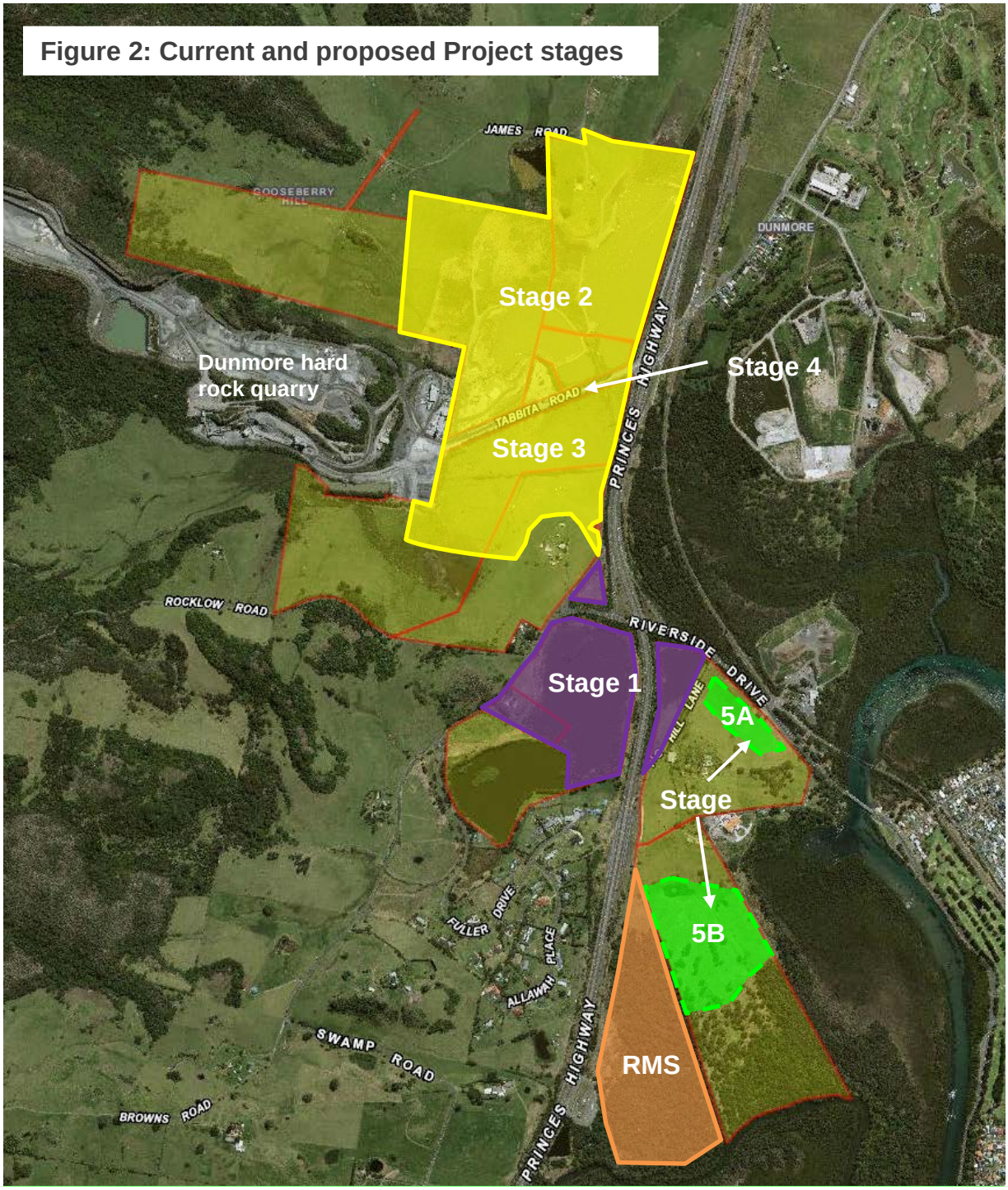
Alternatively, if your organisation has no comments or concerns and are satisfied to await the exhibition of the proposal (to be further notified when dates are determined), we'd appreciate a response to this effect.

We are hoping to gather all responses to the proposal by **14 December**. Thank you for your interest in this letter – we look forward to hearing from you soon.

Yours sincerely,

Adnan Voloder
Planning & Development Manager (NSW & ACT)
Boral Land & Property Group

Figure 2: Current and proposed Project stages



Administration Centre
Shellharbour Civic Centre
76 Cygnet Avenue
(Cnr Cygnet & College Avenue)
Shellharbour City Centre NSW 2529

Postal Address
Locked Bag 155
Shellharbour City Centre NSW 2529

DX 26402 Shellharbour City Centre

p. 02 4221 6111
f. 02 4221 6016
records@shellharbour.nsw.gov.au
www.shellharbour.nsw.gov.au

Council Reference: ECM 11165323

24 January 2019

Mr Adrian Voloder
Boral Land & Property Group
PO Box 6041
North Ryde NSW 2113

Email: adnan.voloder@boral.com.au

Re: Dunmore Sand and Soil - Additional Extraction Area Project

Dear Mr Voloder

Thank you for your emails regarding the Dunmore Sand and Soil - Additional Extraction Area Project.

Council is currently investigating this matter and will be in contact with you in the near future with a response.

If you have any questions in relation to the progress of this matter, please do not hesitate to contact Group Manager City Development, Grant Meredith on (02) 4221 6137.

Yours sincerely

Melissa Boxall
Director Community and Customers

From:	Luke Farrell
To:	Luke Farrell
Subject:	RE: Dunmore Lakes Sand and Soil Operation - Modification 2 to Existing Approval - Notice of Consultation.
Date:	19 February 2019 10:29:39

---------- Forwarded message ---------
From: **Jennifer Southan** <jennifer.southan@shellharbour.nsw.gov.au>
Date: Tue, 5 Feb 2019 at 5:04 pm
Subject: Dunmore Lakes Sand and Soil Operation - Modification 2 to Existing Approval - Notice of Consultation.
To: Voloder, Adnan <adnan.voloder@boral.com.au>

Dear Adnan,

Further to our discussion today, I have reviewed the subject site in light of the proposal and associated submission and note the following:

Any application for extraction will need to address Clause 7(3) of SEPP (Mining, Petroleum Production and Extractive Industries) 2007:

*(3) **Extractive industry** Development for any of the following purposes may be carried out with development consent:*
(a) extractive industry on land on which development for the purposes of agriculture or industry may be carried out (with or without development consent),
(b) extractive industry in any part of a waterway, an estuary in the coastal zone or coastal waters of the State that is not in an environmental conservation zone.

I also note the Coastal SEPP applies to the site. The site is also listed as an Item of European Heritage (local) and Potential Aboriginal Heritage. The application will need to address any impacts in this regard – a Statement of Heritage Impact and supporting documentation in relation to Aboriginal Heritage will be required.

Given the application is to include a site that is not part of existing operations, I would think a new DA would be required to be submitted. I also note that 471 Riverside Drive is not mapped as a mineral transition area.

Council requests that prior to any application being lodged with the Department extensive community consultation must occur.

Please note, this is not a complete assessment. Additional comments may be submitted upon review of the submitted application.

Regards,

Shellharbour CITY COUNCIL

Jennifer Southan | Senior Development Assessment Officer

76 Cygnet Avenue, Shellharbour City Centre
Locked Bag 155, Shellharbour City Centre, NSW 2529
p. (02) 4221 6292 **m.**
www.shellharbour.nsw.gov.au

COLLABORATION | ACCOUNTABILITY | INTEGRITY | RESPECT | SUSTAINABILITY

--
Kind regards,

ADNAN VOLODER Planning and Development Manager (NSW & ACT) Telephone: 02 9033 5535 Mobile: 0401 897 486 Email: adnan.voloder@boral.com.au
Inline images
Boral Property Group
PO Box 6041 North Ryde NSW 2113 www.boral.com.au

Inline images

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3 December 2018

Matthew Fuller
Regional Operations Officer - Illawarra
Metro Branch, NSW Environment Protection Authority
Level 3, 84 Crown Street
Wollongong
NSW 2500

Email: matthew.fuller@epa.nsw.gov.au

Dear Matthew,

DUNMORE LAKES SAND AND SOIL OPERATION – MODIFICATION 2 TO EXISTING APPROVAL - NOTICE OF CONSULTATION

Boral Resources (NSW) Pty Ltd (Boral) is proposing to modify the existing approval for the Dunmore Sand & Soil (DSS) operations located in Tabbitta Road, Dunmore, approximately three kilometres south-south west of Shellharbour and seven kilometres north of Kiama.

DSS has investigated a fine sand resource on an adjoining private property (471 Riverside Drive, Dunmore) to the south and confirmed there is sufficient resource to support three to four more years of extraction over two staged areas (5A and 5B).

In order to meet the demand for a consistent and continuous supply of sand to the Sydney market, Boral proposes to develop these two additional extraction areas. Stage 5A is positioned immediately south of Riverside Drive, while Stage 5B is located to the north of the Minnamurra River.

Mobile plant and equipment would be installed to support extraction at both Stage 5A and 5B. Extraction methods would be identical to those currently implemented at the existing DSS operations.

Extraction from the site would be conducted via dredging of the established resource pits, with collected sand material pumped to the existing operations in Tabbitta Road, traversing land owned by DSS, and freeway reservation space controlled by the NSW Roads and Maritime Services (RMS). The pipeline route and construction methodology is still being finalised in consultation with the RMS.

There would be **no** alteration to the existing site's hours of operation associated with the addition of the Stage 5 extraction area. Similarly, the current output limit of 800 000 tonnes per annum would continue following approval of the modification.

The modification would not increase the current hourly or daily traffic volumes associated with dispatch of processed sand products given the production limit of the Approved

Project would not be altered.

However, the modification would introduce temporary additional heavy vehicle movements along the Princes Highway and Riverside Drive associated with importation of fill material to the Stage 5A extraction area.

Boral is seeking consent for the modification through the NSW Department of Planning and Environment.

As part of preparing the specialist studies and subsequent application, Boral is seeking to consult relevant stakeholders via this letter. Any response received in return will be taken into consideration as the application is finalised.

If you or your colleagues have any questions, or would like to discuss the proposal in more detail, please feel free to contact me on **0401 897 486** or **adnan.voloder@boral.com.au**.

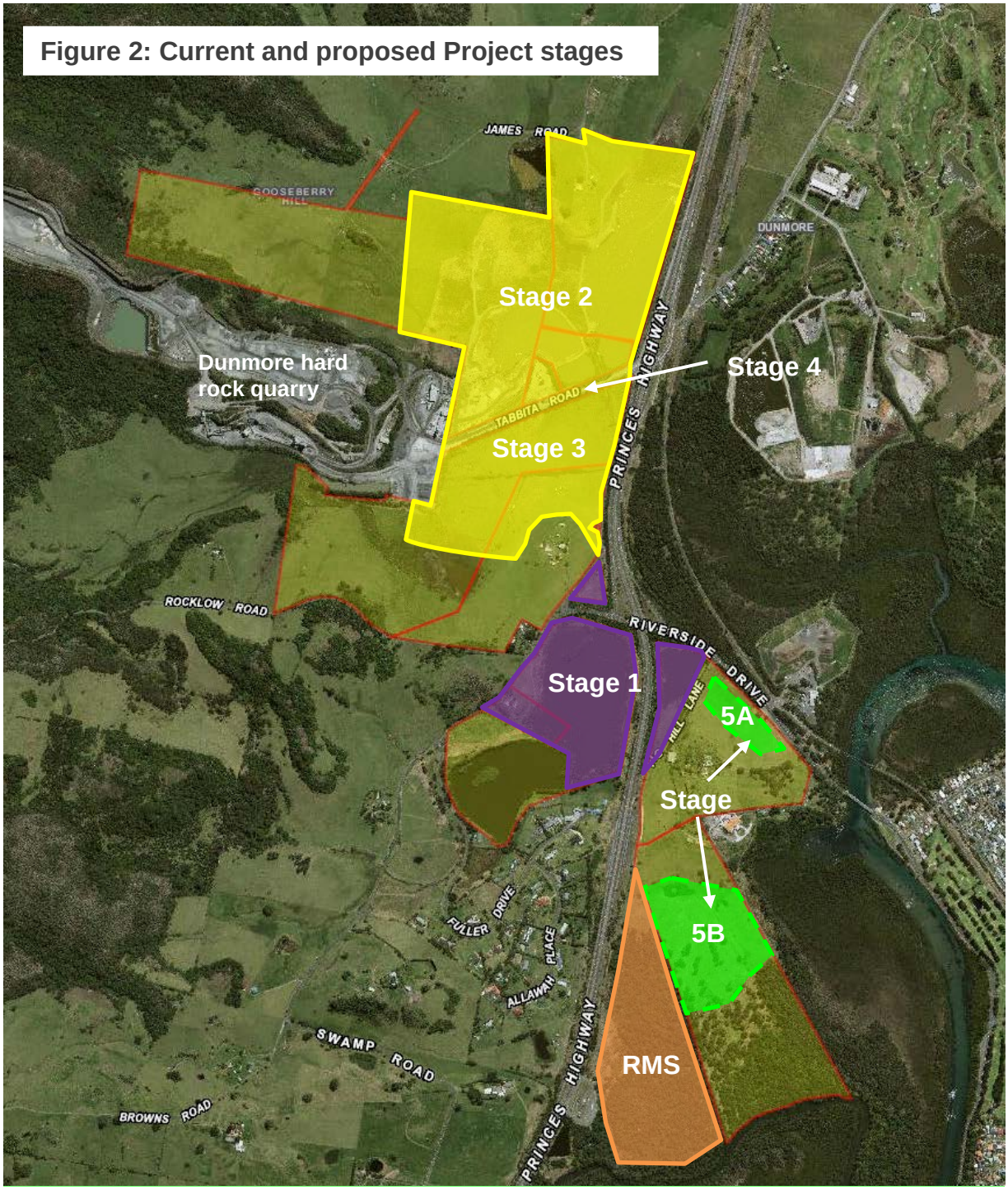
Alternatively, if your organisation has no comments or concerns and are satisfied to await the exhibition of the proposal (to be further notified when dates are determined), we'd appreciate a response to this effect.

We are hoping to gather all responses to the proposal by **14 December**. Thank you for your interest in this letter – we look forward to hearing from you soon.

Yours sincerely,

Adnan Voloder
Planning & Development Manager (NSW & ACT)
Boral Land & Property Group

Figure 2: Current and proposed Project stages



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3 December 2018

Scott Carter
Senior Fisheries Manager - Central/Metro
Aquatic Ecosystems
NSW Department of Primary Industries
Locked Bag 1
NELSON BAY NSW 2315

Email: scott.carter@dpi.nsw.gov.au

Dear Scott

DUNMORE LAKES SAND AND SOIL OPERATION – MODIFICATION 2 TO EXISTING APPROVAL - NOTICE OF CONSULTATION

Boral Resources (NSW) Pty Ltd (Boral) is proposing to modify the existing approval for the Dunmore Sand & Soil (DSS) operations located in Tabbitta Road, Dunmore, approximately three kilometres south-south west of Shellharbour and seven kilometres north of Kiama.

DSS has investigated a fine sand resource on an adjoining private property (471 Riverside Drive, Dunmore) to the south and confirmed there is sufficient resource to support three to four more years of extraction over two staged areas (5A and 5B).

In order to meet the demand for a consistent and continuous supply of sand to the Sydney market, Boral proposes to develop these two additional extraction areas. Stage 5A is positioned immediately south of Riverside Drive, while Stage 5B is located to the north of the Minnamurra River.

Mobile plant and equipment would be installed to support extraction at both Stage 5A and 5B. Extraction methods would be identical to those currently implemented at the existing DSS operations.

Extraction from the site would be conducted via dredging of the established resource pits, with collected sand material pumped to the existing operations in Tabbitta Road, traversing land owned by DSS, and freeway reservation space controlled by the NSW Roads and Maritime Services (RMS). The pipeline route and construction methodology is still being finalised in consultation with the RMS.

There would be **no** alteration to the existing site's hours of operation associated with the addition of the Stage 5 extraction area. Similarly, the current output limit of 800 000 tonnes per annum would continue following approval of the modification.

The modification would not increase the current hourly or daily traffic volumes associated with dispatch of processed sand products given the production limit of the Approved Project would not be altered.

However, the modification would introduce temporary additional heavy vehicle movements along the Princes Highway and Riverside Drive associated with importation of fill material to the Stage 5A extraction area.

Boral is seeking consent for the modification through the NSW Department of Planning and Environment.

As part of preparing the specialist studies and subsequent application, Boral is seeking to consult relevant stakeholders via this letter. Any response received in return will be taken into consideration as the application is finalised.

If you or your colleagues have any questions, or would like to discuss the proposal in more detail, please feel free to contact me on **0401 897 486** or **adnan.voloder@boral.com.au**.

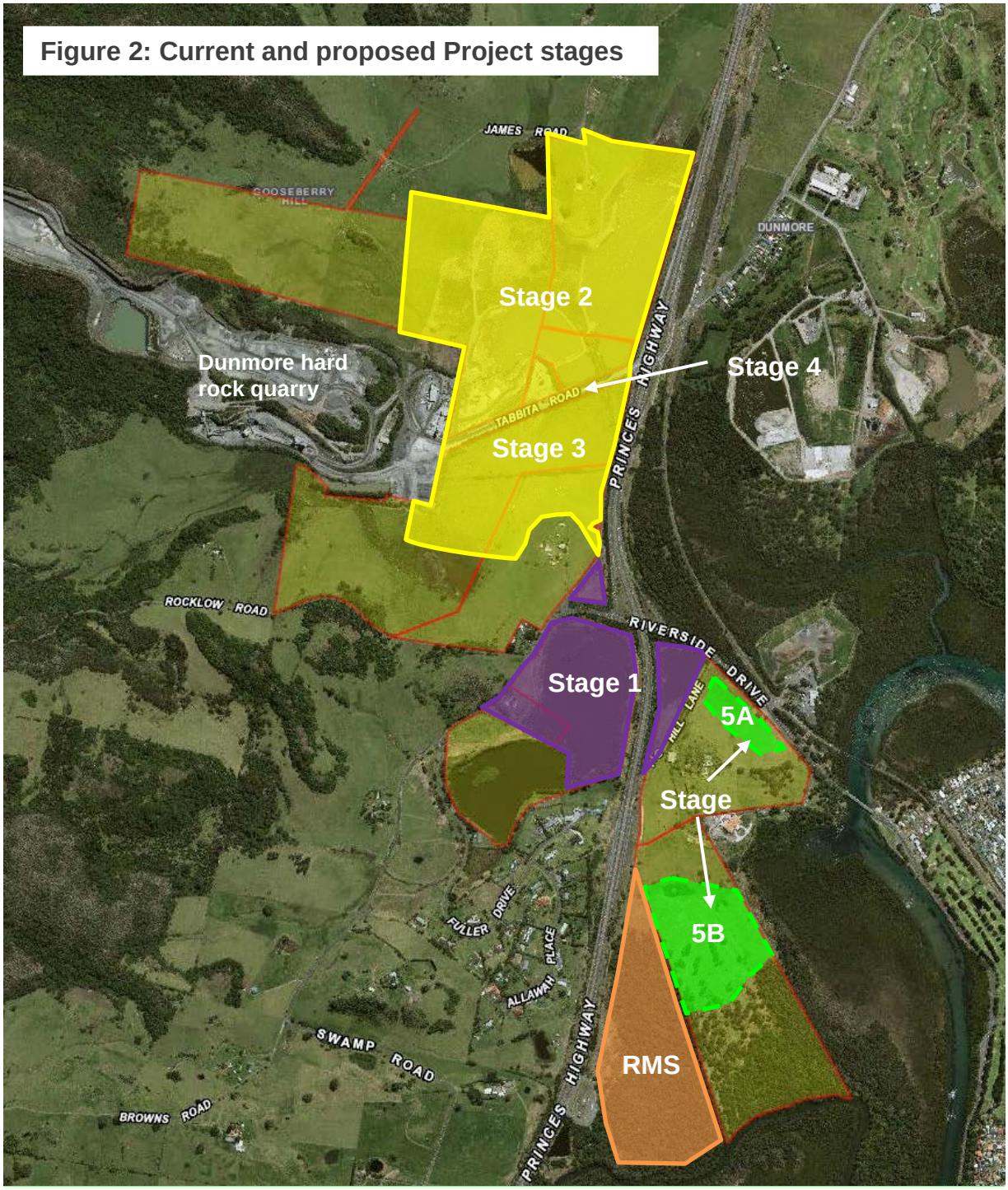
Alternatively, if your organisation has no comments or concerns and are satisfied to await the exhibition of the proposal (to be further notified when dates are determined), we'd appreciate a response to this effect.

We are hoping to gather all responses to the proposal by **14 December**. Thank you for your interest in this letter – we look forward to hearing from you soon.

Yours sincerely,

Adnan Voloder
Planning & Development Manager (NSW & ACT)
Boral Land & Property Group

Figure 2: Current and proposed Project stages



Department of Primary Industries

Our Ref: C18/707

19 December 2018

Adnan Voloder
Planning & Development Manager
BORAL Land & Property Group
PO Box 6041
NORTH RYDE NSW 2113

Dear Mr Voloder,

Dunmore Lakes Sand and Soil Operation – Modification 2 to Existing Approval - Consultation

Thank you for your notification of 3 December 2018 seeking comment from DPI Fisheries, a division of NSW Department of Primary Industries, on the proposed expansion of the sand mining operations at Dunmore Lakes Sand and Soil, Tabbita Road, Dunmore.

DPI Fisheries is responsible for ensuring that fish stocks are conserved and that there is no net loss of key fish habitats upon which they depend. To achieve this, DPI Fisheries ensures that developments comply with the requirements of the *Fisheries Management Act 1994* (namely the aquatic habitat protection and threatened species conservation provisions in Parts 7 and 7A of the Act, respectively), and the associated *Policy and Guidelines for Fish Habitat Conservation and Management (2013)*. In addition, DPI Fisheries is responsible for ensuring the sustainable management of commercial, recreational and Aboriginal cultural fishing, aquaculture and marine protected areas within NSW.

The proposed expansion areas are situated adjacent to Minnamurra River and land identified as "coastal wetland". Parts of the proposal areas are located within land identified as "proximity zone for coastal wetlands". Coastal Wetlands and the Minnamurra River are considered to be Type 1 (highly sensitive), Class 1 (Major) Key Fish Habitats. The Coastal Management SEPP 2018 aims to protect, and where possible enhance the biophysical, hydrological and ecological integrity of these sensitive areas.

The potential impact of the development upon the aquatic habitats and fish communities in the adjacent wetland and waterway from discharge of sediment laden waters, particularly during high rainfall events, as well as groundwater drawdown is of particular interest to this Department.

Environmental Impact Assessment Requirements

The Department advises that the environmental assessment for the proposed expansion of the sand quarry should include consideration of the following issues:

- Description of aquatic environments (watercourses, wetlands) located on the site or adjacent to the site and their regional significance.

- Predictions of any impacts of the development upon riparian or aquatic environments, both at the site and downstream (both temporary and permanent, including groundwater drawdown).
- Predictions of any impacts upon water quality and aquatic threatened species, populations and ecological communities listed under the *Fisheries Management Act 1994*.
- Safeguards to mitigate any impacts upon aquatic environments and riparian habitats (e.g. full details of proposed riparian buffer zones and any riparian rehabilitation and revegetation plans).
- Safeguards to mitigate any impacts upon water quality and any threatened species, including impacts from drawdown. In particular,
  - details of proposed erosion and sediment control during construction (to be incorporated into a Construction Environmental Management Plan – CEMP);
  - proposed water quality monitoring downstream of the development site.
- Details of any proposed waterway crossings or possible obstruction of fish passage

DPI Fisheries recommends the inclusion of riparian corridors wherever possible to provide a buffer between the development areas and adjacent waterways or natural drainage lines to provide protection to riparian and aquatic habitats. Please note that DPI Fisheries policy is that the width of the riparian buffer zone adjacent to Type 1 habitats should be at least 100 metres as measured from the top of the bank.

Where the riparian zone is degraded or disturbed due to past use or development works, rehabilitation of the zone is recommended including planting of endemic riparian vegetation. Retention and replanting of native riparian vegetation will help to protect receiving waters from erosion and runoff and benefit fish habitat.

The design and construction of any watercourse crossings on the site should be undertaken in accordance with the Department's *Policy and Guidelines for Fish Friendly Waterway Crossings* (2004) and *Why Do Fish Need to Cross the Road? Fish Passage Requirements for Waterway Crossings* (2004). These documents are available on our website www.dpi.nsw.gov.au, under 'Aquatic Habitats' and 'Publications'. DPI Fisheries should be consulted in the design phase of waterway crossings to ensure that the works are designed and constructed in accordance with best management practice and with minimal impact on the aquatic environment within the immediate vicinity of the proposed works.

For further detailed advice on DPI Fisheries' aquatic habitat protection requirements, the applicants should refer to the Department's *Policy and Guidelines for Fish Habitat Conservation and Management (2013)* also available on our website www.dpi.nsw.gov.au.

When available, the completed environmental assessment documentation for the development should be referred to the Department for review and further comment.

For further information please do not hesitate to contact me on (02) 4428 3007.

Yours sincerely

Reynolds.

Jillian Reynolds
Fisheries Manager
Coastal Systems – South

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4 December 2018

Rachel Carocci
Roads and Maritime Service
Southern Region
PO Box 477
Wollongong NSW 2520

Email: Rachel.Carocci@rms.nsw.gov.au

Dear Rachel,

DUNMORE LAKES SAND AND SOIL OPERATION – MODIFICATION 2 TO EXISTING APPROVAL - NOTICE OF CONSULTATION

Boral Resources (NSW) Pty Ltd (Boral) is proposing to modify the existing approval for the Dunmore Sand & Soil (DSS) operations located in Tabbitta Road, Dunmore, approximately three kilometres south-south west of Shellharbour and seven kilometres north of Kiama.

DSS has investigated a fine sand resource on an adjoining private property (471 Riverside Drive, Dunmore) to the south and confirmed there is sufficient resource to support three to four more years of extraction over two staged areas (5A and 5B).

In order to meet the demand for a consistent and continuous supply of sand to the Sydney market, Boral proposes to develop these two additional extraction areas. Stage 5A is positioned immediately south of Riverside Drive, while Stage 5B is located to the north of the Minnamurra River.

Mobile plant and equipment would be installed to support extraction at both Stage 5A and 5B. Extraction methods would be identical to those currently implemented at the existing DSS operations.

Extraction from the site would be conducted via dredging of the established resource pits, with collected sand material pumped to the existing operations in Tabbitta Road, traversing land owned by DSS, and freeway reservation space controlled by the NSW Roads and Maritime Services (RMS). The pipeline route and construction methodology is still being finalised in consultation with the RMS.

There would be **no** alteration to the existing site's hours of operation associated with the addition of the Stage 5 extraction area. Similarly, the current output limit of 800 000 tonnes per annum would continue following approval of the modification.

The modification would not increase the current hourly or daily traffic volumes associated with dispatch of processed sand products given the production limit of the Approved

Project would not be altered.

However, the modification would introduce temporary additional heavy vehicle movements along the Princes Highway and Riverside Drive associated with importation of fill material to the Stage 5A extraction area.

Boral is seeking consent for the modification through the NSW Department of Planning and Environment.

As part of preparing the specialist studies and subsequent application, Boral is seeking to consult relevant stakeholders via this letter. Any response received in return will be taken into consideration as the application is finalised.

If you or your colleagues have any questions, or would like to discuss the proposal in more detail, please feel free to contact me on **0401 897 486** or **adnan.voloder@boral.com.au**.

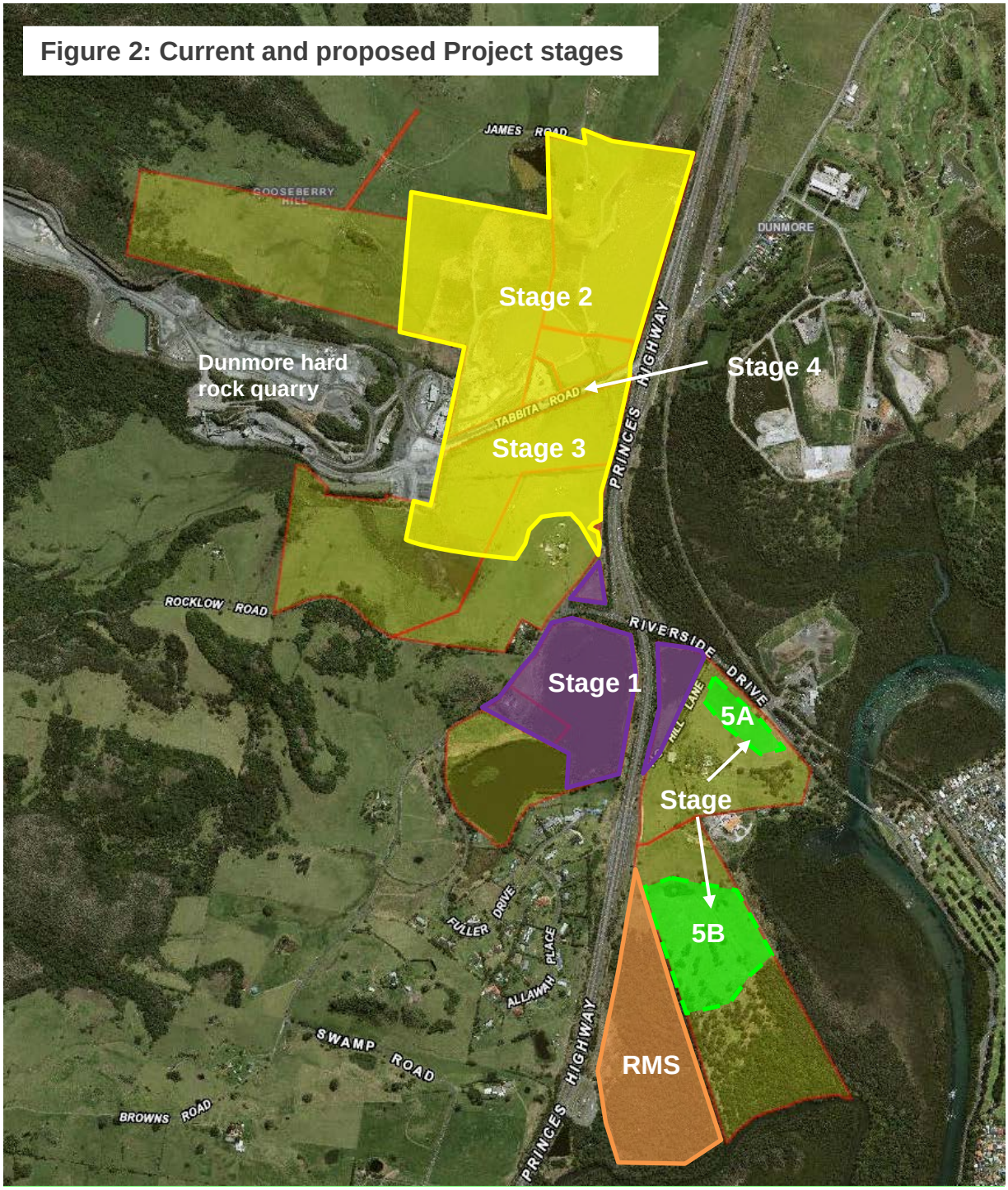
Alternatively, if your organisation has no comments or concerns and are satisfied to await the exhibition of the proposal (to be further notified when dates are determined), we'd appreciate a response to this effect.

We are hoping to gather all responses to the proposal by **14 December**. Thank you for your interest in this letter – we look forward to hearing from you soon.

Yours sincerely,

Adnan Voloder
Planning & Development Manager (NSW & ACT)
Boral Land & Property Group

Figure 2: Current and proposed Project stages



Transport
Roads & Maritime Services

Our ref: STH11/00218/11
Contact: Melissa Steep 4221 2771
Your ref:

17 December 2018

Adnan Voloder
Boral
Adnan.voloder@boral.com.au

DUNMORE LAKES SAND AND SOIL OPERATION – MODIFICATION 2

Dear Adnan,

Roads and Maritime Services (RMS) Land Use Department refers to your correspondence dated 4 December 2018 requesting RMS comment on the subject modification.

RMS has completed an assessment of the development, based on the information provided and focussing on the impact to the State Road Network. For this development, the key state road is the Princes Highway.

RMS requests the applicant give consideration to the following:

- A traffic impact study (TIS) is required. As a guide Table 2.1 of the RTA Guide to Traffic Generating Developments outlines the key issues that may be considered in preparing a TIS. In addition, the TIS must also address the following:
    - Details on road transport routes to be used to provide access to/from the site, including a comparison of the routes used under current operations compared to the proposed.
    - Details of existing movements along the road network and likely additional movements to and from the development site onto the Princes Highway, including the types of vehicles, peak hour movements and maximum daily movements.
    - The existing traffic volumes (based on survey) using the junction of the Princes Highway and Riverside Drive. The traffic study needs to consider the likely impact of the additional traffic associated with the proposed development including the suitability of the existing junctions against Austroads standards, the associated need for upgrades and interruptions to traffic flow on the Princes Highway; and
    - The identification of any suitable infrastructure required to ameliorate any traffic impacts and safety impacts associated with the development including the provision of supporting plans.
- Intersection modelling using SIDRA needs to be undertaken for the intersections of the Princes Highway and Riverside Drive to demonstrate that an acceptable level of service is maintained and assist in determining if upgrade works are required to facilitate the proposed development. The intersection modelling needs to give consideration to the following:

- Full development of the site.
- AM and PM peaks volumes.
- Existing traffic volumes with and without development and 10 year projected volumes with and without the development.
- The base SIDRA models must be calibrated with on site observations in the AM and PM peak. This can be done by measuring existing queue lengths and delays.
- Electronic copies of all SIDRA files needs to be provided to RMS for review

Further consultation can be had with RMS during preparation of the abovementioned study if required. If you have any questions please contact Melissa Steep on 4221 2771.

Please ensure that any further email correspondence is sent to development.southern@rms.nsw.gov.au.

Yours faithfully,

Chris Millet
Manager Land Use
Southern Region

Build something great™

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PO Box 6041
NORTH RYDE
NSW 2113

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F: +61 (02) 9033 5505

3 December 2018

Calvin Houlison
Senior Conservation Planning Officer, Planning (Illawarra)
Office of Environment and Heritage
Level 3, 84 Crown Street, Wollongong, NSW, 2500

Email: calvin.houlison@environment.nsw.gov.au

Dear Calvin,

DUNMORE LAKES SAND AND SOIL OPERATION – MODIFICATION 2 TO EXISTING APPROVAL - NOTICE OF CONSULTATION

Boral Resources (NSW) Pty Ltd (Boral) is proposing to modify the existing approval for the Dunmore Sand & Soil (DSS) operations located in Tabbitta Road, Dunmore, approximately three kilometres south-south west of Shellharbour and seven kilometres north of Kiama.

DSS has investigated a fine sand resource on an adjoining private property (471 Riverside Drive, Dunmore) to the south and confirmed there is sufficient resource to support three to four more years of extraction over two staged areas (5A and 5B).

In order to meet the demand for a consistent and continuous supply of sand to the Sydney market, Boral proposes to develop these two additional extraction areas. Stage 5A is positioned immediately south of Riverside Drive, while Stage 5B is located to the north of the Minnamurra River.

Mobile plant and equipment would be installed to support extraction at both Stage 5A and 5B. Extraction methods would be identical to those currently implemented at the existing DSS operations.

Extraction from the site would be conducted via dredging of the established resource pits, with collected sand material pumped to the existing operations in Tabbitta Road, traversing land owned by DSS, and freeway reservation space controlled by the NSW Roads and Maritime Services (RMS). The pipeline route and construction methodology is still being finalised in consultation with the RMS.

There would be **no** alteration to the existing site's hours of operation associated with the addition of the Stage 5 extraction area. Similarly, the current output limit of 800 000 tonnes per annum would continue following approval of the modification.

The modification would not increase the current hourly or daily traffic volumes associated

with dispatch of processed sand products given the production limit of the Approved Project would not be altered.

However, the modification would introduce temporary additional heavy vehicle movements along the Princes Highway and Riverside Drive associated with importation of fill material to the Stage 5A extraction area.

Boral is seeking consent for the modification through the NSW Department of Planning and Environment.

As part of preparing the specialist studies and subsequent application, Boral is seeking to consult relevant stakeholders via this letter. Any response received in return will be taken into consideration as the application is finalised.

If you or your colleagues have any questions, or would like to discuss the proposal in more detail, please feel free to contact me on **0401 897 486** or **adnan.voloder@boral.com.au**.

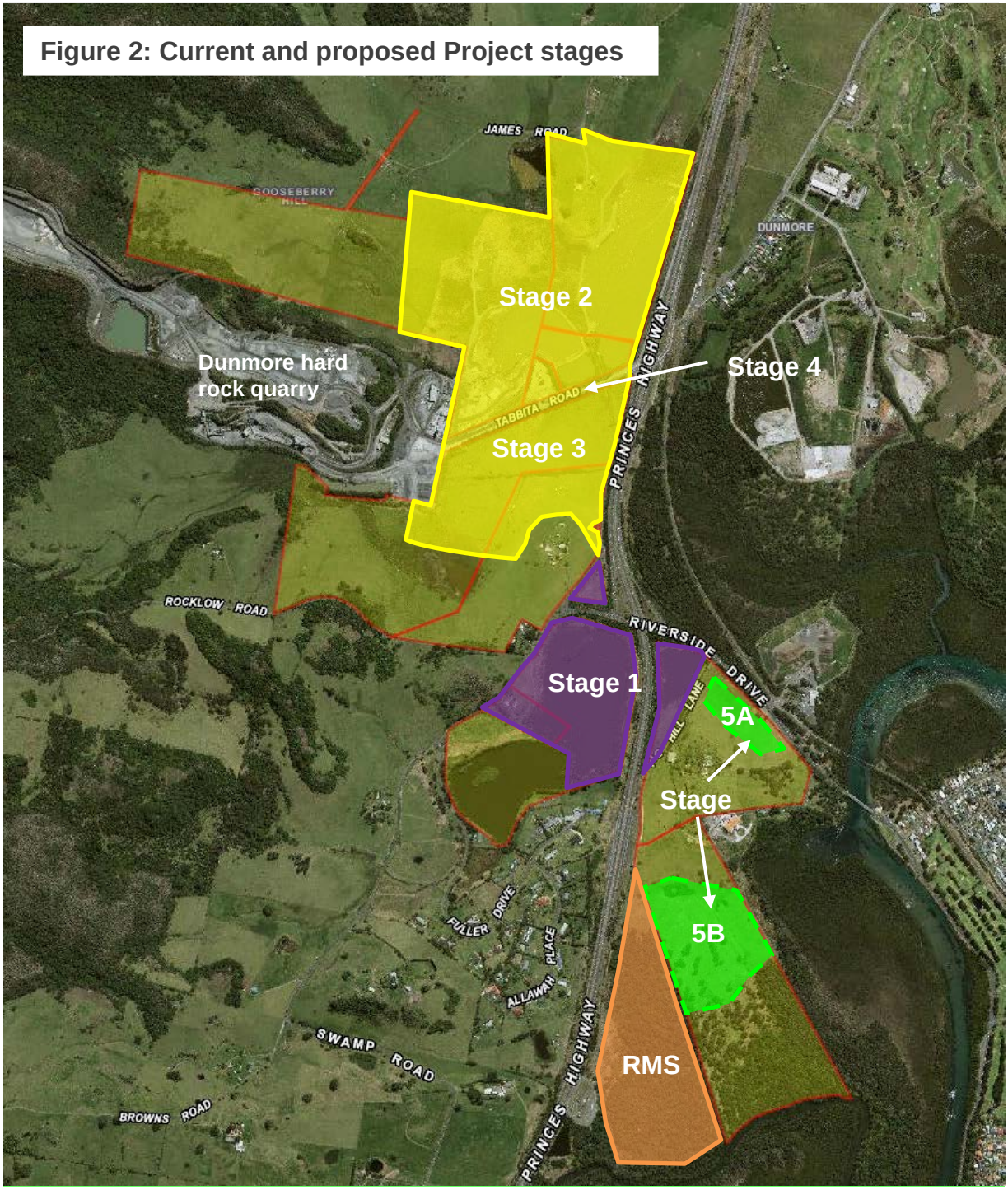
Alternatively, if your organisation has no comments or concerns and are satisfied to await the exhibition of the proposal (to be further notified when dates are determined), we'd appreciate a response to this effect.

We are hoping to gather all responses to the proposal by **14 December**. Thank you for your interest in this letter – we look forward to hearing from you soon.

Yours sincerely,

Adnan Voloder
Planning & Development Manager (NSW & ACT)
Boral Land & Property Group

Figure 2: Current and proposed Project stages



From: Luke Farrell
To: Luke Farrell
Subject: RE: Dunmore Sand and Soil - Additional Extraction Area Project
Date: 19 February 2019 10:33:19

---------- Forwarded message ---------
From: **Calvin Houlison** <Calvin.Houlison@environment.nsw.gov.au>
Date: Tue, 4 Dec 2018 at 4:12 pm
Subject: RE: Dunmore Sand and Soil - Additional Extraction Area Project
To: Voloder, Adnan <adnan.voloder@boral.com.au>

Hi Adnan

Thank you for sending through the attached request for input into Modification 2 sand extraction. In response, comments are provided below:

- The proposed extraction areas at Stages 5A and 5B appear to result in the clearing of scattered trees, and is adjacent to areas of Illawarra Lowlands Grassy Woodland and Bangalay Sand Forest threatened ecological communities. Direct and indirect impacts upon biodiversity should be assessed in accordance with the NSW Biodiversity Conservation Act 2016 and documented in a Biodiversity Development Assessment Report (BDAR). The extent of the EECs should be ground truthed in accordance with OEH survey guidelines, and the proposal's impacts upon these EECs should be quantified in the environmental assessment (EA). We recommend that impacts upon biodiversity are avoided or mitigated wherever possible, with any residual impacts to be offset in accordance with the Biodiversity Assessment Method (BAM).
- The site is located within a landscape of high Aboriginal cultural heritage sensitivity, and a number of AHIMs-listed sites are located within the surrounds. We recommend an Aboriginal Cultural Heritage Assessment Report (ACHAR) be carried out in accordance with relevant OEH guidelines, namely the *Code of Practice for Archaeological Investigation of Aboriginal Objects in NSW* (2010) and the *Guide to investigating, assessing and reporting on Aboriginal cultural heritage in NSW* (2011). Consultation should be undertaken and documented in accordance with the *Aboriginal cultural heritage consultation requirements for proponents* (2010). Given the landscape sensitivity, we would welcome the opportunity for further early consultation regarding the proposed investigations including any test excavations that may be required.
- The EA should demonstrate how the proposal is consistent with the SEPP (Coastal Management) 2018 and contributes to maintaining water quality objectives in sensitive receiving waters of the nearby Minnamurra River estuary. Surface and groundwater assessments should be undertaken as part of the EA to quantify the proposal's impact on water quality.

We request an opportunity to review and comment on the proposed modification once it has been lodged with the Department of Planning & Environment. Finally please note that this advice is preliminary only based on the limited information presented, and does not bind OEH to a position once the modification is lodged.

I'm happy to discuss any of the above further should you require.

regards

Calvin Houlison
Senior Conservation Planning Officer, Planning (Illawarra)
South East Branch
Conservation and Regional Delivery Division
Office of Environment and Heritage
Block D, Level 3, 84 Crown Street, Wollongong, NSW, 2500
PO Box 513, Wollongong, NSW, 2520
T: 02 4224 4179
E: calvin.houlison@environment.nsw.gov.au

From: Voloder, Adnan <adnan.voloder@boral.com.au>
Sent: Monday, 3 December 2018 3:08 PM
To: Calvin Houlison <Calvin.Houlison@environment.nsw.gov.au>
Subject: Dunmore Sand and Soil - Additional Extraction Area Project

Dear Calvin,

Please find attached a document outlining the proposed modification to the Dunmore Sand and Soil operations.

We are seeking your comment during this early stage of the preparation of our application, in order to address any concerns your Department may have.

If you require any further information, please let me know.

Look forward to hearing from you soon.

Cheers.

Kind regards,

ADNAN VOLODER
Planning & Development Manager (NSW & ACT)
Telephone: 02 9033 5535
Mobile: 0401 897 486
Email: adnan.voloder@boral.com.au

Boral Land & Property Group
PO Box 6041
North Ryde NSW 2113

www.boral.com.au

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Any views expressed in this email are those of the individual sender except where the sender expressly and with authority states them to be the views of the NSW Office of Environment and Heritage.

PLEASE CONSIDER THE ENVIRONMENT BEFORE PRINTING THIS EMAIL

--

Kind regards,

ADNAN VOLODER Planning and Development Manager (NSW & ACT) Telephone: 02 9033 5535 Mobile: 0401 897 486 Email: adnan.voloder@boral.com.au

Inline images

Boral Property Group
PO Box 6041 North Ryde NSW 2113 www.boral.com.au

Inline images

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3 December 2018

Wayne Conners
Senior Water Regulation Officer
WaterNSW
Level 11, 10 Valentine Ave
Locked Bag 5123
Parramatta NSW 2124

Email: wayne.conners@waternsw.com.au

Dear Wayne,

DUNMORE LAKES SAND AND SOIL OPERATION – MODIFICATION 2 TO EXISTING APPROVAL - NOTICE OF CONSULTATION

Boral Resources (NSW) Pty Ltd (Boral) is proposing to modify the existing approval for the Dunmore Sand & Soil (DSS) operations located in Tabbitta Road, Dunmore, approximately three kilometres south-south west of Shellharbour and seven kilometres north of Kiama.

DSS has investigated a fine sand resource on an adjoining private property (471 Riverside Drive, Dunmore) to the south and confirmed there is sufficient resource to support three to four more years of extraction over two staged areas (5A and 5B).

In order to meet the demand for a consistent and continuous supply of sand to the Sydney market, Boral proposes to develop these two additional extraction areas. Stage 5A is positioned immediately south of Riverside Drive, while Stage 5B is located to the north of the Minnamurra River.

Mobile plant and equipment would be installed to support extraction at both Stage 5A and 5B. Extraction methods would be identical to those currently implemented at the existing DSS operations.

Extraction from the site would be conducted via dredging of the established resource pits, with collected sand material pumped to the existing operations in Tabbitta Road, traversing land owned by DSS, and freeway reservation space controlled by the NSW Roads and Maritime Services (RMS). The pipeline route and construction methodology is still being finalised in consultation with the RMS.

There would be **no** alteration to the existing site's hours of operation associated with the addition of the Stage 5 extraction area. Similarly, the current output limit of 800 000 tonnes per annum would continue following approval of the modification.

The modification would not increase the current hourly or daily traffic volumes associated with dispatch of processed sand products given the production limit of the Approved Project would not be altered.

However, the modification would introduce temporary additional heavy vehicle movements along the Princes Highway and Riverside Drive associated with importation of fill material to the Stage 5A extraction area.

Boral is seeking consent for the modification through the NSW Department of Planning and Environment.

As part of preparing the specialist studies and subsequent application, Boral is seeking to consult relevant stakeholders via this letter. Any response received in return will be taken into consideration as the application is finalised.

If you or your colleagues have any questions, or would like to discuss the proposal in more detail, please feel free to contact me on **0401 897 486** or **adnan.voloder@boral.com.au**.

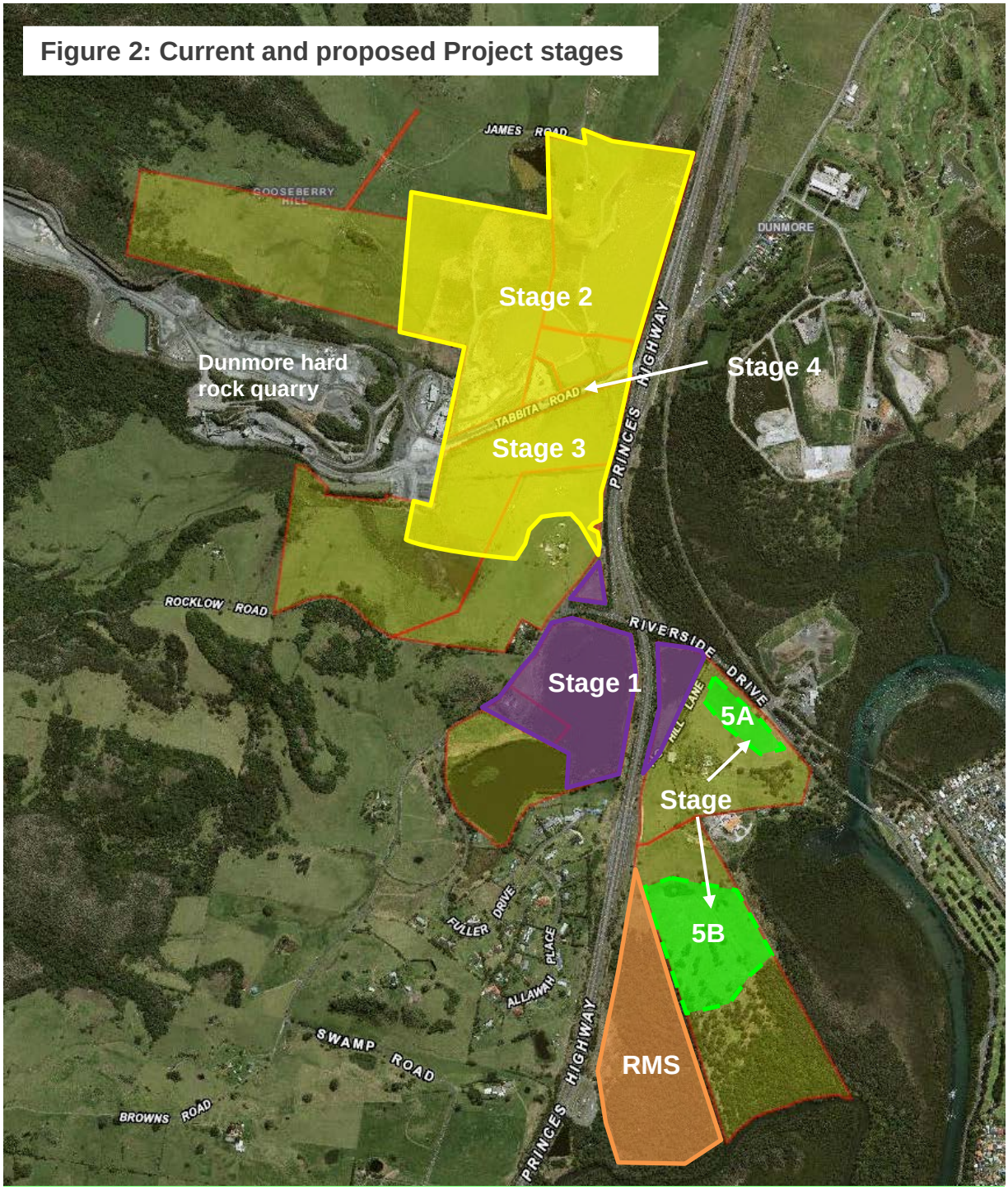
Alternatively, if your organisation has no comments or concerns and are satisfied to await the exhibition of the proposal (to be further notified when dates are determined), we'd appreciate a response to this effect.

We are hoping to gather all responses to the proposal by **14 December**. Thank you for your interest in this letter – we look forward to hearing from you soon.

Yours sincerely,

Adnan Voloder
Planning & Development Manager (NSW & ACT)
Boral Land & Property Group

Figure 2: Current and proposed Project stages



From:	Luke Farrell
To:	Luke Farrell
Subject:	RE: FW: Dunmore Sand and Soil - Additional Extraction Area Project
Date:	19 February 2019 10:35:28
Attachments:	image002.png

---------- Forwarded message ---------
From: **Martin Holland** <Martin.Holland@waternsw.com.au>
Date: Wed, 30 Jan 2019 at 15:39
Subject: Re: FW: Dunmore Sand and Soil - Additional Extraction Area Project
To: Voloder, Adnan <adnan.voloder@boral.com.au>
Cc: Wayne Conners <Wayne.Conners@waternsw.com.au>

Hi Adnan,

I have been advised that NRAR (Natural Resources Access Regulator) have been involved in the first development application regarding the issue of the initial controlled activity approval, and other matters.
As the approving body is the NSW Dept of Planning, this makes sense as it is State Significant Development.
Accordingly, the information received reflects that NRAR have again been referred this new amendment to the original DA. Although the matter hasn't been assigned to any particular officer yet, I'm confident that upon review, if WaterNSW is required to be involved – NRAR will advise us consequently.

You can contact NRAR on –
Website: www.industry.nsw.gov.au/natural-resources-access-regulator,
Email: nrar.enquiries@nrar.nsw.gov.au and
Phone: 1800 633 362.

My initial interpretation of the development amendment is that if there is a requirement to take and use more ground water for production, then WaterNSW might be called upon to assist in advising on increasing your current entitlement (65ML) to account for this.

If you have any other concerns or questions, please give me a call.

Thanks.

Regards,

Martin Holland
Water Regulation Officer
Assessments and Approvals
Customer and Community

WaterNSW
Ground Level

5 O'Keefe Avenue
Nowra NSW 2541
T: 02-98652831 **M:** 0413 186 719
martin.holland@waternsw.com.au
www.waternsw.com.au

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F: +61 (02) 9033 5505

5 February 2019

Natural Resources Access Regulator (NRAR)

Email: nrar.enquiries@nrar.nsw.gov.au

Dear Sir/Madam,

DUNMORE LAKES SAND AND SOIL OPERATION – MODIFICATION 2 TO EXISTING APPROVAL - NOTICE OF CONSULTATION

Boral Resources (NSW) Pty Ltd (Boral) is proposing to modify the existing approval for the Dunmore Sand & Soil (DSS) operations located in Tabbitta Road, Dunmore, approximately three kilometres south-south west of Shellharbour and seven kilometres north of Kiama.

DSS has investigated a fine sand resource on an adjoining private property (471 Riverside Drive, Dunmore) to the south and confirmed there is sufficient resource to support three to four more years of extraction over two staged areas (5A and 5B).

In order to meet the demand for a consistent and continuous supply of sand to the Sydney market, Boral proposes to develop these two additional extraction areas. Stage 5A is positioned immediately south of Riverside Drive, while Stage 5B is located to the north of the Minnamurra River.

Mobile plant and equipment would be installed to support extraction at both Stage 5A and 5B. Extraction methods would be identical to those currently implemented at the existing DSS operations.

Extraction from the site would be conducted via dredging of the established resource pits, with collected sand material pumped to the existing operations in Tabbitta Road, traversing land owned by DSS, and freeway reservation space controlled by the NSW Roads and Maritime Services (RMS). The pipeline route and construction methodology is still being finalised in consultation with the RMS.

There would be **no** alteration to the existing site's hours of operation associated with the addition of the Stage 5 extraction area. Similarly, the current output limit of 800 000 tonnes per annum would continue following approval of the modification.

The modification would not increase the current hourly or daily traffic volumes associated with dispatch of processed sand products given the production limit of the Approved Project would not be altered.

However, the modification would introduce temporary additional heavy vehicle movements along the Princes Highway and Riverside Drive associated with importation of fill material to the Stage 5A extraction area.

Boral is seeking consent for the modification through the NSW Department of Planning and Environment.

As part of preparing the specialist studies and subsequent application, Boral is seeking to consult relevant stakeholders via this letter. Any response received in return will be taken into consideration as the application is finalised.

We previousl engaged with WaterNSW in November 2018, however have only received advice from the authority that we are to engage with yourselves (NRAR), last week. Whilst we understand that this is through no fault of NRAR, the extensive delays we have experienced in the late response from WaterNSW, requires us to expedite our consultations you with.

If you or your colleagues have any questions, or would like to discuss the proposal in more detail, please feel free to contact me on **0401 897 486** or **adnan.voloder@boral.com.au**.

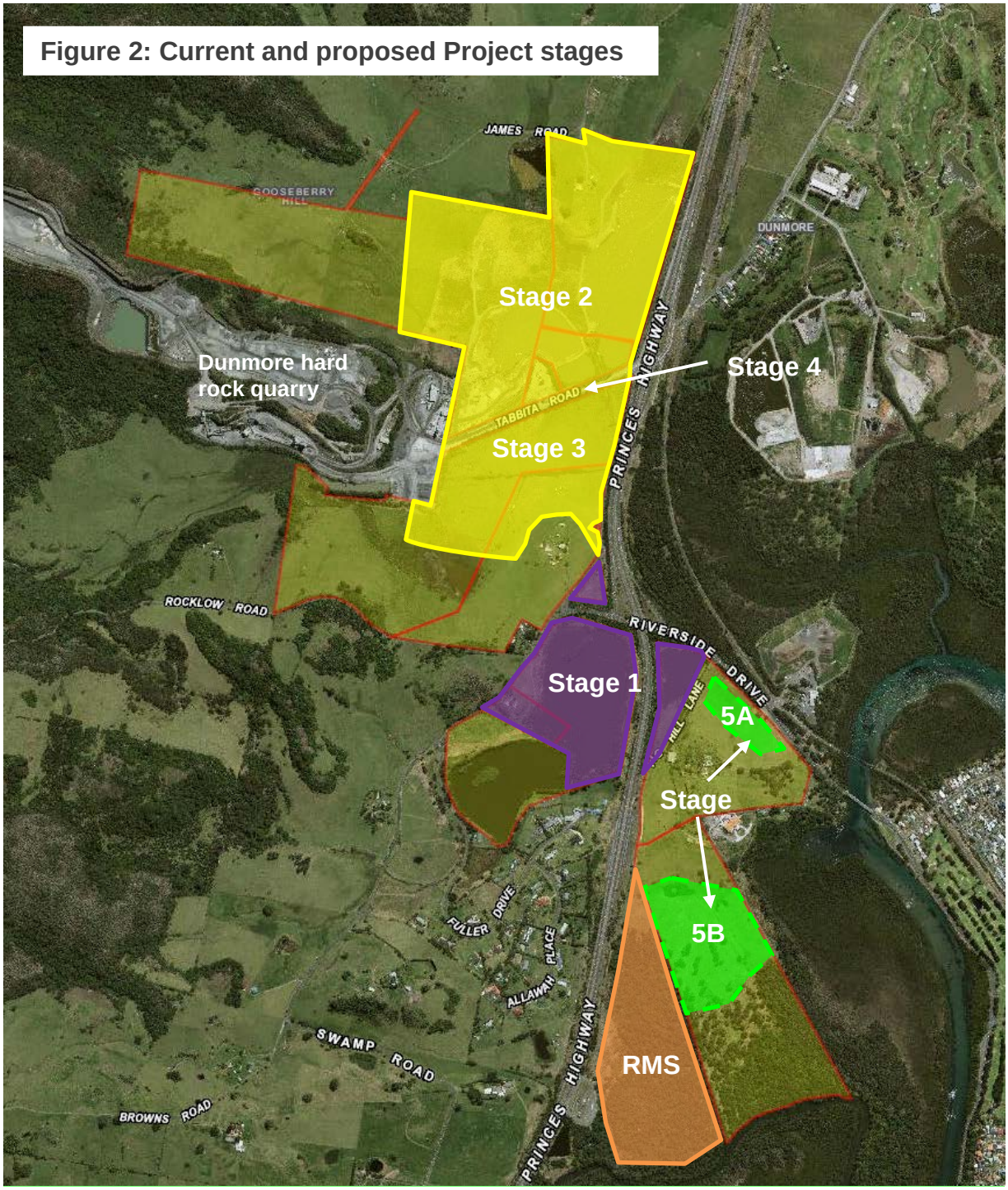
Alternatively, if your organisation has no comments or concerns and are satisfied to await the exhibition of the proposal (to be further notified when dates are determined), we'd appreciate a response to this effect.

We are hoping to gather your response to the proposal by **12 February**. Thank you for your interest in this letter – we look forward to hearing from you soon.

Yours sincerely,

Adnan Voloder
Planning & Development Manager (NSW & ACT)
Boral Land & Property Group

Figure 2: Current and proposed Project stages



From:	Luke Farrell
To:	Luke Farrell
Subject:	RE: ACTION REQUIRED CSP611992 - NRAR - URGENT - Dunmore Sand and Soil - Additional Extraction Area Project
Date:	19 February 2019 10:35:42
Attachments:	image003.png

---------- Forwarded message ---------
From: **Water Referrals** <water.referrals@nrar.nsw.gov.au>
Date: Tue, 19 Feb 2019 at 10:15
Subject: Re: ACTION REQUIRED CSP611992 - NRAR - URGENT - Dunmore Sand and Soil - Additional Extraction Area Project
To: <adnan.voloder@boral.com.au>

Hello Adnan

Thank you for reaching out to NRAR. We will review your final documents when they are submitted to DP&E, due to the current resource constraints.

Best regards
Joanna Pajkowska

Water Referrals

Natural Resources Access Regulator | NSW Department of Industry
10 Valentine Avenue | Parramatta NSW 2150 | Locked Bag 5123 | Parramatta NSW 2124
T: 1800 633 362 | E: water.referrals@nrar.nsw.gov.au
W: www.water.nsw gov.au | www.industry.nsw.gov.au

Requests for review or comment on reports or specific projects can be sent directly to water.referrals@nrar.nsw.gov.au for action.

We work flexibly. *If you have received an email from me outside of normal business hours, I'm sending it at a time that suits me. Unless it's urgent, I'm not expecting you to read or reply until normal business hours.*

On Wed, 6 Feb 2019 at 13:16, NRAR ServiceDesk <nrar.servicedesk@industry.nsw.gov.au> wrote:

> Natural Resources Access Regulator | Lands & Water Division | Department of Industry
> Locked Bag 5123, Parramatta NSW 2124

T: 1800 633 362
E: nrar.enquiries@nrar.nsw.gov.au
W: www.industry.nsw.gov.au/nrar

---------- Forwarded message ---------
From: <csp.servicecentre@industry.nsw.gov.au>
Date: Tue, 5 Feb 2019 at 10:40
Subject: ACTION REQUIRED CSP611992 - NRAR - URGENT - Dunmore Sand and Soil - Additional Extraction Area Project
To: <nrar.servicedesk@industry.nsw.gov.au>

Hi NRAR Service Desk

Please review the following details:

Description: Customer Name - Adnan Voloder

Phone Number - 0401897486

Email Address - adnan.voloder@boral.com.au

Location -

Reference No (if applicable) -

Details -

_____

Dear Sir/Madam,

Please find attached a document outlining the proposed modification to the Dunmore Sand and Soil operations.

We are seeking your comment as part of the preparation of our application, in order to address any concerns your Department may have.

If you require any further information, please let me know.

Look forward to hearing from you soon.

Kind regards,

ADNAN VOLODER

Planning & Development Manager (NSW & ACT)

Telephone: 02 9033 5535

Mobile: 0401 897 486

Email: adnan.voloder@boral.com.au

Boral Land & Property Group

PO Box 6041

North Ryde NSW 2113

www.boral.com.au

.

Call Source: E-mail

Closing product name: NRAR - Licensing

Created Date Time: 5/02/2019 10:25 AM

Incident ID: CSP611992

Customer: Adnan Voloder

Customer email:

Customer Emp No:

Customer Location:

Customer mobile: 0401897486

Customer's Phone:

Close Description:

CSP Service Centre
Corporate Service Partners
NSW Department of Industry

T: 02 6363 7676
E: csp.servicecentre@industry.nsw.gov.au
W: http://intranet.industry.nsw.gov.au

{CMI: MCID1413758}

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APPENDIX D

HYDROGEOLOGICAL IMPACT ASSESSMENT REPORT

ENVIRONMENTAL EARTH SCIENCES
CONTAMINATION RESOLVED

HYDROGEOLOGICAL IMPACT ASSESSMENT, DUNMORE LAKES SAND EXTRACTION PROJECT MODIFICATION 2 (STAGE 5), DUNMORE, NSW

ELEMENT ENVIRONMENT

9 APRIL 2019
118044
VERSION 6

ENVIRONMENTAL EARTH SCIENCES
CONTAMINATION RESOLVED

9 April 2019

Element Environment
PO Box 1563
Warriewood NSW 2120

Attention: **Mr Luke Farrell**
Senior Environmental Consultant

Dear Luke

Hydrogeological Impact Assessment at Boral Dunmore Sand & Soil – Stage 5, NSW

Please find enclosed a copy of our report entitled as above. Thank you for the opportunity to undertake this work.

If you have any queries concerning the investigation or the report, please contact the undersigned.

For and on behalf of
Environmental Earth Sciences NSW

Project Manager / Author
Elin Griffiths
Associate Hydrogeologist

Project Director / Internal Reviewer
Mark Stuckey
Senior Principal Hydrogeologist

118044_v6

EXECUTIVE SUMMARY

Introduction and scope

Dunmore Sand and Soil (DSS) is seeking to modify the current Project Approval (DA 195-8-2004) under Section 75W of the Environmental Planning and Assessment Act 1979 (EP&A Act), to provide for an additional extraction area (Stage 5) on adjoining private land, encompassing two separate extraction areas, Stage 5A located at 471 Riverside Drive, and Stage 5B located at 69 Fig Hill Lane, Dunmore (hereafter referred to as the 'Site').

It is understood that following approval of the proposed modification, up to 800,000 tpa of sand will continue to be extracted across the DSS operations via dredging for commercial sale. The Proposal consists of an area to be disturbed of approximately 12 hectares. The excavation formed would be rehabilitated on completion of the sand extraction activities. Following extraction of the sand in Stage 5A, it is proposed that the excavation would be rehabilitated with appropriately characterised material, it is intended that Stage 5B area remain as a pond and be rehabilitated for wetland purposes.

The objective of this report is to assess potential groundwater impacts during the establishment, operation and decommissioning of the proposed Stage 5 sand extraction area.

Conceptual site model summary

The Proposal is situated on the northern boundary of an unconfined aquifer system that extends along the course of the Minnamurra River. The aquifer is predominantly unconfined and at present, is less than two metres below the surface. Rainfall recharge is expected to be rapid, with infiltration estimated at around 70 per cent. Despite this, moderate to high intensity rainfall events that are regular occurrences will rapidly fully charge the Site aquifer, resulting in 100 per cent run-off (zero recharge or infiltration) in such situations.

Groundwater flow is influenced by topography and regional recharge / discharge zones. In the vicinity of the Site, the hydraulic gradient is expected to be towards the north-east. It is expected that only the upper one to two metres of the aquifer, where the sand is orange/ brown/ white in colour, will experience groundwater movement. Deep groundwater below this depth within the grey sands is expected to undergo little movement.

An immediate response of water-table levels to rainfall recharge is expected, with return of the water-table to pre-elevated levels expected to occur within an approximate one- to two-month timeframe.

Aquifer testing confirms that the unconfined aquifer beneath the Site is very permeable (K values between 3-30 m/day and transmissivity values up to 180 m^2/day), but that due to the low hydraulic gradients, groundwater velocities are relatively low (20-110 m/year). Groundwater flux (Q) is estimated at 675 m3/day (250 ML/a) and the Site aquifer is estimated to account for <0.21 per cent of total catchment discharge.

Collection of physical information from the Site is supported by chemical data. From a water quality perspective, groundwater beneath the Site has a generally neutral pH and is fresh to slightly brackish, with low concentrations of dissolved metals. It is noted that ambient

concentrations are occasionally outside currently consented water quality objectives in Condition 24 for adjacent site (Stage 2-4).

The oxidation-reduction potential results (ORP) confirm the reducing and oxygen depleted nature of this aquifer, which supports the physical assessment that there is very little groundwater movement through this Site, particularly percolation of oxygenated surface recharge water.

On the basis of total dissolved salts (TDS), Sodium (Na), Chloride (Cl) and sulfate (SO_4) levels, groundwater in the alluvial aquifer beneath the Site is suitable for stock watering use, with some locations also suitable for drinking and irrigation use. Dissolved metal concentrations are suitable for all uses other than manganese (Mn) for irrigation at bores MW5A2 and MW5A3. Nitrate (NO_3) narrowly exceeded ecosystem criteria at bore MW5B1, and all other exceedances were aesthetic only.

Impact assessment summary

The proposed operations at the site have the potential to impact groundwater. For example, impacts may result from the establishment of the sand extraction site, extraction of sand, deposition of VENM within the excavated area, and rehabilitation of the area.

The findings of this report have determined that as groundwater movement accounts for less than 0.21 per cent of catchment drainage, excavation of the aquifer sediments should have no discernible effect on catchment hydrology other than increasing the area available for water storage on the Site, particularly in the Stage 5B area. Subsequent reinstatement of excavated areas of the Stage 5A area will simply reduce this temporarily increased storage volume back to near pre-excavation levels.

The greatest risk to the groundwater resource and its identified receptors has been determined to be chemical impact as a result of oxidation and subsequent acidification of in situ PASS.

Mitigation and Monitoring

Soil

Given the presence of known PASS in Stage 5A and the risk of oxidation of PASS material should, it is recommended an Acid Sulfate Soil Management Plan (ASSMP) should be prepared for the Stage 5 extraction area. All material to be used in the rehabilitation of Stage 5 is to be non-PASS VENM. Receival protocols will be addressed within the existing Waste Management Plan for DSS, which is to be reviewed and updated to include the backfilling of Stage 5A and wetland rehabilitation of Stage 5B.

Groundwater

Groundwater monitoring and mitigation requirements will be included in an update to the existing GWMP which is a sub-plan to the Water Management Plan (WMP) prepared in accordance with Schedule 3(34) for Development Consent DA 195-8-2004 (2004) for Stages 2-4.

ENVIRONMENTAL EARTH SCIENCES
CONTAMINATION RESOLVED

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1 INTRODUCTION

1.1 Background

Stage 1 of the Dunmore Lakes Sand Project was issued development consent from the then Minister for Planning in 1999. Stage 1 was on Swamp Road, Dunmore, and encompassed sand extraction by dredging of up to 500,000 tonnes per annum (tpa) for a period of 10 years. The Stage 1 consent included conditions requiring the proponent to lodge a further application for the remaining identified stages of the Dunmore sand resource (being Stages 2 to 4).

The application for Stages 2 to 4 was lodged in 2004, and development consent was received from the Minister for Planning in June 2005. The consent approves extraction of up to 800,000 tpa of sand for a period of 25 years. Boral Resources (NSW) Pty Ltd (hereafter 'Boral') purchased Dunmore Sand & Soil Pty Ltd (DSS), including the Dunmore Lakes Sand Project in mid-2005. The Stage 1 consent has since lapsed following successful extraction of the approved sand resource and rehabilitation of the site in 2010.

Stages 2 to 4 commenced dredging in June 2007. Since then, due to the high demand for sand in the Sydney market, the majority of sand in Stage 2 has been extracted with dredging recently moving into Stage 3. Given recent high demand, the sand resource in Stage 3 is expected to be exhausted in approximately eight to twelve months. The last extraction stage (Stage 4) encompasses an area containing the site's road access and private rail line and supporting infrastructure for the Stage 2 to 4 operations and Boral's adjacent Dunmore hard rock quarry. As such, extraction in this Stage may not commence until future relocation of this infrastructure. This has led DSS to investigate other local sources of sand to continue operations beyond Stage 3.

DSS has been investigating a fine sand resource on an adjoining private property to the south. Investigative drilling has confirmed that there is sufficient sand resource to support three to four more years of extraction from two areas (Stage 5A and 5B).

As such, DSS is seeking to modify the current Project Approval (DA 195-8-2004) under Section 75W of the *Environmental Planning and Assessment Act 1979* (EP&A Act), to provide for an additional extraction area (Stage 5) on adjoining private land, encompassing two separate extraction areas, Stage 5A and Stage 5B (hereafter referred to as the 'Proposal').

Stage 5A is located at 471 Riverside Drive, Dunmore and Stage 5B is located at 69 Fig Hill Lane, Dunmore (the Site). See **Figure 1** for location. It is understood that following approval of the proposed modification, up to 800,000 tonnes per annum of sand will continue to be extracted across the DSS operations via dredging for commercial sale.

Environmental Earth Sciences were commissioned by Element Environment, on behalf of Boral Dunmore Sand and Soil Pty Ltd (DSS), to undertake a study of groundwater physics and chemistry, and an assessment of the sulfidic sediments of proposed Stage 5A and Stage 5B extraction areas.

The study of the Site was conducted to establish the potential impacts (if any) of the proposed sand extraction operations on the surrounding ground and surface water

resources. This investigation focussed upon sediments and associated groundwater of the unconfined sand aquifer system beneath the Site.

A resource exploration report undertaken by Boral (Boral, April 2016) estimated that approximately 234,000 tonnes from Stage 5A and 1,123,000 tonnes from Stage 5B of sand is available for commercial sale.

The purpose of this report is to assess the for potential groundwater impacts associated with the proposal, as outlined in Section 2 below.

It is noted that a significant amount of hydrogeological assessment and monitoring, including impact assessment, has been performed across the wider Dunmore Sands Aquifer area to the north of Stage 5. This information includes data on groundwater chemistry and behaviour that has been collected on at least a quarterly basis by Environmental Earth Sciences since 1992 (for Shellharbour City Council, Boral, and DSS).

1.2 Objectives and scope of works

The objectives of this report are to describe the local hydrogeological setting within the areas of potential impact, to assess the potential impacts and recommend controls and mitigation measures.

The scope of works was a dual approach, incorporating both the collection of site-specific data for the Stage 5 extraction area, and utilising the existing data from Stage 1-4, Dunmore Recycling and Waste Disposal Depot (DRWDD) and former Buckley's Road Quarry areas to the north.

An Acid Sulfate Soil Impact Assessment (ASS) has been provided by Environmental Earth Sciences (Environmental Earth Sciences, 2019). The results of this report are not duplicated herein. It is recommended that this report be read in conjunction with the ASS report.

1.2.1 Existing environment

The first component of works (review of existing data for the local aquifer) in the preparation of a Hydrogeological Impact Assessment report, is to be undertaken using an analytical approach to allow development of a water balance for the aquifer, and subsequent assessment of the potential impacts associated with the proposed works under varying climatic conditions.

This has been supplemented by a second component of works, carried out by Environmental Earth Sciences comprising:

- Installation of a groundwater monitoring bore network at Stage 5;
- Physical aquifer testing on installed bores to determine aquifer parameters;
- Implementation of a groundwater monitoring program to assess changes in groundwater levels and chemistry over time under varying climatic conditions; including
    - Installation of permanent groundwater pressure transducer loggers in select bores to assess groundwater level responses to climatic conditions.

1.2.2 Potential impacts

Once the existing environment is characterised, potential impacts as part of the proposed development can be assessed. These are likely to be associated with excavation of the sand resource to expose the aquifer to enhanced recharge and evaporative losses, which could result in changes to baseflow conditions and quality in the Minnamurra River and other potential receptors (such as stock watering, irrigation and recreational water use).

Based on previous investigations and annual data reviews for Stage 2-4, sand extraction activities have not adversely affected water levels. Previous reports carried out at adjacent sites are summarised in **Table 2**.

1.3 Description of the proposal

The approved operations include extraction and transportation of up to 800,000 tonnes of sand products per annum from Stage 2 to 4 over a period of 25 years. The project forms a modification to the approved project through the establishment of additional extraction areas (Stage 5) on adjoining private property which is to be leased by DSS.

The project would involve establishment of the sand extraction site, extraction of sand from Stages 5A and 5B area by excavator and dredge and pumping it to the existing processing area on Stage 2 for washing, stockpiling and dispatch.

Fines from the washing process would continue to be placed in the Stage 2 fines pond, however, return water would be pumped back to the Stage 5 ponds. Although there would be an increase in the disturbance footprint of the Project and inclusion of additional land, there will be no changes sought to the annual production limit or consent life.

2 SITE OVERVIEW

2.1 Introduction

Existing groundwater information is available around the Site from registered bores and previously conducted groundwater investigation (including long-term on-going water quality and level monitoring). Information prior to the field works included a registered groundwater bore search for nearby bores within a 1km radius of the site and review of previous studies carried out within the area surrounding the site.

2.2 Site Setting

2.2.1 Site locality and surrounding land use

The Site is located off Princes Highway, 30 km south of Wollongong. The project area comprises 2 parcels of land approximately 1 km to the south-east of existing DSS (Stage 2-4) and quarry operations. The existing DSS Stage 2-4 operations is currently approved for extraction of tsunami sand deposits. **Table 1** below presents key identification features of the project area. The site location and context is illustrated on **Figures 1 and 2**.

Table 1: Site details

Item	Details Stage 5A	Details Stage 5B
Site Owner	Private landowner	Private landowner
Address	471 Riverside Drive, Dunmore NSW	69 Fig Hill Lane, Dunmore NSW
Lot & Plan number	Lot 501 DP1174897	Lot 51 DP1012246
Area	Approximately 3.42 hectares	Approximately 8.12 hectares
Proposed sand resource	234,000 tonnes	1,123,000 tonnes
Zoning	RU2 – Rural Landscape	Part RU2 – Rural Landscape Part E3 – Environmental Management
Proposed land use	Extraction of natural resources (sand)	Extraction of natural resources (sand)
Local Government Authority	Shellharbour City Council	Shellharbour City Council
Site Location and Layout	Figure 1 and Figure 2	Figure 1 and Figure 2

2.2.2 Site history

The Site is situated in a predominantly rural area and has been used for cattle grazing throughout its reported history, however, there is an increasing residential and industrial presence in the Shellharbour-Dunmore-Kiama region.

Activities surrounding the Site include two municipal waste depots to the north-east, sand extraction operations, and a hard rock quarry to the north-west of the site (**Figure 1**).

2.2.3 Registered groundwater bore search

Environmental Earth Sciences conducted a search of the BOM Australian interactive groundwater explorer (Beaureau of Meterology, 2019). Bores were identified within a 1 km radius of the Proposal, results of which are summarised in **Appendix B**.

2.2.4 Sensitive groundwater users and groundwater dependent ecosystems (GDEs)

Further assessment of groundwater usage is provided in Section 4.8 of this report. As part of the desktop assessment for the Proposal, investigations into the potential for the presence of GDEs in the vicinity of the Project Site were undertaken. Based on information provided in BOM (2018), a map for the site and surrounding catchments was generated and has been provided as **Figure 7**.

ENVIRONMENTAL EARTH SCIENCES CONTAMINATION RESOLVED		Title:	Site Locality Map
		Location:	Boral Dunmore Sand and Soil - Stage 5
Client:	Element Environmental		Job No: 118044
Project Man:	EG	Scale:	As Shown
Drawn By:	LB	Date:	January 2019
			Figure 1

MW5A3
A
MW5A2
MW5A1
PRINCES HIGHWAY
RIVERSIDE DRIVE
Minnamurra River
MW5B1
MW5B4
B
MW5B3
MW5B2-D
MW5B2-S
MW5B5
Minnamurra River
Source: © NSW Globe 2018
LEGEND:
Lot boundary
Monitoring well location
Latite
0
250
Scale in Metres
ENVIRONMENTAL EARTH SCIENCES
CONTAMINATION RESOLVED
Title: Site Layout and Borehole Locations
Location: Boral Dunmore Sand and Soil - Stage 5
Client: Element Environmental
Job No: 118044
Project Man: EG
Scale: As Shown
Drawn By: LB
Date: January 2019
Figure 2

2.2.5 Review of previous reports and information

Environmental Earth Sciences has been undertaking quarterly water quality and level monitoring on a continual basis at the DRWDD since November 1992, and consequently has a data-set of over 100 individual sampling rounds over 26 years. In addition, this work has included the periodic installation of additional groundwater monitoring bores about the DRWDD.

Environmental Earth Sciences also undertook the Local Environmental Management Plan (LEMP) addendum process for having PASS (from the M5 East freeway project Cook's River tunnel excavation) accepted at the adjoining Buckley's Road sand quarry. This LEMP addendum required approval from NSW EPA and resulted in a new Virgin Excavated Natural Material (VENM) classification of "Class B", being VENM which contained greater than 0.1% mineral sulfides.

Further, Environmental Earth Sciences undertook the Impact Assessment for hydrogeology and acid sulfate soils for Stages 2, 3 and 4 of the Dunmore Lakes sand quarry, to the west of the Project Site across the Princes Highway and have performed on-going groundwater level monitoring at Dunmore Lakes since 2001. The project has involved the installation and monitoring of over 30 bores across the catchment alluvial aquifer to the west of the Princes Highway. A summary of relevant reports, including those in the surrounding area is summarised in **Table 2** below.

2.2.6 Summary of existing information

Based on previous reports, groundwater beneath the wider Dunmore area has a generally neutral pH and is fresh to slightly brackish, with low concentrations of most dissolved metals. To the west of the Princes Highway (i.e. away from swampy and marine sediments), the chemistry tends towards sodium-chloride (Na-Cl) dominant, whilst to the east is calcium bicarbonate(Ca-HCO_3) dominated.

Localised areas of elevated salinity are sea-water influenced from tidal in-flows along Rocklow Creek and the Minnumarra River, locations adjacent to the edge of the aquifer, and locations impacted by leachate from the Dunmore Recycling and Waste Disposal Depot.

The oxidation-reduction potential results (ORP) confirm the reducing and oxygen depleted nature of this aquifer, which supports the physical assessment that there is very little groundwater movement through this Site, particularly percolation of oxygenated surface recharge water. Potential impacts to the environment are likely to arise through the establishment of the sand extraction site, extraction of sand, deposition of non-PASS VENM within the excavated area and rehabilitation of the areas.

Based on the assessment for Stages 2 to 4 of Dunmore sand extraction area, groundwater movement accounts for between 0.1 to 0.5% of catchment drainage even in the driest recorded years and excavation of the aquifer sediments has been observed to have no discernible effect on catchment hydrology other than increasing the area available for water storage on the area of assessment.

Table 2: Summary of relevant reports

Report reference	Key findings
Environmental Earth Sciences NSW, 2017 – *Annual report of groundwater level monitoring at the Swamp Road Quarry, Dunmore, NSW – May 2016 to May 2017*. Letter dated 16 June 2017	Installation of data loggers and review of water level data from data loggers in the vicinity of Swamp Road Quarry (Stage 1) and Stage 3 sand dredging area, as part of the Dunmore Lakes Sand Project: • No observable impact in the form of dewatering from extraction activities on groundwater. • Groundwater flow in an easterly direction as dredging work continues in Stage 3 • Aquifer historically responds rapidly to local rainfall events • The unconfined aquifer is susceptible to tidal influences, at relatively low amplitudes
Environmental Earth Sciences NSW, 2016. *Annual Monitoring Report at 38 Tabbita Road, Dunmore, NSW – October 2016*. Report number 116083 to Dunmore Sand & Soil Pty Ltd, dated 12 October 2016	• Ongoing groundwater level data indicates that there has been little to no impact from sand dredging activities and associated dewatering. • Groundwater levels have remained stable over the course of seven years, including from bores located directly adjacent to and down-gradient of mining activities. • While some minor exceedances of site criteria for native cations were recorded in both the shallow and deep aquifers these are considered to be natural features of regional groundwater under tidal fluctuations, with groundwater chemistry remaining relativity consistent over the past 10 years
Environmental Earth Sciences NSW, 2013. *Hydrogeological assessment for Lot 21 DP 653009, Dunmore Recycling and Waste Disposal Depot, Dunmore, NSW*. Report number 113057 to Hyder Consulting Pty Ltd, dated 26 August 2013.	• Groundwater movement accounts for less than 0.5% of catchment drainage even in the driest recorded years, excavation of the aquifer sediments should have no discernible effect on catchment hydrology other than increasing the area available for water storage on the Project Site. • Subsequent reinstatement of excavated areas of the Project Site with PASS will simply reduce this storage volume back to near pre-excavation levels. • The greatest risk to the groundwater resource and its identified receptors was determined to be chemical impact as a result of oxidation and subsequent acidification of PASS that is to be imported to the site and reinstated in the Project Site excavation void. It has also been determined that this risk can be mitigated to a "moderate" level through diligent management processes and implementation of appropriate mitigation measures. • The greatest risk of oxidation of PASS material at the Project Site is expected to be associated with the imported PASS material.

Report reference	Key findings
Environmental Earth Sciences NSW, 2004. *Hydrogeological and acid sulfate soil/ sulfidic sediment investigation, Dunmore Lakes – Stage 2, 3 and 4, Dunmore, NSW*. Report number 478/06 to Dunmore Sand & Soil Pty Ltd	• Soil and sediment profiles with a risk of producing significant acid on oxidation were found to be generally absent across the Project Site as the natural buffering capacity of the sediments far exceeds its potential to generate acid through sulfide oxidation. • Although the stratigraphy of the Dunmore area promotes a moderately hydraulically conductive aquifer, the low hydraulic gradient across the site results in a very low groundwater linear velocity. Hence, the major requirement during extraction operations will be maintenance of surface water flows through the site. • The findings of this report have determined that as groundwater movement accounts for less than 0.1% of catchment drainage even in the driest recorded years, excavation of the aquifer sediments will should have no discernible effect on catchment hydrology other than increasing the area available for water storage on the Project Site. Subsequent reinstatement of excavated areas of the Project Site with VENM will simply reduce this storage volume back to near pre-excavation levels. • Greater than 99% of water movement onto and off the Project Site occurs as surface flow, hence changes to the aquifer porosity, and recharge and discharge mechanisms, as well as catchment evaporation levels, will not significantly impact either the regional Quaternary aquifer or catchment hydrology. • There is negligible risk for the groundwater table to be lowered, and in fact the larger storage area available to receive catchment run-on to the Project Site will increase recharge potential to the catchment aquifer. This will also ensure the salinity balance of groundwater in the catchment will not be altered, as the potential for recharge of fresh run-on and rainfall to the Project Site aquifer will be enhanced. • There is no evidence indicating that the very localised leachate plume at the Buckley's Road landfill has any potential to impact the Stage 2- 4 area. Any significant future leachate migration (which has shown no potential to occur over the past 11 years of monitoring) is anticipated to discharge to Rocklow Creek directly south of the landfill cells or be captured by a leachate interception trench if required.

The greatest risk to the groundwater resource in the wider project area and its identified receptors was identified as chemical impact as a result of oxidation and subsequent acidification of imported PASS to Stage 2-4. However, PASS soils identified at sites including DSS have been successfully managed through the washing and sorting of materials which mitigated identified risks and did not have an impact on groundwater pH.

3 FIELD STUDY

3.1 Field Investigation

3.1.1 Bore installation

In conjunction with the assessment for PASS, a groundwater bore network comprising seven bores within the proposed extraction area and one bore to the south of Stage 5B area to provide background information was installed between 11 and 13th July 2018. Bore locations are illustrated on **Figure 2**. Full details are provided in bore logs, **Appendix E**.

3.1.2 Ground conditions

The profiles of bores in the Stage 5A area (bores MW_5A1 to MW5A3) were typically described as fine to medium grained grey, cream and brown sand with occasional shell grit in the sand aquifer portion of the profiles. In the Stage 5A area, this was generally underlain by weathered bedrock (Latite), whereas the Stage 5B area was underlain by estuarine clay deposits over weathered bedrock.

Table 3 below provides a summary of the stratigraphy encountered at the Site, and **Table 4** summarises the bore installation details. **Figure 3** (**A** and **B**) provides an illustration of the geological cross section of the Site.

Table 3: Stratigraphy summary

Area	Strata	From (min/ max)	To (min/ max)	Min/ max thickness	Groundwater (min/max)	Comments
Stage 5A	Fine to medium SAND with occasional shell	0.0	5.0/12.25 m	5.0/12.25 m	0.92 / 3.45 mbgl	-
	Clayey SAND	5.0/7.25 m	6.0/8.5 m	1.0/1.25 m		Not encountered in MW5A3
	CLAY	6.0/12.25	9.0/13.0 m	0.75/ >1.5 m		Base not proven in MW5A1
	Latite BEDROCK	9.0/13.0 m	Not proven	-		-

Area	Strata	From (min/ max)	To (min/ max)	Min/ max thickness	Groundwater (min/max)	Comments
Stage 5B	Fine to medium SAND with occasional shell	0.0 m	6.25/11.25 m	6.25/11.25 m	1.84 / 2.7 mbgl	-
	Clayey SAND with shell	6.25/11.25 m	7.0/13.25 m	0.75/2.0 m		-
	Clayey SAND	7.0/13.25 m	14.5 m/ not proven	2.0/ -		Extended beyond max depth in MW5B3 (16m) and MW5B4 (9m)
	Clayey SAND with shell	14.5 m	15.0 m	0.5 m		MW5B2 only
	CLAY with shell	15 m	18 m	3.0 m		MW5B2 only

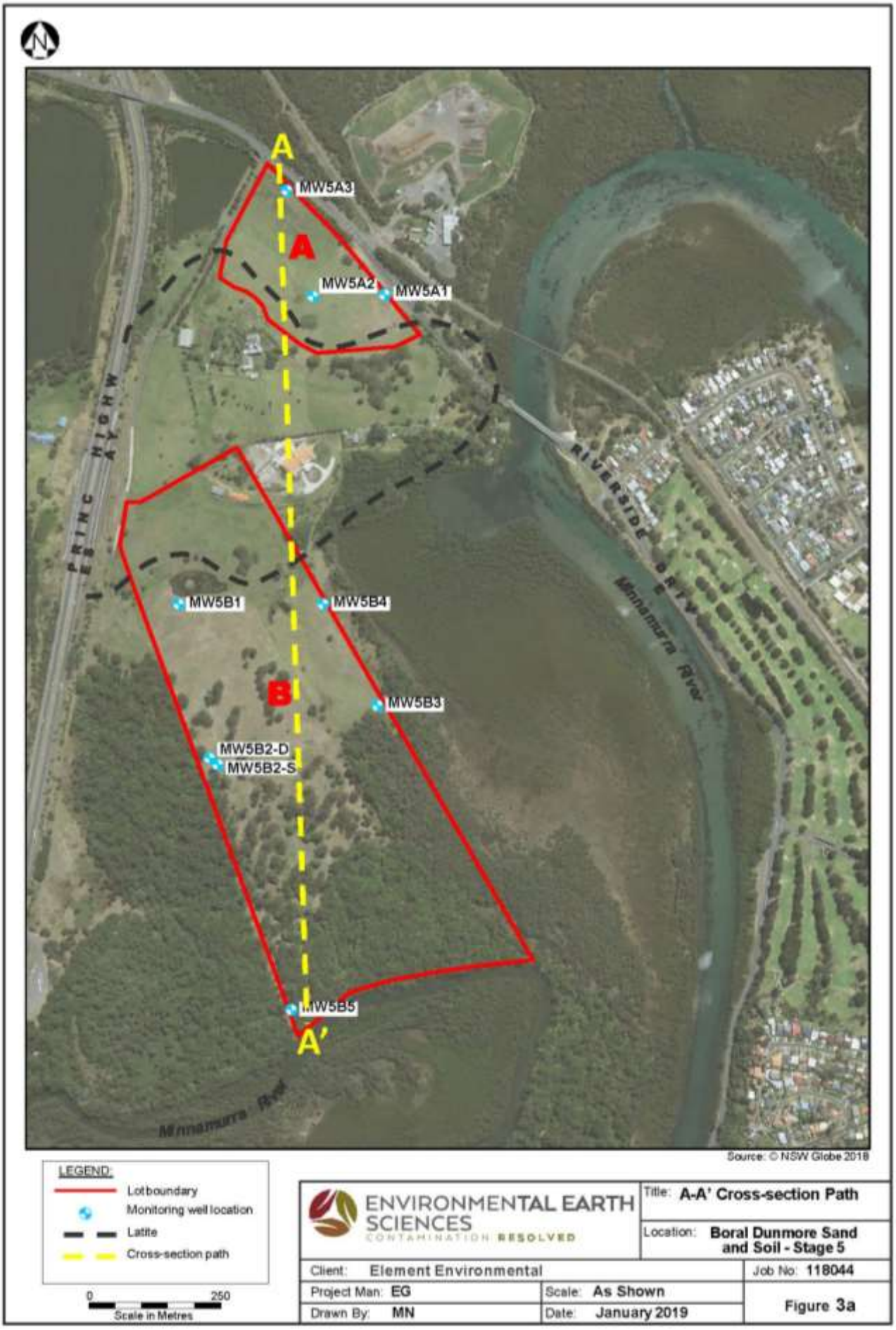
Table 4: Borehole installation summary

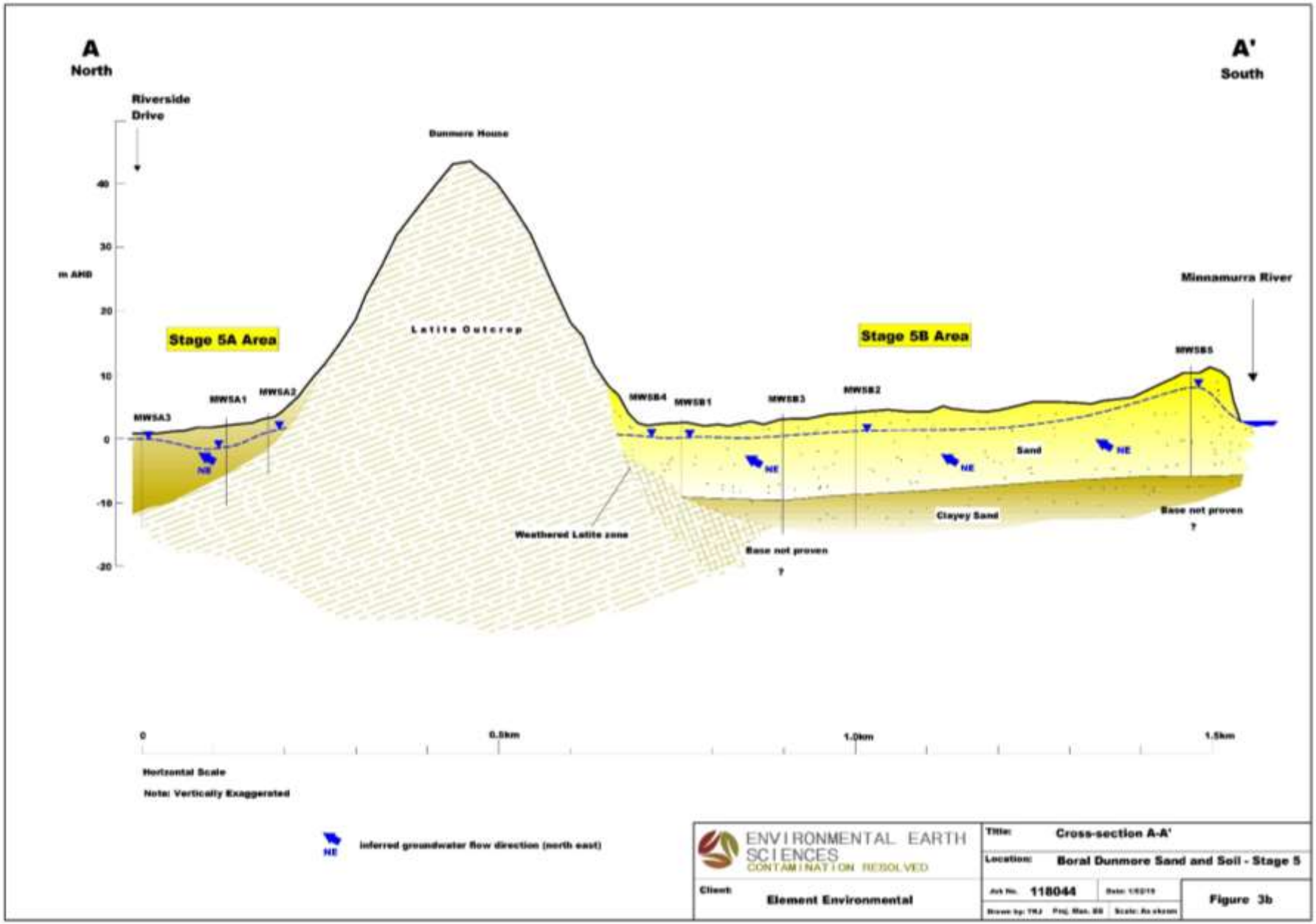
Location	Total Depth (m)	Screen depth (From – To) (m)	
MW_5A1	9.0	3.25 – 7.25	
MW_5A2	9.0	2.0 – 6.0	
MW_5A3	13.0	3.0 – 6.0	9.0 – 13.0
MW_5B1	9.0	2.0 – 6.0	
MW_5B2	18.0	2.0 – 6.0	6.5 – 9.5
MW_5B3	16.0	3.0 – 6.0	8.5 – 11.2
MW_5B4	9.0	2.0 – 6.0	
MW_5B5	16.0	9.0 – 12.0	

3.1.3 Groundwater levels

During drilling, groundwater was encountered within all bores at shallow depths ranging between 0.92 and 3.45 m bgl, being shallowest at bore MW5A3.

Three return monitoring visits were undertaken on 25 October 2018, 27 November 2018 and 15 January 2019. A summary of observed standing water levels (SWL) is presented in **Table 5**. Pertinent field data has been provided in **Appendix C**. Note that bores in Stage 5B were inaccessible in the November 2018 sampling event due to a locked gate.


A
MW5A3
A
MW5A2
MW5A1
PRINC HIGHW AY
RIVERSIDE DRIV E
Minnamurra River
MW5B1
MW5B4
B
MW5B3
MW5B2-D
MW5B2-S
MW5B5
A'
Minnamurra River
Source: © NSW Globe 2018
LEGEND:
Lot boundary
Monitoring well location
Latite
Cross-section path
0
250
Scale in Metres
ENVIRONMENTAL EARTH SCIENCES
CONTAMINATION RESOLVED
Title: A-A' Cross-section Path
Location: Boral Dunmore Sand and Soil - Stage 5
Client: Element Environmental
Job No: 118044
Project Man: EG
Scale: As Shown
Drawn By: MN
Date: January 2019
Figure 3a


A
North
A'
South
Riverside Drive
Dunmore House
m AHD
40
30
20
10
0
-10
-20
Stage 5A Area
Latite Outcrop
Stage 5B Area
Minnamurra River
MWSA3
MWSA1
MWSA2
MWSB4
MWSB1
MWSB3
MWSB2
MWSB5
NE
Sand
Clayey Sand
Weathered Latite zone
Base not proven
?
0
0.5km
1.0km
1.5km
Horizontal Scale
Note: Vertically Exaggerated
inferred groundwater flow direction (north east)
ENVIRONMENTAL EARTH SCIENCES
CONTAMINATION RESOLVED
Client:
Element Environmental
Title:
Cross-section A-A'
Location:
Boral Dunmore Sand and Soil - Stage 5
Job No.
118044
Figure 3b

All bores in the groundwater monitoring network were manually dipped using an interphase probe to ascertain SWL. During the first monitoring visit (25 October 2018), submersible data loggers were installed in bores MW5A1, MW5A3, MW5B2 (shallow) and MW5B2 (deep) to provide continuous monitoring data of groundwater levels across the site.

A hydrograph of SWLs from information provided by the data loggers since 25 October 2018 until January 2019 is illustrated in **Chart 2** in Section 4.5.5 below. Contour maps of SWL during each of the three monitoring periods are presented in **Figures 4a, 4b and 4c**.

Table 5: Groundwater Level Results

Sample	25 Oct 2018		27 Nov 2018		15 Jan 2019	
	Water Level (TOC)	Water Level (mAHD)	Water Level (TOC)	Water Level (mAHD)	Water Level (TOC)	Water Level (mAHD)
MW5A1	3.45	1	3.59	0.86	3.44	1.01
MW5A2	2.252	1.248	2.49	1.01	2.31	1.19
MW5A3	0.94	0.59	1.05	0.48	0.9	0.63
MW5B1	2.445	1.005	*	*	2.41	1.04
MW5B2 shallow	3.813	0.507	*	*	2.71	1.61
MW5B2 deep	3.013	1.457	*	*	2.9	1.57
MW5B3	1.37	1.98	*	*	1.3	2.05
MW5B4	1.84	0.51	*	*	1.78	0.57
MW5B5	4.295	3.255	*	*	4.24	3.31

*Stage 5B area inaccessible at time of sampling.

3.1.4 Sampling

During each of the three return monitoring visits, water samples were obtained from bores MW5A1, MW5A3, MW5B2 (shallow) and MW5B2 (deep) using a submersible pump.

To ensure that representative samples of groundwater were obtained, the following groundwater geochemical field parameters were collected during purging using a calibrated water quality meter (WQM):

- Oxidation Reduction Potential (ORP) – redox.
- pH.
- Dissolved oxygen (DO).
- Electrical conductivity (EC).

- Temperature.

These field parameters were measured *ex-situ* within in-line flow cells, with the following stabilisation criteria indicating that representative groundwater conditions suitable for sample collection:

- ± 10ppm DO when >1 ppm (no criteria for <1 ppm).
- ± 3% EC.
- ± 0.05 pH.
- ± 10mV ORP.

Following purging and stabilisation of field chemical parameters, all samples were stored in appropriate ice-filled coolers prior to transportation to the laboratory for analysis.

SWL, temperature pH, EC and ORP, colour, odour and flow characteristics were noted at each sample location, refer to **Appendix C** at the rear of this report for field data sheets.

3.1.5 Analytical schedule

Groundwater samples collected were sent to Sydney Analytical Laboratories (SAL), a NATA accredited laboratory and analysed for the following determinants:

- full ionic balance suite – pH, TDS, cations (Na, Ca, Mg, K), anions (Cl, SO_4, HCO_3, PO_4, F) and nutrients (NH_3, NO_3 and NO_2); and
- dissolved metals / metalloids including aluminium (Al), arsenic (As), cadmium (Cd), chromium (Cr), copper (Cu), iron (Fe), lead (Pb), manganese (Mn), mercury (Hg), nickel (Ni) and zinc (Zn).

Results that have been used in the current assessment are provided in **Table 13** at the back of this report. Full details are attached in laboratory certificates, **Appendix F**.

3.1.6 Procedures for quality control and quality assurance

Quality control is achieved by using NATA registered laboratories using Australian Standards Materials Testing (ASTM) standard methods supported by internal duplicates, the checking of high, abnormal or otherwise anomalous results against background and other chemical results for the sample concerned.

Quality assurance is achieved by confirming that field results, or anticipated results based upon comparison with field observations, are consistent with laboratory results. Also, that sampling methods are uniform, and decontamination is thorough. In addition, the laboratory undertakes additional duplicate analysis as part of their internal quality assurance program on the basis of one duplicate analysis for every 20 samples analysed.

Field observations are compared with laboratory results when they are not as expected. Confirmation, re-sampling and re-analysis of a sample are undertaken if the results are not consistent with field observations and/or measurements. In addition, field duplicate sample

results have to be within the acceptable range of reproducibility. A discussion of the quality of internal laboratory results and field duplicate relative percentage difference (RPD) calculations are presented in **Appendix H**.

3.1.7 Hydraulic parameter testing

As a part of the groundwater program on 25 October 2018, 'slug-tests' were undertaken at four locations (bores MW5A1, MW5A3, MW5B2s and MW5B2d). Slug (or falling head) tests require piezometers to have the screens fully submerged beneath the piezometric surface. This method was used the determine the *in*-situ hydraulic conductivity (K).

These tests involved causing an instantaneous change in water level in a section of the piezometer by introducing a known volume (i.e. a 'slug') and then measuring the recovery of the water level over time (after Fetter 2001).

Using the data obtained from these tests, values for hydraulic conductivity (K), transmissivity (KD) and groundwater velocity (v) have been determined for the unconfined Quaternary aquifer. The slug-tests were performed across the Site to determine the change in hydraulic properties of the water bearing sediments beneath the Site. The calculations and results of K determinations across the Site are provided in **Appendix G**, while values derived for K, KD and v have been summarised in **Table 6**.

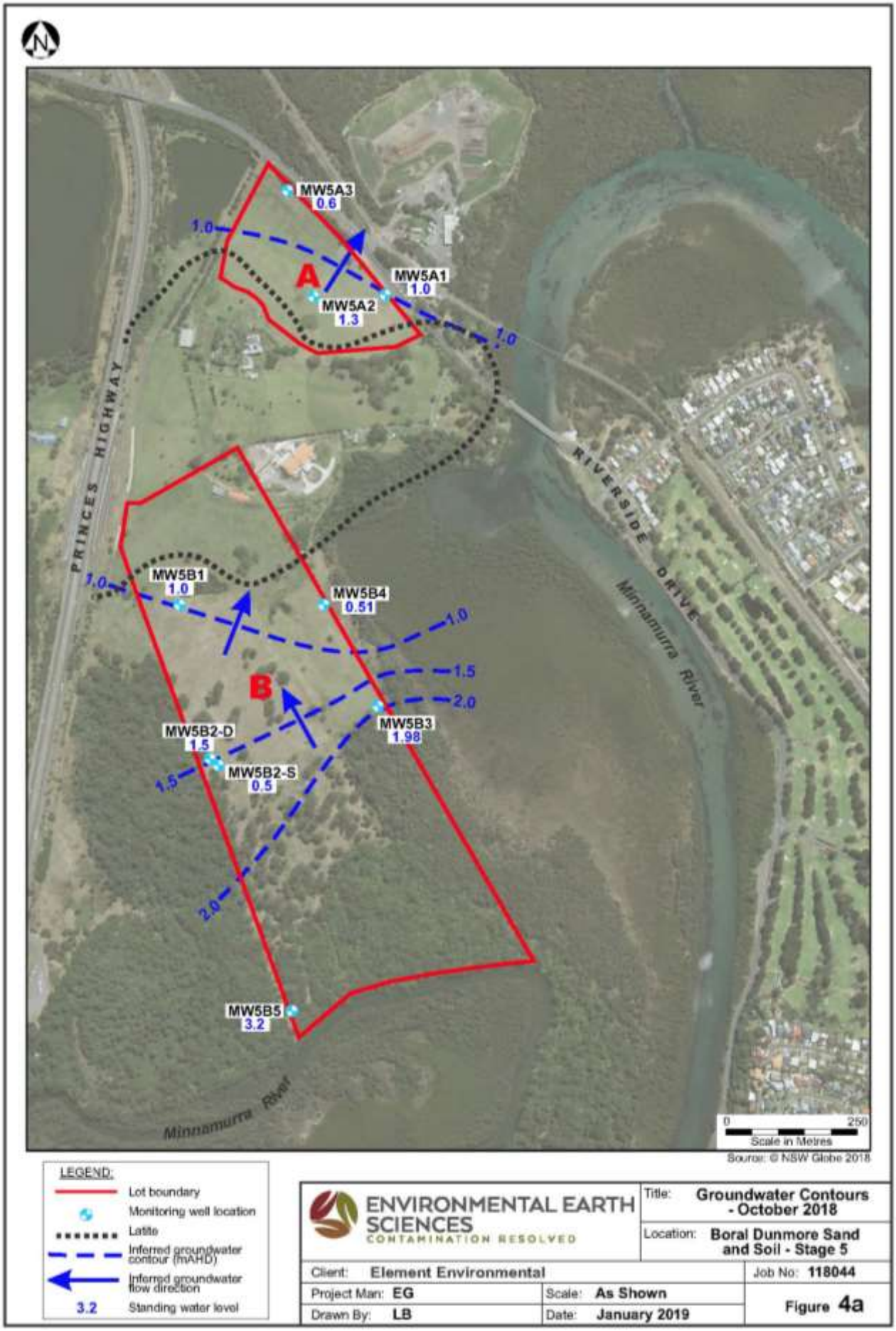
Table 6: Slug test results – October 2018

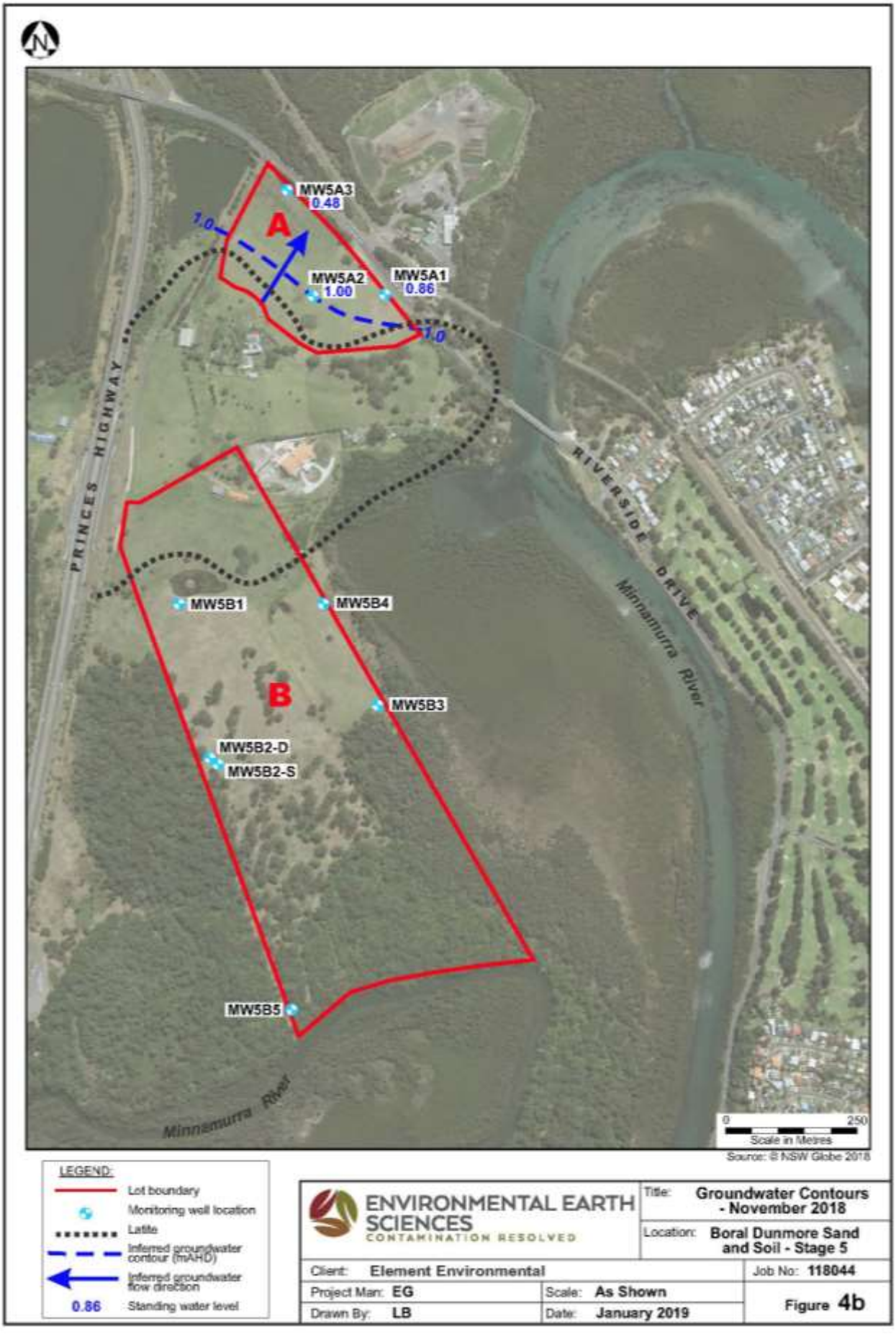
Bore	Screened interval	Test Date	K	KD	Hydraulic Gradient (*i*)	Velocity (v)
	m BGL	-	m/day	m^2/day	m/m	m/year
MW5A1	3.25 – 7.25	25/10/18	30	120	0.002	60
MW5A3	3.0 – 13.0	25/10/18	26	130		54
MW5B2s	2.0 – 6.0	25/10/18	15	180	0.007	110
MW5B2d	6.5 – 9.5	25/10/18	3	40		22

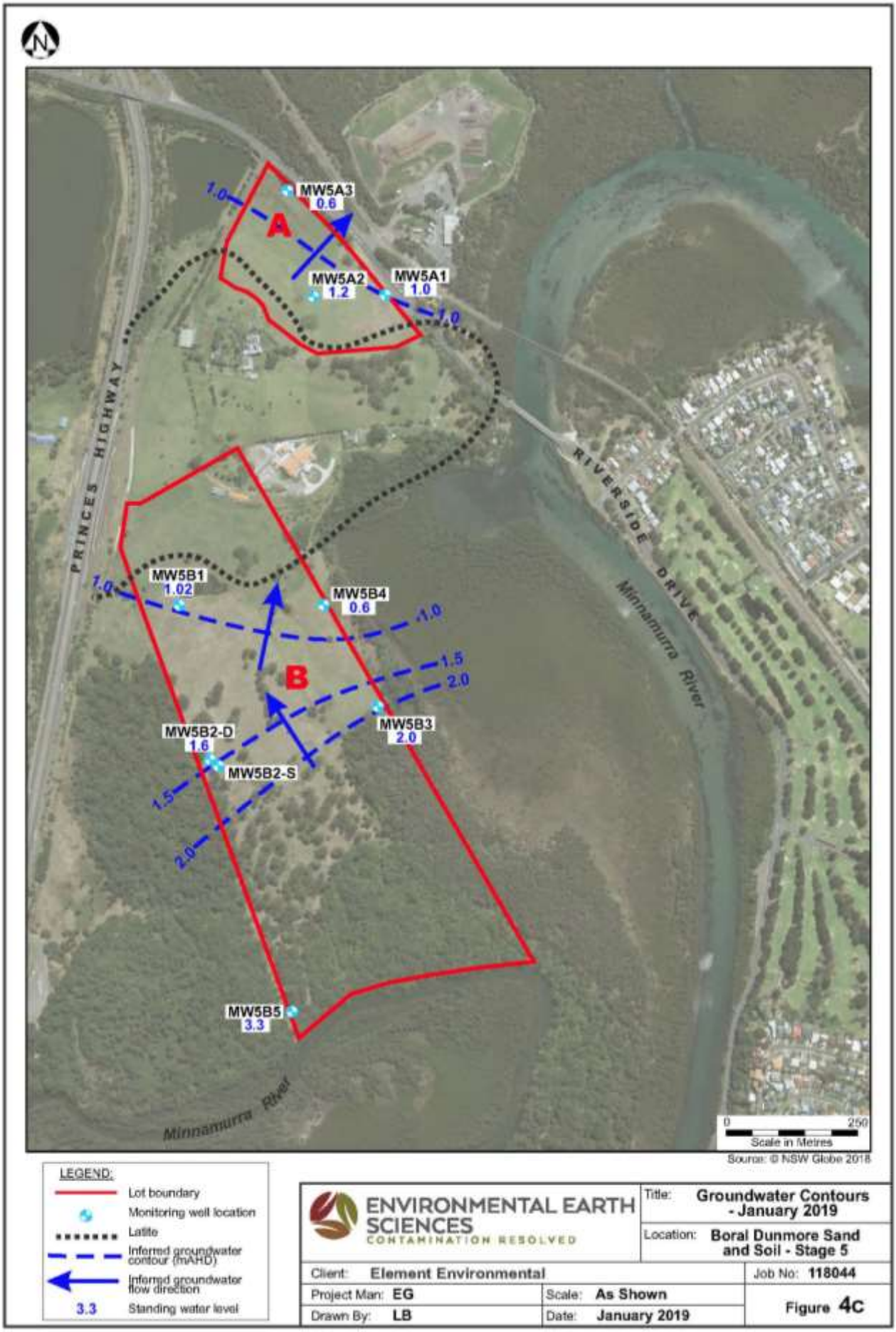
Note(s):
1. K hydraulic conductivity; KD transmissivity; Q yield
2. v average linear velocity was calculated assuming effective porosity of 0.35 in medium grained sand (Freeze and Cherry, 1979, Kruseman and de Ridder, 2000)
3. all tests undertaken using the Hvorslev, Bouwer-Rice and Jacob Recovery test analysis methods, after Fetter 2001 and Kruseman and de Ridder, 2000

3.2 Adequacy of field investigation

Based on the above discussion, it is considered that the aquifer beneath the Site has been assessed to an appropriate degree (both physically and chemically) to this point in time, in order to be able to determine baseline conditions, and provide an analytical assessment of potential impacts from the Proposal. While on-Site sampling events are temporally limited, they are considered spatially appropriate, while assessment of water quality and physical groundwater conditions has occurred in this aquifer for a long period of time (Environmental Earth Sciences, 2004, 2013a, 2013b, 2016, 2017 and 2018).


MW5A3
0.6
MW5A1
1.0
MW5A2
1.3
A
1.0
1.0
MW5B1
1.0
MW5B4
0.51
1.0
1.5
2.0
B
MW5B3
1.98
MW5B2-D
1.5
MW5B2-S
0.5
1.5
2.0
MW5B5
3.2
PRINCES HIGHWAY
RIVERSIDE DRIVE
Minnamurra River
Minnamurra River
0
250
Scale in Metres
Source: © NSW Globe 2018
LEGEND:
Lot boundary
Monitoring well location
Latite
Inferred groundwater contour (mAHD)
Inferred groundwater flow direction
3.2
Standing water level
ENVIRONMENTAL EARTH SCIENCES
CONTAMINATION RESOLVED
Title: Groundwater Contours - October 2018
Location: Boral Dunmore Sand and Soil - Stage 5
Client: Element Environmental
Job No: 118044
Project Man: EG
Scale: As Shown
Drawn By: LB
Date: January 2019
Figure 4a


MW5A3
0.48
A
1.0
MW5A2
1.00
MW5A1
0.86
1.0
PRINCES HIGHWAY
RIVERSIDE DRIVE
Minnamurra River
MW5B1
MW5B4
B
MW5B3
MW5B2-D
MW5B2-S
MW5B5
Minnamurra River
0
250
Scale in Metres
Source: © NSW Globe 2018
LEGEND:
Lot boundary
Monitoring well location
Latite
Inferred groundwater contour (mAHD)
Inferred groundwater flow direction
0.86
Standing water level
ENVIRONMENTAL EARTH SCIENCES
CONTAMINATION RESOLVED
Title: Groundwater Contours - November 2018
Location: Boral Dunmore Sand and Soil - Stage 5
Client: Element Environmental
Job No: 118044
Project Man: EG
Scale: As Shown
Drawn By: LB
Date: January 2019
Figure 4b


MW5A3
0.6
MW5A2
1.2
MW5A1
1.0
A
1.0
1.0
MW5B1
1.02
MW5B4
0.6
1.0
1.5
2.0
B
MW5B3
2.0
MW5B2-D
1.6
MW5B2-S
1.5
2.0
MW5B5
3.3
PRINCES HIGHWAY
RIVERSIDE DRIVE
Minnamurra River
Minnamurra River
0
250
Scale in Metres
Source: © NSW Globe 2018
LEGEND:
Lot boundary
Monitoring well location
Latite
Inferred groundwater contour (mAHD)
Inferred groundwater flow direction
3.3
Standing water level
ENVIRONMENTAL EARTH SCIENCES
CONTAMINATION RESOLVED
Title: Groundwater Contours - January 2019
Location: Boral Dunmore Sand and Soil - Stage 5
Client: Element Environmental
Job No: 118044
Project Man: EG
Scale: As Shown
Drawn By: LB
Date: January 2019
Figure 4C

As such, in combination with the recommended on-going monitoring program for the Site (detailed in Section 6.2 below), it is considered that baseline Site specific conditions have been adequately determined (with data to continue to be collected up until commencement of the Proposal, to further enhance its temporal range).

4 CONCEPTUAL HYDROGEOLOGICAL SITE MODEL (CSM)

4.1 Introduction

A CSM is a two- to three-dimensional interpretation of the soil, geology and hydrogeology relationships within a catchment. Information assessed and presented includes inferred soil/ rock weathering processes and groundwater/ surface water flow characteristics. The CSM aims to inform an exposure assessment of any impact (or potential for impact) identified by demarcating sources, pathways and receptors of the groundwater flow system. The CSM is one of the primary planning tools used to support decision making processes, organising available information about a site or issue in a clear structure that facilitates the identification of data and information gaps.

It is often presented using a variety of media, including text, maps, cross sections, two- or three-dimensional graphics, tables and other visual representations (including Piper, Durov, Stiff or Schoeller Plots, for example). This report includes text and tables, along with appended figures including 2D schematic cross section of the investigation area (**Figure 3**), data tables, Piper Diagrams and Schoeller Plots.

By gaining a greater understanding of the Site, the model can also be used to assess which portions of the Proposal may require further investigation or monitoring. The CSM presented herein is intended to help identify groundwater flow paths and environmental receptors using the available data. The CSM describes the existing hydrogeological environment and constraints.

4.2 Physical setting

4.2.1 Site locality

The Stage 5 extraction area is located approximately 1 km to the south-east of existing quarry operations (Stages 2 to 4) approximately 3 kilometres (km) south-south west of Shellharbour and 7 km north of Kiama, in the Illawarra region of New South Wales. The northern portion of the Stage 5 extraction area has been partially cleared and has historically been used for grazing. The southern portion is more undulating in nature with remnant tree stands and grassland.

4.2.2 Landform and topography

The Stage 5 extraction area is located in close proximity to Rocklow Creek (Stage 5A) and the Minnamurra River (Stage 5A and 5B). As such, these estuarine and alluvial tidal flats are low-lying with water-logging issues due to the permanently high water-tables and are

regularly inundated by brackish tidal waters (Hazelton, 1992). Elevation within the subject site area is typically very low lying and is typically between <1 – 5m AHD. An undulating latite hill separates Stage 5A and 5B with elevations as high as 44 m AHD.

4.2.3 Climate

Regional meteorological data has been sourced from the Bureau of Meteorology (2018) (*www.bom.gov.au*, verified 17 January 2019) Kiama Bombo Headland weather station, Air Station No.068242,approximately 3 km southwest of site, and is summarised in **Chart 1** and detailed in **Table 12** (refer to Tables Appendix). Evaporation data is based on monthly averages from 2018.

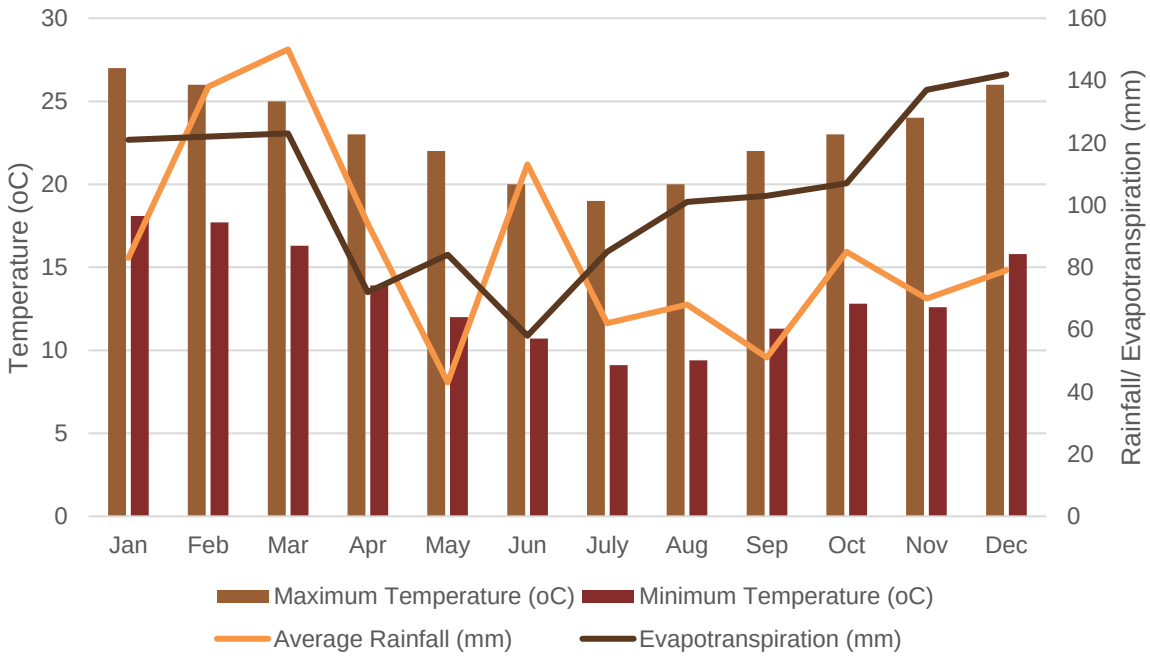


Chart 1 – Average monthly climate data

Dunmore's climate can be described as temperate with mild winters and summers. The temperature ranges from winter with an average daily maximum temperature of 9ºC in the coldest month of July, to warm summers with mean daily maximum temperatures of 27ºC in January.

Average annual rainfall recorded at Dunmore is about 1036 mm and the rainfall pattern has a late spring to summer dominant trend. Monthly total evaporation rates are larger than the average monthly rainfall (**Table 12**) except for May, June and July. It is during these times that the potential for recharge or deep drainage is the greatest. Soil moisture is generally not limiting to plant growth during the hottest summer months although pasture growth of summer active grasses is slowed during the colder months.

4.3 Soil and geology

4.3.1 Geology

The local geology has been described in the Kiama 1:250 000 Geological series sheet 9028-I (1974) as Quaternary alluvium, gravel, beach and dune sand overlying Permian aged (about 250 million years old) volcanics of the Bumbo Latite member. The geology around the perimeter of the Project Site forms the sides of a valley which also extends to the east. separating Stage 5A and Stage 5B as a result of Bumbo Latite outcropping along the edge of a 'drowned' river valley. The valley is in-filled with unconsolidated sediments being Quaternary aged and consisting of gravels, swamp deposits and sand dunes. The regional geology is illustrated on **Figure 5**.

4.3.2 Soil landscape

The sand resource consists of predominantly tsunami deposits of a typically fine to medium grained sand underlain by columnar latite deposits which make up the surrounding undulating hills. The sand contains varying quantities of shells and shell fragments, and in places clay lenses. The extent to which underlying latite is weathered ranges from fresh rock to metres of latitic clay deposits.

The soil observed on the Project Site is described in the Soil landscapes of the Kiama 1:100,000 sheet as belonging to the Killalea Soil Landscape (Hazelton, 1992). A soil landscape is an area of land that has recognisable and specifiable topographies and soils.

Soil landscape information was sourced from eSPADE v2.0 published by the NSW Office of Environment & Heritage (2018) (espade.environment.nsw.gov.au/, verified 16 January 2019). Refer to **Figure 6**.

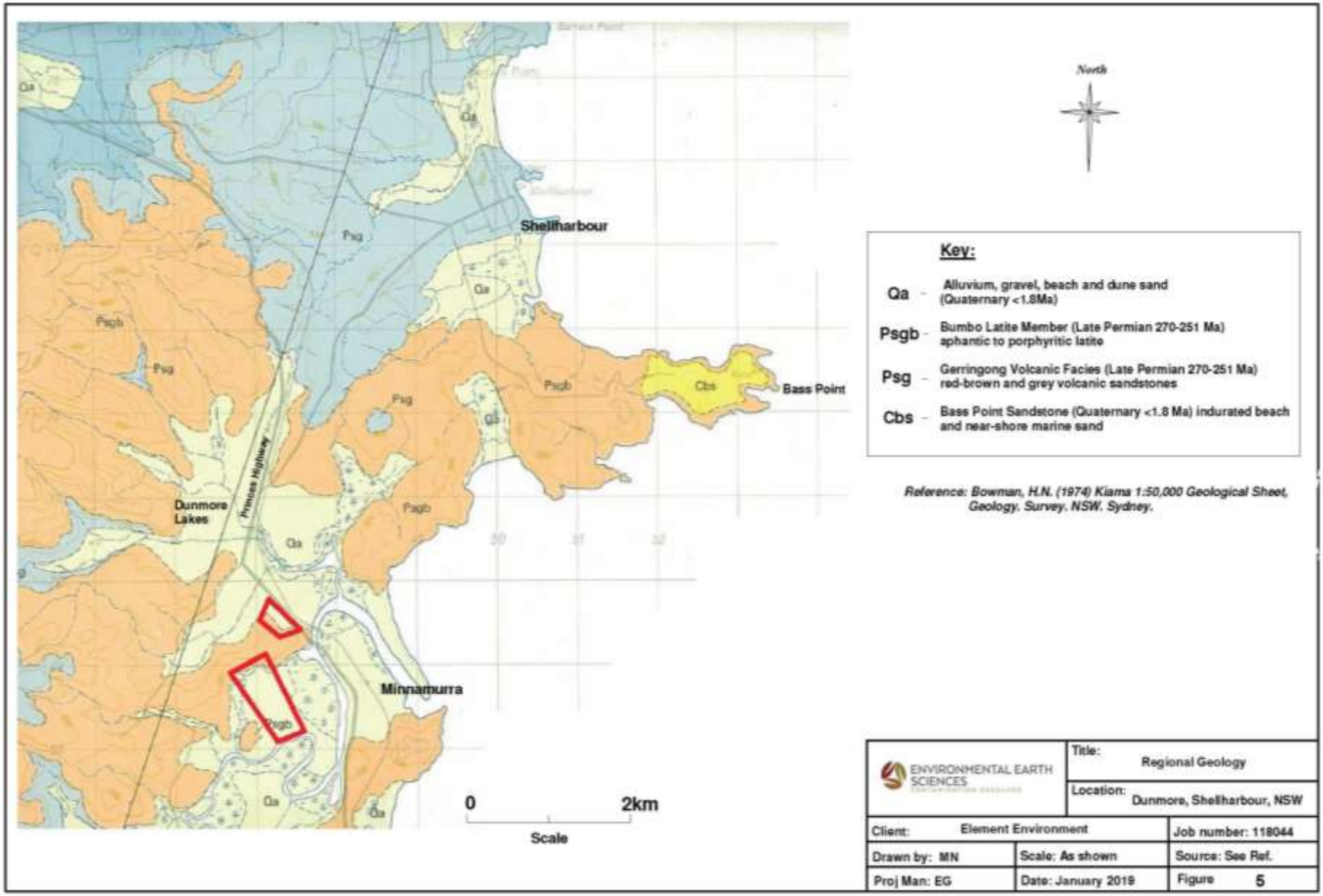
The dominant soil landscape group in the Stage 5 extraction area is called Mangrove Creek, which is typically described as vegetated Holocene sediments of silty to peaty quartz sand, silty and clay with shell layers in sandy mud. The soils may also be sodic and strongly acid. Refer to **Appendix D** for Soil Landscape Reports.

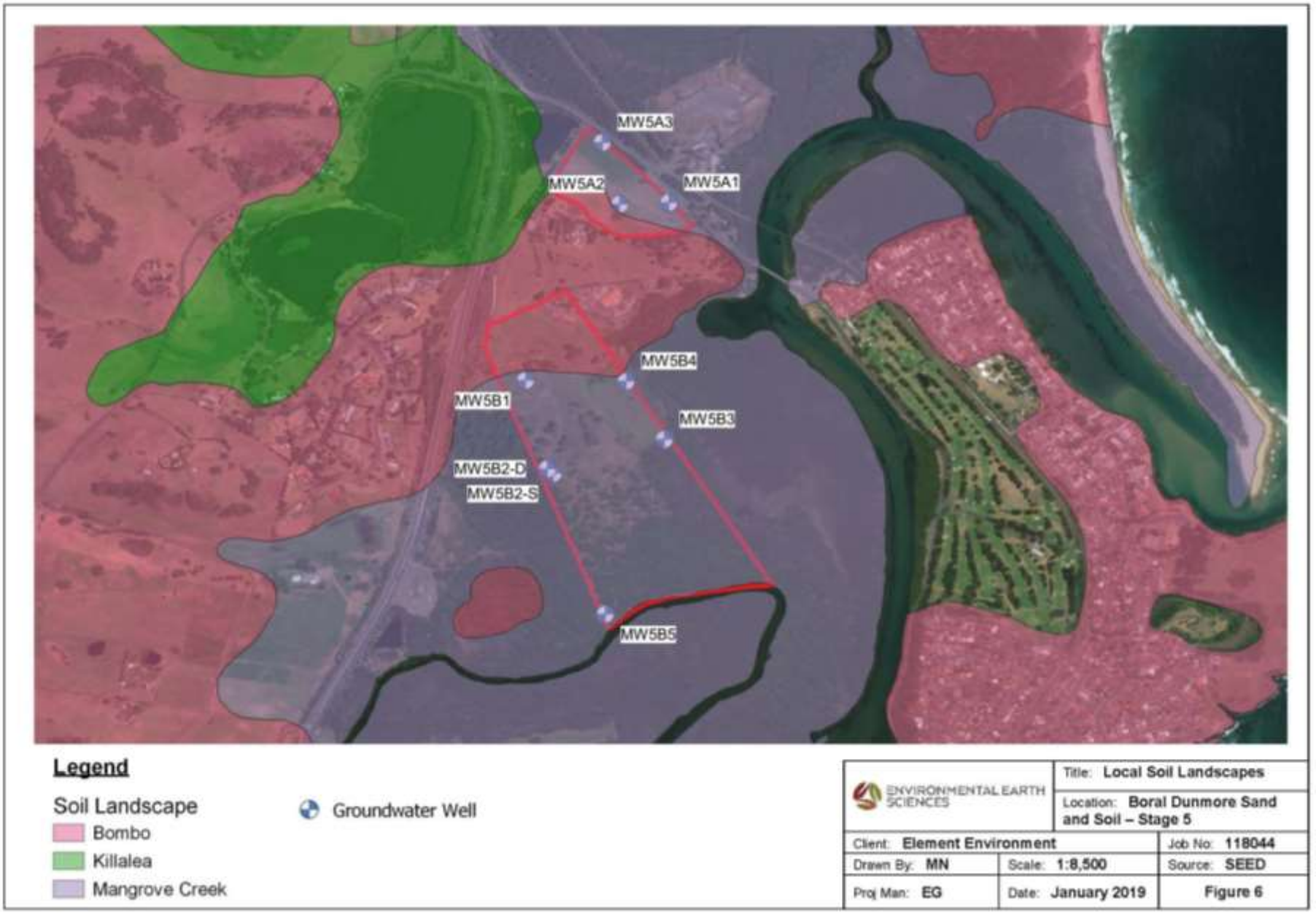
The southern area of Stage 5A and the northern area of Stage 5B is described as Bombo Latite Member. This soil landscape group is typically associated with rolling low hills with benched slopes on Bumbo Latite and shallow structured loams soils and brown and red Podzolic soils on mid and lower slopes.

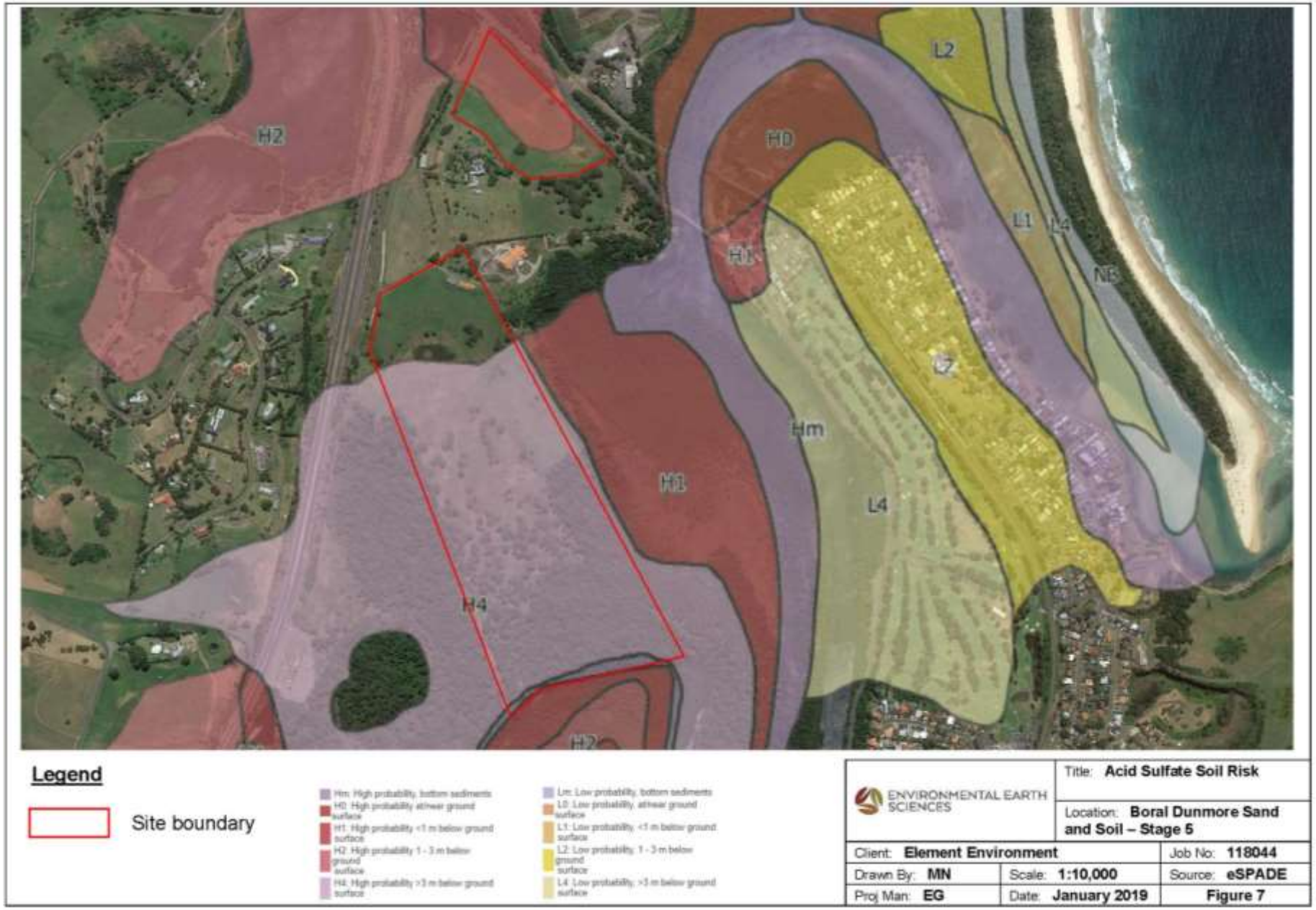
4.3.3 Acid sulfate soils

Stage 5 was reviewed in the Albion Park 1:25,000 Acid Sulfate Soils Map (1997) produced by NSW Department of Land and Water Conservation. The southern area of Stage 5 (5B) is considered low probability for ASS in general, however the north-eastern area of Stage 5A is considered to have a high probability of occurrence of acid sulfate soil materials within the soil profile at or near the surface, associated with estuarine plain deposits, refer to **Figure 7**.

An Acid Sulfate Soils Assessment report by Environmental Earth Sciences (January 2019) concluded two locations (5A2 and 5A3) in Stage 5A reported a moderate to high risk for potential ASS. Regular monitoring was recommended as part of an ASS Management Plan for a proactive monitoring regime to be employed so that early indications of localised acid generation could trigger appropriate management.


North
Shellharbour
Bass Point
Dunmore Lakes
Princes Highway
Minnamurra
Qa
Psg
Psgb
Cbs
0
2km
Scale
Key:
Qa - Alluvium, gravel, beach and dune sand (Quaternary <1.8Ma)
Psgb - Bumbo Latite Member (Late Permian 270-251 Ma) aphantic to porphyritic latite
Psg - Gerringong Volcanic Facies (Late Permian 270-251 Ma) red-brown and grey volcanic sandstones
Cbs - Bass Point Sandstone (Quaternary <1.8 Ma) indurated beach and near-shore marine sand
Reference: Bowman, H.N. (1974) Kiama 1:50,000 Geological Sheet, Geology. Survey. NSW. Sydney.
ENVIRONMENTAL EARTH SCIENCES
Title: Regional Geology
Location: Dunmore, Shellharbour, NSW
Client: Element Environment
Job number: 118044
Drawn by: MN
Scale: As shown
Source: See Ref.
Proj Man: EG
Date: January 2019
Figure 5


MW5A3
MW5A2
MW5A1
MW5B4
MW5B1
MW5B3
MW5B2-D
MW5B2-S
MW5B5
Legend
Soil Landscape
Bombo
Killalea
Mangrove Creek
Groundwater Well
ENVIRONMENTAL EARTH SCIENCES
Title: Local Soil Landscapes
Location: Boral Dunmore Sand and Soil – Stage 5
Client: Element Environment
Job No: 118044
Drawn By: MN
Scale: 1:8,500
Source: SEED
Proj Man: EG
Date: January 2019
Figure 6


H2
H0
L2
L1
L4
NB
H1
Hm
H1
L4
H4
H2
Legend
Site boundary
Hm: High probability, bottom sediments
H0: High probability, at/near ground surface
H1: High probability <1 m below ground surface
H2: High probability 1 - 3 m below ground surface
H4: High probability >3 m below ground surface
Lm: Low probability, bottom sediments
L0: Low probability, at/near ground surface
L1: Low probability, <1 m below ground surface
L2: Low probability, 1 - 3 m below ground surface
L4: Low probability, >3 m below ground surface
ENVIRONMENTAL EARTH SCIENCES
Title: Acid Sulfate Soil Risk
Location: Boral Dunmore Sand and Soil – Stage 5
Client: Element Environment
Job No: 118044
Drawn By: MN
Scale: 1:10,000
Source: eSPADE
Proj Man: EG
Date: January 2019
Figure 7

4.4 Hydrology

Stage 5B is bordered to the south by the Minnamurra River which flows to the east and north lies approximately 500 m to the east of the subject site before discharging to the Pacific Ocean approximately 1 km to the east of the Site. The Minnamurra River is a large catchment with an area of approximately 120 km^2. The predominant land uses are grazing and other rural activities (Environmental Earth Sciences, 2004).

The Site is located on the boundary between the estuarine and marine zones of the Minnamurra River before it discharges into the Pacific Ocean to the east (Panayotou, 2003).

Stage 5B area is classified as a swamp area subject to inundation, whilst there is a small existing pond present in the south western corner of the Stage 5A area. A large pond is present directly to the north of the Stage 5A area, with another 2 large ponds approximately 180 m to the northwest of the Stage 5A area.

Due to the permeable nature of much of the lithology in the Site, infiltration of rainfall is rapid, and little run-off occurs during light to moderate rainfall events. Hence, for the most part, drainage patterns are not definable. The topography is dominated by marine and aeolian depositional landforms creating elongated dunes and linear valleys. While regional groundwater flow has been shown to predominate towards estuaries and the coast, localised hydrology is expected to see movement of infiltrating surface waters towards individual low-lying swales and swamps of the area.

The position of the piezometric surface close to ground level provides an effective barrier for deep percolation of surface waters in this area. While run-off from rainfall consequently occurs, the flat topography and high water-table results in little surface movement of waters. Hence, extensive waterlogging occurs, and the dispersed creeks of the area are the only effective hydrological unit.

4.5 Hydrogeology

4.5.1 Background

The Site is situated in the southern area boundary of an unconfined sand aquifer that is likely connected to Minnamuura River in Stage 5B. As such, Stage 5 may be considered to be partially influenced by both the Rocklow Creek Catchment (Stage 5A) and the Minnamurra River Catchment (Stage 5B).

Geological Survey of New South Wales and New South Wales Office of Water data (Bowman 1974 and BOM 2019) indicates that bores are frequently constructed on the Quaternary sediments of this catchment. This is due to high production rates and low salinity making these waters excellent for domestic, industrial or agricultural use. The aquifer is predominantly unconfined and present less than 2 m below the surface, hence a number of registered bores are located within the catchment, as summarised in **Appendix B**.

The alluvial sands which dominate the geological setting within which the Site is situated, and the low-lying topography, have combined to create an unconfined aquifer system overlying competent bedrock (with some associated silt and clay) to a reported depth exceeding 18 m below the surface (refer to **Figure 3**). The area is recharged from hills to the

west. The presence of the hill outcrop between Stages 5A and Stage 5B is anticipated to act as a recharge point to both the north and south.

Rainfall recharge is expected to be rapid, with infiltration estimated at between 75 to 90%. Despite this, moderate to high intensity rainfall events that are regular occurrences in this area will rapidly fully recharge the Project Site aquifer, resulting in 100% run-off (zero recharge or infiltration) in such situations.

4.5.2 Groundwater flow system

The general concept for groundwater occurrence below the Site is that alluvial groundwater is unconfined and relatively shallow and fresh, as the water table responds relatively rapidly to recharge via rainfall. Groundwater flows towards the Minnumarra River which flows around the south and east of the site in a north-easterly direction.

Recharge mechanisms are expected to be as direct rainfall recharge or recharge to the aquifer from the creeks and low-lying swales during periods of flow, particularly when the water table is depressed following a dry climatic period of low rainfall.

Tidal effect on groundwater is typically limited to between 5 and 50 m from a tidal creek, depending on soil permeability. A dampening effect would occur on tidal effects the further from the Minnamurra Estuary bores are located. There is therefore the possibility that due to tidal inflows, there may be localised increases in conductivity in dredged areas, resulting in an increase of salinity, such as observed within the pond at Stage 3 area.

4.5.3 Aquifers and aquitards

Within the alluvium, sands and gravels would be the primary aquifers, with weathered latite bedrock comprising finer grained silts and clays acting as aquitards. The alluvial aquifer is underlain by an aquitard/ aquiclude of clay overlying latite bedrock. However, within the alluvial aquifer matrix, finer grained sediments are limited to discrete horizontal lenses within a predominant sand matrix, as illustrated on the bore logs provided in **Appendix E**.

4.5.4 Results of registered bore search

Environmental Earth Sciences conducted a search of the NSW Australian Groundwater Explorer Registered Groundwater Bore database (www.bom.gov.au/water/groundwater/explorer/map.shtml) on 10 January 2019 (BOM 2019).

A search of registered groundwater licenses surrounding the site indicates that no bores within a 1 km radius of the Site are registered for any purpose other than monitoring. Full groundwater bore search results are provided in **Appendix B**. Monitoring bores within a 1 km radius of the Site appear to be predominantly screened within the Quaternary alluvial deposits.

4.5.5 Potentiometric surface

Inferred groundwater flow paths have been presented on **Figure 4 (a to c)**. These contours are based on topographical and piezometric surface observations of the recently installed groundwater monitoring network during October 2018, November 2018 and January 2019. A hydrograph of standing water levels from information provided by the data loggers since 25

October 2018 until January 2019 is illustrated in **Chart 2**. Tidal data from nearby Port Kembla was included from BOM Tide predictions (http://www.bom.gov.au/australia/tides/#!/nsw-port-kembla, accessed 24 January 2019).

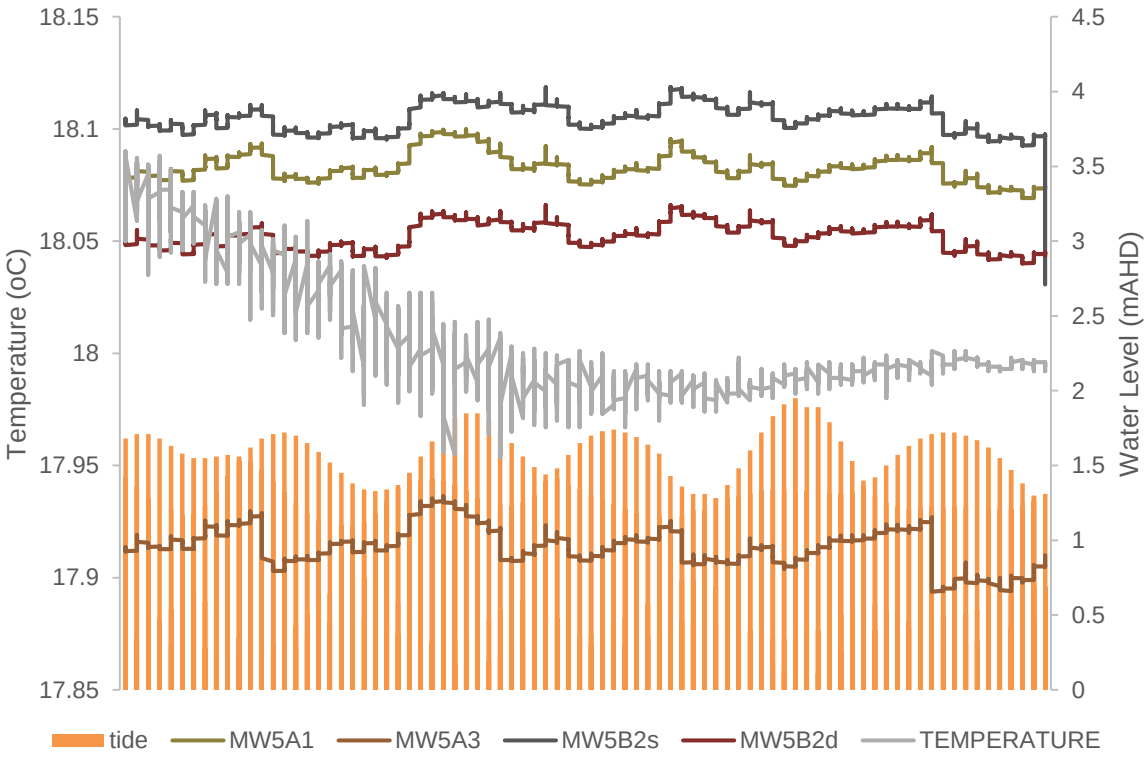


Chart 2 – Bore hydrograph, Oct 2018 – Jan 2019

Groundwater flow is influenced by topography and regional recharge/ discharge zones. Hence, the hydraulic gradient is typically to the north east for both Stage 5A and Stage 5B areas towards the Minnumarra River feeding into the Pacific Ocean. It is anticipated that the outcrop of Latite to the north of Stage 5B is likely to behave as a no-flow boundary.

The position of the piezometric surface close to ground level particularly in the northern areas of Stages 5A and 5B means very little groundwater movement is expected to be experienced. It is expected that only the upper 1 m to 2 m of the aquifer, where the sand is orange/ brown/ white in colour, will experience groundwater movement. Deep groundwater below this depth within the grey sands is expected to undergo little movement. Hence, very little groundwater movement is anticipated in the central area of Stage 5B, where the sand aquifer is deepest.

Overall, the water-table surface is a subdued form of the topography, which is typical of all local and regional groundwater flow systems. Depths to groundwater are greatest in areas of groundwater recharge and shallowest in areas of groundwater discharge.

4.6 Estimated recharge rates and water balance

Groundwater recharge in the superficial aquifer is expected to occur by infiltrating of water generated as surface flow from upgradient in the catchment and through direct infiltration

from surface. Due to the low-lying nature of the site, the catchment area for drainage onto the site is limited and percolating unconfined groundwater is likely to be sourced from an area up to 3 km to the west of the Site.

The contours presented in **Figures 4a to 4c** indicate movement of groundwater predominantly to the north-east. This is consistent with regional and site surface topography, and the location of down-gradient discharge zones (namely Minnamurra River and Pacific Ocean) to the east of the Site.

Crosbie *et al*. (2010b) state that, for the dominant soil type of the catchment (Podosols), recharge would be expected to be in the range of 100-1000 mm/year, with a line of best fit of 350 mm for an annual rainfall of 1,100 mm. This equates to 31% of rainfall recharging the aquifer, which is at the lower range of estimates for coastal alluvium provided by Crosbie *et al*. (2010a).

Groundwater flux (Q) beneath the Stage 5A extraction area, assuming a maximum cross-section flow path area of 3,600 m^2 (300 m length by 12 m thickness of aquifer), K of 20 m/day and hydraulic gradient of 0.002 m/m, is estimated at 144 m^3/day (53 ML/a). Groundwater flux (Q) beneath the Stage 5B area, assuming a maximum cross-section flow path area of 5,680 m^2 (355 m length by 16 m thickness of aquifer), K of 15 m/day and hydraulic gradient of 0.007 m/m, is estimated at 600 m^3/day (220 ML/a).

As the entire aquifer has an estimated cross-sectional area of discharge from the south-west to the north-east of 6,750 m^2 (450 metre wide corridor of the northern boundary between the Latite elevations to the north of the Stage 5B extraction area and a similar length directly north of the north eastern boundary of the Stage 5A extraction area with an average thickness of 15 m), discharge volumes are estimated (under a hydraulic gradient of 0.005 m/m and K of 20 m/day) at 675 m^3/day (250 ML/a).

Based on the total Site area of close to 12 hectares (120,000 m^2), it can be estimated that an average of close to 125,000 m^3 (125 ML, or 340 m^3/day) of rainfall falls on the Site per annum, 30% of which (37 ML/a or 100 m^3/day) is expected to recharge the aquifer and the remainder (88 ML/a or 240 m^3/day) is expected to discharge as surface flow. It has been assumed that evapotranspiration is approximately 70% of recharge, and that the extracted sand will contain approximately 8% moisture and be removed at a rate of 450,000 tonnes per annum. A water balance, based on these calculations, has been presented as **Table 7**.

Table 7: Site Water Balance

Parameter	Inflow (m^3/d)	Outflow (m^3/d)
Recharge	100	
Groundwater inflow	675	
Evapotranspiration		70
Sand Extraction		16
Groundwater outflow		675
TOTAL	775	761

As the entire 120 km^2 Minnamurra River catchment including the Site is calculated to accumulate and discharge close to 120,000,000 m^3 (120,000 ML) in an average rainfall year, the Site groundwater component of catchment discharge can be seen as being minimal (<0.21% of total catchment discharge).

4.7 Groundwater chemistry

4.7.1 Introduction

As part of this groundwater study, the inorganic chemistry of the unconfined aquifer identified beneath the Site was assessed. Ionic balances and dissolved heavy metals including aluminium (Al), nickel (Ni), copper (Cu), lead (Pb), zinc (Zn), cadmium (Cd), chromium (Cr), iron (Fe), arsenic (As), magnesium (Hg) and manganese (Mn) were analysed on collected water samples from all monitoring bores on site (bores MW5A1 to MW5A3 in Stage 5A and bores MW5B1 to MW5B5 in Stage 5B).

Hydrogeochemical characterisation of groundwater to support the development of the CSM, was undertaken using Schoeller plots and Piper diagrams. Schoeller plots express the concentration of ionic constituents in milli-equivalents (meq/L) plotted on logarithmic scale whilst Piper diagrams compare percentages of ionic constituents. Both diagrammatic methods help provide a visual indication of geochemical changes between locations, along flow paths, or to communicate temporal changes in water chemical characteristics.

Results of the field chemical assessment are provided in **Table 13** and **Appendix C**, and correlate well with field observations and laboratory results. The chemical laboratory results of this analysis are also illustrated in **Charts 3, 4 and 5**. Full analytical results are in **Appendix F**. A discussion on field and laboratory chemical results comparison is provided as part of the quality control and assurance section in **Appendix H**.

4.7.2 Ionic balance

In brief, the summed total of anions against cations was less than 2% at all locations assessed, with an average difference of 0.84%. The relative percentage difference (RPD) between field and laboratory pH was an average of 3.0%, and the relationship between TDS and EC was 0.71 across the Site. These results provide confidence in the data set obtained and allow reliance upon the chemical conclusions drawn.

The oxidation-reduction potential (ORP) reported in **Appendix C** indicates a generally reducing and oxygen depleted aquifer, with negative values recorded in most locations. The exception to this was bore MW5A1 which has consistently recorded positive ORP values (as high as 96 mV). This may be attributed to the low-lying nature of the area which was noted to be very reactive to rainfall and became easily waterlogged.

The highly negative ORP values observed elsewhere across the Site compares well with dissolved oxygen (DO) readings, which were minimal, as well as the grey colour of the sand within the aquifer to depth. The highly negative ORP readings (as well as low DO and grey sand colour) support the physical assessment that there is very little groundwater movement through this Site, particularly percolation of oxygenated surface recharge water.

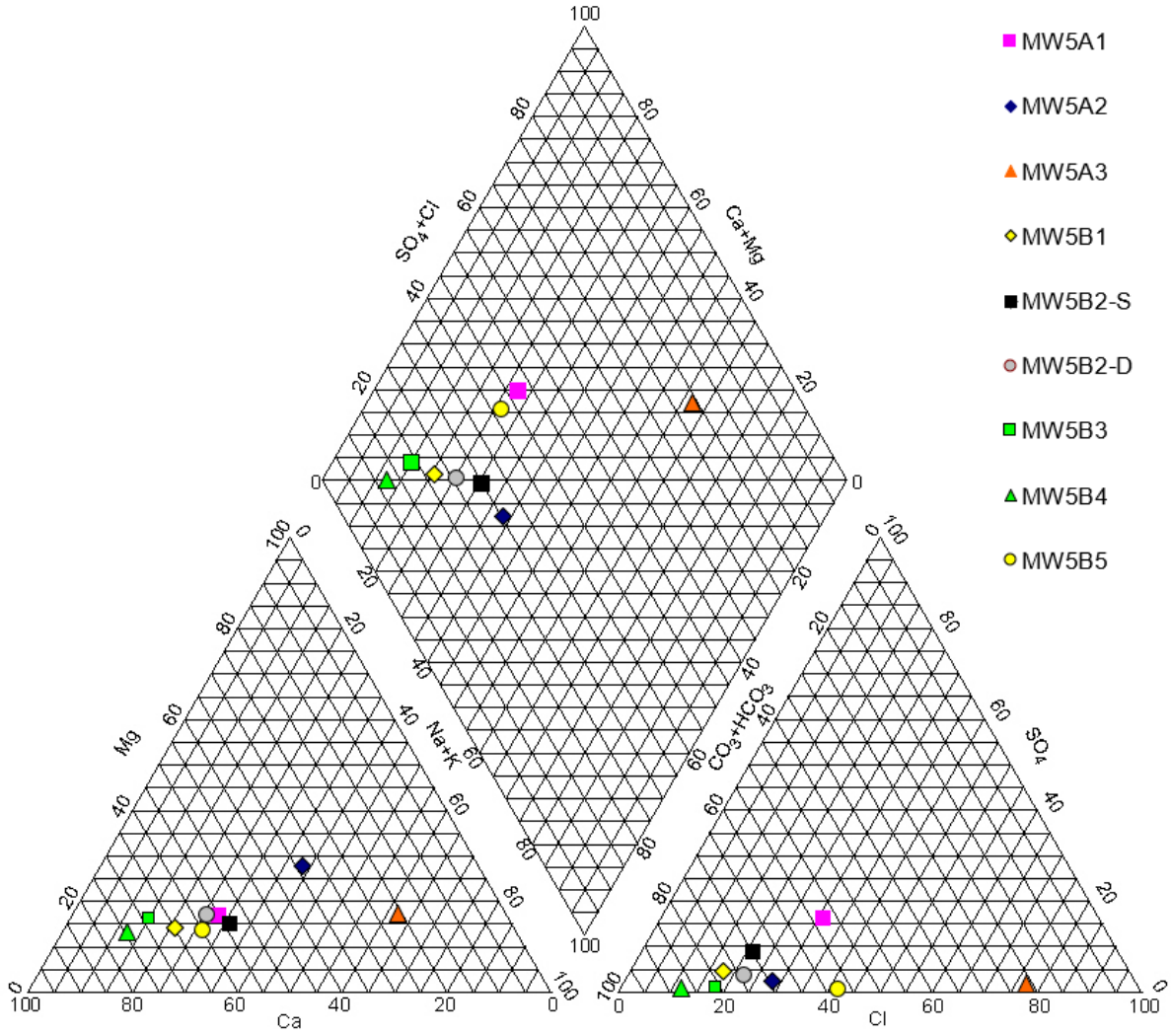


Chart 3: Piper diagram of hydro-chemical facies

Based on the ratios of anions and cations, there appears to be four dominant hydro-chemical facies beneath the Site:

- Bores MW5A1, MW5A2 and MW5B5: Mixed groundwater with no dominant species;
- Bore MW5A3: NaCl (sodium chloride) dominant with slightly higher salinity (TDS >500 mg/L);
- Bores MW5B1 to MW5B4: $CaHCO_3$ (calcium bicarbonate) dominant; and
- Bore MW5B5: $CaHCO_3$ >Na(Mg)Cl and slightly higher salinity (TDS >500 mg/L).

The ionic balance of the groundwaters analysed is consistent with natural uncontaminated waters within the aquifer on this Site. Groundwater beneath the Site was found to range in pH from 6.0 to 7.7, which is locally below the currently agreed water quality objectives (Condition 24) for Stage 2-4 area, which specified a pH range of between pH 6.5 and 8.5. This neutral nature of the groundwater is likely to be due to the large amount of bicarbonate (HCO_3) present within the soil matrix particularly in Stage 5B, likely associated with shell

fragments within the Quaternary sediments. The HCO_3^- (in addition to Ca^{2+}, Mg^{2+} and SO_4^{2-}), when dissolved into the aquifer, will act to buffer any organic acids present in the system.

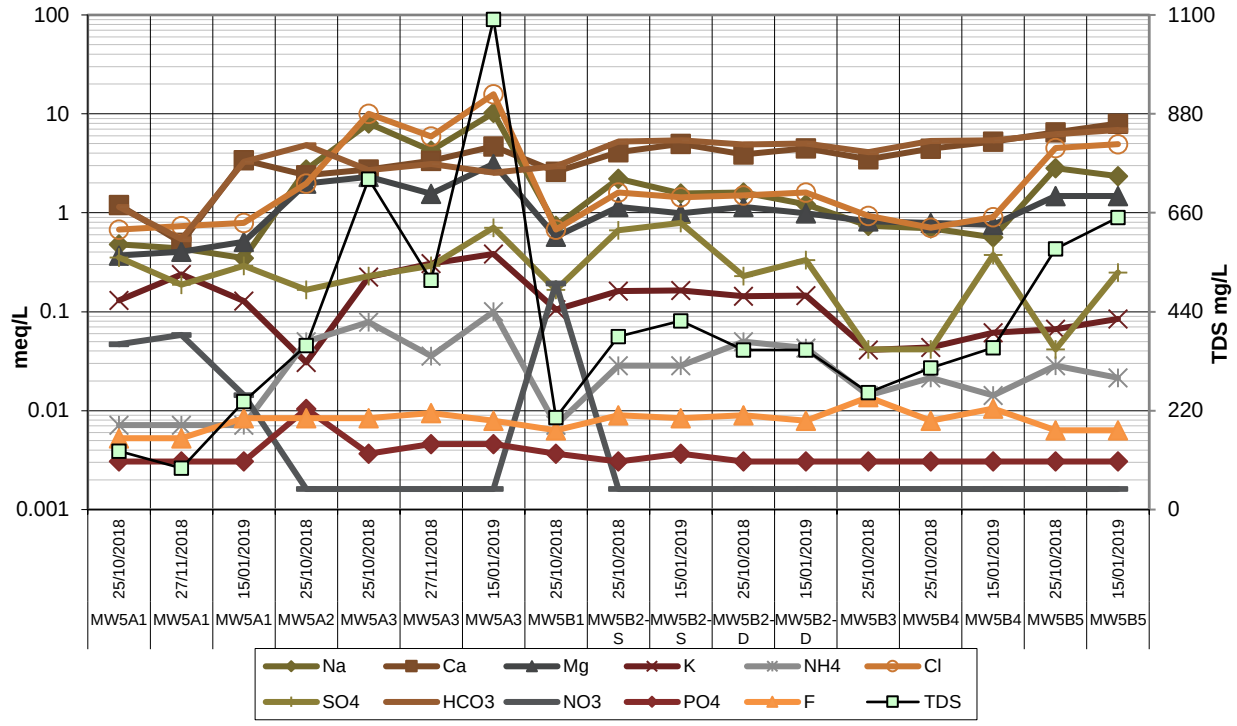


Chart 4: Schoeller Plot of hydro-geochemistry

The aquifer studied as part of this Proposal can be described as having predominantly fresh water within the Stage 5 extraction area (TDS <500 mg/L other than at bores MW5A3 and MW5B5). TDS values from the recent investigation have been presented in **Chart 5**. Bore MW5A3 recorded a TDS value of 1100 is close to a pond to the north of Fig Hill Lane and it is anticipated that the northern corner of the Stage 5A extraction area may be hydraulically impacted by the associated drainage channel to the north of the Site that connects the pond to the Minnamurra River.

Similarly, the elevated TDS levels in bore MW5B5 are expected to be a reflection of the proximity to the Minnamurra River, of which it is in hydraulic connectivity.

Previous data collected for groundwater from surrounding sites (including Stages 2 to 4) correlates well with the results obtained in this study. This provides confidence in the conclusion that this Site's groundwater is chemically similar with the natural groundwater of the Dunmore area.

4.7.3 Comparison to water quality criteria

Groundwater collected from the unconfined aquifer in the above-mentioned bores was also analysed for a range of 11 heavy metals, as shown in **Table 13** at the back of this report. Manganese (Mn) exceeded guidelines for drinking (aesthetic only) and irrigation in bores MW5A2 and MW5A3, while phosphate (PO_4) also exceeded the irrigation criteria at these locations. All dissolved metal concentrations are therefore suitable for all uses other than Mn

and PO_4 for irrigation at bores MW5A2 and MW5A3. Nitrate (NO_3) narrowly exceeded ecosystem criteria at bore MW5B1, and all other exceedances were aesthetic only.

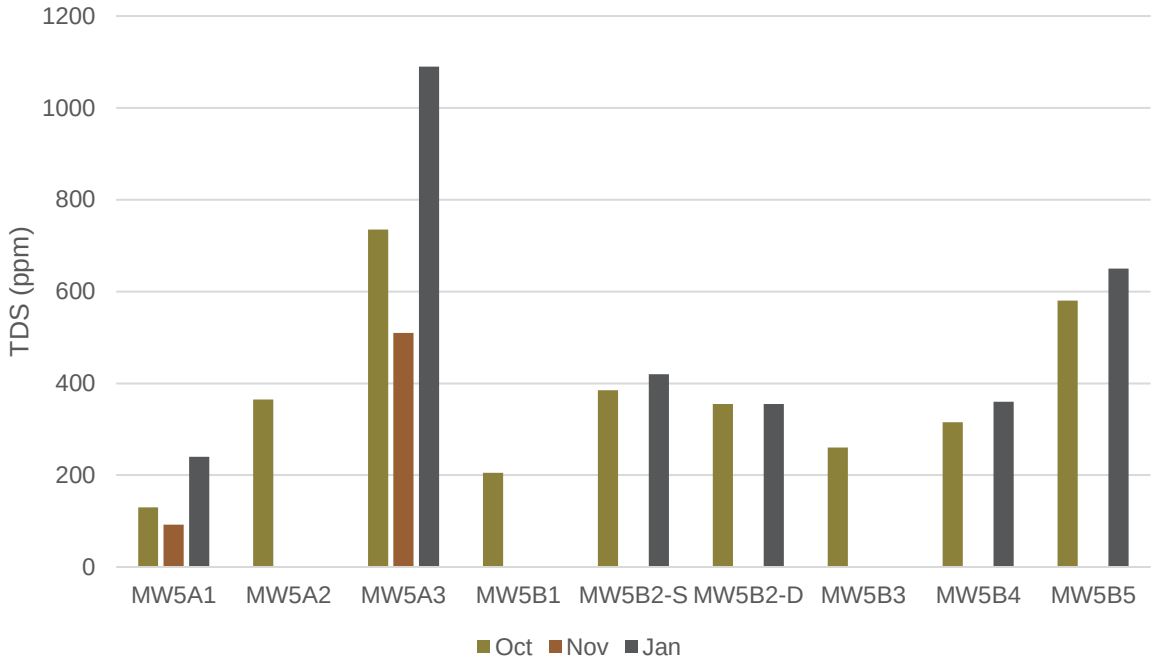


Chart 5: TDS plot

The groundwater quality results are generally considered to be representative of baseline groundwater quality in the study area and provides a good basis for comparison against results for monitoring throughout the life of the Proposal and into closure.

4.8 Groundwater usage and receptors

4.8.1 Introduction

As the current predominant land use for the Site is either industrial or passive recreational use, no extractive use of groundwater is expected. The groundwater resource beneath the Site is of relatively useful yield and quality (as noted earlier in Section 4.5) and is therefore suitable for a number of potential beneficial uses. The search of the BOM bore database did not record stock watering or domestic use within a 1km radius of the Site.

The adjacent site (Stage 2-4) has a current water extraction license for on-site operations, including dust suppression, under Water Access License (WAL24477) issued under the Water Management Act 2000. The license permits the extraction of 65Ml of water from the Sydney Basin the Sydney Basin South Groundwater Source and is subject to a number of conditions. Associated 'work approvals' include 10WA106713 and 10WA106714.

Surface water enters the site ponds at the Stage 2-4 Site from the western, eastern and northern tributaries and flows out of the ponds back into the re-aligned western tributary. The influence of surface water on the site water balance is therefore considered to be

neutral. Water extracted from the ponds is measured and considered in relation to the applicable groundwater licence.

4.8.2 Potential beneficial uses

Beneficial reuse of groundwater in NSW is governed by water quality objectives and associated criteria (DLWC, 1998). Potential beneficial uses of an aquifer are directly associated with potential yield (sustainable or otherwise) and quality. All groundwater, regardless of yield or quality, is required to be protective of the natural ecosystem within which it resides and in particular discharges to, including any groundwater dependent ecosystems (GDEs).

In order to determine potential beneficial uses of an aquifer, a water quality and quantity assessment is undertaken, including:

- desk-top assessment of existing users and ecosystems (including GDEs), as well as any information on yield and quality;
- assessment of potential groundwater yields (quantity), including existing information and collection of additional physical data; and
- assessment of groundwater quality based on existing information, collection of field data and chemical analysis of collected groundwater samples.

A summary of each potential beneficial use of the aquifer beneath the site is provided in **Table 8**.

4.8.3 Summary of groundwater usage

Based on **Table 8**, the relevant beneficial users of groundwater (in order of priority and importance) are:

- the freshwater and marine ecosystems of local surface water features (Minnamurra River in particular) and nearby ephemeral creek systems;
- stock watering;
- recreational, direct contact and aesthetic use; and
- possible irrigation;
- Site use (dust suppression)

Table 13 lists the relevant criteria values adopted, which have been derived to ensure water quality is protective of the relevant beneficial uses.

The local groundwater is not considered to have potential beneficial use as drinking water, while use for irrigation is not currently occurring and is considered unlikely.

Table 8: Potential beneficial use assessment

Potential beneficial use	Assessment
Drinking water	• The water bearing zone beneath the Site is not a known drinking water aquifer, due primarily to limited lateral extent, and variable yield and quality. • the Site is not located in an area containing a major drinking water aquifer; • actual groundwater users have been identified in the vicinity of the Site, and no users of groundwater for drinking have been identified (backed up by chemistry information); and • an assessment of groundwater quality on the basis of TDS and EC, as well as Na, Cl and SO4 in particular has been undertaken, and has confirmed that groundwater ranges from not suitable to marginally suitable for human consumption. Thus, protection of groundwater for drinking supply is not a relevant beneficial use for this Proposal, however as TDS is generally <2,000 mg/L drinking water criteria will still be cited in assessment of the data (as required by DEC 2007).
Recreation, direct contact and aesthetics	• Groundwater is expected to protect human health via potential exposure from recreational, commercial and industrial activity. As such, guidelines provided by NHMRC/ NRMMC (2008 and 2018) have been considered. • NHMRC/ NRMMC (2008) state that criteria for recreational/ direct contact quality can be derived from the values presented in NHMRC / NRMMC (2011, which was updated in 2018), by applying a multiplication factor of 10-20 for non-volatile chemicals. The reasoning for this is that the drinking water criteria are calculated based on the assumption that the average person consumes 2 L of water per day, and the rate of assumed incidental ingestion during a daily swimming session is 100-200 mL. • Drinking criteria and the consequent direct contact/ recreational criteria have been included in **Table 13**. Also included in these tables are aesthetic criteria for certain chemicals relevant to the Site that have potential odour, discolouration and taste issues (TDS, Na, Cl, NH_3 and Fe).
Irrigation	• For reasons similar to the discussion above for drinking water quality, groundwater in the vicinity of the Site is of marginal quality for use as irrigation water. For this reason (in addition to that of the limited areal extent of the aquifer), groundwater is not utilised for irrigation in the catchment, based on field observations and discussions, and assessment of water quality data. • Further, TDS, Na, Cl and Mn concentrations in groundwater are also likely to limit potential groundwater use for irrigation (see **Table 13**). Additionally, analysis of data indicates that the groundwater hardness is on average 250 mg/L as $CaCO_3$, with very few locations below the desired level of 180 mg/L as $CaCO_3$. The saturation indices (Langelier and Ryzner) also indicate that this water is corrosive.

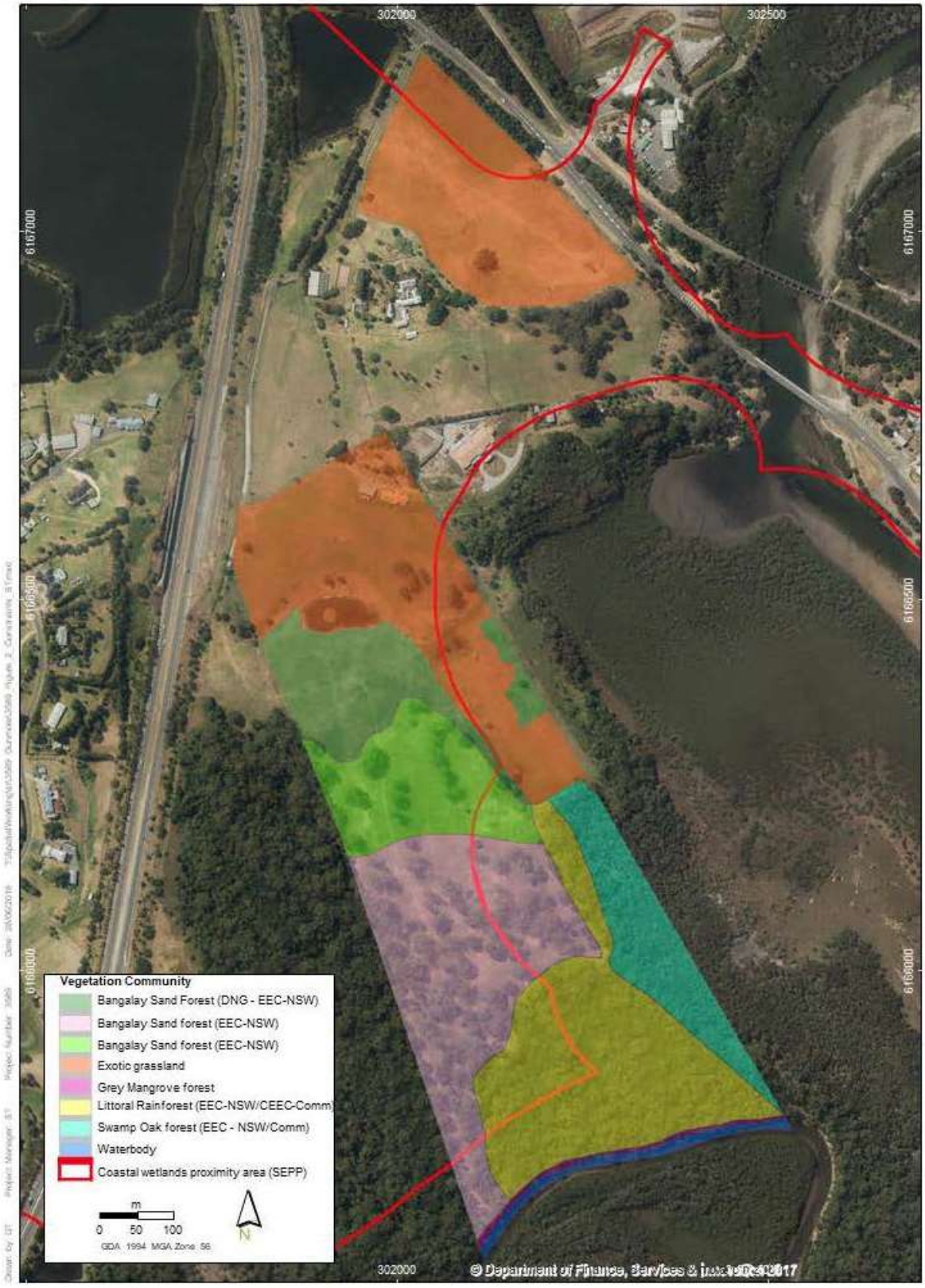
Potential beneficial use	Assessment
Stock watering	• The primary historic use of groundwater in the catchment is expected to have been stock watering. In addition, water quality and yield are within a suitable range for this use. As such, this is a relevant beneficial use that requires protection. Criteria for stock watering are based on values provided in ANZG (2018), and default to NHMRC/ NRMMC (2018) where specific stock watering criteria are otherwise unavailable.
Discharge to surface water (ecosystem protection)	• Ecosystem protection is a primary beneficial use of the aquifer, as the Minnamurra River to the east of the Site is a receptor for groundwater discharge (see **Figures 4a** to **4c**). As such, water quality criteria for protection of 95% of species have been adopted from ANZG (2018), and are provided in **Table 13**.
Groundwater dependent ecosystems (GDE)	• The GDE map provided in **Figure 8** (after BOM, 2019) indicates no aquatic or terrestrial groundwater dependent ecosystems (GDE) are present within the proposed dredging areas. • Vegetation along the south-eastern boundary of Stage 5B area and adjacent to the southern boundary of Stage 5B is identified as a terrestrial GDE, reliant on the hydraulic connectivity between the Minnamurra River and inland groundwaters, associated with its proximity to the Minnamurra River. Vegetation communities identified at the Site are illustrated in **Figure 9**.
Industry	• There are no industrial users of groundwater in the locality. Major reasons for this are the relatively low yield of the aquifer under consideration (alluvium) and its variable quality, as well as the relatively isolated location of the Site away from the nearest industrial centres (Shellharbour to the north and Kiama to the south – see **Figure 1**). As such, this potential beneficial use requires no further consideration.

Legend

Groundwater Dependent Ecosystems

Aquatic	Terrestrial
High potential GDE	High potential GDE
Moderate potential GDE	Moderate potential GDE
Low potential GDE	Low potential GDE

ENVIRONMENTAL EARTH SCIENCES	Title: **Local Groundwater Dependent Ecosystems**	
	Location: **Boral Dunmore Sand and Soil – Stage 5**	
Client: **Element Environment**		Job No: **118044**
Drawn By: **MN**	Scale: **1:8,500**	Source: **BOM**
Proj Man: **EG**	Date: **January 2019**	**Figure 8**



ENVIRONMENTAL EARTH SCIENCES	Title: **Site vegetation communities**	
	Location: **Boral Dunmore Sand and Soil – Stage 5**	
Client: **Element Environment**		Job No: **118044**
Drawn By: **MN**	Scale: **As shown**	Source: **Niche**
Proj Man: **EG**	Date: **January 2019**	**Figure 9**

5 IMPACT ASSESSMENT

This section presents an assessment of the potential physical and chemical impacts of the Proposal, including consideration of the potential impacts to beneficial uses of the groundwater.

5.1 Assessment methodology

Potential impacts to groundwater beneficial users as a result of the Proposal have been assessed in the context of the local hydrogeological setting, i.e. the CSM, and the relevant legislation and guidelines. The CSM was based on:

- a desktop assessment of existing information relating to the Proposal and catchment hydrogeology;
- further assessment of aquifer physical properties at newly installed and existing individual locations; and
- further assessment of aquifer chemical properties at newly installed and existing individual locations.

The nature of the groundwater flow system, i.e. a local flow system discharging to the Minnamurra River and local creeks means that all potential impacts of the Proposal are considered to be locally constrained. The area of potential impacts is constrained to the east and south by Minnamurra River, to the west by the edge of the aquifer and to the north by the Dunmore Recycling and Waste Disposal Depot (DRWDD) (**Figure 2**). All of the potential sources of impact within the Site are to be located within the groundwater flow system flowing to the Minnamurra River.

The assessment of impacts is based on the CSM and on knowledge and experience of the authors of flow systems in similar environments and of similar projects. Where appropriate, calculations of groundwater flow velocity, volumetric groundwater flow rate (flux), and travel time are evaluated, based on Darcy's law (Freeze and Cherry, 1979).

Groundwater flow or transport modelling was not justifiable given that dewatering and associated drawdown will not be taking place. Limited groundwater use for dust suppression is proposed, however this is limited to be limited in use and used for dust suppression. However, given the abundance of existing available surface water reserves. Any surface

The different components of the Proposal are described in Section 5.2. The potential impacts associated with the components of the Proposal are described in **Table 9**. Identified potential groundwater impacts are listed in a summary table (**Table 11**) in which the likelihood, consequence and the resulting potential risk associated with each potential impact is considered based on a risk matrix (**Table 10**).

5.2 Description of the proposal

It is understood that work will be carried out sequentially with sand extraction within Stage 5A to commence prior to Stage 5B operations, with a two-week transition period during which

dredging operations would occur simultaneously between the two extractions areas prior to the rehabilitation of Stage 5A. Components of the Proposal other than those detailed are expected to be limited to the plant required to facilitate the Proposal.

5.2.1 Site Preparation

Prior to commencement of extraction in the Stage 5A area, topsoils would be stripped and stockpiled for future use in rehabilitation efforts and surface water management bunds.

The footprint of the Stage 5B extraction area was reduced during design development to avoid sensitive vegetation areas and the 'coastal wetland proximity area'.

5.2.2 Site Works (excavation)

The sand and water pumped from the dredge in the Stage 5A and Stage 5B extraction areas will pass over an initial screen at the Stage 2 processing plant to separate oversize organic matter or debris and into a large wash tank to float out any fines (<75 µm). After washing, the sand will be pumped through a cyclone and stockpiled for further dewatering. Water removed through the dewatering process will drain to an existing fines pond and a secondary settling pond before being pumped back to the Stage 5A and Stage 5B dredge ponds.

Water pumped from the Stage 5 extraction areas will be returned to these extraction areas via the pumping pipeline. Pumped water volumes will be recorded by a flow meter and the same volume of water will be returned to the Stage 5 extraction areas to balance water extracted.

5.2.3 Site rehabilitation

Upon completion, the Stage 5A extraction area would be backfilled with VENM, topsoil spread and groundcover vegetation re-established to return the land back to pasture at the request of the landowner. The Stage 5B extraction area would be left as a freshwater pond at the request of the landowner.

All rehabilitation initiatives at the site would be carried out in accordance with the principles contained in the approved Dunmore Sand and Soil Project Rehabilitation Management Plan (Arcadis, 2017). The Rehabilitation Management Plan would be updated to include the Stage 5 extraction area.

The major aspect of the Proposal that will minimise the likelihood of impact for all components will be the management and mitigation measures adopted during importation and placement of soil in Stage 5A area. There is no dewatering planned during the Proposal operations because the method of sand excavation is via a suction dredge that will operate from a barge on the lake that is to be created by the excavation extending below the water-table. Therefore, there is not expected to be any significant drawdown of groundwater levels associated with the Proposal.

Across the Site negligible changes in groundwater levels are expected to occur throughout the life of the Proposal and post-closure. The potential impacts of the Proposal are described separately below in **Table 9** and summarised in **Table 11**.

Table 9: Summary of identified potential impacts

Potential physical impacts to groundwater	
Site preparation	• Once vegetation is cleared from the Site there will be increased opportunity for direct recharge of rainfall to the water table, and a coincident increase in the potential for run-on to and run-off from the Site. This increased surface water movement has the potential to consequently increase surface erosion rates, and as such it will be important to have sediment and surface water controls in place prior to vegetation removal. • These surface water and erosion controls will potentially improve the mechanism for water table recharge (i.e. direct infiltration of ponded surface water) which, along with reduced evapo-transpiration following vegetation removal, may result in localised water table elevations beneath the Site. The consequence of such an impact is considered to be **minor** to **negligible** and may even be beneficial by increasing groundwater flux rates from the Proposal Site to Minnamurra River. • The footprint of the Stage 5B extraction area was reduced during design development to avoid areas of identified GDE and the 'coastal wetland proximity area'.
Excavation	• Removal of the aquifer matrix by excavation is likely to have very little physical impact on the groundwater resource. This is because the extraction areas of Stage 5 (11.54 ha) makes up a small proportion (0.1%) of the overall 11,730 hectare (117.3 km^2) Minnamurra River catchment. Whilst the likelihood of any change in water table levels as a result of excavation and consequent alteration of recharge and discharge mechanisms for groundwater at the Site is **possible**, the consequence is **minor**. This is because changes in the water table level (within the ranges predicted below) in the vicinity of the dredge pond will not have a physical consequence for the aquifer or its potential receptors. • Mechanisms for lowering the water-table are expected to be limited to increased evaporation rates in the area of the ponds once the water table is exposed to the atmosphere and reduced run-on to the pond areas. • Based on rainfall and evaporation rates in the area, the difference between rainfall recharge to and evaporation from the ponds in Stage 5 is expected to vary from a deficit of 67 m^3/day in November to an average accumulation of 55 m^3/day in June. Overall the Site is expected to have a net deficit based on rainfall and evaporation of 219 m^3 per annum.
Reinstatement and rehabilitation	• Reinstatement with VENM is likely to have the physical impact of decreasing bulk porosity of the aquifer matrix in the Proposal Site footprint, due to the expected finer texture from an estuarine source compared to *in-situ* sand dominated alluvial sediments. Despite the expectation for this occurrence being "likely" (**Table 8**), the consequence is "minor". • Of the two rehabilitation options, the rehabilitation of Stage 5B as a wetland is considered to have a slightly lower level of overall risk to the backfilling to surface proposed for Stage 5A as the wetland is expected to facilitate water table recharge and return to natural conditions. However, both options have a "negligible" consequence of any physical impact, and hence "minor" overall risk.

Potential chemical impact to groundwater	
Site preparation	• Reduced evapo-transpiration following vegetation removal may result in localised water table elevations beneath the Proposal Site, hence chemical impact as a result of site preparation is expected to be limited to potential increases in fresh water recharge to the aquifer. Any chemical "impact" is therefore likely to be beneficial.
Excavation	• Removal of the aquifer matrix by excavation has the potential to chemically impact on the groundwater resource. Whilst the likelihood of any change in water table levels as a result of excavation and consequent alteration of recharge and discharge mechanisms for groundwater at the Proposal Site is "possible" the chemical consequence of water table lowering is "major" due to the potential for reduced inorganic sulfides to be exposed to oxygen and generate acid. According to Environmental Earth Sciences PASS report (reference 118044_v2), sulfides may be encountered on the Site locally at 5A2 and 5A3 1.25 – 4.0 m of the ground surface, hence maintenance of water table levels in the pond for the area of Stage 5A is an important consideration for the Proposal. • As detailed in Section 4.6 above, it can be estimated from water balance calculations that the water-table would not be expected to drop by any significant degree as a result of the Proposal. As such, a reduction in water-table level does have a very minor potential to expose soil sulfides around the perimeter of the pond in the Stage 5A area and monitoring of water-table and pond levels (as well as management procedures to mitigate any acid production) will be necessary throughout the duration of the Proposal and into closure.
Reinstatement and rehabilitation	• It is proposed to reinstate the Stage 5A area with non-PASS VENM. Depending upon its condition and origin, VENM has the potential to contain some unidentified PASS which has the potential chemical impact of allowing acid to be produced by permanently lowering the water table in the Proposal Site footprint. However, It is proposed to only use non-PASS VENM, which has been tested to certify the classification prior to placement. • The wetland rehabilitation proposed for the Stage 5B area is considered to have a lower level of overall risk compared with the backfilling to surface option (in Stage 5A) as the wetland would be expected to facilitate water table recharge and return to natural conditions.

5.3 Comparison of risks

A summary of the primary potential groundwater impacts of the different components of the Proposal, based on the above discussion, has been provided in **Table 11**. The individual impacts are considered separately in terms of their likelihood and consequence; scores are attributed to both likelihood and consequence on a scale from 1 to 5 in each case. The risk is, in turn, scored as the sum of the likelihood and consequence scores. The risk matrix is illustrated in **Table 10.**

Table 10: Risk matrix

		Likelihood				
Consequence		Very unlikely (5)	Unlikely (4)	Possible (3)	Likely (2)	Very Likely (1)
	Negligible (5)	10	9	8	7	6
	Minor (4)	9	8	7	6	5
	Moderate (3)	8	7	6	5	4
	Major (2)	7	6	5	4	3
	Critical (1)	6	5	4	3	2

Note(s):

Likelihood scale has five categories with scores from 5 to 1, i.e. Very Unlikely (5), Unlikely (4), Possible (3), Likely (2), Very Likely (1)

Consequence scale has five categories with scores from 5 to 1, i.e. Negligible (5), Minor (4), Moderate (3), Major (2), Critical (1)

Overall risk value = Consequence value + Likelihood value; consequence and likelihood are considered separately

Red denotes Extreme Risk (scores of 2-3), Orange denotes High Risk (scores of 4-5), Yellow denotes Moderate risk (scores of 6-7), Green denotes low risk (8-10)

5.4 Summary of impacts

As detailed in **Table 11**, all consequences associated with potential physical impacts are "minor" to "negligible". This is primarily because the Site makes such as small contribution to the overall catchment water balance, and that there are no potential receptors to groundwater discharge down-gradient of the Site other than the ecosystems of Rocklow Creek and the Minnamurra River.

The consequence of any chemical impacts is however more significant. The major reason for this is that any chemical impact is likely to be as a result of oxidation of natural *in-situ* reduced sulfides.

Lowering of the water-table during excavation of *in-situ* sediments could expose PASS around the pond perimeter of Stage 5A (estimated to be close to 500 m in length). Hence, it has been estimated that approximately 600 m^3 of PASS could be oxidised. Assuming a maximum net acidity of 20 kg H_2SO_4/tonne (Environmental Earth Sciences 2019, Table 9), and 960 tonnes of oxidised PASS (assuming a soil bulk density of 1.6 T/m^3), over 19 tonnes of acid could be produced.

Table 11: Qualitative impact assessment

Proposal Component	Aspect	Potential Impacts to Groundwater	Likelihood of Impact	Consequence of Impact	Overall Level of Risk	Comments
Site Preparation	Vegetation Clearing	Physical Impact to Groundwater	Unlikely (4)	Minor (4)	**Low (8)**	Impacts: increased recharge, run-on, run-off and erosion
		Chemical Impact to Groundwater	Very Unlikely (5)	Moderate (3)	**Low (8)**	No mechanism for impact
		Ensuing Physical Impact to Ecosystems or Groundwater Users	Very Unlikely (5)	Negligible (5)	**Low (10)**	Ecosystem **not** heavily reliant on groundwater
		Ensuing Chemical Impact to Ecosystems or Groundwater Users	Very Unlikely (5)	Moderate (3)	**Low (8)**	No mechanism for impact
Excavation	Removal of Aquifer matrix	Physical Impact to Groundwater	Unlikely (4)	Minor (4)	**Low (8)**	Lowering of water-table
		Chemical Impact to Groundwater	Unlikely (4)	Moderate (3)	**Moderate (7)**	Exposure and oxidation of PASS (**Stage 5A only**)
		Ensuing Physical Impact to Ecosystems or Groundwater Users	Unlikely (4)	Minor (4)	**Low (8)**	Ecosystem **not** heavily reliant on groundwater
		Ensuing Chemical Impact to Ecosystems or Groundwater Users	Unlikely (4)	Minor (4)	**Low (8)**	Stage 5B hydraulically up gradient of PASS located in Stage 5A

Proposal Component	Aspect	Potential Impacts to Groundwater	Likelihood of Impact	Consequence of Impact	Overall Level of Risk	Comments
Reinstatement (**Stage 5A only**)	VENM Placement	Physical Impact to Groundwater	Likely (2)	Minor (4)	**Moderate (6)**	Reduction in aquifer porosity, possible lowering water table
		Chemical Impact to Groundwater	Unlikely (4)	Critical (1)	**Moderate (5)**	Non-PASS VENM to be used in reinstatement of Stage 5
		Ensuing Physical Impact to Ecosystems or Groundwater Users	Unlikely (4)	Minor (4)	**Low (8)**	Ecosystem **not** heavily reliant on groundwater
		Ensuing Chemical Impact to Ecosystems or Groundwater Users	Unlikely (4)	Minor (4)	**Low (8)**	Stage 5B is hydraulically up gradient of PASS located in Stage 5A
Rehabilitation Stage 5B	Wetland	Physical Impact to Groundwater	Unlikely (4)	Negligible (5)	**Low (9)**	Risk decreasing over time
		Chemical Impact to Groundwater	Unlikely (4)	Minor (4)	**Low (8)**	-
		Ensuing Physical/Chemical Impact to Ecosystems or Groundwater Users	Unlikely (4)	Negligible (5)	**Low (9)**	Ecosystem **not** heavily reliant on groundwater surface expression

The consequence of chemical impacts to groundwater during rehabilitation is “Low” as any acidification at this stage is expected to (as with the excavation process) be limited to the upper portion of the water table surface. However, there is the potential that the VENM will only be placed to within 1 m of the permanent water table level, hence reduction in consequence from “major” to “moderate”.

In both these instances, it is considered that management and mitigation measures that will be put in place will be able to further reduce their likelihood of occurrence from “possible” to “unlikely” or even “very unlikely”, thus reducing the overall risk to “moderate”.

The direct risk to the groundwater resource associated with PASS acidification is considered to be “moderate”, largely because of the consequences to the groundwater resource. All material to be used in the rehabilitation of Stage 5 is to be non-PASS VENM. Receival protocols will be addressed within the existing Waste Management Plan for DSS, which is to be reviewed and updated to include the backfilling of Stage 5A and wetland rehabilitation of Stage 5B. Therefore, the risk is assessed as “moderate”.

6 MANAGEMENT AND MITIGATION

6.1 Summary of soil mitigation and monitoring recommendations

The chemical risk to groundwater associated with the Proposal components is conservatively considered to be relatively high in comparison to potential physical risks. Chemical risks are essentially limited to the potential for oxidation of reduced sulfides that are present in *in-situ* sediments to be excavated.

In-situ sediments are to be separated on the basis of particle size so that the sand resource can be sold, while the fine fractions, which are associated with containing the reduced sulfides identified in Stage 5A, will drain into the Stage 5 pond.

All material to be used in the rehabilitation of Stage 5 is to be non-PASS VENM. Receival protocols will be addressed within the existing Waste Management Plan for DSS, which is to be reviewed and updated to include the backfilling of Stage 5A and wetland rehabilitation of Stage 5B.

6.2 Summary of groundwater monitoring recommendations

The following recommendations will be formalised in an update to the existing Groundwater Monitoring and Management Plan (GMMP) for DSS to encompass the Stage 5 area (Environmental Earth Sciences, 2018). The GMMP forms a sub-plan to the Water Management Plan (WPM) prepared in accordance with Schedule 3(34) for Development Consent DA 195-8-2004 (2004) for Stages 2, 3 & 4.

The GMMP describes the objectives of the groundwater management and monitoring and details the proposed types and locations of monitoring. It also describes the monitoring observations which would trigger actions, and the proposed action and/ or mitigation should triggers be exceeded (DEC, 2007). The recommended monitoring program is intended to facilitate baseline through to closure-focussed interpretation of the data.

6.2.1 Monitoring network

As a result of dredging, it is anticipated that bores MW5A1 to MW5A3, MW5B1 and MW5B2 may be destroyed. Should this occur, it is recommended that three additional bores be installed about the proposed pond in the Stage 5A extraction area: one to the north; one to the east; and one to the south of the pond. It is also recommended that a further bore be installed to the north of the Stage 5B dredging ponds. It is recommended that all new bores be installed to a depth of at least six metres.

All bores will need to be surveyed for relative height to Australian Height Datum (AHD) with at least 0.001 m accuracy, so that relative groundwater levels can be compared. In addition, the pond surface will need to be surveyed so that the relative height of water in the pond over time can be accurately measured.

6.2.2 Physical assessment of groundwater and pond levels

Static groundwater levels (SWL) and pond water level AHD heights will need to be measured monthly during excavation works, reinstatement works, and during rehabilitation works (bores only). Following rehabilitation, all seven bores (existing and proposed) will be incorporated into the existing quarterly groundwater monitoring program for the wider quarrying area.

6.2.3 Chemical assessment of groundwater and surface water

During excavation works and rehabilitation, in additional to SWL and pond water level measurement, all seven bores and the pond will need to be tested for pH, on a monthly basis. It is recommended that pH measurement be performed in the field with a hand held electronic meter.

In addition to the above recommended measurement for pH, all bores from both Stage 5A and Stage 5B will be incorporated into the pre-existing groundwater management plan, which will be updated as a result of Stage 5 determination.

Groundwater bores will be sampled on a monthly basis for static water levels (SWL) and pH, and tested quarterly for the following analytical suite:

- Field measurement of:
    - pH, electrolytic conductivity (EC), oxidation-reduction potential (ORP), SWL, dissolved oxygen (DO) and temperature;
- Laboratory analysis for:
    - full ionic balance suite – pH, TDS, cations (Na, Ca, Mg, K), anions (Cl, SO_4, HCO_3, PO_4, F) and nutrients (NH_4, NO_3, NO_2, Total N); and
    - dissolved metals – iron (Fe).

6.3 Objectives met

Environmental Earth Sciences considers the objectives of this report to be satisfactorily met to describe the local hydrogeological setting within the areas of potential impact, assess the potential impacts and recommend controls and mitigation measures in regards to the modification to the current Project Approval (DA 195-8-2004) under Section 75W of the *Environmental Planning and Assessment Act 1979* (EP&A Act), to provide for an additional extraction area (Stage 5) on behalf of the Client, Boral Pty Ltd.

7 LIMITATIONS

This report has been prepared by Environmental Earth Sciences NSW ACN 109 404 006 in response to and subject to the following limitations:

1. The specific instructions received from Element Environment Pty Ltd;

2. The specific scope of works issued by Element Environment Pty Ltd for and on behalf of Boral, is included in Section 1.2 (Scope of Work) of this report;

3. This report and all material contained within it is subject to Australian copyright law, and is the property of Boral Limited. Other than in accordance with the *Copyright Act 1968* or the report, no material from the report may, in any form or by any means, be reproduced, distributed, stored in a retrieval system or transmitted, other than with the written consent of Boral Limited or its subsidiaries.

4. May not be relied upon by any third party not named in this report for any purpose except with the prior written consent of Environmental Earth Sciences NSW (which consent may or may not be given at the discretion of Environmental Earth Sciences NSW);

5. This report comprises the formal report, documentation sections, tables, figures and appendices as referred to in the index to this report and must not be released to any third party or copied in part without all the material included in this report for any reason;

6. The report only relates to the site referred to in the scope of works being located at 471 Riverside Drive, Dunmore (Stage 5A) and 69 Fig Hill Lane, Dunmore (Stage 5B) (“the site”);

7. The report relates to the site as at the date of the report as conditions may change thereafter due to natural processes and/or site activities;

8. No warranty or guarantee is made in regard to any other use than as specified in the scope of works and only applies to the depth tested and reported in this report;

9. Fill, soil, groundwater and rock to the depth tested on the site may be fit for the use specified in this report. Unless it is expressly stated in this report, the fill, soil and/or rock may not be suitable for classification as clean fill, excavated natural material (ENM) or virgin excavated natural material (VENM) if deposited off site;

10. This report is not a geotechnical or planning report suitable for planning or zoning purposes; and

11. Our General Limitations set out at the back of the body of this report.

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9 GLOSSARY OF TERMS

The following descriptions are of terms used in the text of this report.

Acid Sulfate Soil (ASS). A soil containing iron sulfides deposited during either the Pleistocene or Holocene geological epochs (Quaternary aged) as sea levels rose and fell.

Alluvial. Describes material deposited by, or in transit in, flowing water.

Aquifer. A rock or sediment in a formation, group of formations, or part of a formation which is saturated and sufficiently permeable to transmit economic quantities of water to wells and springs.

Bore. A hydraulic structure that facilitates the monitoring of groundwater level, collection of groundwater samples, or the extraction (or injection) of groundwater. Also known as a well, monitoring well or piezometer, although piezometers are typically of small diameter and only used for measuring the groundwater elevation or potentiometric surface.

Dissolved Oxygen (DO). Oxygen in the gaseous phase dissolved in water. Measured either as a concentration in mg/L or as a percentage of the theoretical saturation point, which is inversely related to temperature. At 19, 20 and 21 degrees Celsius, the oxygen concentrations in mg/L corresponding to 100% saturation are 9.4, 9.2 and 9.0 respectively.

Electrical Conductivity (EC). The EC of water is a measure of its ability to conduct an electric current. This property is related to the ionic content of the sample, which is in turn a function of the total dissolved (ionisable) solids (TDS) concentration. An estimate of TDS in fresh water can be obtained by multiplying EC by 0.65.

Fluvial. A material deposited by, or in transit, in streams or watercourses.

Groundwater Elevation. The elevation of the groundwater surface measured relative to a specified datum such as the Australian Height Datum (mAHD) or an arbitrary survey datum onsite, or “reduced level” (mRL).

Hydraulic Conductivity (K). A coefficient describing the rate at which water can move through a permeable medium. It has units of length per time. The units for hydraulic conductivity are typically m3/day/m2 or m/day.

Hydraulic Gradient (i). The rate of change in total head per unit of distance of flow in a given direction – the direction is that which yields a maximum rate of decrease in head. Hydraulic Gradient is unit less.

Hydraulic Head (h). The sum of the elevation head and the pressure head at a point in an aquifer. This is typically reported as an elevation above a fixed datum, such as sea level.

Ionic Exchange. Adsorption occurs when a particle with a charge imbalance, neutralises this charge by the attraction (and subsequent adherence of) ions of opposite charge from solution. There are two types of such a charge: pH dependent; and pH independent or crystalline charge. Metal hydroxides and oxy-hydroxides represent examples of the former

type, whilst clay minerals are representative of the latter and are normally associated with cation exchange.

Ions. An ion is a charged element or compound as a result of an excess or deficit of electrons. Positively charged ions are called cations, whilst negatively charged ions are called anions. Cations are written with superscript +, whilst anions use - as the superscript. The major aqueous ions are those that dominate total dissolved solids (TDS). These ions include: Cl-, SO42-, HCO3-, Na+, Ca2+, Mg2+, K+, NH4+, NO3-, NO2-, F-, PO43- and the heavy metals.

Oxidation. Was originally referred only to the addition of oxygen to elements. However oxidation now encompasses the broader concept of the loss of electrons by electron transfer to other ions.

Permeability (k). Property of porous medium relating to its ability to transmit or conduct liquid (usually water) under the influence of a driving force. Where water is the fluid, this is effectively the hydraulic conductivity. A function of the connectivity of pore spaces.

Piezometric or Potentiometric Surface. A surface that represents the level to which water will rise in cased bores. The water table is the potentiometric surface in an unconfined aquifer.

pH. A logarithmic index for the concentration of hydrogen ions in an aqueous solution, which is used as a measure of acidity.

Potential Acid Sulfate Soil (PASS). A soil that has the potential to become acidic if it is exposed to the atmosphere.

Porosity (n). The ratio of the volume of void spaces in a rock or sediment to the total volume of the rock or sediment. Typically given as a percentage.

Porosity, effective (ne). The volume of the void spaces through which water or other fluids can travel in a rock or sediment divided by the total volume of the rock or sediment.

Recharge Area. Location of the replenishment of an aquifer by a natural process such as addition of water at the ground surface, or by an artificial system such as addition through a well

Recovery. The rate at which a water level in a well rises after pumping ceases.

Redox. REDuction-OXidation state of a chemical or solution.

Redox potential (Eh). The oxidation/reduction potential of the soil or water measured as milli-volt.

Subsoil. Subsurface material comprising the B and C horizons of soils with distinct profiles. They often have brighter colours and higher clay content than topsoils.

Total Dissolved Salts (TDS). The total dissolved salts comprise dissociated compounds and undissociated compounds, but not suspended material, colloids or dissolved gases.

Unsaturated Zone. The zone between the land surface and the water table, in which the rock or soil pores contain both air and water (water in the unsaturated zone is present at less than atmospheric pressure). It includes the root zone, intermediate zone and capillary fringe. Saturated bodies such as perched groundwater may exist in the unsaturated zone. Also referred to as the Vadose Zone.

Water table. Interface between the saturated zone and unsaturated zones. The surface in an aquifer at which pore water pressure is equal to atmospheric pressure.

Well. A hydraulic structure that facilitates the monitoring of groundwater level, collection of groundwater samples, or the extraction (or injection) of groundwater. Also known as a Bore.

ENVIRONMENTAL EARTH SCIENCES GENERAL LIMITATIONS

Scope of services
The work presented in this report is Environmental Earth Sciences response to the specific scope of works requested by, planned with and approved by the client. It cannot be relied on by any other third party for any purpose except with our prior written consent. Client may distribute this report to other parties and in doing so warrants that the report is suitable for the purpose it was intended for. However, any party wishing to rely on this report should contact us to determine the suitability of this report for their specific purpose.

Data should not be separated from the report
A report is provided inclusive of all documentation sections, limitations, tables, figures and appendices and should not be provided or copied in part without all supporting documentation for any reason, because misinterpretation may occur.

Subsurface conditions change
Understanding an environmental study will reduce exposure to the risk of the presence of contaminated soil and or groundwater. However, contaminants may be present in areas that were not investigated, or may migrate to other areas. Analysis cannot cover every type of contaminant that could possibly be present. When combined with field observations, field measurements and professional judgement, this approach increases the probability of identifying contaminated soil and or groundwater. Under no circumstances can it be considered that these findings represent the actual condition of the site at all points.

Environmental studies identify actual sub-surface conditions only at those points where samples are taken, when they are taken. Actual conditions between sampling locations differ from those inferred because no professional, no matter how qualified, and no sub-surface exploration program, no matter how comprehensive, can reveal what is hidden below the ground surface. The actual interface between materials may be far more gradual or abrupt than an assessment indicates. Actual conditions in areas not sampled may differ from that predicted. Nothing can be done to prevent the unanticipated. However, steps can be taken to help minimize the impact. For this reason, site owners should retain our services.

Problems with interpretation by others
Advice and interpretation is provided on the basis that subsequent work will be undertaken by Environmental Earth Sciences NSW. This will identify variances, maintain consistency in how data is interpreted, conduct additional tests that may be necessary and recommend solutions to problems encountered on site. Other parties may misinterpret our work and we cannot be responsible for how the information in this report is used. If further data is collected or comes to light we reserve the right to alter their conclusions.

Obtain regulatory approval
The investigation and remediation of contaminated sites is a field in which legislation and interpretation of legislation is changing rapidly. Our interpretation of the investigation findings should not be taken to be that of any other party. When approval from a statutory authority is required for a project, that approval should be directly sought by the client.

Limit of liability
This study has been carried out to a particular scope of works at a specified site and should not be used for any other purpose. This report is provided on the condition that Environmental Earth Sciences NSW disclaims all liability to any person or entity other than the client in respect of anything done or omitted to be done and of the consequence of anything done or omitted to be done by any such person in reliance, whether in whole or in part, on the contents of this report. Furthermore, Environmental Earth Sciences NSW disclaims all liability in respect of anything done or omitted to be done and of the consequence of anything done or omitted to be done by the client, or any such person in reliance, whether in whole or any part of the contents of this report of all matters not stated in the brief outlined in Environmental Earth Sciences NSW's proposal number and according to Environmental Earth Sciences general terms and conditions and special terms and conditions for contaminated sites.

To the maximum extent permitted by law, we exclude all liability of whatever nature, whether in contract, tort or otherwise, for the acts, omissions or default, whether negligent or otherwise for any loss or damage whatsoever that may arise in any way in connection with the supply of services. Under circumstances where liability cannot be excluded, such liability is limited to the value of the purchased service.

TABLES

Table 12: Monthly climate statistics

	Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sep	Oct	Nov	Dec
Maximum Temperature (°C)	27	26	25	23	22	20	19	20	22	23	24	26
Minimum Temperature (°C)	18	18	16	14	12	11	9	9	11	13	13	16
Average Rainfall (mm)	83	138	150	94	43	113	62	68	51	85	70	79
Evapotranspiration (mm)	121	122	123	72	84	58	85	101	103	107	137	142

ENVIRONMENTAL EARTH SCIENCES
CONTAMINATION RESOLVED

Table 13: Laboratory analysis summary and comparison to water quality criteria

					Sample Location		MW5A1	MW5A1	MW5A1	MW5A2	MW5A3	MW5A3	MW5A3	MW5B1	MW5B2-S	MW5B2-S	MW5B2-D	MW5B2-D	MW5B3	MW5B4	MW5B4	MW5B5	MW5B5
					Date		25/10/18	27/11/18	15/01/2019	25/10/18	25/10/18	27/11/18	15/01/2019	25/10/18	25/10/18	15/01/2019	25/10/18	15/01/2019	25/10/18	25/10/18	15/01/2019	25/10/18	15/01/2019
Analyte	**Units**	**Ecological**	**Health**	**Recreation**	**Livestock**	**Irrigation**																	
pH	-	**6.5-9.0**	**6.5-8.5**	**6.5-8.5**	**NE**	**6-8.5**	6.7	6.0	7.2	6.7	6.7	6.7	6.3	7.7	7.6	7.3	7.6	7.3	7.7	7.6	7.3	7.5	7.2
TDS	mg/L	**NE**	**600***	**NE**	**3000**	**NE**	130	92	240	365	735	510	1090	205	385	420	355	355	260	315	360	580	650
Na+	mg/L	**NE**	**180***	**NE**	**NE**	**115-460**	11	10	8.0	63	185	98	235	17	51	36	37	28	17	16	13	65	54
Ca++	mg/L	**NE**	**NE**	**NE**	**1000**	**NE**	24	10	68	48	55	67	94	52	82	100	78	90	70	89	105	130	160
K+	mg/L	**NE**	**NE**	**NE**	**NE**	**NE**	5.1	9.3	5.0	1.2	8.8	12	15	4.1	6.3	6.4	5.6	5.7	1.6	1.7	2.4	2.6	3.3
Mg++	mg/L	**NE**	**NE**	**NE**	**600**	**NE**	4.5	4.9	6.2	24	28	19	38	7.0	14	12	14	12	10	9.6	9.2	18	18
Cl-	mg/L	**NE**	**250***	**NE**	**NE**	**175-700**	24	26	28	70	355	210	560	24	57	51	53	57	33	25	32	160	175
F-	mg/L	**NE**	**1.5**	**15**	**2**	**1**	<0.1	<0.1	0.16	0.16	0.16	0.18	0.15	0.12	0.17	0.16	0.17	0.15	0.26	0.15	0.20	0.12	0.12
NO3-	mg/L	**10.6**	**50**	**500**	**400**	**20**	2.9	3.6	0.89	<0.1	<0.1	<0.1	<0.1	12	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
SO4--	mg/L	**NE**	**500**	**5000**	**1000**	**NE**	17	9	14	8	11	14	34	8	32	38	11	16	<2	<2	18	<2	12
HCO3-	mg/L	**NE**	**NE**	**NE**	**NE**	**NE**	70	33	200	295	165	190	155	180	320	330	300	305	250	325	330	380	420
PO4---	mg/L	**NE**	**NE**	**NE**	**NE**	**0.15**	<0.1	<0.1	<0.1	0.34	0.12	0.15	0.15	0.12	<0.1	0.12	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
NH4-N	mg/L	**2.18**	**0.5***	**NE**	**NE**	**5**	<0.1	<0.1	<0.1	0.7	1.1	0.5	1.4	0.1	0.4	0.4	0.7	0.6	0.2	0.3	0.2	0.4	0.3
Metals																							
Al	mg/L	**NE**	**0.2***	**2**	**5**	**5**	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Ni	mg/L	**0.07**	**0.02**	**0.2**	**1**	**0.2**	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Cu	mg/L	**0.009**	**20**	**2**	**0.5**	**0.1**	<0.001	0.002	<0.001	<0.001	<0.001	0.004	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Pb	mg/L	**0.05**	**0.01**	**0.1**	**0.1**	**2**	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Zn	mg/L	**0.05**	**3***	**NE**	**20**	**2**	0.003	0.009	0.01	0.015	0.003	0.014	0.012	0.013	0.007	0.002	0.004	0.002	0.001	0.003	0.003	0.005	0.005
Cd	mg/L	**0.001**	**0.002**	**0.02**	**0.01**	**0.01**	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
Cr	mg/L	**0.006**	**0.05**	**0.5**	**1**	**0.1**	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Fe	mg/L	**NE**	**0.3***	**NE**	**NE**	**0.2**	1	0.31	0.08	4.4	5.5	2.7	3.4	0.44	0.2	1.3	0.18	0.23	0.27	0.08	0.04	0.06	0.17
Mn	mg/L	**1.9**	**0.5**	**5**	**10**	**0.2**	0.08	<0.01	0.02	1.1	0.24	0.17	0.19	0.08	0.13	0.12	0.1	0.09	0.08	0.07	0.06	0.12	0.1
As	mg/L	**0.024**	**0.01**	**0.1**	**0.5**	**0.1**	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Hg	mg/L	**0.00006**	**0.001**	**0.01**	**0.002**	**0.002**	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001

Note: drinking water guideline is taken from the health values of the Australian Drinking Water Guidelines (version 3.5, 2018)

*aesthetic only

APPENDIX A: RELEVANT LEGISLATION

Table 14: Summary of regulatory environment

Document	Summary
Water Management Act 2000	In NSW the Water Management Act 2000 is the main piece of water legislation. Under this Act a Water Access Licence (WAL) is required to extract or interfere with groundwater in areas where a Water Sharing Plan (WSP) is in place. The aim of the Water Management Act 2000 is the sustainable and integrated management of the State's water for the benefit of both present and future generations. Key instruments of the Water Management Act are the designation of Water Sharing Plans, that ensure that water is provided for the environment and there is more secure access to water users, and the Aquifer Interference Policy, that outlines the approval and licencing process for prescribed aquifer interference activities
Water Sharing Plan (WSP)	Water Sharing Plans (WSPs) are being progressively developed for rivers and groundwater systems across NSW following the introduction of the *Water Management Act 2000*. These WSPs are designed to provide long-term environmental protection and sustainability of the groundwater resources as well as directing how water will be allocated and shared among the various water users. WSPs apply the goals and principles of the State Groundwater Policy at a local and regional level. The WSPs refer to the National Health and Medical Research Council (NHMRC) 1996 *Drinking Water Guidelines for drinking water beneficial use.* Other beneficial uses are defined by the Australian and New Zealand Environment and Conservation Council (ANZECC) 2000 Water Quality Guidelines (ANZECC, 2000). The site falls within the Minnamurra River Coastal zone under the Illawarra Rivers water source management zone. The WSP commenced on 14 January 2018 and continues until 1 July 2021.
Aquifer interference policy 2012	The NSW Aquifer Interference Policy (AIP) was released by the NSW Government in September 2012. It is important to note that the AIP defines an aquifer as any type of saturated geological formation irrespective of permeability or water quality. This differs to the "traditional" definition of an aquifer as being a groundwater system of sufficient permeability such that it can yield productive volumes of water. The key requirements of the AIP, as described by NSW Office of Water (2014) are to: • **Account for, or prevent, the take of water**. Where a proposed activity will take water from an aquifer or connected surface water source, adequate arrangements must be in place to account for this water. It is the proponent's responsibility to enable this to be estimated to a suitable level of accuracy, and to ensure necessary water licences are obtained and held. • **Address the "minimal impact considerations"**. Aquifer interference activities can adversely impact groundwater and connected surface water sources by decreasing groundwater pressure and/or lowering the water table;

Document	Summary
	deteriorating groundwater and surface water quality either due to pollution or increases in salinity; by affecting the health or viability of a groundwater dependent ecosystem (GDE) or impacting on a culturally significant site (CSS). The AIP provides objective, measurable thresholds for considering the degree of impact an activity may have on the water table, groundwater pressure and water quality changes. The assessment criteria differ between aquifer types (e.g. alluvial, porous, fractured) and whether the aquifer is deemed "highly" or "less" productive on the basis of natural water quality and extraction yields. • **Propose remedial actions**. Where impacts are greater than those that were predicted as part of the relevant approval, proposed remedial actions to manage those impacts shall be specified.
Contaminated Land Management Act 1997	Whilst highly unlikely, if activities undertaken at the site during the dredging works contaminate the land, it is the responsibility of the contaminators to notify NSW EPA in writing, in accordance with the Contaminated Land Management Act 1997. Notification to NSW EPA is to be undertaken as soon as practicable after the responsible parties become aware of the contamination. • Notification is to be in a form approved by NSW EPA and is to specify the following matters to the extent that they are within the knowledge of the person required to give the notice: • the location of the land; • the activities that have contaminated the land; • the nature of the contamination; • the nature of the risk posed by the contamination; and • any other matter prescribed by the regulations
Guidelines for Groundwater Protection in Australia (ARMCANZ and ANZECC 1995)	This guideline provides a framework for preventing groundwater contamination in Australia.
NSW State Groundwater Policy and Framework Document (NSW Department of Land and Water Conservation 1997)	The Framework document sets out the overall direction of groundwater management in NSW and provides broad objectives and principles to guide groundwater management.
NSW State Groundwater Quantity Protection Policy (NSW Department of Land and Water Conservation 1998)	Builds on the concepts outlined in the framework document and provides more detail and guidance on how to manage and protect groundwater quantity.

Document	Summary
NSW State Groundwater Quality Protection Policy (NSW Department of Land and Water Conservation 1998)	Builds on the concepts outlined in the framework document and provides more detail and guidance on how to manage and protect groundwater quality.
NSW State Groundwater Dependent Ecosystems Policy (NSW Department of Land and Water Conservation 2002)	This policy is specifically designed to protect valuable Groundwater Dependent Ecosystems (GDE's) which rely on groundwater for survival. It aims to maintain or restore the ecological processes and biodiversity of groundwater dependent ecosystems for the benefit of present and future generations.
Guidelines for Fresh and Marine Water Quality (ANZG 2018)	These guidelines would be adopted to assess groundwater quality, potential beneficial use of groundwater at the Site, and to assess potential impacts to groundwater quality from operation of the proposed development.
Approved Methods for the Sampling and Analysis of Water Pollutants in New South Wales (NSW EPA 2003)	These guidelines would be adopted where sampling and analysis of groundwater samples is required as part of this assessment and during groundwater monitoring
Groundwater Sampling and Analysis – A Field Guide (Geoscience Australia 2009)	The purpose of this field guide is to present a set of standard groundwater sampling protocols that focus on a range of groundwater quantity and quality issues throughout Australia.

APPENDIX B: GROUNDWATER BORE SEARCH RESULTS

Bore ID	Depth (m)	Purpose	From (m)	To (m)	Thickness (m)	Lithology Description	Distance from site
GW102287.1.1	15	Monitoring	0	1	1	Sandy loam	On site (NW corner of Stage 5A)
			1	3	2	Sand, fine grained	
			3	14	11	Sand with shell	
			14	15	1	Clay, yellow	
GW108102.1.1	22	Monitoring	0	3	3	Sand	1 km N of site
			3	5	2	Sand and seashells	
			5	14	9	Sand	
			14	19.5	5.5	Silty sand and clay bands	
			19.5	21	1.5	Sandy clay	
			21	22	1	Marine clay	
GW109974.1.1	15	Monitoring	0	1.5	1.5	Grey sand,fine to medium grained,metal,rock,concrete	1 km N of site
			1.5	8	6.5	Sand,orange,f/medium grained,silt and clay	
			8	15	7	Sand,gry,m/grained,5% silt and clay,5%shell fragments	
GW109975.1.1	9	Monitoring	0	1.5	1.5	Fill	1 km N of site
			1.5	9	7.5	Sand,fine grained,yellow brown,minor shell content.	
GW109976.1.1	9	Monitoring	0	1.5	1.5	Fill	1 km N of site
			1.5	4.5	3	Sand,fine grained,white,minor shell content,yellow brown	
			4.5	5.3	0.8	Gravel and shell	

Bore ID	Depth (m)	Purpose	From (m)	To (m)	Thickness (m)	Lithology Description	Distance from site
			5.3	9	3.7	Sand,fine grained,minor shell content,yellow brown	
GW109977.1.1	9	Monitoring	0	9	9	Sand,fine to medium grained,yellow brown	1 km N of site
GW109979.1.1	9	Monitoring	0	0.8	0.8	Fill,clay	1 km N of site
			0.8	5.6	4.8	Medium sand,dark brown.	
			5.6	9	3.4	Medium sand,grey with shell	
GW109986.1.1	11	Monitoring	0	1.5	1.5	Fill,sand,yellow,brown,fine medium grained	1 km N of site
			1.5	2.2	0.7	Fill,sandy clay,grey,brown	
			2.2	4.4	2.2	Natural sand,yellow,brown,medium grained	
			4.4	7.3	2.9	Natural sand,brown, medium grained with some shell frag.	
			7.3	11	3.7	Sandy clay,grey,brown	
GW109987.1.1	11	Monitoring	0	1.3	1.3	Silty sand, brown	750 m NNW of site
			1.3	6	4.7	Sand,yellow/brown,fine to med.grained	
			6	11	5	Sand,grey/brown,medium grained with shell fragments	
GW114478.1.1	5.2	Monitoring	0	0.1	0.1	Grass	750 m NNW of site
			0.1	0.3	0.2	Dark brown silty sand	
			0.3	1	0.7	Sand medium grained	
			1	3.6	2.6	Sand grading to grey	
			3.6	5.2	1.6	Sand grading to dark grey	
GW114479.1.1	5.1	Monitoring	0	0.5	0.5	Fill,loose,dark brown,silty sand	

Bore ID	Depth (m)	Purpose	From (m)	To (m)	Thickness (m)	Lithology Description	Distance from site
			0.5	1.9	1.4	Sand loose yellow	750 m NNW of site
			1.9	5.1	3.2	Sand grading to dark grey	
GW114480.1.1	5.2	Monitoring	0	0.1	0.1	Grass	750 m NNW of site
			0.1	1.4	1.3	Fill loose,dark brown sandy silt	
			1.4	1.8	0.4	Sand loose,yellow,grey,medium to coarse sand	
			1.8	5.2	3.4	Sand loose grey med.to coarse saturated	
GW114481.1.1	5.1	Monitoring	0	0.4	0.4	Fill loose,dark brown silty gravel	750 m NNW of site
			0.4	0.6	0.2	Sand, loose,dark brown silty gravel	
			0.6	5.1	4.5	Sand natural loose,light grey med.	
GW114482.1.1	5.1	Monitoring	0	0.2	0.2	Fill loose light brown,sandy silt	750 m N of site
			0.2	0.6	0.4	Fill soft,dark brown silty clay	
			0.6	5.1	4.5	Fill loose,medium grey sand	
GW114483.1.1	5.2	Monitoring	0	0.4	0.4	Fill loose,dark brown silty sand	750 m N of site
			0.4	1.2	0.8	Sand loose medium white	
			1.2	5.2	4	Sand grading to grey	
GW114581.1.1	18.5	Monitoring	0	0.3	0.3	Silty clay loam with grass	900 m N of site
			0.3	2	1.7	Sand loose,light grey m/grained	
			2	4	2	Sand loose,dark brown m/grained	
			4	8	4	Sand grading to loose,dark grey m/grained	
			8	18.5	10.5	Sand loose dark grey f/grained,shell	
GW114583.1.1	0.5	Monitoring	0	0.1	0.1	Grass	900 m N of site

APPENDIX C: FIELD DATA SHEETS

ENVIRONMENTAL EARTH SCIENCES
CONTAMINATION RESOLVED

Bore	Date	Depth to Groundwater	Elevation of Measuring Point	Groundwater Elevation	DO	EC	pH	Redox	Temp	Comments
Units	dd.mm.yy	m (TOC)	m(AHD)	m(AHD)	ppm	µs/cm		mV	ºC	
MWBH5A1	25.10.18	3.45	4.0	3	0.2	200	6.36	59	18.1	Silty becoming clear
	27.11.18	3.59		3.14	0.11	176	5.6	96.3	19.2	Very light orange
	15.01.19	3.44		2.99	0.0	396	7.54	33.2	20.3	Orange brown becoming clear
MWBH5A2	25.10.18	2.252	3.0	1.75	0.43	622	6.52	10.9	17.1	
	27.11.18	2.49		1.01	-	-	-	-	-	Dip only
	15.01.19	2.31		1.19	-	-	-	-	-	Dip only
MWBH5A3	25.10.18	0.94	1.0	0.59	0.26	1192	6.22	-47.1	16.2	Silty becoming clear
	27.11.18	1.05		0.48	0.12	981	6.58	-114	17	
	15.01.19	0.90		0.50	0.0	1880	6.54	-140.5	17.5	clear
MWBH5B1	25.10.18	2.45	3.0	1.005	0.86	350	7.55	2.3	18.1	
	15.01.19	2.41		1.04	-	-	-	-	-	Dip only
MWBH5B2 shallow	25.10.18	3.82	4.0	0.507	0.39	642	7.28	-39.6	18.8	Mild sulphurous odour
	15.01.19	2.71		1.61	0.0	660	7.34	-180	19.2	Very mild sulphurous odour
MWBH5B2 deep	25.10.18	3.01	4.0	1.46	0.41	606	7.35	-64.5	18.8	
	15.01.19	2.90		1.57	0.0	210	7.36	-173	18.9	clear

Bore	Date	Depth to Groundwater	Elevation of Measuring Point	Groundwater Elevation	DO	EC	pH	Redox	Temp	Comments
MWBH5B3	25.10.18	1.37	3	1.98	0.37	421	7.6	-34.6	18	Light grey
	15.01.19	1.3		2.05	-	-	-	-	-	Dip only
MWBH5B4	25.10.18	1.84	2	0.51	0.21	513	7.3	-47.1	17.5	
	15.01.19	1.78		0.57	0.0	560	7.46	-149	19.1	Clear
MWBH5B5	25.10.18	4.3	7	3.25	0.13	937	7.2	-44.9	18	
	15.01.19	4.24		3.31	0.03	467	7.27	-148	18.7	Clear

*Stage 5B area inaccessible at time of sampling on 27 November 2018

Multi Parameter Water Meter

Instrument YSI Quatro Pro Plus
Serial No. 11C100764

Air-Met Scientific Pty Ltd
1300 137 067

Item	Test	Pass	Comments
Battery	Charge Condition	✓	
	Fuses	✓	
	Capacity	✓	
Switch/keypad	Operation	✓	
Display	Intensity	✓	
	Operation (segments)	✓	
Grill Filter	Condition	✓	
	Seal	✓	
PCB	Condition	✓	
Connectors	Condition	✓	
Sensor	1. pH	✓	
	2. mV	✓	
	3. EC	✓	
	4. D.O	✓	
	5. Temp	✓	
Alarms	Beeper	✓	
	Settings	✓	
Software	Version	✓	
Data logger	Operation	✓	
Download	Operation	✓	
Other tests:			

Certificate of Calibration

This is to certify that the above instrument has been calibrated to the following specifications:

Sensor	Serial no	Standard Solutions	Certified	Solution Bottle Number	Instrument Reading
1. pH 10.00		pH 10.00		320322	pH 9.63
2. pH 7.00		pH 7.00		307928	pH 7.03
3. pH 4.00		pH 4.00		320612	pH 4.05
4. mV		234mV		320334/311902	243.2mV
5. EC		2.76mS		306341	2.75mS
6. D.O		0.00 ppm		5928	0.02ppm
7. Temp		20.7°C		MultiTherm	20.1°C

Calibrated by: **Sarah Lian**

Calibration date: **23/10/2018**

Next calibration due: **21/04/2019**

Multi Parameter Water Meter

Instrument YSI Quatro Pro Plus
Serial No. 11C100764

Air-Met Scientific Pty Ltd
1300 137 067

Item	Test	Pass	Comments
Battery	Charge Condition	✓	
	Fuses	✓	
	Capacity	✓	
Switch/keypad	Operation	✓	
Display	Intensity	✓	
	Operation (segments)	✓	
Grill Filter	Condition	✓	
	Seal	✓	
PCB	Condition	✓	
Connectors	Condition	✓	
Sensor	1. pH	✓	
	2. mV	✓	
	3. EC	✓	
	4. D.O	✓	
	5. Temp	✓	
Alarms	Beeper	✓	
	Settings	✓	
Software	Version	✓	
Data logger	Operation	✓	
Download	Operation	✓	
Other tests:			

Certificate of Calibration

This is to certify that the above instrument has been calibrated to the following specifications:

Sensor	Serial no	Standard Solutions	Certified	Solution Bottle Number	Instrument Reading
1. pH 10.00		pH 10.00		324189	pH 9.68
2. pH 7.00		pH 7.00		317272	pH 6.96
3. pH 4.00		pH 4.00		320612	pH 4.04
4. mV		234mV		325420/324357	234.5mV
5. EC		2.76mS		320326	2.74mS
6. D.O		0.00 ppm		10175	0.04ppm
7. Temp		19.9°C		MultiTherm	20°C

Calibrated by: **Sarah Lian**

Calibration date: **26/11/2018**

Next calibration due: **25/05/2019**

ENVIRONMENTAL EARTH SCIENCES
THE KNOW AND THE HOW

Equipment Calibration Record – Hanna pH

This equipment calibration record is to be stored in your job folder

Equipment Type: Hanna pH HI9025

Equipment Number: _____

Date Calibrated: 11/9/18

Calibrated By: LV (name)

Job Number: 118044

Details of Calibration:

Electrode Checked (Condition): _____

pH at 4.01 Reading: 4.0

pH at 7.01 Reading: 7.0

pH at 6.88 Reading: _____

ENVIRONMENTAL EARTH SCIENCES
THE KNOW AND THE HOW

Equipment Calibration Record – Hanna pH

This equipment calibration record is to be stored in your job folder

Equipment Type: Hanna pH HI9025

Equipment Number: _____

Date Calibrated: 11/7/18

Calibrated By: _____ (name)

Job Number: 109046

Details of Calibration:

Electrode Checked (Condition): _____

pH at 4.01 Reading: 4.0

pH at 7.01 Reading: 7.0

pH at 6.88 Reading: _____

ENVIRONMENTAL
EARTH SCIENCES
THE KNOW AND THE HOW

Equipment Calibration Record – Hanna pH

This equipment calibration record is to be stored in your job folder

Equipment Type: Hanna pH HI9025

Equipment Number: _____

Date Calibrated: 11/7/18

Calibrated By: CW (name)

Job Number: CC8044

Details of Calibration:

Electrode Checked (Condition): _____

pH at 4.01 Reading: 4.0

pH at 7.01 Reading: 7.0

pH at 6.88 Reading: _____

ENVIRONMENTAL EARTH SCIENCES
THE KNOW AND THE HOW

Equipment Calibration Record – Hanna pH

This equipment calibration record is to be stored in your job folder

Equipment Type: Hanna pH HI9025

Equipment Number: _____

Date Calibrated: 17/07/18

Calibrated By: NE (name)

Job Number: 118044

Details of Calibration:

Electrode Checked (Condition): _____

pH at 4.01 Reading: 4.0

pH at 7.01 Reading: 7.0

pH at 6.88 Reading: _____

ENVIRONMENTAL EARTH SCIENCES
THE KNOW AND THE HOW

Equipment Calibration Record – Hanna pH

This equipment calibration record is to be stored in your job folder

Equipment Type: Hanna pH HI9025

Equipment Number: _____

Date Calibrated: 17/07/18

Calibrated By: NE (name)

Job Number: 118044

Details of Calibration:

Electrode Checked (Condition): _____

pH at 4.01 Reading: 4.0

pH at 7.01 Reading: 7.0

pH at 6.88 Reading: _____

ENVIRONMENTAL
EARTH SCIENCES
THE KNOW AND THE HOW

Equipment Calibration Record – Hanna pH

This equipment calibration record is to be stored in your job folder

Equipment Type: Hanna pH HI9025

Equipment Number: _____

Date Calibrated: 18/07/18

Calibrated By: NE (name)

Job Number: 118044

Details of Calibration:

Electrode Checked (Condition): _____

pH at 4.01 Reading: 4.0

pH at 7.01 Reading: 7.0

pH at 6.88 Reading: _____

ENVIRONMENTAL EARTH SCIENCES
THE KNOW AND THE HOW

Equipment Calibration Record – Hanna pH

This equipment calibration record is to be stored in your job folder

Equipment Type: Hanna pH HI9025

Equipment Number: _____

Date Calibrated: 18/07/18

Calibrated By: NE (name)

Job Number: 118044

Details of Calibration:

Electrode Checked (Condition): _____

pH at 4.01 Reading: 4.0

pH at 7.01 Reading: 7.0

pH at 6.88 Reading: _____

ENVIRONMENTAL EARTH SCIENCES
THE KNOW AND THE HOW

Equipment Calibration Record – Hanna pH

This equipment calibration record is to be stored in your job folder

Equipment Type: Hanna pH HI9025

Equipment Number: _____

Date Calibrated: 19/07/18

Calibrated By: NE (name)

Job Number: 118044

Details of Calibration:

Electrode Checked (Condition): _____

pH at 4.01 Reading: 4.0

pH at 7.01 Reading: 7.0

pH at 6.88 Reading: _____

Multi Parameter Water Meter

airmet
Air-Met Scientific Pty Ltd
1300 137 067

Instrument YSI Quatro Pro Plus
Serial No. 11K101271

Item	Test	Pass	Comments
Battery	Charge Condition	✓	
	Fuses	✓	
	Capacity	✓	
Switch/keypad	Operation	✓	
Display	Intensity	✓	
	Operation (segments)	✓	
Grill Filter	Condition	✓	
	Seal	✓	
PCB	Condition	✓	
Connectors	Condition	✓	
Sensor	1. pH	✓	
	2. mV	✓	
	3. EC	✓	
	4. D.O	✓	
	5. Temp	✓	
Alarms	Beeper	✓	
	Settings	✓	
Software	Version	✓	
Data logger	Operation	✓	
Download	Operation	✓	
Other tests:			

Certificate of Calibration

This is to certify that the above instrument has been calibrated to the following specifications:

Sensor	Serial no	Standard Solutions	Certified	Solution Bottle Number	Instrument Reading
1. pH 10.00		pH 10.00		324189	pH 9.93
2. pH 7.00		pH 7.00		317272	pH 6.96
3. pH 4.00		pH 4.00		320612	pH 4.05
4. mV		234mV		325420/324357	232.4mV
5. EC		2.76mS		320325	2.77mS
6. D.O		0.00 ppm		10175	0.00ppm
7. Temp		20.6°C		MultiTherm	19.8°C

Calibrated by: Sarah Lian

Calibration date: 02/01/2019

Next calibration due: 01/07/2019

APPENDIX D: SOIL LANDSCAPE

mc MANGROVE CREEK

Landscape—vegetated tidal flats in estuarine areas on Holocene sediments. Relief <3 m. Slopes <3%. Mangrove open-scrub, saltmarsh herbland, sedgeland and low open-forest.

Soils—deep (>150 cm) Siliceous Sands (Uc1.21) and Calcareous Sands (Uc1.11) and Solonchaks (Uc1.11) occur on mangrove flats. Humic Gley Soils (Uc4.53) and Solonchaks (Uc1.11) occur on saltmarshes.

Limitations—regular tidal flooding and waterlogging, saline soil, very low soil fertility.

LOCATION

Vegetated tidal flats in estuarine areas on Holocene sediments on the Coastal Plain. Examples occur at Mangrove Island, Minnamurra River and Crookhaven River and Greenwell Point.

LANDSCAPE

Geology

Holocene sediments—silty to peaty quartz sand, silt and clay. Common shell layers in sandy mud and muddy sand.

Topography

Local relief <3 m and slopes <3%. These tidal flats and creeks in coastal inlets and estuaries are regularly inundated by brackish tidal waters. Four shore parallel zones are recognised, each zone with a different drainage and inundation pattern. At the lowest elevation is the mudflat zone. In order of increasing elevation are the mangrove zone, the saltmarsh zone and littoral forest zone. Minor differences in topography often result in a mosaic of zones.

The mudflat zone is inundated except at low tide. It is characterised by rapidly migrating, shallow (<70 cm), non-directional, meandering channels with reversible flows which widen rapidly in the downstream direction.

The mangrove zone is inundated only during high tide, and the saltmarshes are inundated only during spring flood tides. These zones have non-directional, often interrupted drainage. The forest zone is rarely flooded and has interrupted or absent drainage. Clarke and Hannon (1967, 1969, 1970 and 1971) have described the plant ecology of tidal flat communities.

Vegetation

Mainly open-scrub where the common species are grey mangrove (*Avicennia marina*), river mangrove (*Aegiceras corniculatum*) and scattered decorative paperbark (*Melaleuca decora*).

Shoreward of the mangroves the low open-forest is dominated by swamp oak (*Casuarina glauca*) and less commonly swamp mahogany (*Eucalyptus robusta*), forest red gum (*Eucalyptus tereticornis*) and bangalay (*Eucalyptus botryoides*). This open-forest often has an understorey of sand couch (*Sporobolus virginicus*).

Saltmarsh is found in areas less frequently inundated. Common species of saltmarsh include sea-blite (*Suaeda australis*), glasswort (*Salicornia quinqueflora*), sand couch (*Sporobolus virginicus*), streaked arrowgrass (*Triglochin striata*) and sea rush (*Juncus kraussi*).

Land Use

Mangroves and saltmarshes are recognised as important breeding areas for commercial fish and crustaceans (West 1985) and for some species of water birds. Oyster leases are located on the seaward edges of tidal flats at Minnamurra and Greenwell Point.

Existing Erosion

There is little appreciable erosion. Minor wave erosion is caused by powerboats (Scholar 1974). Sediments eroded from surrounding catchments are often deposited on this unit, enlarging the mangrove communities (West 1985).

SOILS

Dominant Soils Materials

mc1—Greasy smelly organic mottled dark brown silty loam (topsoil)

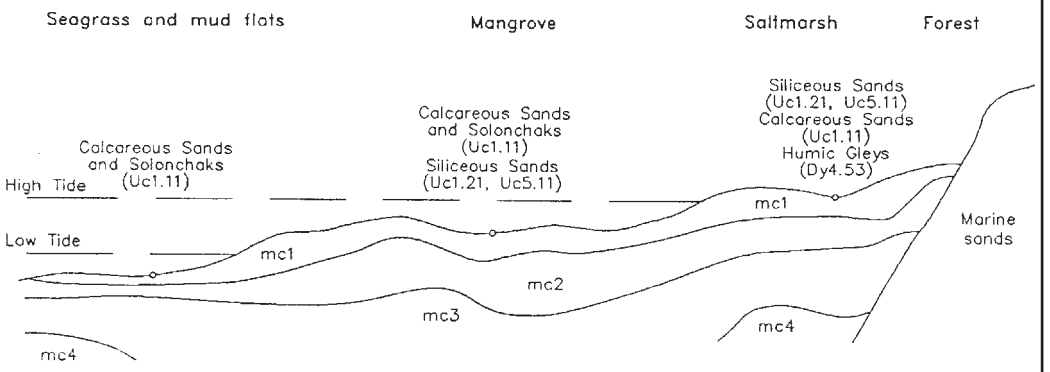
Colour	dark brown (10YR 3/3) to yellowish grey (2.5Y 4/1) with dark red mottles (50%)
Texture	silty loam
Structure	apedal massive
Fabric	earthy
pH	7.0–8.5
Stones	nil
Roots	nil

mc2—Shelly organic black sandy loam (subsoil)

Colour	black (10YR 2/1) to dull yellowish brown (10YR 4/3)
Texture	sandy loam
Structure	apedal massive
Fabric	sandy
pH	5.0–8.5
Stones	nil
Roots	common

mc3—Shelly greyish yellow sand (subsoil)

Colour	dark greyish yellow
Texture	sand
Structure	apedal single-grained
Fabric	sandy
pH	6.5–9.0
Stones	quartz pebbles common
Roots	rare



■ ***Schematic cross-section of Mangrove Creek soil landscape illustrating the occurrence and relationship of the dominant soil materials.***

mc4—Gleyed mottled sandy clay (subsoil)

Colour	grey (5Y 5/1) with orange brown mottles (40%)
Texture	sandy clay
Structure	apedal massive
Fabric	sandy
pH	7.5–9.0
Stones	nil
Roots	rare

Associated Soil Materials

Charcoal Sands. Up to 80% charcoal fragments within a sandy loam matrix

Midden Materials. Large quantities of oyster and other mollusc shells occur in the soil materials. These are Aboriginal sites and should not be disturbed.

Occurrence and Relationships

Mangrove Flats. Up to 30 cm greasy smelly organic mottled dark brown silty loam **(mc1)** overlies <50 cm shelly organic black sandy loam **(mc2)** and >100 cm shelly greyish yellow sand **(mc3).** The boundaries are gradual to diffuse [Siliceous Sands (Uc1.21, Uc5.11), Calcareous Sands (Uc1.11) and Solonchaks (Uc1.11)]. Total soil depth is >200 cm.

Saltmarshes. Up to 20 cm **mc1** overlies <20 cm **mc2** and <50 cm **mc3** which in turn overlies >200 cm gleyed mottled sandy clay **(mc4).** Boundaries are gradual to diffuse [Humic Gley Soils (Uc4.53) and Calcareous Sands (Uc1.11)]. Total soil depth is >300 cm.

LIMITATIONS TO DEVELOPMENT

Soil Limitations

mc1 Low wet bearing strength
Strongly saline
Low permeability
High organic matter
Very low fertility
Acid sulphate potential
Strongly sodic

mc2 High organic matter
Strongly sodic
Strongly saline
Low wet bearing strength
Very low fertility
Very strongly acid
Acid sulphate potential
Potential aluminium toxicity

mc3 High organic matter
Strongly saline
Strongly sodic
Very low fertility
Strongly acid
Acid sulphate potential
Low wet bearing strength

mc4 Low wet bearing strength
Strongly saline
Strongly sodic
Low permeability
Low available water-holding capacity
Low fertility
Acid sulphate potential
Moderately alkaline

Fertility

The general fertility is very low. The soil materials are strongly saline and are frequently inundated by tidal waters. These soils should not be drained as this will result in organic sulphur compounds being oxidised. The sulphuric acid produced results in the soils becoming extremely acid.

Erodibility

mc1 and **mc2** have very low erodibility. They consist of sands strongly bound by abundant organic fibrous matter. **mc3** has very low erodibility consisting predominantly of well-drained coarse sands. **mc4** has a moderate erodibility as it has a low organic matter content and consists of fine and coarse sand grains imbedded in a clay matrix. **mc4** clays are highly dispersible in freshwater, where they are highly erodible.

Erosion Hazard

The erosion hazard for non-concentrated flows is low. Calculated soil loss for the first 12 months of urban development ranges up to 10 t/ha of topsoil and 20 t/ha of exposed subsoil. The erosion hazard for wave and concentrated flows is also low.

Surface Movement Potential

These materials become highly reactive following draining and leaching. Both drained *in situ* material and deposited fill composed of these materials should be tested to determine surface movement potential prior to construction.

Landscape Limitations

Flood hazard
Waterlogging
Permanently high watertable
Wave erosion hazard

Urban Capability

Generally high to severe limitations for urban development.

Rural Capability

Generally high to severe limitations for regular cultivation and grazing.

bo BOMBO

Landscape—rolling low hills with benched slopes and sea cliffs with extensive rock platforms on Bumbo Latite. Relief 40–100 m. Slope gradients 15–25%. Extensively cleared with stands of closed-forest and tall open-forest.

Soils—shallow (<50 cm) Structured Loams (Um6) occur on crests, moderately deep (50–100 cm) Krasnozems (Gn4.11) on upper slopes and benches. Brown Podzolic Soils (Db1.11, Db1.21) and Red Podzolic Soils (Dr2.21) occur on mid and lower slopes.

Limitations—rock fall hazard, wave erosion hazard, rock outcrop, hardsetting, low wet bearing strength, sodicity.

LOCATION

Rolling low hills with benched slopes and sea cliffs with extensive rock platforms on latite and basalt on the Coastal Plain. Examples include Bombo, Dunmore and extensive areas within Jamberoo Valley.

LANDSCAPE

Geology

Bumbo Latite Member—alphanitic to porphoryitic latite.

Topography

Rolling low hills. Relief 40–100 m. Slope gradients 15–25%. Crests are narrow. Convex ridges are long and gently inclined. Moderately inclined slopes with isolated steep (25–40%) slopes. Scattered benches and terracettes on upper slopes. Narrow incised drainage lines. Coastal headlands with cliffs and extensive rock platforms. Springs may occur on the mid and footslopes—for example, Rose Valley.

Vegetation

Extensively cleared with remnant stands of closed-forest and tall open-forest. Common closed-forest species include cabbage tree palm (*Livistona australis*), bastard rosewood (*Synoum glandulosum*), red cedar (*Toona australis*), brush cherry (*Syzygium australe*), bolly gum (*Litsea reticulata*), white cedar (*Melia azedarach* var. *australasica*), northern boobialla (*Myoporum acuminatum*), smooth mock olive (*Notelaea venosa*), snow-wood (*Parachidendron pruinsom*), celery wood (*Polyscias elegans*), black apple (*Planchonella australis*), plum pine (*Polocarpus elatus*), yellowwood, moreton bay fig (*Ficus macrophylla*), port jackson fig (*Ficus rubiginosa*) and flintwood (*Scolopia braunii*).

Common tall open-forest species include turpentine (*Syncarpia glomulifera*), grey ironbark (*Eucalyptus paniculata*), pittosporum (*Pittosporum* spp.) and sydney blue gum /bangalay (*Eucalyptus saligna/botryoides*). Forest red gum (*Eucalyptus tereticornis*) and prickly-leaved paperbark (*Melaleuca styphelioides*) are found in poorly drained areas.

The vegetation on the associated soil mater-ial includes coastal tea-tree (*Leptospermum laevigatum*), coastal banksia (*Banksia integrifolia*), swamp oak (*Casuarina glauca*), bracelet honey-myrtle (*Melaleuca armillaris*) and drooping she-oak (*Allocasuarina verticillata*).

Land Use

Dairying, grazing and hobby farms on improved pasture, recreation areas including Jamberoo Recreation Park and quarrying of latite at Bombo and Dunmore.

Existing Erosion

Evidence of minor mass movement (terracettes) on moderately steep lower slopes. Moderate rill erosion on batters of footslopes where soils have been disturbed.

Included Soil Landscapes

Small areas of Fountaindale **(fo)** and Jamberoo **(ja)** soil landscapes occur.

SOILS

Dominant Soil Materials

bo1—Friable reddish brown sandy clay loam (topsoil)

Colour	reddish brown (5YR 4/6)
Texture	sandy clay loam
Structure	apedal massive to weakly pedal, <2 mm crumb peds
Fabric	earthy and rough-faced, porous
pH	5.5
Stones	nil
Roots	abundant, ex-ped

bo2—Hardsetting brownish black sandy loam (topsoil)

Colour	brownish black (5YR 3/1) to dark reddish brown (5YR 3/3) occasionally at depth
Texture	sandy loam
Structure	weakly pedal, <2 mm crumb peds
Fabric	rough-faced, porous
pH	6.0
Stones	2–10% 2–6 mm angular, dispersed
Roots	abundant, ex-ped

bo3—Reddish brown light medium clay (subsoil)

Colour	reddish brown (2.5YR 4/8)
Texture	light medium clay
Structure	moderately pedal, 5–10 mm polyhedral peds
Fabric	rough-faced, porous
pH	4.0
Stones	nil (but can be localised rounded basalt or latite stones 20–60 mm 2–10% dispersed)
Roots	few, ex-ped

bo4—Reddish brown sandy clay (subsoil)

Colour	reddish brown (2.5YR 4/6)
Texture	sandy clay
Structure	moderately pedal, 5–10 mm polyhedral peds
Fabric	rough-faced, porous
pH	5.0
Stones	nil
Roots	many, ex-ped

bo5—Brown strongly pedal medium clay (subsoil)

Colour	brown (7.5YR 4/6)
Texture	medium clay
Structure	strongly pedal, 5–10 mm polyhedral and crumb peds
Fabric	rough-faced, porous
pH	4.0
Stones	nil
Roots	nil

Associated Soil Materials

Very shallow (<50 cm) indurated beach and fine grey Quaternary sands occur (Bass Point).

Occurrence and Relationships

Crests. Up to 15 cm friable reddish brown sandy clay loam **(bo1)** overlies bedrock [Structured Loams (Um6)].

Upper slopes and benches. Up to 15 cm **bo1** overlies <50 cm reddish brown sandy clay **(bo4)** which overlies <60 cm reddish brown light medium clay **(bo3)**. The boundaries are gradual [Krasnozems (Gn4.11)]. Total soil depth is <120 cm.

Midslopes and lower Slopes. Up to 10 cm hardsetting brownish black sandy loam **(bo2)** overlies

<15 cm **bo4**. Up to 40 cm brown strongly pedal medium clay **(bo5)** is overlain by <35 cm **bo3**. The boundaries are clear to gradual [Brown Podzolic Soils (Db1.11, Db1.21), Red Podzolic Soils (Dr2.21)]. Total depth is <120 cm.

LIMITATIONS TO DEVELOPMENT

Soil Limitations

bo1 High organic matter
Low wet bearing strength
High shrink-swell
Sodicity
High aluminium toxicity

bo2 Stoniness
Hardsetting
Low permeability
Sodicity

bo3 Strongly acid
Sodicity

bo4 Sodicity

bo5 Strongly acid
Sodicity

Fertility

General fertility is moderate to low. The topsoil **(bo1)** is friable. The soils are deep, well structured, freely drained on crests and upper slopes. They are strongly acid with low to moderate CEC.

Erodibility

bo1 has high erodibility. **bo2** has moderate erodibility, and the strongly structured subsoils **(bo3, bo4** and **bo5)** have low erodibility.

Erosion Hazard

Erosion hazard for non-concentrated flows is extreme. The calculated soil loss for the first 12 months of urban development ranges up to 100 t/ha for topsoils and 100 t/ha for exposed subsoils. The erosion hazard for concentrated flows is moderate to high.

Surface Movement Potential

These soils are generally stable; however, there are localised occurrences of moderately reactive soils.

Landscape Limitations

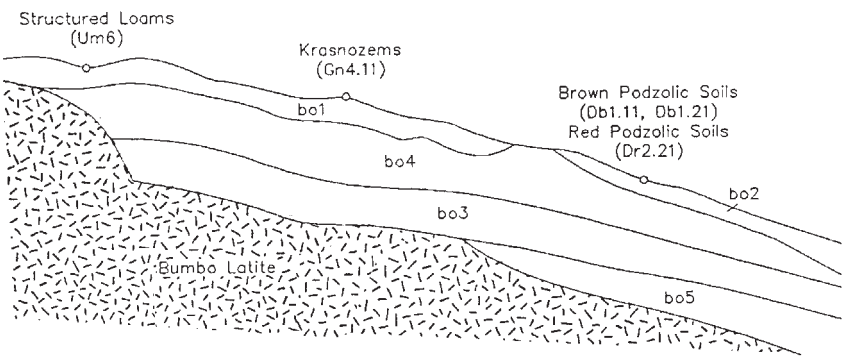
Steep slopes (localised)
Mass movement hazard (localised)
Rock fall hazard
Wave erosion hazard (coasts)
Rock outcrop
Run-on (localised)

Urban Capability

Generally moderate limitations for urban development. High to severe limitations on slopes greater than 20%.

Rural Capability

Generally high to severe limitations for regular cultivation. Generally low to moderate limitations for grazing but high to severe limitations for grazing on steep slopes.



■ ***Schematic cross-section of Bombo soil landscape illustrating the occurrence and relationship of the dominant soil materials.***

ka KIAMA

Landscape—rolling low hills with broad crests, long convex slopes and steep coastal headlands on Blow Hole Latite. Relief 40–60 m. Slopes <20%. Extensive rock outcrop. Extensively cleared with stands of closed-forest.

Soils—deep (>150 cm) Krasnozems (Gn4.11) on crests and upper slopes and Prairie Soils (Gn4.51, Gn4.81) on lower slopes.

Limitations—run-on, water erosion hazard (localised), mass movement hazard (localised), sodicity, low permeability, low wet bearing strength, moderate shrink-swell (subsoil).

LOCATION

Rolling low hills and steep coastal headlands on latite on the Coastal Plain. Examples include Kiama, Gerringong and Gerroa.

LANDSCAPE

Geology

Blow Hole Latite Member—mid grey latite, generally aphanitic.

Topography

Rolling low hills. Relief 40–60 m. Slopes <20%. Crests are broad with long moderately inclined convex slopes and gently inclined concave footslopes. Extensively scattered rock outcrops on upper slopes. Drainage plains <100 m wide. Steep coastal headlands with narrow rock platforms and occasional blow holes.

Vegetation

Extensively cleared with isolated stands of closed-forest. Common species include lillypilly (*Acmena smithii*), native quince (*Alectryon subcinereus*), brush bloodwood (*Baloghia lucida*), red-fruited olive plum (*Cassine australis*), brittlewood (*Claoxylon australe*), hairy clerodendrum (*Clerodendrum tomentosum*), murrogun (*Cryptocarya microneura*), giant stinging tree (*Dendrocnide excelsa*), black plum (*Diospyros australis*), sassafras (*Doryphora sassafras*), corkwood (*Duboisia myoporoides*), koda (*Ehretia acuminata*), bolwarra (*Eupomatia laurina*) (Gerroa only), moreton bay fig (*Ficus macrophylla*), deciduous fig (*Ficus superba*), cabbage tree palm (*Livistona australis*), northern boobialla (*Myoporum acuminatum*), large mock olive (*Notelaea longifolia*), snow-wood (*Parachidendron pruinosum*), pittosporum (*Pittosporum* spp.), black apple (*Planchonella australis*), plum pine (*Polocarpus elatus*), yellowwood (*Sarcomelicope simplicifolia*), flintwood (*Scolopia braunii*), wilkiea (*Wilkiea huegeliana*), whalebone tree (*Streblus brunonianus*), bastard

rosewood (*Synoum glandulosum*), buff hazelwood (*Symplocos thwaitesii*), scrub beefwood (*Stenocarpus salignus*), olivers sassafras (*Cinnamomum oliveri*), coast canthium (*Canthium coprosmoides*), bird lime tree (*Pisonia umbellifera*).

Land Use

Cattle grazing on improved pastures, urban development including service and tourist centres of Kiama, Gerringong and Gerroa.

Existing Erosion

Moderate sheet and gully erosion only where a poor vegetative cover exists.

Included Soil Landscape

Small areas of Fountaindale **(fo)** soil landscape occur.

SOILS

Dominant Soil Materials

ka1—Friable brownish black sandy clay loam (topsoil)

Colour	brownish black (5YR 2/2)
Texture	sandy clay loam to light sandy clay loam
Structure	moderately pedal, <2 mm crumbs to polyhedral peds
Fabric	rough-faced, porous
pH	4.5–6.0
Stones	10–20% 2–20 mm sub-rounded, dispersed
Roots	common, ex-ped

ka2—Brown weakly pedal light clay (subsoil)

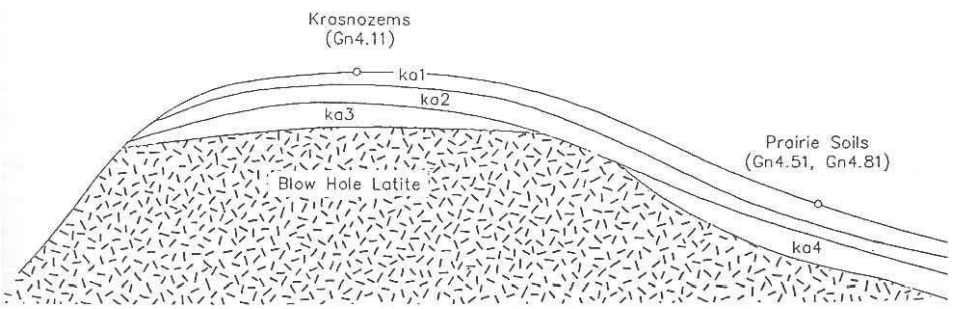
Colour	brown (10YR 4/4)
Texture	light clay to sandy clay
Structure	weakly pedal, 10–20 mm polyhedral peds
Fabric	rough-faced, porous
pH	4.5
Stones	nil
Roots	few, ex-ped

ka3—Dark red weakly pedal heavy clay (subsoil)

Colour	dark red (10R 3/6) to dark reddish brown (10R 3/3)
Texture	heavy clay
Structure	weakly to moderately pedal, 2–5 mm sub-angular blocky peds
Fabric	rough-faced, porous
pH	4.5–5.5
Stones	2–10%, 6–20 mm angular, dispersed
Roots	common, ex-ped

ka4—Bright yellowish brown moderately pedal light medium clay (subsoil)

Colour	bright yellowish brown (10YR 6/6) to dull yellow orange (10YR 6/4) with localised brown and grey (<50%) mottling
Texture	light medium clay to sandy clay
Structure	moderately pedal, 10–20 mm sub-angular blocky peds
Fabric	rough-faced, porous
pH	5.0–5.5
Stones	nil
Roots	nil



■ ***Schematic cross-section of Kiama soil landscape illustrating the occurrence and relationship of the dominant soil materials.***

Occurrence and Relationships

Crests and upper slopes. Up to 50 cm friable brownish black clay loam **(ka1)** overlies <20 cm brown weakly pedal light clay **(ka2)**. Up to 150 cm dark red weakly pedal heavy clay **(ka3)** is overlain by <20 cm **ka2**. Boundaries are gradual [Krasnozems (Gn4.11)]. Total depth is 100–200 cm.

Lower slopes and drainage plains. Up to 50 cm **ka1** overlies <20 cm **ka2** which overlies <150 cm bright yellowish brown light medium clay **(ka4)**. Boundaries are clear to gradual [Prairie Soils (Gn4.51, Gn4.81)]. Total depth is 100–200 cm.

LIMITATIONS TO DEVELOPMENT

Soil Limitations

ka1 Stoniness
Sodicity
Low available water-holding capacity
High organic matter

ka2 Low fertility
Sodicity
Strongly acid

ka3 Stoniness
Low permeability
Sodicity
Strongly acid
Low available water-holding capacity

ka4 Shrink-swell potential
Low permeability
Low wet bearing strength
Strongly acid

Fertility

General fertility is moderate to low. The topsoil **(ka1)** is friable. The subsoils are deep, well structured, freely drained on crests and upper slopes. They are strongly acid with low to moderate CEC.

Erodibility

The topsoil **(ka1)** has moderate erodibility. The subsoils **(ka2, ka3** and **ka4)** have high erodibility.

Erosion Hazard

Erosion hazard for non-concentrated flows is extreme. The calculated soil loss for the first 12 months of urban development ranges up to 1 300 t/ha for topsoils and 900 t/ha for exposed subsoils. The erosion hazard for concentrated flows is moderate.

Surface Movement Potential

These moderate to deep clay soils **(ka1, ka2, ka3)** are slightly reactive. The subsoil **ka4** is moderately reactive.

Landscape Limitations

Rock fall hazard (localised)
Rock outcrop (localised)
Steep slopes (localised)
Run-on
Water erosion hazard (localised)

Urban Capability

Generally low limitations for urban development. Moderate limitations on steeper slopes.

Rural Capability

Generally high to severe limitations for regular cultivation. Low to moderate limitations for grazing.

APPENDIX E: BOREHOLE LOGS

Geological Borelog

ENVIRONMENTAL EARTH SCIENCES
CONTAMINATION RESOLVED

LOCATION: Dunmore Sand and Soil - Stage 5		Borehole Log: MW5A1	Logged by: LV
SURFACE ELEVATION:	JOB NUMBER: 118044		
GROUNDWATER: 3.45m BGL	DATUM:	PROJECT: Dunmore	Proj. Manager: LV
DRILL METHOD: sonic drill	DATE DRILLED: 11/07/18		

STRATIGRAPHY	GRAPHIC LOG	Depth metres	Sample Depth	Sample ID	Moisture Content	PID/FID Background	PID/FID Reading	pH - soil	pH - water	Construction Details	Comments
NATURAL Loose, light brown/grey, medium grained SAND.		0.5						6.4	5.8	Concrete	
								6.5	5.6	Bentonite	
NATURAL Loose, brown, medium to fine grained SAND.		1.0			DM			6.6	5.6		
								6.6	5.7		
NATURAL Loose, cream, medium to fine grained SAND		1.5			DM			6.5	5.7		
								6.7	5.8	Casing	
		2.0						6.8	5.7		
								6.8	5.8		
		2.5						6.8	5.6		
								6.9	5.6		
NATURAL Loose, cream medium to fine grained SAND.		3.0			DM			6.8	5.6		
NATURAL Loose, brown, medium to fine grained, silty SAND.		3.5			M			6.9	6.8		Roots and organic plant matter. SWL at 3.45mBGL
NATURAL Loose, cream, medium to fine grained, silty SAND.					M			6.7	5.1		
NATURAL Loose, brownish grey, medium to coarse grained, SAND.		4.0			M			6.7	5.3		FD2 sampled here
								6.7	1.7	Screen	Sample sent to lab
		4.5						6.4	2.4		
								6.5	2.3		Sample sent to lab (FD1)
		5.0			M			6.6	5.1		
								7.3	6		

NOTE: This bore log is for environmental purposes only and is not intended to provide geotechnical information.

Geological Borelog

ENVIRONMENTAL EARTH SCIENCES
CONTAMINATION RESOLVED

LOCATION: Dunmore Sand and Soil - Stage 5		Borehole Log: MW5A1	Logged by: LV
SURFACE ELEVATION:	JOB NUMBER: 118044		
GROUNDWATER: 3.45m BGL	DATUM:	PROJECT: Dunmore	Proj. Manager: LV
DRILL METHOD: sonic drill	DATE DRILLED: 11/07/18		

STRATIGRAPHY	GRAPHIC LOG	Depth metres	Sample Depth	Sample ID	Moisture Content	PID/FID Background	PID/FID Reading	pH - soil	pH - water	Construction Details	Comments
NATURAL Loose, grey, fine to medium grained, SAND, fine shell grit throughout.								7.7	5.7		
		5.5						7.9	6		
								8	5.9		Sulfuric odour
		6.0						8.3	5.7		Sample sent to lab
					M			7.9	5.8		
NATURAL Loose, grey, fine to medium grained, SAND, fine shell grit throughout.		6.5						8	5.8		
								8.3	5.6		Sample sent to lab
		7.0			M			8.5	5.6		
NATURAL Loose, grey, coarse, SAND, coarse shell grit and organic plant matter.								8.6	5.6		Weathered bedrock?
NATURAL Firm, brown/grey,fine to medium grained, clayey SAND, no shells.		7.5						8.7	5.7	Bentonite Plug	Sample sent to lab
								8.4	5.7		
		8.0			M			8.4	5.6	Backfill	
NATURAL Firm, grey/brown, fine to medium grained, clayey SAND, no shells.								8.3	5.8		
		8.5			M			8.2	5.8		
NATURAL Firm, grey, fine grained, sandy CLAY, no shells.								8.2	5.9		
		9.0						8.1	5.8		
End of hole											
		9.5									
		10.0									

NOTE: This bore log is for environmental purposes only and is not intended to provide geotechnical information.

Geological Borelog

ENVIRONMENTAL EARTH SCIENCES
CONTAMINATION RESOLVED

LOCATION: Dunmore Sand and Soil Stage 5		Borehole Log: MW5A2	Logged by: LV
SURFACE ELEVATION:	JOB NUMBER: 118044		
GROUNDWATER: 2.35 mBGL	DATUM:	PROJECT: Dunmore	Proj. Manager: LV
DRILL METHOD: sonic drill	DATE DRILLED: 11/07/18		

STRATIGRAPHY	GRAPHIC LOG	Depth metres	Sample Depth	Sample ID	Moisture Content	PID/FID Background	PID/FID Reading	pH - soil	pH - water	Construction Details	Comments
FILL/REWORKED NATURAL Firm, dark brown, sandy CLAY, with gravels and latite cobble, plant matter (roots).					DM			6.4	5.8	Concrete	Latite amd clay fallen from hill weathered at surface
		0.5						6.5	5.6		
NATURAL Loose, dark brown, fine to medium grained, silty SAND.					DM			6.6	5.6	Bentonite	
		1.0						6.6	5.7		
NATURAL Loose, dark grey/brown, fine to medium grained, silty SAND.					DM			6.5	5.4	Casing	
		1.5						6.7	5.8		
								6.8	5.7		
		2.0						6.8	5.8		
NATURAL Loose, grey/brown, fine to medium grained, SAND.					M			6.8	5.6		Water level at 2.35 mBGL
		2.5						6.9	5.6		
NATURAL Loose, grey, medium grained, SAND.					M			6.8	5.6		
		3.0						6.8	5.6		
NATURAL Loose, dark grey, medium grained, SAND.					M			6.9	6.8		Sample sent to lab
		3.5						6.7	5.1	Screen	
								6.7	5.3		Sample sent to lab
		4.0						6.7	1.7		Sample sent to lab
NATURAL Loose, dark grey, medium grained, SAND, 25 % sub-angular gravel, cobble, rounded gravel.					M			6.4	2.4		Alluvium? Paleochannel?
		4.5						6.5	2.3		
NATURAL Loose, grey/brown fine to medium grained, SAND.					M			6.6	5.1		
		5.0						7.3	6		Sample sent to lab

NOTE: This bore log is for environmental purposes only and is not intended to provide geotechnical information.

Geological Borelog

ENVIRONMENTAL EARTH SCIENCES
CONTAMINATION RESOLVED

LOCATION: Dunmore Sand and Soil Stage 5		Borehole Log: MW5A2	Logged by: LV
SURFACE ELEVATION:	JOB NUMBER: 118044		
GROUNDWATER: 2.35 mBGL	DATUM:	PROJECT: Dunmore	Proj. Manager: LV
DRILL METHOD: sonic drill	DATE DRILLED: 11/07/18		

STRATIGRAPHY	GRAPHIC LOG	Depth metres	Sample Depth	Sample ID	Moisture Content	PID/FID Background	PID/FID Reading	pH - soil	pH - water	Construction Details	Comments
NATURAL Firm, brown/grey, clayey SAND, no shells					M			7.7	5.7		Weathered bedrock
Becoming more grey.		5.5						7.9	6		
								8	5.9		
NATURAL Very dense, grey, CLAY.		6.0			M			8.3	5.7		Sample sent to lab
								7.9	5.8	Bentonite	End of well at 6 mBGL
		6.5						8	5.8		Weathered bedrock, extremely hard, difficult to cut/sample.
								8.3	5.6		
		7.0						8.5	5.6		
								8.6	5.6		
		7.5						8.7	5.7	Backfill	
								8.4	5.7		
		8.0						8.4	5.6		
								8.3	5.8		
		8.5						8.2	5.8		
								8.2	5.9		
End of hole @ 9m (Latite)		9.0						8.1	5.8		
		9.5									
		10.0									

NOTE: This bore log is for environmental purposes only and is not intended to provide geotechnical information.

Geological Borelog

ENVIRONMENTAL EARTH SCIENCES
CONTAMINATION RESOLVED

LOCATION: Dunmore Sand and Soil Stage 5		Borehole Log: MW5A3	Logged by: LV
SURFACE ELEVATION:	JOB NUMBER: 118044		
GROUNDWATER: 0.92 mBGL	DATUM:	PROJECT: Dunmore	Proj. Manager: LV
DRILL METHOD: sonic drill	DATE DRILLED: 11/07/18		

STRATIGRAPHY	Depth metres	Sample Depth	Sample ID	Moisture Content	PID/FID Background	PID/FID Reading	pH - soil	pH - water	Comments
NATURAL Loose, dark brown, fine to medium grained, silty SAND, with roots and plant matter.				DM			6.8	4.6	
	0.5						6.3	4.1	
NATURAL Loose, light brown, medium grained, SAND.				DM			5.9	4.4	
	1.0						5.9	4	SWL
NATURAL Loose, dark grey, medium grained, SAND.				M			5.8	1.9	Sample sent to lab
	1.5						5.5	2	
							4.8	1.9	Sample sent to lab
	2.0						5.3	2	
							5.3	2	
	2.5						5.5	2	
								2	Sample sent to lab
	3.0						5.6	2.1	
							7.3	2.1	
	3.5						7.2	1.8	
NATURAL Becoming fine to medium grained.				M			7.2	1.9	
	4.0						7.5	1.9	Sample sent to lab
							7	1.9	
	4.5							1.8	
NATURAL Becoming medium grained.				M			7.1	1.8	
	5.0						7	5.5	

Construction Details: Concrete; Bentonite; Casing; Screen

NOTE: This bore log is for environmental purposes only and is not intended to provide geotechnical information.

Geological Borelog

ENVIRONMENTAL EARTH SCIENCES
CONTAMINATION RESOLVED

LOCATION: Dunmore Sand and Soil Stage 5		Borehole Log: MW5A3	Logged by: LV
SURFACE ELEVATION:	JOB NUMBER: 118044		
GROUNDWATER: 0.92 mBGL	DATUM:	PROJECT: Dunmore	Proj. Manager: LV
DRILL METHOD: sonic drill	DATE DRILLED: 11/07/18		

STRATIGRAPHY	GRAPHIC LOG	Depth metres	Sample Depth	Sample ID	Moisture Content	PID/FID Background	PID/FID Reading	pH - soil	pH - water	Construction Details	Comments
NATURAL Loose, dark grey, medium grained, SAND, with very coarse shell grit (75%).					M			7.6	6.9		
		5.5						7.9	2.3		
NATURAL Loose, dark grey, medium to coarse grained, SAND.					M			8.2	2.3		Sample sent to lab
		6.0						7.9	2.2		
NATURAL Loose, fawn, medium grained, SAND. some faun/sandy clay (10%).					M			7.9	2.4		
		6.5						7.9	2.2		
								7.7	2.2		
		7.0						7.6	2.1		Sample sent to lab
NATURAL Loose, fawn/grey, medium grained, SAND.					M			7.8	3.9		Sample sent to lab Sandy clay lense <5cm @7.25 mBGL
		7.5						7.7	2.3		
								7.7	2.2		
		8.0						7.3	2.2		
NATURAL Loose, grey, medium grained, SAND.					M			6.7	2.4		
		8.5						6	2.2		
								6	2.3		Sample sent to lab
		9.0						6	2.3		
		9.5						6	2.2		Sample sent to lab
		10.0						6	2.3		

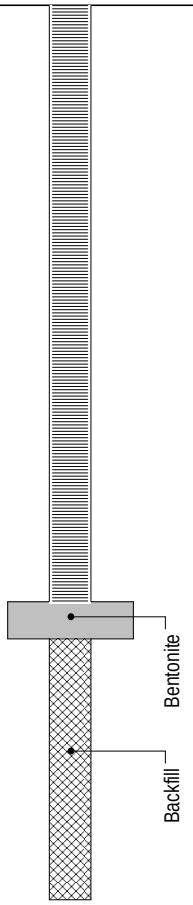
NOTE: This bore log is for environmental purposes only and is not intended to provide geotechnical information.

Geological Borelog

ENVIRONMENTAL EARTH SCIENCES
CONTAMINATION RESOLVED

LOCATION: Dunmore Sand and Soil Stage 5		Borehole Log: MW5A3	Logged by: LV
SURFACE ELEVATION:	JOB NUMBER: 118044		
GROUNDWATER: 0.92 mBGL	DATUM:	PROJECT: Dunmore	Proj. Manager: LV
DRILL METHOD: sonic drill	DATE DRILLED: 11/07/18		

STRATIGRAPHY	GRAPHIC LOG	Depth metres	Sample Depth	Sample ID	Moisture Content	PID/FID Background	PID/FID Reading	pH - soil	pH - water	Construction Details	Comments
		10.5						6.7	3.5		
		11.0						6.3	4.4		
		11.5						6.9	6.3		
NATURAL Loose, grey, medium grained, SAND, very coarse shell grit (90%).		12.0			M			7	6.6		
NATURAL Firm, grey, CLAY.					D			8.6	8.1		
No shells		12.5						8.2	2.4		Sample sent to lab Assumed weathered bedrock until end of hole.
End of hole @ 13m (Refusal on Latite)		13.0									
		13.5									
		14.0									
		14.5									
		15.0									



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Geological Borelog

ENVIRONMENTAL EARTH SCIENCES
CONTAMINATION RESOLVED

LOCATION: Dunmore Sand and Soil - Stage 5		Borehole Log: BH_5 B1a	Logged by: LV
SURFACE ELEVATION:	JOB NUMBER: 118044		
GROUNDWATER:	DATUM:	PROJECT: Dunmore	Proj. Manager: LV
DRILL METHOD: sonic drill	DATE DRILLED: 12/7/18		

STRATIGRAPHY	GRAPHIC LOG	Depth (metres)	Sample Depth	Sample ID	PID (ppm)	Moisture Content	Comments
Natural Loose, dark grey/brown, silty SAND (medium grained) with roots/organic topsoil.		0.2 0.4					No well constructed due to Latite at 7m.
Natural Loose, brown/grey medium grained silty SAND with roots.		0.6 0.8 1.0 1.2					
Natural Loose, dark brown, silty SAND.		1.4					
Natural Loose, faun, medium grained silty SAND.		1.6 1.8 2.0					
Natural Loos, grey, medium to coarse grained SAND, with fine shell grit.		2.2 2.4					
Natural Loose, dark grey, medium grained SAND with coarse shell grit.		2.6 2.8					
Natural Loose, dark grey, fine to medium grained SANDand very fine shell grit.		3.0 3.2 3.4 3.6 3.8 4.0 4.2 4.4 4.6 4.8					
fine to medium shell grit.		5.0 5.2					
Coarse shell grit.		5.4					
Very coarse shell grit and sub rounded cobbles.		5.6 5.8 6.0					Paleo charcoal?
Natural Loose, grey, medum to coarse grained SAND.		6.2					Weathered bedrock
Natural Firm, brownish grey, CLAY.		6.4 6.6 6.8 7.0					
End of hole @ 7m (Refusal on latite)		7.2 7.4 7.6 7.8 8.0					

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Geological Borelog

ENVIRONMENTAL EARTH SCIENCES
CONTAMINATION RESOLVED

LOCATION: Dunmore Sand and Soil - Stage 5		Borehole Log: MW5B1	Logged by: LV
SURFACE ELEVATION:	JOB NUMBER: 118044		
GROUNDWATER: 2.45 mBGL	DATUM:	PROJECT: Dunmore	Proj. Manager: LV
DRILL METHOD: sonic drill	DATE DRILLED: 12/07/18		

STRATIGRAPHY	GRAPHIC LOG	Depth metres	Sample Depth	Sample ID	Moisture Content	PID/FID Background	PID/FID Reading	pH - soil	pH - water	Construction Details	Comments
NATURAL Loose, dark brown/grey, silty SAND, with roots.					D			8.8		Cement	
NATURAL Loose, grey/brown, medium grained, SAND.		0.5			D			8.7		Bentonite	
								5.2			
NATURAL Loose, dark brown, fine to medium grained, silty SAND.		1.0			DM			8		Casing	Sample sent to lab
		1.5						7.4			
								7.3			
								6.9			
NATURAL Loose, brown, fine to medium grained, silty SAND.		2.0			M			6.8			
								6.6			
		2.5						6.6			SWL
								6.4			
NATURAL Loose, grey, fine grained, SAND, with shell grit throughout.		3.0			M			6.4			
								8.9		Screen	
		3.5						9.4			Sample sent to lab
								7.1			
		4.0						8.8			
								9.4			Sample sent to lab
		4.5						9.4			
								9.3			
		5.0						9.1			

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Geological Borelog

ENVIRONMENTAL EARTH SCIENCES
CONTAMINATION RESOLVED

LOCATION: Dunmore Sand and Soil - Stage 5		Borehole Log: MW5B1	Logged by: LV
SURFACE ELEVATION:	JOB NUMBER: 118044		
GROUNDWATER: 2.45 mBGL	DATUM:	PROJECT: Dunmore	Proj. Manager: LV
DRILL METHOD: sonic drill	DATE DRILLED: 12/07/18		

STRATIGRAPHY	GRAPHIC LOG	Depth metres	Sample Depth	Sample ID	Moisture Content	PID/FID Background	PID/FID Reading	pH - soil	pH - water	Construction Details	Comments
								9.1			
		5.5						9			
Shell grit increasing from medium to coarse.					M						
								9			
		6.0						8.9			
NATURAL Firm, grey, clayey, fine grained SAND, no shells. Extremely weathered bedrock.					D					Bentonite	Assumed extremely weathered bedrock until end of hole.
								8.9			
		6.5						8.9			
								8.9			
		7.0						8.8		Backfill	Sample sent to lab
								-			
		7.5						8.5			
								8.5			
		8.0						8.9			
		8.5									
NATURAL Latite.					D						
		9.0									
End of hole @ 9m (Refusal on latite)											
		9.5									
		10.0									

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Geological Borelog

ENVIRONMENTAL EARTH SCIENCES
CONTAMINATION RESOLVED

LOCATION: Dunmore Sand and Soil - Stage 5		Borehole Log: MW5B2	Logged by: LV
SURFACE ELEVATION:	JOB NUMBER: 118044		
GROUNDWATER: 2.7 mBGL	DATUM:	PROJECT: Dunmore	Proj. Manager: LV
DRILL METHOD: sonic drill	DATE DRILLED: 12/07/18		

STRATIGRAPHY	GRAPHIC LOG	Depth metres	Sample Depth	Sample ID	Moisture Content	PID/FID Background	PID/FID Reading	pH - soil	pH - water	Construction Details	Comments
NATURAL Loose, dark brown/grey, medium grained, silty SAND with organics (roots and charcoal).					D			6.6	3.3	Cement	
		0.5			D			6.2	4.4	Bentonite	
NATURAL Loose, brown, medium grained, silty SAND.								5.9	4.1		
		1.0			DM			5.6	4.6	Casing of deep groundwater bore	
NATURAL Loose, brown, medium grained, SAND.								5.9	4.8		
Becoming lighter in colour.		1.5						5.8	5.3		
								5.8	5.2		Sample sent to lab
		2.0			M			5.8	5.3	Casing of shallow groundwater bore	
NATURAL becoming faun in colour..								5.8	5.5		
		2.5			M			5.8	5.7	Screen	
NATURAL Loose, grey, fine to medium grained, SAND, with very fine grained shell grit throughout.								7	6.3		SWL
		3.0						8			Sample sent to lab
								8.5	6.6		
		3.5						8.9	7		
shell grit becoming fine to medium grained.								8.8	6.7		
		4.0						9	6.6		
becoming dark grey in colour.								8.8	6.8		
		4.5						8.9	6.6		
								8.8	6.5		
		5.0						9	6.6		Sample sent to lab

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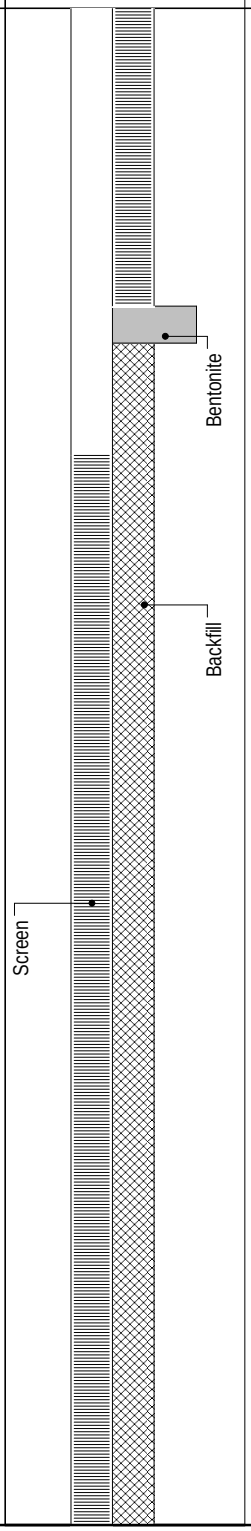
Geological Borelog

ENVIRONMENTAL EARTH SCIENCES
CONTAMINATION RESOLVED

LOCATION: Dunmore Sand and Soil - Stage 5		Borehole Log: MW5B2	Logged by: LV
SURFACE ELEVATION:	JOB NUMBER: 118044		
GROUNDWATER: 2.7 mBGL	DATUM:	PROJECT: Dunmore	Proj. Manager: LV
DRILL METHOD: sonic drill	DATE DRILLED: 12/07/18		

STRATIGRAPHY	Depth metres	Sample Depth	Sample ID	Moisture Content	PID/FID Background	PID/FID Reading	pH - soil	pH - water	Comments
intact shell pieces.							8.9	6.8	
	5.5						9	6.6	
							9	6.4	
	6.0						9.4	6.5	Sample sent to lab
							9.2	6.6	
	6.5						9.2	7.2	
							9.1	6.6	
	7.0						9.1	6.9	
							9	5.7	Sample sent to lab
	7.5						9.1	6.5	
occasional whole shells							8.9	6.4	
	8.0						9	6	
NATURAL Loose, grey, medium grained, SAND, with coarse shell grit throughout.				M			8.7	6.3	
	8.5						9.1	6.2	Sample sent to lab
				M			8.7	6.3	
NATURAL Loose, grey, fine to medium grained, SAND, with fine shell grit throughout.	9.0						8.6	6.3	
							8.7	6.2	
becoming medium grained.	9.5						9	6.4	
							9.3	6.3	Sample sent to lab
	10.0			M			8.9	6.2	

Construction Details



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Geological Borelog

ENVIRONMENTAL EARTH SCIENCES
CONTAMINATION RESOLVED

LOCATION: Dunmore Sand and Soil - Stage 5		Borehole Log: MW5B2	Logged by: LV
SURFACE ELEVATION:	JOB NUMBER: 118044		
GROUNDWATER: 2.7 mBGL	DATUM:	PROJECT: Dunmore	Proj. Manager: LV
DRILL METHOD: sonic drill	DATE DRILLED: 12/07/18		

STRATIGRAPHY	GRAPHIC LOG	Depth metres	Sample Depth	Sample ID	Moisture Content	PID/FID Background	PID/FID Reading	pH - soil	pH - water	Construction Details	Comments
NATURAL Loose, dark grey, fine grained, SAND, with medium grained shell grit throughout.								8.5	6.9		
NATURAL Soft, dark grey, fine grained, clayey SAND, with fine grained shell grit (5%).		10.5			M			8.6	6.7	Bentonite	Assumed esturine clays
NATURAL Soft, dark grey, fine grained, clayey SAND, with shell grit (5%).								9	6.9		Sample sent to lab
		11.0						9.1	6.9		
								9	7.4		
		11.5						9.2	7.3		
								9.4	6.3	Backfill	
		12.0						9.4	5.9		Sample sent to lab
								9.1	6.3		
NATURAL Soft, grey, fine grained, clayey SAND, with no shells, homogenous.		12.5			M			9	6.4		
								9.3	6.8		
		13.0						8.8	6.3		
								9.2	6.1		
		13.5						9.3	6.1		
								9.3	5.7		
		14.0						9.4	5.5		
								9.3	5.8		
NATURAL Soft, dark grey, fine grained, clayey SAND, with fine grained shell grit (5%).		14.5			DM			9.3	2.6		Sample sent to lab
								9.4	4.7		
		15.0			DM			9.4	6.4		Sample sent to lab

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Geological Borelog

ENVIRONMENTAL EARTH SCIENCES
CONTAMINATION RESOLVED

LOCATION: Dunmore Sand and Soil - Stage 5		Borehole Log: MW5B2	Logged by: LV
SURFACE ELEVATION:	JOB NUMBER: 118044		
GROUNDWATER: 2.7 mBGL	DATUM:	PROJECT: Dunmore	Proj. Manager: LV
DRILL METHOD: sonic drill	DATE DRILLED: 12/07/18		

STRATIGRAPHY	GRAPHIC LOG	Depth metres	Sample Depth	Sample ID	Moisture Content	PID/FID Background	PID/FID Reading	pH - soil	pH - water	Construction Details	Comments
NATURAL Firm, grey, CLAY, with shell grit (5%).		15.5						9.5	6.8		
								9.4	6.5		
		16.0						9.7	6.6		
								9.6	6.9		
		16.5									
		17.0						9.6	7.4		
		17.5									
End of hole @ 18 m.		18.0						18.5	7.7		
		18.5									
		19.0									
		19.5									
		20.0									

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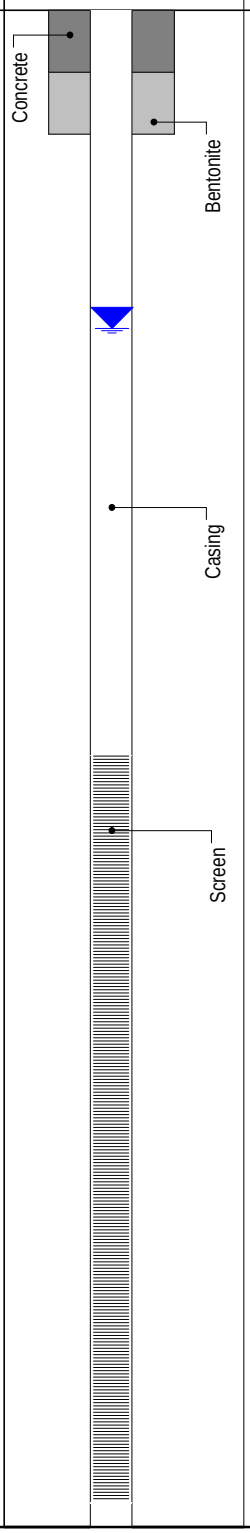
Geological Borelog

ENVIRONMENTAL EARTH SCIENCES
CONTAMINATION RESOLVED

LOCATION: Dunmore Sand and Soil - Stage 5		Borehole Log: MW5B3	Logged by: LV
SURFACE ELEVATION:	JOB NUMBER: 118044		
GROUNDWATER: 1.28 mBGL	DATUM:	PROJECT: Dunmore	Proj. Manager: LV
DRILL METHOD: sonic drill	DATE DRILLED: 16/07/18		

STRATIGRAPHY	Depth metres	Sample Depth	Sample ID	Moisture Content	PID/FID Background	PID/FID Reading	pH - soil	pH - water	Comments
NATURAL Firm, dark brown, LOAMY TOPSOIL, with roots.				D			7.9	6.2	
	0.5						8.1	6.3	
NATURAL Loose, tan, fine grained, clayey SAND (5%).				DM			8.1	6.3	
	1.0						8.3	6.4	
NATURAL Loose, tan, fine grained, SAND. becoming grey				M			8	6.3	SWL
	1.5						8	6.2	
NATURAL Loose, grey, fine grained, SAND, with very fine grained shell grit throughout.				M			8.2	6.4	
	2.0						8	6.2	Sample sent to lab
				M			7.6	6.2	
	2.5						7.6	5.9	
							7.8	6.2	
NATURAL Loose, grey, medium grained SAND, with medium grained shell grit.	3.0						8	6	
				M			8	6.1	Sample sent to lab
NATURAL Loose, dark grey, medium grained, SAND, with medium grained shell grit with coarse shells, timber, marine barnacles.	3.5			M			8	6.1	Barnacles + timber
NATURAL Loose, dark grey, fine grained, SAND, with fine grained shell grit throughout.							8.1	6.1	
	4.0						8.6	6	Sample sent to lab
							8.6	6.3	
	4.5						8.5	6.2	
							8.4	6.3	
	5.0						8.4	6.3	
							8.5	6.3	
	5.5						8.4	6.1	
							8.5	6	
	6.0						8.5	6.2	



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Geological Borelog

LOCATION: Dunmore Sand and Soil - Stage 5		Borehole Log: MW5B3	Logged by: LV
SURFACE ELEVATION:	JOB NUMBER: 118044		
GROUNDWATER: 1.28 mBGL	DATUM:	PROJECT: Dunmore	Proj. Manager: LV
DRILL METHOD: sonic drill	DATE DRILLED: 16/07/18		

STRATIGRAPHY	GRAPHIC LOG	Depth metres	Sample Depth	Sample ID	Moisture Content	PID/FID Background	PID/FID Reading	pH - soil	pH - water	Construction Details	Comments
NATURAL Loose, dark grey, medium grained, SAND, with coarse shell grit throughout.								8.6	5.8		
		6.5						8.7	6	Casing	
					M			8.6	6.1		
NATURAL Loose, dark grey, coarse grained, SAND, with coarse grain shell grit (90%).		7.0						8.7	5.9		
					M			8.8	5.8		Sample sent to lab
NATURAL Loose, grey, medium grained, SAND, no shell grit.		7.5						8.9	6		
								9	5.8		Sample sent to lab
		8.0						8.6	6		
								8.8	6		
		8.5						8.8	6		
								8.7	6		
		9.0						8.6	6.3		
								9.1	6.1		
		9.5						9.1	6.1	Screen	
								9	6.1		
		10.0						9.2	6		Sample sent to lab
								9.1	6.2		
		10.5						9	6.1		
								9.1	6.4		
		11.0						9.3	6.3		
								9.1	6.2		
NATURAL Loose, brown/grey, medium grained, clayey SAND, with shell grit (5%).		11.5			DM			9.1	6.2	Bentonite	Assumed esturine clayey sand.
								9	6.3		
		12.0						9.1	6.2	Backfill	

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Geological Borelog

ENVIRONMENTAL EARTH SCIENCES
CONTAMINATION RESOLVED

LOCATION: Dunmore Sand and Soil - Stage 5		Borehole Log: MW5B3	Logged by: LV
SURFACE ELEVATION:	JOB NUMBER: 118044		
GROUNDWATER: 1.28 mBGL	DATUM:	PROJECT: Dunmore	Proj. Manager: LV
DRILL METHOD: sonic drill	DATE DRILLED: 16/07/18		

STRATIGRAPHY	GRAPHIC LOG	Depth metres	Sample Depth	Sample ID	Moisture Content	PID/FID Background	PID/FID Reading	pH - soil	pH - water	Construction Details	Comments
								9.4	5.9		Sample sent to lab
		12.5						8.9	6.1		
								8.7	6.2		
		13.0						8.6	6.4		
NATURAL Soft, brown, fine grained, clayey SAND, with no shell grit.					DM			8.2	6		Assumed weathered bedrock, homogeneous until end of hole
		13.5						8.3	5.9		
NATURAL Soft, grey, fine grained, clayey SAND, with no shell grit.					DM			8.2	5.6	Backfill	
		14.0						8.4	5.4		Sample sent to lab
								7.5	5.8		
		14.5						7.5	5.5		
								7.2	5.7		
		15.0						7.3	5.7		
								7.3	5.6		
		15.5						7.7	5.4		
								7.6	5.5		
		16.0						7.3	6.2		
End of hole @ 16m.											
		16.5									
		17.0									
		17.5									
		18.0									

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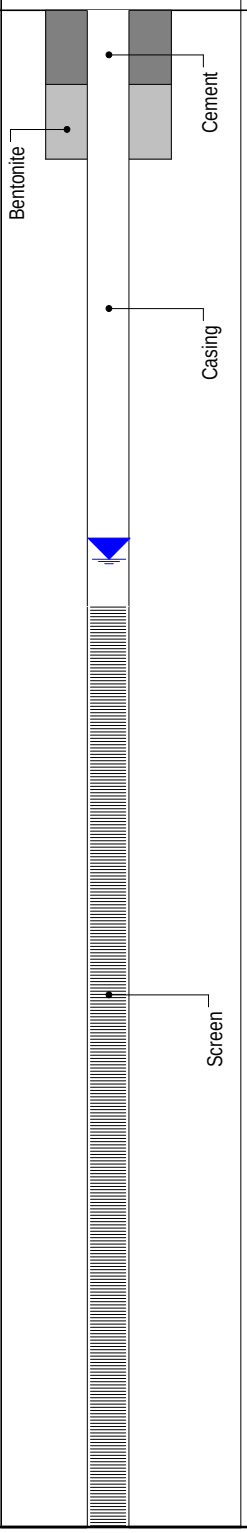
Geological Borelog

ENVIRONMENTAL EARTH SCIENCES
CONTAMINATION RESOLVED

LOCATION: Dunmore Sand and Soil - Stage 5		Borehole Log: MW5B4	Logged by: LV
SURFACE ELEVATION:	JOB NUMBER: 118044		
GROUNDWATER: 1.84 mBGL	DATUM:	PROJECT: Dunmore	Proj. Manager: LV
DRILL METHOD: sonic drill	DATE DRILLED: 16/07/18		

STRATIGRAPHY	Depth metres	Sample Depth	Sample ID	Moisture Content	PID/FID Background	PID/FID Reading	pH - soil	pH - water	Comments
NATURAL Loose, brown, fine grained, silty SAND.							6.7	6.2	
NATURAL Loose, cream, fine grained, SAND.	0.5						8.2	6.2	5 % clay.
							8.5	6.3	
	1.0						8.8	6.4	
							9	6	
	1.5						9	5.9	Sample sent to lab
NATURAL Loose, fawn, fine grained, SAND.							8.7	6	SWL
	2.0						8.8	5.8	Sample sent to lab
NATURAL Loose, grey, fine grained, SAND.							8.6	5.8	
	2.5						8.7	6.1	
NATURAL Loose, grey, fine grained, SAND, with very fine grained shell grit throughout.							8.7	5.9	
	3.0						8.6	5.9	
							8.5	5.7	Sample sent to lab
	3.5						8.2	6.5	
							8	6.6	
	4.0						8.6	6.9	
NATURAL Loose, grey, medium grained, SAND.							8.6	6.7	
	4.5						8.6	6.1	Sample sent to lab
							8.5	7	
	5.0						8.7	6.3	



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Geological Borelog

ENVIRONMENTAL EARTH SCIENCES
CONTAMINATION RESOLVED

LOCATION: Dunmore Sand and Soil - Stage 5		Borehole Log: MW5B4	Logged by: LV
SURFACE ELEVATION:	JOB NUMBER: 118044		
GROUNDWATER: 1.84 mBGL	DATUM:	PROJECT: Dunmore	Proj. Manager: LV
DRILL METHOD: sonic drill	DATE DRILLED: 16/07/18		

STRATIGRAPHY	GRAPHIC LOG	Depth metres	Sample Depth	Sample ID	Moisture Content	PID/FID Background	PID/FID Reading	pH - soil	pH - water	Construction Details	Comments
								8.3	6.6		Sample sent to lab
NATURAL Loose, grey, medium grained SAND, with grey, very coarse, shell grit.		5.5						8.5	6.3	Screen	
								8.4	6.4		
NATURAL Loose, grey, medium grained, SAND.		6.0						8.4	6.36.3		
NATURAL Loose, grey, medium grained, clayey SAND, with shell (5%).								8.6	5.9	Bentonite	Assumed esturine clay.
NATURAL Loose, grey, medium grained, clayey SAND, with coarse shell (20%) and latite cobble.		6.5						8.5	5.9		Sample sent to lab
								8.4	6.4		
NATURAL Loose, brown, fine grained, clayey SAND.		7.0						8.5	6	Backfill	Assumed weathered bedrock.
								8.5	5.8		Sample sent to lab
		7.5						8.2	6		
								8.3	5.8		
		8.0						8.3	5.8		
NATURAL Loose, grey, fine grained, clayey SAND.								8.5	5.6		Sample sent to lab Assumed extremely weathered bedrock
		8.5						8.2	5.6		
								8.2	6		
End of hole @ 9.0 m.		9.0						7.6	5.8		
		9.5									
		10.0									

NOTE: This bore log is for environmental purposes only and is not intended to provide geotechnical information.

Geological Borelog

ENVIRONMENTAL EARTH SCIENCES
CONTAMINATION RESOLVED

LOCATION: Dunmore Sand and Soil - Stage 5		Borehole Log: MW5B5	Logged by: LV
SURFACE ELEVATION:	JOB NUMBER: 118044		
GROUNDWATER: 2.15 mBGL	DATUM:	PROJECT: Dunmore	Proj. Manager: LV
DRILL METHOD: sonic drill	DATE DRILLED: 13/07/18		

STRATIGRAPHY	GRAPHIC LOG	Depth metres	Sample Depth	Sample ID	Moisture Content	PID/FID Background	PID/FID Reading	pH - soil	pH - water	Construction Details	Comments
NATURAL Loose, dark brown, silty SAND, with organic plant matter and roots.		0.0								Bentonite, Cement	
NATURAL Loose, brown, coarse, silty SAND, with organic plant matter and roots.		0.5									
NATURAL Loose, orange/brown, medium grained, SAND. becoming light brown.		1.0 1.5 2.0 2.5								Casing	SWL
NATURAL Loose, cream, medium grained, SAND, with medium grained shell grit throughout.		3.0 3.5 4.0								Screen	
NATURAL Loose, grey, fine to medium grained, SAND, with very fine grained shell grit throughout.		4.5 5.0 5.5									
NATURAL Loose, grey, fine to medium grained, SAND, with medium grained shell grit.											
NATURAL		6.0									

NOTE: This bore log is for environmental purposes only and is not intended to provide geotechnical information.

Geological Borelog

ENVIRONMENTAL EARTH SCIENCES
CONTAMINATION RESOLVED

LOCATION: Dunmore Sand and Soil - Stage 5		Borehole Log: MW5B5	Logged by: LV
SURFACE ELEVATION:	JOB NUMBER: 118044		
GROUNDWATER: 2.15 mBGL	DATUM:	PROJECT: Dunmore	Proj. Manager: LV
DRILL METHOD: sonic drill	DATE DRILLED: 13/07/18		

STRATIGRAPHY	GRAPHIC LOG	Depth metres	Sample Depth	Sample ID	Moisture Content	PID/FID Background	PID/FID Reading	pH - soil	pH - water	Construction Details	Comments
NATURAL Loose, grey, fine to medium grained, clayey SAND (5%).		6.5 7.0 7.5 8.0 8.5								Casing	
NATURAL Loose, grey, medium grained, SAND, with medium grained shell grit.		9.0 9.5 10.0 10.5 11.0 11.5 12.0								Casing Bentonite	

NOTE: This bore log is for environmental purposes only and is not intended to provide geotechnical information.

Geological Borelog

ENVIRONMENTAL EARTH SCIENCES
CONTAMINATION RESOLVED

LOCATION: Dunmore Sand and Soil - Stage 5		Borehole Log: MW5B5	Logged by: LV
SURFACE ELEVATION:	JOB NUMBER: 118044		
GROUNDWATER: 2.15 mBGL	DATUM:	PROJECT: Dunmore	Proj. Manager: LV
DRILL METHOD: sonic drill	DATE DRILLED: 13/07/18		

STRATIGRAPHY	GRAPHIC LOG	Depth metres	Sample Depth	Sample ID	Moisture Content	PID/FID Background	PID/FID Reading	pH - soil	pH - water	Construction Details	Comments
NATURAL Loose, grey, fine to medium grained, SAND, with fine grained shell grit throughout.		12.5 13.0 13.5 14.0 14.5 15.0 15.5 16.0								Bentonite Backfill	
End of hole @ 16.0 m.		16.5 17.0 17.5 18.0									

NOTE: This bore log is for environmental purposes only and is not intended to provide geotechnical information.

ENVIRONMENTAL EARTH SCIENCES
CONTAMINATION RESOLVED

APPENDIX F: LABORATORY TRANSCRIPTS AND CHAIN OF CUSTODY

SYDNEY
ANALYTICAL
LABORATORIES

Office:
PO BOX 48
ERMINGTON NSW 2115

Laboratory:
1/4 ABBOTT ROAD
SEVEN HILLS NSW 2147
Telephone: (02) 9838 8903
Fax: (02) 9838 8919
A.C.N. 003 614 695
A.B.N. 81 829 182 852
NATA No: 1884

ANALYTICAL REPORT for:

ENVIRONMENTAL & EARTH SCIENCES

PO BOX 380
NORTH SYDNEY 2059

ATTN: L.VISINTIN

JOB NO:	SAL26969
CLIENT ORDER:	118044
DATE RECEIVED:	26/10/18
DATE COMPLETED:	07/11/18
TYPE OF SAMPLES:	WATERS
NO OF SAMPLES:	10

NATA Accredited for compliance with ISO/IEC 17025 Testing

.....
Issued on 08/11/18
Lance Smith
(Chief Chemist)

ANALYTICAL REPORT

JOB NO: SAL26969
CLIENT ORDER: 118044

DATE OF COLLECTION		25/10/18	25/10/18
SAMPLES		MW5A1	MW5A2
pH		6.7	6.7
Total Dissolved Solids	mg/L	130	365
Aluminium	mg/L	<0.1	<0.1
Nickel	mg/L	<0.01	<0.01
Copper	mg/L	<0.001	<0.001
Lead	mg/L	<0.001	<0.001
Zinc	mg/L	0.003	0.015
Cadmium	mg/L	<0.0002	<0.0002
Chromium	mg/L	<0.01	<0.01
Iron	mg/L	1.0	4.4
Manganese	mg/L	0.08	1.1
Arsenic	mg/L	<0.01	<0.01
Mercury	mg/L	<0.0001	<0.0001

	mg/L	meq/L	mg/L	meq/L
Sodium Na+	11	0.479	63	2.741
Calcium Ca++	24	1.198	48	2.395
Potassium K+	5.1	0.131	1.2	0.031
Magnesium Mg++	4.5	0.370	24	1.975
Ammonia (Total)	<0.1		0.7	0.050
TOTAL CATIONS		2.178		7.192
Chloride Cl-	24	0.677	70	1.974
Fluoride F-	<0.1		0.16	0.008
Nitrate NO3-	2.9	0.047	<0.1	
Sulphate SO4--	17	0.354	8	0.166
Bicarbonate HCO3-	70	1.148	295	4.838
Phosphate PO4---	<0.1		0.34	0.011
TOTAL ANIONS		2.226		6.997

ANALYTICAL REPORT

JOB NO: SAL26969
CLIENT ORDER: 118044

DATE OF COLLECTION		25/10/18	25/10/18
SAMPLES		MW5A3	MW5B1
pH		6.7	7.7
Total Dissolved Solids	mg/L	735	205
Aluminium	mg/L	<0.1	<0.1
Nickel	mg/L	<0.01	<0.01
Copper	mg/L	<0.001	<0.001
Lead	mg/L	<0.001	<0.001
Zinc	mg/L	0.003	0.013
Cadmium	mg/L	<0.0002	<0.0002
Chromium	mg/L	<0.01	<0.01
Iron	mg/L	5.5	0.44
Manganese	mg/L	0.24	0.08
Arsenic	mg/L	<0.01	<0.01
Mercury	mg/L	<0.0001	<0.0001

	mg/L	meq/L	mg/L	meq/L
Sodium Na+	185	8.047	17	0.739
Calcium Ca++	55	2.745	52	2.595
Potassium K+	8.8	0.225	4.1	0.105
Magnesium Mg++	28	2.304	7.0	0.576
Ammonia (Total)	1.1	0.079	0.1	0.007
TOTAL CATIONS		13.400		4.022
Chloride Cl-	355	10.011	24	0.677
Fluoride F-	0.16	0.008	0.12	0.006
Nitrate NO3-	<0.1		12	0.193
Sulphate SO4--	11	0.229	8	0.166
Bicarbonate HCO3-	165	2.706	180	2.952
Phosphate PO4---	0.12	0.004	0.12	0.004
TOTAL ANIONS		12.958		3.998

ANALYTICAL REPORT

JOB NO: SAL26969
CLIENT ORDER: 118044

DATE OF COLLECTION		25/10/18	25/10/18
SAMPLES		MW5B2-S	MW5B2-D
pH		7.6	7.6
Total Dissolved Solids	mg/L	385	355
Aluminium	mg/L	<0.1	<0.1
Nickel	mg/L	<0.01	<0.01
Copper	mg/L	<0.001	<0.001
Lead	mg/L	<0.001	<0.001
Zinc	mg/L	0.007	0.004
Cadmium	mg/L	<0.0002	<0.0002
Chromium	mg/L	<0.01	<0.01
Iron	mg/L	0.20	0.18
Manganese	mg/L	0.13	0.10
Arsenic	mg/L	<0.01	<0.01
Mercury	mg/L	<0.0001	<0.0001

	mg/L	meq/L	mg/L	meq/L
Sodium Na+	51	2.219	37	1.610
Calcium Ca++	82	4.092	78	3.892
Potassium K+	6.3	0.161	5.6	0.143
Magnesium Mg++	14	1.152	14	1.152
Ammonia (Total)	0.4	0.029	0.7	0.050
TOTAL CATIONS		7.653		6.847
Chloride Cl-	57	1.607	53	1.495
Fluoride F-	0.17	0.009	0.17	0.009
Nitrate NO3-	<0.1		<0.1	
Sulphate SO4--	32	0.666	11	0.229
Bicarbonate HCO3-	320	5.248	300	4.920
Phosphate PO4---	<0.1		<0.1	
TOTAL ANIONS		7.530		6.653

ANALYTICAL REPORT

JOB NO: SAL26969
CLIENT ORDER: 118044

DATE OF COLLECTION		25/10/18	25/10/18
SAMPLES		MW5B3	MW5B4
pH		7.7	7.6
Total Dissolved Solids	mg/L	260	315
Aluminium	mg/L	<0.1	<0.1
Nickel	mg/L	<0.01	<0.01
Copper	mg/L	<0.001	<0.001
Lead	mg/L	<0.001	<0.001
Zinc	mg/L	0.001	0.003
Cadmium	mg/L	<0.0002	<0.0002
Chromium	mg/L	<0.01	<0.01
Iron	mg/L	0.27	0.08
Manganese	mg/L	0.08	0.07
Arsenic	mg/L	<0.01	<0.01
Mercury	mg/L	<0.0001	<0.0001

	mg/L	meq/L	mg/L	meq/L
Sodium Na+	17	0.739	16	0.696
Calcium Ca++	70	3.493	89	4.441
Potassium K+	1.6	0.041	1.7	0.044
Magnesium Mg++	10	0.823	9.6	0.790
Ammonia (Total)	0.2	0.014	0.3	0.021
TOTAL CATIONS		5.110		5.992
Chloride Cl-	33	0.931	25	0.705
Fluoride F-	0.26	0.014	0.15	0.008
Nitrate NO3-	<0.1		<0.1	
Sulphate SO4--	<2		<2	
Bicarbonate HCO3-	250	4.100	325	5.330
Phosphate PO4---	<0.1		<0.1	
TOTAL ANIONS		5.045		6.043

ANALYTICAL REPORT

JOB NO: SAL26969
CLIENT ORDER: 118044

DATE OF COLLECTION		25/10/18	25/10/18
SAMPLES		MW5B5	FD1
pH		7.5	7.5
Total Dissolved Solids	mg/L	580	570
Aluminium	mg/L	<0.1	<0.1
Nickel	mg/L	<0.01	<0.01
Copper	mg/L	<0.001	<0.001
Lead	mg/L	<0.001	<0.001
Zinc	mg/L	0.005	0.004
Cadmium	mg/L	<0.0002	<0.0002
Chromium	mg/L	<0.01	<0.01
Iron	mg/L	0.06	0.08
Manganese	mg/L	0.12	0.12
Arsenic	mg/L	<0.01	<0.01
Mercury	mg/L	<0.0001	<0.0001

	mg/L	meq/L	mg/L	meq/L
Sodium Na+	65	2.828	62	2.697
Calcium Ca++	130	6.487	135	6.737
Potassium K+	2.6	0.067	2.6	0.067
Magnesium Mg++	18	1.481	17	1.399
Ammonia (Total)	0.4	0.029	0.4	0.029
TOTAL CATIONS		10.892		10.929
Chloride Cl-	160	4.512	165	4.653
Fluoride F-	0.12	0.006	0.13	0.007
Nitrate NO3-	<0.1		<0.1	
Sulphate SO4--	<2		<2	
Bicarbonate HCO3-	380	6.232	375	6.150
Phosphate PO4---	<0.1		<0.1	
TOTAL ANIONS		10.750		10.810

ANALYTICAL REPORT

JOB NO: SAL26969
CLIENT ORDER: 118044

DATE OF COLLECTION		25/10/18	25/10/18
SAMPLES		MW5B2-S DUP	BLANK
pH		7.6	7.1
Total Dissolved Solids	mg/L	390	<1
Aluminium	mg/L	<0.1	<0.1
Nickel	mg/L	<0.01	<0.01
Copper	mg/L	<0.001	<0.001
Lead	mg/L	<0.001	<0.001
Zinc	mg/L	0.007	<0.001
Cadmium	mg/L	<0.0002	<0.0002
Chromium	mg/L	<0.01	<0.01
Iron	mg/L	0.18	<0.01
Manganese	mg/L	0.12	<0.01
Arsenic	mg/L	<0.01	<0.01
Mercury	mg/L	<0.0001	<0.0001

	mg/L	meq/L	mg/L	meq/L
Sodium Na+	49	2.132	<0.1	
Calcium Ca++	81	4.042	<0.1	
Potassium K+	5.9	0.151	<0.1	
Magnesium Mg++	15	1.235	<0.1	
Ammonia (Total)	0.4	0.029	<0.1	
TOTAL CATIONS		7.589		
Chloride Cl-	58	1.636	<1	
Fluoride F-	0.17	0.009	<0.1	
Nitrate NO3-	<0.1		<0.1	
Sulphate SO4--	33	0.686	<2	
Bicarbonate HCO3-	315	5.166	<1	
Phosphate PO4---	<0.1		<0.1	
TOTAL ANIONS		7.497		

SYDNEY ANALYTICAL LABORATORIES

LABORATORY DUPLICATE REPORT

JOB NO: SAL26969
CLIENT ORDER: 118044

Sample Number	Analyte	Units	MDL	Sample Result	Duplicate Result	%RPD
MW5B2-S	pH		0.1	7.6	7.6	0
MW5B2-S	TDS	mg/L	1	385	390	1
MW5B2-S	Sodium	mg/L	0.1	51	49	4
MW5B2-S	Calcium	mg/L	0.1	82	81	1
MW5B2-S	Potassium	mg/L	0.1	6.3	5.9	7
MW5B2-S	Magnesium	mg/L	0.1	14	15	7
MW5B2-S	Chloride	mg/L	1	57	58	2
MW5B2-S	Fluoride	mg/L	0.1	0.17	0.17	0
MW5B2-S	Nitrate	mg/L	0.1	<0.1	<0.1	0
MW5B2-S	Sulphate	mg/L	2	32	33	3
MW5B2-S	Bicarbonate	mg/L	1	320	315	2
MW5B2-S	Phosphate	mg/L	0.1	<0.1	<0.1	0
MW5B2-S	Ammonia	mg/L	0.1	0.4	0.4	0
MW5B2-S	Aluminium	mg/L	0.1	<0.1	<0.1	0
MW5B2-S	Nickel	mg/L	0.01	<0.01	<0.01	0
MW5B2-S	Copper	mg/L	0.001	<0.001	<0.001	0
MW5B2-S	Lead	mg/L	0.001	<0.001	<0.001	0
MW5B2-S	Zinc	mg/L	0.001	0.007	0.007	0
MW5B2-S	Cadmium	mg/L	0.0002	<0.0002	<0.0002	0
MW5B2-S	Chromium	mg/L	0.01	<0.01	<0.01	0
MW5B2-S	Iron	mg/L	0.01	0.20	0.18	11
MW5B2-S	Manganese	mg/L	0.01	0.13	0.12	8
MW5B2-S	Arsenic	mg/L	0.01	<0.01	<0.01	0
MW5B2-S	Mercury	mg/L	0.0001	<0.0001	<0.0001	0

Acceptance criteria:

RPD <50% for low level (<10xMDL)
RPD <20% for medium level (10-50xMDL)
RPD <10% for high level (>50xMDL)
No limit applies at <2xMDL

MDL = Method Detection Limit

All results are within the acceptance criteria

ANALYTICAL REPORT

JOB NO: SAL26969
CLIENT ORDER: 118044

METHODS OF PREPARATION AND ANALYSIS

The tests contained in this report have been carried out on the samples as received by the laboratory, in accordance with APHA Standard Methods of Water and Wastewater 22nd Edition, or other approved methods listed below:

4500B	pH
2540C	Total Dissolved Solids
3500B	Sodium Na+
3111B	Calcium Ca++
3500B	Potassium K+
3111B	Magnesium Mg++
4500D	Chloride Cl-
4500C	Fluoride F-
4500F	Nitrate NO3-
4110B	Sulphate SO4--
2320B	Bicarbonate HCO3-
4500F	Phosphate PO4---
4500G	Ammonia (Total)
3111D	Aluminium
3111B	Nickel
3111C	Copper
3111C	Lead
3111C	Zinc
3111C	Cadmium
3111B	Chromium
3111B	Iron
3111B	Manganese
3114B	Arsenic
3112B	Mercury

CHAIN OF CUSTODY - INORGANIC ANALYSIS REQUEST FORM

ENVIRONMENTAL EARTH SCIENCES
THE KNOW AND THE HOW

Job #: 118044 Site Location: Dunmore Lanes Sampler: EG + MN

Date: 26/10/2018 Laboratory: SAL Report To: Loretta Visintin

Sample ID		date sampled	Sample Description: SOIL	WATER	SEDIMENT	Analysis Required	IONIC BALANCE**	11 dissolved metals									ANTICIPATED RESULTS/ TURN AROUND TIME
	MW5A1	25/10/18		X			X	X									
	MW5A2	25/10/18		X			X	X									
	MW5A3	25/10/18		X			X	X									
	MW5B1	25/10/18		X			X	X									
	MW5B2-s	25/10/18		X			X	X									
	MW5B2-d	25/10/18		X			X	X									
	MW5B3	25/10/18		X			X	X									
	MW5B4	25/10/18		X			X	X									
	MW5B5	25/10/18		X			X	X									
	FD1	25/10/18		X			X	X									
	TOTAL	10.00															

Turn Around: NORMAL / 3 DAYS / 48 HRS / 24 HRS Sheet: 1 of 1

Comments: dissolved metals - Al,As,Cd, Cr, Cu, Pb, Hg, Ni, Mn, Fe and Zn

Report to: lvisintin@eesigroup.com , egriffiths@eesigroup.com

Invoice to: accounts@eesi.biz lvisintin@eesigroup.com

	Time	Date	Lab Supervisor:
Left EES Site:		26/10/2018	
Transported By:			
Received Lab:			
Fax Results Rec'd			
Typed Results Rec'd			

We can be contacted on:

Phone: (02) 9922 1777

Fax: (02) 9922 1010

Job No.: SAL26969
Received By: K-S
Date: 26/10/18
Temp: Warm Ambient (Cool)
Date Due: 8/11/18

SYDNEY
ANALYTICAL
LABORATORIES

Office:
PO BOX 48
ERMINGTON NSW 2115

Laboratory:
1/4 ABBOTT ROAD
SEVEN HILLS NSW 2147
Telephone: (02) 9838 8903
Fax: (02) 9838 8919
A.C.N. 003 614 695
A.B.N. 81 829 182 852
NATA No: 1884

ANALYTICAL REPORT for:

ENVIRONMENTAL & EARTH SCIENCES

PO BOX 380
NORTH SYDNEY 2059

ATTN: E.GRIFFITHS

JOB NO:	SAL27074
CLIENT ORDER:	118044
DATE RECEIVED:	16/01/19
DATE COMPLETED:	25/01/19
TYPE OF SAMPLES:	WATERS
NO OF SAMPLES:	7

NATA Accredited for compliance with ISO/IEC 17025 Testing

.....
Issued on 25/01/19
Lance Smith
(Chief Chemist)

ANALYTICAL REPORT

JOB NO: SAL27074
CLIENT ORDER: 118044

DATE OF COLLECTION		15/01/19	15/01/19
SAMPLES		MW5A1	MW5A3
pH		7.2	6.3
Total Dissolved Solids	mg/L	240	1090
Aluminium	mg/L	<0.1	<0.1
Nickel	mg/L	<0.01	<0.01
Copper	mg/L	<0.001	<0.001
Lead	mg/L	<0.001	<0.001
Zinc	mg/L	0.010	0.012
Cadmium	mg/L	<0.0002	<0.0002
Chromium	mg/L	<0.01	<0.01
Iron	mg/L	0.08	3.4
Manganese	mg/L	0.02	0.19
Arsenic	mg/L	<0.01	<0.01
Mercury	mg/L	<0.0001	<0.0001

	mg/L	meq/L	mg/L	meq/L
Sodium Na+	8.0	0.348	235	10.223
Calcium Ca++	68	3.393	94	4.691
Potassium K+	5.0	0.128	15	0.384
Magnesium Mg++	6.2	0.510	38	3.127
Ammonia (Total)	<0.1		1.4	0.100
TOTAL CATIONS		4.379		18.525
Chloride Cl-	28	0.790	560	15.792
Fluoride F-	0.16	0.008	0.15	0.008
Nitrate NO3-	0.89	0.014	<0.1	
Sulphate SO4--	14	0.291	34	0.707
Bicarbonate HCO3-	200	3.280	155	2.542
Phosphate PO4---	<0.1		0.15	0.005
TOTAL ANIONS		4.383		19.054

ANALYTICAL REPORT

JOB NO: SAL27074
CLIENT ORDER: 118044

DATE OF COLLECTION		15/01/19	15/01/19
SAMPLES		MW5B2-S	MW5B2-D
pH		7.3	7.3
Total Dissolved Solids	mg/L	420	355
Aluminium	mg/L	<0.1	<0.1
Nickel	mg/L	<0.01	<0.01
Copper	mg/L	<0.001	<0.001
Lead	mg/L	<0.001	<0.001
Zinc	mg/L	0.002	0.002
Cadmium	mg/L	<0.0002	<0.0002
Chromium	mg/L	<0.01	<0.01
Iron	mg/L	1.3	0.23
Manganese	mg/L	0.12	0.09
Arsenic	mg/L	<0.01	<0.01
Mercury	mg/L	<0.0001	<0.0001

	mg/L	meq/L	mg/L	meq/L
Sodium Na+	36	1.566	28	1.218
Calcium Ca++	100	4.990	90	4.491
Potassium K+	6.4	0.164	5.7	0.146
Magnesium Mg++	12	0.988	12	0.988
Ammonia (Total)	0.4	0.029	0.6	0.043
TOTAL CATIONS		7.737		6.886
Chloride Cl-	51	1.438	57	1.607
Fluoride F-	0.16	0.008	0.15	0.008
Nitrate NO3-	<0.1		<0.1	
Sulphate SO4--	38	0.790	16	0.333
Bicarbonate HCO3-	330	5.412	305	5.002
Phosphate PO4---	0.12	0.004	<0.1	
TOTAL ANIONS		7.652		6.950

ANALYTICAL REPORT

JOB NO: SAL27074
CLIENT ORDER: 118044

DATE OF COLLECTION		15/01/19	15/01/19
SAMPLES		MW5B4	MW5B5
pH		7.3	7.2
Total Dissolved Solids	mg/L	360	650
Aluminium	mg/L	<0.1	<0.1
Nickel	mg/L	<0.01	<0.01
Copper	mg/L	<0.001	<0.001
Lead	mg/L	<0.001	<0.001
Zinc	mg/L	0.003	0.005
Cadmium	mg/L	<0.0002	<0.0002
Chromium	mg/L	<0.01	<0.01
Iron	mg/L	0.04	0.17
Manganese	mg/L	0.06	0.10
Arsenic	mg/L	<0.01	<0.01
Mercury	mg/L	<0.0001	<0.0001

	mg/L	meq/L	mg/L	meq/L
Sodium Na+	13	0.566	54	2.349
Calcium Ca++	105	5.240	160	7.984
Potassium K+	2.4	0.061	3.3	0.084
Magnesium Mg++	9.2	0.757	18	1.481
Ammonia (Total)	0.2	0.014	0.3	0.021
TOTAL CATIONS		6.638		11.919
Chloride Cl-	32	0.902	175	4.935
Fluoride F-	0.20	0.011	0.12	0.006
Nitrate NO3-	<0.1		<0.1	
Sulphate SO4--	18	0.374	12	0.250
Bicarbonate HCO3-	330	5.412	420	6.888
Phosphate PO4---	<0.1		<0.1	
TOTAL ANIONS		6.699		12.079

ANALYTICAL REPORT

JOB NO: SAL27074
CLIENT ORDER: 118044

DATE OF COLLECTION		15/01/19	15/01/19
SAMPLES		FD1	BLANK
pH		6.3	7.2
Total Dissolved Solids	mg/L	1110	<1
Aluminium	mg/L	<0.1	<0.1
Nickel	mg/L	<0.01	<0.01
Copper	mg/L	<0.001	<0.001
Lead	mg/L	<0.001	<0.001
Zinc	mg/L	0.010	<0.001
Cadmium	mg/L	<0.0002	<0.0002
Chromium	mg/L	<0.01	<0.01
Iron	mg/L	3.6	<0.01
Manganese	mg/L	0.19	<0.01
Arsenic	mg/L	<0.01	<0.01
Mercury	mg/L	<0.0001	<0.0001

	mg/L	meq/L	mg/L	meq/L
Sodium Na+	240	10.440	<0.1	
Calcium Ca++	97	4.840	<0.1	
Potassium K+	15	0.384	<0.1	
Magnesium Mg++	40	3.292	<0.1	
Ammonia (Total)	1.5	0.107	<0.1	
TOTAL CATIONS		19.063		
Chloride Cl-	575	16.215	<1	
Fluoride F-	0.13	0.007	<0.1	
Nitrate NO3-	<0.1		<0.1	
Sulphate SO4--	33	0.686	<2	
Bicarbonate HCO3-	155	2.542	<1	
Phosphate PO4---	0.16	0.005	<0.1	
TOTAL ANIONS		19.455		

ANALYTICAL REPORT

JOB NO: SAL27074
CLIENT ORDER: 118044

METHODS OF PREPARATION AND ANALYSIS

The tests contained in this report have been carried out on the samples as received by the laboratory, in accordance with APHA Standard Methods of Water and Wastewater 22nd Edition, or other approved methods listed below:

4500B	pH
2540C	Total Dissolved Solids
3500B	Sodium Na+
3111B	Calcium Ca++
3500B	Potassium K+
3111B	Magnesium Mg++
4500D	Chloride Cl-
4500C	Fluoride F-
4500F	Nitrate NO3-
4110B	Sulphate SO4--
2320B	Bicarbonate HCO3-
4500F	Phosphate PO4---
4500G	Ammonia (Total)
3111D	Aluminium
3111B	Nickel
3111C	Copper
3111C	Lead
3111C	Zinc
3111C	Cadmium
3111B	Chromium
3111B	Iron
3111B	Manganese
3114B	Arsenic
3112B	Mercury

CHAIN OF CUSTODY - INORGANIC ANALYSIS REQUEST FORM

ENVIRONMENTAL EARTH SCIENCES
THE KNOW AND THE HOW

Job #: 118044 Site Location: Dunmore Lakes - Stage 5 (Round 2) Sampler: MN

Date: 7/12/2018 Laboratory: SAL Report To: Elin Griffiths

Sample ID		date sampled	Sample Description: SOIL	WATER	SEDIMENT	Analysis Required:	IONIC BALANCE**	11 dissolved metals									ANTICIPATED RESULTS/ TURN AROUND TIME
	MW5A1	27/11/18		X			X	X									
	MW5A3	27/11/18		X			X	X									
	FD1	27/11/18		X			X	X									
	TOTAL	3															

Job No.: SAL27041
Received By: K.S.
Date: 7/12/18
Temp: Warm Ambient Cool
Date Due: 18/12/18

Turn Around: NORMAL Sheet: 1 of 1

Comments: dissolved metals - Al,As,Cd, Cr, Cu, Pb, Hg, Ni, Mn, Fe and Zn

Report to: mnarracott@eesigroup.com , egriffiths@eesigroup.com

Invoice to: accounts@eesi.biz egriffiths@eesigroup.com

	Time	Date	Lab Supervisor:
Left EES Site:		7/12/2018	
Transported By:			
Received Lab:			
Fax Results Rec'd			
Typed Results Rec'd			

We can be contacted on:

Phone: (02) 9922 1777

Fax: (02) 9922 1010

SYDNEY
ANALYTICAL
LABORATORIES

Office:
PO BOX 48
ERMINGTON NSW 2115

Laboratory:
1/4 ABBOTT ROAD
SEVEN HILLS NSW 2147
Telephone: (02) 9838 8903
Fax: (02) 9838 8919
A.C.N. 003 614 695
A.B.N. 81 829 182 852
NATA No: 1884

ANALYTICAL REPORT for:

ENVIRONMENTAL & EARTH SCIENCES

PO BOX 380
NORTH SYDNEY 2059

ATTN: L.VISINTIN

JOB NO:	SAL27041
CLIENT ORDER:	118044
DATE RECEIVED:	07/12/18
DATE COMPLETED:	18/12/18
TYPE OF SAMPLES:	WATERS
NO OF SAMPLES:	3

NATA Accredited for compliance with ISO/IEC 17025 Testing

.....
Issued on 18/12/18
Lance Smith
(Chief Chemist)

ANALYTICAL REPORT

JOB NO: SAL27041
CLIENT ORDER: 118044

DATE OF COLLECTION		27/11/18	27/11/18
SAMPLES		MW5A1	MW5A3
pH		6.0	6.7
Total Dissolved Solids	mg/L	92	510
Aluminium	mg/L	<0.1	<0.1
Nickel	mg/L	<0.01	<0.01
Copper	mg/L	0.002	0.004
Lead	mg/L	<0.001	<0.001
Zinc	mg/L	0.009	0.014
Cadmium	mg/L	<0.0002	<0.0002
Chromium	mg/L	<0.01	<0.01
Iron	mg/L	0.31	2.7
Manganese	mg/L	<0.01	0.17
Arsenic	mg/L	<0.01	<0.01
Mercury	mg/L	<0.0001	<0.0001

	mg/L	meq/L	mg/L	meq/L
Sodium Na+	10	0.435	98	4.263
Calcium Ca++	10	0.499	67	3.343
Potassium K+	9.3	0.238	12	0.307
Magnesium Mg++	4.9	0.403	19	1.564
Ammonia (Total)	<0.1		0.5	0.036
TOTAL CATIONS		1.575		9.513
Chloride Cl-	26	0.733	210	5.922
Fluoride F-	<0.1		0.18	0.009
Nitrate NO3-	3.6	0.058	<0.1	
Sulphate SO4--	9	0.187	14	0.291
Bicarbonate HCO3-	33	0.541	190	3.116
Phosphate PO4---	<0.1		0.15	0.005
TOTAL ANIONS		1.519		9.343

ANALYTICAL REPORT

JOB NO: SAL27041
CLIENT ORDER: 118044

DATE OF COLLECTION		27/11/18	27/11/18
SAMPLES		FD1	BLANK
pH		6.7	7.2
Total Dissolved Solids	mg/L	520	<1
Aluminium	mg/L	<0.1	<0.1
Nickel	mg/L	<0.01	<0.01
Copper	mg/L	0.003	<0.001
Lead	mg/L	<0.001	<0.001
Zinc	mg/L	0.012	<0.001
Cadmium	mg/L	<0.0002	<0.0002
Chromium	mg/L	<0.01	<0.01
Iron	mg/L	3.0	<0.01
Manganese	mg/L	0.18	<0.01
Arsenic	mg/L	<0.01	<0.01
Mercury	mg/L	<0.0001	<0.0001

	mg/L	meq/L	mg/L	meq/L
Sodium Na+	100	4.350	<0.1	
Calcium Ca++	66	3.293	<0.1	
Potassium K+	12	0.307	<0.1	
Magnesium Mg++	19	1.564	<0.1	
Ammonia (Total)	0.7	0.050	<0.1	
TOTAL CATIONS		9.564		
Chloride Cl-	210	5.922	<1	
Fluoride F-	0.19	0.010	<0.1	
Nitrate NO3-	<0.1		<0.1	
Sulphate SO4--	13	0.270	<2	
Bicarbonate HCO3-	190	3.116	<1	
Phosphate PO4---	0.13	0.004	<0.1	
TOTAL ANIONS		9.322		

SYDNEY ANALYTICAL LABORATORIES

ANALYTICAL REPORT

JOB NO: SAL27041
CLIENT ORDER: 118044

METHODS OF PREPARATION AND ANALYSIS

The tests contained in this report have been carried out on the samples as received by the laboratory, in accordance with APHA Standard Methods of Water and Wastewater 22nd Edition, or other approved methods listed below:

4500B	pH
2540C	Total Dissolved Solids
3500B	Sodium Na+
3111B	Calcium Ca++
3500B	Potassium K+
3111B	Magnesium Mg++
4500D	Chloride Cl-
4500C	Fluoride F-
4500F	Nitrate NO3-
4110B	Sulphate SO4--
2320B	Bicarbonate HCO3-
4500F	Phosphate PO4---
4500G	Ammonia (Total)
3111D	Aluminium
3111B	Nickel
3111C	Copper
3111C	Lead
3111C	Zinc
3111C	Cadmium
3111B	Chromium
3111B	Iron
3111B	Manganese
3114B	Arsenic
3112B	Mercury

CHAIN OF CUSTODY - ANALYSIS REQUEST FORM

Job No: 118044 Laboratory: SAL

Project Manager: EG Sampler: MN Site Location: Dunmore Stage 5 **Sheet:** 1 **of** 1

No. of samples	Sample ID/ Depth	Anticipated Result (PID)/EC reading	Date sampled	Time sampled	Sample Matrix: Soil	Sample Matrix: Water	Sample Matrix: Sediment	Analysis Required: IONIC BALANCE	Analysis Required: 11 dissolved metals	Sample-specific instructions/ notes
	MW5A1		1/15/2019			X		X	X	
	MW5A3		1/15/2019			X		X	X	
	MW5B2-S		1/15/2019			X		X	X	
	MW5B2-D		1/15/2019			X		X	X	
	MW5B4		1/15/2019			X		X	X	
	MW5B5		1/15/2019			X		X	X	
	FD1		1/15/2019			X		X	X	
	TOTAL									

Job No.: SAL27074
Received By: K.S.
Date: 16/1/19
Temp: Warm Ambient Cool
Date Due: 31/1/19

Turn Around *(circle)*: **NORMAL**

Comments/ Instructions: dissolved metals - Al,As,Cd, Cr, Cu, Pb, Hg, Ni, Mn, Fe and Zn

Lab Quotation No. *(if applicable)*:

Send report to *(email address)*: egriffiths@eesigroup.com

Cc: report to *(email address)*: mnarracott@eesigroup.com

Cc: invoice to *(email address)*: accounts@eesigroup.com

	Name	Signature	Date	Time
Sent off Site/Office by:				
Receiving Lab:				
Receiving Lab:				

ENVIRONMENTAL EARTH SCIENCES
CONTAMINATION RESOLVED
Phone: (02) 9922 1777
Fax: (02) 9922 1010
PO Box: 380, North Sydney NSW 2059
Email: eesNSW@eesigroup.com

APPENDIX G: SLUG TEST DATA

Dunmore_Stage 5 *118044*

Slugtests, 25 October 2018

MW5A1 - Slug Test

Parameters		Jacob Approximation		Hvorslev		Bouwer & Rice				h>Lw	
		*T = 2.3Q/4*pi*delta s*		*To=(ln(0,37/E)/F*		*Lw=h*				*h>Lw*	
Depth (m)	7.2	slope	0.1	E	1.2515	Le/R	53.3333333			A	3
Static (m)	3			F	-3.147	C	2.5			B	0.6
Hydraulic gradient (m/m)	0.002	**delta S**	0.2303			Ho	1.54			ln (Re/R)	2.5898
Aquifer thickness (b,m)	4.2	**S**	2.10E-05	To	0.387	Ht	0.13				
Le (m)	4	**KD (m2/d)**	71.539	**KD (m2/d)**	291.137	t	2.5				
Lw (m)	4.2	**K (m/d)**	17.0332	**K (m/d)**	69.3184	**KD (m2/d)**	87.562			**KD (m2/d)**	72.5977
R (m)	0.075	**v (m/d)**	0.113554	**v (m/d)**	0.462123	**K (m/d)**	20.8482			**K (m/d)**	17.2852
Porosity	0.3	**v (m/year)**	41.447	**v (m/year)**	168.675	**v (m/d)**	0.138988			**v (m/d)**	0.11523
						v (m/year)	50.731			**v (m/year)**	42.0606
Q (m3/d)	90.000	62.50 L/min									
Water (m)	4.2	0.001042									

MW5A3 - Slug Test

Parameters		Jacob Approximation		Hvorslev		Bouwer & Rice				h>Lw	
		*T = 2.3Q/4*pi*delta s*		*To=(ln(0,37/E)/F*		*Lw=h*				*h>Lw*	
Depth (m)	9.7	slope	0.3	E	1.4213	Le/R	40			A	2.4
Static (m)	0.41			F	-1.457	C	2			B	0.5
Hydraulic gradient (m/m)	0.003	**delta S**	0.6908			Ho	0.57			ln (Re/R)	2.9073
Aquifer thickness (b,m)	9.3	**S**	4.64E-05	To	0.924	Ht	0.13				
Le (m)	3	**KD (m2/d)**	107.309	**KD (m2/d)**	333.367	t	2				
Lw (m)	9.3	**K (m/d)**	11.5697	**K (m/d)**	35.9425	**KD (m2/d)**	221.652			**KD (m2/d)**	179.3585
R (m)	0.075	**v (m/d)**	0.115697	**v (m/d)**	0.359425	**K (m/d)**	23.8977			**K (m/d)**	19.3378
Porosity	0.3	**v (m/year)**	42.229	**v (m/year)**	131.190	**v (m/d)**	0.238977			**v (m/d)**	0.19338
						v (m/year)	87.227			**v (m/year)**	70.5831
Q (m3/d)	405.000	281.25 L/min									
Water (m)	9.3	**0.0046875** L/sec									

MW5B2-shallow

Parameters		Jacob Approximation		Hvorslev		Bouwer & Rice				h>Lw	
		*T = 2.3Q/4*pi*delta s*		*To=(ln(0,37/E)/F*		*Lw=h*				*h>Lw*	
Depth (m)	6.72	slope	0.97	E	0.3198	Le/R	53.3333333			A	3
Static (m)	3.5			F	0.426	C	2.5			B	0.5
Hydraulic gradient (m/m)	0.007	**delta S**	2.2335			Ho	1.491			ln (Re/R)	2.5093
Aquifer thickness (b,m)	12.00	**S**	6.00E-05	To	0.342	Ht	0.017				
Le (m)	4	**KD (m2/d)**	66.377	**KD (m2/d)**	941.073	t	6				
Lw (m)	3.2	**K (m/d)**	5.5314	**K (m/d)**	78.4228	**KD (m2/d)**	177.929			**KD (m2/d)**	151.5575
R (m)	0.075	**v (m/d)**	0.129066	**v (m/d)**	1.829864	**K (m/d)**	14.8274			**K (m/d)**	12.6298
Porosity	0.3	**v (m/year)**	47.109	**v (m/year)**	667.900	**v (m/d)**	0.345972			**v (m/d)**	0.29470
						v (m/year)	126.280			**v (m/year)**	107.5637
Q (m3/d)	810.000	562.50 L/min									
Water (m)	3.22	**0.009375** L/sec									

MW5B2-deep

Parameters		Jacob Approximation		Hvorslev		Bouwer & Rice				h>Lw	
		*T = 2.3Q/4*pi*delta s*		*To=(ln(0,37/E)/F*		*Lw=h*				*h>Lw*	
Depth (m)	10.90	slope	0.365	E	0.9674	Le/R	18			A	2
Static (m)	2.543			F	-0.027	C	1.5			B	0.5
Hydraulic gradient (m/m)	0.003	**delta S**	0.8404			Ho	1.2685			ln (Re/R)	2.1151
Aquifer thickness (b,m)	12	**S**	6.00E-05	To	35.597	Ht	0.9441				
Le (m)	0.9	**KD (m2/d)**	4.573	**KD (m2/d)**	29.231	t	10				
Lw (m)	8.4	**K (m/d)**	0.3811	**K (m/d)**	2.4359	**KD (m2/d)**	35.654			**KD (m2/d)**	22.4894
R (m)	0.05	**v (m/d)**	0.003811	**v (m/d)**	0.024359	**K (m/d)**	2.9712			**K (m/d)**	1.8741
Porosity	0.3	**v (m/year)**	1.391	**v (m/year)**	8.891	**v (m/d)**	0.029712			**v (m/d)**	0.01874
						v (m/year)	10.845			**v (m/year)**	6.8405
Q (m3/d)	21.000	14.58 L/min									
Water (m)	8.357										

APPENDIX H: QAQC REPORT

ENVIRONMENTAL EARTH SCIENCES
CONTAMINATION RESOLVED

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APPENDIX A: Calibration records

1 INTRODUCTION AND BACKGROUND

1.1 Introduction

The aim of quality control and quality assurance (QA/QC) is to deliver data that is:

- representative of what is sampled;
- precise;
- accurate; and
- reproducible.

As investigations involve both field and laboratory QA/QC, these are similarly divided. The objective of this document is to evaluate and identify the data quality objectives (DQOs) and the data quality indicators (DQIs), which are used to assess whether the DQOs have been met.

All surface water, groundwater and soil sampling procedures to be followed are described in full in our Soil, gas and groundwater sampling manual (Environmental Earth Sciences Pty Ltd 2011). This document should be referred to for field procedures for sampling and conveyance. Copies are available for inspection if required.

The NSW guideline documents used in the evaluation of the data set for this investigation are:

- National Environment Protection Council (NEPC) (2013). National Environment Protection (Assessment of Site Contamination) Amendment Measure;
- NSW Department of Environment and Conservation (DEC) (2006). Contaminated sites: Guidelines for NSW Site Auditors Scheme (2nd edition);
- NSW Environment Protection Authority (EPA) (1995). Contaminated Sites: Sampling design guidelines; and
- NSW Office of Environment and Heritage (OEH) (2011). Contaminated sites: Guidelines for consultants reporting on contaminated sites.
- Standards Australia (2005). Guide to the investigation and sampling of sites with potentially contaminated soil, Part 1: Non-volatile and semi-volatile compounds (AS 4482.1); and
- Standards Australia (1999). Guide to the investigation and sampling of sites with potentially contaminated soil, Part 2: Volatile substances (AS4482.2).

Data quality is typically discussed in terms of precision, accuracy, representativeness, comparability and completeness. These are referred to as the PARCC parameters. The PARCC (and additional QA) parameters are discussed within this report.

The following items form part of the QA/QC appendix:

- repeatability;
- precision;
- accuracy;
- representativeness;
- completeness;
- comparability;
- sensitivity;
- holding times;
- blanks; and
- procedures for anomalous samples and confirmation checking.

1.2 Background

Quality Assurance (QA) is “a set of activities intended to establish confidence that quality requirements will be met” (AS/NZS ISO 9000:2005).

This encompasses all actions, procedures, checks and decisions undertaken to ensure the accuracy and reliability of analysis results. It includes routine procedures which ensure proper sample control, data transfer, instrument calibration, the decisions required to select and properly train staff, select equipment and analytical methods, and the day to day judgements resulting from regular scrutiny and maintenance of the laboratory system.

Quality Control (QC) is “a set of activities intended to ensure that quality requirements are actually being met” (AS/NZS ISO 9000:2005). In other words, the operational techniques and activities used to fulfil the requirements for quality.

These are the components of QA which serve to monitor and measure the effectiveness of other QA procedures by comparison with previously decided objectives. They include measurement of the quality of reagents, cleanliness of apparatus, accuracy and precision of methods and instrumentation, and reliability of all these factors as implemented in a given laboratory from day to day.

A complete discussion of either of these terms or the steps for implementing them is beyond the scope of this document. It is widely recognised, however, that adoption of sound laboratory QA and QC procedures is essential, and readers are referred to documentation available from the National Association of Testing Authorities (NATA), if further information is required.

2 DATA QUALITY OBJECTIVES

Development of data quality objectives (DQOs) for each project is a requirement of the NEPC (2013). This is based on a DQO process formulated by the USEPA for contaminated land assessment and remediation and provides sound guidance for a consistent approach in understanding site assessment and remediation.

The DQOs are defined in a series of seven steps. Table 1 outlines the seven steps and refers to the sections of the report which address these quality objectives.

Table 1: Data quality objectives

Step	Description	Comment	Location in main report
1	State the problem	The problem will be addressed directly by scientists from Environmental Earth Sciences NSW. The site is currently undeveloped, and the proposal is for the extraction of sand via dredging. The purpose of this investigation is to support a modification to the existing approval under EPL No. 11147.	Section 1
2	Identify the decision	A hydrogeological impact assessment has been commissioned to determine if the proposed activities have the potential to adversely impacted the site or environment. If required, Environmental Earth Sciences NSW will provide guidance on actions required to ensure the site becomes suitable for continued or future use.	Section 1
3	Identify the inputs for the decision	The study inputs include historical investigation, review of previous investigations, a groundwater investigation at the site and reference to published guidelines to assist the decision-making process.	Sections 2,3 and 4
4	Define the boundaries for the study	The site location and physical boundaries are shown on Figure 1 and Figure 2 and defined in Section 2 of the report. The temporal boundary of the project is restricted to the timing of the investigation.	Section 4, Figures 1 and 2
5	Develop a decision rule	All analytical data will be compared and evaluated against appropriate published criteria. The NEPC (2013) will be used as the primary guidance document in decision making on action levels. Dependent upon the sampling and analysis design, statistical parameters such as arithmetic mean, standard deviation and 95% upper confidence limits (95% UCLs) may be applied to designated soil populations for particular analytes. In the event that action levels are exceeded, a management plan, remedial action plan, and/or qualitative risk assessment (with modelling of potential groundwater impacts on the local receiving environment) will be required. These procedures constitute the alternative action plan.	Section 4

Step	Description	Comment	Location in main report
6	Specify tolerable limits on decision error	Acceptable limits for field data analysis (relative percent differences for primary and duplicate results) are between 50 and 150 percent (depending on the origin of the sample and volatility of the chemicals present). Acceptable limits for laboratory duplicate analysis may be affected by the heterogeneity of soil and will be set based on site specific information such as background concentrations. These are summarised in Table 2 as the measurement data quality indicators (MDQIs), which will be used to establish whether the DQOs have been met. Most of the procedures in the Standards Australia AS 4482.1 (2005) *Guide to the investigation and sampling of sites with potentially contaminated soil. Part 1: Non-volatile and semi-volatile compounds* and NEPC (2013) have risk probabilities associated with allowable error margins incorporated into them. It is therefore proposed that no further "tolerable limits" be investigated at this stage of the project.	Section 3, QA/QC Appendix H
7	Optimise the design for obtaining data	The sample design will be undertaken with reference to AS4482.1. As well as a statistically justifiable *systematic* sampling design, this sampling pattern has also taken into account targeted areas of concern on the site (i.e. *judgemental* sampling locations). Environmental Earth Sciences NSW believes that the sampling design is optimal considering temporal limitations and access constraints. The density of the sampling pattern and the quality of the data set are suitable for determination of the suitability of the site for its current use. Additional monitoring wells have been recommended to be included to form an on-going monitoring network during the operational lifetime of the project.	Section 6

Based on the DQOs the following measurement data quality indicators (MDQIs) are provided in Table 2 below.

Table 2: Measurement data quality indicators (MDQIS)

Parameter	Procedure	Minimum Frequency	Criteria	
			(5 to 10x LOR[4])	>10x LOR
Precision	Field Duplicates	1 in 20 - metals	<80 RPD	<50 RPD
		1 in 20 - semi-volatiles	<100 RPD	<80 RPD
		1 in 20 - volatiles	<150 RPD	<130 RPD
	Lab Replicate*	1 in 20	<50 RPD	<30 RPD
Accuracy*	Reference Material	1 in 10	60% to 140%R	80% to 120%R
	Matrix spikes			
	Surrogate spikes			
Representativeness*	Reagent Blanks	1 per batch	No detection	
	Holding Times*	Every sample	-	
Blanks**	Trip Blank	1 per batch	No detection	

Parameter	Procedure	Minimum Frequency	Criteria	
			(5 to 10x LOR[4])	>10x LOR
	Rinsate Blanks			
Sensitivity	Limit of Reporting	Every sample	LOR < ½ site criteria	

Notes:
1. RPD – relative percentage difference;
2. %R – percent recovery;
3. LOR – limit of reporting;
4. no limit at <5x LOR;
5. * the MDQI is usually specified in the standard method. If not, use the default values set out in this table; and
6. ** only necessary when measuring dissolved metals and volatile organic compounds in water samples.

It should be noted that Standards Australia (AS4482.1) specify that typical MDQIs for precision should be ≤50% RPD, however also acknowledge that low concentrations and organic compounds in particular can be acceptably outside this range. The standard suggests that ≤50% RPD be used as a 'trigger' and values above this level of repeatability need to be noted and explained.

Our adopted MDQIs for precision acknowledge the intrinsic heterogeneity of metal and semi volatile chemical concentrations in disturbed soil that may potentially cause large variations in results between laboratory subsamples (although all efforts are made to homogenise non-volatile duplicate samples). Similarly, large variations in volatile chemical concentrations between duplicates may be unavoidable even when using best practice sampling methodology, especially as we seek to minimise the disturbance to the sample while splitting it which means a high degree of inherent heterogeneity is expected.

As such, our adopted RPD criteria are considered to be a suitable measure for the reproducibility of results within a naturally heterogeneous media such as soil. A ≤50% RPD trigger value will be used, with any exceedance discussed and assessed for acceptability.

3 QUALITY CONTROL AND QUALITY ASSURANCE

3.1 Measurement data quality objectives

Step 7 of the DQO process (Section 2.0) is a focus on the quality of the information by measurement, that is, measurement data quality objectives (MDQOs). The aim of a quality control and quality assurance (QA/QC) is to deliver data that is representative of what is sampled, precise, accurate and reproducible. As investigations involve both field and laboratory QA/QC, these are similarly divided. The objective of this section is to provide the MDQOs and the measurement data quality indicators (MDQIs), which will be used to establish whether the DQOs have been met.

All surface water, groundwater and soil sampling procedures need to be undertaken according to a standard procedure, for example those procedures set out in:

- NSW Environment Protection Authority (EPA) (1995). Contaminated sites: Sampling design guidelines;
- NSW OEH (2011). Contaminated sites: Guidelines for consultants reporting on contaminated sites;
- Standards Australia (2005). Guide to the investigation and sampling of sites with potentially contaminated soil, Part 1: Non-volatile and semi-volatile compounds, (AS 4482.1). Homebush, NSW; and
- Standards Australia (1999). Guide to the investigation and sampling of sites with potentially contaminated soil, Part 2: Volatile substances, (AS 4482.2). Homebush, NSW.

3.2 Field QA/QC

3.2.1 Details of sampling team

Fieldwork was conducted by the following sampling teams from Environmental Earth Sciences:

- soil sampling: [Loretta Visintin];
- groundwater borehole construction and installation: [Loretta Visintin];
- groundwater borehole development: [Loretta Visintin];
- groundwater sampling for chemical analysis: [Matthew Narracott]; and
- groundwater sampling for physical analysis: [Matthew Narracott].

3.2.2 Sampling controls

Decontamination procedures carried out between sampling events included the following.

All sampling equipment that was re-used which came into contact with groundwater samples, were thoroughly washed with detergent (Decon 90 or similar) water, then rinsed with clean water before the collection of each sample. Any items accidentally contaminated were similarly washed before re-use.

Where boreholes were sampled using the same pump/bailer, these were rinsed with the proceeding boreholes groundwater or with detergent and water, if the preceding borehole was potentially chemically impacted. Between each location the flow cell and water quality meters were rinsed using a mixture of orange-based surfactant and distilled water, followed by a rinse with distilled water. Groundwater samples were collected directly from the pump tubing/bailer and did not pass through the flow cell.

Sample notation details

The borehole log details for each sample collected (including time, location, initials of sampler, duplicate locations, duplicate type and field screening details) are presented in Appendix E. The chemical analyses performed on each sample are presented on the chain of custody documentation (Appendix F) which also identified for each sample – the sampler, nature of the sample, collection date, analyses to be performed, sample preservation method (if any), departure time from the site and dispatch courier.

Site observations during sampling are described in Section 3.0 of the main report.

Primary and intra (blind) duplicate samples for this project was completed by SAL.

Intra (blind) and Inter (split) duplicate sampling

For this project one intra (blind) samples was collected for each round of analysis. The summary of the relative percentage differences (RPDs) of the collected inter and intra duplicate samples in presented in Table 3.

Table 3: Field intra and inter duplicate results

Locations	MW5B5	FD1	RPD(%)	MW5A3	FD1	RPD(%)	MW5B5	FD1	RPD(%)
Date	October 2018			November 2018			January 2019		
Report No	SAL26969			SAL27041			SAL27074		
pH	7.5	7.5	0%	6.7	6.7	0%	6.3	6.3	0%
TDS	580	570	2%	510	520	2%	1090	1110	2%
Na+	65	62	5%	98	100	2%	235	240	2%
Ca++	130	135	4%	67	66	2%	94	97	3%
K+	2.6	2.6	0%	12	12	0%	15	15	0%
Mg++	18	17	6%	19	19	0%	38	40	5%
Cl-	160	165	3%	210	210	0%	560	575	3%
F-	0.12	0.13	8%	0.18	0.19	5%	0.15	0.13	14%
NO3-	<0.1	<0.1	0%	<0.1	<0.1	0%	<0.1	<0.1	0%
SO4--	<2	<2	0%	14	13	7%	34	33	3%
HCO3-	380	375	1%	190	190	0%	155	155	0%
PO4---	<0.1	<0.1	0%	0.15	0.13	14%	0.15	0.16	6%
NH4-N	0.4	0.4	0%	0.5	0.7	33%	1.4	1.5	7%
Al	<0.1	<0.1	0%	0.1	0.1	0%	<0.1	<0.1	0%
Ni	<0.01	<0.01	0%	<0.01	<0.01	0%	<0.01	<0.01	0%
Cu	<0.001	<0.001	0%	0.004	0.003	29%	<0.001	<0.001	0%
Pb	<0.001	<0.001	0%	<0.001	<0.001	0%	<0.001	<0.001	0%
Zn	0.005	0.004	22%	0.014	0.012	15%	0.012	0.010	18%
Cd	<0.0002	<0.0002	0%	<0.0002	<0.0002	0%	<0.0002	<0.0002	0%
Cr	<0.01	<0.01	0%	<0.01	<0.01	0%	<0.01	<0.01	0%
Fe	0.06	0.08	29%	2.7	3	11%	3.4	3.6	6%
Mn	0.12	0.12	0%	0.17	0.18	6%	0.19	0.19	0%
As	<0.01	<0.01	0%	<0.01	<0.01	0%	<0.01	<0.01	0%
Hg	<0.0001	<0.0001	0%	<0.0001	<0.0001	0%	<0.0001	<0.0001	0%

Notes:
RPDs have only been considered where a concentration is greater than 1 times the EQL.
High RPDs are in bold (Acceptable RPDs for each EQL multiplier range are: 80 (1-10 x EQL); 50 (10-30 x EQL); 30 (> 30 x EQL))

Environmental Earth Sciences NSW did not consider analysis of trip blanks, background samples, rinsate blanks or trip spikes necessary as the nature of this assessment was to provide background values against which the effects of dredging activities could be compared.

3.2.3 Field instrument calibration

The following field instruments were calibrated for the groundwater sampling program:

- YSI.

Field equipment used for the groundwater investigation was appropriate for the required works and was used in the appropriate manner. The instruments were calibrated in accordance with the manufacturer specifications and Environmental Earth Sciences VIC field procedure and QA/QC documentation. Calibration records are provided in Appendix A.

3.2.4 Comparison between field and laboratory data

Quality assurance procedures include comparison of field and laboratory data, and collating records of purging volumes, sampling methods and chemical stability. Field chemical data has been reported and comparison of field and laboratory chemistry has been undertaken. Results of field and laboratory pH and field measured EC and laboratory TDS were reviewed, with field and laboratory pH measurements within the acceptable limits (RPD <10%). The TDS/EC relationship was within the acceptable range of 0.55 to 0.8 for the majority of the samples.

3.3 Laboratory QA/QC

Laboratory analysis of primary and intra (blind) duplicate samples for this project were completed by SAL. The laboratory is accredited by NATA for the methods used, details of this accreditation can be viewed at http://www.nata.asn.au/, while details of the samples sent to each laboratory and the analysis requested are contained in the chain of custody documentation held in Appendix F. The analytical methods are noted on the laboratory transcripts.

3.3.1 Holding times

The collection date of samples, laboratory extraction date and allowable holding times are presented in the laboratory quality reports. All analysis was completed within the allowable holding times with the exception of pH in groundwater, which has a 6 hour holding time, and was also measured in the field.

3.3.2 Limits of reporting

Acceptable limits of reporting (LOR) were mostly provided by the analytical laboratory to allow the results to be compared against the soil and groundwater investigation levels with the exception of few analytes (list analytes) that were considered not be a chemicals of concern.

3.3.3 Internal laboratory QA/QC

SAL complete a laboratory blank a laboratory duplicate and analysis of a certified reference material. These results are reported in SAL reports SAL 26969, SAL27041 and SAL27074 (Appendix F).

3.3.4 Ionic balance

Quality control is also assessed through comparison of the RPD between the summed total of anions (TA in milliequivalents per litre [meq/L]) and cations (TC in meq/L) in each water sample, which is known as the charge balance equation (CBE). As groundwater systems always strive to attain equilibrium concentrations of dissolved cations and anions, the CBE for any given groundwater sample should be <10% (or even <5%). The CBE for samples analysed were generally within the acceptable limit.

3.4 QA/QC data evaluation

The overall assessment of the data quality is as follows:

- all samples were analysed within recommended holding times;
- field observations and measurements were generally comparable to laboratory data;
- the use of field instruments was acceptable;
- decontamination procedures are considered acceptable; and
- the dataset as a whole is considered reliable.

Based on information presented in Sections 3.1, 3.2 and 3.3 of this appendix it can be confidently stated that the MDQO's for this project have been met and the data set is considered to be reliable.

4 QA/QC APPENDIX REFERENCES

American Public Health Association (APHA) 2012, *Standard methods for the examination of water and waste-water*, 22nd edition, APHA, Washington DC.

Australian/New Zealand Standard (AS/NZS) 2008, *Quality management systems - Requirements (AS/NZS ISO 9001:2008)*, Standards Australia/Standards New Zealand, Sydney/Wellington.

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APPENDIX A: CALIBRATION RECORDS

Multi Parameter Water Meter

airmet
Air-Met Scientific Pty Ltd
1300 137 067

Instrument YSI Quatro Pro Plus
Serial No. 11K101271

Item	Test	Pass	Comments
Battery	Charge Condition	✓	
	Fuses	✓	
	Capacity	✓	
Switch/keypad	Operation	✓	
Display	Intensity	✓	
	Operation (segments)	✓	
Grill Filter	Condition	✓	
	Seal	✓	
PCB	Condition	✓	
Connectors	Condition	✓	
Sensor	1. pH	✓	
	2. mV	✓	
	3. EC	✓	
	4. D.O	✓	
	5. Temp	✓	
Alarms	Beeper	✓	
	Settings	✓	
Software	Version	✓	
Data logger	Operation	✓	
Download	Operation	✓	
Other tests:			

Certificate of Calibration

This is to certify that the above instrument has been calibrated to the following specifications:

Sensor	Serial no	Standard Solutions	Certified	Solution Bottle Number	Instrument Reading
1. pH 10.00		pH 10.00		324189	pH 9.93
2. pH 7.00		pH 7.00		317272	pH 6.96
3. pH 4.00		pH 4.00		320612	pH 4.05
4. mV		234mV		325420/324357	232.4mV
5. EC		2.76mS		320325	2.77mS
6. D.O		0.00 ppm		10175	0.00ppm
7. Temp		20.6°C		MultiTherm	19.8°C

Calibrated by: Sarah Lian

Calibration date: 02/01/2019

Next calibration due: 01/07/2019

APPENDIX E

ABORIGINAL CULTURAL HERITAGE ASSESSMENT REPORT

DUNMORE LAKES SAND PROJECT – STAGE 5 MODIFICATIONS
DUNMORE, NSW

Aboriginal Cultural Heritage Assessment Report

Prepared for Element Environment Pty Ltd
on behalf of Dunmore Sand and Soil Pty Ltd

Shellharbour Local Government Area

February 2019

Ref. 1745

KELLEHER NIGHTINGALE CONSULTING PTY LTD
Archaeological and Heritage Management
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SYDNEY NSW 2000

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Prepared by	Dr Matthew Kelleher, Ana Jakovljevic, Ben Anderson
Approved by	Dr Matthew Kelleher

Executive Summary

Dunmore Sand and Soil Pty Ltd (DSS) is seeking approval for a modification to their existing development consent (DA 195-8-2004) for Stages 2 to 4 of the Dunmore Lakes Sand Project at Dunmore on the NSW South Coast. The proposed modification is for a new extraction stage (Stage 5) on adjoining land and would be a S75W modification to the existing consent. The proposed pit expansion is required to enable the continuation of the current sand extraction operations.

Kelleher Nightingale Consulting Pty Ltd (KNC) was engaged by Element Environment Pty Ltd on behalf of Boral Resources (NSW) Pty Ltd (Boral) as the owner of DSS to prepare an Aboriginal Cultural Heritage Assessment Report (CHAR) to inform the environmental assessment (EA) for the expansion project. The CHAR assessment process has included detailed Aboriginal cultural heritage assessment comprising Aboriginal community consultation and archaeological investigations, including a test excavation program.

The assessment was carried out in accordance with the Office of Environment and Heritage (OEH) requirements and guidelines for Aboriginal community consultation and archaeological assessment including the *Code of Practice for Archaeological Investigation of Aboriginal Objects in NSW; Guide to investigating, assessing and reporting on Aboriginal cultural heritage in NSW* and *Aboriginal cultural heritage consultation requirements for proponents 2010.*

Consultation with registered Aboriginal stakeholders was undertaken to identify Aboriginal heritage in the study area, assess impacts of the proposed expansion activities and develop appropriate mitigation measures.

Three Aboriginal archaeological sites were identified in the proposed pit expansion area: DLS Boral AFT 1, DLS Boral AFT 2 and DLS Boral AFT 3. All three sites would be impacted by the proposed works.

Archaeological significance of the identified Aboriginal sites was determined by their research value, representativeness, intactness and rarity. On the basis of these criteria, sites DLS Boral AFT 1 and DLS Boral AFT 2 display moderate-high archaeological significance and site DLS Boral AFT 3 displays low archaeological significance.

Consultation with the 19 registered Aboriginal stakeholders identified that the study area has cultural heritage value to the local Aboriginal community. In particular, Aboriginal stakeholders expressed the cultural importance and significance of the landscape around the study area. Boral values Aboriginal community consultation and is committed to ongoing consultation with Aboriginal stakeholders for the Dunmore Lakes Sand Project.

A mitigation program comprising archaeological salvage, undertaken prior to the commencement of the proposed works, is required where portions of significant Aboriginal sites would be impacted by the proposal. Significant Aboriginal sites are identified as exhibiting at least moderate archaeological value. Two sites within the study area require salvage excavation: DLS Boral AFT 1 and DLS Boral AFT 2.

The significance of the DLS Boral AFT 1 and DLS Boral AFT 2 archaeological resource resides in the information it contains, its intactness and rarity in the local region. Sites DLS Boral AFT 1 and DLS Boral AFT 2 contain a large number and diverse range of cultural material, have largely intact stratified deposits, and are in fair to good condition with some surface disturbance. The rarity of the archaeological landscape and selective nature of the identified Aboriginal objects means that recovery of the sites' information will offer substantial scientific and cultural knowledge. In this regard, salvage excavation of DLS Boral AFT 1 and DLS Boral AFT 2 is a suitable heritage outcome for the archaeological sites as it will retrieve and curate a representative sample of the information exhibited by the archaeological sites.

A modified development consent is sought for the entirety of the lands subject to the proposed Stage 5 expansion and specifically for Aboriginal objects associated with the following sites:

DLS Boral AFT 1	AHIMS 52-5-0907	Moderate-High significance	Total Impact	Salvage excavation to mitigate impact
DLS Boral AFT 2	AHIMS 52-5-0908	Moderate-High significance	Total Impact	Salvage excavation to mitigate impact
DLS Boral AFT 3	AHIMS 52-5-0909	Low significance	Total Impact	No mitigation required

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Plate 43. Sandstone ground stone (ID 331), TS 10C, spit 7. 48

1 Introduction

Dunmore Sand & Soil Pty Ltd (DSS) is seeking approval for a modification to their existing development consent (DA 195-8-2004) for Stages 2 to 4 of the Dunmore Lakes Sand Project at Dunmore on the NSW South Coast. The proposed modification is for a new extraction stage (Stage 5) on adjoining land and would be a S75W modification to the existing consent. The proposed pit expansion is required to enable the continuation of the current sand extraction operations. The proposed expansion location (the 'study area' for this assessment) is shown in Figure 1.

The original application for Stages 2 to 4 was lodged in 2004, and the Project received development consent from the Minister for Planning in 2005. The consent approves extraction of up to 800,000 tonnes per annum of sand for a period of 25 years. Boral Resources (NSW) Pty Ltd (Boral) purchased DSS (including the Project) in mid-2005. Due to the high demand for sand in the Sydney market, existing approved dredging has moved recently to Stage 3, which is expected to be exhausted in 3 to 4 years. The last approved extraction stage, Stage 4, will be extracted progressively in stages, as it holds the site road access and private rail line and services for the Project and Boral's Dunmore hard rock quarry. This has led DSS to investigate other local sources of sand to continue the Project beyond Stage 3.

DSS has been investigating a fine sand resource located to the south of Stages 2-4. Drilling has confirmed that there is enough sand to support 3 to 4 more years of extraction from two areas (Stage 5A and 5B) (Figure 2). The proposed works for Stages 5A and 5B are located within Lot 51 DP 1012246 and Lot 502 DP 1174897 in the Shellharbour Local Government Area (LGA).

The previous Aboriginal cultural heritage assessment for Dunmore Lakes Sand Extraction Stages 2, 3 and 4 was completed by Robert Paton Archaeological Studies in 2004, including a site survey and consultation with the local Aboriginal community. The archaeological field survey identified the Raised Wetland Rim landform as having moderate archaeological sensitivity and the likelihood for containing artefact scatters. A test excavation program was recommended in these areas if any impacts were proposed, in order to make a full assessment of significance and to create and implement management and mitigation measures for any Aboriginal archaeological sites likely to be impacted by the proposed sand extraction works.

Kelleher Nightingale Consulting Pty Ltd (KNC) was engaged by Element Environment Pty Ltd on behalf of Boral to undertake an Aboriginal archaeological assessment and prepare an Aboriginal Cultural Heritage Assessment Report (CHAR) to inform the environmental assessment (EA) for the proposed Stage 5 expansion project.

The CHAR has been prepared in accordance with the EA requirements for the project and Office of Environment and Heritage (OEH) requirements and guidelines for Aboriginal community consultation and archaeological assessment.

1.1 Location and scope of activity

The proposed development area (hereafter referred to as the 'study area') is situated in Dunmore, approximately 120 kilometres south of the Sydney CBD (Figures 1 and 2). The proposed extraction sites are located within Lot 51 DP 1012246 and Lot 502 DP 1174897 in the Shellharbour Local Government Area (LGA). Required access routes and sand pipelines have also been included in the study area.

The proposed activities associated with sand extraction include:

- Vegetation clearance;
- Extraction of sand by excavator (Stage 5A with a total area of 3.42 ha, and Stage 5B with a total area of 8.12ha);
- Dredging and pumping the sand onto the existing processing area on Stage 2 for washing, stockpiling and dispatch;
- Installation of two pumping stations/boosters;
- Installation of sand pipeline connecting extraction and processing areas;
- Installation of two access roads, 240 metres and 970 metres in length, 3.5 metres in width; and
- Installation of a temporary portable site office and 10 light vehicle spaces

1.2 Project requirements

The objective of the Aboriginal cultural heritage assessment was to combine Aboriginal community consultation with archaeological investigation to identify if the proposed expansion would impact on Aboriginal cultural heritage and if so, what measures could be undertaken to manage or mitigate Aboriginal heritage impacts.

The assessment was carried out in accordance with the:

- NSW Department of Planning and Environment requirements;
- *Code of Practice for Archaeological Investigation of Aboriginal Objects in NSW* (OEH 2010b);
- *Guide to investigating, assessing and reporting on Aboriginal cultural heritage in NSW* (OEH 2011); and
- *Aboriginal cultural heritage consultation requirements for proponents 2010* (OEH 2010c).

The assessment included:

- effective consultation with Aboriginal communities to identify Aboriginal heritage in the study area, assess impacts of the proposed expansion activities and develop appropriate mitigation measures;
- detailed archaeological investigation of the study area, including archaeological test excavation;
- Aboriginal cultural heritage assessment, including both cultural and archaeological significance; and
- preparation of impact mitigation and management measures.

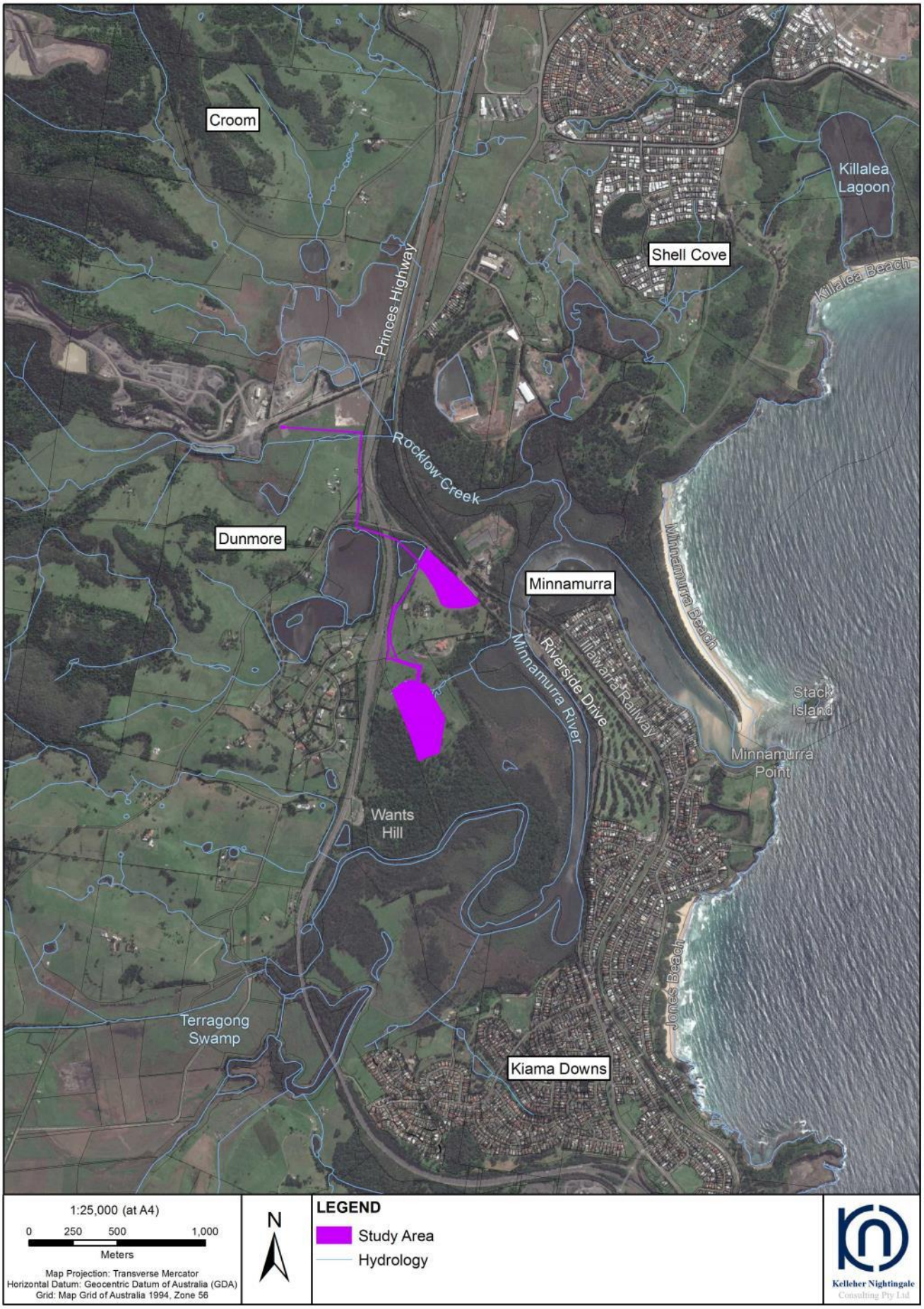

Figure 1. Location of the study area (Stage 5 Modification)

Figure 2. Proposed expansion area (Stage 5A and Stage B).

2 Aboriginal Community Consultation

The aim of Aboriginal community consultation is to integrate cultural and archaeological knowledge and ensure registered stakeholders have information to make decisions on Aboriginal cultural heritage. For the preparation of this CHAR consultation with Aboriginal people has been undertaken in accordance with the OEH *Aboriginal Cultural Heritage Consultation Requirements for Proponents 2010* (OEH 2010c) and the requirements of Clause 80C of the *National Parks and Wildlife Regulation 2009*. The formal consultation process has included:

- government agency notification letters (letters dated 08/06/2018);
- advertising for registered stakeholders in local media (*Illawarra Mercury* 20/04/2018: refer Appendix A);
- notification of closing date for registration (25/07/2018);
- ongoing compilation of registrants list, through continuing to register individuals and groups for consultation on the project;
- provision of project information and proposed cultural heritage assessment methodology (letters dated 20/08/2018) allowing for a 28 day review period;
- provision of proposed test excavation methodology for comment and review (20/08/2018), allowing for a 28 day review period;
- provision of draft CHAR (25/01/2019), allowing for a 30 day review period; and
- ongoing consultation with the local Aboriginal community.

Aboriginal stakeholders were consulted throughout all stages of the assessment process. A full log of consultation is attached as Appendix B. Boral is committed to ongoing consultation with the Aboriginal community.

2.1 Registration of interest

Aboriginal people who hold knowledge relevant to determining the cultural heritage significance of Aboriginal objects and Aboriginal places in the area were invited to register an interest in a process of community consultation. Nineteen groups or individuals registered an interest in the project. Investigations included consultation with Aboriginal community individuals and groups as listed in Table 1.

Table 1. Registered Aboriginal stakeholders

Registered Aboriginal Stakeholder	Representative and/or Contact Person
Illawarra Local Aboriginal Land Council	Paul Knight
Duncan Falk Consultancy	Duncan Falk
Leanne Tungai	Leanne Tungai
Darug Land Observations	Anna O'Hara
Woronora Plateau Gundangara Elders Council	Kayla Williamson
Goobah	Basil Smith
Biamanga	Janaya Smith
Cullendulla	Corey Smith
Gary Caines	Gary Caines
Gulaga	Wendy Smith
Murramarang	Roxanne Smith
Guunamaa Dreamin Sites and Surveying	Richard Campbell
Tungai Tonghi	Troy Tungai
Murra Bidgee Mullangari Aboriginal Corporation	Ryan Johnson
Muragadi Heritage Indigenous Corporation	Jesse Johnson
Merrigarn Indigenous Corporation	Shaun Carroll
Barraby Cultural Services	Lee Field
Yurrandaali Cultural Services	Bo Field
Wodi Wodi Coomaditchie Aboriginal Corporation	Heather Ball
James Davis	James Davis

2.2 Consultation regarding the land and proposed activity

Following on from Stage 1 of the consultation process undertaken by KNC (stakeholder identification and registration), project-specific consultation was undertaken. Information regarding the proposed extraction project was provided to registered Aboriginal stakeholder groups in a letter dated 20/08/2018. Information included an outline of the proposal, location of the study area, development approval context and an invitation to consult during the assessment.

Stakeholders were also provided with the proposed assessment methodology for the Cultural Heritage Assessment Report, and invited to review and provide feedback (review period of 28 days, closing on 17/09/2018). An invitation was extended for Aboriginal cultural knowledge holders and stakeholders to provide comments on the proposed cultural heritage assessment methodology, including any protocols regarding the gathering of information and any matters such as issues/areas of cultural significance that might affect, inform or refine the assessment methodology.

2.3 Stakeholder responses to the proposed assessment methodology for the Cultural Heritage Assessment Report

Responses to the proposed assessment methodology were received from Barraby Cultural Services (BCS), Duncan Falk Consultancy (DFC), Murra Bidgee Mullangari Aboriginal Corporation (MBMAC), Muragadi Heritage Indigenous Corporation (Muragadi), Tungai Tonghi, Woronora Plateau Gundangara Elders Council (WPGEC), and Yurrandaali Cultural Services (Yurrandaali).

BCS stated that they supported the proposed assessment methodology for the project (email dated 22/08/2018).

DFC stated they had read and reviewed the methodology and endorsed the proposed approach (email/letter dated 28/08/2018).

MBMAC expressed support for the recommendations in the assessment methodology (email dated 21/08/2018).

Muragadi stated they had reviewed the project information and proposed methodology and endorsed the proposed approach (email dated 21/08/2018).

Tungai Tonghi affirmed their interest in the project (email dated 23/08/2018).

WPGEC advised they had received the methodology (email dated 20/08/2018) and asked for further detail regarding the test excavation program (specific number of test pits and size of the test areas). Dr Matthew Kelleher (KNC) responded via phone call on 27/08/2018 to confirm the location of test areas and identified sensitive landforms, and discuss the amount of test squares estimated to be required to sample these. WPGEC agreed with the proposed approach.

Yurrandaali stated that they supported the proposed methodology (22/08/2018).

2.4 Review of draft CHAR

The draft CHAR was provided to stakeholders with an invitation to review and provide comment. Stakeholders were invited to comment on the Aboriginal cultural significance of the study area and the identified sites, along with the management recommendations presented in the report. A 30 day review and comment period was provided.

Comments and information received from stakeholders during this period are attached in full in Appendix C and summarised below.

2.5 Stakeholder responses to draft CHAR

Responses to the draft CHAR were received from Barraby Cultural Services (BCS), Duncan Falk Consulting (DFC), Guunamaa Dreamin Sites and Surveying (GDSS), Leanne Tungai, Murra Bidgee Mullangari Aboriginal Corporation (MBMAC), Muragadi Heritage Indigenous Corporation (Muragadi), Merrigarn Indigenous Corporation (Merrigarn), Yurrandaali Cultural Services (Yurrandaali) and Woronora Plateau Gundangara Elders Council (WPGEC).

BCS acknowledged receipt of the draft CHAR but did not provide any further comment (email dated 28/01/2019).

DFC stated they had reviewed the draft CHAR and agreed with the proposed salvage. DFC also noted they supported the proposed two-stage salvage approach, in order to identify the best locations for open area salvage (email dated 26/01/2019).

GDSS acknowledged receipt of the draft CHAR and expressed their interest in being involved in the proposed salvage excavation fieldwork at the sites (email dated 25/01/2019).

Leanne Tungai acknowledged receipt of the draft CHAR and stated that she would like to be involved in future work on this project (email dated 26/01/2019). No further comment was provided during the review period.

MBMAC stated they had read the draft CHAR and agreed with the recommendations (email dated 25/01/2019).

Muragadi stated they agreed with the recommendations made by KNC (email dated 25/01/2019).

Merrigarn also stated they had reviewed the draft CHAR and agreed with the recommendations (email dated 25/01/2019).

Yurrandaali acknowledged receipt of the draft CHAR but did not provide any further comment (email dated 28/01/2019).

WPGEC reconfirm the identified archaeological value of the project area; however expressed opposition to the proposed development on several grounds (email/letter dated 25/02/2019), noting that the property is significant for several reasons:

1. WPGEC believe the site is “a rare undisturbed estuary”.

   Response: While the site exhibits archaeological value it is not an undisturbed environment. The project area is largely cleared of trees, used for agricultural activity and filled in low lying areas (Stage 5A). The tree clearing and agricultural activities have resulted in pockets of intense disturbance (holes in the ground) and contributed to a low intensity blanket of disturbance (c.25cm deep) over the majority of the land. Archaeology remaining between the pockets of disturbance and beneath the agricultural layer displays an intactness of information, but it is not an undisturbed environment.

2. WPGEC state the “intactness” and “distribution of artefacts clearly show that occupation and activities at this site occurred during a prolonged period of time and on a repeated basis”. Furthermore, WPGEC state that the information from the test excavation “may suffice for the purposes of understanding and managing sites in similar estuarine environments”.

   Response: The current level of archaeological assessment, in accordance with the OEH Code of Practice, identifies the archaeological significance of the site. Much of that significance resides in the information the site offers rather than any inherent value. Mitigation of the site will assist in unlocking the site’s scientific values. No chronological information exists for the site, thus it is not possible to determine the length of occupation or if occupation extended over multiple events. Obtaining a chronology for the archaeology is an important part of the proposed mitigation and would add considerable value to understanding the region’s archaeology. The information gained from salvage excavation will directly assist in managing similar sand environments because it will show if sand bodies are maintaining longer term archaeological records or are they simply single events representing a sand erosion cycle – old sand and any associated heritage being washed away and then replaced by new sand and heritage.

3. WPGEC link the location of a massacre site south of the project area to the current project area.

   Response: The Dunmore Lake Sands Project has no direct or indirect connection to the massacre site located loosely on the Minnamurra River. The proposed operations will not impact the massacre site. The historic massacre is an important event in Aboriginal history, however the archaeology of the project area shows no connection to the massacre event.

4. WPGEC state the project area has a “high potential of containing burials”.

   Response: Aboriginal burials may exist anywhere given the correct conditions. The project area is no more or less likely than other similar environment to contain burials. A procedure for human remains is included in section 11 of the CHAR. The archaeological assessment and test excavation program undertaken for the Dunmore Lake Sands Project identified no indication that Aboriginal burials exist on the property.

2.6 Ongoing consultation

Boral values Aboriginal community consultation and is committed to ongoing consultation with Registered Aboriginal Stakeholders for the Dunmore Lakes Sand Project.

2.7 Aboriginal cultural values

It has been identified during the consultation process that the wider study area has cultural heritage value to the local Aboriginal community. Some of the Aboriginal cultural heritage values expressed by stakeholders include:

- strong association with the land
- responsibility to look after the land, including the heritage sites, plants and animals, creeks and the land itself
- scarred trees
- artefact sites and middens
- creek lines and rivers, especially major landscape features such as the Minnamurra River, its tributaries and floodplains
- indigenous plants and animals
- general concern for burials, as their locations are not always known and they can be found anywhere. Consultation has identified that burials are known to the Aboriginal community along the banks of the Minnamurra River to the south of the study area (James Davis, phone call 16/11/2018).
- connection to more recent (post-European) Aboriginal history including a massacre site on the Minnamurra River recently acknowledged by Kiama Council (see section 3.3).

Aboriginal cultural values and knowledge of the area have been provided by registered stakeholders throughout the consultation process and are summarised below.

Darug Land Observations (DLO) noted during registration that members of the contemporary Aboriginal community retained strong story, song lines, oral history and continued contact with the area (letter/email dated 12/07/2018).

Guunamaa Dreamin Sites and Surveying (GDSS) also noted the presence of songlines in the area as well as other known Aboriginal sites including scarred trees (email dated 12/07/2018).

Woronora Plateau Gundangara Elders Council (WPGEC) advised that the area held high value and cultural significance for a number of reasons, including its value as forming part of a “rare undisturbed estuary environment” within the wider Illawarra region (letter and email dated 25/02/2019). The intact archaeology of the sites demonstrated “continuous occupation with evidence of a lengthy and maintained connection to this land”. WPGEC also noted the presence of the recorded massacre site on the Minnamurra River approximately 500 metres to the south, and noted that the study area’s proximity to this site meant it should be afforded appropriate respect. In addition, WPGEC noted a high potential for Aboriginal burials, both older and more recent instances given the sandy deposit, proximity to water and the known massacre site.

3 Description of the Area

3.1 Landform, geology and soil landscapes

The study area is located within the Illawarra subregion of the Sydney Basin. It is within the Coastal Plain physiographic region that lies between the Illawarra Escarpment and the sea. The Sydney Basin is a large geological feature stretching from Batemans Bay in the south to Newcastle in the north and Lithgow in the west. The basin formed between the Permian and Triassic when sedimentary rocks were created by the deposition of sediment from fluctuating marine advance and regression onto older basement rocks of the Lachlan Fold Belt and Late Carboniferous volcanoclastic sediments (Mayne et al. 1974). Earth movements between 180 and 200 million years ago within the southern side of the basin forced the layers of sedimentary and volcanic rock upwards (Young 1980a). The combination of erosion and the downward movement of debris on the southern side of the basin produced the Illawarra Escarpment which stretches from the Royal National Park in the north to Berry in the south and overlooks the Illawarra Coastal Plain.

The basal geology of the study area consists of Bumbo Latite, a member of the Gerringong volcanic facies and an intrusive feature of the Budgong Sandstone Formation (Figure 3). Bumbo Latite is a fine grained basalt-like aphanitic to porphyritic latite which formed during the Permian Period (298 – 252 million years ago) (Bowman 1974: 37). The latite ranges from mid grey to black in colour with commonly occurring columnar jointing, breccia zones and inclusions of metamorphosed sandstones. In areas of the thickest development, the latite occurs in three flows that are separated by breccia zones and discontinuous sediment. Bumbo Latite is porphyric basalt with a fine-grained groundmass varying from mid grey to black in colour.

Quaternary deposition within the Coastal Plain has mainly taken place within coastal barrier, estuarine plain and alluvial plain settings. The rising sea within the coastal lowland developed into estuaries with tidal channels and flats along margins. As the water level rose, the flooded area was fringed by freshwater marshes in which peat bog could develop. These sedimentary environments form a dynamic system that can shift landward or seaward, with superimposition of one type of sediment over another in response to a number of factors including the rate of sea level rise, sediment supply and accumulation space. This dynamic character implies that at any time during the Holocene all different types of sediments could have existed next to one another sometimes even over short distances (Bailey *et al*. 2017: 227). The New South Wales Coastal Geology Maps Series has produced map coverage of unconsolidated sedimentary deposits in the coastal areas of NSW. These deposits have been classified into three depositional systems, each of which is distinguished by a particular range of sediment types, processes and geomorphic features. Most of the units are also differentiated by age as Holocene (deposited within the last 12,000 years during the post-glacial marine transgression and rising sea level), or Pleistocene (deposited prior to this time, during low sea levels). According to this mapping, the study area lies within three Quaternary depositional units (Figure 3):

- Qhef (Holocene tidal-delta flat) – northern part of Stage 5A within this estuarine plain system, characterised by marine sand, silt, clay , shell and gravel;
- Qhbf (Holocene backbarrier flat) – southern parts of Stage 5A within this coastal barrier system, characterised by marine sand, silt, clay, gravel and shell;
- Qhbr (Holocene beach ridge and associated strandplain) – Stage 5B within this coastal barrier system, characterised by marine sand, shell and gravel.

Estuarine depositional environments occur within the transitional zone between alluvial and coastal barrier environments. Deposition takes place in and around enclosed to partially enclosed water bodies of brackish to marine salinity, generally under regular to intermittent tidal influence. Tidal-delta flats (Qhef - northern section of Stage 5A) represent older, vegetated areas that are generally mantled by swamps or palaeochannels. They may grade into backbarrier flats (Qhbf), often beneath freshwater swamp cover.

Coastal barriers occur within the most seaward parts of the coastal plain. Beach ridges generally occur in a subparallel series to form a beach-ridge plain (Qhbr - Stage 5B study area). The ridges represent successive periods of beach and frontal dune accretion along coastal sectors experiencing net accretion over geological time scales.

Areas of low elevation and relief occupying the landward portions of barrier systems are termed backbarrier flats (Qhbf - southern section of Stage 5A). They are considered to be formed through storm washover deposition in the initial stages of barrier formation. Such processes become inactive over time due to the growth of dunes and/or increase in the width of the barrier system through seaward progradation. Thus, backbarrier flats are generally relict features unrelated to contemporary processes.

The study area lies in its entirety within the Mangrove Creek Soil Landscape (Figure 3) as classified by Hazelton (1992). These soils are Holocene sediments that occur within four different shore zones each with a different drainage and inundation pattern. At the lowest elevation is the mudflat zone, which is regularly inundated except during low tide; with increasing elevation are mangrove zones inundated only during high tide; the saltmarsh zone inundated only

during spring flooding; and finally littoral rain forest that is rarely flooded and has interrupted or absent drainage. Local relief is <3 metres and slopes <3%. Mangrove Creek soils are deep Siliceous Sands and Calcareous Sands on mangrove flats, and Humic Gley soils on salt marshes. They consist of up to 30 centimetres of organic mottled brown silty loam occurring as topsoil (Horizon A), overlying <50 centimetres of organic black sandy loam, and <100 centimetres of shelly greyish yellow sand occurring as subsoil (Hazelton 1992: 131-133). Boundaries between soil layers are gradual to diffuse. The soil landscape is abundant in organic fibrous matter and its erodibility is generally very low.

Analysis of European land use and its subsequent effect on regional soils has identified that while evidence for erosion in the form of gullying and sheet erosion is widespread, overall soil erosion in the Illawarra region is generally low (Young 1980b). This relates to the biased European selection of volcanic/sandstone geological contexts (and subsequent soil landscape development) for agriculture and use as pasture. Land on coastal sands was largely ignored for farming due to the low fertility of the sandy soils, but was used for grazing. As intensive grazing requires a stable soil matrix to support good grass cover, these areas have generally been well maintained in order to facilitate their use as pasture.

Topographically, the study area is located across floodplain and estuarine landforms associated with the Minnamurra River and its estuary (Figure 4). Stage 5A and Stage 5B are dissected by an extensive ridgeline running north-east towards the floodplain. The southern section of Stage 5A is located to the west of the Minnamurra River on a backbarrier flat between the saline swamp and a tidal flat. The northern section of Stage 5A is situated within the tidal flat landform which extends along Rocklow Creek, a major tributary to the Minnamurra River. Stage 5B is within a beach ridge landform, located to the south of the ridgeline, and west and north of the Minnamurra River.

Hydrology around the study area is characterised by the presence of the Minnamurra River and its estuary. Rocklow Creek, one of its major tributaries is located to the north of the study area. Saline water from the tidal influence of the Minnamurra River normally reaches the section of Rocklow Creek east of the Illawarra Railway Line and can extend into the section west of the Princes Highway, within the Stage 5A study area. Several small drainage lines run west-east and empty into the Minnamurra River, with one of these running along the northern boundary of the Stage 5B study area. One small dam is located to the north of the Stage 5B area and is associated with this drainage line.

Boral completed a drilling program in 2016 in order to investigate the presence and viability of the sand resource within Stages 5A and 5B. Total depth of sediments varied according to sand presence/absence, depth and quantity and was between 6.4 and 27 metres. The general soil profile within Stage 5B consisted of sandy topsoil and weathered sand between 2 and 3.5 metres depth, overlying between 2.5 and 9 metres of fresh (unweathered) tsunami-deposited medium and fine sands with varying shell content. Fresh sands overlie fluvial sand deposits, but are separated by a small layer of clay deposit. The underlying base rock is latite, which sits closer to the surface or outcrops within the areas adjacent to the hill, to the north of the Stage 5B area. The northern section of the Stage 5A area that lies within the tidal flat, revealed weathered topsoil sand deposit to 0.75 metres, overlying 5 metres of fresh unweathered sand. The southern sections of the Stage 5A area within the backbarrier flat revealed topsoil of weathered sand between 4 and 4.5 metres depth, overlying between 1 and 3 metres of fresh, tsunami-deposited unweathered sand. These fresh sands overlie clayey sand, clay and latite base rock.

The geology, soil and landforms of the study area influence the presence of Aboriginal archaeological features. Coastal and estuarine environments within the study area would have made it an attractive locale for past Aboriginal people. Estuarine, swamp/wetland and the littoral and marine resources of the coast were all available, along with fresh water from smaller streams. The variety of habitats would also have encouraged a diverse population of fauna. Many fish and crustacean species breed in estuaries and then spend their adult lives in the sea. This makes estuaries a good feeding ground for a number of wading birds who feed on the juveniles. Raw materials suitable for tool-making are available from surrounding geologies and may have been sourced directly from outcrops or as stream and river cobbles transported to the coast from deposits further inland. The soils derived from the volcanic geology of the study area also supported varied native vegetation which was utilised by past Aboriginal people as a resource.

The adjacent catchment areas of Frazers Creek and Rocklow Creek would also have offered important resources. These would have differed significantly during the Holocene when the flood plains and eastern portion of Rocklow Creek formed an estuary. Topographically, elevated and well-drained portions of the study area would have been a preferable camping place surrounded by a variety of resources.

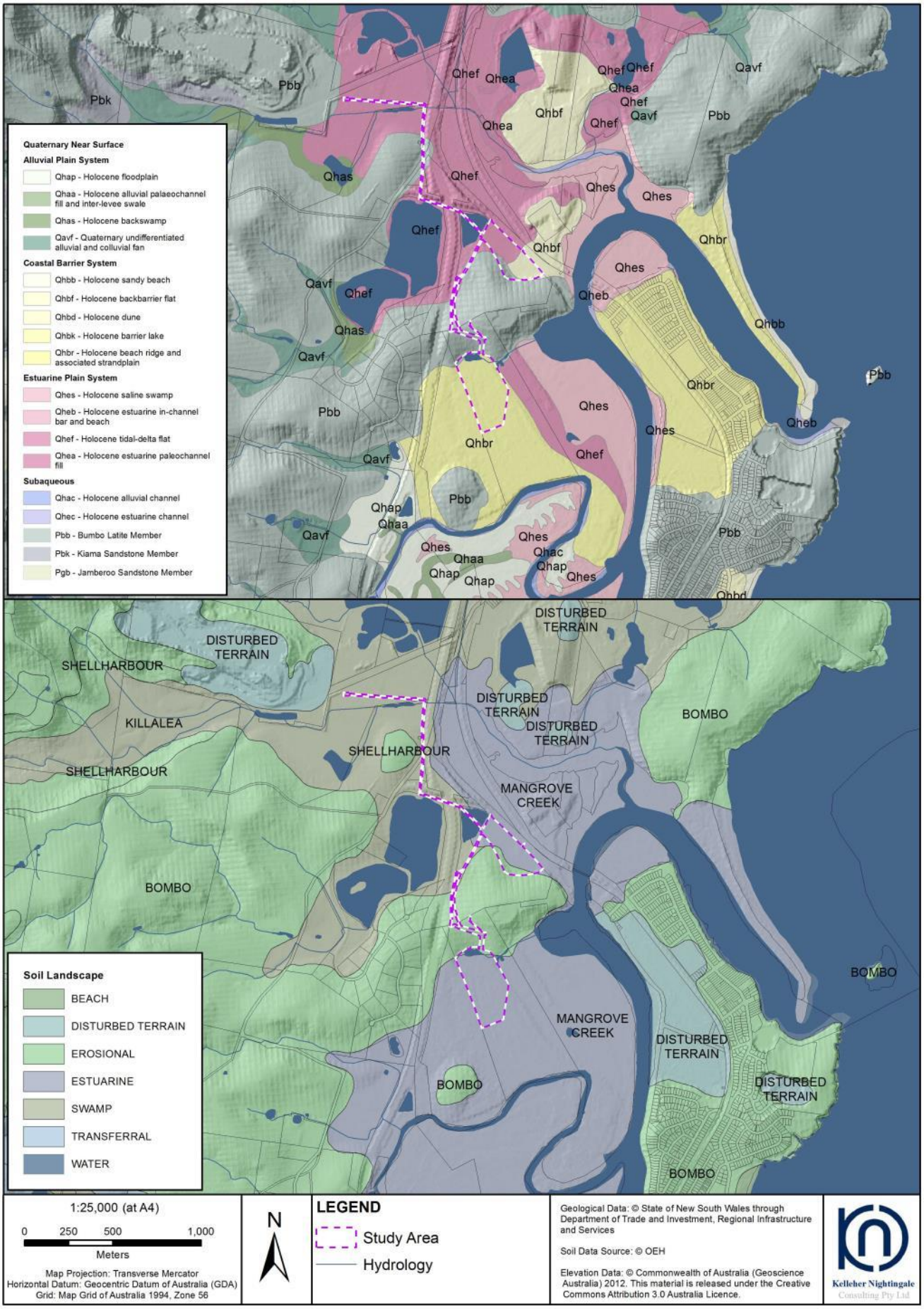

Figure 3. Geology and soil landscapes within the study area

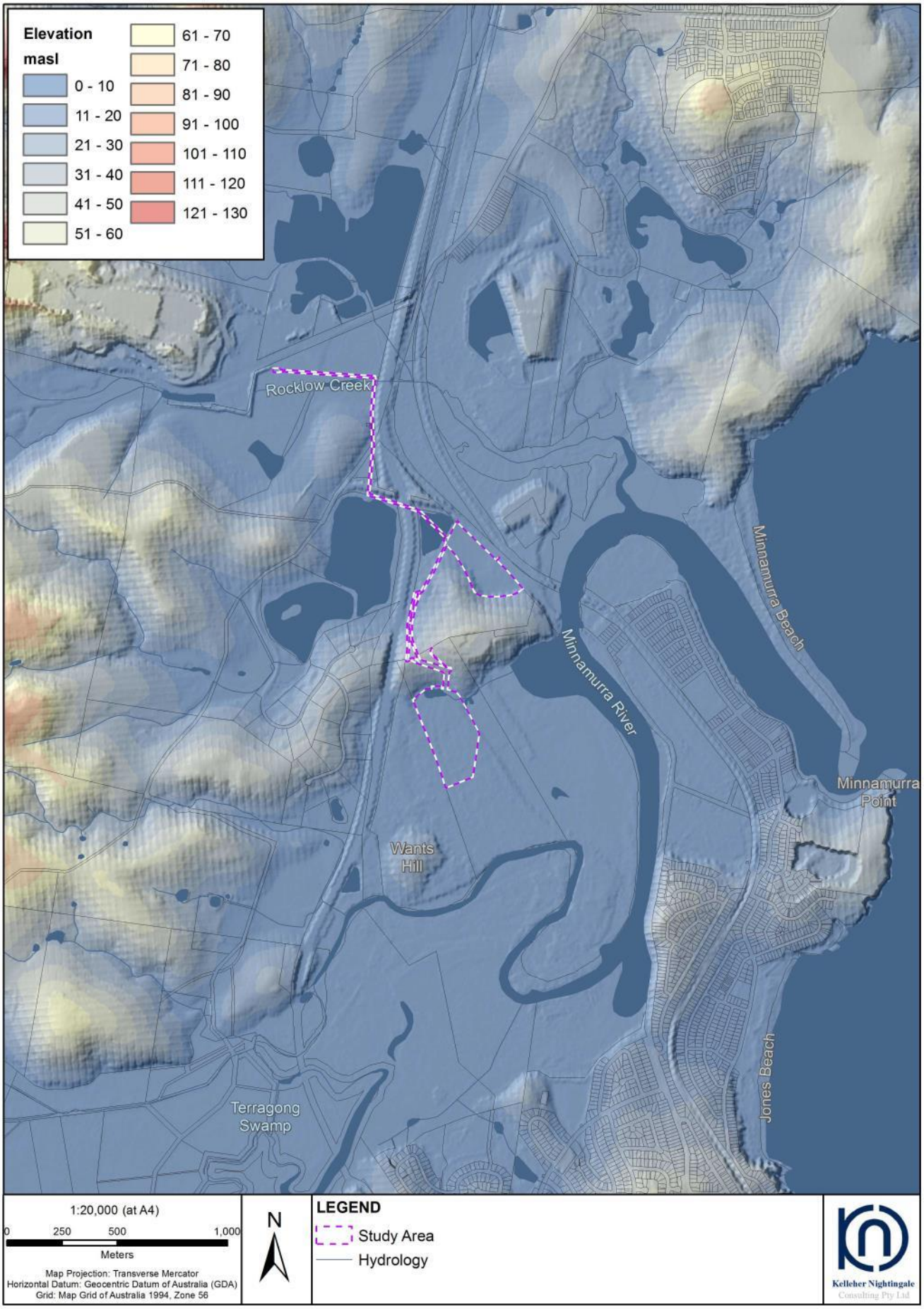

Figure 4. Topography of the study area.

3.2 Vegetation and land use

The study area is located within the Lake Illawarra Alluvial Plains as mapped by NSW Department of Conservation and Climate Change (DECC) in 2002 (Mitchell Landscape). Most of the plains are cleared, but originally had Forest Gum *(Eucalyptus tereticornis)*, Woolybutt *(E. longifolia)*, White Stringybark *(E. globoidea)*, Thin-leaved Stringybark *(E. eugenoides)* and extensive stands of Swamp Oak *(Casuarina glauca)*, Prickly Paperbark *(Melaleuca styphelioides)* and decorative paperbark *(Melaleuca sp.)* on brackish wet ground near creeks. River Oak *(Casuarina cunninhammiana)* is found close to fresh water streams. The understorey varies and contains either a dense ground layer containing grasses, herbs and sedges to a height of 1 metre; or a shrubby layer, sometimes including plants such as *Pittosporum* species to a height of 2 metres.

Much of the vegetation on the coastal plain of the Illawarra and South Coast region has been cleared, fragmented or heavily modified. At least 75% of the ecological community has been cleared and it is still subject to clearing due to ongoing development of the region. Other impacts stem from stock grazing, changes to fire regimes and recreational activities. A small area in the south-western corner of Stage 5B contains thinned sand forest vegetation.

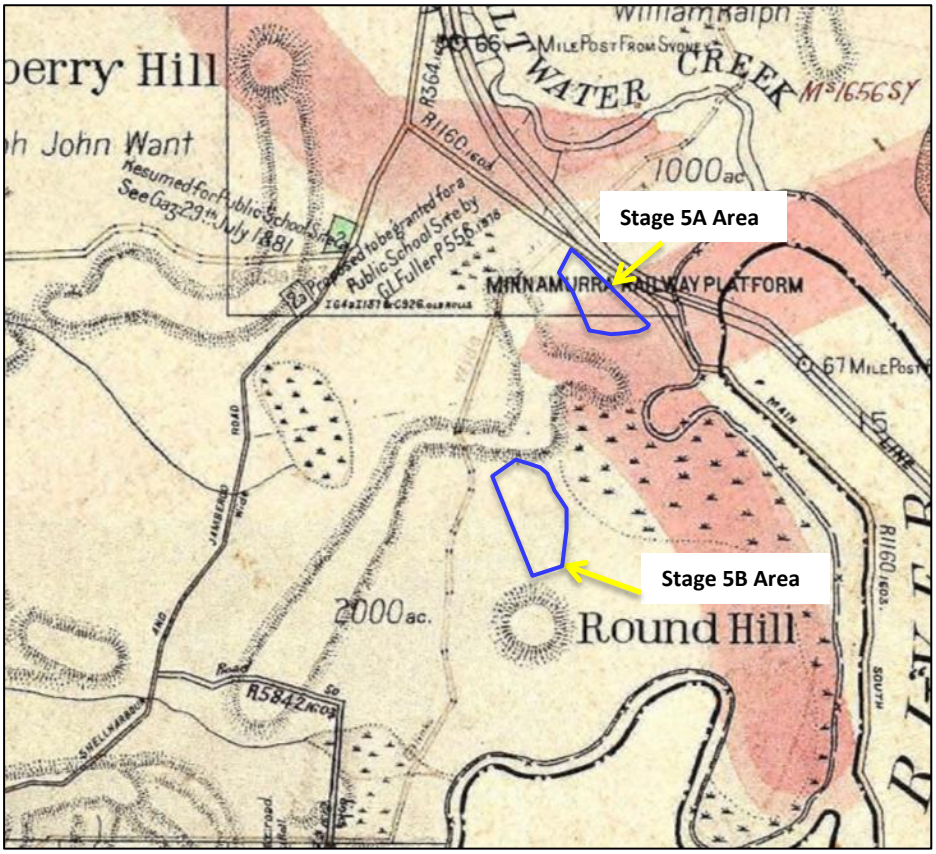

Plate 1. Parish of Terragong, County of Camden Map, 1895. Courtesy of Land and Water Conservation 138329. (approximate locations of Stage 5A and 5B extraction area outlined in blue).

Historical land use within the region included the cultivation of crops, grazing cattle and quarrying. Review of the historical parish maps revealed that the study area has been through very limited land modifications in the last 200 years (Plate 1). Extensive swamps are mapped to the east of the Stage 5B area, adjacent to the Minnamurra River. Major disturbances within the study area surroundings are associated with the construction of 'Dunmore House' and its outbuildings and access roads. It is located on the prominent ridgeline between Stage 5A and Stage 5B. Past land use activities within areas are limited to land clearance and installation of fences and informal access paths. Aerial photography dated from 1948 revealed that the majority of native vegetation had already been extensively cleared. The entire Stage 5A area was cleared with only a few remnant trees; Stage 5B area showed tree cover south of the small dam. These land use practices would have removed the majority of mature native trees.

Removal of trees would also have caused disturbance of surface soil layers, causing mixing of topsoil sand deposits. The drainage line located to the north of Stage 5B has not gone through any major modifications. Both areas are currently covered in short pasture grass, with scattered trees present to the south of Stage 5B. A dam located to the north of Stage 5B is most likely natural and associated with a small drainage line flowing west-east to the Minnamurra River. Currently, the study area is used for cattle pasture. The study area contains numerous dirt tracks used for both vehicle and pedestrian access.

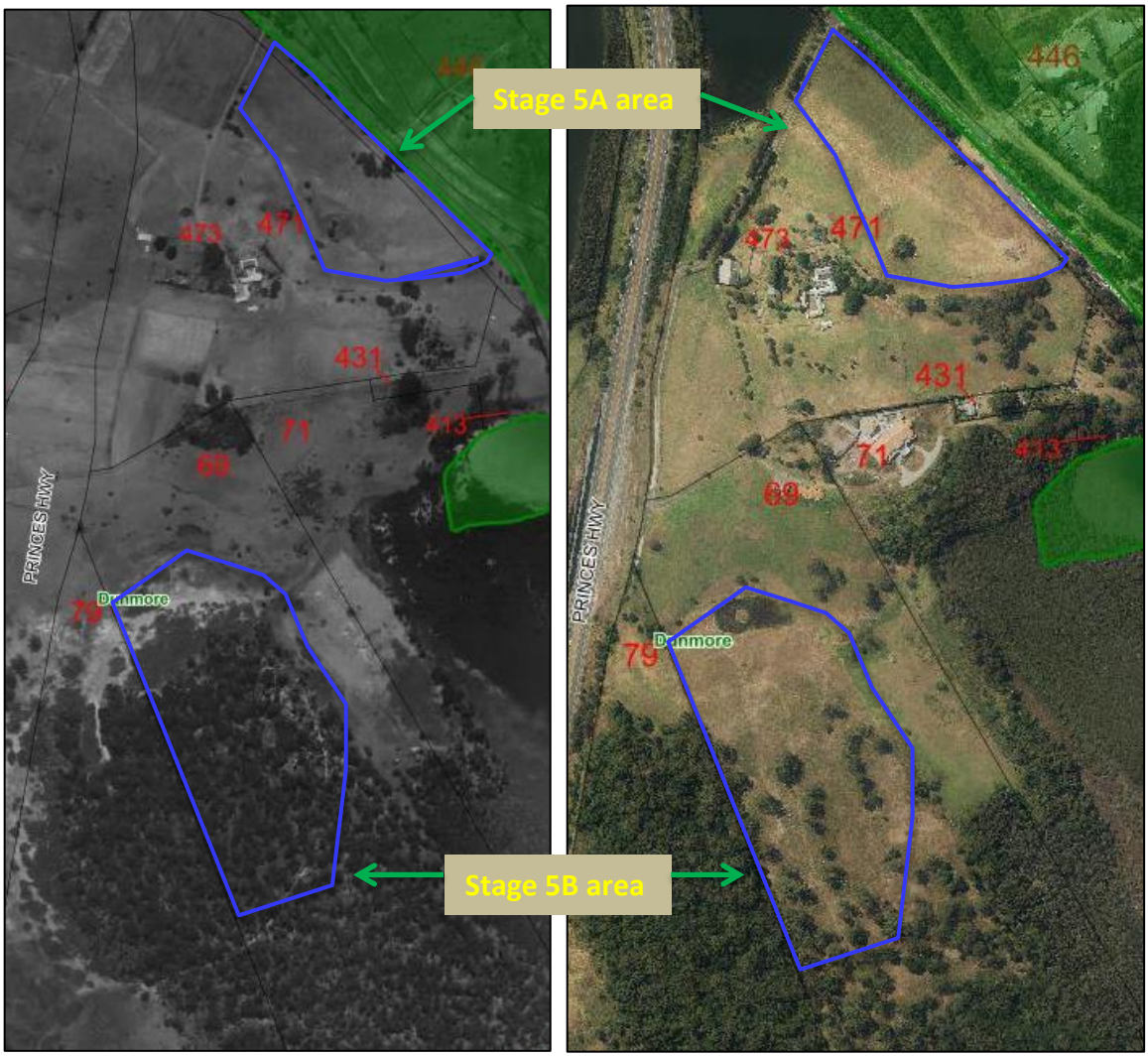

Plate 2. Comparison aerials of Stage 5A and 5B: 1948 and 2016, courtesy of Shellharbour City Council (approximate locations of Stage 5A and 5B extraction areas outlined in blue)

3.3 Ethnohistoric context

The study area lies within a landscape which was important to, and intensively used by, past Aboriginal people. Aboriginal people living in the Illawarra spoke various dialects of the language known as Tharawal (also spelled Dharawal, Thurrawal, Turuwul, Darawal etc.), a local word for cabbage palm. It was spoken and understood from Botany Bay and Sydney in the north, west towards the Blue Mountains, Moss Vale and Goulburn, and south to the Shoalhaven River and Jervis Bay (DEC 2005: 6). The Tharawal language was largely associated with coastal groups however the boundaries of "languages or dialects can only be indicative at best", chiefly because groups of people and their language do not move around based on straight lines dividing language groups (Attenbrow 2002:34-35). The Tharawal people living in the vicinity of the study area were known as the Wodi Wodi (also spelled Wadi Wadi), whose traditional oral histories tell of their arrival at Lake Illawarra by canoe, long ago when the Ancestors were animals (DEC 2005:6). Traditional stories tell how they brought the Dharawal cabbage tree palm with them from the north and were named for it (DEC 2005:6).

Early European accounts indicate that the Wodi Wodi lived as a highly mobile and dispersed population, primarily in small territorial clans and local clans of extended family groups, forming larger bands through social and cultural links including marriage and communal participation in subsistence activities. The Illawarra and wider NSW South Coast offered many lakes, estuaries, sandy beaches and intertidal zones with a diversity and abundance of resources for the local people to use. In the Illawarra region, local Aboriginal people were identified as fresh or salt water people due to their occupation of particular marine or estuarine landscapes and their use of the natural resources found in these environments. They would have access to a wide range of avian, terrestrial and marine fauna; repeated firing of the vegetation would have opened up foliage allowing ease of access through and between different eco zones.

European observers noted that the large water bodies such as Lake Illawarra were important fishing areas for past Aboriginal people and were fished from canoes used bone hooks and lines or specially constructed spears (DEC 2005:10). Historical accounts also recorded the use of the many creeks of the area for fishing using spears and fish traps made of loosely woven plant fibre and sticks. Spears, pit traps and snares were used to hunt wallabies in the forested hinterland away from the coast, while possums were smoked out of hollow trees and logs (DEC 2005: 12). Reptiles were hunted in the open forests along the escarpment, and wild honey collected from native bee hives. Plant resources, as well as providing important foodstuffs, were also used to construct spears, digging sticks, boomerangs and other tools. Forest trees yielded bark strips suitable for canoes and shelters, as well as fibres for string and rope. Plants from the swamps on the coastal plain were particularly used for fish nets and string bag-making. Other plants provided fish poison, dyes and paints.

Following the first land grants in the Illawarra from the early nineteenth century, Aboriginal land use and resources were depleted by the introduction of livestock, exotic plants, tree clearing and fencing. Land grants were mainly given fronting fresh water creeks or rivers, which limited Aboriginal people from obtaining the economic resources concentrated around these water bodies. They were pushed to the fringes of their Country, mainly towards the coast. In addition to this, introduction of exotic diseases including smallpox further decreased the number of local Aboriginal people in the area, with an estimated half the population affected (Organ 1990: 5). Conflict between the European settlers and local Aboriginal people became more common as pressure on the traditional owners increased, with numerous instances of Aboriginal people taking crops and livestock from settlers as their own traditional economic resources were subsumed (DEC 2005:18-19). This often led to violent reprisals from settlers, with a number of Aboriginal people shot or mutilated in retaliation for the 'thefts' or during other disputes. Settlers rarely faced serious punishment for their treatment of Aboriginal people. One such instance was recorded along the Minnamurra River south of the study area.

> *In October 1818 Lieutenant Weston, land owner at Dapto and Cornelius O'Brien, formerly a stockman at Sandon Point and now the overseer of a property at Yallah, organised a group of seven labourers and convicts. Unusually armed with muskets, cutlasses and pikes, they headed to Kiama supposedly to fetch two muskets lent to a group of people living on the Minnamurra River. According to Young Bundle, who was long trusted by the British, the posse killed all the people at the camp. The attackers admitted only to wounding a boy in self-defence. After a sharp letter of protest from Charles Throsby to Governor Macquarie, the murders were investigated by D'Arcy Wentworth, the Principal Superintendent of Police, along with other magistrates. They took no action against the killers despite a letter from Governor Macquarie to D'Arcy Wentworth expressing his "surprise, regret and displeasure" at their findings.* (Donaldson et al 2017:13).

Kiama Council formally acknowledged this massacre in October 2018 at a public ceremony and acknowledgement of the event will form part of interpretation strategies for the new Minnamurra Boardwalk project on the opposite side of the river, with a permanent plaque to be laid. Contemporary Aboriginal people maintain a strong connection to the area and retain both cultural and historical knowledge of its settlement history. The value of the general area to both the past and the present Aboriginal community is underscored by the ongoing cultural connection expressed by the contemporary Aboriginal community, as evidenced during the formal consultation process.

4 Archaeological Context

4.1 Heritage register searches

The Aboriginal Heritage Information Management System (AHIMS) is a database operated by OEH, regulated under section 90Q of the *National Parks and Wildlife Act 1974*. AHIMS contains information and records related to registered Aboriginal archaeological sites (Aboriginal objects, as defined under the Act) and declared Aboriginal places (as defined under the Act) in NSW.

A search of AHIMS was conducted on 20 April 2018 to identify registered (known) Aboriginal sites or declared Aboriginal places within or adjacent to the study area (AHIMS Client Service ID: 340468). The search results are attached as Appendix D. Subsequently recorded sites within the study area were registered as part of the current assessment following test excavation (see section 7.4).

The AHIMS Web Service database search was conducted within the following coordinates (GDA, Zone 56):

Eastings:	300800 to 304650
Northings:	6164300 to 6169300
Buffer:	200 metres (search area included an extensive buffer)

The AHIMS search results revealed 29 Aboriginal sites had been recorded within the search area (Figure 5). No Aboriginal places had been declared within the search area. Site features ('site types') are listed in the table below.

Table 2. Registered Aboriginal sites around the study area (AHIMS results)

Site Context	Site Features (Site Type)	Total	*%*
Open	Artefact	9	*31.1*
	Shell; Artefact (Midden)	18	*62.1*
	Shell	1	*3.4*
	Restricted Site*	1	*3.4*
	Total	29	*100*

*Discussions were held with the AHIMS registrar regarding the location of the restricted site. It was confirmed that this site is not located within the vicinity of the study area (David Gordon, personal communication, 18/12/2018).

Other sources of information including heritage registers and lists were also searched for known Aboriginal heritage in the vicinity of the study area. These included:

- Shellharbour Local Environmental Plan 2013
- Kiama Local Environmental Plan 2011
- State Heritage Register and State Heritage Inventory
- Commonwealth Heritage List
- National Heritage List
- Australian Heritage Database
- Australian Heritage Places Inventory
- Register of the National Estate (non-statutory list).

No Aboriginal archaeological sites or Aboriginal heritage items listed on AHIMS or the heritage lists were situated within the study area.

The location of registered Aboriginal sites within the search area is shown on Figure 5.

Figure 5. Registered Aboriginal sites near the study area (AHIMS results)

4.2 Previous investigations around the study area

A number of Aboriginal archaeological surveys and assessments have been undertaken associated with the existing Dunmore Hard Rock Quarry, located to the north west of the study area. These have included a 2003 survey and assessment of Lot 1 DP 571406, Dunmore Hard Rock Quarry (Australian Archaeological Survey Consultants Pty Ltd (AASC) 2003); 2003 and 2004 survey and assessment as part of the DA for the increase in production at the quarry (Robert Paton Archaeological Studies Pty Ltd 2003, R.W. Corkery & Company Pty Limited 2003, AASC 2004); and in 2008 survey and assessment as part of the Statement of Environmental Effects for the proposed Hard Rock Quarry extension (AASC in R.W. Corkery & Company Pty Limited 2008). These previous assessments identified one open artefact scatter (site DQ1; AHIMS 52-2-1791) and one scarred tree (site DQ2; AHIMS 52-5-0300) within the existing Dunmore Hard Rock Quarry area.

KNC has also undertaken archaeological investigations for the Dunmore Hard Rock Quarry (KNC 2017). Three test excavation areas were identified within the assessment area on a south east running spurline in proximity to a natural reservoir. Soils consisted of erosional Bombo Soil Landscape occurring as sandy clay loams, underlain by Bumbo Latite. Test excavations recovered a total of 86 artefacts. Raw materials included primarily fine grained siliceous stone, classified as agate, chalcedony and chert, as well as smaller quantities of quartz, silicified tuff, mudstone, unidentified fine grained siliceous, jasper, unidentified medium grained siliceous, igneous, petrified wood and quartzite. Artefact types included a hatchet/anvil fragment which had been recycled for use as a core, modified cobbles, whole flakes and a backed artefact. The three areas were subsequently identified as three artefact scatter sites (Croome West AFT 1, Croome West AFT 2 and Croome West AFT 3). Croome West AFT 1 and Croome West AFT 2 were identified as having moderate archaeological significance and have subsequently been salvaged in accordance with mitigation measures. Croome West AFT 3 was assessed as having low archaeological significance and no further assessment was deemed necessary.

Salvage excavations were completed by KNC in 2018 of two artefact scatter sites, Croome West AFT 1 (CW1) and Croome West AFT 2 (CW2). The assemblages consisted of a total of 1,188 artefacts from both CW1 and CW2. They were mostly comprised of flakes, with limited on site manufacturing, as evidenced by the limited number of cores and mainly low artefact density across CW2. The generally low frequency of cores and slightly higher frequency of modified flakes (including 21 backed artefacts) all trended towards a non-utilitarian use of the hill crest. Cultural activity on the site was likely to have been for a specific cultural practice, with lithic resources carried in from the surrounding area or even coastal gravels to the east.

Closer to the current study area, Sullivan completed an assessment in 1977 of an area adjacent to the Minnamurra River, where she identified two concentrations of archaeological material. A dense scatter of artefacts and shell was identified over an area of 5 square metres on the margins of a large pond resulting from sand mining, on a Quaternary alluvial plain, approximately 500 metres south-west of the current study area. The site was recorded as Minnamurra Glengowrie (AHIMS 52-5-0072) (Figure 5). At another location augering indicated that stratified deposit 10-20 centimetres thick was present at 20 centimetres depth. This second site was identified within the coastal beach ridge landform, at the bottom of the Wants Hill, approximately 100 metres south of the study area. It was recorded as artefact scatter Minnamurra (AHIMS 52-5-0117) (Figure 5). Identified cultural material included scattered shell, charcoal, burnt bone fragments and flaked stone material exposed and disturbed by local sand mining. Considering the proximity to estuarine resources, it was noted that there was a high likelihood that further Aboriginal archaeological material could occur within the area, particularly around the base of the hill to the north and east.

An archaeological survey as part of an EIS was completed by K. Gollan within the Tabbagong property in 1983. One Aboriginal shell midden and artefact scatter site was identified 10 metres from the wetland margin north of the Minnamurra River, approximately 500 metres south-west of the current study area. The site was recorded as Tabbagong; Tabbagong 1 (AHIMS 52-5-0159), and consisted of shell material and fine grained siliceous stone artefacts located within an area of 20x30 metres and to 30 centimetres depth under 10 centimetres of organic cover. It was considered that good pasture grass was protecting the surface of the site and that there was no threat to the midden from erosion or traffic.

A survey for the Shellharbour Waste Disposal Depot at Dunmore, one kilometre north of the current study area identified one site, a remnant midden, that is recorded on the AHIMS register as two separate sites: Dunmore Midden Shellharbour Waste Disposal Dump (AHIMS 52-5-0201) and Dunmore Midden (AHIMS 52-5-0213) (Figure 5), 20 metres south of Rocklow Creek (Bonhomme 1985). The site covered an area of 25 square metres, on a flat area adjacent to the swamp on a Quaternary alluvium, extensively disturbed by sand mining. It has since been destroyed. No further archaeological sites were identified.

Previous research undertaken by Sullivan in 1982 on the south coast has shown that middens in the estuarine environments were usually located on elevated ground around the margins of the estuaries. Navin (1987) found that areas around Lake Illawarra contain sites on raised surfaces of older sediments above the inundation zones.

A number of other studies have been undertaken surrounding the study area with some interesting archaeological results. These have included identification of a series of Aboriginal sites (all artefact scatters) associated with lowland alluvial and former estuarine deposits.

Five open artefact scatter sites were recorded to west of the current study area during an archaeological assessment of a proposed development area at Dunmore (Navin 1989). The cluster of recordings was associated with an alluvial plain and wetlands overlying earlier estuarine sand deposits. Dunmore 1 (AHIMS 52-2-0251) was a small open artefact scatter identified on the edge of a ridge crest which formed a major boundary between the Minnamurra River and the wetlands associated with the lower reaches of Rocklow Creek. Five artefacts were identified including a scraper, flakes and a flaked piece of silcrete, fine grained siliceous material, rhyolite and chert. Shell fragments of Sydney cockle and southern mud oyster were also identified. The site had been disturbed by European land use practices including agriculture and road construction.

Dunmore 2 (AHIMS 52-2-0252) was a larger open artefact scatter identified on the eastern margins of the alluvial plain, at the base of a low ridge spur. Over 35 artefacts were identified across an area of approximately 60m x 40m, with exposed sections along a vehicle track containing artefacts at a depth of 30cm. The north western portion of the site was disturbed by road construction, erosion and sand mining but the majority of the site was considered likely to be intact. Artefacts included cores, choppers and retouched flakes, a scraper and numerous flakes and flake fragments. A wide range of raw materials was identified including rhyolite, silcrete, petrified wood, basalt and other igneous materials. Shell fragments of oyster, Sydney cockle and mud whelk were also identified at the site. The variation in artefact types and raw materials was considered reflective of a wide range of site activities.

Open artefact scatter site Dunmore 3 (AHIMS 52-2-0253) was identified less than 50 metres west of Stage 5A on the edge of a low terrace at the base of a north-running ridge spur, approximately 18 metres west of the Dunmore House boundary fence. Based on topography, it was considered likely the terrace represented a former beach line or dune feature during the estuarine phase. Nineteen artefacts were exposed in the spoil of a cattle burial pit across a 10m x 7m area. The exposure faced north and was located on the eastern margin of the alluvial lowland plain. Artefacts included a grey silcrete blade, red silcrete geometric microlith, red silcrete flaked piece, rhyolite blade, flakes of grey and red silcrete and fine grained volcanic flaked pieces, as well as alluvial basalt pebble manuports. It was considered that the site most likely had subsurface deposits in a largely undisturbed context.

Dunmore 4 (AHIMS 52-2-0254) was identified along the northern edge of a low dunal sand body, considered to be an eroded relic of a beach line from the area's estuarine or inlet phase. Twelve artefacts were identified across a recent exposure of the dune slope associated with tree removal works. Associated shell material included fragmented and weathered pieces of Sydney cockle, oyster and mud whelk species. Artefacts included flakes and flaked pieces of rhyolite, chert, silcrete and quartz. Fine grained volcanic pebbles and pebble pieces were also identified. The low density of artefactual material was considered to indicate a mostly subsurface site which had been exposed through disturbance. The site may have been destroyed during construction of the highway upgrade.

Dunmore 5 (AHIMS 52-2-0255) was identified approximately 150m south of Dunmore 4, on the same dunal sand body. A medium density scatter of 40 artefacts and three oyster shell fragments were identified in an exposure of approximately 25 x 25m. The site had been disturbed by construction of a carpark to the south, which had effectively levelled and truncated the dune deposit. Artefacts included large (>50mm) quartz flakes and fractured pebbles, a chalcedony flake, pebble manuports, rhyolite scraper, rhyolite flakes, petrified wood flaked pieces, silcrete and chert flakes and flaked pieces, fine grained siliceous flakes, volcanic flakes and fractured pebbles and a retouched fine grained siliceous flaked piece displaying platform preparation. Given the landform context, it was considered highly likely that intact archaeological subsurface deposit occurred within the dunal body between sites Dunmore 4 and Dunmore 5. Further archaeological investigation was recommended if impact to sites Dunmore 3, 4 and 5 could not be avoided.

Archaeological assessment of Aboriginal sites was completed by Silcox in 1990 for the proposed North Kiama Bypass between Dunmore and Bombo. Sections of the highway (currently Princes Highway A1) are located 100 metres west of the current study area. Survey resulted in re-location of three previously recorded Aboriginal sites (52-5-0251, 52-5-0253 and 52-5-0072), and identification of one new Aboriginal site and areas of archaeological potential. Site KB1 was identified at the east side of the sand mine pondage, directly opposite site 52-5-0072. The site consisted of a sparse scatter of shell fragments and two stone artefacts on the sloping banks of the sand mine pondage on 'Glengowrie'. It was considered that the site would be most likely impacted by the construction zone. KB1 is not registered on AHIMS. Two locations were identified as having potential for archaeological deposits: area KBx was located in the vicinity of site 52-5-0253 within the terrace; and area KBy was identified west of the Minnamurra River on a low ridge south of the pondage on 'Glengowrie'. These two areas were identified on the basis of previous research undertaken by Sullivan (1982) and Navin (1987) indicating that Aboriginal sites were likely to occur on toeslopes and elevated surfaces, such as terraces around the margins of estuaries and floodplains. Due to slope processes or to sediment accumulation from floodplain dynamics, such sites may have been buried, and their existence could be established only through test excavations.

A test excavation on a remnant beach ridge at Dunmore north of the current study area recovered 939 stone artefacts from 19 of the 20 test pits (Navin Officer 2000). All test pits revealed a profile dominated by well-sorted sandy matrix, of probable Aeolian/beach origin. Small quantities of midden shell were recovered from seven pits. Artefact material was predominantly chert and silcrete (over 40%) with quartz, chalcedony and volcanic material comprising much of the rest of the assemblage, with very small amounts of jasper, quartzite, petrified wood, mudstone, limestone and porphyry and sandstone. The site has since been destroyed.

Mary Dallas identified shell midden and artefact site Minnamurra River Shell Midden 1 (MR1) (AHIMS 52-5-0526), located approximately 180 metres east of the current study area. The Aboriginal cultural material was exposed within an area of 20x30 square metres, with the densest shell component over 20x7 square metres. Shell species included mature edible individuals of primarily Hercules Whelk *(Pyrazus ebeninus)*, Sydney Rock Oyster *(Saccostrea glomerata)*, with lesser amounts of Sydney Cockle *(Anadara trapezia)*. No other shell species and no other animal or fish bone was noted. The shells were present in the light grey to brown grey sandy matrix that contained small amount of rounded pumice indicating reworking/redeposition by storm action, therefore the presence of nearby coast or ocean shore in the past. A total of 7 artefacts were recorded within the exposure consisting of quartz, coarse grained silcrete, chert, quartzite and fine grained siliceous flakes and a core. It was recommended that archaeological test excavations be undertaken in order to establish full extent of the site.

In 2015 Neville Baker recorded an Aboriginal shell and artefact scatter site, Riverside Drive 1 (AHIMS 52-5-0819), located approximately 100 metres east of the study area (Figure 5). Five stone artefacts consisting of silcrete and quartz flakes and one quartzite hammerstone were identified within a disturbed infrastructure area within the active Minnamurra River tidal flat. Estuarine shell fragments were also identified in association with the artefacts. It was considered that prior to modern development the area would have been subject to active cycles of erosion and deposition which do not favour the preservation of Aboriginal sites. The soil is unconsolidated alluvial sand indicative of a very recent deposition. This suggested a very disturbed nature or imported cultural material.

Overall, previously recorded Aboriginal archaeological sites around the study area demonstrate a variety of site types and geographical locations. AHIMS results and background research indicate that a relationship exists between site type and environmental context, demonstrating the different ways in which Aboriginal people used the landscape and the subsequent archaeological record of these activities.

General assumptions that stem from the results of previous assessments in the estuarine environments point out that various sedimentation processes associated with the infilling of the estuary and the aggrading nature of lower slopes may have resulted in covering of the archaeological sites. Test excavations would most likely be necessary in order to determine whether the subsurface archaeological deposit is present. The most likely Aboriginal site types to occur within the study area and its surroundings are artefact scatters often associated with shell middens. They are likely to occur on the well-drained, remnant landforms bordering the estuary resource zones. They often might be exposed by land use practices, such as mining activities and removal of trees, or geomorphological processes, such as erosion and fluvial activity.

Within lowland areas along watercourses, artefact scatter sites and isolated finds are the most common site type, reflecting the day-to-day economic activities and camping locations of Aboriginal people. Along waterways closer to the coast, the association of shell remains with artefact deposits also indicates the exploitation of freshwater molluscs and possibly, earlier estuarine food resources, such as at sites 52-5-0251 – 52-5-0255. Higher levels of disturbance have also been reported at the lowland sites, in part due to the more concentrated modern land use of these areas for intensive agriculture, mining/quarrying, transport and urban development. Artefact raw materials identified at the sites are available from the diverse underlying regional geologies.

Artefact scatter sites have also been identified along ridgelines and in elevated areas, including at Locking Hill in the vicinity of the study area (52-2-1791) and on the high mid-slopes of Stockyard Mountain to the west (52-5-0310/52-5-0311). Previous archaeological investigations have suggested these elevated areas were used as travel corridors between the different resource zones of the coast and hinterland. Steep slopes and drainage gullies along the ridges are also less likely to have been subject to European land clearance, increasing the likelihood of remnant old growth vegetation and the survival of scarred trees.

Summary

The review of background information revealed there were no known Aboriginal archaeological sites within the study area. There are four AHIMS registered sites within 200 metres of the study area. Three AHIMS sites (52-5-0526, 52-5-0253 and 52-5-0819) identified within tidal flats and saline swampy environments were subject to active, recent cycles of erosion and deposition processes. As such, any cultural material identified is unlikely to have been in its primary context and it is highly unlikely that deep stratified deposits occur in these conditions. One AHIMS site located approximately 100 metres south of the study area within the same beach ridge landform as Stage 5B, revealed stratified cultural deposits of shell and artefacts (52-5-0117). Another Aboriginal archaeological site was recorded within the same environmental conditions approximately 500 meters south-west of the study area (52-5-0159).

The identification of these sites in close proximity to and within the same landforms as the study area indicates that the study area may display archaeological sensitivity to retain Aboriginal archaeological material. The northern portion of the Stage 5A has some moderate sensitivity to contain scattered cultural material that would not be in its primary context. The southern section has a high archaeological sensitivity to contain Aboriginal objects. Stage 5B has a high archaeological sensitivity to contain deep stratified cultural deposits relating to Aboriginal activities on this specific landform. Areas of archaeological potential will be dependent on the levels of previous disturbance including natural agents and recent land modifications.

5 Visual Inspection

Visual inspections were carried out as part of the Aboriginal heritage assessment of the study area. The visual inspection included a pedestrian walk and assessment of the entire study area. Visual inspection aimed to assess the integrity of the archaeologically sensitive landforms identified within the area, the nature and extent of previous disturbance, the potential for Aboriginal objects to be present within the area and heritage potential of the trees within the study area.

Assessment of the pipeline and access tracks west and north of Stage 5A between Princes Highway found the area substantially disturbed by previous construction and crossed mostly lower sensitivity tidal flat areas in association with Rocklow Creek and the Minnamurra River. Visibility was on average good with areas of exposure located around the pond and within access tracks. The entire low lying area has been significantly disturbed due to past land use, with no areas of archaeological potential identified.

Plate 3. Looking south from the pond between Princes Highway and Riverside Drive.

Plate 4. Conditions around the pond and access tracks.

The inspection continued along the spurline that connects the tidal flat with the ridgeline, east of 'Dunmore House' (Plate 5). South of the ridgeline an extensive alluvial flat (Plate 6) was encountered that contains a few landforms in association with the Minnamurra River estuary. A small drainage line and a pond is located at the bottom of the ridge, flowing east through to the estuary. The Stage 5B area is located within the beach ridge landform that encompasses the pond and the area to its immediate south. The entire area was covered in short grass, with occasional patches of mid to high grass and some scattered tress present within the southern section (Plate 7). Average ground surface visibility varied between excellent in areas stripped of grass and poor within areas of dense vegetation cover. Areas of exposure were visible throughout the inspected area (Plate 8). Some areas of surface disturbance were visible that most likely stem from patchy previous sand extraction, tree removals and cattle trampling. Exposures were visible around the pond and trees, and small eroded areas due to water run off.

Assessment of Stage 5B found the Holocene beach ridge sand/soils and Holocene back barrier flat sand/soil all exhibiting high archaeological potential.

The estuarine environment around the Minnamurra River that established after the stabilisation of sea levels provided a great variety of predictable seasonal resources throughout the year for Aboriginal people. Sand bodies on the estuarine fringes are archaeologically sensitive landforms as they are elevated landforms that represent depositional land systems created by repeated and successive dune accretion, and as such are prone to conserve deep archaeological deposits. They would also have offered attractive camping locations.

Plate 5. Access driveway along the spurline, facing south.

Plate 6. View of the beach ridge from the ridgeline, facing south-east.

Plate 7. Scattered trees present within the southern section of area 5B.

Plate 8. Soil conditions within study area 5B.

Along the base of the hill representing the northern edge of Stage 5B was a truncated creek and pond (Plate 9). The exposed sands around the pond and creek exhibited numerous Aboriginal objects and some natural shell. The shell consisted of gastropod adult Mud Whelk *(Pyrazus ebeninus)* (Plate 10) in low dispersed densities and a natural size range. The Aboriginal objects consisted of flakes made from silcrete, jasper, petrified wood and chert; pebble cores of silcrete and quartzite; blades of fine silcrete and jasper (Plates 11 and 12). The site was recorded as Aboriginal artefact scatter DLS Boral AFT 1 (AHIMS 52-5-0907). It was determined that further Aboriginal cultural material and subsurface stratified archaeological deposits were likely present within the entire beach ridge landform in the Stage 5B area.

Plate 9. Conditions and exposures within the pond, facing south.

Plate 10. Non artefactual Mud Whelk species located within the exposed banks of the pond.

Plate 11. Pebble cores and flakes made of silcrete, jasper and petrified wood, located within the pond exposures

Plate 12. Petrified wood, jasper, silcrete and chert flakes and blades, located within the pond exposures in Stage 5B.

Further inspection was carried out within the southern section of the Stage 5B area within the entire beach ridge landform. The southern extent of this portion of the study area is covered with scattered trees. The surface was mainly covered in short to high grass, with scattered trees that included mainly regrowth, with occasional mature trees (Plate 13). The south-western section revealed denser grass cover than the northern part, with only occasional areas of exposure (Plate 14). Sandy conditions were noted with some shallow surface disturbance due to cattle trampling, tree removal activities, installation of fences and pedestrian and light vehicle traffic. Trees were carefully inspected for possible cultural modifications. No Aboriginal scarred trees were identified.

Considering the identification of artefacts within eroded banks of the pond, beach ridge sandy soils and low levels of previous disturbance, the section of the Stage 5B study area to the south was considered to have high archaeological potential for further Aboriginal cultural material to be present (Plate 16). Aboriginal stakeholders also noted that these landforms were sensitive for Aboriginal burials to occur.

Plate 13. Southern section of Stage 5B area, within beach ridge, facing north-east.

Plate 14. South-western section of Stage 5B area, general conditions, facing north.

A small depression located along the eastern boundary of the Stage 5B area indicates the location of the tidal flat associated with the Minnamurra River estuary. Vegetation cover in this section was evidently thicker and greener which stems from swampy, wet conditions. A small pond in this landform contained water and its banks were covered in vegetation. No mature native trees were observed that could have contained cultural scars. Ground surface visibility was moderate with occasional areas of exposure due to water runoff and cattle trampling. No evident disturbance was noted, with the surface revealing sandy conditions.

The tidal flat landform is low-lying and would not have been a preferred long-term occupation area in the past. In addition, tidal flats are subject to geomorphologically active cycles of erosion and deposition which do not favour the preservation of Aboriginal sites. Results of the AHIMS review revealed that Aboriginal sites can however occur in these environmental settings. Any archaeological material located would be in a disturbed context with no stratified occupational deposits, and would represent dispersed cultural material. No Aboriginal cultural material was observed during the site inspection and no areas of potential subsurface archaeological deposits were identified.

Plate 15. Tidal flat landform and small pond located to the east of the beach ridge in Stage 5B area, facing north-west.

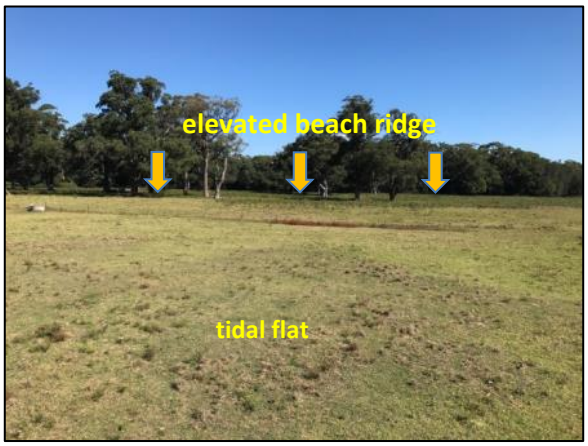

Plate 16. Looking south-west from the tidal flat across the elevated beach ridge within Stage 5B area.

Site inspection then continued within the proposed Stage 5A area, located to the immediate west of Riverside Drive. The northern section of the study area lies within a tidal flat located between Riverside Drive and the slopes associated with the ridgeline. It grades into the backbarrier flat (sand body) to the south, which was clearly marked by distinct vegetation cover and a slightly raised ground level (Plate 18).

The tidal flat landform was covered in thick but short pasture grass (Plate 17). Ground surface visibility was very low with some exposure areas limited to the informal vehicle track located along the bottom of the slopes. Very swampy, wet conditions were also observed in this section of the study area, with a sandy loam soil matrix. The tidal flat landform is an active land system prone to repeated erosion and deposition events, and as such is unlikely to preserve archaeological material *in situ*. Any cultural material located within this landform would not be in its primary context. No Aboriginal cultural material was located during the site inspection within the northern section of 5A, in the tidal flat landform. Archaeological potential for deep stratified occupational deposits to be present in this landform was considered to be low.

Plate 17. Tidal flat, Stage 5A study area, looking from slopes, facing north-east.

Plate 18. Tidal flat and backbarrier flat within Stage 5B study area, facing south-east.

The eastern extension of the Stage 5A study area (designated as an overburden stockpile area) is located within the steep lower slopes of the ridgeline that extends between Stages 5A and 5B. Slopes revealed very shallow soils consisting of silty loams and exposed latite bedrock (Plates 19-20). Significant levels of disturbance were also evident in this section of the area, due to the installation of a well for grazing purposes. Exposures were visible in these disturbed areas and also due to water runoff and stock trampling. Steep slopes would not be conducive for human occupation and shallow soils would not preserve any subsurface archaeological deposits. The slope landform was considered to have very low archaeological potential for Aboriginal cultural material to be present.

Plate 19. Steep slopes of the ridgeline and exposed latite bedrock, facing south.

Plate 20. Shallow soil conditions on steep slope landform, western part of Stage 5B area.

An extensive sand body was encountered during the site inspection within the southern section of the Stage 5A area, to the immediate south of the tidal flat. This area corresponds to a coastal barrier backbarrier flat. It was a slightly elevated landform with fine sandy conditions (Plate 21). The sand body extended from Riverside Drive to the east to the slopes of the ridgeline to the west and south. Ground surface visibility was moderate with some exposures observed due to disturbed areas and cattle trampling. Disturbance was visible mainly within the south-eastern portion, likely due to tree removal. A decayed wood dump was also noted in this area (Plate 22).

The back barrier flat landform represents a remnant landform formed by storm washover deposition during the initial stages of barrier evolution. It is generally a relict feature that is unaffected by contemporary geomorphological processes. As such it may retain deep stratified deposits. Any cultural material located within these deposits would be well preserved and most likely in primary context. The elevated nature of the sand body would make it a preferable location for repeated occupation events by Aboriginal people in the past, considering proximity to resources. Recent land use practices would impact on sandy surface soils, but the majority of the sandy deposit would be intact. No surface Aboriginal cultural material was identified during the site inspection. This southern section of Stage 5A was considered to have high archaeological potential to contain deep stratified occupation deposits.

Plate 21. Sand body - back barrier flat located within the southern section of the Stage 5A study area, facing north; general conditions.

Plate 22. Disturbances within the back barrier flat, facing west.

Summary

Previous archaeological assessments and the distribution of recorded archaeological sites across the landscape indicate a strong relationship between site type and geological, topographic and geographic factors. Additionally, environmental factors contribute directly to survivability of archaeological sites within the landscape. Within the study area, elevated sand bodies above the former estuarine environments are the most archaeologically sensitive landform. Aboriginal archaeological sites associated with these landscape features would have the potential to contribute significantly to our understanding of Aboriginal landscape use of these unique environmental contexts.

Visual inspection confirmed the potential for Aboriginal objects based on: stability of deposit, intact soil profiles, topographically favourable features related to elevated level ground and vistas, proximity to known archaeological sites and presence of surface Aboriginal objects within the eroded areas. Ground surface visibility within the study area varied from high to low with some exposures limited within tracks, around trees and within the banks of a pond in the Stage 5B area. Identified artefacts were recorded as DLS Boral AFT 1, an artefact scatter site (Figure 6) located within the beach ridge landform. Archaeological potential for subsurface archaeological deposits was assessed as high.

The Stage 5A area revealed dense grass cover and a lack of exposure areas. No Aboriginal objects were identified during the field inspection. Considering the environmental setting, low degree of previous disturbance, intact sandy soil conditions and previously recorded sites within similar conditions, it was considered that the southern portion of the Stage 5A area within the back barrier flat contains high archaeological potential for subsurface Aboriginal objects to be present. The tidal flat located in the northern section of the Stage 5A area was considered to have moderate potential to contain cultural material that would be in a secondary (disturbed geomorphic) context.

Further detailed investigation (subsurface testing) was therefore recommended to determine the nature, extent and significance of any archaeological sites and potential archaeological deposits within the study area.

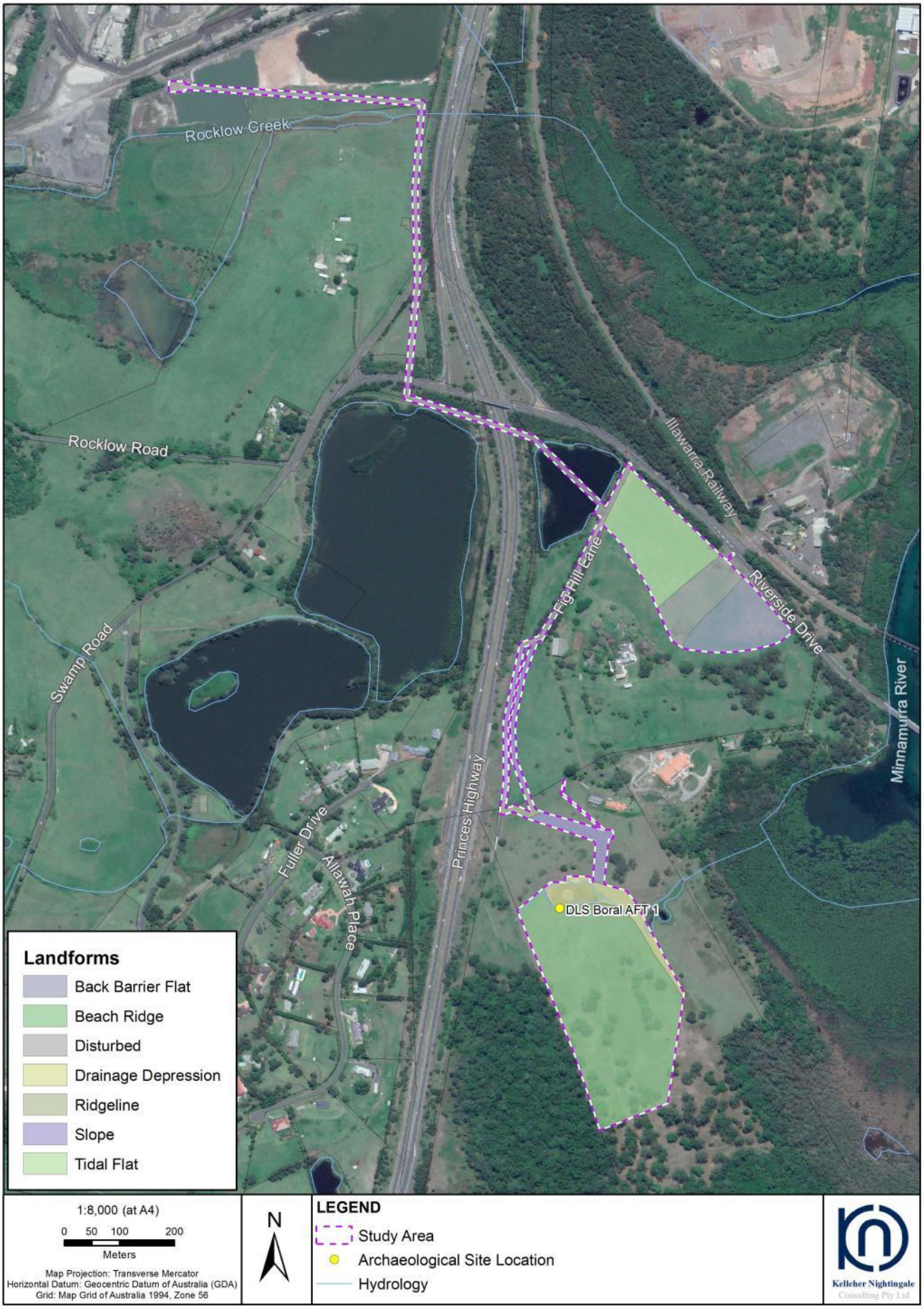

Figure 6. Visual inspection results, landforms and recorded Aboriginal site, DLS Boral AFT 1.

6 Archaeological Test Excavation

Archaeological test excavation was carried out by KNC and registered Aboriginal stakeholders over five days between in November 2018, in accordance with the OEH *Code of Practice for Archaeological Investigation of Aboriginal Objects in New South Wales*. Aims, methodology and results of the test excavation program are presented below.

6.1 Aims

The purpose of the test excavation program was to collect information about the nature, extent and significance of the Aboriginal site DLS Boral AFT 1 recorded during the site inspection within the Stage 5B area; and to determine whether subsurface Aboriginal objects occurred in the Stage 5A area. Test areas at Stage 5B and the southern portion of Stage 5A were considered to have high archaeological potential for subsurface Aboriginal objects to be present. Therefore the primary aim of the test program was to confirm the presence, nature and extent of potential archaeological deposits within the 5A and 5B areas. Additional goals of the test excavation were: to assess the boundary of the site areas in relation to the proposed development, to investigate the relationship between specific topographic features and archaeological deposits and to observe the effects of disturbance on archaeological deposits.

Test excavation results would inform the archaeological assessment, including development of appropriate management and mitigation measures. The testing area was restricted to ensure an adequate sample without having significant impact on the archaeological value of any identified sites.

Plate 23. View to south-east along baseline transect from TS4, Stage 5B study area; natural pond at left.

6.2 Methodology

The field methodology was developed and carried out in accordance with Requirement 16a of the OEH *Code of Practice for Archaeological Investigation of Aboriginal Objects in New South Wales*. The study area was divided into two excavation areas based on the proposed extraction stages. The back barrier in the Stage 5A area and the beach ridge in 5B were considered to have high archaeological potential; the tidal flat in 5A was considered to have moderate archaeological potential. The main aim of testing the tidal flat was to determine soil conditions in order to assess if they would be prone to conserving subsurface archaeological deposits. The proposed test areas were differentiated from the surrounding landscape by the presence of unique Quaternary depositional systems (coastal barrier units) and spatially defined by the presence of flanking estuarine and alluvial landforms. Test transects were placed across the areas to confirm the presence/absence, location and extent of archaeological deposits.

Test transects were placed on a systematic grid at 20m intervals and test excavation units placed at 10-40m intervals along these transects, based on the encountered surface disturbance and/or the extent of the study area. Easting/northing coordinates were taken at the north west corner of each excavation unit. The test units at each area were then given an arbitrary identifying number (e.g. TS 1, TS 2, TS 3). Test excavation units measured 50cm x 50cm. At five locations, additional test excavation units were placed next to the already excavated units in order to test the depth of encountered archaeological deposit or its nature. These additional adjoining units were given an additional reference letter (e.g.1B, 1C). A total of 45 test squares (11.25m^2) were excavated: 17 at Stage 5A and 28 at Stage 5B.

In accordance with the *Code of Practice*, the first excavation unit of each investigation area (each landform) was excavated in 5cm spits onto a culturally sterile deposit to determine the nature of the subsurface deposit and the presence or absence of artefactual material. The majority of test excavation squares were limited to 1m depth. Two excavation units were excavated to 1.2m in order to determine if the same soil matrix with archaeological deposit was present. Based on the results of the first excavation square, subsequent squares in each area were excavated in 10cm spits until culturally sterile deposit or 1m depth was reached.

Where artefacts were identified during excavation (i.e. *in situ*), measurements were taken of the artefact's position and depth in the excavation unit, as well as its relation to any other features such as charcoal, baked clay, tree roots or other evidence of disturbance. When possible cultural features were encountered, these was excavated and sieved as a separate unit.

All excavation was undertaken using hand tools. All excavated material was placed in buckets and transported to the adjacent sieving area and dry sieved using a combination of nested 5 millimetre and 2.5 millimetre wire mesh screens. Artefacts retrieved from the excavation were retained for further investigation.

The information from each test excavation square including a detailed deposit description, any excavated features and unit depths were recorded onto standardised excavation forms. At the end of the excavation program, all squares were photographed and soil section profiles were drawn. As per OEH requirements, the test excavation ceased when enough information had been recovered to adequately characterise the archaeological deposits or Aboriginal objects present with regard to their nature and significance.

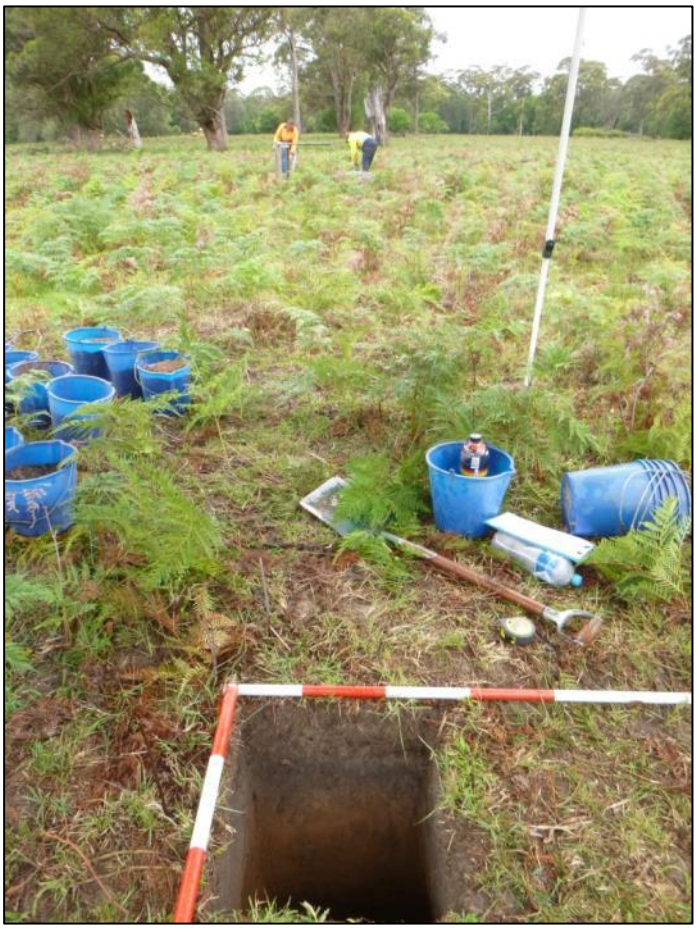

Plate 24. Hand excavated 50cm x 50cm test square, TS20, Stage 5B study area, facing south.

Excavation Director: Dr Matthew Kelleher
Archaeologist/Site Supervisor: Ana Jakovljevic
KNC Archaeologists**:** Owen Barrett, Carly Todhunter, Waleed Al Mendin
Aboriginal Stakeholder Representatives: Steven Henry (ILALC), James Davis, Kayla Williamson (WPGEC), Mark Dutton (Goobah) and Leanne Tungai.

6.3 Results

6.3.1 Stage 5A area

Test excavation at Stage 5A aimed to determine if subsurface archaeological deposits existed within two landforms: the back barrier flat landform located within the southern section of Stage 5A that was assessed as having high archaeological potential; and the tidal flat landform located within the northern section of Stage 5A that was assessed as having moderate archaeological potential. The entire study area has gone through varied levels of previous disturbance including vegetation clearance and stump removal. Localised areas of tree dumping were present within the southernmost part of the study area, but overall the integrity of this part of the study area was good. Observation of the soils suggested a stable profile.

A total of 17 test squares were excavated across 5 transects. Transects were placed in a north-west – south-east, and north-east – south-west direction, with test squares on a 20m interval grid (Figure 7).

The northern section of the study area was located within the low lying tidal flat, with dense vegetation cover and very wet surface conditions. A total of 2 test squares were excavated along a north-east – south-west oriented transect, spaced 20 metres apart (TS 15 and TS 16).

Within the central part of the study area, a slightly elevated landform with loamy surface conditions was subject to test excavation. Three test squares were excavated along a north-west – south-east transect, 20 metres apart (TS 1, TS 2 and TS 3).

The back barrier flat landform comprised an elevated sand body within the southern section of the study area. The area had sparse vegetation cover with one section at the southernmost part observed to have gone through previous disturbance. A total of 12 test squares were excavated along three transects: two transects along a north-west – south-east orientation (TS 4 – 11, including TS 6A and 6B), and one transect along a north-east – south-west orientation (TS 12 – 14), in 20m intervals.

Plate 25. Tidal flat, facing west, showing TS 15 across the landform towards the slopes.

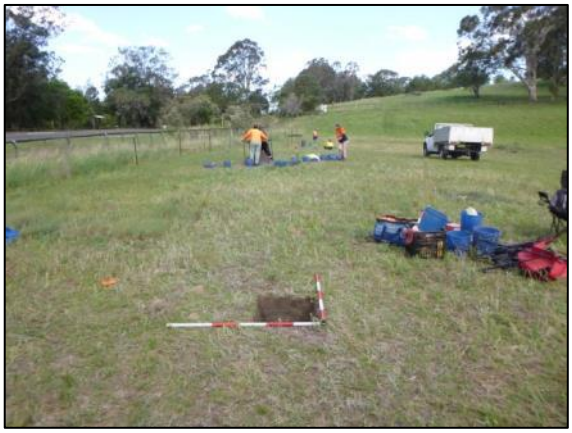

Plate 26. Facing south-east, showing TS 5 across the back barrier sand body and TS 6A and 6B in the distance.

6.3.1.1 Soils, stratigraphy and disturbance

Sediment profiles varied across the two different landforms. One area of significant disturbance was identified stretching throughout the central section of the study area. Representative sections of test squares across the study area are presented and described below according to three different soil profiles.

The elevated landform area identified within the central section of the study area revealed a significant amount of fill material throughout (TS 1-3) Units were excavated to a maximum depth of 35 centimetres. No natural soils were encountered. It was considered that the entire elevated area had a significant amount of fill material deposited (Plate 27).

The southern section of the study area within the back barrier sand body revealed a deep sandy soil matrix to the base of test squares. Some fill material was encountered from 5 to 25 centimetres depth in TS 4, 11, 12, 13 and 14. A pipeline was also encountered in TS 10 at 60 cm depth and the pit was abandoned. Fine root systems were present throughout the area, with charcoal flecks and burnt tree roots encountered in the majority of excavated units, limited to the first 60 cm depth. Soil profiles were relatively uniform throughout the landform.

Deep sandy deposits consisted of between 30 and 60 centimetres of grey sand with frequent charcoal flecks and fragments, overlying up to 40 centimetres of light greyish brown and light brown sand, and slightly darker, orange brown sand from on average 80 centimetres depth to base levels of up to 1.2 metres depth (Plate 28).

The tidal flat located within the northern low lying section of the study area revealed very wet, swampy conditions. No areas of significant ground disturbance were identified. Fine root systems were present within the first 10 centimetres. Soils consisted of up to 10 centimetres of dark grey, almost black sand with gravel and ironstone inclusions, overlying between 10 and 20 centimetres of moist brown grey sand, and up to 30 centimetres of light brown sand. The base of excavation encountered the water table at an average of 70 centimetres depth (Plate 29). The tidal flat represented an area of relatively rapid (humic) soil cycling and damp-wet soils generally less suitable for intensive occupation by past Aboriginal people.

Plate 27. Stage 5A - TS3 south section

I. 0-25cm: Dark grey-brown loam, humic. Abundant rock inclusions to <15cm 20% including road base, bricks, sandstone and ironstone. Scattered lumps of clay. Diffuse boundary to:
II. 25cm-35cm: Dark orange brown clayey loam. Mixed lumps of clay, ironstone pieces and scattered rocks and gravel.
III. At 35cm: Orange and grey clay clumps, mixed with rocks and gravels.

Plate 28. Stage 5A, back barrier landform, TS6B east section

I. 0-8cm: Medium grey sand, humic layer. Frequent fine root systems throughout. Diffuse boundary to:
II. 8-36cm: Medium grey sand. Charcoal fragments between 30 and 36cm. Diffuse boundary to:
III. 36-63cm: Light greyish brown fine sand. Larger charcoal fragments between 45 and 60 cm mainly within the southern section. Diffuse boundary to:
IV. 63-78cm: Light orangy brown sand. Some mottled light brown sand mottled. Diffuse boundary to:
V. 78cm-base: Orangy brown sand, moist. Continuing to the base
VI. Base: Orangy brown sand.

Plate 29. Stage 5A, tidal flat landform, TS15, north section

I. 0-9cm: Dark grey sand, humic layer. Frequent fine root systems throughout. Diffuse boundary to:
II. 9-30cm: Dark grey, almost black sand, moist. Ironstone and gravel inclusions, approximately 10%. Possible acid sulphate contamination due to the strong odour. Clear boundary to:
III. 30-48cm: Brown grey sand, moist. Diffuse boundary to:
IV. 48cm-base: Light brown sand, high moisture content. Clear boundary to:
V. Base: Light brown sand. Water table encountered.

6.3.1.2 Artefact Distribution

Three artefacts were recovered from the three units excavated within the disturbed area (TS 1-3). They consisted of two quartz angular fragments, and one quartz retouched flake. Since they were identified within disturbed fill material, they are not located within their primary context. It is possible that they were imported to the area or they represent dispersed cultural material from the vicinity. These three artefacts were recorded as an Aboriginal site representing isolated, disturbed cultural material: DLS Boral AFT 3 (AHIMS 52-5-0909).

A more significant deposit was identified across the back barrier landform test area (TS 4 – 14). A total of 461 artefacts were recovered from the 12 test excavation units within this back barrier landform. The site was recorded as artefact scatter DLS Boral AFT 2 (AHIMS 52-5-0908). Artefact densities for these test squares are shown in Table 3 and Figure 7.

Table 3. Test excavation artefact densities at site DLS Boral AFT 2

Test square	Total artefacts
4	9
5	47
6A	24
6B	39
7	89
8	66
9	29
10	2
11	61
12	36
13	47
14	12

Artefact distribution within DLS Boral AFT 2 was characterised by low to high density deposits. Test square 10 contained the lowest number of artefacts. This is due to the fact that the test unit was abandoned at 50 cm depth due to identified disturbance, so results from this test square are not relevant for the discussion of overall results. Apart from TS 10, test squares 9 and 14 contained the lowest number of artefacts. These excavation units were located within the margins of the back barrier sand body, i.e. at the margins of the site extent. The area of the highest artefact density was located within the middle section of the sand body, with no areas of identified disturbance. Test square 7 had the highest (extrapolated) mean artefact density with 356/m^2, followed by test square 8 (264/m^2) and TS 11 (244/m^2).

Extrapolated to square metres, the site area displayed a mean artefact density of 115.3/m^2.

Table 4. Spit depths and artefact count.

Test square	*4*	*5*	*6A*	*6B*	*7*	*8*	*9*	*10*	*11*	*12*	*13*	*14*	*Total*
0-10	4	1	1			1				1	10		**18**
10-20		2				1				1	3		**7**
20-30		3	1			2					1	2	**9**
30-40		1		2	2		5		1			9	**20**
40-50			2	1	5	2	5		3		1		**19**
50-60		5	7	8	9	2	13	2	17	11	6		**80**
60-70	1	17	12	23	66	16	3		34	23	25		**220**
70-80	2	16	1	5		32	3		3		1	1	**64**
80-90	1	2			6	10			2				**21**
90-100	1				1				1				**3**
	9	**47**	**24**	**39**	**89**	**66**	**29**	**2**	**61**	**36**	**47**	**12**	**461**

The majority of artefacts were found from 60 to 70 cm depth (n=220, 48%), followed by between 50 and 60cm (n=81, 17%) and between 70 and 80cm (n=64, 13%) (Table 4). All of these artefacts were recovered from light orange-brown sand deposits. These results indicate that the majority of the cultural material is preserved within the subsoil sandy horizon that represents a relatively stable and intact soil. Although artefact numbers decrease from 80 centimetres depth, they were still recovered from as deep as 1 metre. Considering that the same sandy matrix that contains artefacts appeared to continue below 1 metre, it is still possible that cultural material could occur in the area within deeper sandy deposits.

A total of 14 artefacts were recovered from the top 17 centimetres in both TS4 and TS13, which contained fill material. Although it is not possible to determine their primary context, these artefacts were included in the assemblage as they were found within the perimeter of the site. Raw material and artefact types indicate that it is possible they represent dispersed/disturbed cultural material from the area that was mixed with the introduced fill.

Figure 7. Stage 5A study area test square locations and artefact density.

6.3.1.3 Lithics

The dominant raw material was quartz (n=225, 48.8%), followed by silcrete (n=84, 18%), fine grained siliceous (FGS) (n=59, 12.7%) and chert (n=47, 10%). A range of other raw material was recorded including chalcedony, medium grained siliceous, petrified wood, tuff, and one each of mudstone, sandstone and quartzite (Table 5). Artefacts were generally small, with the majority between 5 and 14 millimetres (Table 5). The least number of artefacts were between 35 and 59 millimetres. The largest artefact was between 100 and 104 millimetres, comprising a hammerstone made from MGS recovered *in situ* from 65-69 centimetres depth in TS 13 (Plate 30). Artefacts measuring between 24 and 29 millimetres had the greatest variety of raw material present.

The majority of artefacts were flakes (n=200, 43.3%) and non-diagnostic flaked angular fragments (n=159, 34%) (Table 6). Other artefact types had much lesser representation, including proximal, distal and split flake fragments (average 5% each). Cores were not abundant in the assemblage (n=11, 2.3%), but were represented across a variety of raw materials, with the majority made of quartz and silcrete, and one each of chalcedony, chert, FGS and jasper. A jasper core was identified in TS 9 from depths between 50 and 60 centimetres; it was previously a flake, but recycled to be used as a core with one clear negative scar. The same test square contained four more jasper artefacts with one retouched angular fragment at 30-40cm depth (Plate 30) and one angular fragment at 70 centimetres depth. The recycling indicates that this material was likely highly valued in the area. Two bipolar quartz cores were recovered from TS 12, one from 10 centimetres and one from 50-60 centimetres.

No formal tools were recorded within DLS Boral AFT 2, but a total of 20 retouched/backed artefacts were identified, both with and without usewear. The majority of backed artefacts were made of white and grey white crystalline quartz, with one exhibiting characteristics of a chisel point, recovered from TS 11, spit 7 (Plate 32). Three retouched crystalline quartz backed artefacts were recovered from TS 7, and two from TS 6B located 20 metres to the north-west. This indicates that a particular activity was most likely occurring in this area. TS 9 contained three retouched artefacts made of jasper, chalcedony and silcrete (Plates 31 and 33). These were located at depths of 30-60 centimetres, from a light grey sandy layer. It is unclear if this preference of raw material for backed artefacts indicates events from two different occupation deposits, stemming from different episodes of site use. Further investigations would be required in order to answer this question.

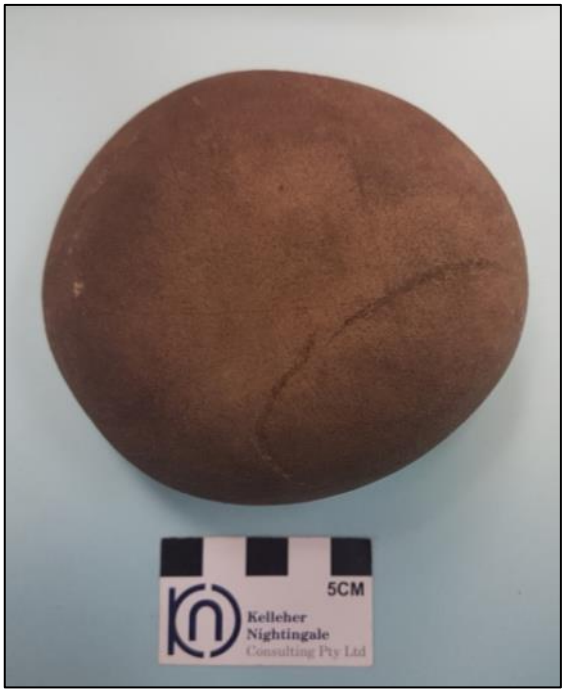

Plate 30. Hammerstone made from MGS recovered *in situ* from TS 13 from 65-69 centimetres depth (ID 430).

Plate 31. Jasper core and flakes (ID 297-299), TS 9, 50-60cm depth, jasper retouched angular fragment (ID 281), 30-40cm depth.

Plate 32. Crystalline quartz backed artefacts (ID 118 - TS 6B, ID 150, 151 and 155 TS 7, spit 7.

Plate 33. Variety of raw material in TS 9 (ID 297,298, 293) including silcrete retouched flake (ID 292) and jasper (ID 306).

Although low in artefact count, TS 9 revealed the greatest variety of raw material types. A general trend was observed that chalcedony, jasper, chert and FGS were more frequent in upper layers, with quartz prevailing within deeper light yellow sandy soils, followed by a small representation of silcrete and chert (Plate 33).

It was noted that the majority of artefacts do not show traces of reworking or other damage from movement or disturbance, indicating the stable soil matrix forms their primary archaeological context.

Table 5. Artefact raw material distribution and size at DLS Boral AFT 2

Raw Material	0-4mm	5-9mm	10-14mm	15-19mm	20-24mm	25-29mm	30-34mm	35-39mm	45-49mm	50-54mm	55-59mm	100-104mm	*Total*
Quartz	29	97	63	15	11	4	1		1		1		***222***
Quartzite				1									***1***
Chalcedony		6	7	2									***15***
Chert	3	14	17	7	3	3							***47***
FGS	5	25	18	8	1	2							***59***
MGS		1	2			1		1		1		1	***7***
P. Wood		5		1		1							***7***
Igneous			1										***1***
Jasper		5	4	3	1	1							***14***
Mudstone						1							***1***
Sandstone						1							***1***
Silcrete	1	34	27	6	9	3	3	1					***84***
Tuff						2							***2***
Total	***38***	***187***	***139***	***43***	***25***	***19***	***4***	***2***	***1***	***1***	***1***	***1***	***461***

Table 6. Reduction types at DLS Boral AFT 2

Raw Material	Flake	Proximal Fragment	Distal Fragment	Split Fragment	Medial Fragment	Angular Fragment	Core	Hammerstone
Quartz	106	5	9	12	2	84	4	
Quartzite	1							
Chalcedony	11		1			2	1	
Chert	25	3	6	4		8	1	
FGS	14	6	5	5	1	27	1	
MGS	2					4		1
P. Wood	4	1				2		
Igneous	1							
Jasper	5		3			5	1	
Mudstone	1							
Sandstone						1		
SIlcrete	28	10	8	7	7	21	3	
Tuff	1					1		
Total	***199***	***25***	***32***	***28***	***10***	***155***	***11***	***1***

Cortex was relatively infrequent on artefacts recovered from DLS Boral AFT 2. Cortex was recorded on 47 artefacts, representing 10.2% of the site assemblage (Table 7). Artefacts made of petrified wood, igneous, jasper, mudstone and sandstone did not display any cortex. Quartz was the raw material that displayed the highest frequency of cortex (n=31, 65.9% of all cortical artefacts). Surfaces of 1-30% cortex were recorded on 41 artefacts (87% of cortical artefacts), with only 2 quartz cores having >70% cortex. The results indicate that while some knapping did occur in the area, primary and secondary reduction of cores was not a focus of activity at the site.

Table 7. Amount of cortex on artefacts from DLS Boral AFT 2, in relation to raw material and artefact type.

	0%	1-30%	31-69%	*>70%*	*Total*
Quartz	191	27	2	2	222
Quartzite	1				1
Chalcedony	14		1		15
Chert	44	3			47
FGS	56	3			59
MGS	5		2		7
Petrified Wood	7				7
Igneous	1				1
Jasper	14				14
Mudstone	1				1
Sandstone	1				1
Silcrete	78	6			84
Tuff	1	1			2
Total	414	40	5	2	461

	0%	1-30%	31-69%	*>70%*	*Total*
Core	7	1	1	2	***11***
Flake	181	14	4		***199***
Proximal Fragment	24	1			***25***
Distal Fragment	29	3			***32***
Split Flake	26	2			***28***
Medial Fragment	10				***10***
Angular Fragment	136	19			***155***
Hammerstone	1				***1***
Total	414	40	5	2	***461***

6.3.2 Stage 5B area

Test excavations within the Stage 5B area aimed to determine if further subsurface archaeological deposits occurred in association with the recorded Aboriginal cultural material within the exposed banks of the pond, recorded as artefact scatter site DLS Boral AFT 1. The site was recorded during the site inspection, when it was considered that the entire beach ridge landform south of the pond had high archaeological potential for subsurface Aboriginal objects to occur. Stage 5B is located in its entirety within the beach ridge landform. Beach ridge landforms represent successive periods of beach and frontal dune accretion during prolonged geological time scales; therefore it most likely contains deep stratified intact sandy deposits. It is also located adjacent to the estuarine environments that would have contained a wide variety of resources extensively utilised by Aboriginal people in the past. Sandy, elevated and well-drained landforms are known to be suitable for long-term and /or repeated human occupation.

A total of 28 test units along a series of east-west, and north-west – south-east transects were excavated at 20-40 metre intervals across the study area (Figure 8). The entire study area has gone through varied levels of disturbance including vegetation clearance, stump removal and agricultural activity. Overall, the study area was flat with some undulating sections, possibly due to minor sand extraction activities within the southernmost parts. On average the integrity of the study area was good. Observation of the soils suggested a stable profile.

Fine root systems were present throughout the area, mainly within first 20 centimetres. Larger root channels were occasionally found within topsoil (e.g. TS 15) but also within the lower depths of 80-100cm (TS 2A and 2B). Small fragmented pieces of charcoal were dispersed throughout the deposit in the majority of test squares; they were in most cases associated with burnt tree roots, and were limited to upper soil horizons. Some artefacts that were observed to have been affected by heat were most likely affected by these post-depositional impacts.

Naturally occurring colluvial latite pebbles were evident in TS 1A and 1B at 50-58 centimetres depth. No cultural material was recovered in association with these rocks. Other areas did not contain latite gravel and rocks. Some fill material was encountered in TS 13 to 32 centimetres depth above natural grey sand.

One charcoal feature was identified in TS 10C between 44 and 48 cm depth. It consisted of a circular cluster of charcoal fragments and two *in situ* artefacts located outside of this feature. The feature was separately excavated and sieved, with a total of 8 artefacts recovered including one large possible manuport. No other cultural material or features were noted.

One burning event was evident in TS 19 but no cultural material could be associated with it. It was considered to be a remnant of a natural event.

The soil profiles revealed deep fine sandy sediments, with few inclusions present (Plate 30, 31 and 33). Grey organic sand was present up to 40cm depth occasionally mottled with underlying pale light orange grey sand occurring to an average of 70cm. Slightly darker orange brown sand was encountered at the base of test squares at 1 metre. At the southern section of the study area two test squares (TS 21 and 22) revealed somewhat different soil profiles with deposits having more consistent brown sands that extended from 40cm to the base level of 1 metre.

Plate 34. DLS Boral AFT 1 – TS1A, west section

I. 0-12cm: Pale grey sand, humic. Frequent fine root systems.
II. 12-31cm: Pale grey sand. Infrequent charcoal fragments inclusions. Diffuse boundary to:
III. 31-58cm: Pale brownish grey sand. Small latite gravel and large colluvial latite cobbles from 50-58cm. Some charcoal flecks scattered. Diffuse boundary to:
IV. 58-70cm: Dark brownish red sand becoming dark orange brown towards the base. Increasing moisture
V. Base: Dark orange brown sand .

Plate 35. DLS Boral AFT 1 – TS 10C, south section

I. 0-12cm: Reddish grey weak sand, humic, organic. Frequent fine root systems throughout. Diffuse boundary to:
II. 12-47cm: Grey sand mottled with some pale orange sand. Bioturbated. Charcoal flecks and fragments scattered from 44 to 49cm. Diffuse boundary to:
III. 47cm-base: Orange brown sand. Becoming slightly darker towards the base.
IV. Base: Dark orange brown sand.

Plate 36. DLS Boral AFT 1 – TS10C charcoal feature, facing south.

I. Charcoal feature at 44cm depth and two artefacts *in situ*

Plate 37. DLS Boral AFT 1 - TS 21, north section

I. 0-10cm: Light grey loamy sand, humic. Frequent fine root systems throughout. Diffuse boundary to:
II. 10-25cm: Light grey sand. Charcoal flecks scattered. Some roots inclusions. Clear boundary to:
III. 25-35cm: Light pinkish grey soft. Some occasional flecks scattered. Diffuse boundary to:
IV. 35-base: Yellowish brown sand, moist.
V. Base: Yellowish brown sand.

6.3.3 Artefact Distribution

A total of 828 artefacts were recovered from 28 test excavation units at Stage 5B within the beach ridge landform and site DLS Boral AFT 1 (AHIMS 52-5-0907). Artefact densities for test squares are shown in Table 8 and Figure 8.

Table 8. Test excavation artefact densities at site DLS Boral AFT 1

Test Square	Total	Test Square	Total	Test Square	Total
1A	44	**9A**	10	**17**	78
1B	40	**9C**	6	**18**	19
2A	11	**10A**	22	**19**	31
2B	26	**10C**	40	**20**	43
3	1	**11**	2	**21**	75
4	2	**12**	1	**22**	46
5	33	**13**	9	**23**	103
6	5	**14**	3	**24**	10
7	70	**15**	5		
8	23	**16**	70		

Artefact distribution within DLS Boral AFT 1 site was characterised by variable density deposit (Table 8). All test squares exhibited Aboriginal objects. Two test squares had one artefact each (TS 3 and TS 12), and two test squares had two artefacts each (TS 4 and TS 11). High and low density areas varied across the tested landform. This variation in artefact density was not associated with previous ground disturbance, however a pattern of occupation could not be established at this time. It is possible that the high density areas represent separate occupational deposits from possibly different times during the year, or they represent repeated occupation throughout prolonged periods of time. Low artefact densities were recorded within the central-east section along the margins of the estuary and within a small patch to the south-west of the pond (Figure 8). Areas of the highest artefact density were located from about 20 metres south of the pond within the middle section of the beach ridge. Test square 23 had the highest (extrapolated) mean artefact density with 412/m^2, followed by TS 17 (312/m^2) and TS 21 (300/m^2). TS 16, located 20 metres north-west of TS 21, also revealed a high (extrapolated) mean artefact density (280/m^2). TS 7 with the same number of artefacts as TS 16 possibly represents a separate occupation or targeted activity event, as the surrounding test pits revealed much lesser artefact density. Extrapolated to square metres, the test area displayed a mean artefact density of 118.3/m^2.

Artefact densities for the test squares are shown in Table 9 and Figure 8.

Table 9. Spit depths and artefact count

	0-10	*10-20*	*20-30*	*30-40*	*40-50*	*50-60*	*60-70*	*70-80*	*80-90*	*90-100*	*Total*
1A				7	9	28					44
1B			9	1	17	8	5				40
2A		1	7	1		1			1		11
2B			3	14	9						26
3				1							1
4			1			1					2
5		4	2	12	15						33
6					4	1					5
7				2	5			63			70
8			1	1	18	1	2				23
9A		1	1		3		4	1			10
9C					2	1	2	1			6
10A	2	6	4	1	1	1	7				22
10C	7	10		1	18		3	1			40
11	2										2
12	1										1
13			1	1	5	2					9
14		1		2							3
15		1	3		1						5
16		1		3	20	43	3				70
17		4	2	10	9	17	32	4			78
18		1		4	1	6	4	3			19
19	7	10	6		5				3		31
20	9	1	2	3	11	15	2				43
21			2	5	20	8	34	4	2		75
22			23	5	8	7	2	1			46
23	1	1	6	5	8	27	33	17	4	1	103
24			1		9						10
Total	29	42	74	79	198	167	133	95	10	1	828

The majority of artefacts were found from 40 to 70 cm depth (n=499, 60%), followed by between 70 and 80cm (n=95, 11%) and between 30 and 40cm (n=79, 9.5%) (Table 9). The highest number of artefacts was recorded within the orange brown sand deposits. The topsoil grey sands (to an average of 40 centimetres) contained 224 artefacts (27%), and the darker orange brown sand deposits encountered at an average of 80 centimetres contained less than 2% of the entire assemblage. These results indicate that the majority of the cultural material is preserved within the subsoil sandy horizon that represents intact and stable soils. Although artefact numbers decrease from 80 centimetres depth, they are still recovered from as deep as 1 metre. Considering that the same sandy matrix that contains artefacts is continuing to levels deeper than 1 metre, it is still possible that some cultural material could occur in the area within these deeper sandy deposits.

One artefact was recovered from the top 13 centimetres within the fill material in TS 13, and it was included in this assemblage, although its provenance could not be established.

The charcoal feature recorded between 44 and 48cm depth within TS 10C (Plate 32) was less than 10 centimetres in diameter, consisting of charcoal flecks with two *in situ* artefacts recorded outside of this feature, and an additional five artefacts recovered from the sieves with one possible manuport. Considering the small size of the feature and its location within topsoil layers it is most likely that it does not represent a cultural feature.

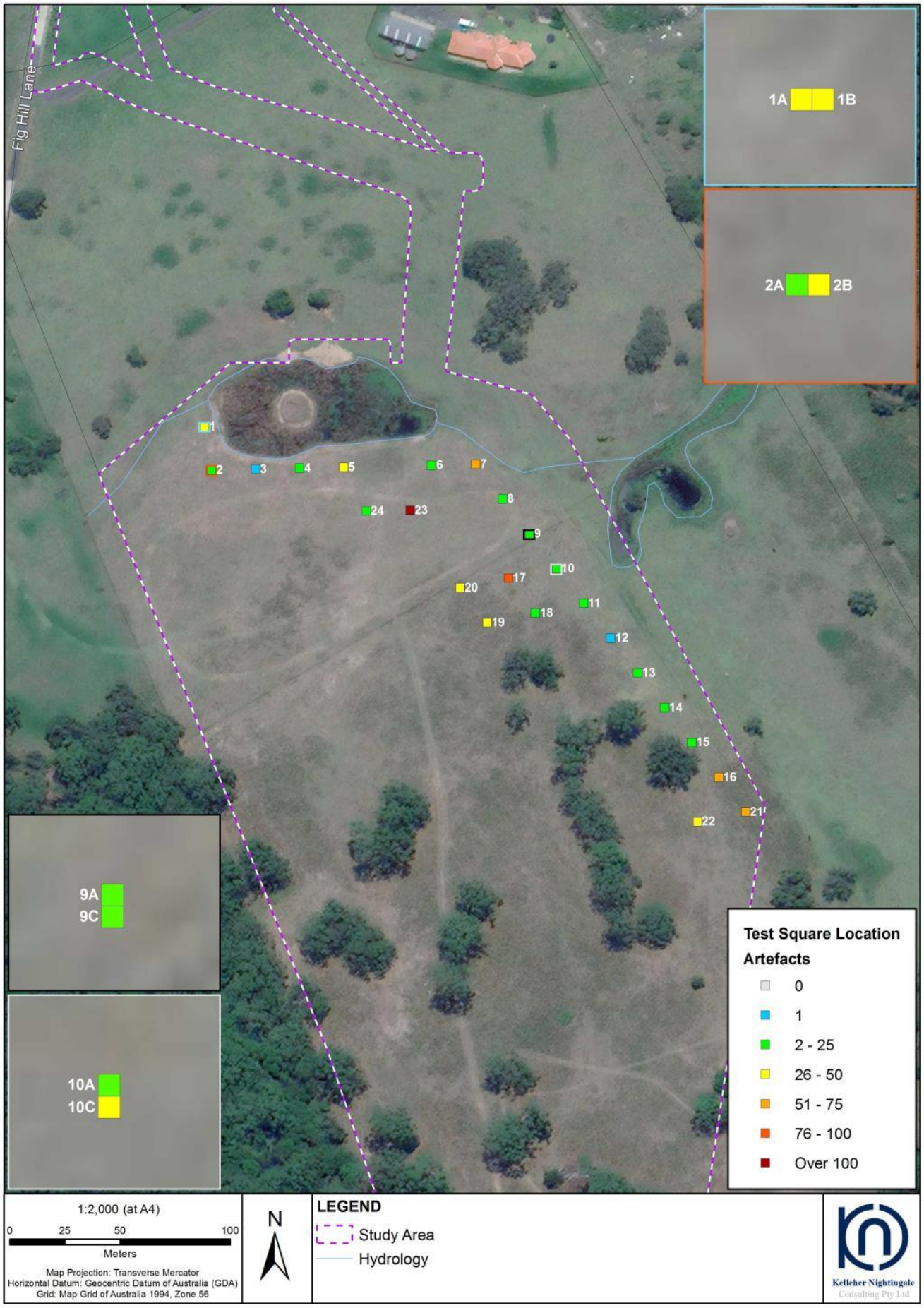

Figure 8. Stage 5B test square locations and artefact density in DLS Boral AFT 1.

6.3.4 Lithics

The dominant raw material for Stage 5B artefacts was silcrete (n=202, 24%), followed closely by a similar representation of quartz (n=120, 14%), jasper (n=115, 13.8%) and chert (n=99, 12%). A range of other raw material was recorded including unidentified fine and medium grained siliceous (FGS and MGS), chalcedony and petrified wood, agate, quartzite and coarse silcrete, and a very small percentage (less than 1%) of sandstone and igneous raw material was included in the assemblage (Table 12).

Artefacts were generally small, with the majority between 5 and 9 millimetres (Table 6). Artefacts greater than 29mm were scarce and comprised 4% of the entire assemblage. The largest artefact was an angular fragment of MGS between 100 and 104 millimetres recovered from TS 22 from between 20 to 30 centimetres depth. Artefacts measuring between 5 and 24 millimetres had the greatest variety of raw material present.

The majority of artefacts were flake debitage (Table 7). Non-diagnostic flaked angular fragments were the most common artefact type overall, accounting for 53.7% of the assemblage (n=223). Complete flakes were represented by 27% (n=223), with flake fragments (proximal, medial, distal, and split) making up 15.5% of the assemblage. Cores were not abundant in the assemblage (n=28, 3.3%), with chert being the most preferable raw material (n=11, 29%). Chalcedony, silcrete and FGS were more frequently chosen over jasper, quartz and quartzite and petrified wood. This preference might stem from the fact that chert is readily available in the area, and the finer, chalcedony varieties were more valued and preserved. A petrified wood core with a great amount of cortex was identified in TS 17 from 30 to 40 centimetres depth. The same spit contained an additional four flake fragments (Plate 38) that could have come off the core, indicating that a knapping event most likely took place in the area.

Plate 38. Petrified wood core and flake fragments (ID 431-435), TS 17, spit 4.

Plate 39. Artefacts variety at TS 23, petrified wood, silcrete, jasper, chert and chalcedony.

An unidentified rock fragment was recovered from TS 10C in association with the charcoal feature. It did not display any diagnostic features nor traces of modification, such as pecking or flaking. However, considering the raw material is not known to source in the local area, it most likely has been brought to the area. It was referred to as manuport and is not considered further in the lithics analysis.

Test Square 23 revealed the highest number and the greatest variety of raw material present. Silcrete comprised almost 50% of all occurring raw material and was recorded throughout all soil layers. Layers deeper than 50 centimetres contained a greater number and range of artefacts, including five backed artefacts. Only two artefacts contained a small amount of cortex, indicating that knapping was not occurring at this section of the site.

Table 10. Raw material distribution within DLS Boral AFT 1.

Raw Material	0-4mm	5-9mm	10-14mm	15-19mm	20-24mm	25-29mm	30-34mm	35-39mm	40-44mm	45-49mm	50-54mm	55-59mm	*64-69mm*	*100-104mm*	*Total*
Agate		8	4	5	2										***19***
Chalcedony	1	23	22	18	3	2	1								***70***
Chert	1	37	22	20	10	8		1							***99***
Coarse silcrete		3	2	1	2	1	2	1							***12***
FGS		21	23	18	7	2	2		1	1		1			***76***
Igneous		1	1	1	1	1	1				1				***7***
Jasper	2	52	26	24	2	4	4	1							***115***
MGS	5	24	12	9	6	2			1					1	***60***
Petrified Wood		7	12	6	2	4	1	3							***35***
Quartz	4	51	39	24	1				1						***120***
Quartzite		1	4	5	1			1							***12***
Sandstone													1		***1***
Silcrete	8	83	46	28	14	15	1	5	2						***202***
Total	***21***	***311***	***213***	***159***	***51***	***39***	***12***	***12***	***5***	***1***	***1***	***1***	***1***	***1***	***828***

Table 11. Reduction types at DLS Boral AFT 1.

Raw Material	Flake	Proximal Fragment	Distal Fragment	Split Fragment	Medial Fragment	Angular Fragment	Core	Hammerstone	Ground stone
Quartz	31	2	1	3		81	1	1	
Quartzite	1	2	3	1		4	1		
Chalcedony	22	6	6	3	1	27	4		
Chert	36	6	6	8	2	31	11		
FGS	11	3	5	2	2	48	5		
MGS	11	1			1	47			
Petrified Wood	10	2	3	1		18	1		
Igneous	1		1	1	1	3			
Jasper	31	5	5	4		68	2		
Agate	3			2		14			
Sandstone									1
Silcrete	62	8	17	7	7	98	3		
Coarse silcrete	3	1	2			6			
Total	***222***	***36***	***49***	***32***	***14***	***445***	***28***	***1***	***1***

Cortex was relatively infrequent at DLS Boral AFT 1. It was recorded on 48 artefacts, representing 13.6% of the entire assemblage (Table 12). Artefacts made of sandstone and MGS did not display any cortex. Quartz was the raw material that contained the highest frequency of cortex (n=32, 28.3%). Surfaces of 1-30% cortex were recorded on 78 artefacts (69%), with only seven artefacts having >70% of cortex. The results indicate that most likely dispersed knapping events occurred throughout the site at different locations and at most likely different times.

Table 12. Presence of cortex in relation to raw material and artefact types, at DLS Boral AFT 1.

	0%	1-30%	31-69%	>70%	Total
Agate	16	2		1	***19***
Chalcedony	62	4	3	1	***70***
Chert	84	11	4		***99***
Coarse silcrete	8	3	1		***12***
FGS	69	5	2		***76***
Igneous	5	2			***7***
Jasper	103	9	3		***115***
MGS	60				***60***
Petrified Wood	28	5	2		***35***
Quartz	88	25	5	2	***120***
Quartzite	9	2		1	***12***
Sandstone	1				***1***
Silcrete	182	10	8	2	***202***
Total	***715***	***78***	***28***	***7***	***828***

	0%	1-30%	31-69%	>70%	Total
Core	15	7	6		***28***
Flake	198	22	2		***222***
Proximal Fragment	31	3	2		***36***
Distal Fragment	45	3	1		***49***
Split Fragment	27	3	2		***32***
Angular Fragment	384	40	15	7	***446***
Medial Fragment	14				***14***
Pebble	1				***1***
Total	***715***	***78***	***28***	***7***	***828***

Coarse silcrete was of particular interest as it was identified in three excavation units, mainly from spit 6. Four flaked fragments had cortex, and were on average 25mm, displaying slightly greater size than the most of the artefacts within the assemblage (Plate 40). Test square 16 contained 8 artefacts, and although a core was not recovered at this location, the presence of flaked fragments with cortex indicates the possibility that a knapping floor could be encountered in this portion of the site. The same pattern was observed in TS 17 with two flaked fragments containing cortex found at the same depth. These could indicate two discrete knapping floor events, possibly around a similar time periods.

Plate 40. Coarse silcrete flake fragments with cortex (ID 384, 385) TS 16, (ID 460, 461) TS 17, spit 6.

Plate 41. Backed artefacts at TS 17 – spit 6: chalcedony, chert and jasper (ID 464, 472, 478).

A total of 38 tools and modified artefacts were recovered at DLS Boral AFT 1 (Table 15), occurring across the entire tested area. TS 23 had the highest number of modified artefacts, consisting of silcrete, chert and petrified wood backed flake fragments, ranging from 30 to 80 centimetres depth. Five backed blades were recovered in total, three from TS 17 (Plate 41). Geometric microliths were made of finer siliceous raw material, petrified wood and chalcedony varieties of jasper and agate (Plate 42).

Table 13. Tools and modified artefacts

Tool Type	Backed blade	Retouched	Geometric microlith	Usewear	Ground stone fragment	Hammerstone
Chalcedony	2			2		
Chert	2	5				
Petrified Wood	1	3	2			
Agate			1			
Jasper		2	1	3		
FGS		1	2			
Quartz		1				1
Silcrete		6		2		
Sandstone					1	
Total number	**5**	**18**	**6**	**7**	**1**	**1**

One weathered sandstone fragment (Plate 41) was found in spit 7 of TS 10C that exhibited smooth, ground surfaces with some pecking. Its use could not be determined due to the lack of diagnostic features, but its flat bottom indicates its possible use as an anvil.

Plate 42. Jasper backed artefact, petrified wood backed blade and agate geometric microlith (ID 356, 333 and 61)

Plate 43. Sandstone ground stone (ID 331), TS 10C, spit 7.

Some artefacts revealed signs of being affected by heat. These artefacts were confined to the upper 50 centimetres and are most likely associated with bushfire events and burning that extended to tree roots. Therefore, heat damage is most likely post-depositional impact, and not the result of a deliberate act, as no clear evidence of hearths was encountered. The local latite which outcrops in the area is not fine grained or durable enough for stone tool use and all artefact raw materials uncovered by the test excavation program had to be brought in to the area. Agates can occur as nodules formed in gaseous cavities of volcanic rocks and are known to be found in gravels along the coast to the north of Dunmore, in the vicinity of Shellharbour and Bass Point. Examples of artefacts recovered during the test excavation program with smooth cobble cortex suggest these were sourced in stream gravels, from coastal gravels, or possibly from breccia deposits associated with igneous intrusions.

Most of the artefacts were of good quality isotropic stone, with zero cortex, and small in size (<19 millimetres) suggesting that artefact raw materials were being conserved. The only raw material that was possibly sourced or brought to the site to be modified is coarse silcrete. Results of test excavation indicate that primary reduction processes were occurring at the site. The presence of a high number of backed artefacts suggests that some particular activities were also taking place across the site. No worn margins and a silica-gloss patina consistent with natural wearing of the surfaces through water action were noted. Artefacts revealed stable and relatively intact soil conditions indicating their primary context.

6.4 Discussion

The test excavation of the study area identified three Aboriginal archaeological sites:

- DLS Boral AFT 1
- DLS Boral AFT 2
- DLS Boral AFT 3

Test squares averaged 80 centimetres to 1 meter in depth, with two excavation units excavated to 1.2 metres. Two tested areas lie within different landform elements but are part of the same coastal barrier land system with similar geomorphological deposition processes. Generally, both areas contain a stable, sandy soil matrix that is the result of successive periods of storm deposition or dune accretion over long geological time scales. As such, the soils become inactive and represent relict features that are prone to conserving archaeological subsurface material in its primary context. Soils across the study area contained deep sandy deposits that extended beyond the limit of excavation however all identified deposits show a trend of minimal archaeology below 1 metre.

Artefact distribution was characterised by high artefact density deposits encountered throughout the tested area. Some patchy low density areas were localised towards the margins of the sand bodies. The highest artefact density was recorded within the central, most elevated parts of the sand beach ridge and backbarrier flat. DLS Boral AFT 1 did not reveal evidence of significant previous ground disturbances that could have impacted on subsurface archaeological deposits. The only previous disturbance was evident within very shallow surface soils due to repeated natural fire events and land clearing. These land use practices and natural events would cause some horizontal and shallow vertical movement of archaeological deposit, but would not remove it in its entirety. In addition, these disturbances are patchy and were not identified in all test excavation units. The majority of the site is within very stable intact sandy deposits. DLS Boral AFT 2 had some areas that revealed imported fill deposits up to 35 centimetres depth. These were limited to the southern and western sections of the sand body. Natural sandy deposits are still present under fill material containing high to low density Aboriginal cultural material.

Flaked artefacts were made of a diverse range of stone raw materials. This included agate, chalcedony, chert, quartz, quartzite, jasper, silcrete, petrified wood, unidentified fine and mid grained siliceous, tuff and igneous rock. Sources of these raw materials are known in the immediate vicinity of the test excavation areas, within Shellharbour and Bass Point, located approximately 5 kilometres from the study area. The predominantly small size of artefacts and evidence of artefact recycling indicate that the materials were brought to the area from elsewhere (perhaps from sources along the nearby Minnamurra River). Some knapping was also occurring at dispersed locations and most likely different times throughout the site. The presence of backed artefacts indicates particular and selective activities.

The results of the test excavation program demonstrate that DLS Boral AFT 1 and DLS Boral AFT 2 have moderate-high archaeological research potential due to the high number and diversity of raw material and tool types, relatively intact nature of the subsurface deposit at these locations and their proximity to estuarine environments. DLS Boral AFT 3 has low archaeological research potential due to the low density of artefacts recovered and the disturbed nature of the site.

6.5 Conclusion

Aboriginal sites identified within the Stage 5A and 5B areas reflect both the preference for occupation and the survivability of archaeological deposit in these intact landforms. Estuary environments were extensively used by Aboriginal people in the past, and elevated, well drained and sandy locales would have served as preferable camping locations. The elevated location was selected for its topographic nature and its position adjacent to a variety of resources associated with the Minnamurra River estuary. Beach ridge and back barrier flat were most likely focal points in the landscape where Aboriginal people performed a variety of tasks associated with the everyday and specialised activities. Considering the nature of these landforms, they were also subject to repeated and frequent occupation, resulting in accumulation of cultural material from different times and stemming from diverse activities.

7 Identified Aboriginal Sites

Aboriginal cultural heritage assessment, including review of previous archaeological investigations, Aboriginal community consultation and test excavation has identified three Aboriginal archaeological sites within the study area (Figure 9). These sites comprise three artefact scatters and are listed in Table 14.

Table 14. Identified Aboriginal cultural heritage values within the study area

Site Name	AHIMS #	Site Feature
DLS Boral AFT 1	52-5-0907	Artefact
DLS Boral AFT 2	52-5-0908	Artefact
DLS Boral AFT 3	52-5-0909	Artefact

DLS Boral AFT 1
Site DLS Boral AFT 1 was located within the beach ridge landform within the proposed Stage 5B area, to the immediate south of the natural pond and the small drainage line. Test excavations determined that the site extends throughout the entire landform and contains relatively intact high density archaeological deposits. A total of 828 artefacts were excavated from 28 50x50cm excavation units.

Artefact density within the test excavation area, extrapolated to square metres, displayed a mean of 118.3/m^2. Artefact distribution was characterised by high density deposits with a localised low density towards the margins of the sand body. The majority of the artefacts were recovered between 40 and 70 centimetres depth. They were preserved within the subsoil orange brown sandy horizon that represents relatively stable soils, most likely intact and not related to geomorphic processes. The quality and aesthetic nature of the raw material indicated a selective activity area. Results of test excavation indicate that the area contains evidence of dispersed and varied occupation activities that occurred during a prolonged period of time and on repeated occasions.

DLS Boral AFT 2
Site DLS Boral AFT 2 was located within the back barrier sand body within Stage 5A study are, adjacent to the tidal flat in association with the estuary of the Minnamurra River. Test excavation determined that the site retained an intact, high density archaeological deposit located across the entire remnant sand body. A total of 461 artefacts were recovered from 12 50x50cm test units.

Artefact density within the test excavation area was similar to within DLS Boral AFT 1 and extrapolated to square metres, the test area displayed a mean artefact density of 115.3/m^2. Artefact distribution was characterised by a moderate to high artefact density across all excavated test units. Localised low density was recorded along the margins of the landform that indicates the site boundary. The highest artefact density was recorded within the central elevated section of the sand body. Some surface fill material was identified within the first 35 centimetres that did not impact on integrity of deeper sandy archaeological deposits. The assemblage contained a small quantity of cores and formalised tools indicating that the creation of stone tools occurred at the site but was secondary to the maintenance and use of stone tools. The quality and aesthetic nature of the raw material indicated a selective activity area.

DLS Boral AFT 3
Site DLS Boral AFT 3 was located within the artificially raised area to the immediate west of Riverside Drive. It is located between the tidal flat and back barrier flat landforms. Test excavations determined that the raised area is made of fill material. This fill was most likely brought into the area during the construction of the road and the modification of a small drain that runs parallel to Riverside Drive. A total of three artefacts were recovered from three test pits.

They consisted of two quartz angular fragments, and one quartz retouched flake. It is possible that they were brought in with the fill material or they represent dispersed/disturbed isolated cultural material from the local area. No further cultural material was identified and the entire raised area was considered to have very low archaeological potential for intact deposits.

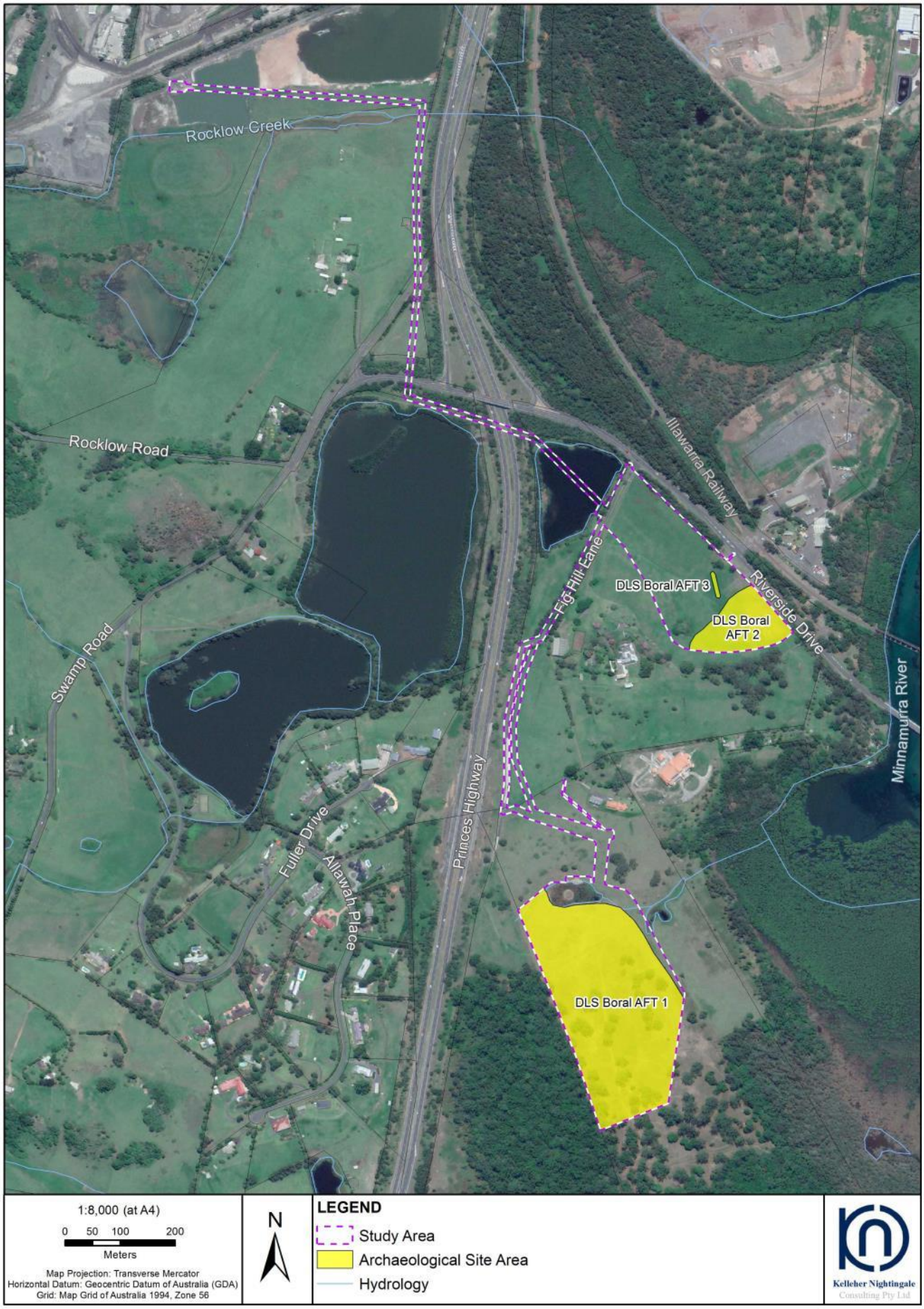

Figure 9. Identified Aboriginal archaeological sites in the study area

8 Cultural heritage values and statement of significance

8.1 Significance assessment criteria

One of the primary steps in the process of cultural heritage management is the assessment of significance. Not all sites are equally significant and not all are worthy of equal consideration and management (Sullivan and Bowdler 1984, Pearson and Sullivan 1995:7). The determination of significance can be a difficult process as the social and scientific context within which these decisions are made is subject to change (Sullivan and Bowdler 1984). This does not lessen the value of the heritage approach, but enriches both the process and the long-term outcomes for future generations, as the nature of what is conserved and why, also changes over time.

Significance assessments can generally be described under three broad headings (Pearson and Sullivan 1995:7):

- value to groups such as Aboriginal communities;
- value to scientists and other information gatherers; and
- value to the general public in the context of regional, state and national heritage.

The assessment of significance is a key step in the process of impact assessment for a proposed activity as the significance or value of an object, site or place will be reflected in resultant recommendations for conservation, management or mitigation.

The *Code of Practice for Archaeological Investigation of Aboriginal Objects in New South Wales* (OEH 2010b) requires significance assessment according to criteria established in the *Australia ICOMOS Burra Charter* (Australia ICOMOS 2013). The *Burra Charter* and its accompanying guidelines are considered best practice standard for cultural heritage management, specifically conservation, in Australia. Guidelines to the *Burra Charter* set out four criteria for the assessment of cultural significance:

- Aesthetic value - relates to the sense of the beauty of a place, object, site or item;
- Historic value - relates to the association of a place, object, site or item with historical events, people, activities or periods;
- Scientific value - scientific (or research) value relates to the importance of the data available for a place, object, site or item, based on its rarity, quality or representativeness, as well as on the degree to which the place (object, site or item) may contribute further substantial information; and
- Social value - relates to the qualities for which a place, object, site or item has become a focus of spiritual, political, national or other cultural sentiment to a group of people. In accordance with the OEH *Guide to investigating, assessing and reporting on Aboriginal cultural heritage in NSW*, the social or cultural value of a place (object, site or item) may be related to spiritual, traditional, historical or contemporary associations. "Social or cultural value can only be identified though consultation with Aboriginal people" (OEH 2011:8).

Significance assessment for identified archaeological sites focusses on the social/cultural, historic, scientific and aesthetic significance of Aboriginal heritage values as identified in *The Burra Charter* (Australia ICOMOS 2013). The identification of significance is developed in consultation with the registered Aboriginal stakeholders. Assessed values for the site within the study area are detailed below.

Cultural / social significance

This area of assessment concerns the value(s) of a place, feature or site to a particular community group, in this case the local Aboriginal community. Aspects of social significance are relevant to sites, objects and landscapes that are important or have become important to the local Aboriginal community. This importance involves both traditional links with specific areas as well as an overall concern by Aboriginal people for sites generally and their continued protection. Aboriginal cultural significance may include social, spiritual, historic and archaeological values and is determined by the Aboriginal community.

It has been identified during the consultation process that the local area has cultural heritage value (social value) to the local Aboriginal community. Specific cultural or social values for the sites within the project area provided by the registered Aboriginal stakeholders will be included in the final version of this document following the review of the draft CHAR.

Historic significance

Community consultation and historical research has not identified any information regarding specific historical significance of identified Aboriginal archaeological sites in or near the study area. Any specific historical significance for the sites within the project area provided by the registered Aboriginal stakeholders will be included in the final version of this document following the review of the draft CHAR. Archaeologically, the study area does not contain these values in relation to Aboriginal heritage.

Scientific / archaeological significance

For archaeologists, scientific significance refers to the potential of a site to contribute to current research questions. Alternately, a site may be an in situ repository of demonstrably important information, for example rare artefacts of unusually high antiquity.

Scientific significance is assessed using criteria to evaluate the contents of a site, state of preservation, integrity of deposits, representativeness of the site type, rarity/uniqueness and potential to answer research questions on past human behaviour. OEH's recommended criteria for assessing archaeological significance include:

- Archaeological Research Potential - significance may be based on the potential of a site or landscape to explain past human behaviour and can incorporate the intactness, stratigraphic integrity or state of preservation of a site, the association of the site to other sites in the region (connectivity), or a datable chronology.

- Representativeness - all sites are representative of those in their class (site type/subtype) however the issue here relates to whether particular sites should be conserved to ensure a representative sample of the archaeological record is retained. Representativeness is based on an understanding of the regional archaeological context in terms of site variability in and around the study area, the resources already conserved and the relationship of sites across the landscape.

- Rarity – which defines how distinctive a site may be, based on an understanding of what is unique in the archaeological record and consideration of key archaeological research questions (i.e. some sites are considered more important due to their ability to provide certain information). It may be assessed at local, regional, state and national levels.

High significance is usually attributed to sites which are so rare or unique that the loss of the site would affect our ability to understand an aspect of past Aboriginal use/occupation of an area. In some cases a site may be considered highly significant because it is now rare due to destruction of the archaeological record through development. Moderate (medium) significance is attributed to sites which provide information on an established research question. Sites with moderate significance are those that offer the potential to yield information that will contribute to the growing holistic understanding of the Aboriginal cultural landscape of the project area. Archaeological investigation of moderately significant sites will contribute knowledge regarding site type interrelationships, cultural use of landscape features and occupation patterns Low significance is attributed to sites which cannot contribute new information about past Aboriginal use/occupation of an area. This may be due to site disturbance or the nature of the site's contents.

Aesthetic Values

Aesthetic values are often closely related to the social values of a site or broader cultural landscape. Aspects may include scenic sights, smells and sounds, architectural fabric and creative aspects of a place. No specific aesthetic values for identified sites within the study area have been identified by registered Aboriginal stakeholders to date. Any aesthetic values provided by the registered Aboriginal stakeholders will be included in the final version of this document following the review of the draft CHAR. Archaeologically, the study area does not contain these values in relation to Aboriginal heritage.

8.2 Statements of significance

The study area has cultural value for the local Aboriginal community. The identified cultural value is a feeling of attachment and responsibility for the land. These values become tangible when tied to identified Aboriginal objects found at the archaeological sites. In this way, the Aboriginal objects can be seen as exhibiting both scientific information and cultural meaning, knowledge about the past tied with social values and belief systems.

The study area contained three identified Aboriginal archaeological sites as defined under the *National Parks and Wildlife Act 1974*. Significance assessment was based on consideration of the research value, representativeness, intactness and rarity of the sites in a local and regional context as outlined below.

DLS Boral AFT 1

Site DLS Boral AFT 1 was a high density artefact scatter located within the remnant beach ridge landform adjacent to the Minnamurra River estuary. The site had been subject to limited human disturbance and the results from the test excavation suggest that movement within the deposit was also limited. The site represents a commonly occurring site type in the coastal region; however recorded intact (coastal) sites are becoming less common as the majority of landforms in similar environmental settings are increasingly impacted by contemporary land use practices.

The range of raw material and artefact types found at the site and stratified context adjacent to an estuarine environment is less common. The site demonstrated moderate-high scientific value and it is likely that further investigation will contribute to the understanding of Aboriginal landscape use within coastal areas and assist in understanding the management of coastal sites and identification/conservation of future sites based on geomorphic features (beach ridge).

Based on the intactness, representativeness, and research potential of the site, DLS Boral AFT 1 was determined to have moderate-high archaeological significance.

DLS Boral AFT 2

Site DLS Boral AFT 2 was a high density artefact scatter located within the remnant back barrier flat landform adjacent to the Minnamurra River estuary. The site had been subject to some recent land modifications and the results from the test excavation suggest that limited areas experienced importing of some fill material. Generally, this did not impact on the majority of the artefact-bearing sandy deposits. The site represents a commonly occurring site type in the region; however the majority of landforms in similar environmental settings have been significantly impacted by recent land use practices. The range of raw material and artefact types found at the site and stratified context adjacent to the estuarine environment is less common. The site demonstrated moderate-high scientific value and it is likely that further investigation will contribute to the understanding of Aboriginal landscape use within coastal areas and assist in understanding the management of coastal sites and identification/conservation of future sites based on geomorphic features (back barrier sands).

Based on the intactness, representativeness, and research potential of the site, DLS Boral AFT 2 was determined to have moderate-high archaeological significance.

DLS Boral AFT 3

Site DLS Boral AFT 3 was a low density artefact scatter situated with a highly disturbed area. The site is located within fill material with an absence of natural soils. The site represents a commonly occurring site type in the region. The site demonstrated no scientific value due to the disturbed nature and low density of the archaeological deposit. Further investigation will not contribute to the understanding of Aboriginal landscape use in the region.

Based on the intactness, representativeness and research potential of the site, DLS Boral AFT 3 is determined to have low archaeological significance.

9 Proposed activity and impact assessment

DSS is seeking approval for a modification to their existing development consent (DA 195-8-2004) for Stages 2 to 4 of the Dunmore Lakes Sand Project at Dunmore. The proposed modification is for a new extraction stage (Stage 5) on adjoining land and would be a S75W modification to the existing consent. The proposed new extraction stage is required to enable the continuation of the current sand extraction operations. The entirety of the study area will be impacted by the proposed modification and associated activities.

The three identified Aboriginal sites would be impacted by the proposal. Assessed impacts to sites identified within the study area are detailed in Table 7.

Table 15. Aboriginal heritage impacts

Site Name	AHIMS ID	Type of harm	Degree of harm	Consequence of harm	Significance of harm
DLS Boral AFT 1	52-5-0907	Direct	Total	Total loss of value	High
DLS Boral AFT 2	52-5-0908	Direct	Total	Total loss of value	High
DLS Boral AFT 3	52-5-0909	Direct	Total	Total loss of value	Low

10 Avoiding and/or mitigating harm

The three Aboriginal archaeological sites identified within the study area have been considered by DSS in relation to the proposed extraction pit expansion. While conservation is the best approach when considering Aboriginal heritage, impact to the three sites is unfortunately unavoidable due to the nature of the expansion project. The most significant sites are situated within the areas of proposed impact.

The scientific value of archaeological sites is linked to the physical information the sites contain. Site DLS Boral AFT 3 has low archaeological significance and does not warrant further archaeological investigation; however, measures for mitigating harm to Aboriginal objects (salvage excavation) are recommended for sites DLS Boral AFT 1 and DLS Boral AFT 2.

The loss of intrinsic Aboriginal cultural value of impacted sites cannot be offset; however the salvaged information will increase our understanding, strengthen our interpretations and improve ongoing and future management of Aboriginal heritage in the surrounding area. The presence of archaeological deposits and activities related to Aboriginal occupation within coastal barrier landform contexts in association with estuaries is little known due to limited large excavation data, and the levels of previous disturbance in these environmental conditions within the Illawarra Coastal Plain. In this light, the project offers a unique opportunity to significantly advance the interpretation and management of Aboriginal heritage of the surrounding area by providing a foundation for future heritage assessments.

11 Management and recommendations

The following management and mitigation measures are required for identified Aboriginal heritage within the Stage 5A and 5B expansion area.

11.1 Mitigation through archaeological salvage excavation

The archaeological sites in Table 16 are of moderate-high Aboriginal heritage significance and will be impacted by the project. These sites require archaeological salvage excavation to mitigate the impacts. Salvage excavation can only occur after approval for the modification to existing development consent DA 195-8-2004 is obtained and in accordance with the terms of that approval.

Salvage excavation must be completed prior to any activities which may harm Aboriginal objects at these site locations. Salvage excavation activities would be undertaken in accordance with the methodology attached as Appendix E. Salvage excavation may be completed in stages to suit the extraction program.

Table 16. Aboriginal sites requiring mitigation (salvage excavation)

Archaeological sites requiring mitigation	
Archaeological Sites (requiring salvage)	DLS Boral AFT 1 DLS Boral AFT 2

11.2 No archaeological mitigation required

No archaeological mitigation is required for the site in Table 17. The site may only be impacted after after approval for the modification to existing development consent DA 195-8-2004 is obtained and in accordance with the terms of that approval.

Table 17. Aboriginal sites with no further archaeological mitigation required

No further archaeological mitigation required	
Archaeological Sites (no archaeological mitigation)	DLS Boral AFT 3

11.3 Procedures for Handling Human Remains

- **Note that Project or Modification Approvals do not include the destruction of Aboriginal remains**

This section outlines the procedure for handling human remains in accordance with the Skeletal Remains – Guidelines for the Management of Human Skeletal Remains under the *Heritage Act 1977* (NSW Heritage Office 1998) and the Aboriginal Cultural Heritage Standards and Guidelines Kit (NPWS 1997). In the event that construction activity reveals possible human skeletal material (remains), the following procedure is to be followed:

1. as soon as remains are exposed, all work is to halt at that location immediately and the Project environmental manager on site is to be immediately notified to allow assessment and management;
    i. stop all activities; and
    ii. secure the site.
2. contact police, the discovery of human remains triggers a process which assumes that they are associated with a crime. The NSW Police retain carriage of the process until such time as the remains are confirmed to be Aboriginal or historic;
3. DP&E, as the approval authority, will be notified when human remains are found;
4. once the police process is complete and if remains are not associated with a contemporary crime contact DP&E. DP&E will determine the process, in consultation with OEH and/or the Heritage Office as appropriate;
    i. if the remains are identified as Aboriginal, the site is to be secured and DP&E and all Aboriginal stakeholders are to be notified in writing. DP&E will act in consultation with OEH as appropriate. OEH will be notified in writing according to DP&E instructions; or
    ii. if the remains are identified as non-Aboriginal (historical) remains, the site is to be secured and the DP&E is to be contacted. DP&E will act in consultation with the Heritage Division as appropriate. The Heritage Division will be notified in writing according to DP&E instructions;
5. once the police process is complete and if the remains are identified as not being human work can recommence once the appropriate clearances have been given.

11.4 Salvaged Aboriginal objects

The short term management of collected Aboriginal objects is as follows:

- Any Aboriginal objects that are removed from the land by actions authorised by the project approval, must be moved as soon as practicable to the temporary storage location (see below) pending any agreement reached about the long term management of the Aboriginal objects.
- The temporary storage location would be: Kelleher Nightingale Consulting Pty Ltd, Level 10, 25 Bligh Street, Sydney NSW 2000.
- Any Aboriginal objects stored at the temporary storage location must not be further harmed, except in accordance with the conditions of the approval.

The long term management of collected Aboriginal objects is as follows:

- Recovered objects will be lodged with the Australian Museum in the first instance in accordance with the *Australian Museum Archaeological Collection Deposition Policy* (January 2012, available online at: http://australianmuseum.net.au/document/Protocols-for-the-deposition-of-archaeological-materials). If required, a variation will be sought for recovered objects to be held by the Aboriginal community or reburied.
- Requirement 26 "Stone artefact deposition and storage" in the *Code of Practice for Archaeological Investigation of Aboriginal Objects in NSW* (24 September 2010, available online at: http://www.environment.nsw.gov.au/resources/cultureheritage/10783FinalArchCoP.pdf) must be complied with.

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Appendix A Advertisement for registration of interest

General Notices

Notice for Registration of Interest

Dunmore Sand & Soil Pty Ltd is investigating a modification to the development consent (DA 195-8-2004) of the Dunmore Lakes Sand Project, located at Tabbita Road, Dunmore on the NSW South Coast. The proposed modification is for an additional extraction stage (Stage 5) on adjoining land. The project is located in the Shellharbour Local Government Area. The proponent is Dunmore Sand & Soil Pty Ltd (Rod Wallace, Planning and Development Manager - 38 Tabbita Road, Dunmore NSW 2529).

The proposal has been deemed to be a modification to an existing Part 3A project and is subject to assessment and approval under Section 75W of the Environmental Planning and Assessment Act 1979. Dunmore Sand & Soil Pty Ltd proposes to carry out consultation with Aboriginal people in accordance with the Office of Environment and Heritage Aboriginal cultural heritage consultation requirements for proponents 2010. The purpose of this consultation process is to inform the preparation of environmental assessment documentation and to assist the Department of Planning and Environment in its consideration of any future project applications related to the proposal.

Dunmore Sand & Soil Pty Ltd invites Aboriginal groups and/or Aboriginal people who hold cultural knowledge relevant to determining the significance of Aboriginal objects and/or places at Dunmore NSW to register interest in a process of community consultation with the contact shown below (on behalf of Dunmore Sand & Soil Pty Ltd):

Dunmore Sand & Soil Pty Ltd c/o Kelleher Nightingale Consulting

Level 10, 25 Bligh Street

Sydney NSW 2000

phone 9232 5373

fax 9223 0680

The closing date for registration is 25 July 2018.

Appeared in: Illawarra Mercury (Wednesday 11 July 2018)

Appendix B Aboriginal community consultation log

RECORD OF ABORIGINAL COMMUNITY CONSULTATION AND CONSULTATION LOG
Aboriginal cultural heritage consultation requirements for proponents 2010 (OEH)
Dunmore Lakes Sand Project – Stage 5 Modifications, Dunmore NSW

Step	Task Requirement	Action	Outcome
4.1.1	Identify if native title exists in relation to the project area.	Conducted National Native TitleVision (NNTV) search on 27/05/2018. Wrote to National Native Title Tribunal (NNTT) for a list of registered native title claimants, native title holders and registered Indigenous Land Use Agreements (letter dated 08/06/2018).	NNTV search showed no native title holders and registered Indigenous Land Use Agreements in the project area (27/05/2018). 11/06/2018 NNTT: Provided overlap reports for Shellharbour and Kiama LGAs. The study area overlaps one (undetermined) claim by the South Coast People (NC2017/003) Advised no determined native title holders or registered Indigenous Land Use Agreements within these LGAs. South Coast People claimants were invited to register as part of step 4.1.3.
4.1.2	Ascertain, from reasonable sources of information, the names of Aboriginal people who may hold cultural knowledge relevant to determining the significance of Aboriginal objects and/or places. Compile a list of Aboriginal people who may have an interest for the proposed project area and hold knowledge relevant to determining the cultural significance of Aboriginal objects and/or places	Wrote to various government agencies to obtain names and contact details of parties that may have an interest or hold cultural knowledge for the project area (letters dated 06/06/2018): Shellharbour City Council (SCC); Illawarra ROG, Office of Environment and Heritage (OEH); Illawarra Local Aboriginal Land Council (DLALC); The Registrar, *Aboriginal Land Rights Act 1983* for a list of Aboriginal owners (ORALRA); The National Native Title Tribunal (NNTT) for a list of registered native title claimants, native title holders and registered Indigenous Land Use Agreements; Native Title Services Corporation (NTSCORP Limited); and Wollongong East Local Land Services (LLS), formerly the Catchment Management Authority (CMA). (Letters dated 08/06/2018).	Responses received from: 11/06/2018 NNTT: Provided overlap reports for Shellharbour and Kiama LGAs. Advised no determined native title holders or registered Indigenous Land Use Agreements within these LGAs. 28/06/2018 OEH: Provided a list of Aboriginal stakeholders known to OEH that may have an interest in the project. Notes that consultation must be carried out before making an application for an AHIP and that consultation does not equal employment. Advises consultants must still advertise for interested parties. 16/07/2018 ORALRA: Advised that a search of the Register of Aboriginal Owners returned no results for the project area. Suggested contacting ILALC for further assistance.
4.1.3	Written notification and advertisement: Write to the Aboriginal people whose names were obtained in step 4.1.2 and the relevant LALC(s) to notify	Notification letters (dated 11/07/2018) and invitation to register interest sent to people and groups identified in step 4.1.2, including: Badu	Responses for registration of interest from written notification and advertisement were received from: Barraby Cultural Services (email 13/07/2018)

Step	Task Requirement	Action	Outcome
4.1.3 contd.	them of the proposed project. Place a notice in the local newspaper circulating in the general location of the proposed project, explaining the project and its exact location. Notification by letter and newspaper must include: (a) the name and contact details of the proponent (b) a brief overview of the proposed project that may be the subject of an application for an AHIP, including the location of the proposed project (c) a statement that the purpose of community consultation with Aboriginal people is to assist the proposed applicant in the preparation of an application for an AHIP and to assist the Director-General of OEH in his or her consideration and determination of the application (d) an invitation for Aboriginal people who hold cultural knowledge relevant to determining the significance of Aboriginal object(s) and/or place(s) in the area of the proposed project to register an interest in a process of community consultation with the proposed applicant regarding the proposed activity (e) a closing date for the registration of interests.	Barraby Cultural Services Biamanga Bellambi Indigenous Corporation Gandangara Traditional Owners Bilinga CHTS Bilinga Coomaditchie United Aboriginal Corporation Cullendulla Darryl Caines Dharug Darug Land Observations Duncan Falk Consultancy Garrara Aboriginal Corporation Gadhu Dreaming Gary Caines Guunamaa Dreamin Sites and Surveying Goobah Gundungurra Tribal Technical Services Gunyuu CHTS Gunyuu Illawarra Aboriginal Corporation Illawarra LALC James Davis Jerringong Karrial Korewal Elouera Jerrungurah Tribal Elders Council Ken Foster Kullila Site Consultants and Koori Site Management Leanne Tungai La Perouse Botany Bay Corporation Murra Bidgee Mullangari Aboriginal Corporation Minnamunnung Munyunga CHTS Munyunga Murramarang Murrumbul CHTS Murrumbul NIAC Norma Simms Nundagurri Pemulwuy Raymond Garbutt South Coast People (Native Title Claimant) South West Rocks Corporation Three Ducks Dreaming Surveying and Consulting Thoorga Nura Tungai Tonghi Wadi Wadi Coomaditchie Aboriginal Corporation Walbunja Warra Bingi Nunda Gurri Wingikara Woronora Plateau Gundangara Elders Council Wullung Wodi Wodi Elders Corporation	Biamanga (email dated 17/07/2018) Cullendulla (email dated 17/07/2018) Duncan Falk Consultancy (20/07/2018) Darug Land Observations (email/letter dated 12/07/2018) Guunamaa Dreamin Sites and Surveying (email dated 12/07/2018) Goobah (email dated 17/07/2018) Gulaga (email dated 17/07/2018(Illawarra LALC (email dated 12/07/2018) James Davis (email dated 27/07/2018) Leanne Tungai (email dated 12/07/2018) Murra Bidgee Mullangari (email dated 13/07/2018) Merrigarn (email dated 13/07/2018) Muragadi HIC (email 13/07/2018) Murramarang (email dated 17/07/2018) Tungai Tonghi (email dated 13/07/2018) Wodi Wodi Coomaditchie Aboriginal Corporation (phone call 26/07/2018) Woronora Plateau Gundangara Elders Council (email dated 13/07/2018) Yurrandaali Cultural Services (email dated 14/07/2018)

Step	Task Requirement	Action	Outcome
4.1.3 contd.		Yurrandaali Cultural Services Yerramurra Advertisement inviting people to register interest in consultation published in the *Illawarra Mercury* on 11/07/2018. Advertisement attached as Appendix A. Closing date for registration of interest was 25/07/2018.	
4.1.4	A minimum of 14 days from the date the letter was sent or notice published in the newspaper to register an interest.	Closing date for registration of interest included in the notification letters and notice in the newspaper was at least 14 days from the date the letters were sent and notice appeared in the newspaper. Closing date for registration of interest was 25/07/2018.	Copy of newspaper advertisement attached.
4.1.5	Must advise Aboriginal people who are registering an interest that their details will be forwarded to OEH and the LALC unless they specify that they do not want their details released.	Groups informed by letters (dated 11/07/2018) or verbally over the phone if they registered by phone.	No Aboriginal stakeholder groups specified that they did not want their details to be released.
4.1.6	Make a record of the names of each Aboriginal person who registered an interest. Provide a copy of that record and copy of the notification from step 4.1.3 to the relevant OEH EPRG regional office and LALC	List of registered stakeholders compiled. No registered Aboriginal stakeholder groups specified that they did not want their details to be released.	Letters sent to OEH and Illawarra LALC with list of registered Aboriginal stakeholders (letters dated 31/07/2018). No registered Aboriginal stakeholder groups specified that they did not want their details to be released.
4.1.7	LALCs holding cultural knowledge relevant to determining the significance of Aboriginal objects and places in the proposed project area who wish to register an interest to be involved in consultation must register their interest as an Aboriginal organisation rather than individuals.	Illawarra LALC registered interest to be involved in consultation.	Illawarra LALC registered interest as an organisation. Provided contact details for the LALC and the name of a LALC representative to act as contact person (Paul Knight).

Step	Task Requirement	Action	Outcome
4.1.8	Where an Aboriginal organisation representing Aboriginal people who hold cultural knowledge has registered an interest, a contact person for that organisation must be nominated. Aboriginal cultural knowledge holders who have registered an interest may indicate they have appointed a representative to act on their behalf. Where this occurs, the registered Aboriginal party must provide written confirmation and contact details of those individuals to act on their behalf.	Responses received from organisations and individuals registering interest in the project. Contact details and names of representatives were also provided.	Aboriginal stakeholders have registered as an organisation name or as individuals. Contact details and names of representatives for the organisations were also provided and confirmed during the registration of interest process.
4.2	Presentation of information about the proposed project	Information regarding the proposed project provided throughout the consultation process including letters sent on 11/07/2018 and 20/08/2018. Informal discussions also held during the registration of interest period.	No responses to the provision of project information.
4.3.1-4.3.2	Notification of proposed assessment methodology	Copy of the proposed assessment methodology sent to all registered stakeholders with an invitation to provide comment (letters dated 20/08/2018). A 28 day review period was provided.	Responses to the proposed assessment methodology were received from Barraby Cultural Services (BCS), Duncan Falk Consultancy (DFC), Murra Bidgee Mullangari Aboriginal Corporation (MBMAC), Muragadi Heritage Indigenous Corporation (Muragadi), Tungai Tonghi, Woronora Plateau Gundangara Elders Council (WPGEC), and Yurrandaali Cultural Services (Yurrandaali). BCS stated that they supported the proposed assessment methodology for the project (email dated 22/08/2018). DFC stated they had read and reviewed the methodology and endorsed the proposed approach (email/letter dated 28/08/2018). MBMAC expressed support for the recommendations in the assessment methodology (email dated 21/08/2018). Muragadi stated they had reviewed the project information and proposed methodology and endorsed the proposed approach (email dated 21/08/2018).

Step	Task Requirement	Action	Outcome
4.3.1-4.3.2			Tungai Tonghi affirmed their interest in the project (email dated 23/08/2018). WPGEC advised they had received the methodology (email dated 20/08/2018) and asked for further detail regarding the test excavation program (specific number of test pits and size of the test areas). Dr Matthew Kelleher (KNC) responded via phone call on 27/08/2018 to confirm the location of test areas and identified sensitive landforms, and discuss the amount of test squares estimated to be required to sample these. WPGEC agreed with the proposed approach. Yurrandaali stated that they supported the proposed methodology (22/08/2018).
4.3.3	Gathering information about cultural significance	Aboriginal stakeholders invited to provide information about cultural significance the area (letters dated 11/07/2018, 20/08/2018 and 25/01/2019). Previous comments recognised and additional comments sought.	Throughout the assessment process, cultural knowledge regarding the Aboriginal cultural/social values of the study area and identified archaeological sites was sought from registered stakeholders. Identified Aboriginal cultural values of the study area are discussed in section 2.6 of the CHAR.
4.4	Review of draft cultural heritage assessment report	Stakeholders were provided with a copy of the draft CHAR and invited to review and provide comments/feedback (review package sent 25/01/2019). A 30 day review period was provided, ending on 25/02/2019 – review period extended in consideration of Christmas holiday period	Responses to the draft CHAR were received from Barraby Cultural Services (BCS), Duncan Falk Consulting (DFC), Guunamaa Dreamin Sites and Surveying (GDSS), Leanne Tungai, Murra Bidgee Mullangari Aboriginal Corporation (MBMAC), Muragadi Heritage Indigenous Corporation (Muragadi), Merrigarn Indigenous Corporation (Merrigarn), Yurrandaali Cultural Services (Yurrandaali) and Woronora Plateau Gundangara Elders Council (WPGEC). BCS acknowledged receipt of the draft CHAR but did not provide any further comment (email dated 28/01/2019). DFC stated they had reviewed the draft CHAR and agreed with the proposed salvage. DFC also noted they supported the proposed two-stage salvage approach, in order to identify the best locations for open area salvage (email dated 26/01/2019). GDSS acknowledged receipt of the draft CHAR and expressed their interest in being involved in the proposed salvage excavation fieldwork at the sites (email dated 25/01/2019).

Step	Task Requirement	Action	Outcome
4.4 contd.			Leanne Tungai acknowledged receipt of the draft CHAR and stated that she would like to be involved in future work on this project (email dated 26/01/2019). No further comment was provided during the review period. MBMAC stated they had read the draft CHAR and agreed with the recommendations (email dated 25/01/2019). Muragadi stated they agreed with the recommendations made by KNC (email dated 25/01/2019). Merrigarn also stated they had reviewed the draft CHAR and agreed with the recommendations (email dated 25/01/2019). Yurrandaali acknowledged receipt of the draft CHAR but did not provide any further comment (email dated 28/01/2019). WPGEC reconfirmed the identified archaeological value of the project area; however expressed opposition to the proposed development on several grounds (email/letter dated 25/02/2019). A response is provided in Section 2.5 of the CHAR.

Appendix C Aboriginal stakeholder comments on draft CHAR

Cristany Milicich

From: lee field <barrabyculturalservices@gmail.com>
Sent: Monday, 28 January 2019 11:37 AM
To: Cristany Milicich
Subject: Re: 1745 Dunmore Lakes Sand draft CHAR review - BCS

Categories: Purple Category

Received, Thankyou.

Regards
Lee Field

On Fri, Jan 25, 2019 at 4:31 PM Cristany Milicich <cristany.milicich@knconsult.com.au> wrote:

> Dear registered Aboriginal stakeholder,
>
> We have completed the draft CHAR report for the proposed Stage 5 modification at the Dunmore Lakes Sand quarry.
>
> Thank you for your comments and involvement in the project to date. Please find attached a cover letter and a copy of the draft report for your review.
>
> We are recommending salvage excavation for two sites within the area.
>
> If you have any comments please send these through to myself or Zac using the details in the attached cover letter.
>
> The review period closes on **Monday 25 February 2019.**
>
> Thanks and regards,
>
> **Cristany Milicich**
>
> Project Archaeologist
>
> **Kelleher Nightingale Consulting Pty Ltd**
>
> Level 10, 25 Bligh St
>
> Sydney NSW 2000
>
> p 02 9232 5373

1

Cristany Milicich

From: Duncan Falk <DuncanFalk@hotmail.com>
Sent: Saturday, 26 January 2019 3:31 PM
To: Cristany Milicich
Subject: Re: 1745 Dunmore Lakes Sand draft CHAR review - DFC

Categories: Purple Category

Hey Cristany,

Happy New Year to you too and I had a great time off thanks for asking.

I have read through the draft and can see from the test excavation results that a salvage is needed and that proceeding to complete it in two stages would be the best method to identify the area and then continue to the large area salvage. I didn't find any discrepancies within the document provided.

With thanks,

Duncan

[redacted]

From: Cristany Milicich <cristany.milicich@knconsult.com.au>
Sent: Friday, 25 January 2019 4:35 PM
To: Duncan Falk
Subject: 1745 Dunmore Lakes Sand draft CHAR review - DFC

Hi Duncan,

Happy New Year and I hope you had a good break.

We have completed the draft CHAR report for the proposed Stage 5 modification at the Dunmore Lakes Sand quarry.
Thank you for your comments and involvement in the project to date. Please find attached a cover letter and a copy of the draft report for your review.

We are recommending salvage excavation for two sites within the area.

If you have any comments please send these through to myself or Zac using the details in the attached cover letter. The review period closes on **Monday 25 February 2019.**

Thanks and regards,

Cristany Milicich
Project Archaeologist
Kelleher Nightingale Consulting Pty Ltd
Level 10, 25 Bligh St
Sydney NSW 2000
p 02 9232 5373

1

Cristany Milicich

From: Richard Campbell <richardcampbell123@outlook.com>
Sent: Friday, 25 January 2019 5:47 PM
To: Cristany Milicich
Subject: Re: 1745 Dunmore Lakes Sand draft CHAR review - GDSS

Categories: Purple Category

Hi thnks for email but can my group be involved with the salvage this time as i missed out on the work bfor.

Kind regards

Richard

On 25 Jan. 2019 4:37 pm, Cristany Milicich <cristany.milicich@knconsult.com.au> wrote:

Hi Richard,

Happy New Year and I hope you had a good break.

We have completed the draft CHAR report for the proposed Stage 5 modification at the Dunmore Lakes Sand quarry.

Thank you for your comments and involvement in the project to date. Please find attached a cover letter and a copy of the draft report for your review.

We are recommending salvage excavation for two sites within the area.

If you have any comments please send these through to myself or Zac using the details in the attached cover letter.

The review period closes on **Monday 25 February 2019.**

Thanks and regards,

Cristany Milicich

Project Archaeologist

1

Cristany Milicich

From: Leanne Tungai <leannecaroltungai@gmail.com>
Sent: Saturday, 26 January 2019 1:02 AM
To: Cristany Milicich
Subject: Re: 1745 Dunmore Lakes Sand draft CHAR review - Leanne Tungai

Categories: Purple Category

Thanks, I'll take a look.
And would like to be involved in future work on this project please

On Fri, 25 Jan 2019 at 4:43 pm, Cristany Milicich <cristany.milicich@knconsult.com.au> wrote:

> Hi Leanne,
>
> Happy New Year and I hope you had a good break.
>
> We have completed the draft CHAR report for the proposed Stage 5 modification at the Dunmore Lakes Sand quarry.
>
> Thank you for your comments and involvement in the project to date. Please find attached a cover letter and a copy of the draft report for your review.
>
> We are recommending salvage excavation for two sites within the area.
>
> If you have any comments please send these through to myself or Zac using the details in the attached cover letter.
>
> The review period closes on **Monday 25 February 2019.**
>
> Thanks and regards,
>
> **Cristany Milicich**
>
> Project Archaeologist
>
> **Kelleher Nightingale Consulting Pty Ltd**
>
> Level 10, 25 Bligh St

1

Cristany Milicich

From: Ryan Johnson <murrabidgeemullangari@yahoo.com.au>
Sent: Friday, 25 January 2019 7:25 PM
To: Cristany Milicich
Subject: RE: 1745 Dunmore Lakes Sand draft CHAR review - MBMAC

Categories: Purple Category

Hi Cristany,
I have read the project information and draft CHAR for the above project, I endorse the recommendations made by Kelleher Nightingale. If you require further details please contact me via mobile 0475565517.
Thanks
Ryan Johnson | **Murra Bidgee Mullangari**

Aboriginal Corporation Cultural Heritage

A: PO Box 246, Seven Hills, NSW, 2147
E: murrabidgeemullangari@yahoo.com.au
ICN: 8112

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From: Cristany Milicich [mailto:cristany.milicich@knconsult.com.au]
Sent: Friday, 25 January 2019 4:43 PM
To: Ryan Johnson <murrabidgeemullangari@yahoo.com.au>
Subject: 1745 Dunmore Lakes Sand draft CHAR review - MBMAC

Hi Ryan,

Happy New Year and I hope you had a good break.

1

We have completed the draft CHAR report for the proposed Stage 5 modification at the Dunmore Lakes Sand quarry.
Thank you for your comments and involvement in the project to date. Please find attached a cover letter and a copy of the draft report for your review.

We are recommending salvage excavation for two sites within the area.

If you have any comments please send these through to myself or Zac using the details in the attached cover letter. The review period closes on **Monday 25 February 2019.**

Thanks and regards,

Cristany Milicich
Project Archaeologist
Kelleher Nightingale Consulting Pty Ltd
Level 10, 25 Bligh St
Sydney NSW 2000
p 02 9232 5373

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Cristany Milicich

From: Shaun Carroll <Merrigarn@hotmail.com>
Sent: Friday, 25 January 2019 7:54 PM
To: Cristany Milicich
Subject: RE: 1745 Dunmore Lakes Sand draft CHAR review - MIC

Categories: Purple Category

Hi Cristany,
I have read the Draft CHAR review, I endorse the recommendations made by Kelleher Nightingale for the above project.
Kind regards
Shaun Carroll

From: Cristany Milicich [mailto:cristany.milicich@knconsult.com.au]
Sent: Friday, 25 January 2019 4:45 PM
To: merrigarn@hotmail.com
Subject: 1745 Dunmore Lakes Sand draft CHAR review - MIC

Hi Shaun,

Happy New Year and I hope you had a good break.

We have completed the draft CHAR report for the proposed Stage 5 modification at the Dunmore Lakes Sand quarry.
Thank you for your comments and involvement in the project to date. Please find attached a cover letter and a copy of the draft report for your review.

We are recommending salvage excavation for two sites within the area.

If you have any comments please send these through to myself or Zac using the details in the attached cover letter. The review period closes on **Monday 25 February 2019.**

Thanks and regards,

Cristany Milicich
Project Archaeologist
Kelleher Nightingale Consulting Pty Ltd
Level 10, 25 Bligh St
Sydney NSW 2000
p 02 9232 5373

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Cristany Milicich

From: Muragadi <muragadi@yahoo.com.au>
Sent: Friday, 25 January 2019 7:59 PM
To: Cristany Milicich
Subject: RE: 1745 Dunmore Lakes Sand draft CHAR review - MHIC

Categories: Purple Category

HI Cristany,
I have read the project information, draft CHAR report for 1745 Dunmore Lakes Sand and agree with the recommendations made by Kelleher Nightingale Consulting.
Kind regards
Anthony

From: Cristany Milicich [mailto:cristany.milicich@knconsult.com.au]
Sent: Friday, 25 January 2019 4:44 PM
To: jesse johnson <muragadi@yahoo.com.au>
Subject: 1745 Dunmore Lakes Sand draft CHAR review - MHIC

Hi Jesse,

Happy New Year and I hope you had a good break.

We have completed the draft CHAR report for the proposed Stage 5 modification at the Dunmore Lakes Sand quarry.
Thank you for your comments and involvement in the project to date. Please find attached a cover letter and a copy of the draft report for your review.

We are recommending salvage excavation for two sites within the area.

If you have any comments please send these through to myself or Zac using the details in the attached cover letter. The review period closes on **Monday 25 February 2019.**

Thanks and regards,

Cristany Milicich
Project Archaeologist
Kelleher Nightingale Consulting Pty Ltd
Level 10, 25 Bligh St
Sydney NSW 2000
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DUNMORE LAKES SAND PROJECT – STAGE 5 MODIFICATIONS – DUNMORE - NSW

Woronora Plateau Gundangara Elders Council (WPGEC) do not support the proposed modifications of extraction of DLS Boral AFT 1 & DLS Boral AFT 2. The proposed modifications & extraction will see the mine's life extended for a further three to four years, causing irreparable and complete destruction of a rare and valuable natural and cultural landscape. Dunmore Lakes is one of very few undisturbed estuarine environments remaining in the Illawarra region and wider surrounds, holds an intact and rich archaeological site, and encompasses land of cultural and modern historical importance. The identified high significance of harm to the impacted area must be considered to be of more worth than the profits to be made from the proposed destructive activities by Boral (insert the full name of company or whoever is responsible here). Mitigation, in this case of direct and total loss of value of this site, would be an inadequate solution and it is preferred that the afore mentioned modifications and further mining activities cease completely.

WPGEC along with other key stakeholder groups and the local Aboriginal community are of the strong belief that this site is significant for several reasons:

1. Its value as a rare undisturbed estuary environment in the Illawarra region.

2. The intactness of its archaeological deposits and its cultural importance as a site of continuous occupation with evidence of a lengthy and maintained connection to this land. This has been established through previous archaeological investigations, the most recent and relevant to this specific study area being the test excavations of 5A and 5B completed by Kelleher Nightingale Consulting and registered stakeholder groups between the 19th and 23rd November 2018. A total of 461 artefacts found at site DLS Boral AFT 1 and 828 artefacts found at site DLS Boral AFT 2. These artefacts included coarse silcrete flaked fragments with cortex, crystalline quartz backed artefacts, retouched jasper and silcrete, a petrified wood backed blade, an agate geometric microlith, a charcoal feature, and a hammerstone which was recorded *in situ* at around 65cm depth and a sandstone ground stone. The number and distribution of artefacts clearly show that occupation and activities at this site occurred during a prolonged period of time, and on a repeated basis. Furthermore, analysis and interpretation of the material recovered from these test excavations may suffice for the purposes of understanding and managing sites in similar estuarine environments, thus not requiring the data from the proposed salvage and allowing this site to remain otherwise intact.

3. Its proximity to the site of a massacre which occurred just to the south of the study area.

   "In October 1818 Lieutenant Weston, land owner at Dapto and Cornelius O'Brien, formerly a stockman at Sandon Point and now the overseer of a property at Yallah, organised a group of seven labourers and convicts. Unusually armed with muskets, cutlasses and pikes, they headed to Kiama supposedly to fetch two muskets lent to a group of people living on the Minnamurra River. According to Young Bundle, who was long trusted by the British, the posse killed all the people at the camp. The attackers admitted only to wounding a boy in self-defence. After a sharp letter of protest from Charles Throsby to Governor Macquarie, the murders were investigated by D'Arcy Wentworth, the Principal Superintendent of Police, along with other magistrates. They took no action against the killers despite a letter from Governor Macquarie to D'Arcy Wentworth expressing his "surprise, regret and displeasure" at their findings".
   (Donaldson et al 2017:13).

   This atrocity has now been formally acknowledged by Kiama Council, an action which should prompt appropriate respect for the site and its surrounds.

4. Its high potential of containing burials due to the traditional practices in the Illawarra region of digging graves in the soft soil along waterways, including the Minnamurra River, or into sand banks. Additionally, the proximity to the massacre noted in (3) may provide further weight to the possibility of burials. Observations by early European settlers of similar mass deaths in the region detail how the dead would be buried nearby and close to water. Lynch (1820), for example, recounts how around seventy men, killed in the battle of Fairy Meadow, were buried in the scrub between the battle ground and the sea, between the two arms of Fairy Creek. There is therefore reason to suspect, due to the natural landscape of the Dunmore Lakes area, its recent history, and comparable information, that there may be burials from both the distant and more recent past.

The Aboriginal people of Australia possess one of the oldest continuous living cultures in the world. The protection of cultural and spiritual landscapes and materials, including sacred sites and artefacts, both past and present, is vital to maintaining this culture. We believe any type of mining of the land is unacceptable, especially for the financial gain of a highly profitable company that has already destroyed other parts of the land and impacted the local communities and environment to date. The Australian Government has legislation in place such as the Heritage Act, 1977 and the Environmental Planning and Assessment Act 1979, which acts to protect heritage listed items as they represent Australian and European culture and history, and this is seen being enforced around Australia on a daily basis. Aboriginal culture and history demands the same respect and value, through the regular and repeated preservation and protection of significant sites such as Dunmore Lakes.

WE OPPOSE ANY APPROVAL FOR THE MINING OF SAND FOR THIS PROJECT.

Kind Regards
Kayla Williamson
Woronora Plateau Gundangara Elders Council

REFERENCES

Donaldson, M., L. Bursill, & M. Jacobs, 2017. A History of Aboriginal Illawarra, Volume 2: Colonisation, Dharawal Publications: Yowie Bay, NSW.

https://www.environment.nsw.gov.au/resources/cultureheritage/illawarraAboriginalHistory.pdf

Kelleher Nightingale Consulting Pty Ltd (KNC) 2019. Dunmore Lakes Sand Project – Stage 5 Modifications, DUNMORE: CHAR.

We have supporting signatures below of stakeholder groups and community members that also have the same view as listed above.

NAME	GROUP/COMMUNITY	SIGNATURE
L. Brown	Coonaditchie Aboriginal Corp	Lorraine Brown
N THOMAS	COONADITCHIE ABORIGINAL	Narelle Thomas
J brown	Dunghutti	Jbrown
A Day	Coonaditchie Dunghutti	
N. Archibald	Coonaditchie	N Archibald
R. Dutton	Goobah	R. Dutton
KIM DAVIS.	WODI-WODI.	K Davis.
BROOKE DAVIS	WODI-WODI	B Davis.
Julie Luland	Noogaleek.	
Bronwyn	Noogaleek-Yuin	
Tanya Moran	Noogaleek-Yuin	
Teresa Doyle	Noogaleek	
Manda Schembri	Noogaleek	
Cheryl Price	Noogaleek	
mackettLaurena	NOOGALEEK	M.S. Laurena
Roslynne Webb	Yuin	

NAME	GROUP/COMMUNITY	SIGNATURE
MARK PIETRUSZEWSKI	ELDURA. ELSER.	M. Pietruszewski

NAME	GROUP/COMMUNITY	SIGNATURE
Leanne Tungai	Leanne Tungai (Nogarini)	
Steve Henry	community member	
Kevin Booth	Community Member	
James DAVIS	Wodi Wodi	
Clint Davis	Wodi Wodi	
Bryan Tebbutt	Wodi wodi	
Megan Dalmazzo	wodi wodi	
Paul Cumming	Eloura Tribal Elder	
TROY TUNSDI	TUNSOI / TONSNI	
KRISTY THOMAS	COOMADITCHIE	
Sandra Campbell	THOCGA NURA	
PAUL KNIGHT	COMMUNITY MEMBER	
Renai Smith	(IAC) Wiradyuri	
Irene Mooi	(IAC) Yuin	
Dale Thelt	(IAC) Yuin	
E Henry	KANGAROO. DC	
William Henry	CEO IAC	
RICHARD DAVIS	CHAIRPERSON IAC	

Cristany Milicich

From: Bo Field <yurrandaali_cs@hotmail.com>
Sent: Monday, 28 January 2019 11:40 AM
To: Cristany Milicich
Subject: Re: 1745 Dunmore Lakes Sand draft CHAR review - YCS

Categories: Purple Category

Recieved,

Thankyou
Bo Field

Sent from Outlook

From: Cristany Milicich <cristany.milicich@knconsult.com.au>
Sent: Friday, 25 January 2019 4:48 PM
To: Yurrandaali_cs@hotmail.com
Subject: 1745 Dunmore Lakes Sand draft CHAR review - YCS

Dear registered Aboriginal stakeholder,

We have completed the draft CHAR report for the proposed Stage 5 modification at the Dunmore Lakes Sand quarry.
Thank you for your comments and involvement in the project to date. Please find attached a cover letter and a copy of the draft report for your review.

We are recommending salvage excavation for two sites within the area.

If you have any comments please send these through to myself or Zac using the details in the attached cover letter. Also please let me know if you would like a hard copy. The review period closes on **Monday 25 February 2019.**

Thanks and regards,

Cristany Milicich
Project Archaeologist
Kelleher Nightingale Consulting Pty Ltd
Level 10, 25 Bligh St
Sydney NSW 2000
p 02 9232 5373

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Appendix D Extensive AHIMS search results

Office of Environment & Heritage

AHIMS Web Services (AWS)

Extensive search - Site list report

Your Ref/PO Number : 1745
Client Service ID : 386985

SiteID	SiteName	Datum	Zone	Easting	Northing	Context	Site Status	SiteFeatures	SiteTypes	Reports
52-5-0159	Tabbagong;Tabbagong 1;	AGD	56	301865	6165336	Open site	Valid	Shell : -, Artefact : -	Midden	
	Contact	Recorders	Klim Gollan					Permits		
52-5-0160	Minnamurra;	AGD	56	301143	6164865	Open site	Valid	Shell : -, Artefact : -	Midden	1473,99329
	Contact	Recorders	ASRSYS					Permits		
52-5-0162	Minnamurra River;Gainsborough Estate;	AGD	56	302350	6164600	Open site	Valid	Shell : -, Artefact : -	Midden	99329
	Contact	Recorders	Rod Wellington					Permits		
52-5-0167	Minnamurra;Minnamurra Spit 2;	AGD	56	303260	6166700	Open site	Valid	Shell : -, Artefact : -	Midden	
	Contact	Recorders	Rod Wellington					Permits		
52-5-0168	Minamurra;Minamurra Spit 1;	AGD	56	303490	6166280	Open site	Valid	Shell : -, Artefact : -	Midden	
	Contact	Recorders	ASRSYS					Permits		
52-5-0169	Minamurra; Bass Point SRA;	AGD	56	302750	6167400	Open site	Valid	Shell : -, Artefact : -	Midden	102212
	Contact	Recorders	Miss.Marjorie Sullivan					Permits		
52-5-0251	Dunmore 1	AGD	56	301540	6166460	Open site	Valid	Artefact : -	Open Camp Site	687,1662,2048
	Contact	Recorders	Kerry Navin,Mr.Kelvin Officer					Permits		
52-5-0252	Dunmore 2;	AGD	56	301360	6166600	Open site	Valid	Artefact : -	Open Camp Site	1662
	Contact	Recorders	Kerry Navin,Mr.Kelvin Officer					Permits		
52-5-0253	Dunmore 3	AGD	56	301830	6166930	Open site	Valid	Artefact : -	Open Camp Site	687,1662,2048
	Contact	Recorders	Kerry Navin,Mr.Kelvin Officer					Permits		
52-5-0254	Dunmore 4;	AGD	56	301480	6167260	Open site	Valid	Artefact : -	Open Camp Site	1662
	Contact	Recorders	Kerry Navin,Mr.Kelvin Officer					Permits	1519	
52-5-0255	Dunmore 5;	AGD	56	301400	6167110	Open site	Valid	Artefact : -	Open Camp Site	1662
	Contact	Recorders	Kerry Navin,Mr.Kelvin Officer					Permits	1519	
52-5-0112	Minnamurra;	AGD	56	302052	6165157	Open site	Valid	Shell : -, Artefact : -	Midden	2048
	Contact	Recorders	Kate Sullivan					Permits		
52-5-0116	Dunmore; Killalea;	AGD	56	303652	6167475	Open site	Valid	Shell : -, Artefact : -	Midden	
	Contact	Recorders	Kate Sullivan					Permits		
52-5-0117	Minnamurra;	AGD	56	301856	6165793	Open site	Valid	Artefact : -	Open Camp Site	
	Contact	Recorders	Kate Sullivan					Permits		
52-5-0118	Dunmore;	AGD	56	304265	6168860	Open site	Valid	Artefact : -	Open Camp Site	102212
	Contact	Recorders	A Henderson					Permits		
52-5-0199	Killalea Beach;S.R.A.;Albion Park;	AGD	56	304150	6168000	Open site	Valid	Shell : -, Artefact : -	Midden	102212
	Contact	Recorders	A Anderson					Permits		
52-5-0201	Dunmore Midden Shellharbour Waste Disposal Dump	AGD	56	302000	6167800	Open site	Valid	Artefact : -	Open Camp Site	901
	Contact	Recorders	Ms.Laila Haglund,Bonhomme Craib & Associates					Permits		

Report generated by AHIMS Web Service on 04/12/2018 for Kristen Taylor for the following area at Datum :GDA, Zone : 56, Eastings : 300800 - 304650, Northings : 6164300 - 6169300 with a Buffer of 200 meters. Additional Info : to help with determining archaeological potential. Number of Aboriginal sites and Aboriginal objects found is 29

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Page 1 of 2

Office of Environment & Heritage

AHIMS Web Services (AWS)

Extensive search - Site list report

Your Ref/PO Number : 1745
Client Service ID : 386985

SiteID	SiteName	Datum	Zone	Easting	Northing	Context	Site Status	SiteFeatures	SiteTypes	Reports
52-5-0213	Dunmore Midden	AGD	56	302000	6167800	Open site	Valid	Artefact : -, Shell : -	Midden,Open Camp Site	901
	Contact	Recorders	Bonhomme Craib & Associates					Permits		
52-5-0072	Minnamurra Glengowrie	AGD	56	301450	6165490	Open site	Valid	Shell : -, Artefact : -	Midden	687,1662,2048
	Contact	Recorders	R L Black					Permits		
52-5-0240	Min 1;	AGD	56	300650	6164660	Open site	Valid	Shell : -, Artefact : -	Midden	1473,99329
	Contact	Recorders	Margrit Koettig					Permits		
52-5-0241	Minnamurra Site 1;	AGD	56	302800	6165900	Open site	Valid	Shell : -, Artefact : -	Midden	1525
	Contact	Recorders	I Lilley					Permits	4350	
52-5-0242	Minammurra Site 2;	AGD	56	302900	6165500	Open site	Valid	Shell : -, Artefact : -	Midden	1525
	Contact	Recorders	I Lilley					Permits		
52-5-0243	Green Three"Minnamurra Golf Course";	AGD	56	302900	6165820	Open site	Valid	Shell : -, Artefact : -	Midden	
	Contact	Recorders	Doctor Johan Kamminga					Permits		
52-5-0200	Minnamarra;S.R.A.;Albion Park;	AGD	56	302840	6166930	Open site	Valid	Shell : -, Artefact : -	Midden	
	Contact	Recorders	A Anderson					Permits		
52-5-0819	Riverside Drive 1	GDA	56	302395	6166973	Open site	Valid	Artefact : 1, Shell : 1		
	Contact	Recorders	Mr.Neville Baker,Baker Archaeology					Permits		
52-5-0825	Restriction applied. Please contact ahims@environment.nsw.gov.au.					Open site	Valid			
	Contact	Recorders	Rod Wellington					Permits		
52-5-0526	Minnamurra River Shell Midden 1 (MR1)	AGD	56	302054	6166338	Open site	Valid	Shell : -, Artefact : -		
	Contact	Recorders	Mary Dallas Consulting Archaeologists					Permits	2920	
52-5-0869	James Oates Reserve midden	GDA	56	303744	6165971	Open site	Valid	Shell : -		
	Contact	Recorders	Rod Wellington,NPWS - Narooma					Permits		
52-5-0451	MR-IF-1, Kiama	AGD	56	301530	6165440	Open site	Valid	Artefact : 1		
	Contact T Russell	Recorders	Jim Kelton					Permits		

Report generated by AHIMS Web Service on 04/12/2018 for Kristen Taylor for the following area at Datum :GDA, Zone : 56, Eastings : 300800 - 304650, Northings : 6164300 - 6169300 with a Buffer of 200 meters. Additional Info : to help with determining archaeological potential. Number of Aboriginal sites and Aboriginal objects found is 29

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Page 2 of 2

Appendix E Salvage Excavation Methodology

Methodology

Research Aims

The main aims of the proposed salvage excavation program are:

- To salvage a representative sample of the identified archaeological sites prior to development impact.
- To analyse the salvaged archaeological material to gain and conserve knowledge and understanding of the scientific and cultural information exhibited by the activities associated with coastal landforms.

The further scientific aim of the salvage excavation program would be to determine the subsurface integrity, extent, spatial distribution and nature of the cultural deposit and the specific types of associated archaeological/cultural activities.

- Determining the integrity of the deposit involves assessing the degree of disturbance which is present.
- Determining the statistical extent of the sites and/or activity areas involves identifying the boundaries associated with the identified archaeological deposit.
- Assessing the spatial distribution involves identifying the presence/absence of archaeological material across the identified archaeological sites.
- The nature of the sites refers to the type of activities indicated by the artefactual material (e.g. primary production, domestic knapping, hunting camps). The goal would be to retrieve entire assemblages from specific activities if such activities were present.
- Retrieved assemblages would be compared with the results from other relevant archaeological projects in order to assess significance.

Research Questions

Archaeologically, sites DLS Boral AFT 1 and 2 represent important resource enabled (from estuary environments) focal points. Such focal points are often associated with very selective activity, which is reinforced by the selective and high quality nature of the artefacts recovered during the test program. The results of the proposed salvage excavation would increase our understanding of subsurface archaeology within the study area. In particular, research would focus on the archaeologically-identifiable cultural activities that took place within the beach sand bodies adjacent to the Minnamurra River estuary. DLS Boral AFT 1 and DLS Boral AFT 2 represent site types uncommon due to their low levels of previous disturbance in the region and the close association with an estuary may have facilitated longer, repeated or more specialised use of this area.

What can we expect?

It is anticipated that differences in stone tool assemblages may be related to different cultural activities (e.g. primary reduction vs maintenance flaking). Results from the test excavation program indicate that the sites may display assemblages with different characteristics, possibly representing different activities or site use over a prolonged time or repeated occasions. The science of archaeology is paramount to any research question and it is important to stress that the goal for the salvage program for all excavated sites is straight forward: to retrieve a viable sample for comparative analysis using established techniques (see Field Methods below). In this regard interpretation would not precede data collection. The proposed archaeological program would systematically sample the relevant areas using standard techniques with the outcome being a viable, robust and comparable sample. Analysis of the sample would follow and interpretations would be made distinctly separate from the results.

Question 1: What cultural activities are archaeologically identifiable in association with exploitation of estuarine environments?

Question 2: How does past Aboriginal use of this area relate to activities in adjacent areas (alluvial plains, ridgelines and the more elevated sandstone escarpments further west)?

Question 3: Do the sites display any unique or distinguishing traits that may be the result of their location in a unique landscape?

Question 4: Do sites contain evidence for repeated or specialised activities across long periods of time, or a single event in time? Is this reflected within the artefact assemblage (i.e. preference for certain raw material or artefact types)?

Archaeological Salvage Areas

Salvage excavation would be undertaken on identified archaeological sites DLS Boral AFT 1 and DLS Boral AFT 2. Salvage excavation of these sites would focus on the extraction of collections of artefacts related to activity areas and geomorphic information.

FIELD METHODS

The goal of the field excavation program is to recover significant assemblages of artefacts and investigation of contributing geomorphic processes.

Salvage Program

In order to achieve the most robust and comparable result, KNC advocates an open area salvage excavation. The first phase in open area salvage is to establish the statistical boundaries of the previously identified archaeological deposit. This approach is designed to salvage the spatial properties of the site as shown in the lithic continuum; in other words, recording the spread of activities across the site and wider landscape.

Phase 1

Where Phase 1 test results identified information bearing deposit Phase 2 excavation will be completed. Information bearing deposits are identified by triggers such as: significant quantities of artefacts, variations in raw material, unusual artefacts, chronological material and/or taphonomic indicators. In this context chronologic material is anything that can be used to date artefacts or deposit: charcoal or charcoal bearing deposit (e.g. hearth ash), sandy deposit, gravels (e.g. aluminium feldspar). Where necessary additional Phase 1 squares can be excavated at 20m intervals on a transect grid overlain on each site to confirm the spread of lithics and related geomorphic activity. Phase 1 squares would be positioned to complement and augment the information from the previous test excavation program.

Phase 1 excavation would also determine the depth of intact archaeological material to ensure the retrieved sample is representative of cultural activity. Geoarchaeological assessment will us 50mm micro cores to assist the determination of the depth of archaeological material.

Phase 2

Open area salvage, Phase 2 will expand on Phase 1 squares to encompass entire activity areas. It is anticipated that around 75-100m^2 will be excavated during the Phase 2 salvage program.

Individual excavation squares measuring 1 m^2 would be hand excavated in stratigraphic units (Unit A, Unit B, etc.). Squares would be excavated until the basal layer or culturally sterile deposit is reached (on average to 80 centimetres, potentially up to 1.5m below the surface). Excavation will be undertaken by stratigraphic unit.

Sieving of the excavated deposit is required with a minimum sieve size of 2.5mm. The use of the 1mm sieve mesh will also be used to capture micro debitage (where required) for assessing depositional movement (possibly pumice debitage that could indicate natural reworking activity) and interpreting activity area. The use of 1mm sieve mesh has been shown to contribute significant information about site integrity and artefact reduction.

Sampling of the sandy matrix to at least 1.5m depth will be undertaken in areas revealing high density or significant cultural deposits. In addition, thin section profiles (where feasible) would also be collected from open areas. The soil profiles of all areas would be fully documented and appropriate records would be archived.

Carbon samples will be collected and analysed for material relating to both the archaeology and geomorphology. Where appropriate cosmogenic and radiometric dating of soils and rock surfaces will be applied (Nishiizumi et al. 1986, 1993).

The location of each excavated square would be identified on a surveyed plan of the site. Stratigraphic sections detailing the stratigraphy and features within the excavated deposit would be drawn and all squares would be photographed.

Analysis

Artefacts would be analysed on a comparable level with previous analyses of excavated assemblages. Information derived from this analysis; in particular the identification of specific artefact types and their distributions and associations; would be used to put together interpretations about how sites were used, where sites were located across the landscape, the age of sites and to assess cultural heritage values. By comparing different areas it would be possible to determine whether there were differences in the kinds of activities carried out and if different activities were related to different landforms.

The geoarchaeological assessment will focus on the integrity of the deposit and the ramifications of geomorphic change for: artefact survivability, interspatial assessments and scientific significance.

A range of stone artefacts may be present across the salvage areas and the analysis would expand accordingly to account for artefact variability. All information would be recorded in database form (MS Excel). Various types of evidence would be used to determine the kinds of activities that were carried out. A short description of the proposed analysis in outlined below.

- Field analysis would record basic data, such as material type, number and any significant technological characteristics, such as backing or bipolar techniques; added to this would be any provenance data such as pit ID and spit number. The purpose of the field recording is twofold: 1) establish a basic recording of artefacts retrieved and 2) to allow on-going assessment of the excavation regime (e.g. whether higher stratigraphic resolution is required while digging).
- Detailed (laboratory) analysis would entail recording a larger number of characteristics for each individual artefact. These details would be recorded in matrices suitable for comparative analysis (e.g. multivariate and univariate) of the excavated assemblage on a local and regional basis.
- Lithic characteristics to be recorded cover a range of basic information but are not limited to these categories (see example below). For transparency, terms and category types would in large part be derived from Holdaway and Stern (2004).

Sample Categories		
Record Number	% Cortex	Flake Type
Pit ID	Length	Termination Type
Spit Number	Width	Core Type
Count	Thickness	Number of Scars (Core)
Raw Material	Weight	Scar Type (Core)
Colour	Modification	Shape of Flake
Quality	Reduction Type	Platform Type

- A detailed explanation and glossary would be provided with the final excavation report.
- Minimum Number of Flake (MNF) calculations formulated by Hiscock (2002) would be undertaken where applicable (although past experience indicates MNF calculations would not be required for this excavation program).

The analysis of artefacts recovered during the excavation program would be undertaken in a transparent and replicable fashion so as to permit the comparison of the entire excavated assemblage with data from other areas. This would also allow for an interpretation of the study area's archaeological significance.

Field Team

KNC directors, Dr Matthew Kelleher and Alison Nightingale, would be responsible for the salvage excavation program. Dr Matthew Kelleher would direct the excavation component of the Aboriginal archaeological assessment. Matthew has extensive experience in managing archaeological excavations and research projects. Matthew would also be the principal contact for the overall Aboriginal archaeological assessment for the project. The salvage excavation will be undertaken in partnership with registered Aboriginal stakeholders.

APPENDIX F

BIODIVERSITY DEVELOPMENT ASSESSMENT REPORT

niche
Environment and Heritage

Dunmore Lakes Sand Project Modification 2

Biodiversity Development Assessment Report

Prepared for Dunmore Sand & Soil Pty Ltd

April 2019

Document control

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Cover photograph: Bangalay Sand Forest within the site (Lucy Porter)

Executive summary

Context

Stage 1 of the Dunmore Lakes Sand Project (the 'Approved Project') was issued development consent from the then Minister for Planning in 1999. Stage 1 was on Swamp Road, Dunmore, and encompassed sand extraction by dredging of up to 500,000 tonnes per annum (tpa) for a period of 10 years. The Stage 1 consent included conditions requiring the proponent to lodge a further application for the remaining identified Stages of the Dunmore sand resource (being Stages 2 to 4).

The application for Stages 2 to 4 was lodged in 2004, and development consent was received from the Minister for Planning in June 2005. The consent approves extraction of up to 800,000 tpa of sand for a period of 25 years. Boral Resources (NSW) Pty Ltd (hereafter 'Boral') purchased Dunmore Sand & Soil Pty Ltd (DSS), including the Dunmore Lakes Sand Project in mid-2005. The Stage 1 consent has since lapsed following successful extraction of the approved sand resource and rehabilitation of the site in 2010.

Stages 2 to 4 commenced dredging in June 2007. Since then, due to the high demand for sand in the Sydney market, the majority of sand in Stage 2 has been extracted with dredging recently moving into Stage 3. Given recent high demand, the sand resource in Stage 3 is expected to be exhausted in approximately 3-5 months. The last extraction stage (Stage 4) encompasses an area containing the site's road access and private rail line, and supporting infrastructure for the Stage 2 to 4 operations and Boral's adjacent Dunmore hard rock quarry. Given this, Stage 4 cannot be extracted until these activities are relocated. This has led DSS to investigate other local sources of sand to continue operations beyond Stage 3.

DSS has been investigating a fine sand resource on an adjoining private property to the south (referred to as Stage 5). Investigative drilling has confirmed that there is sufficient sand resource to support three to four more years of extraction from two areas (Stage 5A and 5B).

As such, DSS is seeking to modify the current Project Approval (DA 195-8-2004) under Section 75W of the *Environmental Planning and Assessment Act 1979* (EP&A Act), to provide for an additional extraction area (Stage 5) on adjoining private land, encompassing two separate extraction areas, Stage 5A and Stage 5B (hereafter referred to as the 'project').

The modification proposed above will constitute Modification 2 to the current Project Approval. The Minister for Planning is the consent authority for the modification.

Aims

Niche Environment and Heritage Pty Ltd was commissioned by DSS via Element Environment to assess the ecological values and impacts associated with the proposed modification of the Dunmore Lakes Sand project. The primary objective of this report is to use the methodology provided in the Biodiversity Assessment Methodology (OEH 2017a) to describe and assess the ecological values within the site, and determine how the project is likely to have an impact on threatened biodiversity listed under the NSW *Biodiversity Conservation Act 2016, NSW Fisheries Management Act 1994,* and the *Commonwealth Environment Protection and Biodiversity Conservation Act 1999*.

Survey overview

Niche performed ecological surveys for the project over April - May 2018 and January 2019. Field survey employed methods consistent with the NSW BAM to map and quantify the condition of Plant Community Types (PCTs) within the site. In addition, targeted fauna surveys were performed for Gang-gang Cockatoo

(*Callocephalon fimbriatum*), Glossy Black-Cockatoo (*Calyptorhynchus lathami*), Eastern Pygmy-possum (*Cercartetus nanus*), Little Eagle (*Hieraaetus morphnoides*), Green and Golden Bell Frog (*Litoria aurea*), Square-tailed Kite (*Lophoictinia isura*) and Southern Myotis (*Myotis macropus*).

Native vegetation Assessment

The majority of the modification site constitutes exotic Grassland/shrubland, with stock grazing and other disturbances having occurred over decades. Two native vegetation types were identified within the site: Bangalay Sand Forest and Swamp Oak Floodplain Forest. Both communities are listed Threatened Ecological Communities (TECs) under State or Commonwealth legislation. Swamp Oak Floodplain Forest would not be impacted by any vegetation clearing. Bangalay Sand Forest was present in three different condition classes: good, moderate and poor (derived native grassland). Refinements to the design of the proposed modification were made to avoid and limit impacts to areas of good condition vegetation.

Threatened fauna

Limited fauna habitat was present throughout areas of the modification site requiring clearing, with notable habitat elements consisting of scattered trees and stags with hollows and a single farm dam which provides some aquatic habitat.

Seven species of threatened fauna were detected during targeted survey within the study area, including Dusky Woodswallow (*Artamus cyanopterus cyanopterus*), Varied Sittella (*Daphoenositta chrysoptera*), Southern Myotis (*Myotis macropus*), Eastern Bentwing-bat (*Miniopterus schreibersii oceanensis*), Eastern Freetail-bat (*Mormopterus norfolkensis*), Grey-headed Flying Fox (*Pteropus poliocephalus*) and White-bellied Sea Eagle (*Haliaeetus leucogaster*).

Threatened flora

No threatened flora were recorded within the proposed modification area during field survey and none are expected to occur.

Impacts – Native vegetation

The main impact on terrestrial biodiversity associated with the proposed modification is clearing of native vegetation and removal of associated habitat within the study area. The extent of clearing of native vegetation communities is conservatively estimated at 7.5 hectares.

One native vegetation community, comprising a Threatened Ecological Community (TEC), will be impacted by the proposed modification – Bangalay sand forest, Sydney Basin and South East Corner bioregions (listed as an Endangered Ecological Community (EEC) under the BC Act and Critically Endangered Ecological Community (CEEC) under the EPBC Act). Approximately 7.5 hectares of the TEC would be impacted. Three condition zones of this community would be impacted, including:

- Good condition: Consisting of close patches of Eucalypt stands with a mixture of native and exotic ground cover. This condition class has a vegetation integrity score of 41.8.
- Moderate condition: Consisting of a few sparsely scattered Eucalypts, with a mixture of native and exotic ground cover. This condition class has a vegetation integrity score of 26.5.
- Poor condition: Consisting of a number of exotic pasture species within areas dominated by native grasses. No overstorey or midstorey species present. This condition class has a vegetation integrity score of 9.2.

An offset for the impact has been provided for this TEC as per the requirements of the BAM.

Impacts – Threatened fauna

Three species credit fauna, and one EPBC listed threatened and migratory fauna are considered to be affected by the proposed modification. Most of these species are likely to utilise the foraging habitat of the modification area on an intermittent basis.

The Barking Owl, Masked Owl and Southern Myotis would be offset according to the requirements of the BAM.

Assessments of Significance completed for the EPBC Act listed fauna, has indicated that a significant impact toward the Grey-headed Flying Fox is unlikely, therefore a referral to the Commonwealth DoEE is not required as the proposed modification will not significantly impact on MNES (biodiversity).

Impacts – Threatened flora

No threatened flora are likely to be impacted by the proposed modification given the lack of suitable habitat and results of the field survey.

Avoidance and minimisation

The project design process has demonstrated avoidance to biodiversity impacts as far as practical. Avoidance measures incorporated into design planning for the proposed modification have avoided or minimised impacts on biodiversity through the following actions:

- Project designed to use existing processing and transport infrastructure which avoids impacts from the establishment of new infrastructure.
- Significant reduction of the 5A and 5B proposed dredge pond areas to minimise impacts on TECs, threatened species habitat and limit proximity to Coastal SEPP areas.
- Relocation of minor infrastructure that requires clearing and excavation onto non-sensitive land.
- Avoidance of direct impacts within the 'proximity area for coastal wetlands' located immediately east of the Stage 5B extraction area.

Avoidance measures regarding the positioning of the project footprint are limited by the position of the available sand resource, a requirement for close proximity to existing processing infrastructure, avoidance of public or reserved land (often coincident with coastal sand resources) and avoidance of other constraints such as heritage items.

Mitigation and management

The project will reduce impacts to biodiversity through a range of measures to protect remaining adjacent vegetation and rehabilitation of specific areas post extraction. Specific measures are provided within this report.

Offset credit calculations

Seventy-one (71) ecosystem credits are required for clearing of 4.53 ha of Bangalay Sand Forest. Nineteen species credits are required for clearing of 1.4 ha of Southern Myotis habitat. Seventy-one credits are required for clearing of 2.23 ha of Masked Owl and Barking Owl habitat. It is likely that this credit obligation would be satisfied via payments into the NSW Biodiversity Conservation Fund.

Glossary

Term	Definition
Clearing area	Means the area directly impacted by the site either by clearing of vegetation or trimming of vegetation.
Modification site (site)	Means the location of the proposed Stage 5 extraction area and associated infrastructure. Direct impacts occur wholly within this area.
Locality	The site and surrounds, nominally a 10 km radius from the site.
Development envelope	Stage 5A and 5B extraction areas (see also clearing area).
Study area	Means the site and surrounding land where surveys were conducted.
Trimming	Removal of parts of a tree or shrub but not the entire plant.

Abbreviations

Acronym	Term/Definition
BAM	Biodiversity Assessment Methodology
BDAR	Biodiversity Development Assessment Report
BAM Calculator	Biodiversity Credit Calculator
BC Act	*Biodiversity Conservation Act 2016* (NSW)
BOS	*NSW Biodiversity Offsets Scheme*
CEEC	Critically Endangered Ecological Community
DP&E	NSW Department of Planning and Environment
DNG	Derived Native Grassland
EEC	Endangered Ecological Community
EIS	Environmental Impact Statement
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999* (Commonwealth)
FM Act	*Fisheries Management Act 1994*
FFMP	Flora and Fauna Management Plan
ha	Hectare/s
IBRA	Interim Biogeographic Regionalisation for Australia
MNES	Matters of National Environmental Significance (from the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*).
m	Metre/s
m^2	Metres square
OEH	Office of Environment and Heritage (formerly DECCW, DECC, DEC)
PCT	Plant Community Type
SAII	Serious and Irreversible Impacts
SSD	State Significant Development
TEC	Threatened Ecological Community

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1. Introduction

1.1 Project description

Stage 1 of the Dunmore Lakes Sand Project (the 'Approved Project') was issued development consent from the then Minister for Planning in 1999. Stage 1 was on Swamp Road, Dunmore, and encompassed sand extraction by dredging of up to 500,000 tonnes per annum (tpa) for a period of 10 years. The Stage 1 consent included conditions requiring the proponent to lodge a further application for the remaining identified Stages of the Dunmore sand resource (being Stages 2 to 4).

The application for Stages 2 to 4 was lodged in 2004, and development consent was received from the Minister for Planning in June 2005. The consent approves extraction of up to 800,000 tpa of sand for a period of 25 years. Boral Resources (NSW) Pty Ltd (hereafter 'Boral') purchased Dunmore Sand & Soil Pty Ltd (DSS), including the Dunmore Lakes Sand Project in mid 2005. The Stage 1 consent has since lapsed following successful extraction of the approved sand resource and rehabilitation of the site in 2010.

Stages 2 to 4 commenced dredging in June 2007. Since then, due to the high demand for sand in the Sydney market, the majority of sand in Stage 2 has been extracted with dredging recently moving into Stage 3. Given recent high demand, the sand resource in Stage 3 is expected to be exhausted in approximately 3-5 months. The last extraction stage (Stage 4) encompasses an area containing the site's road access and private rail line, and supporting infrastructure for the Stage 2 to 4 operations and Boral's adjacent Dunmore hard rock quarry. Given this, Stage 4 cannot be extracted until these activities are relocated. This has led DSS to investigate other local sources of sand to continue operations beyond Stage 3.

DSS has been investigating a fine sand resource on an adjoining private property to the south (referred to as Stage 5). Investigative drilling has confirmed that there is sufficient sand resource to support three to four more years of extraction from two areas (Stage 5A and 5B).

As such, DSS is seeking to modify the current Project Approval (DA 195-8-2004) under Section 75W of the *Environmental Planning and Assessment Act 1979* (EP&A Act), to provide for an additional extraction area (Stage 5) on adjoining private land, encompassing two separate extraction areas, Stage 5A and Stage 5B (hereafter referred to as the 'project').

The modification proposed above will constitute Modification 2 to the current Project Approval. The Minister for Planning is the consent authority for the modification.

The Dunmore Lakes Sand Project is near Dunmore, approximately 3 kilometres (km) south-south west of Shellharbour and 7 km north of Kiama, in the Illawarra region of New South Wales. The site is approximately 88 hectares (ha) and is immediately west of the Princes Highway near Tabbita Road, Dunmore (Figure 1; Figure 2).

The modification site is located approximately 1.1 km south-south east of the existing site.

The modification site covers an area of approximately 38 ha and is on an alluvial coastal flood plain, adjacent to the tidal reaches of the Minnamurra River. The northern portion of the extraction area has been partially cleared and has historically been used for grazing.

The modification site is bound by Riverside Drive to the north and Princes Highway to the west.

Key elements of proposed infrastructure for the proposed modification include the two extraction areas - Stage 5A (immediately south of Riverside Drive), and Stage 5B (to the north of Minnamurra River), an access road and overland pipelines comprising two parallel 355 millimetres polyethylene pipes (Figure 1). The overland pipeline would be established from the Stage 5B extraction area to the existing Stage 2 processing area adjacent to Tabbitta Road.

1.2 General description of site and land use

The modification site predominantly constitutes land currently used for grazing, containing a mix of native vegetation and exotic pasture. Historically, logging has occurred throughout much of the site and adjacent areas with better condition vegetation remaining to the south (private property) and west (Roads and Maritime Services road easement) of the Stage 5B area, and connecting to a riparian corridor along the Minnamurra River. Other activities such as excavation for dams and equestrian activities have impacted the proposed extraction areas of the site. Ancillary infrastructure within the site will occur on grazing land as well as easements which are either cleared or support revegetation.

1.3 Construction footprint and development activities

The final development footprint (Figure 2), has been revised and is now significantly smaller than originally proposed. Construction of the proposed extraction areas would require the construction of primary components comprising of extraction areas:

- Stage 5A dredge pond (3.42 ha).
- Stage 5B dredge pond (8.12 ha).
- Stage 5A overburden area (2,500 m^2 - included within overall 5A area.
- Flood bunding around dredge ponds, comprising construction of earth embankments (included within 5A and 5B areas and ancillary infrastructure).
- Access road using primarily existing road footprint (1.21 km, long 3.5 m wide) or else within exotic grassland or otherwise exotic dominated and highly disturbed areas.
- Access driveway along Riverside Drive.
- Overland pipeline (two parallel 355 mm pipes within 1.5 m corridor). Pipelines would be introduced without clearing, however some minor trimming (e.g. of low branches) may be required in areas of revegetation. Laydown areas for the pipeline would utilise existing access roads and tracks and would be confined to already cleared areas or areas of exotic vegetation.
- Temporary Office and 10 light vehicle spaces adjacent to 5A dredge pond within exotic grassland.
- Pumping stations / booster pads positioned adjacent to pipeline areas within areas of exotic grassland.
- Electricity connection adjacent to temporary offices, booster pads and pumping stations.

Sand extraction within Stage 5A would involve clearing and grubbing of the primarily exotic groundcover vegetation. Topsoil would be stripped and stockpiled along the southern edge of the extraction area for later re-use in rehabilitation. The sand would initially be extracted from Stage 5A via excavator to create a large enough pond to float a dredge and accommodate fresh water pumping from the dredge via overland pipeline to the processing plant in Stage 2 (area already developed under existing approvals). The dredge will then progressively extract sand in an easterly direction. Sand will be extracted to a maximum depth of approximately 12 m below the water table.

Operations within Stage 5B would not commence until the completion of extraction in Stage 5A. However, there would be a two week transition period in which dredging operations are likely to occur within both Stage 5A and Stage 5B. Sand would be extracted in the northern end of the Stage 5B extraction area, via excavator to create a large enough pond to float a dredge and accommodate fresh water pumping from the dredge via overland pipeline to the processing plant in Stage 2. The dredge will then progressively extract

sand in a southerly direction. Sand will be extracted to a maximum depth of approximately 27 m below the water table.

An overland pipeline would be established from the Stage 5B extraction area to the Stage 2 processing area, and would comprise two parallel 355 millimetres polyethylene pipelines. Pipes will be sitting on the ground and placed to avoid clearing native vegetation. Pipes will be held in place by star pickets or earth mounds if deemed necessary.

Water removed through the dewatering process will drain to an existing fines pond and a secondary settling pond before being pumped back to the Stage 5A and Stage 5B dredge ponds via the pumping pipeline. Pumped water volumes will be recorded by a flow meter and the same volume of water will be returned to the Stage 5 extraction areas to balance, as best possible, water extracted.

1.4 Purpose of this report

Niche Environment and Heritage Pty Ltd (Niche) was commissioned by DSS to assess the ecological values and impacts associated with the proposed modification. The primary objective of this report is to use the *Biodiversity Assessment Methodology* (BAM) (OEH 2017a) to describe and assess the ecological values within the site and surrounds, and determine how the project is likely to have an impact on threatened biodiversity listed under the NSW *Biodiversity Conservation Act 2016* (BC Act) and F*isheries Management Act 1994*. The report also assesses any impacts on Commonwealth biodiversity matters as outlined under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). Further legislative context is provided in Section 1.5.

1.5 Biodiversity assessment process

1.5.1 Application of the NSW BAM

As part of stakeholder consultation for the project, the NSW Office of Environment and Heritage (OEH), has requested that the project use the BAM to assess impacts on biodiversity. The BAM is a framework for assessment of biodiversity impacts and determination of offsetting requirements under the NSW BC Act and Biodiversity Offsets Scheme (BOS).

This Biodiversity Development Assessment Report (BDAR) describes the biodiversity values present within the modification site and identifies impacts from the proposed modification on these values. This assessment has used the BAM Calculator (version 1.2.5.00).

1.5.2 Commonwealth approval and assessment process

Matters of National Environmental Significance (MNES) are protected under the EPBC Act. The BAM also requires proponents to identify and assess impacts on all nationally listed threatened species and threatened ecological communities that may be present on or near the site. Therefore, the BAM has partly been used to perform assessment of impacts under the EPBC Act. In addition, assessment of impacts under the EPBC Act has been undertaken via assessments of significance for EPBC Act listed species with the potential to be affected by the proposed project (Appendix 9).

1.6 Assessment format

This BDAR has two broad stages consistent with the BAM methodology:

Stage 1 – Biodiversity Assessment

- assessment of landscape features
- assessment of native vegetation
- assessment of threatened species and populations.

- avoid and minimise impacts on biodiversity values
- consider impact and offset thresholds
- determine and calculate offset requirements.

1.7 Assessment resources and assessor qualifications

This BDAR has been prepared by the following accredited assessors:

- Simon Tweed – Senior Ecologist/Ecology Team Leader/Accredited BAM assessor: flora and fauna field survey, data management, data entry, credit calculations, review of credit calculations, report preparation/review.
- Alex Christie – Ecologist/Accredited BAM assessor: field survey, reporting and data preparation.
- Lucy Porter – Ecologist/Accredited BAM assessor: field survey, reporting and data preparation.

Other specialist staff involved in preparing the assessment include:

- Greg Tobin: mapping.

2. Biodiversity Assessment

2.1 Landscape assessment

2.1.1 Methods

As detailed in section 4 of the BAM (OEH 2017a), a landscape assessment for the proposal is required, which was conducted within the BAM Calculator. Landscape value is an assessment of a number of factors including:

- native vegetation cover
- rivers, streams and estuaries
- areas of geological significance
- habitat connectivity.

2.1.2 Landscape features and scoring

Table 1 below provides details of the landscape settings and scored landscape features for the proposed modification.

Table 1: Landscape features and scoring under the NSW BAM

Landscape features	Description	Figure reference
IBRA bioregion/subregion	The proposed modification is located in the Illawarra subregion which is within the Sydney Basin Interim Biogeographic Regionalisation for Australia (IBRA) bioregion.	Figure 1
Mitchell Landscapes	Mitchell Landscapes found within the site include: • Kiama Coastal Slopes • Lake Illawarra Alluvial Plans	Figure 1
Rivers, streams and estuaries and Strahler stream order	There are no mapped creeks or watercourses within the site. Minnamurra River is an estuarine watercourse located approximately 150 m to the east of Stage 5A and 400 m to the south and east of Stage 5B. Minnamurra River supports a range of marine and estuarine wildlife. It is fringed by a narrow strip of Grey Mangroves in the intertidal zone.	Figure 1
Wetlands within and adjacent to development	Grey Mangrove Forrest, Swamp Oak Forrest, Freshwater Wetlands and Littoral Rainforest have been mapped 400 m to the south and 100 m to the east of the site. These areas are also mapped as SEPP Coastal Wetland. The Coastal Wetland proximity area overlaps with a portion of area 5A and abuts area 5B (Figure 3). Riverside Drive separates the Stage 5A extraction area from adjacent coastal wetland areas and is at a higher elevation than the proposed Stage 5A extraction area decreasing connectivity between these areas.	Figure 2
Cleared areas	The majority of the site has been cleared or thinned for grazing or other development. Where cleared, ground-cover is typically dominated by exotic species, which has been factored into vegetation mapping.	Figure 3-7
Connectivity features	The southern portion of study area is part of a vegetation corridor along the northern bank of the Minnamurra River. The corridor is at its widest at this point with narrower areas north and south of the site along the Minnamurra	Figure 1

Landscape features	Description	Figure reference
	River.	
Buffer area (percent native vegetation cover)	A 1,500m buffer was applied to the modification site resulting in an overall buffer area of 1,125.5 ha. Existing vegetation mapping (OEH 2016) identified areas of native vegetation within the buffer area. ***Woody vegetation cover*** The native vegetation extent and cover of woody vegetation was determined via aerial photography interpretation and vegetation mapping based on canopy cover. For woody vegetation, 21.4% (240.3 ha) of the buffer area was determined to support native woody vegetation with benchmark cover. ***Non-woody vegetation cover*** Non-woody vegetation cover included freshwater and saline wetlands which composed 12.3% (138.1 ha) of the buffer area. Native grasslands were not considered to occur within the buffer area. ***Total native vegetation cover*** Combining the estimated woody and non-woody vegetation cover resulted in 33.7% of the buffer area supporting native vegetation. This falls into the 30-70% category within the BAM Calculator.	Figure 1
Site context	Site based assessment.	
Geological significance and soils	There are no karst, caves, crevices, cliffs or other areas of geological significance within the site. There are no high hazard soil areas. The modification site does contain extensive deposits of sand below vegetation.	

2.2 Native vegetation and flora assessment

2.2.1 Methods – data review

Atlas of NSW Wildlife Database

A review of spatial records of threatened flora within a 5 km radius of the modification site was undertaken using data obtained from the Atlas of NSW Wildlife. Records were obtained prior to field survey. Results were considered during field survey and likelihood of occurrence analysis.

EPBC Act Protected Matters Search

A Protected Matters Search (EPBC Act) was carried out for a 10 km area around the site (DoEE 2018b). Results were considered during field survey and likelihood analysis.

Vegetation mapping

Sources consulted during a review of vegetation mapping included:

- NSW Landscapes (Mitchell 2002) version 3.1 (OEH 2017b)
- EMM (2016) Minnamurra Ecological Constraints Assessment Vegetation Mapping
- OEH (2016) Priority 5 Mapping Area (P5MA) - Vegetation Extent VIS_ID 2193 Kiama 2193.

2.2.2 Methods – field survey

Ecological values were appraised via survey of vegetation communities and their condition as well as threatened species habitat. Plant community types (PCTs) across the site were recorded and mapped using

a combination of vegetation quadrats, rapid data points and driving transects or walking meanders. Plot/transect surveys and targeted threatened species surveys were also used within the BAM Calculator to generate credit requirements.

2.2.3 Methods - plant community delineation and mapping

Detailed vegetation mapping conducted by EMM in their initial constraints analysis at the study area was used along with on-ground observations regarding the presence and density of vegetation to map vegetation zones (type and condition).

All vegetation within the study area was validated via field survey. Vegetation community descriptions and species used to aid in determining vegetation types are provided in Appendix 1. Previously mapped communities were aligned with PCTs used in the BAM Calculator as tabled below (Table 2). Five vegetation types were identified within the site, including Bangalay Sand Forest, Swamp Oak Floodplain Forest, Regenerating Acacia Shrubland and Exotic Grassland/shrubland. Clearing would not be required in Swamp Oak Floodplain Forest community or areas Regenerating Acacia Shrubland.

Different condition classes were given to vegetation where differences in structure and quality occurred. Vegetation zones were established for each combination of vegetation type and condition, however only those within the final site design have been presented and used within the BAM calculator (Table 3 and Table 2).

Table 2: Vegetation mapping and alignment for vegetation types within the site

Plant Community Type (PCT) Name e	Vegetation Type Abbreviation for this Assessment (Niche)	Threatened Ecological Community and Status	Vegetation Formation (OEH (2019a)	Vegetation Class (OEH (2019a)	PCT % cleared
659 - Bangalay - Old-man Banksia open forest on coastal sands, Sydney Basin Bioregion and South East Corner Bioregion	Bangalay Sand Forest	Bangalay Sand Forest of the Sydney Basin and South East Corner bioregions (BC Act – endangered) EPBC Act – not listed	Dry Sclerophyll Forests (Shrubby sub-formation)	South Coast Sands Dry Sclerophyll Forests	50
1232 - Swamp Oak floodplain swamp forest, Sydney Basin Bioregion and South East Corner Bioregion	Swamp Oak Floodplain Forest	Swamp Oak Floodplain Forest of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions EPBC Act - endangered	Forested Wetlands	Coastal Floodplain Wetlands	95
Regenerating Acacia Shrubland	Acacia Shrubland	-	N/A	N/A	-
Cleared land	Exotic Grassland/shrubland	-	-	-	-

2.2.4 Survey effort

The BAM plot requirements were determined using the BAM (OEH 2017a). The number of plots conducted and required for each Plant Community Type (PCT) and zone is provided in Table 3 and the location of completed plots is illustrated in Figure 5-7. Plot/transect surveys for use within the BAM Calculator were conducted in April-May of 2018 and January 2019. BAM plots were not conducted within the proposed pipeline and ancillary infrastructure areas as clearing within these areas was confined to exotic vegetation.

Native vegetation and flora survey consisted of the following:

Preliminary Environmental Assessment conducted by EMM on 14 July 2016

- Possible ecological constraints within the site were identified via a constraints assessment and vegetation boundaries mapped.

Biodiversity Assessment conducted by Niche from April-May 2018 and January 2019

- Vegetation boundaries and habitat features were surveyed via walked transects (Figure 5-7).
- Fourteen BAM plots were carried out within the study area (Figure 5-7). Six of these were used for site scoring within the BAM Calculator, consisting of those plots performed within the final site.
- Walking meanders were carried out at habitat observation points and around plot locations. The combined foot traverses carried out complied with the recommended number and length of traverses per area of stratification unit (vegetation community) according to the OEH's working draft *Threatened Biodiversity Survey and assessment - Guidelines for Developments and Activities (DEC 2004)*. The walking meanders were also used to survey for threatened flora across the study area.
- Walking meanders of the proposed pipeline area to identify vegetation boundaries.

Table 3: Vegetation zone and associated plot/transect survey requirements for the proposed site

Zone number	Vegetation mapping	PCT – best fit	Condition	Plots required (BAM)	Area 5A clearing (ha)	Area 5B clearing (ha)	Ancillary infrastructure clearing (ha)
1	Bangalay Sand Forest	659 - Bangalay - Old-man Banksia open forest on coastal sands, Sydney Basin Bioregion and South East Corner Bioregion	Good	1	0	1.42	0
2	Bangalay Sand Forest Thinned		Moderate	2	0	3.11	0
3	Bangalay Sand Forest Derived Native Grassland		Poor (DNG)	2	0	2.97	0
4	Regenerating Acacia Shrubland	-	Moderate	None (no clearing is proposed within these areas)	0	0	0
5	Exotic pastureGrassland/shrubland	Cleared land	Poor	None (however one plot was conducted to test cover values and species richness)	3.43	0.63	<0.25
Total				**5**	**11.54**		

2.2.5 Plant community descriptions

Refer to Appendix 1 for plant community descriptions and diagnostic species for each plant community.

2.2.6 Site values

Flora

Floristic data recorded from floristic plots performed throughout the identified vegetation zones (Figure 5-7) is included within Appendix 2. A total of 115 species were recorded comprising 74 native species and 38 exotic species.

Plot and transect values

The results of the plot data and species list obtained during the field assessment is provided in Appendix 2.

Site value scores

The site value assessment was carried out by entering plot data into the BAM Calculator. The data provides quantitative measures of composition, structure and function for each vegetation zone (Appendix 3). The BAM Calculator compares the values recorded with the benchmark for the vegetation class to provide the site value score. This score represents the overall condition of the vegetation compared against the benchmark (out of 100).

The score from these inputs, coupled with data in the following section of this report, is used to determine the number of ecosystem credits that are required for offsetting of the development.

One vegetation type within the site (Exotic Grassland/shrubland) does not require offsetting.

One vegetation zone within the site scored less than 15 out of 100 due to its highly disturbed and poor condition. Therefore, no ecosystem credit offsets are required for impacts to this vegetation zone within the modification site.

2.2.7 High threat and priority weeds

During the field surveys, five high threat weeds were recorded as listed under the NSW *Biosecurity Act 2015*. The high threat weed species are sporadically distributed throughout the modification site particularly where high levels of soil disturbance have occurred. High threat weeds include the following: Sheep's sorrel (*Acetosella vulgaris)*, Cape Ivy (*Delairea odorata)*, Lantana (*Lantana camara*), Panic veldtgrass (*Ehrharta erecta*), Sprenger's asparagus (*Asparagus aethiopicus*), Balloon Vine (*Cardiospermum grandiflorum*), Rhodes grass (*Chloris gayana*), African boxthorn (*Lycium ferocissimum*), St. Augustine grass (*Stenotaphrum secundatum*) and Dallis grass (*Paspalum dilatatum*).

Priority weeds for the South East region include *Lycium ferocissimum*, Bridal creeper (*Asparagus asparagoides*), *Lantana camara* and Fireweed (*Senecio madagascariensis*).

2.2.8 Threatened ecological communities

The following TECs were identified as being present within the site (Figure 5-7):

- Bangalay Sand Forest of the Sydney Basin and South East Corner bioregions (Endangered Ecological Community (EEC) under the BC Act and not listed under the EPBC Act)
- Swamp Oak Floodplain Forest of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions (EEC under the BC Act and Endangered under the EPBC Act).

The Bangalay Sand Forest community was identified in Stage 5B of the site in three different condition classes: good, moderate and poor (derived grassland). The condition deteriorated the further the community moved north into areas which have historically been cleared and are now exotic grassland.

Areas in poor condition (derived grassland) had no canopy or midstorey cover and a high cover of exotic grass and other introduces species. These areas are essentially pasture with persistence of some hardy native groundcover species. Moderate condition areas had higher (though still limited) native species

diversity and scatted canopy trees including some large hollow bearing Bangalay (*Eucalyptus botryoides*) trees. There has been limited recruitment of younger trees and shrubs due to frequent grazing. Good condition sites had higher plant diversity, some understorey and midstorey cover, and a denser canopy cover.

The Swamp Oak Floodplain Forest community was identified along the proposed pipeline easement adjacent to the dam west of the Stage 5A dredge pond. The community is considered to be in moderate condition and predominantly consists of regenerating or young Swamp Oak (*Casuarina glauca*) and a mix of native and exotic ground cover. The proposed overland pipeline from the Stage 5A and 5B extraction areas to the Stage 2 processing area, would be placed through some sections of Swamp Oak Flood Plain Forest. Some minor trimming of *Casuarina glauca* may be required however, no vegetation clearing would occur. The proposed location of the booster pump station was inspected and found to contain exotic ground cover.

Swamp Oak Floodplain Forest and Littoral Rainforest occur to the south east of the site but would not be directly impacted by the modification.

2.2.9 Threatened flora

No threatened flora were detected during field survey and therefore it is considered unlikely that threatened flora would be affected by the proposed modification. Vegetation was in poor condition throughout the northern half of the modification site due to consistent disturbance historically, which contributes to the low likelihood of occurrence for any threatened flora. Threatened flora with the potential to occur, as generated by the BAM Calculator, are presented in Table 5 and Appendix 4. All are assumed to be absent from the modification site based on non-detection of the species during targeted searches over multiple seasons.

2.3 Aquatic habitat

A review of protected habitat (FM Act) mapping and potentially occurring threatened species listed under the FM Act was undertaken as part of this assessment. No areas of protected habitat or threatened species are present within the site. Areas of protected habitat comprising mangroves, saltmarsh and seagrass occur to east of the site, with the closest mapped areas 150 m to the east of area 5B (Figure 4). Key fish habitat is also present within all major rivers and large tributaries in the area including the Minnamurra River and Rocklow Creek. The Black Rock Cod could potentially use the Minnamurra River estuary.

2.4 Fauna assessment

2.4.1 Methods – data review

Atlas of NSW Wildlife Database

A review of spatial records of threatened flora and fauna within a 5 km radius of the site was undertaken using data obtained from the Atlas of NSW Wildlife. Records were obtained prior to field survey. Results were considered during field survey and likelihood of occurrence analysis.

EPBC Act Protected Matters Search

A Protected Matters Search (EPBC Act) was carried out for a minimum 10 km radius around the site by inputting the site centroid coordinates into the EPBC Act Protected Matters Search Tool and applying a 10km buffer. Results were considered during field survey and likelihood analysis.

2.4.2 Methods – field survey

Fauna field survey consisted of:

Preliminary Environmental Assessment conducted by EMM on 14 July 2016

Possible ecological constraints within the southern lot (in which Stage 5B dredge pond is located) were identified via a constraints assessment.

Biodiversity Assessment conducted by Niche April - May 2018 and January 2019

Fauna survey was undertaken throughout the site to inform the design of the project and to ensure compliance with regulatory requirements or guidelines (OEH 2018; OEH 2004; DoEE 2010a; DoEE 2010b; Harris and Goldingay 2005 and DECC 2009). The methods and survey effort relating to the fauna survey are presented in Table 4 and illustrated in Figure 8.

Table 4: Fauna survey methods, timing and effort

Method	Target species	Timing	Effort
Diurnal bird survey and checks around hollow trees	Threatened birds (Glossy-black Cockatoo and Swift Parrot)	24 April, 3 and 10 May 2018	4 x 20 – 60 minute bird survey as well as opportunistic observations
Diurnal bird surveys	Gang-gang Cockatoo and Square-tailed Kite	14 –17 January 2019	3 x 20 – 60 minute bird survey as well as opportunistic observations
Nocturnal species survey	Nocturnal birds and mammals	3 May 2018	3 hours walked transect
Diurnal and nocturnal frog searches	Green and Golden Bell Frog	14 –17 January 2019	2 hours of active searches x 3 nights
Elliot (A) trapping	Eastern Pygmy Possum	14 –18 January 2019	4 nights x 25 traps = 100 trap nights
Camera trapping	Eastern Pygmy Possum	14 –18 January 2019	4 nights x 6 cameras = 24 trap nights
Anabat detectors	Microchiropteran Bats	3 May 2018	2 x detectors set for 1 night
	Microchiropteran Bats focusing on Southern Myotis.	14 –18 January 2019	4 x detectors set for 4 nights
Searches for microbat roosts via walked traverses through culverts using spotlight	Microbat species known to use culverts including Southern Myotis.	10 May 2018	1 hour
Incidental and indirect observations	All species	24 April, 3, 10 May 2018, 14 – 18 January 2019	Over eight days of survey

2.4.3 Assessment of threatened species and populations

Threatened species predicted or potentially occurring within the IBRA subregion were reviewed. This list was refined after the initial field survey for the site within the BAM Calculator, considering vegetation types, condition and habitat features. The list was refined again after all field survey was completed to incorporate the results of field survey. The list of predicted and candidate species generated via the BAM Calculator is in Table 5 below. A status for each species is provided which represents the basis for deciding

whether a species was present or absent from the modification site. No ecosystem credit species were omitted from the BAM Calculator despite there being very limited habitat present within the modification site for many of the predicted species.

Table 5: List of predicted and candidate threatened species generated by the BAM calculator for the proposed project

Common Name	Scientific Name	Status
Predicted threatened species (ecosystem credit species)		
Barking Owl (foraging)	*Ninox connivens*	Assumed present
Eastern Bentwing-bat (foraging)	*Miniopterus schreibersii oceanensis*	Assumed present
Eastern Freetail-bat	*Mormopterus norfolkensis*	Assumed present
Gang-gang Cockatoo (foraging)	*Callocephalon fimbriatum*	Assumed present
Glossy Black-Cockatoo (foraging)	*Calyptorhynchus lathami*	Assumed present
Greater Broad-nosed Bat	*Scoteanax rueppellii*	Assumed present
Grey-headed Flying-fox (foraging)	*Pteropus poliocephalus*	Observed
Koala (foraging)	*Phascolarctos cinereus*	Assumed present
Little Bentwing-bat (foraging)	*Miniopterus australis*	Assumed present
Little Eagle (foraging)	*Hieraaetus morphnoides*	Assumed present
Little Lorikeet	*Glossopsitta pusilla*	Assumed present
Long-nosed Potoroo	*Potorous tridactylus*	Assumed present
Masked Owl (foraging)	*Tyto novaehollandiae*	Assumed present
Regent Honeyeater (foraging)	*Anthochaera phrygia*	Assumed present
Spotted-tailed Quoll	*Dasyurus maculatus*	Assumed present
Square-tailed Kite (foraging)	*Lophoictinia isura*	Assumed present
Swift Parrot (foraging)	*Lathamus discolor*	Assumed present
Varied Sittella	*Daphoenositta chrysoptera*	Assumed present
Yellow-bellied Glider	*Petaurus australis*	Assumed present
Yellow-bellied Sheathtail-bat	*Saccolaimus flaviventris*	Assumed present
Candidate species (species credit species)		
Regent Honeyeater Breeding)	*Anthochaera phrygia*	No (surveyed, no breeding habitat present on site and is not a key breeding site)
Gang-gang Cockatoo (Breeding)	*Callocephalon fimbriatum*	No (surveyed) Breeding
Glossy Black-Cockatoo (Breeding)	*Calyptorhynchus lathami*	No (surveyed) Breeding
Eastern Pygmy-possum	*Cercartetus nanus*	No (surveyed)
Large-eared Pied Bat	*Chalinolobus dwyeri*	No (no suitable habitat on site or within 2km)
Sand Spurge	*Chamaesyce psammogeton*	No (surveyed, this species grows on fore-dunes or exposed headlands which are not present on site. Furthermore, this species is unlikely to remain undetected

Common Name	Scientific Name	Status
		during field surveys)
Giant Burrowing Frog	*Heleioporus australiacus*	No (no habitat present on site). See further explanation below this table.
Little Eagle (Breeding)	*Hieraaetus morphnoides*	No (Surveyed) Breeding
Southern Brown Bandicoot	*Isoodon obesulus obesulus*	No (no suitable habitat on site - requires dense ground cover in a variety of habitats)
Swift Parrot	*Lathamus discolor*	No (no breeding habitat on site. This species nests in Tasmania)
Green and Golden Bell Frog	*Litoria aurea*	No (surveyed)
Square-tailed Kite	*Lophoictinia isura*	No (surveyed)
Little Bentwing-bat (Breeding)	*Miniopterus australis*	No (no breeding habitat present)
Eastern Bentwing-bat (Breeding)	*Miniopterus schreibersii oceanensis*	No (no breeding habitat present)
Southern Myotis	*Myotis macropus*	Yes (surveyed – Anabat detectors recorded possible recording of species at the farm dam in area 5B and probable recording in Bangalay Sand Forest)
Barking Owl (Breeding)	*Ninox connivens*	Assumed present. While there was no evidence to suggest the species would breed at the site, the species could not be ruled out given survey guidelines were not implemented.
Squirrel Glider	*Petaurus norfolcensis*	No. Species considered a vagrant (see below).
Koala (Breeding)	*Phascolarctos cinereus*	No. No important habitat on site (see below).
Grey-headed Flying-fox (Breeding)	*Pteropus poliocephalus*	No (no breeding camps on site or site surrounds)
Magenta Lilly Pilly	*Syzygium paniculatum*	No (surveyed, species unlikely to remain undetected during field survey)
Masked Owl	*Tyto novaehollandiae*	Assumed present. While there was no evidence to suggest the species would breed at the site, the species could not be ruled out given survey guidelines were not implemented.

Giant Burrowing Frog

The Giant Burrowing Frog is found in heath, woodland and open dry sclerophyll forest on a variety of soil types except those that are clay based. The species spends more than 95% of its time in non-breeding habitat in areas up to 300 m from breeding sites. Whilst in non-breeding habitat it burrows below the soil

surface or in the leaf litter. Individual frogs occupy a series of burrow sites, some of which are used repeatedly.

The home ranges of both sexes appear to be non-overlapping suggesting exclusivity of non-breeding habitat. Home ranges are approximately 0.04 ha in size. The species is confined to the sandstone geology of the Sydney Basin and extending as far south as Ulladulla, and a southern population occurring from north of Narooma through to Walhalla, Victoria (OEH 2019c). The site does not occur on sandstone geologies.

The habitat present within the site is considered substantially degraded such that this species is unlikely to utilise the site, in accordance to Section 6.4.1.17 of the BAM (OEH 2017a). There are no creeks of the nature that the species prefers within or adjacent to the modification site. Nine records of Giant burrowing frog occur within the Illawarra IBRA subregion (OEH 2019d) (1980 - 2019), the closest of which is approximately 32 km south of the site. The species would not occur at the site.

Squirrel Glider

Squirrel Gliders inhabit mature or old growth Box, Box-Ironbark woodlands and River Red Gum forest west of the Great Dividing Range and Blackbutt-Bloodwood forest with heath understorey in coastal areas. The species prefer a mixed species stands with a shrub or Acacia midstorey (OEH 2019c).

One record of this species occurs within the Illawarra IBRA subregion (1980 - 2019) – approximately 36 km south-west of the site, and as such this species is a vagrant and considered unlikely to occur at the modification site. No further assessment is required as stated in Section 6.4.1.14 of the BAM (OEH 2017a).

Koala

There is no important Koala habitat present within the modification site. No primary feed trees for Koala are present within the modification site, and Bangalay is not listed as a secondary or supplementary feed tree (e.g. *State Environmental Planning Policy No 44—Koala Habitat Protection*). Koala density within the IBRA subregion is low, with only nine records (1980 - 2019) of Koala occurring within the Illawarra IBRA subregion (OEH 2019c). In addition, the Shellharbour and Kiama local government areas are not identified within SEPP 44, as Koalas are not generally known from the area.

2.4.4 Fauna habitat

The modification site is situated within or adjacent to a relatively large area of remnant floodplain vegetation associated with the Minnamurra River of approximately 200 ha. This moderately large patch of native vegetation is predominantly associated with low-lying areas subject to inundation and thus relatively protected from development. Within the broader landscape the patch of vegetation is isolated from remnant vegetation of the escarpment and foothills and other large areas of woodland or forest vegetation along the coastal margin. Highways and significant areas of agricultural and residential lands to the west, north and south of the study area, limit the capacity of the woodland present to provide habitat for a range of species reliant on large connected patches of forest vegetation. Nevertheless, given the moderate size of the forest patch remaining, the modification site offers habitat to a range of native fauna.

Available fauna habitat within the modification site is primarily influenced by the prevailing vegetation type and condition. Fauna habitat over the modification site varies, with the northern portion of the modification site having been historically cleared or thinned. While much of the understorey and midstorey components have been removed some large remnant Bangalay (*Eucalyptus botryoides*) still remain and contain a large number of hollows.

The following broad and specific fauna habitat types and associated characteristics occur across the modification site (Plates 1 – 5):

- Bangalay Sand Forest of the Sydney Basin and South East Corner bioregions
    - This woodland has been historically cleared/thinned with an exotic dominated understorey and lack of recruitment of canopy species. Large remnant eucalypts still occur scattered throughout this community and provide a large amount of hollow resources for fauna.
    - Occasional hollow logs are present under larger trees, however these have generally been removed for firewood or other purposes.
    - Log piles and small piles of building materials provide some habitat for reptiles.
    - This community also contains some large Banksia (*Banksia integrifolia*) which would provide foraging resources for some species of birds and nectivorous mammals.
- Swamp Oak Floodplain Forest of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions
    - A small patch of this forest type in moderate condition coincides with the proposed site on the north western boundary of the modification site is in. Clearing would not occur in this area, however some trimming of low branches may occur in order to install the required pipeline.
- Cleared Grassland/shrubland
    - Much of this habitat is Bangalay Sand Forest which has been cleared and is now dominated by exotic weeds and grasses.
    - Bracken fern (*Pteridium esculentum*) is patchily distributed amongst some of the heavily disturbed paddocks.
- Watercourses
    - A small ephemeral drainage with a shallow farm dam containing a few species of aquatic macrophytes occurs to the north of the Stage 5B extraction area. This dam provides some aquatic habitat for fauna including common frog species and mobile waterbirds.
    - Large dams occurs in the north western part of the modification site. The dams contain fringing aquatic macrophytes and provide habitat for waterbirds and frogs.
- Culverts
    - Culverts are present underneath the Princes Highway where pipelines will be installed. Culverts can offer habitat for roosting microbats, however on inspection of the culverts, no evidence of roost sites was apparent. Further, there is very limited capacity for the culverts to be used as roost sites since features that allow for roosting such as scuppers, expansion joints and other cavities were limited or absent. It is also noted that flood waters can reach almost the culvert roof (South East Engineering and Environmental 2019), which would further diminish their capacity to act as long-term roost habitat.
- Hollows, tree stags and logs
    - Hollows are present in scattered paddock trees and within remnant woodland patches. 11 hollow bearing trees (with 29 hollows) were recorded within the impact area. Small, medium and large hollows were recorded with a greater proportion of small and medium sized hollows (< 30 cm diameter) (Appendix 5).
    - Stags and logs occur sporadically throughout the modification site. Logs were typically embedded within the ground under larger trees.

Plate 1. Bangalay Sand Forest poor condition (Derived Native Grassland)

Plate 2. Bangalay Sand Forest which has been thinned and is in moderate condition

Plate 3. Small farm dam within the northern section of proposed 5B dredge pond

Plate 4. Large dam next to the Princes Highway to the North West of the site (outside of site)

Plate 5. An example of one of the medium-large sized hollows occurring within *Eucalyptus botryoides*

2.4.5 Fauna recorded from field surveys

Fauna field surveys using the methods described in Section 1.9.2 were undertaken with a focus on areas in the Stage 5B extraction area, with the suite of methods employed in each habitat type dependant on the potential presence of subject threatened fauna within that habitat type. Notable opportunistic sightings whilst travelling between areas within the modification site were also recorded. A complete species list is provided in (Appendix 6).

A total of 74 species were recorded during field surveys from the site, comprising 17 mammal, 51 bird, 2 reptile and 4 frog species.

A number of common bird species (most commonly Sulphur-crested Cockatoo and Rainbow Lorikeet) were observed to use hollows within the Stage 5B extraction area. It is likely that microbats also use these hollow resources, potentially including threatened species such as the Yellow-bellied Sheathtail Bat, which was recorded close to sunset.

2.4.6 Connectivity

Adjacent patches of intact vegetation provide the main connectivity pathways to and around the study area. Area 5A is cleared and disconnected from remnant vegetation areas and thus does not contribute to local or regional connectivity. Area 5B is adjacent to consolidated patches of vegetation which provide local connectivity and contribute to regional connectivity. The 5B area has been designed to minimise clearing of consolidated vegetation, therefore reducing potential impacts on connectivity. No significant bushland

fragments are considered to be diminished via the current proposal. Connectivity around the 5B area would continue to be provided by consolidated areas of vegetation that are approximately 150m to 250m wide to the west and south of the 5B area respectively.

Significant barriers to local and regional connectivity for a range of less mobile species occur within the locality, including linear transport infrastructure (such as the Princes Highway and the south coast rail line), residential development and areas cleared for quarrying or farming. These heighten the natural barrier effect of the Minnamurra River.

2.4.7 Threatened fauna

Seven species of threatened fauna were detected during targeted survey within the modification site (Figure 9, Table 6): Dusky Woodswallow (*Artamus cyanopterus cyanopterus*), Varied Sittella (*Daphoenositta chrysoptera*), Southern Myotis (*Myotis macropus*), Eastern Bentwing-bat (*Miniopterus schreibersii oceansis*), Eastern Freetail-bat (*Mormopterus norfolkensis*), Grey-headed Flying Fox (*Pteropus poliocephalus*) and White-bellied Sea Eagle (*Haliaeetus leucogaster*).

Two Dusky Woodswallow were sighted on the south eastern boundary of the modification site. One Varied Sittella was seen foraging in the littoral rainforest area, which will be retained towards the south east of the modification site. White-bellied Sea Eagle were recorded flying through the modification site, but were not observed nesting within the disturbance footprint. One probable recording of a Southern Myotis was recorded within the Bangalay Sand Forest – good condition. The Eastern Bentwing-bat, Eastern Freetail-bat and East-coast Freetail Bat were recorded in the Bangalay Sand Forest. Given the limited aquatic habitat (one relatively small farm dam) within or immediately adjacent to the modification site, it appears unlikely that the Southern Myotis would roost within the modification site, since the species typically roosts close to major foraging networks which are typically focussed on permanent waterways.

Table 6: Threatened species recorded during field survey of the site

Credit type	Scientific name	Common name	BC Act Status	EPBC Act Status
Ecosystem	*Artamus cyanopterus cyanopterus*	Dusky Woodswallow	Vulnerable	-
Ecosystem	*Daphoenositta chrysoptera*	Varied Sittella	Vulnerable	-
Species	*Myotis macropus*	Southern Myotis	Vulnerable	-
Ecosystem	*Miniopterus schreibersii*	Eastern Bentwing-bat	Vulnerable	-
Ecosystem	*Mormopterus norfolkensis*	Eastern Freetail-bat	Vulnerable	-
Species/Ecosystem	*Pteropus poliocephalus*	Grey-headed Flying Fox	Vulnerable	Vulnerable
Species/Ecosystem	*Haliaeetus leucogaster*	White-bellied Sea Eagle	Vulnerable	Migratory

2.4.8 Migratory species

Two migratory species (White-bellied Sea-Eagle and Cattle Egret) were observed adjacent to or within the site. The White-bellied Sea Eagle is not expected to nest or breed within the site and thus impacts would be limited given the extent of proposed clearing and strict adherence to limits of the clearing area.

The Cattle Egret is widespread within the locality, as is its available foraging habitat where it is known from farm paddocks.

The remainder of the species identified as potentially occurring are associated with potential flooding of the site, offering infrequent opportunistic foraging habitat. While the area of flooding may be altered slightly from the proposal (in response to minor changes in flood patterns), the overall area of opportunistic foraging habitat available to migratory birds is not expected to change and impacts from the proposal on these species are likely to be negligible, being confined to opportunistic foraging habitat.

Expansion in the area of permanent ponds within the locality via the proposal may result in some increased habitat being supplied for particular migratory species and consequent positive impacts. These are expected to be relatively minor in the short-term.

3. Impact Assessment

The Impact Assessment forms Stage 2 of the BDAR as detailed in the BAM.

3.1 Avoid and minimise impacts

In accordance with the BAM, proponents must demonstrate the measures employed to avoid, mitigate and offset impacts of a project on biodiversity values. This section of the report outlines the avoidance, management and mitigation measures that DSS has incorporated into the design of the Stage 5 extraction area or will employ during construction, operation or completion of the proposed modification to reduce impacts on biodiversity values.

3.1.1 Avoidance measures (pre-construction).

DSS has aimed to avoid and minimise environmental impacts from the proposed modification during the design process. A preliminary Environmental Constraints Assessment for the Stage 5B extraction area was conducted, which included consideration of constraints such as threatened vegetation communities, threatened species habitat and other identified ecological constraints.

After further ecological survey (described herein) there has been substantial re-design of the modification site including reducing the disturbance footprint of the Stage 5B dredge pond, and siting specific project infrastructure to avoid and mitigate impacts to biodiversity with a particular emphasis on avoiding the following features:

- Threatened ecological communities (i.e. Bangalay Sand Forest (particularly areas in good condition), Swamp Oak Floodplain Forest and Littoral Rainforest) and other intact native vegetation
- Coastal wetlands (including wetlands listed in the Coastal SEPP)
- Hollow bearing trees.

In addition to avoidance measures incorporated into design, planning for the proposed modification has avoided or minimised impacts on biodiversity through the following actions:

- Relocation of infrastructure that requires clearing and excavation on non-sensitive land. Eleven (11) hollow bearing trees were avoiding through this measure
- Avoidance of direct impacts within the 'proximity area for coastal wetlands' located immediately east of the Stage 5B extraction area.

3.1.2 Mitigation measures (construction and post construction)

The following management and mitigation measures will be further developed and implemented during the construction and operation phases. The existing Flora and Fauna Management Plan (FFMP) for DDS will be updated for the Stage 5 extraction area to incorporate the management and mitigation measures below:

- Establishment of fenced buffer areas around the modification site where native vegetation is adjacent to protect trees and other vegetation outside of the modification site, with fencing maintained throughout the construction and operational phases of the proposed modification.
- Pre-clearing inspections of hollow trees to be removed to ensure the absence of roosting/breeding threatened species with the potential to occur. Any native vertebrate fauna present within hollow trees will be managed to minimise the risk of mortality or injury. Tree clearing will be undertaken in accordance with best practise principles.
- Clearing of hollow trees should not be undertaken during the breeding season for the majority of hollow-dwelling fauna (spring).

- Installation of nest boxes to the south of the Stage 5B extraction area. The number and size of nest boxes will be at least equal to that of the existing number of hollows that are to be removed by the proposed modification as determined via a final survey of hollow trees. Establishment and documentation of a nest box management plan would be included within the FFMP.
- Existing protocols for monitoring of weeds and their management would be incorporated into the FFMP, with relevant practices adopted within vegetated areas adjacent to Area 5B. The purpose would be to ensure no increased weed incursions from a result of the modification occurring within adjacent vegetation. As the adjacent area to the west presently has a high density of weeds, this would likely result in overall weed reduction.
- Ensuring vehicles remain on designated roads and tracks whenever possible through use of signposting and driver education during the induction process and in ongoing project discussions.
- Establishment and regular maintenance of erosion and sediment controls during construction and until excavated areas are vegetated.
- Management and removal of all waste from the site.
- All rehabilitation initiatives at the modification site would be carried out in accordance with the principles contained in the approved Dunmore Sand and Soil Project Rehabilitation Management Plan (Arcadis, 2017) in order to minimise the potential for adverse impacts associated with generation of dust and erosion and sedimentation arising from unstabilised surfaces.
- The Rehabilitation Management Plan would be updated to include the Stage 5 extraction area and any additional management strategies to ensure temporary stabilisation of exposed surfaces, permanent stabilisation strategies, progressive rehabilitation of exposed surfaces with groundcover vegetation during dredging operations, and final rehabilitation as soon as practical after exhaustion of the sand resource in each extraction area.

3.2 Impact Summary

The proposed modification would affect biodiversity, including threatened biodiversity through both direct and indirect impacts during construction and operation. The majority of impacts on biodiversity would occur during construction from clearing of native vegetation and removal of habitat for a limited range of flora and fauna. The extent of direct impacts has been minimised through design (avoidance) and alignment. Clearing of vegetation would be the primary direct impact of the proposed modification and would affect up to 4.53 ha of native vegetation.

3.2.1 Direct Impacts

The following residual direct impacts would result from the proposed modification:

- Clearing of vegetation to the extent specified in Table 3. The extent of clearing of native vegetation communities is conservatively estimated at 4.53 ha
- Clearing of associated threatened species habitat including:
    - Hollow bearing trees and stags.

The majority of vegetation likely to be affected by the proposed modification has been subject to historic clearing and other agricultural activities such as grazing and is therefore thinned, fragmented and predominantly consists of exotic grassland.

Twelve trees containing hollows (one of which is a stag), all *Eucalyptus botryoides,* would require removal.

3.2.2 Indirect impacts

Indirect impacts would occur within and adjacent to the modification site as a result of construction and operation of the proposed modification. Potential indirect impacts include:

- Facilitation of weed spread via construction activities
- Migration of sediments to waterways from construction of roads and tracks or other infrastructure
- Increased light, noise and dust.

The above impacts would be mitigated via the FFMP (see below) and sediment and erosion control plans.

Indirect impact	Likely impact from the Project	Potential extent of the indirect impact prior to mitigation measure	Mitigation measure	Expected success of mitigation measure
Edge effects	The establishment of the modification area would result in the creation of new edges adjacent to areas of existing native vegetation to the south. The new edges could facilitate the establishment and spread of introduced plant species, however appropriate monitoring and control measures would be implemented during and after construction, to counteract the potential for weed occurrences. The modification area would be progressively rehabilitated, with area 5A returned to pasture and Area 5B revegetated around the edges of the pond to allow for establishment of a vegetated buffer including native midstorey and canopy species.	Varying distance from subject site. Potentially occurring within 50 metres from the disturbance area throughout the active life of the Project.	Fencing and/or the use of highly visible rope or tape boundaries will be used to delineate the boundary of vegetation clearing at the edge of the emplacement, in particular areas of Bangalay Sand Forest mapped adjacent to the Study Area as shown in Figure 3. Signposting and education will be also be used to inform Project personnel of no-go areas. Weed management and monitoring to be updated in the existing Flora and Fauna Management Plan.	Active weed, and pest management are anticipated to be successful at managing edge effects from the Project.
Weeds	Weeds have the opportunity to establish themselves in areas of disturbed vegetation. The greatest establishment of weeds are in areas already disturbed or subject to agricultural land use. Weeds impacting on native vegetation occur to the west and to a lesser extent south of Area 5B. The project has the potential to increase or lead to the establishment of weed species where they do not currently exist through the operation of machinery during construction. New weed species can potentially be introduced as a result of the movement of construction vehicles and materials into the Study Area. Areas more likely to be exposed to weed increases are areas of native vegetation that occur to the west and south of Area 5B. However, weeds will be controlled during and after construction in accordance with the Flora and Fauna Management Plan and thus indirect impacts from weeds is likely to be minor within the adjacent woodland areas.	Variable depending on topography. However, typically would occur within close proximity to disturbance area.	Weed management and monitoring to be implemented in accordance with the Flora and Fauna Management Plan.	Active weed control methods are likely to be successful in managing the spread of weeds within adjacent areas.
Erosion and sedimentation	Erosion of soils and associated sedimentation associated with the proposed modification area may involve the following:	Variable depending on topography and operation.	Stormwater management measures will be implemented in accordance	Sedimentation control measures are well established and

Indirect impact	Likely impact from the Project	Potential extent of the indirect impact prior to mitigation measure	Mitigation measure	Expected success of mitigation measure
	• Alteration of soil structure beneath access roads. • The increase of surface water flow from the modification area during rain events into adjacent areeas. • The deposition of soil particulates in remnant vegetation and into the surrounding Minnamurra wetland.		with an erosion and sediment control plan. Solutions to encourage rapid vegetation of areas with exposed soil including bunded areas will be a key component of the plan.	implemented for road and other projects.
Dust	Dust will be generated from the construction of the modification area. Dust generated during construction of the modification area has the potential to impact upon the health of plants and vegetation particularly in those areas of dense native woodland immediately adjacent to the site. Research shows that the impacts of dust on vegetation can have both positive and negative impacts, however the impacts of increased levels of dust on animals are unknown (Farmer 1993). Farmer (1993) anticipated that dust may increase the susceptibility of plants and vegetation to secondary stresses, such as drought, insects and pathogens, or allow penetration of toxic metals or phytotoxic gaseous pollutants.	Variable depending on wind conditions. Potential for dust emissions likely during the construction of mine.	Dust impacts will be mitigated through the onsite use of water suppression during construction. Further, vegetation clearing protocols for the Project will seek to minimise exposed areas with the potential to generate dust by completing vegetation clearing as close to extraction as practical.	Successful implementation of dust control would minimise dust. The effectiveness of these measures will be similar to the effectiveness of dust suppression measures for existing operations.
Noise	Noise will be generated from the construction and operation of the modification area. However, the Project is unlikely to result in exceedances of the relevant noise criteria during the day, evening or night time. Although relevant research is limited, studies have found that traffic noise can mask the important contact calls of certain birds such as the budgerigar, canary, and Zebra Finch, (Lohr et al. 2003). Parris and Schneider (2008) found that it was increased volumes of noise and not increased volumes of traffic that were important. Various studies have indicated that changes in bird calls in response to traffic noise are twofold, either the birds change the characteristics of their call to avoid interaction of the sound of the call with the created sounds or they limit calling to periods when the levels of noise are reduced. The Project is unlikely to result in any additional noise impacts on local fauna.	Variable depending on wind conditions. Potential for noise impacts likely throughout the life of the quarry.	It should be noted that noise emissions from the establishment and operation of the modification areas would be managed and monitored in accordance the Flora and Fauna Management Plan, which includes all reasonable and feasible noise mitigation measures.	No mitigation measures proposed

Indirect impact	Likely impact from the Project	Potential extent of the indirect impact prior to mitigation measure	Mitigation measure	Expected success of mitigation measure
Increased lighting	In relation to night-time lighting, there is no proposed change to the existing Quarry lighting. The light that is currently emitted from the existing operations is from the lighting associated with the out-of-pit works, primarily the processing plant and surrounds, which is the main light source from the Quarry.	Light spill into nearby woodland areas to the west may occur – these areas currently exposed to lighting from vehicle usage along the Princes Highway.	Boral to continue with their existing night-time lighting as proposed.	No mitigation measures proposed.
Fire	Bushfires tend to be associated with a proficient growth of native vegetation following large rain events. During summer, following rain events, dry vegetation pose a bushfire hazard when placed near a source of ignition. Vehicles driven through long grass with hot exhausts may cause a fire particularly during the hotter months of the year.	Low	The Flora and Fauna Management Plan will incorporate bushfire management protocols to prevent and deal with the potential for bushfire.	Given the existing quarry operations have not resulted in any significant fires, the implementation of the Flora and Fauna Management Plan would likely assist in fire prevention.

3.2.3 Cumulative impacts

Cumulative impacts are the successive, incremental and combined impacts (both positive and negative) of an activity on the environment (Franks et al., 2010). In relation to the Project, the cumulative impacts are considered to be the total impact on the environment that would result from the current proposal plus any additional impacts likely to occur due to subsequent projects that are of a similar nature or that are partly or wholly contingent on the Project.

Consideration of cumulative impacts to be considered in the locality from the proposed modification are outlined below:

- Bangalay Sand Forest within the Sydney Basin and South East Corner is estimated to have 50% of its former distribution remaining, however, within the Sydney basin proportion of its distribution there is significant less remnant vegetation of this type remaining due to high development pressure within coastal areas.
- The majority of past and future clearing of this PCT and associated coastal areas has occurred due to development for housing and agriculture.
- The proposed modification allows for the supply of sand, predominantly to the Sydney region from the Dunmore area for an additional 5-7 years.
- It is not apparent that approval of the current project would act to facilitate further clearing of native vegetation outside of the current modification, however there is some chance that additional adjacent resources could be subject to future applications.
- Development of available sand resources within the region is limited by available resources and land use constraints, such as a high proportion of remaining coastal areas reserved for recreation or conservation.
- The modification is sited such that development for processing infrastructure is largely avoided, which would not be the case for the establishment of extraction in new areas.
- The current development will result in clearing in predominantly cleared or low condition vegetation areas. There is likely to be continued demand for sand from urban development and therefore an increase in pressure on areas with available sand deposits. Similar or greater pressure is present from development from housing.
- Greater protection and conservation of an area of Bangalay Sand Forest or other similar vegetation type of an equal or greater conservation status (estimated at four times larger than the extent of clearing) is likely to occur as a result of offset requirements from the proposal. Offsets for the proposal may be sourced within the Illawarra IBRA subregion or adjacent IBRA subregions.

3.2.4 Flora and Fauna Management Plan

The existing DSS FFMP would be updated to include additional management activities associated with the Stage 5 modification area. These management activities would be undertaken throughout the life of the proposed modification in order to protect and manage important biodiversity values. Key commitments to be included in the FFMP include:

- Threatened species management;
- Protocols for tree clearing including pre-clearing surveys and mitigation measures for any fauna found within hollow bearing trees;
- Pest and weed prevention measures for construction activities and management of any priority pest and weeds within the site;
- Vegetation management plan; and an erosion and sediment control plan.

Some of the above management plans may be covered in separate documents to the FFMP, as part of the wider suite of management plans for the Approved Project.

3.2.5 Serious and irreversible impacts

There are no candidate species which have potential to experience serious and irreversible impacts (SAII) as a result of the proposed modification.

3.2.6 Coastal Wetland SEPP assessment

The Coastal Wetland SEPP states that: *Development consent must not be granted to development on land identified as "proximity area for coastal wetlands" or "proximity area for littoral rainforest" on the Coastal Wetlands and Littoral Rainforests Area Map unless the consent authority is satisfied that the proposed development will not significantly impact on:*

> *(a) the biophysical, hydrological or ecological integrity of the adjacent coastal wetland or littoral rainforest, or*
>
> *(b) the quantity and quality of surface and ground water flows to and from the adjacent coastal wetland or littoral rainforest.*

The mapped coastal wetland proximity area coincides with Area 5A and is adjacent to Area 5B (Figure 2). The presence of coastal wetland habitat within areas mapped as coastal wetlands was confirmed during field survey and consists of Swamp Oak Floodplain Forest (Forested Wetland formation under Keith 2014), saltmarsh and mangroves (Saline Wetland formations under Keith 2014).

There would be no direct impacts to the mapped coastal wetland areas as a result of the proposal. There is some risk of indirect impacts to coastal wetlands via both groundwater and surface water changes. No other measurable adverse indirect ecological impacts are expected to occur from the proposal.

Groundwater and surface water impacts from the proposed modification have been assessed as part of the modification application for the proposed modification (Southeast Engineering and Environmental 2019; Environmental Earth Sciences 2019). The specialist reports were reviewed as part of this assessment.

In regard to groundwater changes the specialist report states:

"The findings of this report have determined that as groundwater movement accounts for less than 0.21 per cent of catchment drainage, excavation of the aquifer sediments should have no discernible effect on catchment hydrology other than increasing the area available for water storage on the Site"

The surface water report for the proposal highlights potential impacts on coastal wetland areas via flooding of dredge ponds and subsequent transportation of sediments to coastal wetland areas. It is considered that should a moderately large proportion of dredge-pond sediment be transported to coastal wetlands there would be potential to have significant impacts on these areas. Separation of floodwaters from dredge waters via flood-bundling will significantly lower this risk.

Residual key risks to aquatic habitats have also been outlined within the surface water report (Southeast Engineering and Environmental 2019) including erosion of exposed areas post-clearing and during flood bund construction. These risks also apply to coastal wetland areas. Key to reducing these risk would be development and implementation of an appropriate and adequate erosion and sediment control plan.

The key risks to coastal wetlands have been examined within technical studies comprising the groundwater and surface water reports for the proposed modification. Provided that the avoidance and mitigation measures stated within these reports are successfully achieved, it is considered unlikely that significant impacts would occur for mapped coastal wetland areas.

3.2.7 Quantifying offset requirements

The BAM identifies the BAM Calculator as the appropriate tool for quantifying the offsets required in both Ecosystem Credit and Species Credit terms. A calculation of the nature and extent of offset credits required due to biodiversity impacts associated with the proposed modification has been undertaken using the BAM Calculator.

3.2.1 Summary of ecosystem credits required

The results of the BAM calculator in terms of vegetation integrity scoring for vegetation zones and associated ecosystem offset credit requirements are shown in Table 7. Two vegetation zones identified within the modification site generated ecosystem credit requirements as a result of vegetation integrity scores being greater than 15, as outlined in Section 10.3.1.1 of the BAM.

Ecosystem credit species will be offset via offsetting of associated vegetation types as per Table 5. It is likely that this credit obligation would be satisfied via payments into the NSW Biodiversity Conservation Fund.

Table 7: Ecosystem credit requirements

Niche vegetation mapping	PCT – best fit	Area 5A clearing (ha)	Area 5B clearing (ha)	Vegetation Integrity Score	Area 5A credit requirement	Area 5B credit requirement
Bangalay Sands Forest (good condition)	659 - Bangalay - Old-man Banksia open forest on coastal sands, Sydney Basin Bioregion and South East Corner Bioregion	0	1.42	41.8	0	30
Bangalay Sands Forest (moderate condition)	659 - Bangalay - Old-man Banksia open forest on coastal sands, Sydney Basin Bioregion and South East Corner Bioregion	0	3.11	26.5	0	41
Bangalay Sands Forest (poor condition (DNG)	659 - Bangalay - Old-man Banksia open forest on coastal sands, Sydney Basin Bioregion and South East Corner Bioregion	0	2.97	9.2	0	0
Exotic Grassland/shrubland	Cleared land	3.43	0.63	N/A	N/A	N/A
Total			**11.54**			**71**

3.2.2 Summary of species credits required

Offsets required for species credit species are shown in Table 8. Species credits are required for Southern Myotis, Masked Owl and Barking Owl (Table 8). It is likely that this credit obligation would be satisfied via payments into the NSW Biodiversity Conservation Fund.

Table 8: Species credit species requirements

Species Credit Species	Cleared habitat area (ha)	Area 5A credit requirement	Area 5B credit requirement
Southern Myotis (*Myotis macropus*)	1.4	0	19
Masked Owl (*Tyto novaehollandiae*)	2.23	0	30
Barking Owl (*Ninox connivens*)	2.23	0	30

3.2.3 Commonwealth impact assessment

Potential impacts were assessed under the BC Act and the EPBC Act. Grey-headed Flying-fox were considered to have the potential to be impacted by the proposed modification, and as such a Commonwealth Assessment of Significance was undertaken (Appendix 9). The assessment concluded that there would be no significant impact on the species, therefore a referral to the Commonwealth DoEE is not required as the proposed modification will not significantly impact on MNES (biodiversity).

4. Conclusion

This report provides a BDAR in accordance with the BAM in order to address the potential impacts associated with the DSS Stage 5 Modification Area. This report also provides an assessment for threatened biodiversity listed under the EPBC Act.

The Project will result in the disturbance of 4.53 ha of native vegetation. Indirect impacts may include dust, noise, erosion and sedimentation which will be mitigated by measures provided in section 3.2 of this report.

During the field survey one TEC - Bangalay Sand Forest of the Sydney Basin and South East Corner bioregions was found to occur within the Study Area. Three condition zones were attributed to the TEC to assist with offsetting of clearing impacts. The Project will result in disturbance to approximately 4.53 ha of the TEC listed under the BC Act. This TEC would be offset according to the requirements of the BAM.

No threatened flora are likely to be impacted by the Project given the lack of habitat and absence of threatened flora during the field survey.

Seventeen threatened and migratory fauna species are considered to be affected by the Project. Most of these species are likely to utilise the foraging habitat of the Study Area on an intermittent basis. No further assessment of impact is required for the ecosystem credit species based on the requirements of the BAM and the offsetting of the associated PCTs Ecosystem Credit Species under the BAM which do not require further assessment of impact as they would be offset with their associated PCTs.

The Southern Myotis, Masked Owl and Barking Owl are the only listed Species Credit Species which require an offset for the Project given their detection or assumed presence within, or adjacent to the Study Area.

One threatened fauna species listed under the EPBC Act, Grey-headed Flying Fox, was recorded within the Study Area. An EPBC Act Assessment of Significance for Grey-headed Flying Fox was completed and concluded that a significant impact on this species is unlikely. A number of migratory species protected under the EPBC Act may use the

Mitigation measures associated with indirect impacts have been proposed through the revision and implementation of existing management plans.

A total of 71 Ecosystem Credits are required to offset PCT impacts and associated threatened fauna habitat surrogates; 19 Southern Myotis, 30 Masked Owl and 30 Barking Owl credits.

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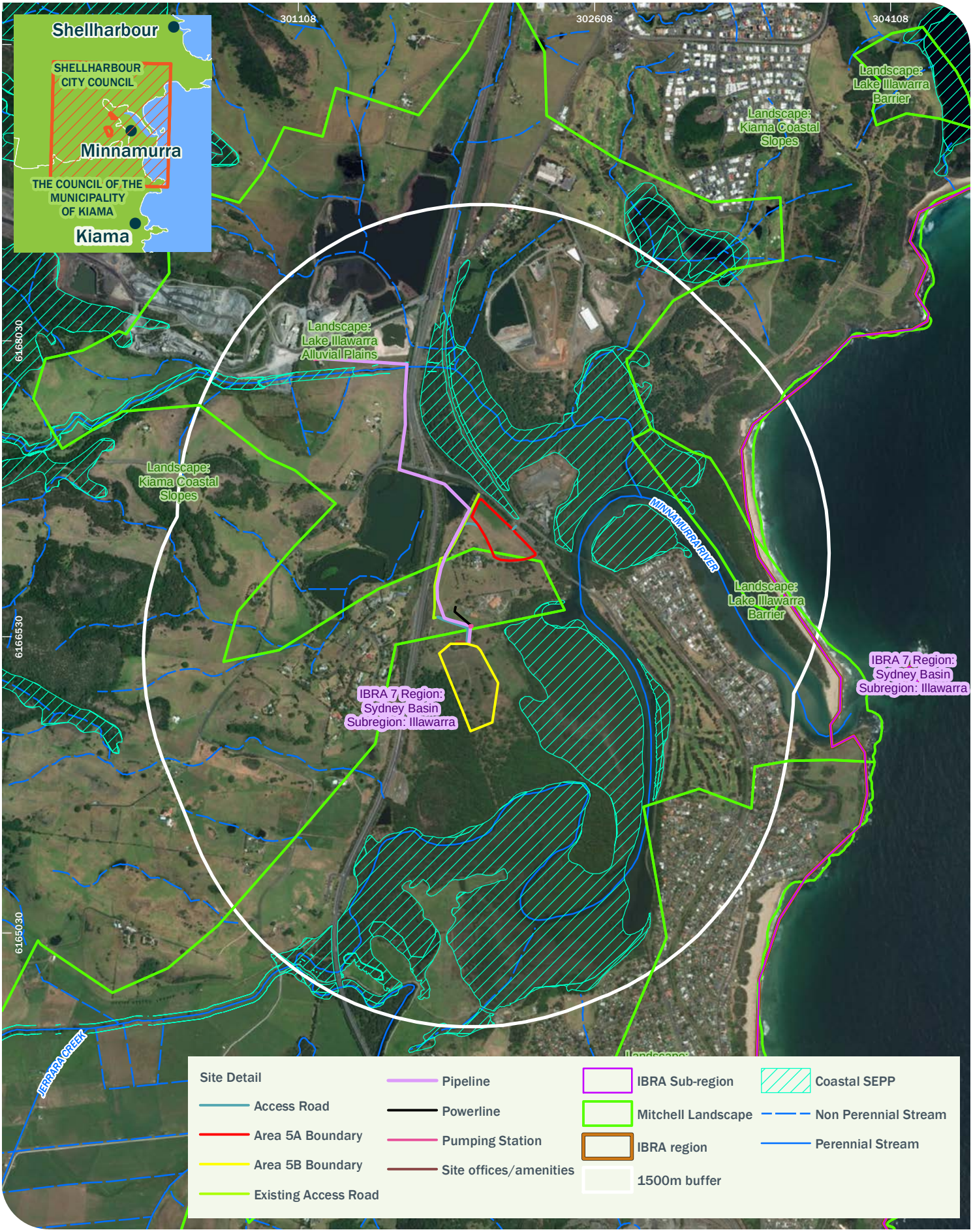
Figures



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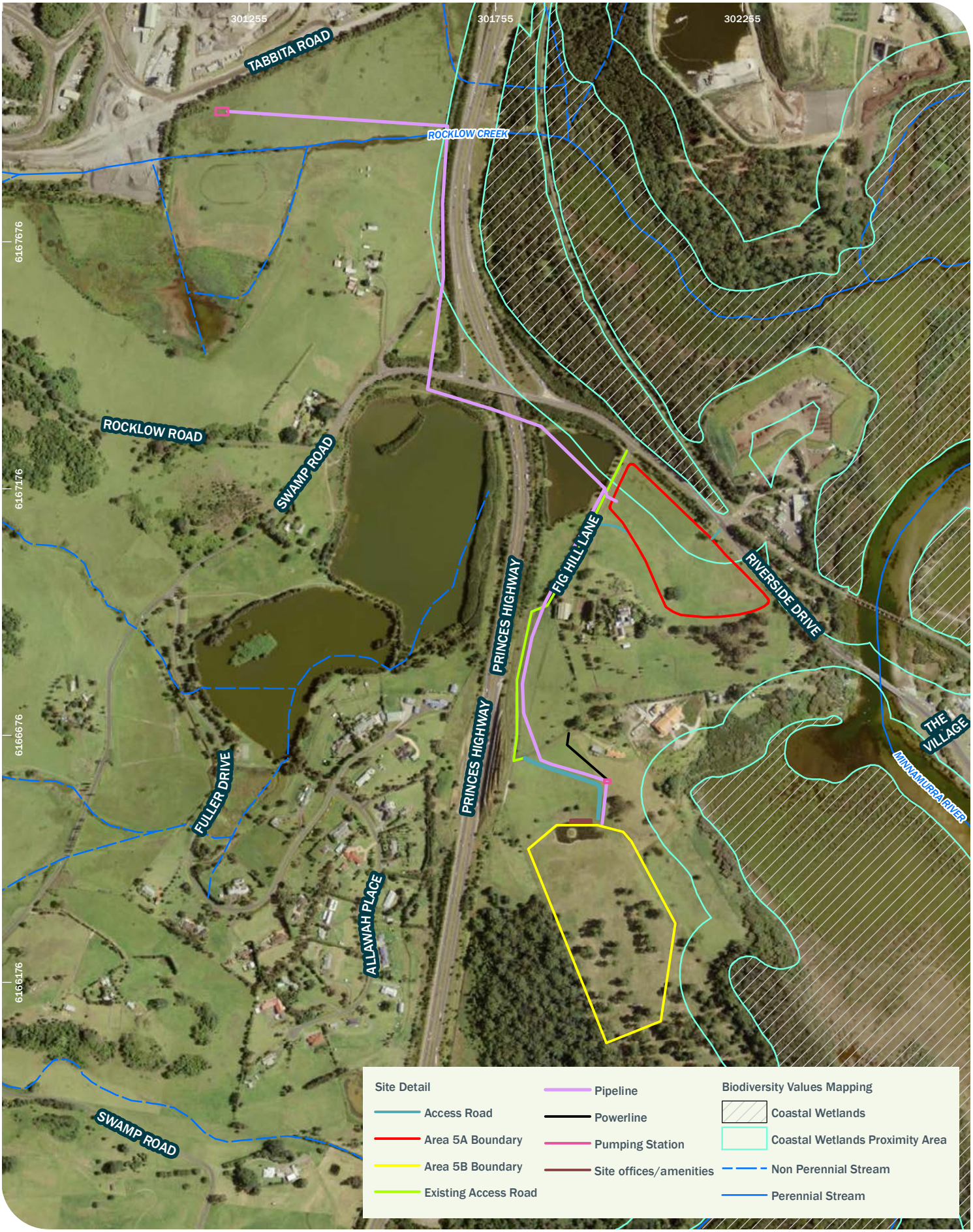
Location Map

Dunmore Lakes Sand Project

Niche PM: Simon Tweed
Niche Proj. #: 3589
Client: Element Environmental

Figure 1

World Imagery: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community



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Site Map
Dunmore Lakes Sand Project

Niche PM: Simon Tweed
Niche Proj. #: 3589
Client: Carbonvision Pty Ltd

Figure 2

sixmaps/LPI_Imagery_Best: © Department of Finance, Services & Innovation 2017

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- Access Road
- Area 5A Boundary
- Area 5B Boundary
- Existing Access Road
- Pipeline
- Powerline
- Pumping Station
- Site offices/amenities
- e65, River Mangrove
- e70, Seagrass Meadow (Zostera)
- p105, Floodplain Swamp Forest
- p106, Estuarine Fringe Forest
- p107, Estuarine Creekflat Scrub
- p109, Estuarine Mangrove Forest
- p110, Warm Temperate Layered Forest
- p111, Subtropical Dry Rainforest
- p113, Coastal Warm Temperate Rainforest
- p3, Illawarra Lowland Swamp Woodland
- p313, Coastal Freshwater Lagoon
- p46, Basalt Hilltop Scrub
- p509, Estuarine Saltmarsh
- p64, Coastal Sand Forest
- p99, Illawarra Gully Wet Forest

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GDA 1994 MGA Zone 56

Previous vegetation mapping
Dunmore Lakes Sand Project

Niche PM: Simon Tweed
Niche Proj. #: 3589
Client: Carbonvision Pty Ltd

Figure 3

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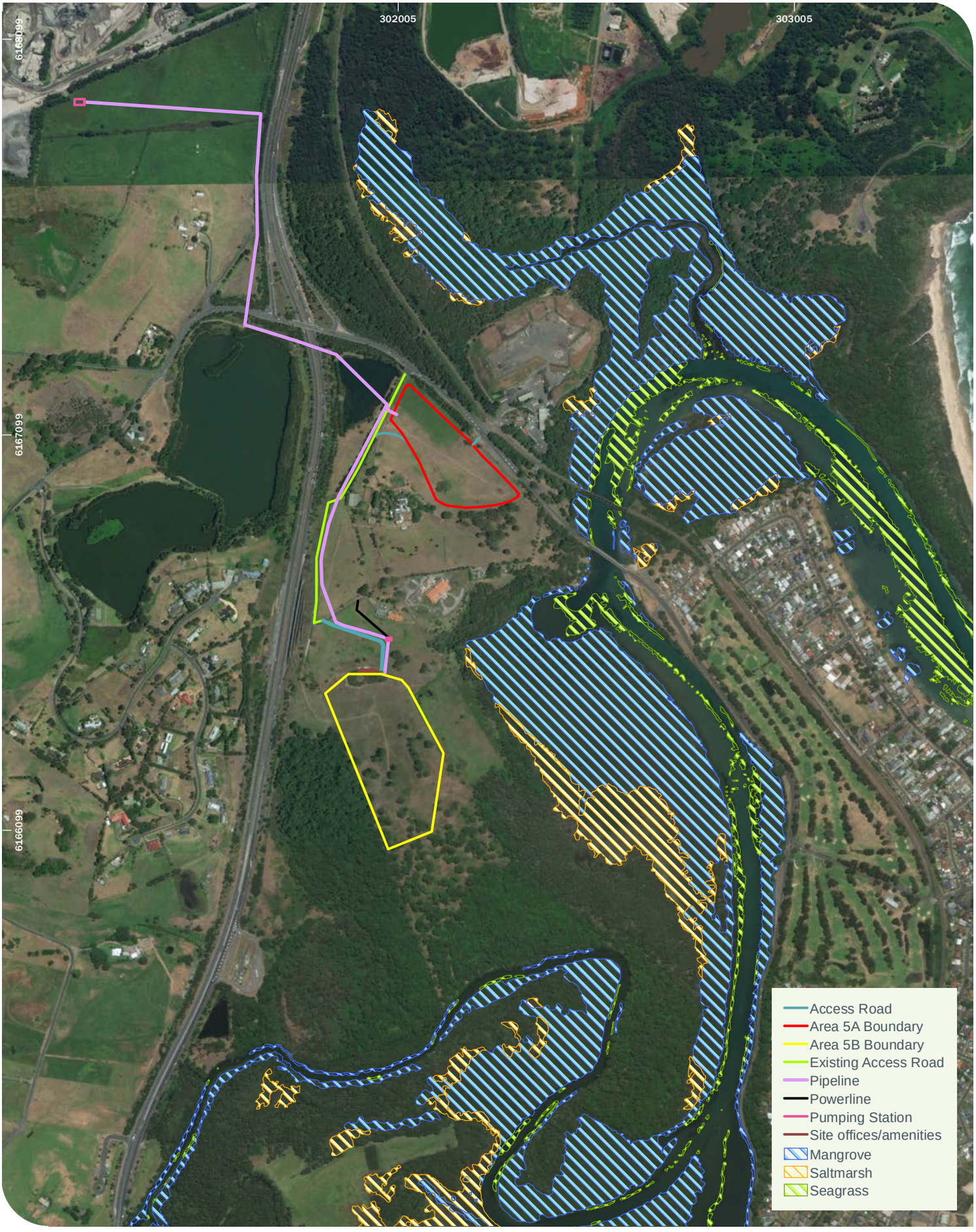

niche Environment and Heritage

0 200
m
GDA 1994 MGA Zone 56

Aquatic vegetation mapping
Dunmore Lakes Sand Project

Niche PM: Simon Tweed
Niche Proj. #: 3589
Client: Carbonvision Pty Ltd

Figure 4

World Imagery: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Drawn by: Matt Harris File: T:\spatial\projects\a3500\a3589_Dunmore_SP_S5_BAIM\gis\report\BDAR3589_Figure_4_AquaticVeg.mxd Last updated: 4/10/2019 11:34:58 AM

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niche Environment and Heritage

0 75
m
GDA 1994 MGA Zone 56

Vegetation zones, potential clearing areas and plot locations: North

Dunmore Lakes Sand Project

Niche PM: Simon Tweed
Niche Proj. #: 3589
Client: Carbonvision Pty Ltd

Figure 5

World Imagery: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

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Drawn by: Matt Harris File: T:\spatial\projects\a3500\a3589_Dunmore_SP_S5_BAM\qgis\report\BDAR3589_Figure_5_7_VegetationDetailed.mxd Last updated: 4/10/2019 1:21:10 PM

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GDA 1994 MGA Zone 56

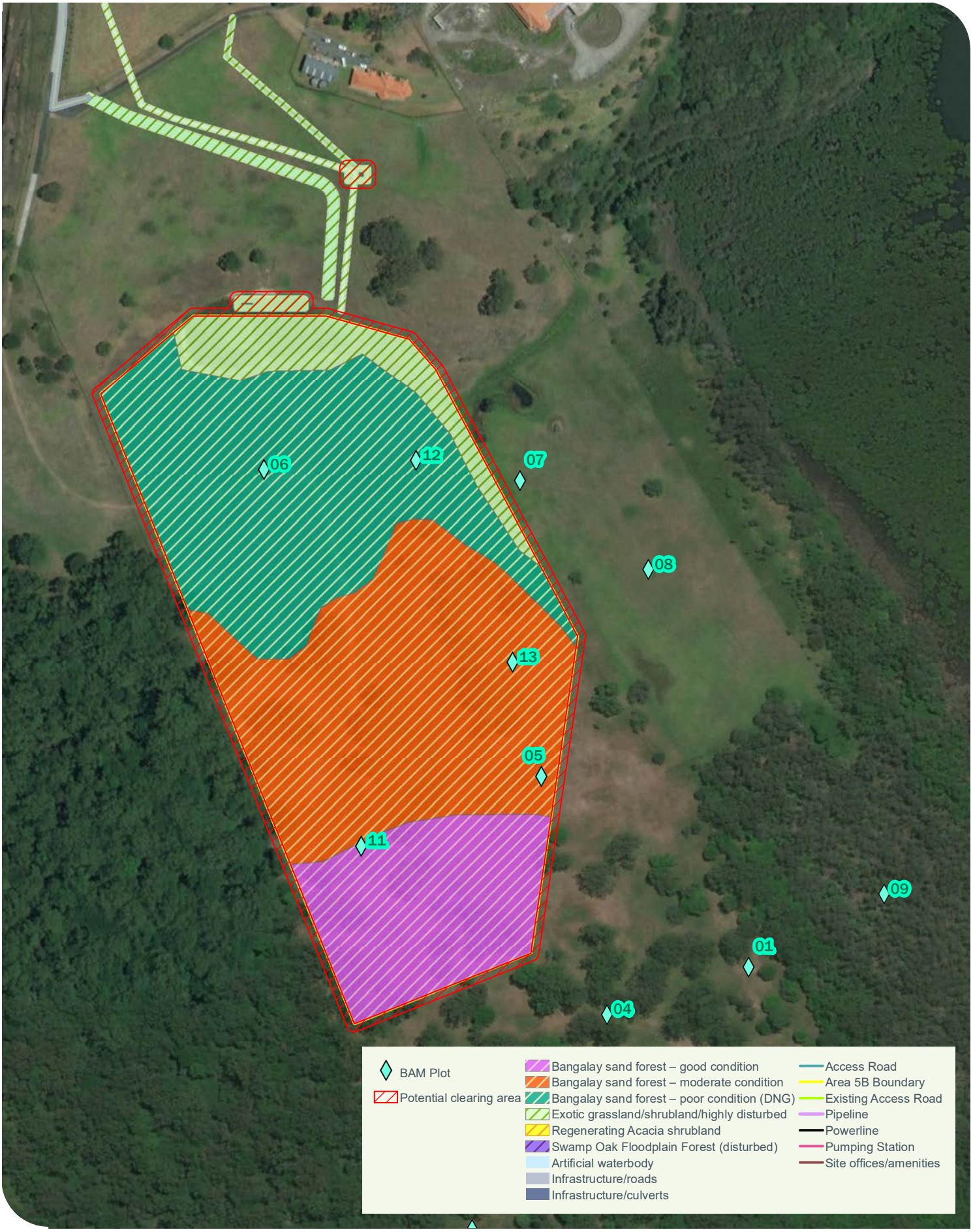
Vegetation zones, potential clearing areas and plot locations: Centre

Dunmore Lakes Sand Project

Niche PM: Simon Tweed
Niche Proj. #: 3589
Client: Carbonvision Pty Ltd

Figure 6

World Imagery: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community



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m

GDA 1994 MGA Zone 56

Vegetation zones, potential clearing areas and plot locations: South

Dunmore Lakes Sand Project

Niche PM: Simon Tweed
Niche Proj. #: 3589
Client: Carbonvision Pty Ltd

Figure 7

World Imagery: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Drawn by: Matt Harris File: T:\spatial\projects\a3500\a3589_Dunmore_SP_S5_BAM\qa\report\BDAR3589_Figure_5_7_VegetationDetailed.mxd Last updated: 4/10/2019 1:21:10 PM

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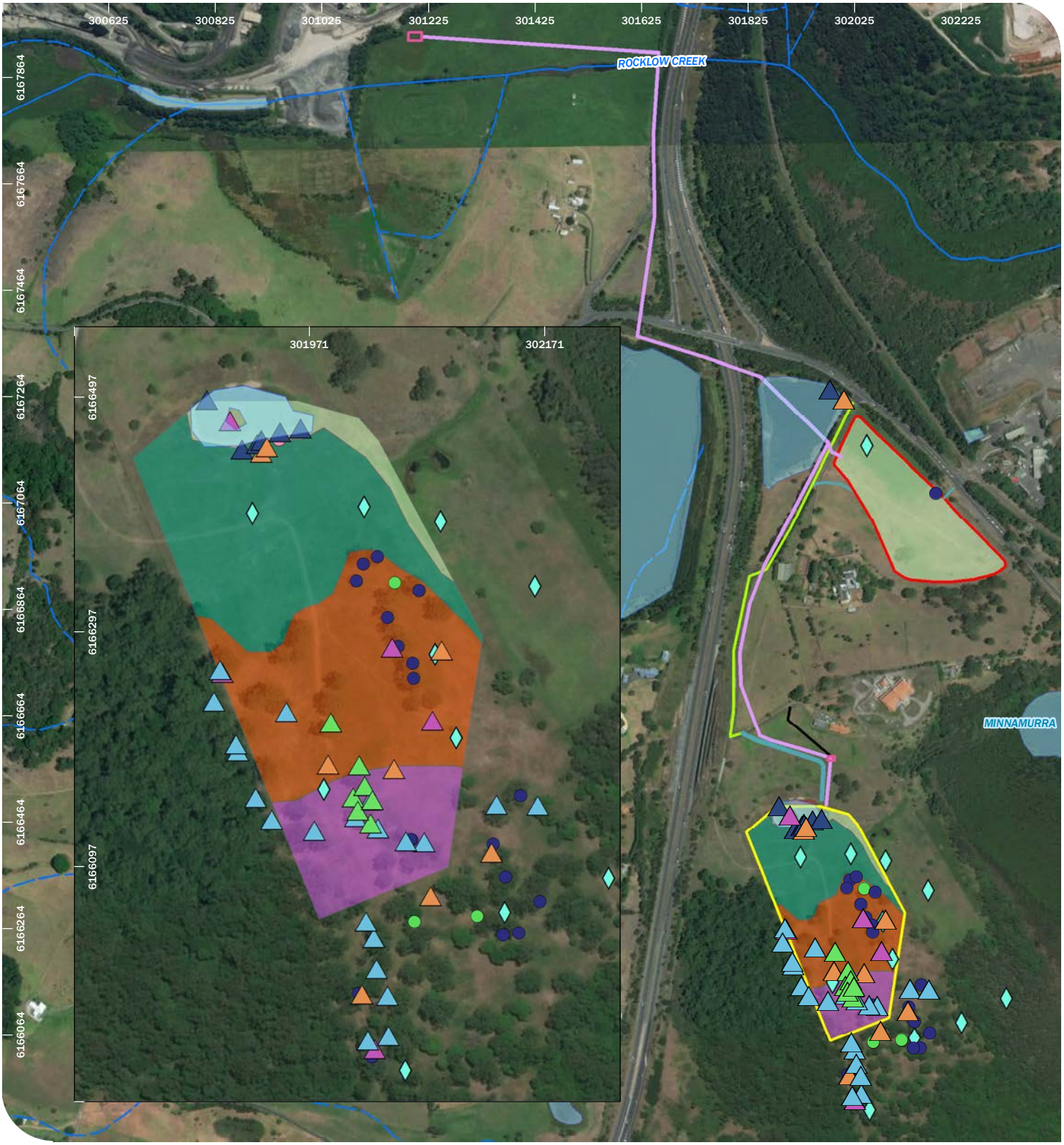

- Bird survey
- Echolocation recording
- Eilliot trap
- Frog survey
- Remote Camera
- Dam
- Hollow-bearing stag
- Hollow-bearing tree
- BAM Plot
- Bangalay sand forest – good condition
- Bangalay sand forest – moderate condition
- Bangalay sand forest – poor condition (DNG)
- Exotic grassland
- Access Road
- Area 5A Boundary
- Area 5B Boundary
- Existing Access Road
- Pipeline
- Powerline
- Pumping Station
- Site offices/amenities
- Waterbody
- Non Perennial Stream
- Perennial Stream

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m
GDA 1994 MGA Zone 56

Fauna methods/survey effort
Dunmore Lakes Sand Project

Niche PM: Simon Tweed
Niche Proj. #: 4356
Client: Element Environmental

Figure 8

World Imagery: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Drawn by: Matt Harris File: T:\spatial\projects\a3500\a3589_Dunmore_SP_S5_BAM\apsx\report\BDAR3589_Figure_8_FaunaMethods_LegendAsGraphic.mxd Last updated: 4/10/2019 12:11:00 PM

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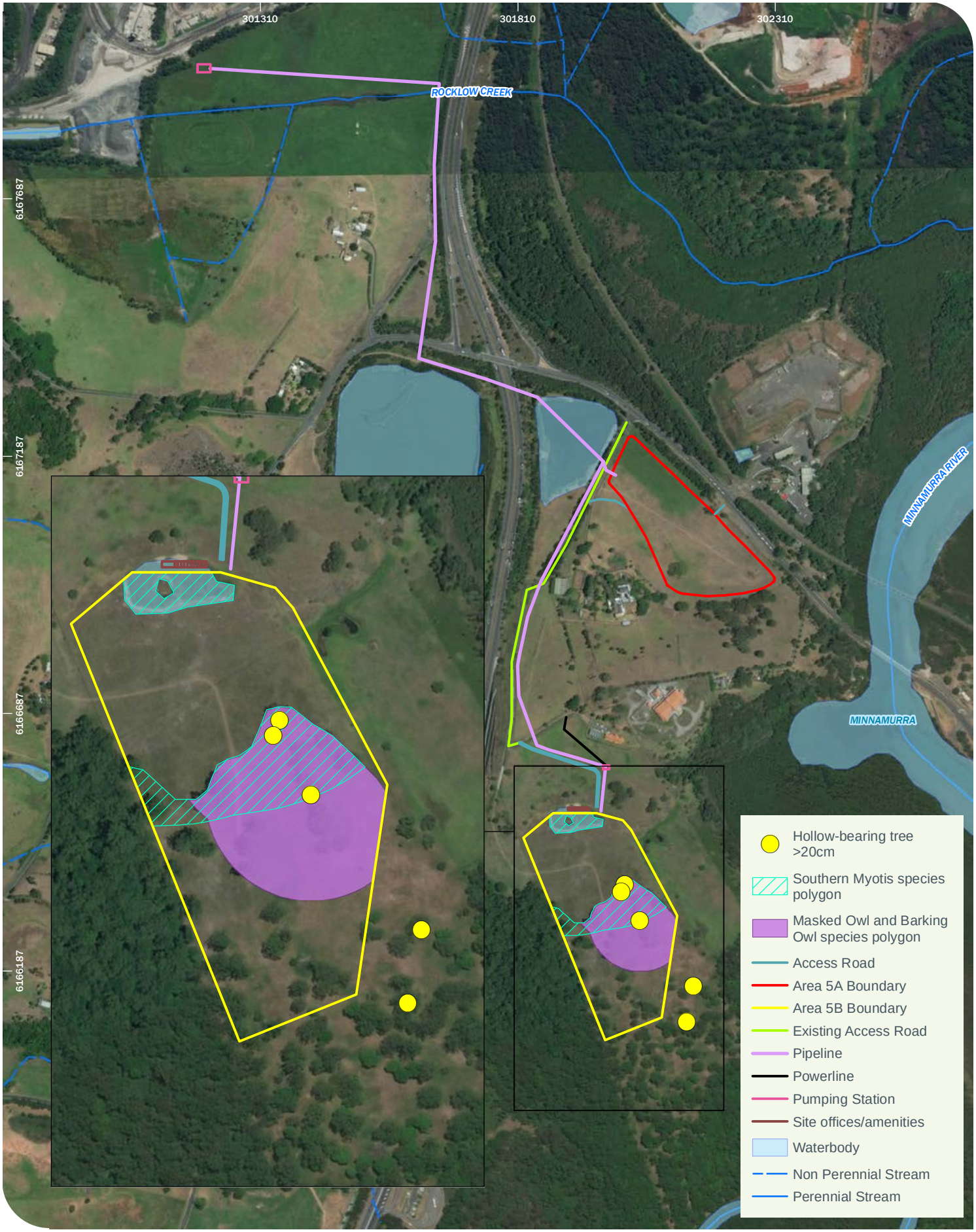

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m
GDA 1994 MGA Zone 56

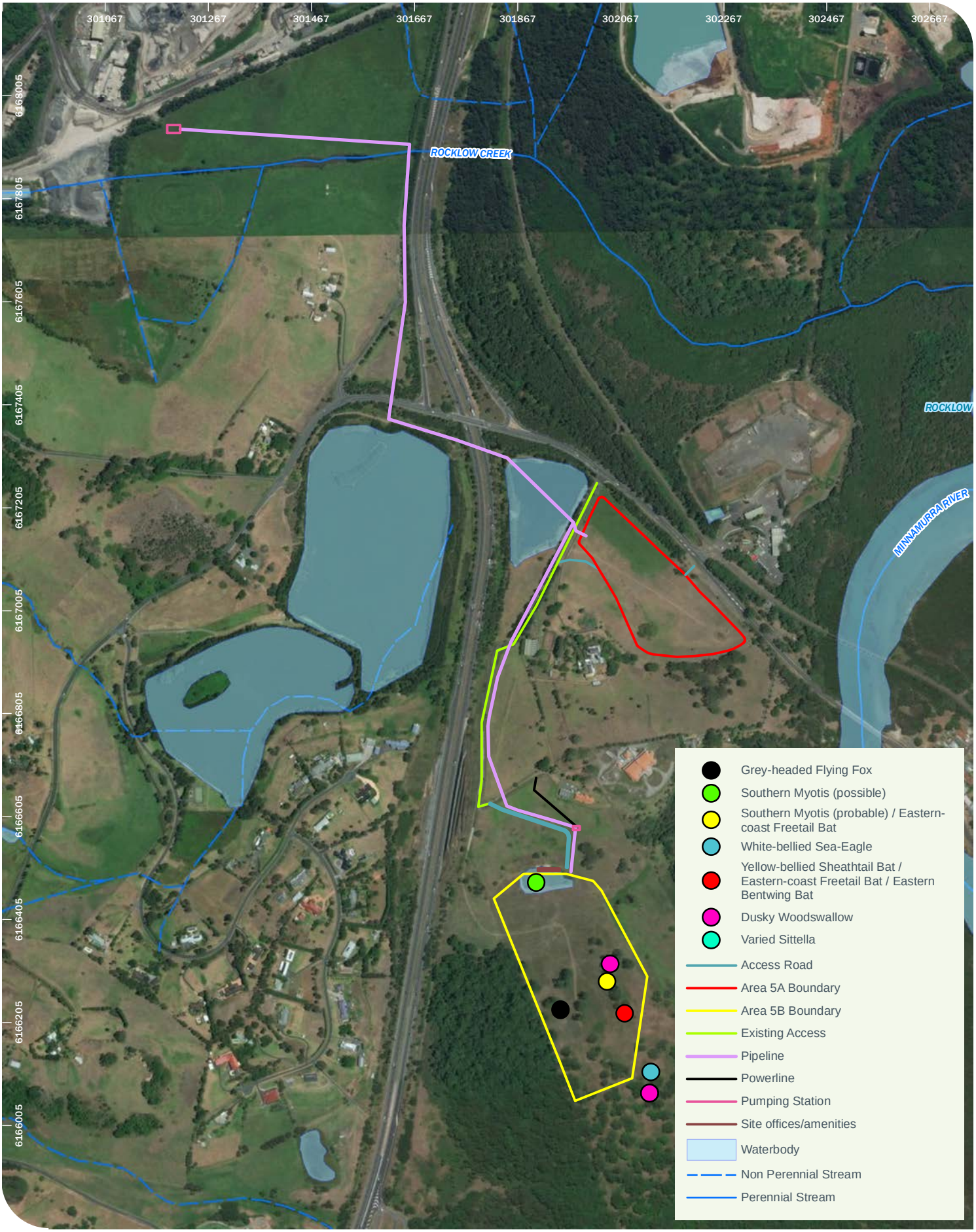
Species polygons for potentially impacted species credit species

Dunmore Lakes Sand Project

Niche PM: Simon Tweed
Niche Proj. #: 4356
Client: Element Environmental

Figure 8

World Imagery: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community



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m
GDA 1994 MGA Zone 56

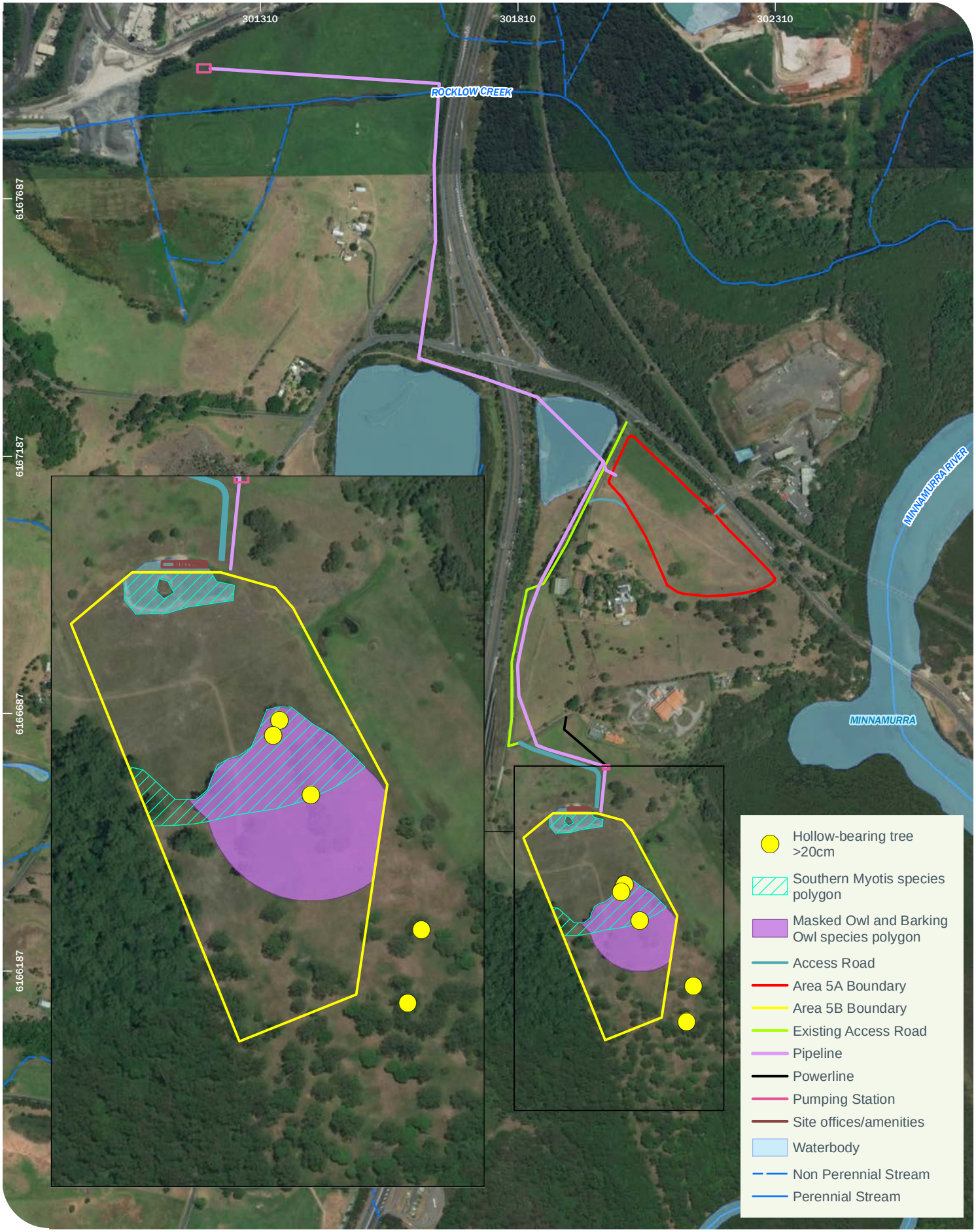
Threatened species recorded during survey
Dunmore Lakes Sand Project

Niche PM: Simon Tweed
Niche Proj. #: 4356
Client: Element Environmental

Figure 9

World Imagery: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

v2.0



niche Environment and Heritage

0 150
m
GDA 1994 MGA Zone 56

Species polygons for potentially impacted species credit species

Dunmore Lakes Sand Project

Niche PM: Simon Tweed
Niche Proj. #: 4356
Client: Element Environmental

Figure 10

World Imagery: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Drawn by: Matt Harris File: T:\spatial\projects\a3500\a3589_Dunmore_SP_S5_BAM\gis\report\BDAR\3589_Figure_10_SpeciesPolygon.mxd Last updated: 4/10/2019 12:12:46 PM

Appendix 1. Plant community descriptions (only plant communities within the site are described)

Bangalay Sand Forest of the Sydney Basin and South East Corner bioregions (Good condition)

Habitat: This community predominantly occurs within flat well drained sandy soils.

Structure/Characteristics: Good condition Bangalay Sand Forest with only the overstorey layer still somewhat intact occurs to the south of Stage 5B. A number of exotic pasture species occur within areas dominated by the native grasses.

Overstorey/midstorey: The overstorey consists of Bangalay. Midstorey is dominated by *Melicope micrococci*, *Glochidion ferdinandi* (Cheese tree) and *Banksia integrifolia* (Coast Banksia).

Distribution within site: Occurs within the southern section of Stage 5B.

Condition and Presence of Weeds: The vegetation has been exposed to previous vegetation clearing and grazing. Much of the understory contains weeds including: *Setaria gracilis* (Marsh Bristlegrass), *Axonopus compressus* (Blanket Grass), *Cynodon dactylon* (Couch Grass), *Pennisetum clandestinum* (Kikuyu) and *Chloris gayana* (Rhodes Grass).

Conservation Status: Bangalay Sand Forest of the Sydney Basin and South East Corner Bioregions is listed as an EEC under the BC Act.

Bangalay Sand Forest of the Sydney Basin and South East Corner bioregions (Moderate condition)

Habitat: This community predominantly occurs within flat well drained sandy soils.

Structure/Characteristics: Moderate condition Bangalay Sand Forest with only a sparse overstorey layer occurs in the middle of Stage 5B. A number of exotic pasture species occur within areas dominated by the native grasses.

Overstorey/midstorey: The overstorey consists of Bangalay. Midstorey is dominated by *Brachychiton populneus* (Kurrajong) and *Acacia maidenii* (Maiden's Wattle).

Distribution within site: Occurs within the middle section of the Stage 5B.

Condition and Presence of Weeds: The vegetation has been exposed to previous vegetation clearing and grazing. Much of the understory contains weeds including: *Acetosella vulgaris* (Sheep's Sorrel), *Cynodon dactylon*, *Pennisetum clandestinum*, *Chloris gayana*, *Gomphocarpus fruticosus* (Narrow leaf cotton bush) and *Paspalum dilatatum* (Dallis grass).

Conservation Status: Bangalay Sand Forest of the Sydney Basin and South East Corner Bioregions is listed as an EEC under the BC Act.

Bangalay Sand Forest of the Sydney Basin and South East Corner bioregions (Poor condition (Derived Native Grassland)

Habitat: This community predominantly occurs within flat well drained sandy soils.

Structure/Characteristics: Poor condition Bangalay Sand Forest (derived native grassland) occurs to the north of Stage 5B. A number of exotic pasture species occur within areas dominated by the native grasses.

Overstorey/midstorey: No native overstorey or midstorey occur within this condition class.

Distribution within site: Occurs within the northern section of the Stage 5B.

Condition and Presence of Weeds: The vegetation has been exposed to previous vegetation clearing and grazing. Much of the understory contains weeds including: *Cynodon dactylon*, *Chloris gayana*, *Gomphocarpus fruticosus* and *Stellaria media* (Chickweed).

Conservation Status: Bangalay Sand Forest of the Sydney Basin and South East Corner Bioregions is listed as an EEC under the BC Act.

Swamp Oak Floodplain Forest (Moderate condition)

Habitat: This community predominantly occurs within the north west of the modification site in low lying areas around the dam. Clearing would not occur in this area, however some trimming of low branches may occur in order to install the required pipeline.

Structure/Characteristics: Moderate condition Swamp Oak Floodplain Forest occurs to the north west of the site surrounding the dam. A number of exotic pasture species occur within areas dominated by the native grasses.

Overstorey/midstorey: The overstorey is dominated by *Casuarina glauca*. No native midstorey occurs within this vegetation zone.

Distribution within site: Occurs within the north western section of the site.

Condition and Presence of Weeds: The vegetation had low diversity and has been exposed to previous vegetation clearing and grazing. The groundcover was dominated by the weeds including: *Cynodon dactylon* and Largeleaf Pennywort (*Hydrocotyle bonariensis*).

Conservation Status: Swamp Oak Floodplain Forest of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions is listed as an EEC under the BC Act and endangered under the EPBC Act.

Exotic Grassland/shrubland

This degraded community occupies the northern portion of Stage 5B and the entire area of Stage 5A. This community has both overstorey and midstorey layers entirely removed and contains little to no native resilience. Native vegetation has been mostly replaced by a range of exotic weeds and pasture. The exotic pasture consists predominantly of the following species: *Acetosella vulgaris, Senecio madagascariensis, Sida rhombifolia, Hypochaeris radicata, Plantago lanceolata, Sporobolus africanus, Stenotaphrum secundatum, Pennisetum clandestinum, Paspalum dilatatum, Axonopus compressus, Conyza bonariensis, Chloris gayana* and *Verbena bonariensis*.

Appendix 2. Floristic plot data

Plot no.	Species name	Cover (%)	Abundance (stems)
1	*Acacia maidenii*	20	1
1	*Asparagus aethiopicus* *	2	10
1	*Breynia oblongifolia*	2	5
1	*Cardiospermum grandiflorum* *	1	5
1	*Centella asiatica*	7	500
1	*Ceratopetalum apetalum*	10	2
1	*Commelina cyanea*	3	40
1	*Delairea odorata* *	7	50
1	*Diospyros australis*	8	2
1	*Ehretia acuminata var. acuminata*	10	2
1	*Ehrharta erecta* *	2	30
1	*Eucalyptus botryoides*	35	2
1	*Eustrephus latifolius*	3	30
1	*Ficus coronata*	10	2
1	*Ficus macrophylla*	5	4
1	*Ficus rubiginosa* *	2	1
1	*Geitonoplesium cymosum*	5	100
1	*Glochidion ferdinandi*	35	50
1	*Lantana camara* *	5	10
1	*Lomandra longifolia*	0.5	1
1	*Maclura cochinchinensis*	10	50
1	*Marsdenia rostrata*	5	5
1	*Oplismenus imbecillis*	10	500
1	*Parsonsia straminea*	15	20
1	*Pittosporum spinescens*	3	3
1	*Solanum nigrum* *	2	8
1	*Stephania japonica*	2	5
1	*Streblus brunonianus*	5	5
1	*Urtica incisa*	0.2	5
2	*Acacia maidenii*	0.5	3
2	*Acetosella vulgaris* *	0.3	20
2	*Alphitonia excelsa*	0.1	3
2	*Banksia integrifolia*	5	1
2	*Bidens pilosa* *	0.5	20
2	*Cardiospermum grandiflorum* *	0.2	2
2	*Chloris gayana* *	50	1000
2	*Commelina cyanea*	7	100
2	*Cynodon dactylon* *	5	100
2	*Delairea odorata* *	0.2	1
2	*Ehrharta erecta* *	2	50
2	*Einadia nutans*	0.1	1
2	*Eucalyptus botryoides*	35	2
2	*Geitonoplesium cymosum*	0.2	3
2	*Geranium solanderi*	0.5	30
2	*Glochidion ferdinandi*	10	3
2	*Glycine clandestina*	0.1	1
2	*Hibbertia scandens*	0.1	1
2	*Hypochaeris radicata* *	0.1	5
2	*Lantana camara* *	7	5
2	*Lycium ferocissimum* *	0.2	1
2	*Myrsine howittiana*	0.5	3
2	*Oplismenus aemulus*	0.1	5
2	*Pennisetum clandestinum* *	3	100
2	*Pteridium esculentum*	25	100
2	*Rumex brownii*	0.2	20
2	*Stellaria flaccida*	0.1	1
2	*Stephania japonica*	0.1	1
3	*Acacia maidenii*	0.3	3
3	*Alectryon subcinereus*	5	5

Plot no.	Species name	Cover (%)	Abundance (stems)
3	*Alphitonia excelsa*	10	5
3	*Asparagus aethiopicus* *	1	50
3	*Banksia integrifolia*	3	1
3	*Blechnum ambiguum*	3	30
3	*Breynia oblongifolia*	0.3	15
3	*Cardiospermum grandiflorum* *	0.2	5
3	*Carex appressa*	1	50
3	*Chloris gayana* *	0.2	5
3	*Commelina cyanea*	0.5	50
3	*Delairea odorata* *	5	50
3	*Desmodium varians*	1	50
3	*Ehrharta erecta* *	0.5	30
3	*Entolasia stricta*	4	1000
3	*Eustrephus latifolius*	3	20
3	*Ficus macrophylla*	3	1
3	*Geitonoplesium cymosum*	15	50
3	*Geranium solanderi*	0.1	5
3	*Glochidion ferdinandi*	25	20
3	*Glycine clandestina*	0.1	3
3	*Hibbertia scandens*	0.5	5
3	*Lantana camara* *	3	20
3	*Lomandra longifolia*	0.5	10
3	*Maclura cochinchinensis*	30	50
3	*Melicope micrococca*	20	20
3	*Microlaena stipoides*	0.5	50
3	*Morinda jasminoides*	0.5	5
3	*Myrsine variabilis*	0.1	3
3	*Notelaea longifolia*	20	30
3	*Oplismenus aemulus*	0.5	20
3	*Pandorea pandorana*	0.8	3
3	*Paronychia brasiliana* *	5	1
3	*Parsonsia straminea*	1	10
3	*Pittosporum revolutum*	2	5
3	*Pittosporum undulatum*	2	1
3	*Rubus parvifolius*	0.1	1
3	*Senecio sp.* *	0.1	1
3	*Setaria gracilis* *	0.2	10
3	*Stellaria media* *	5	200
4	*Acacia maidenii*	0.5	5
4	*Acetosella vulgaris* *	4	500
4	*Banksia integrifolia*	25	1
4	*Bidens pilosa* *	1	50
4	*Breynia oblongifolia*	0.5	5
4	*Cardiospermum grandiflorum* *	0.2	5
4	*Chloris gayana* *	25	500
4	*Clerodendrum tomentosum*	0.1	2
4	*Commelina cyanea*	10	200
4	*Cynodon dactylon* *	15	200
4	*Cyperus spp.*	0.2	2
4	*Echinopogon caespitosus*	0.1	1
4	*Ehrharta erecta* *	10	500
4	*Einadia nutans*	0.1	10
4	*Eucalyptus botryoides*	30	1
4	*Geitonoplesium cymosum*	1	3
4	*Geranium solanderi*	2	100
4	*Glochidion ferdinandi*	8	20
4	*Hibbertia scandens*	8	50
4	*Hypochaeris radicata* *	5	150
4	*Imperata cylindrica*	0.1	5

Plot no.	Species name	Cover (%)	Abundance (stems)
4	*Lantana camara* *	2	5
4	*Lomandra longifolia*	5	20
4	*Melicope micrococca*	10	10
4	*Microlaena stipoides*	10	100
4	*Myrsine howittiana*	0.5	5
4	*Oxalis perennans*	0.5	50
4	*Pennisetum clandestinum* *	15	100
4	*Pteridium esculentum*	15	
4	*Rubus parvifolius*	0.5	5
4	*Senecio madagascariensis* *	0.1	1
4	*Setaria gracilis* *	0.1	5
4	*Stephania japonica*	0.1	1
5	*Acetosella vulgaris* *	15	200
5	*Brachychiton populneus*	3	1
5	*Breynia oblongifolia*	0.1	1
5	*Chloris gayana* *	5	200
5	*Cynodon dactylon* *	1	50
5	*Cyperus spp.*	0.2	5
5	*Ehrharta erecta* *	0.5	10
5	*Hibbertia scandens*	0.5	5
5	*Hypochaeris radicata* *	1	50
5	*Imperata cylindrica*	10	500
5	*Lomandra longifolia*	0.5	1
5	*Oxalis perennans*	0.2	50
5	*Plantago lanceolata* *	0.2	20
5	*Pteridium esculentum*	40	150
5	*Senecio madagascariensis* *	1	50
5	*Setaria gracilis* *	0.5	50
5	*Sporobolus creber*	0.5	3
5	*Tagetes minuta* *	0.1	1
5	*Unidentified* *	0.1	1
5	*Verbascum virgatum* *	0.1	1
6	*Acetosella vulgaris* *	1	100
6	*Chloris gayana* *	7	100
6	*Cynodon dactylon* *	60	1000
6	*Hypochaeris radicata* *	0.5	50
6	*Microlaena stipoides*	1	500
6	*Oxalis perennans*	0.2	100
6	*Paronychia brasiliana* *	0.2	20
6	*Pteridium esculentum*	20	300
6	*Senecio madagascariensis* *	1	50
6	*Setaria gracilis* *	1	50
6	*Sida rhombifolia* *	0.5	60
6	*Sporobolus spp.* *	1	50
7	*Axonopus compressus* *	5	300
7	*Cynodon dactylon var. dactylon* *	15	500
7	*Hypochaeris radicata* *	1	100
7	*Paspalum dilatatum* *	5	300
7	*Pennisetum clandestinum* *	25	7000
7	*Plantago lanceolata* *	1	80
7	*Senecio madagascariensis* *	0.5	40
7	*Sida rhombifolia* *	0.5	50
7	*Sporobolus africanus* *	15	1000
7	*Stenotaphrum secundatum* *	25	1000
8	*Axonopus compressus* *	7	500
8	*Chloris gayana* *	20	
8	*Conyza bonariensis* *	0.2	30
8	*Cynodon dactylon var. dactylon* *	10	
8	*Cyperus laevigatus*	0.1	6
8	*Dichondra repens*	0.1	40
8	*Geranium solanderi*	0.1	3
8	*Hypochaeris radicata* *	5	200
8	*Microlaena stipoides*	5	100
8	*Oxalis perennans*	0.1	30
8	*Paspalum dilatatum* *	7	1000
8	*Plantago lanceolata* *	0.5	80
8	*Pteridium esculentum*	25	200
8	*Senecio madagascariensis* *	0.5	40
8	*Sida rhombifolia* *	0.5	50
8	*Sporobolus africanus* *	20	
8	*Unidentified sp.* *	0.1	1
9	*Atriplex prostrata* *	0.1	1
9	*Casuarina glauca*	10	30
9	*Juncus kraussii subsp. australiensis*	25	60
9	*Lagunaria patersonia*	25	40
9	*Parsonsia straminea*	0.1	1
9	*Phragmites australis*	0.1	10
9	*Sporobolus virginicus*	5	1000
9	*Suaeda australis*	25	20
10	*Axonopus compressus* *	55	
10	*Conyza bonariensis* *	12	200
10	*Cyperus spp.*	5	100
10	*Dianella caerulea*	0.1	1
10	*Juncus usitatus*	2	200
10	*Paspalum dilatatum* *	35	1000
10	*Paspalum urvillei* *	2	50
10	*Ranunculus spp.*	0.2	50
10	*Rumex brownii*	0.1	2
10	*Senecio madagascariensis* *	0.2	20
10	*Verbena bonariensis* *	0.2	5
11	*Acetosella vulgaris* *	2	300
11	*Axonopus compressus* *	10	100
11	*Banksia integrifolia*	0.2	2
11	*Breynia oblongifolia*	0.01	2
11	*Cardiospermum grandiflorum* *	0.1	1
11	*Chloris gayana* *	30	
11	*Commelina cyanea*	0.2	20
11	*Cynodon dactylon* *	10	100
11	*Einadia hastata*	0.2	10
11	*Hypochaeris radicata* *	2	250
11	*Imperata cylindrica*	5	100
11	*Lantana camara* *	0.5	8
11	*Microlaena stipoides*	25	350
11	*Oxalis perennans*	0.5	100
11	*Pteridium esculentum*	40	500
11	*Senecio madagascariensis* *	5	80
12	*Carex appressa*	0.1	1
12	*Chloris gayana* *	20	
12	*Conyza bonariensis* *	3	50
12	*Cynodon dactylon* *	10	
12	*Cyperus laevigatus*	0.1	42
12	*Dichelachne spp.*	2	30
12	*Entolasia stricta*	2	30
12	*Eragrostis brownii*	1	31
12	*Gomphocarpus fruticosus* *	10	
12	*Hypochaeris radicata* *	3	
12	*Microlaena stipoides*	10	
12	*Oxalis perennans*	2	100
12	*Plantago lanceolata* *	0.1	25
12	*Pteridium esculentum*	20	
12	*Rumex acetosella* *	1	300
12	*Senecio madagascariensis* *	3	200
12	*Sida rhombifolia* *	0.1	3
12	*Stellaria media* *	5	50

Plot no.	Species name	Cover (%)	Abundance (stems)
12	*Unidentified sp.* *	0.1	3
12	*Unidentified sp.* *	0.1	2
12	*Wahlenbergia gracilis*	0.1	18
13	*Acacia irrorata*	0.1	2
13	*Acacia maidenii*	3	1
13	*Breynia oblongifolia*	0.1	5
13	*Chloris gayana* *	5	
13	*Commelina cyanea*	0.1	15
13	*Cynodon dactylon* *	15	
13	*Cyperus spp.*	0.1	16
13	*Ehrharta erecta* *	0.1	10
13	*Einadia hastata*	0.1	10
13	*Eucalyptus botryoides*	15	1
13	*Gomphocarpus fruticosus* *	5	
13	*Hibbertia scandens*	0.1	2
13	*Hypochaeris radicata* *	1	100
13	*Imperata cylindrica*	10	
13	*Microlaena stipoides*	10	
13	*Oxalis perennans*	0.1	68
13	*Paspalum dilatatum* *	5	
13	*Pennisetum clandestinum* *	10	
13	*Plantago lanceolata* *	0.1	23
13	*Pteridium esculentum*	30	
13	*Rubus parvifolius*	0.1	10
13	*Rumex acetosella* *	0.1	100
13	*Senecio madagascariensis* *	0.1	50
13	*Unidentified sp.* *	0.1	1
14	*Acacia irrorata*	0.1	8
14	*Anagallis arvensis* *	0.1	1
14	*Asparagus aethiopicus* *	0.1	1
14	*Banksia serrata*	0.1	5
14	*Bidens pilosa* *	0.1	3
14	*Breynia oblongifolia*	0.1	23
14	*Chloris sp.* *	5	
14	*Commelina cyanea*	0.1	50
14	*Cynodon dactylon* *	10	
14	*Dichelachne sp.*	5	
14	*Dichondra repens*	0.1	1
14	*Echinopogon caespitosus*	5	
14	*Einadia hastata*	0.1	8
14	*Eucalyptus botryoides*	5	1
14	*Eustrephus latifolius*	0.1	1
14	*Ficus coronata*	0.1	1
14	*Glochidion ferdinandi*	1	6
14	*Glycine clandestina*	0.1	10
14	*Gomphocarpus fruticosus* *	0.1	16
14	*Hibbertia scandens*	0.2	6
14	*Hypochaeris radicata* *	1	100
14	*Isolepis inundata*	0.1	1
14	*Lantana camara* *	0.1	1
14	*Lomandra longifolia*	5	
14	*Melicope micrococca*	1	40
14	*Microlaena stipoides*	15	
14	*Oxalis perennans*	0.1	60
14	*Pennisetum clandestinum* *	10	
14	*Plantago lanceolata* *	0.1	15
14	*Pteridium esculentum*	5	
14	*Rubus parvifolius*	0.1	1
14	*Rumex acetosella* *	0.5	200
14	*Senecio madagascariensis* *	0.5	100
14	*Setaria gracilis* *	15	
14	*Veronica plebeia*	0.1	1

*exotic

Appendix 3. Plot transect scores

Plot no.	PCT code	PCT abbreviated name and condition	Species richness						Cover (%)						
			Tree species	Shrub species	Grass species	Forb species	Fern species	Other species	Tree	Shrub	Grass	Forb	Fern	Other	High threat weed
1	910	Littoral rainforest	7	4	2	3	0	6	112.0	23.0	10.5	10.2	0	40	17.0
2	659	Bangalay sand forest - good condition	5	1	2	5	1	4	50.6	0.5	5.1	7.9	25	0.5	59.9
3	910	Littoral rainforest	0	0	0	0	0	0	0.0	0.0	0	0	0	0	0.0
4	659	Bangalay sand forest - good condition	5	4	6	4	1	3	63.6	11.5	30.4	12.6	15	9.1	41.2
5	659	Bangalay sand forest - moderate condition	1	1	5	1	1	1	3.0	0.1	12.2	0.2	40	0.5	20.5
6	659	Bangalay sand forest - poor condition (DNG)	0	0	3	1	1	0	0.0	0.0	62	0.2	20	0	8.0
7		Exotic Grassland/shrubland	0	0	1	0	0	0	0.0	0.0	15	0	0	0	30.0
8		Exotic Grassland/shrubland	0	0	3	3	1	0	0.0	0.0	15.1	0.3	25	0	27.0
9	1232	Swamp oak forest	2	1	2	0	0	1	35.0	25.0	5.1	0	0	0.1	0.0
10		Exotic Grassland/shrubland	0	0	2	3	0	0	0.0	0.0	7	0.4	0	0	35.0
11	659	Bangalay sand forest - good condition	1	1	3	3	1	0	0.2	0.0	40	0.9	40	0	32.6
12	659	Bangalay sand forest - poor condition (DNG)	0	0	0	0	0	0	0.0	0.0	0	0	0	0	0.0
13	659	Bangalay sand forest - moderate condition	2	3	4	3	1	1	18.0	0.3	35.1	0.3	30	0.1	10.1
14	659	Bangalay sand forest - good condition	3	5	5	5	1	3	6.1	1.4	35.1	0.5	5	0.4	0.2

Plot no.	Tree regeneration	Large trees (count)	Trees with hollows (count)	Litter cover (%)	Fallen logs (m)	Tree composition (count)				
						Stems 5 to 10 cm	Stems 10 to 20cm	Stems 20 to 30 cm	Stems 30 to 50 cm	Stems 50 to 80 cm
1	1	1	3	88.0	18.0	1	1	1	0	1
2	0	2	2	68.0	78.0	0	0	1	1	1
3	1	3	1	65.0	29.0	1	1	1	1	1
4	0	1	1	36.0	8.0	1	0	1	1	1
5	0	0	0	7.6	0.0	0	0	1	0	0
6	1	0	0	14.0	0.0	0	0	0	0	0
7	1	0	0	3.0	0.0	0	0	0	0	0
8	0	0	0	3.6	0.0	0	0	0	0	0
9	0	2	0	58.0	45.0	1	1	1	1	1
10	1	0	0	20.0	0.0	0	0	0	0	0
11	1	0	0	31.0	0.0	0	0	0	0	0
12	0	0	0	7.0	0.0	0	0	0	0	0
13	1	2	2	11.0	3.0	0	0	0	1	1
14	1	4	4	47.0	3.0	0	0	0	0	1

Appendix 4. Threatened species matrix, status and likelihood of occurrence

Scientific Name	Common Name	BC Act	EPBC Act	Habitat	Likelihood of Occurrence	Potential for impact
Amphibians						
Litoria aurea	Green and Golden Bell Frog	E	V	Inhabits a very wide range of water bodies including marshes, dams and streams, particularly those containing emergent vegetation such as bullrushes or spikerushes. It also inhabits numerous types of man-made water bodies including quarries and sand extraction sites. Optimum habitat includes water-bodies that are un-shaded, free of predatory fish such as Plague Minnow, have a grassy area nearby and diurnal sheltering sites available.	Low – no known populations within locality.	Low – not recorded during survey. Proposal unlikely to decrease potential habitat.
Birds						
Actitis hypoleucos	Common Sandpiper	-	M, MA	Utilises a wide range of coastal wetlands and some inland wetlands, mostly found around muddy margins or rocky shores. Forages in shallow water and on soft mud, roosts on rocks or vegetation such as mangroves. Northern hemisphere breeding.	Low	-
Anthochaera phrygia	Regent Honeyeater	CE	CE	The Regent Honeyeater mainly inhabits temperate woodlands and open forests of the inland slopes of south-east Australia. Birds are also found in drier coastal woodlands and forests in some years. There are only three known key breeding regions remaining: north-east Victoria (Chiltern-Albury), and in NSW at Capertee Valley and the Bundarra-Barraba region. In NSW the distribution is very patchy and mainly confined to the two main breeding areas and surrounding fragmented woodlands. In some years flocks converge on flowering coastal woodlands and forests.	Low	-
Apus pacificus	Fork-tailed Swift	-	M	The Fork-tailed Swift is almost exclusively aerial, flying from less than one metre to at least 300 m above ground and probably much higher.	Low	-
Ardea alba	Great Egret	-	M	Great Egrets prefer shallow water, particularly when flowing, but may be seen on any watered area, including damp grasslands.	Moderate –only during flood.	Low – location of floodwater areas may shift slightly due to the proposal.
Ardea ibis	Cattle Egret	-	M	The Cattle Egret is found in grasslands, woodlands and wetlands, and is not common in arid areas. It also uses pastures and croplands, especially where drainage is poor.	Known (recorded during survey)	Low – small area of potential low quality habitat to be removed for high mobile species.
Arenaria interpres	Ruddy Turnstone	-	M	Mainly found in coastal regions with exposed rock coast lines or coral reefs. Also found on rock platforms with shallow tidal pools, and occasionally beaches and estuaries. Northern hemisphere breeding.	None	-

Scientific Name	Common Name	BC Act	EPBC Act	Habitat	Likelihood of Occurrence	Potential for impact
Artamus cyanopterus cyanopterus	Dusky Woodswallow	V	-	Often reported in woodlands and dry open sclerophyll forests, usually dominated by eucalypts, including mallee associations. It has also been recorded in shrublands and heathlands and various modified habitats, including regenerating forests; very occasionally in moist forests or rainforests.	Known (recorded during survey)	Low – small area of potential habitat to be removed. Large extent of similar habitat surrounds the site.
Botaurus poiciloptilus	Australasian Bittern	E	E	The Australasian Bittern is widespread but uncommon over south-eastern Australia. In NSW they may be found over most of the state except for the far north-west. Favours permanent freshwater wetlands with tall, dense vegetation, particularly bullrushes and spikerushes.	Low	-
Burhinus grallarius	Bush Stone-curlew	E	-	The Bush Stone-curlew is found throughout Australia except for the central southern coast and inland, the far south-east corner, and Tasmania. Only in northern Australia is it still common however and in the south-east it is either rare or extinct throughout its former range. Inhabits open forests and woodlands with a sparse grassy ground layer and fallen timber. Largely nocturnal, being especially active on moonlit nights.	Low	-
Calidris acuminata	Sharp-tailed Sandpiper	-	M	Prefers muddy edges of shallow or brackish wetlands, with inundated or emergent sedges, saltmarsh or other low vegetation. Also found foraging in sewage ponds and flooded paddocks. Northern hemisphere breeding.	Moderate	Low
Calidris alba	Sanderling	V	M	Found in coastal areas on low beaches of firm sand, near reefs and inlets, along tidal mudflats and bare open coastal lagoons; individuals are rarely recorded in near-coastal wetlands. Northern hemisphere breeding.	None	-
Calidris canutus	Red Knot	-	M, E	Usually found foraging in soft substrate near the edge of the water on intertidal mudflats. Also have been recorded at nearby lakes, sewage ponds and floodwaters. Roosts on sandy beaches, spits and islands. Northern hemisphere breeding.	Moderate –only during flood.	Low – location of floodwater areas may shift slightly due to the proposal.
Calidris ferruginea	Curlew Sandpiper	E	CE, M	It occurs along the entire coast of NSW, particularly in the Hunter Estuary, and sometimes in freshwater wetlands in the Murray-Darling Basin. It generally occupies littoral and estuarine habitats, and in New South Wales is mainly found in intertidal mudflats of sheltered coasts. It also occurs in non-tidal swamps, lakes and lagoons on the coast and sometimes the inland. Northern hemisphere breeding.	Low	Low
Calidris melanotos	Pectoral Sandpiper	-	M	Prefers shallow fresh to saline wetlands, found at coastal lagoons, estuaries, bays, swamps, inundated grasslands, saltmarshes and artificial wetlands. Northern hemisphere breeding.	Moderate –only during flood.	Low – location of floodwater areas may shift slightly due to the proposal.
Calidris	Red-necked Stint	-	M	Mostly found in coastal areas including inlets, bays, lagoons and estuaries with intertidal mudflats.	None	-

Scientific Name	Common Name	BC Act	EPBC Act	Habitat	Likelihood of Occurrence	Potential for impact
ruficollis				Occasionally on exposed ocean beaches and sometimes rocky shores and reefs. Northern hemisphere breeding.		
Calidris tenuirostris	Great Knot	V	M, CE	In NSW, this species has been recorded at scattered sites along the coast to about Narooma. It has also been observed inland at Tullakool, Armidale, Gilgandra and Griffith. Occurs within sheltered, coastal habitats containing large, intertidal mudflats or sand flats, including inlets, bays, harbours, estuaries and lagoons. Often recorded on sandy beaches with mudflats nearby, sandy spits and islets and sometimes on exposed reefs or rock platforms. Northern hemisphere breeding.	None	-
Callocephalon fimbriatum	Gang-gang Cockatoo	V	-	In summer, occupies tall montane forests and woodlands, particularly in heavily timbered and mature wet sclerophyll forests. Also occur in subalpine snow gum woodland and occasionally in temperate or regenerating forest. In winter, occurs at lower altitudes in drier, more open eucalypt forests and woodlands, particularly in box-ironbark assemblages, or in dry forest in coastal areas. It requires tree hollows in which to breed.	Low	-
Calyptorhynchus lathami	Glossy Black-Cockatoo	V	-	Inhabits forest with low nutrients, characteristically with key Allocasuarina spp. Tends to prefer drier forest types with a middle stratum of Allocasuarina below Eucalyptus or Angophora. Often confined to remnant patches in hills and gullies. Breed in hollows stumps or limbs, either living or dead. Endangered population in the Riverina.	Low	-
Charadrius bicinctus	Double-banded Plover	-	M	Found on littoral, estuarine and fresh or saline terrestrial wetlands, rocky beaches, bays and inlets. Sometimes found on exposed reefs and rock platforms. Migrates to breed in New Zealand.	Low	-
Charadrius leschenaultii	Greater Sand Plover	V	M, V	Occur on sheltered sandy, shelly or muddy beaches with large intertidal mudflats or sandbanks, as well as sandy estuarine lagoons. Non-breeding in Australia.	None	-
Charadrius mongolus	Lesser Sand Plover	V	M, E	Inhabits large intertidal sand flats or mudflats in sheltered bays, harbours and estuaries, and occasionally sandy ocean beaches, coral reefs, wave-cut rock platforms and rocky outcrops. Non-breeding in Australia.	None	-
Circus assimilis	Spotted Harrier	V	-	The Spotted Harrier occurs throughout the Australian mainland, except in densely forested or wooded habitats of the coast, escarpment and ranges, and rarely in Tasmania. Individuals disperse widely in NSW and comprise a single population. Occurs in grassy open woodland including acacia and mallee remnants, inland riparian woodland, grassland and shrub steppe. It is found most commonly in native grassland, but also occurs in agricultural land, foraging over open habitats including edges of inland wetlands.	Low	-
Cuculus optatus, Cuculus saturatus	Oriental Cuckoo	-	M, MA	Mainly inhabits coniferous, deciduous and mixed forests. Breeds in northern hemisphere. Brood parasite, laying eggs in nests of other birds.	Low	-
Daphoenositta chrysoptera	Varied Sittella	V	-	The Varied Sittella is sedentary and inhabits most of mainland Australia except the treeless deserts and open grasslands. Distribution in NSW is nearly continuous from the coast to the far west. Inhabits eucalypt forests and woodlands, especially those containing rough-barked species and mature smooth-barked gums with dead branches, mallee and Acacia woodland. Feeds on arthropods gleaned from crevices in rough or decorticating bark, dead branches, standing dead trees and small branches and twigs	Known	Low –small impact area and large areas of similar habitat surrounding site

Scientific Name	Common Name	BC Act	EPBC Act	Habitat	Likelihood of Occurrence	Potential for impact
				in the tree canopy.		
Dasyornis brachypterus	Eastern Bristlebird	E	E	Found in coastal woodlands, dense scrub and heathlands, particularly where it borders taller woodlands.	Low	-
Epthianura albifrons	White-fronted Chat	V	-	Low vegetation in salty coastal and inland areas and crops. Runs along ground and is found in local flocks in Winter.	None	-
Gallinago hardwickii	Latham's Snipe	-	M	Latham's Snipe is a non-breeding migrant to the south east of Australia including Tasmania, passing through the north and New Guinea on passage. Latham's Snipe breed in Japan and on the east Asian mainland. Seen in small groups or singly in freshwater wetlands on or near the coast, generally among dense cover. They are found in any vegetation around wetlands, in sedges, grasses, lignum, reeds and rushes and also in saltmarsh and creek edges on migration.	Moderate	Low – proposal would possibly increase potential habitat.
Gallinago megala	Swinhoe's Snipe	-	M	Occurs at edges of wetlands, swamps and freshwater streams. Also known to occur in grasslands, sewage ponds and drying claypans. Northern hemisphere breeding.	Low	-
Gallinago stenura	Pin-tailed Snipe	-	M	Occurs at edges of shallow freshwater swamps, ponds and lakes with emergent, sparse to dense cover of grass/sedge or other vegetation. Also found on more open wetlands, claypans and sewage ponds. Breeds in the northern hemisphere.	Low	-
Haematopus fuliginosus	Sooty Oystercatcher	V	-	In NSW the Sooty Oystercatcher occupies rocky headlands, reefs and offshore islands along the entire coast, apparently as a single continuous population.	None	-
Haematopus longirostris	Pied Oystercatcher	E	-	The Pied Oystercatcher inhabits marine littoral habitats, including islands. It occupies muddy, sandy, stony or rocky estuaries, inlets and beaches, particularly intertidal mudflats and sandbanks in large marine bays.	None	-
Haliaeetus leucogaster	White-bellied Sea-Eagle	V	MA	Inhabits coastal and near coastal areas, building large stick nests, and feeding mostly on marine and estuarine fish and aquatic fauna.	Moderate	Low –small impact area and large areas of similar habitat surrounding site
Hieraaetus morphnoides	Little Eagle	V	-	Most abundant in lightly timbered areas with open areas nearby. Often recorded foraging in grasslands, crops, treeless dune fields, and recently logged areas. May nest in farmland, woodland and forest in tall trees.	Moderate	Low –small impact area and large areas of similar habitat surrounding site
Hirundapus caudacutus	White-throated Needletail	-	M, MA	An aerial species found in feeding concentrations over cities, hilltops and timbered ranges.	Low	-
Irediparra gallinacea	Comb-crested Jacana	V	-	Inhabits permanent wetlands with a good surface cover of floating vegetation, especially water-lilies.	Low	-
Lathamus	Swift Parrot	E	CE	The Swift Parrot occurs in woodlands and forests of NSW from May to August, where it feeds on eucalypt	Low	-

Scientific Name	Common Name	BC Act	EPBC Act	Habitat	Likelihood of Occurrence	Potential for impact
discolor				nectar, pollen and associated insects. The Swift Parrot is dependent on flowering resources across a wide range of habitats in its wintering grounds in NSW. This species is migratory, breeding in Tasmania and also nomadic, moving about in response to changing food availability.		
Limosa lapponica baueri	Bar-tailed Godwit	-	M, V	Bar-tailed Godwit (spp baueri) is the eastern Australian / New Zealand sub species. Mainly found in coastal habitats such as intertidal sand flats, mudflats, estuaries, inlets, coastal lagoons and bays. Often found around beds of seagrass and saltmarsh. Northern hemisphere breeding.	None	-
Limosa limosa	Black-tailed Godwit	V	M	Primarily a coastal species. Usually found in sheltered bays, estuaries and lagoons with large intertidal mudflats and/or sand flats. Further inland, it can also be found on mudflats and in water less than 10 cm deep, around muddy lakes and swamps. Northern hemisphere breeding.	None	-
Lophoictinia isura	Square-tailed Kite	V	-	Typically inhabits coastal forested and wooded lands of tropical and temperate Australia. In NSW it is often associated with ridge and gully forests dominated by Eucalyptus longifolia, Corymbia maculata, E. elata or E. smithii. Individuals appear to occupy large hunting ranges of more than 100km2. They require large living trees for breeding, particularly near water with surrounding woodland -forest close by for foraging habitat. Nest sites are generally located along or near watercourses, in a tree fork or on large horizontal limbs.	Low	--
Macronectes giganteus	Southern Giant Petrel	E	E	The Southern Giant Petrel has a circumpolar pelagic range from Antarctica to approximately 20 S and is a common visitor off the coast of NSW. Over summer, the species nests in small colonies amongst open vegetation on antarctic and subantarctic islands, including Macquarie and Heard Islands and in Australian Antarctic territory.	None	-
Macronectes halli	Northern Giant-petrel	V	V	Breeding in Australian territory is limited to Macquarie Island and occurs during spring and summer.	None	-
Merops ornatus	Rainbow Bee-eater	-	M	Found throughout mainland Australia most often in open forests, woodlands and shrublands, and cleared areas, usually near water. It will be found on farmland with remnant vegetation and in orchards and vineyards. It will use disturbed sites such as quarries, cuttings and mines to build its nesting tunnels.	Low	-
Monarcha melanopsis	Black-faced Monarch	-	M	Found along the coast of eastern Australia, becoming less common further south. Inhabits rainforests, eucalypt woodlands, coastal scrub and damp gullies. It may be found in more open woodland when migrating.	Moderate	Low –small impact area and large areas of similar habitat surrounding site
Monarcha trivirgatus	Spectacled Monarch	-	M	Coastal north-eastern and eastern Australia, including coastal islands, from Cape York, Queensland to Port Stephens, New South Wales. Prefers thick understorey in rainforests, wet gullies and waterside vegetation, as well as mangroves.	Low	-
Myiagra cyanoleuca	Satin Flycatcher	-	M	The Satin Flycatcher is found along the east coast of Australia from far northern Queensland to Tasmania, including south-eastern South Australia. Found in tall forests, preferring wetter habitats such as heavily forested gullies, but not rainforests.	Low	-
Neophema	Orange-bellied	CE	CE	The Orange-bellied Parrot breeds in the south-west of Tasmania and migrates in autumn to spend the	Low	-

Scientific Name	Common Name	BC Act	EPBC Act	Habitat	Likelihood of Occurrence	Potential for impact
chrysogaster	Parrot			winter on the mainland coast of south-eastern South Australia and southern Victoria. There are occasional reports from NSW, with the most recent records from Shellharbour and Maroubra in May 2003. Typical winter habitat is saltmarsh and strandline-foredune vegetation communities either on coastlines or coastal lagoons. Spits and islands are favoured but they will turn up anywhere within these coastal regions. The species can be found foraging in weedy areas associated with these coastal habitats or even in totally modified landscapes such as pastures, seed crops and golf courses.		
Ninox connivens	Barking Owl	V	-	Generally found in open forests, woodlands, swamp woodlands and dense scrub. Can also be found in the foothills and timber along watercourses in otherwise open country.	Moderate	Low –small impact area and large areas of similar habitat surrounding site
Ninox strenua	Powerful Owl	V	-	Occupies wet and dry eucalypt forests and rainforests. Can occupy both un-logged and lightly logged forests as well as undisturbed forests where it usually roosts on the limbs of dense trees in gully areas. It is most commonly recorded within turpentine tall open forests and black she-oak within open forests. Large mature trees with hollows at least 0.5 m deep are required for nesting. Tree hollows are particularly important for the Powerful Owl because a large proportion of the diet is made up of hollow-dependent arboreal marsupials. Nest trees for this species are usually emergent with a diameter at breast height of at least 100 cm.	Moderate	Low –small impact area and large areas of similar habitat surrounding site
Numenius madagascariensis	Eastern Curlew	-	CE, MA, M	A primarily coastal distribution. Found in all states, particularly the north, east, and south-east regions including Tasmania. Rarely recorded inland. Mainly forages on soft sheltered intertidal sand flats or mudflats, open and without vegetation or cover. Breeds in the northern hemisphere.	None	-
Numenius minutus	Little Curlew	-	M	Feeds in short, dry grassland and sedgeland, including dry floodplains and black soil plains, which have scattered, shallow freshwater pools. Northern hemisphere breeding.	None	-
Numenius phaeopus	Whimbrel	-	M	Usually found on intertidal mudflats of sheltered coasts. Also found in harbours, lagoons, estuaries and river deltas, often those with mangroves. Northern hemisphere breeding.	None	-
Oxyura australis	Blue-billed Duck	V	-	Widespread in NSW, but most common in the southern Murray-Darling Basin area. Birds disperse during the breeding season to deep swamps up to 300 km away. It is generally only during summer or in drier years that they are seen in coastal areas. The Blue-billed Duck prefers deep water in large permanent wetlands and swamps with dense aquatic vegetation.	Low	-
Pandion cristatus, Pandion haliaetus	Eastern Osprey	V	M, MA	Ospreys are found right around the Australian coast line, except for Victoria and Tasmania. They are common around the northern coast, especially on rocky shorelines, islands and reefs. The species is uncommon to rare or absent from closely settled parts of south-eastern Australia. Favour coastal areas, especially the mouths of large rivers, lagoons and lakes. Feed on fish over clear, open water.	Low	-
Petroica boodang	Scarlet Robin	V	-	The Scarlet Robin is found from SE Queensland to SE South Australia and also in Tasmania and SW Western Australia. In NSW, it occurs from the coast to the inland slopes. The Scarlet Robin lives in dry eucalypt forests and woodlands. The understorey is usually open and grassy with few scattered shrubs.	Low	-

Scientific Name	Common Name	BC Act	EPBC Act	Habitat	Likelihood of Occurrence	Potential for impact
Petroica phoenicea	Flame Robin	V	-	Flame Robins are found in a broad coastal band from southern Queensland to just west of the South Australian border. The species is also found in Tasmania. The preferred habitat in summer includes eucalypt forest and woodland, whilst in winter prefers open woodlands and farmlands. It is considered migratory. The Flame Robin breeds from about August to January.	Moderate	Low –small impact area and large areas of similar habitat surrounding site
Pluvialis fulva	Pacific Golden Plover	-	M	Coastal habitats such as beaches, mudflats, sand flats, estuaries, lagoons and evaporation ponds in salt works. Northern hemisphere breeding.	None	-
Pterodroma leucoptera	Gould's Petrel	V	E	Pelagic marine species, spending much of its time foraging at sea and coming ashore only to breed. The Australian subspecies breeds and roosts on two islands off NSW, Cabbage Tree and Boondelbah Islands. They nest predominantly in natural rock crevices among the rock scree and also in hollow fallen palm trunks, under mats of fallen palm fronds and in cavities among the buttresses of fig trees.	None	-
Pterodroma neglecta neglecta	Kermadec Petrel (west Pacific subspecies)	V	V	Typically nests on the surface in loose colonies among rocks and vegetation. On Ball's Pyramid it nests only on steep cliffs above 400 m. On Phillip I. it nests under stands of African Olive. This species is marine and highly pelagic, rarely approaching land except at colonies.	None	-
Puffinus carneipes	Flesh-footed Shearwater	V	-	The Flesh-footed Shearwater mainly occurs in the subtropics over continental shelves and slopes and occasionally inshore waters	None	-
Rhipidura rufifrons	Rufous Fantail	-	M	Found along the east coast of Australia from far northern Queensland to Tasmania, including south-eastern South Australia. Inhabits tall forests, preferring wetter habitats such as heavily forested gullies, but not rainforests.	Low	-
Rostratula australis	Australian Painted Snipe	E	E, MA	In NSW, this species has been recorded at the Paroo wetlands, Lake Cowell, Macquarie Marshes and Hexham Swamp. Most common in the Murray-Darling Basin. Prefers fringes of swamps, dams and nearby marshy areas where there is a cover of grasses, lignum, low scrub or open timber. Nests on the ground amongst tall vegetation, such as grasses, tussocks or reeds.	None	-
Sternula albifrons	Little Tern	E	M	In Australia, Little Terns inhabit sheltered coastal environments, including lagoons, estuaries, river mouths and deltas, lakes, bays, harbours and inlets, especially those with exposed sandbanks or sand-spits, and also on exposed ocean beaches.	None	-
Sternula nereis nereis	Fairy Tern	-	V	Distribution includes the southern half of NSW coast. Fairy Terns utilise a variety of habitats including offshore, islands in estuaries or lakes, wetlands, beaches and spits.	None	-
Stictonetta naevosa	Freckled Duck	V	-	Breeds in permanent fresh swamps that are heavily vegetated. Found in fresh or salty permanent open lakes, especially during drought. Often seen in groups on fallen trees and sand spits.	None	-
Tringa brevipes, Heteroscelus brevipes	Grey-tailed Tattler	-	M, MA	Found on sheltered coasts with reefs and rock platforms, intertidal mudflats, estuaries and coastal lagoons, especially fringed with mangroves. Northern hemisphere breeding.	None	-
Tringa nebularia	Common Greenshank	-	M	Variety of inland wetlands and sheltered coastal habitats of varying salinity. Found on mudflats, saltmarsh, mangroves in embayments, harbours, deltas and lagoons. Breeds in northern hemisphere.	None	-

Scientific Name	Common Name	BC Act	EPBC Act	Habitat	Likelihood of Occurrence	Potential for impact
Tringa stagnatilis	Marsh Sandpiper	-	M	Permanent or ephemeral wetlands of varying salinity, including swamps, lagoons, billabongs, saltpans, saltmarshes, estuaries, sewage farms and salt works. Northern hemisphere breeding.	Moderate	Low – proposal will increase potential habitat
Mammals						
Chalinolobus dwyeri	Large-eared Pied Bat	V	V	Located in a variety of drier habitats, including the dry sclerophyll forests and woodlands to the east and west of the Great Dividing Range. Can also be found on the edges of rainforests and in wet sclerophyll forests. This species roosts in caves and mines in groups of between 3 and 37 individuals.	Low	-
Dasyurus maculatus maculatus	Spotted-tailed Quoll	V	E	Spotted-tailed Quoll are found on the east coast of NSW, Tasmania, eastern Victoria and north-eastern Queensland. Only in Tasmania is it still considered common. Recorded across a range of habitat types, including rainforest, open forest, woodland, coastal heath and inland riparian forest, from the sub-alpine zone to the coastline.	Low	Low –small impact area and large areas of similar habitat surrounding site
Isoodon obesulus obesulus	Southern Brown Bandicoot (eastern)	E	E	Prefers sandy soils with scrubby vegetation and-or areas with low ground cover that are burn from time to time. A mosaic of post fire vegetation is important for this species.	Low	-
Miniopterus australis	Little Bentwing-bat	V	-	Coastal north-eastern NSW and eastern Queensland. The Little Bentwing-bat is an insectivorous bat that roost in caves, in old mines, in tunnels, under bridges, or in similar structures. They breed in large aggregations in a small number of known caves and may travel hundreds of kilometres from feeding home ranges to breeding sites. They have a preference for moist eucalypt forest, rainforest or dense coastal banksia scrub where it forages below the canopy for insects.	Moderate	Low –small impact area and large areas of similar habitat surrounding site
Miniopterus schreibersii oceanensis	Eastern Bentwing-bat	V	-	Eastern Bentwing-bats occur along the east and north-west coasts of Australia. Caves are the primary roosting habitat, but also use derelict mines, storm-water tunnels, buildings and other man-made structures. Form discrete populations centred on a maternity cave that is used annually in spring and summer for the birth and rearing of young.	Moderate	Low –small impact area and large areas of similar habitat surrounding site
Mormopterus norfolkensis	Eastern Freetail-bat	V	-	Most records are from dry eucalypt forests and woodlands to the east of the Great Dividing Range. Appears to roost in trees, but little is known of this species' habits.	Low	-
Myotis macropus	Southern Myotis	V	-	The Southern Myotis is found in the coastal band from the north-west of Australia, across the top-end and south to western Victoria. Generally roost in groups of 10 - 15 close to water in caves, mine shafts, hollow-bearing trees, stormwater channels, buildings, under bridges and in dense foliage.	Moderate	Low –small impact area and large areas of similar habitat surrounding site
Petauroides volans	Greater Glider population in the Eurobodalla local government area	EP	-	This population of Greater Gliders on the south coast of NSW is bounded by the Moruya River to the north, Coila Lake to the south and the Princes Highway and cleared land exceeding 700 m in width to the west. The Greater Glider occurs in eucalypt forests and woodlands.	Moderate	Low –small impact area and large areas of similar habitat

Scientific Name	Common Name	BC Act	EPBC Act	Habitat	Likelihood of Occurrence	Potential for impact
						surrounding site
Petauroides volans	Greater Glider	-	V	The Greater Glider is restricted to eastern Australia, occurring from the Windsor Tableland in north Queensland through to central Victoria. It is typically found in highest abundance in taller, montane, moist eucalypt forests with relatively old trees and abundant hollows.	Low	-
Phascolarctos cinereus	Koala	V	V	Inhabits eucalypt forests and woodlands. The suitability of these forests for habitation depends on the size and species of trees present, soil nutrients, climate and rainfall.	Low	-
Potorous tridactylus tridactylus	Long-nosed Potoroo	V	V	Inhabits coastal heath and wet and dry sclerophyll forests. Generally found in areas with rainfall greater than 760 mm. Requires relatively thick ground cover where the soil is light and sandy.	Low	-
Pseudomys novaehollandiae	New Holland Mouse	-	V	The New Holland Mouse currently has a disjunct, fragmented distribution across Tasmania, Victoria, New South Wales and Queensland. Across the species' range the New Holland Mouse is known to inhabit open heathlands, open woodlands with a heathland understorey, and vegetated sand dunes.	Low	-
Pteropus poliocephalus	Grey-headed Flying-fox	V	V	This species is a canopy-feeding frugivore and nectarivore of rainforests, open forests, woodlands, melaleuca swamps and banksia woodlands. Bats commute daily to foraging areas, usually within 15 km of the day roost although some individuals may travel up to 70 km.	Known (recorded during survey)	Low – small impact area and large areas of similar habitat surrounding site. No camps observed during field survey and no known camps within the study area or adjacent.
Scoteanax rueppellii	Greater Broad-nosed Bat	V	-	Prefer moist gullies in mature coastal forests and rainforests, between the Great Dividing Range and the coast. They are only found at low altitudes below 500 m. In dense environments they utilise natural and human-made opening in the forest for flight paths. Creeks and small rivers are favoured foraging habitat. This species roosts in hollow tree trunks and branches.	Moderate	Low –small impact area and large areas of similar habitat surrounding site
Reptiles						
Hoplocephalus bungaroides	Broad-headed Snake	E	V	Occurs almost exclusively in association with communities occurring on Triassic sandstone within the Sydney Basin. Typically found among exposed sandstone outcrops with vegetation types ranging from woodland to heath. Within these habitats they spend most of the year sheltering in and under rock crevices and exfoliating rock. However, some individuals will migrate to tree hollows to find shelter during hotter parts of summer.	Low	-
Plants						
Acacia	Bynoe's Wattle	E	V	Grows mainly in heath and dry sclerophyll forest in sandy soils. Mainly south of Dora Creek-Morisset area	Low	-

Scientific Name	Common Name	BC Act	EPBC Act	Habitat	Likelihood of Occurrence	Potential for impact
bynoeana				to Berrima and the Illawarra region, west to the Blue Mountains, also recorded from near Kurri Kurri in the Hunter Valley and from Morton National Park.		
Caladenia tessellata	Thick-lip Spider Orchid	E	V	The Tessellated Spider Orchid is found in grassy sclerophyll woodland on clay loam or sandy soils, though the population near Braidwood is in low woodland with stony soil. Known from the Sydney area (old records), Wyong, Ulladulla and Braidwood in NSW. Populations in Kiama and Queanbeyan are presumed extinct.	Low	-
Chorizema parviflorum	Chorizema parviflorum Benth. in the Wollongong and Shellharbour Local Government Areas	EP	-	This endangered population has been recorded from between Austinmer and Albion Park in the local government areas of Wollongong and Shellharbour. All known sites (excluding the site at Austinmer) occupy woodland or forest dominated by Eucalyptus tereticornis and-or E. longifolia. At Austinmer, the species is recorded from a coastal headland.	None	-
Cryptostylis hunteriana	Leafless Tongue-orchid	V	V	Does not appear to have well defined habitat preferences and is known from a range of communities, including swamp-heath and woodland. The larger populations typically occur in woodland dominated by Scribbly Gum, Silvertop Ash, Red Bloodwood and Black She-oak and appears to prefer open areas in the understorey of this community.	Low	-
Cynanchum elegans	White-flowered Wax Plant	E	E	Recorded from rainforest gullies scrub and scree slopes from the Gloucester district to the Wollongong area and inland to Mt Dangar.	Low	-
Genoplesium baueri	Bauer's Midge Orchid	E	E	Grows in dry sclerophyll forest and moss gardens over sandstone. Flowers February to March. Has been recorded between Ulladulla and Port Stephens. Currently the species is known from just over 200 plants across 13 sites. The species has been recorded in Berowra Valley Regional Park, Royal National Park and Lane Cove National Park and may also occur in the Woronora, O'Hares, Metropolitan and Warragamba Catchments.	None	-
Gentiana wingecarribiensis	Wingecaribee Gentian	CE	E	Known only from Hanging Rock Swamp and Wingecarribee Swamp on the Southern Highlands. An annual herb growing in bogs, in Sphagnum Moss humps and in sedge communities.	None	-
Gossia acmenoides	Gossia acmenoides - endangered population	EP		Known from Shellharbour, Wollongong and Kiama LGAs and encompasses all occurrences south of the Georges River. Found in subtropical and dry rainforest on the ranges and coastal plain of eastern Australia	None	-
Haloragis exalata subsp. exalata	Square Raspwort	V	V	Occurs in 4 widely scattered localities in eastern NSW. It is disjunctly distributed in the central coast, south coast and north-western slopes botanical subdivisions of NSW. The species appears to require protected and shaded damp situations in riparian habitats.	None	-
Irenepharsus trypherus	Illawarra Irene	E	E	Typically inhabits steep rocky slopes near cliff lines and ridge tops. The species is less typically found growing out of rock crevices or on narrow benches along cliff lines. Most sites are recorded from the upper slopes of the ridge systems that extend south and east of the Illawarra escarpment, although the species has also been recorded from the deep sandstone gorges of the Shoalhaven River. Associated vegetation includes moist sclerophyll forest, ironwood thicket, and rainforest.	None	-

Scientific Name	Common Name	BC Act	EPBC Act	Habitat	Likelihood of Occurrence	Potential for impact
Melaleuca biconvexa	Biconvex Paperbark	V	V	Grows in damp places, often near streams or low-lying areas on alluvial soils of low slopes or sheltered aspects. Scattered and dispersed populations found in the Jervis Bay area in the south and the Gosford-Wyong area in the north.	None	-
Persoonia hirsuta	Hairy Geebung	E	E	Distributed from Singleton in the north, along the east coast to Bargo in the south and the Blue Mountains to the west. A large area of occurrence, but occurs in small populations, increasing the species' fragmentation in the landscape. Found in sandy soils in dry sclerophyll open forest, woodland and heath on sandstone. Usually present as isolated individuals or very small populations. Probably killed by fire (as other Persoonia spp. are) but will regenerate from seed.	None	-
Pimelea curviflora var. curviflora		V	V	Confined to the coastal area of Sydney between northern Sydney in the south and Maroota in the north-west. Former range extended south to the Parramatta River and Port Jackson region including Five Dock, Bellevue Hill and Manly. Occurs on shale-lateritic soils over sandstone and shale-sandstone transition soils on ridgetops and upper slopes amongst woodlands.	None	-
Pimelea spicata	Spiked Rice-flower	E	E	Once widespread on the Cumberland Plain, the Spiked Rice-flower occurs in two disjunct areas; the Cumberland Plain (Narellan, Marayong, Prospect Reservoir areas) and the Illawarra (Landsdowne to Shellharbour to northern Kiama). In both the Cumberland Plain and Illawarra environments this species is found on well-structured clay soils. On the inland Cumberland Plain sites it is associated with grey box and Ironbark. In the coastal Illawarra it occurs commonly in Coast Banksia open woodland with a better developed shrub and grass understorey.	Low	-
Prasophyllum affine	Jervis Bay Leek Orchid, Culburra Leek-orchid, Kinghorn Point Leek-orchid	E	E	Jervis Bay Leek Orchid is currently known from three areas south-east of Nowra on South Coast. These are Kinghorne Point, Wowly Gully near the town of Callala Bay, and near the township of Vincentia. Grows on poorly drained grey clay soils that support low heathland and sedgeland communities.	None	-
Pterostylis gibbosa	Illawarra Greenhood	E	E	Known from a small number of populations in the Hunter region (Milbrodale), the Illawarra region (Albion Park and Yallah) and the Shoalhaven region (near Nowra). It is apparently extinct in western Sydney which is the area where it was first collected (1803). All known populations grow in open forest or woodland, on flat or gently sloping land with poor drainage.	Low	-
Solanum celatum		E	-	Restricted to an area from Wollongong to just south of Nowra, and west to Bungonia. Majority of records are prior to 1960 and the majority of populations are likely to have been lost to clearing. Grows in rainforest clearings, or in wet sclerophyll forests. Flowers August to October and produces fruit December to January. Fire sensitive obligate seeder, with adults plants killed by fire and recruitment occurring from a soil stored seed bank. Normally recorded in disturbed margins and clearings.	Moderate	Low – not recorded during surveys
Syzygium paniculatum	Magenta Lilly Pilly	E	V	Found only in NSW, in a narrow, linear coastal strip from Bulahdelah to Conjola State forest. On the south coast the species occurs on grey soils over sandstone, restricted mainly to remnant stands of littoral rainforest. On the central coast it occurs on gravels, sands, silts and clays in riverside gallery rainforests and remnant littoral rainforest communities.	None	-
Thesium	Austral Toadflax	V	V	Grows in very small populations scattered across eastern NSW, along the coast, and from the Northern to	Moderate	Low – host

Scientific Name	Common Name	BC Act	EPBC Act	Habitat	Likelihood of Occurrence	Potential for impact
australe				Southern Tablelands. It is also found in Tasmania and Queensland and in eastern Asia. Occurs in grassland or grassy woodland. Grows on Kangaroo Grass tussocks but has also been recorded within the exotic Coolatai Grass.		species not recorded during surveys
Zieria granulata	Hill Zieria	E	E	Restricted to the Illawarra region where it is recorded from a number of sites. The species primarily occupies the coastal lowlands between Oak Flats and Toolijooa, in the local government areas of Shellharbour and Kiama. This is a range of approximately 22 km. The typical habitat is dry ridge tops and rocky outcrops on shallow volcanic soils, usually on Bumbo Latite. Less frequently found on the moist slopes of the Illawarra escarpment and in low-lying areas on Quaternary sediments. Associated vegetation includes Bracelet Honey-myrtle scrub, Forest Red Gum woodland and rainforest margins, although the species has been recorded from a number of other vegetation types. Most vegetation types are also listed as Endangered Ecological Communities.	None	-

Appendix 5. Hollow bearing trees to be removed

Habitat feature	Tree species	Number of hollows	Size class	Latitude	Longitude
Hollow-bearing tree	Eucalyptus botryoides	3	0-5, 15-20, 20-30	-34.63	150.84
Hollow-bearing stag	Eucalyptus botryoides	1	5-10	-34.63	150.84
Hollow-bearing tree	Eucalyptus botryoides	2	15-20,40-50	-34.63	150.84
Hollow-bearing tree	Eucalyptus botryoides	1	05-10	-34.63	150.84
Hollow-bearing tree	Eucalyptus botryoides	5	15-20, 20-30, 30-40, 40-50	-34.63	150.84
Hollow-bearing tree	Eucalyptus botryoides	1	05-10	-34.63	150.84
Hollow-bearing tree	Eucalyptus botryoides	5	0-5, 5-10, 10-15	-34.63	150.84
Hollow-bearing tree	Eucalyptus botryoides	2	15-20, 5-10	-34.63	150.84
Hollow-bearing tree	Eucalyptus botryoides	2	15-20	-34.63	150.84
Hollow-bearing tree	Eucalyptus botryoides	3	10-15, 5-10	-34.63	150.84
Hollow-bearing tree	Eucalyptus botryoides	5	15-20, 10-15, 5-10	-34.63	150.84

Appendix 6. Fauna species list

Class Name	Common Name	Scientific Name	Observation type	BC Act Status	EPBC Status
Amphibia	*Crinia signifera*	Common eastern froglet	Heard call	P	P
Amphibia	*Litoria dentata*	Bleating Tree Frog	Heard call	P	P
Amphibia	*Litoria peronii*	Peron's Tree Frog	Heard call	P	P
Amphibia	*Litoria phyllochroa*	Leaf Green Tree Frog	Heard call	P	P
Aves	*Acanthiza uropygialis*	Chestnut-rumped Thornbill	Observed	P	P
Aves	*Acanthorhynchus tenuirostris*	Eastern Spinebill	Observed	P	P
Aves	*Anthochaera carunculata*	Red Wattlebird	Observed	P	P
Aves	*Anthochaera carunculata*	Red Wattlebird	Heard call	P	P
Aves	*Ardea ibis*	Cattle Egret	Observed	M	P
Aves	*Artamus cyanopterus*	Dusky Woodswallow	Observed	V	P
Aves	*Cacatua galerita*	Sulphur-crested Cockatoo	Observed	P	P
Aves	*Chalcophaps indica*	Common emerald dove	Observed	P	P
Aves	*Chenonetta jubata*	Australian Wood Duck	Observed	P	P
Aves	*Colluricincla harmonica*	Grey Shrike-thrush	Heard call	P	P
Aves	*Columba leucomela*	White-headed Pigeon	Heard call	P	P
Aves	*Coracina novaehollandiae*	Black-faced Cuckoo-shrike	Observed	P	P
Aves	*Cormobates leucophaea*	White-throated Treecreeper	Observed	P	P
Aves	*Corvus coronoides*	Australian Raven	Observed	P	P
Aves	*Cracticus tibicen*	Australian Magpie	Observed	P	P
Aves	*Cracticus torquatus*	Grey Butcherbird	Observed	P	P
Aves	*Dacelo novaeguineae*	Laughing Kookaburra	Observed, Heard call	P	P
Aves	*Daphoenositta chrysoptera*	Varied Sittella	Observed	V	P
Aves	*Egretta novaehollandiae*	White-faced Heron	Observed	P	P
Aves	*Elanus axillaris*	Black-shouldered Kite	Observed	P	P
Aves	*Eolophus roseicapillus*	Galah	Observed	P	P
Aves	*Eurystomus orientalis*	Dollarbird	Heard call	P	P
Aves	*Falco cenchroides*	Nankeen Kestrel	Observed	P	P
Aves	*Fulica atra*	Eurasian Coot	Observed	P	P
Aves	*Grallina cyanoleuca*	Magpie-lark	Heard call	P	P
Aves	*Haliaeetus leucogaster*	White-bellied Sea-Eagle	Observed	V	P
Aves	*Malurus cyaneus*	Superb Fairy-wren	Observed	P	P
Aves	*Meliphaga lewinii*	Lewin's Honeyeater	Observed, Heard call	P	P
Aves	*Myzomela sanguinolenta*	Scarlet Honeyeater	Observed	P	P
Aves	*Pachycephala pectoralis*	Golden Whistler	Heard call	P	P
Aves	*Pardalotus punctatus*	Spotted Pardalote	Heard call, Observed	P	P
Aves	*Pelecanus conspicillatus*	Australian Pelican	Observed	P	P
Aves	*Phalacrocorax sulcirostris*	Little Black Cormorant	Observed	P	P
Aves	*Phalacrocorax varius*	Pied Cormorant	Observed	P	P
Aves	*Platycercus elegans*	Crimson Rosella	Observed	P	P

Class Name	Common Name	Scientific Name	Observation type	BC Act Status	EPBC Status
Aves	*Platycercus eximius*	Eastern Rosella	Observed	P	P
Aves	*Podargus strigoides*	Tawny Frogmouth	Observed	P	P
Aves	*Porphyrio porphyrio*	Purple Swamphen	Observed	P	P
Aves	*Psophodes olivaceus*	Eastern Whipbird	Camera, Heard call	P	P
Aves	*Ptilonorhynchus violaceus*	Satin Bowerbird	Heard call	P	P
Aves	*Pycnonotus jocosus*	Red-whiskered bulbul	Heard call	-	-
Aves	*Rhipidura albiscapa*	Grey Fantail	Observed	P	P
Aves	*Rhipidura leucophrys*	Willie Wagtail	Observed	P	P
Aves	*Scythrops novaehollandiae*	Channel-billed Cuckoo	Heard call	P	P
Aves	*Sericornis frontalis*	White-browed Scrubwren	Observed	P	P
Aves	*Strepera graculina*	Pied Currawong	Heard call	P	P
Aves	*Threskiornis molucca*	Australian White Ibis	Observed	P	P
Aves	*Threskiornis spinicollis*	Straw-necked Ibis	Observed	P	P
Aves	*Todiramphus sanctus*	Sacred Kingfisher	Observed	P	P
Aves	*Trichoglossus haematodus*	Rainbow Lorikeet	Observed	P	P
Aves	*Zosterops lateralis*	Silvereye	Observed, Heard call	P	P
Mammalia	*Antechinus stuartii*	Brown Antechinus	Trapped or netted, Camera	P	P
Mammalia	*Petaurus breviceps*	Sugar Glider	Camera, Observed	P	P
Mammalia	*Pseudocheirus peregrinus*	Common Ringtail Possum	Observed	P	P
Mammalia	*Pteropus poliocephalus*	Grey-headed Flying-fox	Observed	V	V
Mammalia	*Vombatus ursinus*	Common Wombat	Indirect observed	P	P
Mammalia	*Wallabia bicolor*	Swamp Wallaby	Observed	P	P
Reptilia	*Amphibolurus muricatus*	Jacky Lizard	Camera	P	P
Reptilia	*Eulamprus quoyii*	Eastern Water-skink	Camera	P	P

Key: P = Protected; V = Vulnerable; E = Endangered; M = Marine; - = not listed under act (exotic/introduced species).

Bats detected by ultrasonic detection on the evening of 3rd May 2018. Species are in order of earliest detection from 159 valid passes.

Species	Common Name	Earliest detection time	Frequency of passes
Chalinolobus gouldii	Gould's Wattled Bat	17:23	Frequent
Saccalaimus flaviventrus	Yellow-bellied Sheathtail Bat*	17:24	1 or 2
Mormopterus ridei	Eastern Freetail-bat*	17:38	Frequent
Austronomus australis	White-striped Freetail Bat	17:39	Frequent
Vespadelus vulturnus	Little Forest Bat	17:45	Frequent
Chalinolobus morio	Chocolate Wattled Bat	17:58	Infrequent
Nyctophilus sp.	Long-eared bat species	18:12	1
Mormopterus norfolkensis	East-coast Freetail Bat*	18:52	Frequent
Miniopterus schreibersii	Eastern Bentwing-bat*	18:58	Frequent later
Vespadelus darlingtoni	Large Forest Bat	19:35	Infrequent

*Threatened species (Vulnerable)

Bats detected by ultrasonic detection during targeted Southern Myotis surveys (11-19 January 2019).

Detector	Night of	*Mormopterus norfolkensis*	*Myotis macropus*	*Nyctophilus or Myotis*	*Nyctophilus spp.*	Total passes above 32khz
51	14/01/2019			2		54
51	15/01/2019			1	2	36
54	14/01/2019	1				262
54	15/01/2019		1		1	216
54	16/01/2019					331
54	17/01/2019	1				191
Total		**2**	**1**	**3**	**3**	**1090**

Appendix 7. Ecosystem credits required for the proposed development

BAM Credit Summary Report

Proposal Details

Assessment Id	Proposal Name	BAM data last updated *
00010557/BAAS17040/19/00010575	Dunmore Lakes Sand Project-Proposed Stage 5 Modification	04/01/2019
Assessor Name	**Report Created**	**BAM Data version ***
Simon Tweed	11/04/2019	6
Assessor Number	* Disclaimer: BAM data last updated may indicate either complete or partial update of the BAM calculator database. BAM calculator database may not be completely aligned with Bionet.	
BAAS17040		

Ecosystem credits for plant communities types (PCT), ecological communities & threatened species habitat

Zone	Vegetation zone name	Vegetation integrity loss / gain	Area (ha)	Constant	Species sensitivity to gain class (for BRW)	Biodiversity risk weighting	Candidate SAII	Ecosystem credits
Bangalay - Old-man Banksia open forest on coastal sands, Sydney Basin Bioregion and South East Corner Bioregion								
1	659_Good	41.8	1.4	0.25	High Sensitivity to Potential Gain	2.00		30
2	659_Moderate	26.5	3.1	0.25	High Sensitivity to Potential Gain	2.00		41

3	659_Poor_DNG	9.2	3.0	0.25	High Sensitivity to Potential Gain	2.00		0
							Subtotal	**71**
							Total	**71**

Species credits for threatened species

Vegetation zone name	Habitat condition (HC)	Area (ha) / individual (HL)	Constant	Biodiversity risk weighting	Candidate SAII	Species credits
Myotis macropus / Southern Myotis (Fauna)						
659_Moderate	26.5	1.4	0.25	2	False	19
					Subtotal	**19**
Ninox connivens / Barking Owl (Fauna)						
659_Moderate	26.5	2.23	0.25	2	N/A	30
					Subtotal	**30**
Tyto novaehollandiae / Masked Owl (Fauna)						
659_Good	41.8	0	0.25	2	N/A	0
659_Moderate	26.5	2.23	0.25	2	N/A	30
					Subtotal	**30**

Appendix 8. Species credits required for the proposed modification

3	659_Poor_DNG	9.2	3.0	0.25	High Sensitivity to Potential Gain	2.00		0
							Subtotal	**71**
							Total	**71**

Species credits for threatened species

Vegetation zone name	Habitat condition (HC)	Area (ha) / individual (HL)	Constant	Biodiversity risk weighting	Candidate SAII	Species credits
Myotis macropus / Southern Myotis (Fauna)						
659_Moderate	26.5	1.4	0.25	2	False	19
					Subtotal	**19**
Ninox connivens / Barking Owl (Fauna)						
659_Moderate	26.5	2.23	0.25	2	N/A	30
					Subtotal	**30**
Tyto novaehollandiae / Masked Owl (Fauna)						
659_Good	41.8	0	0.25	2	N/A	0
659_Moderate	26.5	2.23	0.25	2	N/A	30
					Subtotal	**30**

Appendix 9. Threatened Species Assessments of Significance (EPBC Act)

Unless otherwise stated, information provided below is sourced from the relevant Commonwealth and State species profile database (Department of Environment and Energy, *Species Profile and Threat Database*, http://www.environment.gov.au/cgi-bin/sprat/public/, (DoEE 2018a) and Office of Environment and Heritage, Threatened Species Profile Database https://www.environment.nsw.gov.au/threatenedSpeciesApp/ (OEH 2018b).

An Assessment of Significance was undertaken for the following species:

- Grey-headed Flying-fox

Grey-headed Flying-fox	
Criteria (Vulnerable Species)	Address of Criteria
An action is likely to have a significant impact on a vulnerable species if there is a real chance or possibility that it will:	
Lead to a long-term decrease in the size of a population	The Grey-headed Flying-fox was not recorded during the current field survey, however it is likely the species would utilise the modification site for foraging on an irregular basis. No known camp sites exist within the modification site or adjacent areas, however there is a known maternity camp approximately 5km to the south west. Approximately 4.5 hectares of predominantly low-condition potential foraging habitat would be cleared for the surface infrastructure, however foraging habitat is widespread and extensive throughout the locality. It is unlikely that the modification would lead to a long-term decrease of any population.
Reduce the area of occupancy of the species	It is unlikely that the proposed development would reduce the area of occupancy of the Grey-headed Flying-fox as: • A small area (4.5 ha) of potential foraging habitat will be impacted by the proposed modification. • No known camp sites occur within the modification site or in the surrounding area. • The species has an extensive range.
Fragment an existing population into two or more populations	It is unlikely that the proposed development would fragment an existing population of the Grey-headed Flying-fox as: • The vegetation clearing area is small (4.5 ha) and surrounded by vegetation to the east, south and west. • The species is highly mobile.
Adversely affect habitat critical to the survival of a species	No critical habitat has been listed for the species on the EPBC Act Register of Critical Habitat.
Disrupt the breeding cycle of a population	The following is known about the breeding cycle of the Grey-headed Flying-fox: 1. Occur in subtropical and temperate rainforests, tall sclerophyll forests and woodlands, heaths and swamps as well as urban gardens and cultivated fruit crops. 2. Roosting camps are generally located within 20 km of a regular food source and are commonly found in gullies, close to water, in vegetation with a dense canopy. 3. Individual camps may have tens of thousands of animals and are used for mating, and for giving birth and rearing young. 4. Annual mating commences in January and conception occurs in April or May; a single young is born in October or November. 5. Site fidelity to camps is high; some camps have been used for over a century. 6. Can travel up to 50 km from the camp to forage; commuting distances are more often <20 km. 7. Feed on the nectar and pollen of native trees, in particular Eucalyptus, Melaleuca and Banksia, and fruits of rainforest trees and vines.

Grey-headed Flying-fox	
Criteria (Vulnerable Species)	Address of Criteria
	8. Also forage in cultivated gardens and fruit crops. It is uncertain whether mating occurs early in winter or in spring. The proposed development is unlikely to have an adverse effect on the species ability to breed successfully due to the following: • Clearing of 4.5 ha of largely degradedly habitat is unlikely to adverse breeding of the species. • Habitat features within the broader area are likely to be extensive and very limited areas of potential habitat would be impacted by the proposed development.
Modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline	A small area (4.5 ha) of potential foraging habitat would be impacted by the development. Habitat is relatively extensive throughout the locality. The species is unlikely to decline due to the proposed modification.
Result in invasive species that are harmful to a critically endangered or endangered species becoming established in the critically endangered or endangered species' habitat	The current Flora and Fauna Management Plan (FFMP) for DDS will be updated for the Stage 5 extraction area which would include weed control measures to minimise impacts to adjacent bushland which is likely to be foraging habitat for the species. It is unlikely that the proposed modification would result in an increase in feral pest activity that may impact Grey-headed Flying-fox.
Introduce disease that may cause the species to decline, or	It is unlikely that the proposed development would result in the introduction of a disease that may cause the species to decline.
Interfere substantially with the recovery of the species.	The proposed development is unlikely to interfere substantially with the recovery of the species as: • An important population is unlikely to occur within the modification site where loss of habitat through native vegetation clearing would occur. • A small area of (4.5 ha) will be impacted by the proposed modification. Large areas of better condition vegetation surround the modification site.
Conclusion: The proposed action is unlikely to have a significant impact on the Grey-headed Flying-fox due to the following: • No known camps are located on or near the modification site. • Habitat to be removed is relatively extensive throughout the locality. • A small area (4.5 ha) of potential habitat would be removed.	

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APPENDIX G

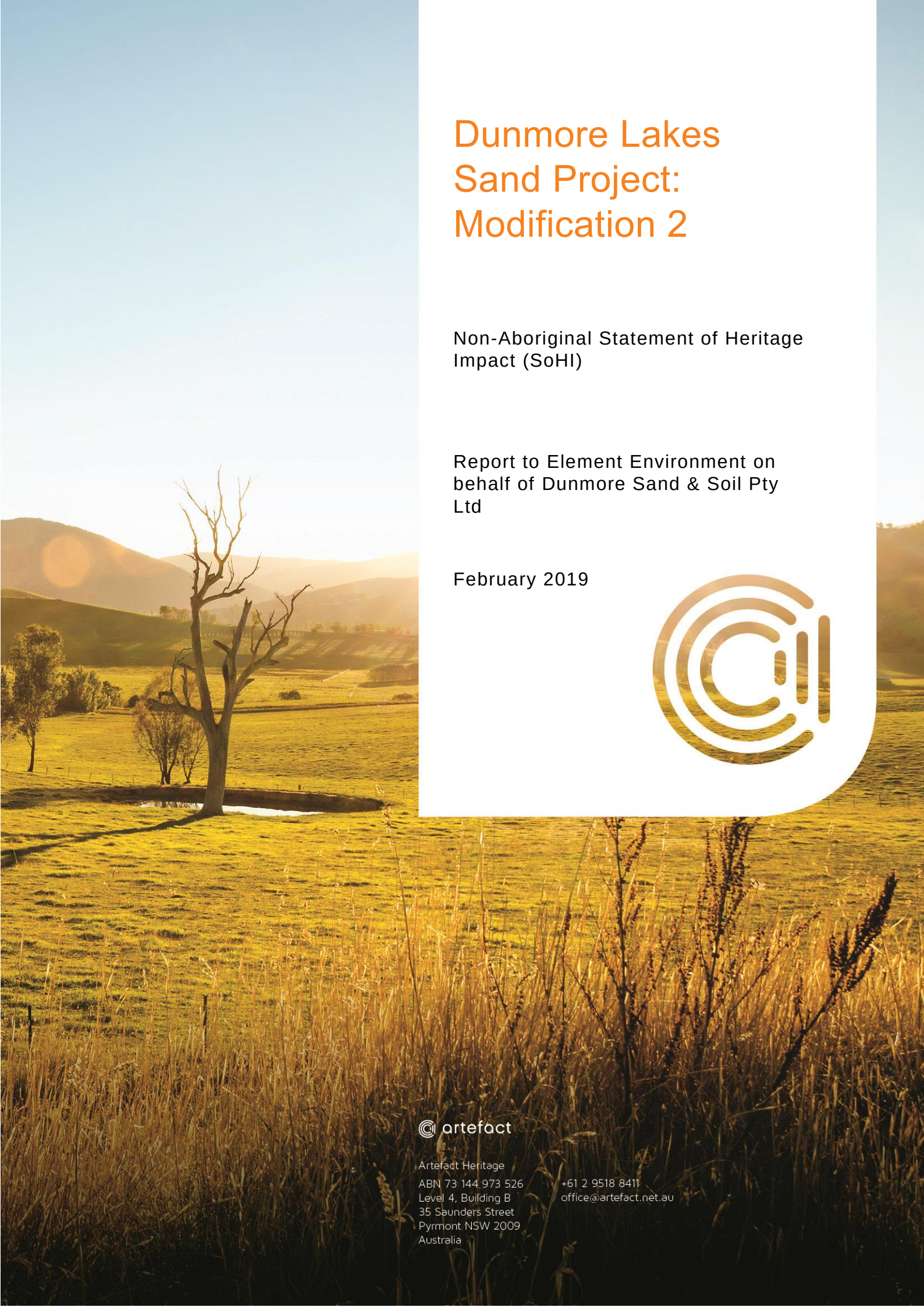
STATEMENT OF HERITAGE IMPACT REPORT

Dunmore Lakes Sand Project: Modification 2

Non-Aboriginal Statement of Heritage Impact (SoHI)

Report to Element Environment on behalf of Dunmore Sand & Soil Pty Ltd

February 2019



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EXECUTIVE SUMMARY

Background

Stage 1 of the Dunmore Lakes Sand Project (the 'Approved Project') was issued development consent from the then Minister for Planning in 1999. Stage 1 was on Swamp Road, Dunmore, and encompassed sand extraction by dredging of up to 500,000 tonnes per annum (tpa) for a period of 10 years. The Stage 1 consent included conditions requiring the proponent to lodge a further application for the remaining identified Stages of the Dunmore sand resource (being Stages 2 to 4).

The application for Stages 2 to 4 was lodged in 2004, and development consent was received from the Minister for Planning in June 2005. The consent approves extraction of up to 800,000 tpa of sand for a period of 25 years. Boral Resources (NSW) Pty Ltd (Boral) purchased Dunmore Sand & Soil Pty Ltd (DSS), including the Dunmore Lakes Sand Project in mid 2005. The Stage 1 consent has since lapsed following successful extraction of the approved sand resource and rehabilitation of the site in 2010.

Stages 2 to 4 commenced dredging in June 2007. Since then, due to the high demand for sand in the Sydney market, the majority of sand in Stage 2 has been extracted with dredging recently moving into Stage 3. Given recent high demand, the sand resource in Stage 3 is expected to be exhausted in approximately eight to twelve months. The last extraction stage (Stage 4) encompasses an area containing the site's road access and private rail line, and supporting infrastructure for the Stage 2 to 4 operations and Boral's adjacent Dunmore hard rock quarry. As such, this area may not be extracted until this infrastructure is relocated in future. This has led DSS to investigate other local sources of sand to continue operations beyond Stage 4.

DSS has been investigating a fine sand resource on an adjoining private property to the south. Investigative drilling has confirmed that there is sufficient sand resource to support three to four more years of extraction from two areas (Stage 5A and 5B). As such, DSS is seeking to modify the current Project Approval (DA 195-8-2004) under Section 75W of the *Environmental Planning and Assessment Act 1979* (EP&A Act), to provide for an additional extraction area (Stage 5) on adjoining private land, encompassing two separate extraction areas, Stage 5A and Stage 5B (hereafter referred to as the 'modification').

The modification proposed above will constitute Modification 2 to the current Project Approval. The Minister for Planning is the consent authority for the modification.

Artefact Heritage have been engaged by Element Environment, on behalf of DSS, to provide a non-Aboriginal (historic) Statement of Heritage Impact (SoHI) for the modification. This SoHI will be included in the Section 75W modification. The aim of this SoHI is to identify heritage items and archaeological remains that may be affected by the modification, determine the level of heritage significance of each item, assess the potential impacts to those items, recommend mitigation measures to reduce the level of heritage impact and identify other management or statutory obligations.

Overview of findings

There are four listed heritage items within the study area. This includes:

- Dunmore House Complex, Dry Stone Walls and Trees (SLEP 2013 Item No. I027)
- 'Anglesboro' and Trees (SLEP 2013 Item No. I028)
- Minnamurra Vegetation Area (SLEP 2013 Item No. I358)

- Rocklow Road Dry Stone Wall (SLEP 2013 Item No. I253).

The proposed works would have a **moderate** physical and visual impact on the following heritage items:

- Minnamurra Vegetation Area (SLEP 2013 Item No. I358)
- Dunmore House Complex, Dry Stone Walls and Trees (SLEP 2013 Item No. I027).

The proposed works would have a **negligible** (temporary) visual impact on the following heritage items:

- 'Anglesboro' and Trees (SLEP 2013 Item No. I028).

The proposed works would have a **neutral** physical impact on the following heritage items:

- 'Anglesboro' and Trees (SLEP 2013 Item No. I028)
- Rocklow Road Dry Stone Wall (SLEP 2013 Item No. I253).

The proposed works would have a **neutral** visual impact on the following heritage items:

- Rocklow Road Dry Stone Wall (SLEP 2013 Item No. I253).

Indirect impact by way of vibrations during construction works is not anticipated for any heritage items located within the study area.

Non-Aboriginal archaeology

The project modification site has been assessed as having nil to low potential to contain locally significant archaeological remains, and as such archaeological impact is unlikely.

Recommendations

The following recommendations will aid in mitigating the impact of the modification on nearby heritage items and the wider Shellharbour cultural landscape:

- As the modification has been assessed as potentially resulting in a moderate physical and visual impact on the Minnamurra Vegetation Area (SLEP 2013 Item No. I358) and moderate temporary visual impact on the Dunmore House Complex, Dry Stone Walls and Trees (SLEP 2013 Item No. I027), consultation with Shellharbour City Council would be required
- Should significant amendments to the design of the proposed works be made, this report should be updated to assess the potential heritage impact of the revised proposed works
- Any unexpected archaeological remains within the modification site remain protected by the NSW *Heritage Act 1977* (Heritage Act). If a potential relic is uncovered in the course of the works, work in the vicinity should cease, and the Heritage Division should be contacted for advice
- A heritage induction should be presented to workers before commencement of works in the vicinity of heritage items within the study area. The induction should include the heritage values of the place, avoidance procedure, and contacts for reporting unexpected archaeological finds or inadvertent impacts to heritage items.

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1.0 INTRODUCTION AND BACKGROUND

1.1 Background

Stage 1 of the Dunmore Lakes Sand Project (the 'Approved Project') was issued development consent from the then Minister for Planning in 1999. Stage 1 was on Swamp Road, Dunmore, and encompassed sand extraction by dredging of up to 500,000 tonnes per annum (tpa) for a period of 10 years. The Stage 1 consent included conditions requiring the proponent to lodge a further application for the remaining identified Stages of the Dunmore sand resource (being Stages 2 to 4).

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1.2 Site location

Dunmore is located within the Shellharbour Local Government Area (LGA) in the Illawarra region of New South Wales (NSW) about 90km south of Sydney. The project modification site is located approximately 1.1km south-south east of the existing Dunmore Lakes Sand Project. The site is located on an alluvial coastal flood plain adjacent to the tidal reaches of the Minnamurra River. The location of the modification is shown in Figure 1.

1.2.1 Study area

For the purposes of this SoHI, the study area has been defined as a visual buffer zone set at 50m around the modification site and associated infrastructure, which has been established to encapsulate nearby heritage items and any visual impacts of the modification on these items. For further information refer to Section 1.3.2. The study area is shown in Figure 2.

Figure 1: Location of the modification.

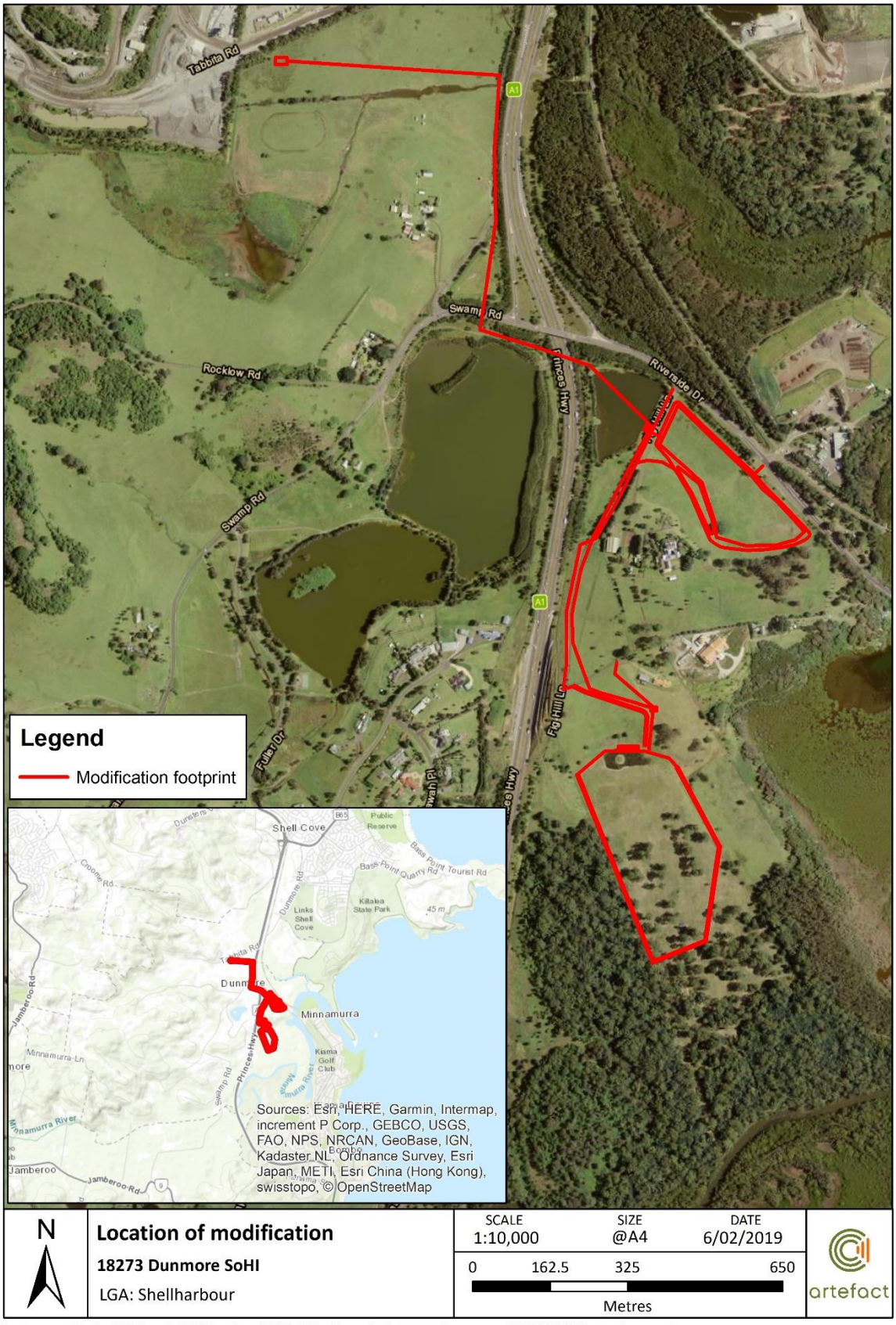

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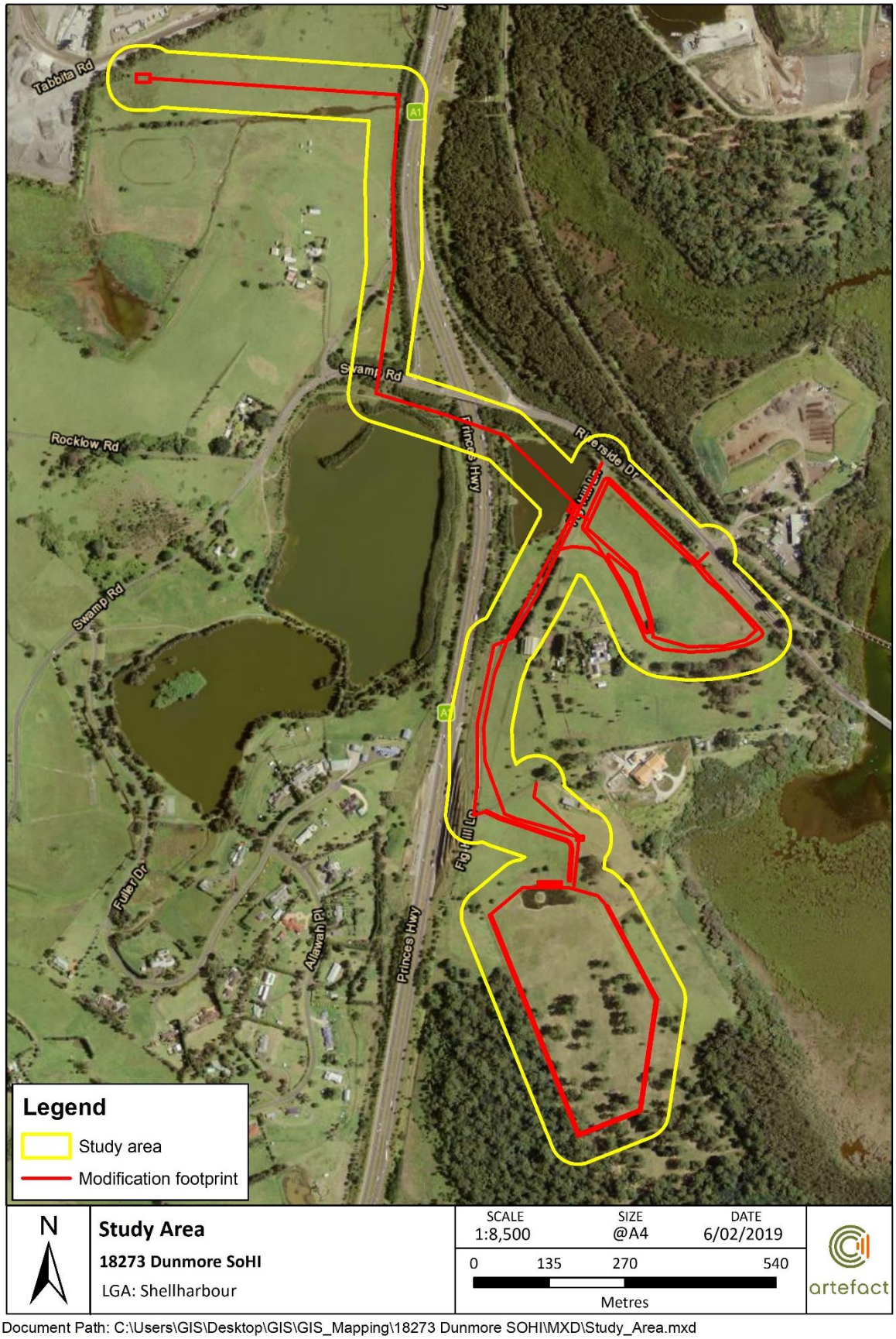
Figure 2: Study area (50m visual buffer zone).



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1.3 Report methodology

This SoHI has been prepared using the guidelines contained within *Statement of Heritage Impact* (2002), prepared by the NSW Heritage Office as part of the *NSW Heritage Manual.*

1.3.1 Significance assessment guidelines

Determining the significance of heritage items and archaeological remains is undertaken by utilising a system of assessment centred on the *Burra Charter* of Australia ICOMOS and Bickford and Sullivan's *Assessing the Research Significance of Historic Sites* (1984).[1] The principles of the Burra Charter are relevant to the assessment, conservation and management of sites and relics. Bickford and Sullivan's work examines the concept and assessment of archaeological research potential; that is, the extent to which archaeological resources can address research questions. They developed three questions which can be used to assess the research potential of an archaeological site:

- Can the site contribute knowledge that no other resource can?
- Can the site contribute knowledge that no other site can?
- Is this knowledge relevant to:
  - General questions about human history?
  - Other substantive questions relating to Australian history?
  - Other major research questions?

The assessment of heritage significance is outlined through legislation in the NSW *Heritage Act* 1977 (Heritage Act) and implemented through the *NSW Heritage Manual* and the *Archaeological Assessment Guidelines*.[2] If an item meets one of the seven heritage criteria, and retains the integrity of its key attributes, it can be considered to have heritage significance.

The significance of an item or potential archaeological site can then be assessed as being of local or State significance. If a potential relic is not considered to reach the local or State significance threshold, then it is not a relic under the Heritage Act.

'State heritage significance', in relation to a place, building, work, relic, moveable object or precinct, means significance to the State in relation to the historical, scientific, cultural, social, archaeological, architectural, natural or aesthetic value of the item. *'Local heritage significance',* in relation to a place, building, work, relic, moveable object or precinct, means significance to an area in relation to the historical, scientific, cultural, social, archaeological, architectural, natural or aesthetic value of the item.[3]

The overall aim of assessing heritage and archaeological significance is to identify whether an archaeological resource, deposit, site or feature is of cultural value. The assessment will result in a succinct statement of heritage significance that summarises the values of the place, site, resource, deposit or feature. The heritage significance assessment criteria are as follows:

[1] Bickford, A and S Sullivan 1984, 'Assessing the Research Significance of Historic Sites', in Sullivan S and S Bowdler (eds), Site Surveys and Significance Assessment in Australian Archaeology (Proceedings of the 1981 Springwood Conference on Australian Prehistory), Department of Prehistory, Research School of Pacific Studies, The Australian National University, Canberra pp 23–24.
[2] NSW Heritage Office 1996; 25-27
[3] This section is an extract based on the Heritage Office Assessing Significance for Historical Archaeological Sites and Relics 2009:6.

Table 1: NSW heritage assessment criteria.

Criteria	Description
A – Historical Significance	An item is important in the course or pattern of NSW's or the local area's cultural or natural history.
B – Associative Significance	An item has strong or special associations with the life or works of a person, or group of persons, of importance in NSW's or the local area's cultural or natural history.
C – Aesthetic Significance	An item is important in demonstrating aesthetic characteristics and/or a high degree of creative or technical achievement in NSW or the local area.
D – Social Significance	An item has strong or special association with a particular community or cultural group in NSW or the local area for social, cultural or spiritual reasons.
E – Research Potential	An item has potential to yield information that will contribute to an understanding of NSW or the local area's cultural or natural history.
F – Rarity	An item possesses uncommon, rare or endangered aspects of NSW's or the local area's cultural or natural history.
G - Representativeness	An item is important in demonstrating the principal characteristics of a class of NSW's or the local area's cultural or natural places, or cultural or natural environments.

1.3.2 Visual buffer

Heritage items are often classified as being significant due to their appearance, form or organisation, and other visual characteristics. Developments that block or impair the potential to see these visual characteristics can be classified as heritage impacts. An area that extends for 50m in all directions from the boundary of the modification has been created as the visual buffer zone. Heritage items that fall within the visual buffer zone will be assessed for potential visual impacts.

In order to assess visual impact, sight-lines from the heritage item to the modification have been established. Both the views *towards* the heritage item (whether the modification would impair views of the item's significant visual characteristics) and views *away* from the item (whether the modification would impair views of the heritage-significant surroundings or character of the item) will be assessed.

1.3.3 Types of impact

An impact assessment is provided for direct, visual impact, and potential indirect impacts. Each type of impact is described in Table 2 below.

Table 2: Terminology for heritage impact types.

Impact	Definition
Direct	Impacts resulting from works located within the curtilage boundaries of the heritage item.
Visual	Impact to views, vistas and setting of the heritage item resulting from proposed works inside or outside the curtilage boundaries of the heritage item.
Potential	Impacts resulting from increased noise, vibrations and construction works located outside the

Impact	Definition
indirect	curtilage boundaries of the heritage item.

1.3.4 Grading of impacts

In order to consistently identify the potential impact of the proposed works, the terminology contained in Table 3 has been referenced throughout this document. This terminology, and corresponding definitions, are based on those contained within guidelines produced by the International Council on Monuments and Sites (ICOMOS).[4]

Table 3: Terminology for assessing the magnitude of heritage impact.

Grading	Definition
Major	Actions that would have a long-term and substantial impact on the significance of a heritage item. Actions that would remove key historic building elements, key historic landscape features, or significant archaeological materials, thereby resulting in a change of historic character, or altering of a historical resource. These actions cannot be fully mitigated.
Moderate	Actions involving the modification of a heritage item, including altering the setting of a heritage item or landscape, partially removing archaeological resources, or the alteration of significant elements of fabric from historic structures. The impacts arising from such actions may be able to be partially mitigated.
Minor	Actions that would result in the slight alteration of heritage buildings, archaeological resources, or the setting of an historical item. The impacts arising from such actions can usually be mitigated.
Negligible	Actions that would result in very minor changes to heritage items.
Neutral	Actions that would have no heritage impact.

1.4 Limitations and constraints

This document deals with non-Aboriginal heritage only, including a review of the significance of heritage items in proximity to the modification site, analysis of views and vistas, a preliminary assessment of historical archaeological potential, and assessment of potential impacts to those items from the proposed works. The preliminary assessment of historical archaeological potential is based on a desktop assessment and site survey.

1.5 Authorship

This report was prepared by Charlotte Simons (Senior Heritage Consultant, Artefact Heritage) and Jennifer Norfolk (Heritage Consultant, Artefact Heritage) with input and review from Dr Sandra Wallace (Director, Artefact Heritage).

[4] Including the document *Guidance on Heritage Impact Assessments for Cultural World Heritage Properties*, ICOMOS, January 2011.

2.0 STATUTORY CONTEXT

2.1 Introduction

There are several items of State legislation that form the basis for managing non-Aboriginal heritage in NSW. This section provides a summary of these items of legislation and associated statutory registers.

2.2 Environmental Protection and Biodiversity Conservation Act 1999

The *Environment Protection and Biodiversity Conservation Act 1999* (Cwlth) (EPBC Act) provides a legislative framework for the protection and management of matters of national environmental significance, that is, flora, fauna, ecological communities and heritage places of national and international importance. Heritage items are protected through their inscription on the World Heritage List, Commonwealth Heritage List or the National Heritage List.

The EPBC Act stipulates that a person who has proposed an action that will, or is likely to, have a significant impact on a World, National or Commonwealth Heritage site must refer the action to the Minister for Sustainability, Environment, Water, Population and Communities (hereafter Minister). The Minister will then determine if the action requires approval under the EPBC Act. If approval is required, an environmental assessment would need to be prepared. The Minister would approve or decline the action based on this assessment.

A significant impact is defined as “an impact which is important, notable, or of consequence, having regarded to its context or intensity.” The significance of the action is based on the sensitivity, value and quality of the environment that is to be impacted, and the duration, magnitude and geographic extent of the impact. If the action is to be undertaken in accordance with an accredited management plan, approval is not needed and the matter not need be referred to the Minister.

2.2.1 Commonwealth Heritage List

The Commonwealth Heritage List (CHL) has been established to list heritage places that are either entirely within a Commonwealth area, or outside the Australian jurisdiction and owned or leased by the Commonwealth or a Commonwealth Authority. The CHL includes natural, Indigenous and historic heritage places which the Minister for Sustainability, Environment, Water, Population and Communities is satisfied have one or more Commonwealth Heritage values.

No sites within or near the study area are included on the CHL.

2.2.2 National Heritage List

The National Heritage List (NHL) has been established to list places of outstanding heritage significance to Australia. It includes natural, historic and Indigenous places that are of outstanding national heritage value to the Australian nation.

No sites within or near the study area are included on the NHL.

2.3 Heritage Act 1977

The NSW *Heritage Act 1977* (Heritage Act) provides protection for items of ‘environmental heritage’ in NSW. ‘Environmental heritage’ includes places, buildings, works, relics, movable objects or

precincts considered significant based on historical, scientific, cultural, social, archaeological, architectural, natural or aesthetic values. Items considered to be significant to the State are listed on the SHR and cannot be demolished, altered, moved or damaged, or their significance altered without approval from the Heritage Council of NSW.

2.3.1.1 The 2009 'Relics provisions'

The Heritage Act also provides protection for 'relics', which includes archaeological material or deposits. According to Section 139 (Division 9: Section 139, 140-146):

(1) A person must not disturb or excavate any land knowingly or having reasonable cause to suspect that the disturbance or excavation will or is likely to result in a relic being discovered, exposed, damaged or destroyed unless the disturbance is carried out in accordance with an excavation permit.

(2) A person must not disturb or excavate any land on which the person has discovered or exposed a relic except in accordance with an excavation permit.

(3) This section does not apply to a relic that is subject to an interim heritage order made by the Minister or a listing on the State Heritage Register.

(4) The Heritage Council may by order published in the Gazette create exceptions to this section, either unconditionally or subject to conditions, in respect of any of the following:

a. Any relic of a specified kind or description,

b. Any disturbance of excavation of a specified kind or description,

c. Any disturbance or excavation of land in a specified location or having specified features or attributes,

d. Any disturbance or excavation of land in respect of which an archaeological assessment approved by the Heritage Council indicates that there is little likelihood of there being any relics in the land.

Section 4 (1) of the Heritage Act (as amended in 2009) defines a relic as:

> *...any deposit, artefact, object or material evidence that:*
>
> *relates to the settlement of the area that comprises New South Wales, not being Aboriginal settlement, and is of State or local heritage significance*

A relic has been further defined as:

> *Relevant case law and the general principles of statutory interpretation strongly indicate that a 'relic' is properly regarded as an object or chattel. A relic can, in some circumstances, become part of the land be regarded as a fixture (a chattel that becomes permanently affixed to land).*[5]

Excavation permits are issued by the Heritage Council of NSW, or its Delegate, under Section 140 of the Heritage Act for relics not listed on the State Heritage Register (SHR) or under Section 60 for relics listed on the SHR. An application for an excavation permit must be supported by an Archaeological Research Design and Archaeological Assessment prepared in accordance with the NSW Heritage Division archaeological guidelines. Minor works that will have a minimal impact on

[5] *Assessing Significance for Archaeological Sites and 'Relics'*, Heritage Branch, Department of Planning, 2009:7.

archaeological relics may be granted an exception under Section 139 (4) or an exemption under Section 57 (2) of the Heritage Act.

Definition of works

The Heritage Act includes archaeological 'works' as a separate category to archaeological 'relics'. Exposure of a 'work' does not trigger reporting obligations under the Act. The following examples are commonly considered to be 'works': former road surfaces or pavement, kerbing, evidence of former infrastructure (such as drains or drainage pits where there are no relics in association), tram and train tracks and ballast and evidence of former rail platforms and bridges.

2.3.2 State Heritage Register

The SHR was established under Section 22 of the Heritage Act and is a list of places and objects of particular importance to the people of NSW, including archaeological sites. The SHR is administered by the Heritage Division of the Office of Environment and Heritage (OEH). This includes a diverse range of over 1,500 items, in both private and public ownership. To be listed, an item must be deemed to be of heritage significance for the whole of NSW.

No sites within or near the study area are included on the SHR.

2.3.3 Section 170 registers

Under the Heritage Act all government agencies are required to identify, conserve and manage heritage items in their ownership or control. Section 170 (s170) requires all government agencies to maintain a Heritage and Conservation Register that lists all heritage assets and an assessment of the significance of each asset. They must ensure that all items inscribed on its list are maintained with due diligence in accordance with State Owned Heritage Management Principles approved by the Government on advice of the NSW Heritage Council. These principles serve to protect and conserve the heritage significance of items and are based on NSW heritage legislation and guidelines.

No sites within or near the study area are included on any s170 registers.

2.4 Environmental Planning and Assessment Act 1979

The *Environmental Planning and Assessment Act 1979* (NSW) (EP&A Act) establishes the framework for cultural heritage values to be formally assessed in the land use planning and development consent process. The EP&A Act requires that environmental impacts are considered prior to land development; this includes impacts on cultural heritage items and places as well as archaeological sites and deposits. The EP&A Act requires that Local Governments prepare planning instruments (such as Local Environmental Plans [LEPs] and Development Control Plans [DCPs]) in accordance with the Act, to provide guidance on the level of environmental assessment required.

The current study area falls within the boundaries of the Shellharbour Local Government Area (LGA) and is subject to the Shellharbour LEP (SLEP) 2013. This includes a schedule of local heritage items and planning controls related to development in the vicinity of heritage items.

2.4.1 Shellharbour LEP 2013

The study area falls within the SLEP 2013. The SLEP 2013 aims to conserve the heritage significance of heritage items and heritage conservation areas, including associated fabric, settings and views; and to protect archaeological sites. The LEP stipulates development controls in relation to

development proposed on or near heritage listed properties, archaeological sites, or Aboriginal places of heritage significance.

There are several heritage items listed on the SLEP 2013 that are located within the study area. These items are listed in Table 4 and shown in Figure 2.

2.4.2 Shellharbour DCP 2013

The Shellharbour DCP (SDCP) 2013 provides guidelines for development proposals and heritage under Part 3. It provides examples of the types of development and how this could affect heritage, and what requirements are needed before development can commence, such as heritage impact statements. Controls are listed depending on what type of development is proposed. The controls for currently listed LEP items encourage the retention of the items while enabling sympathetic change. New development must not diminish the significance of the item.

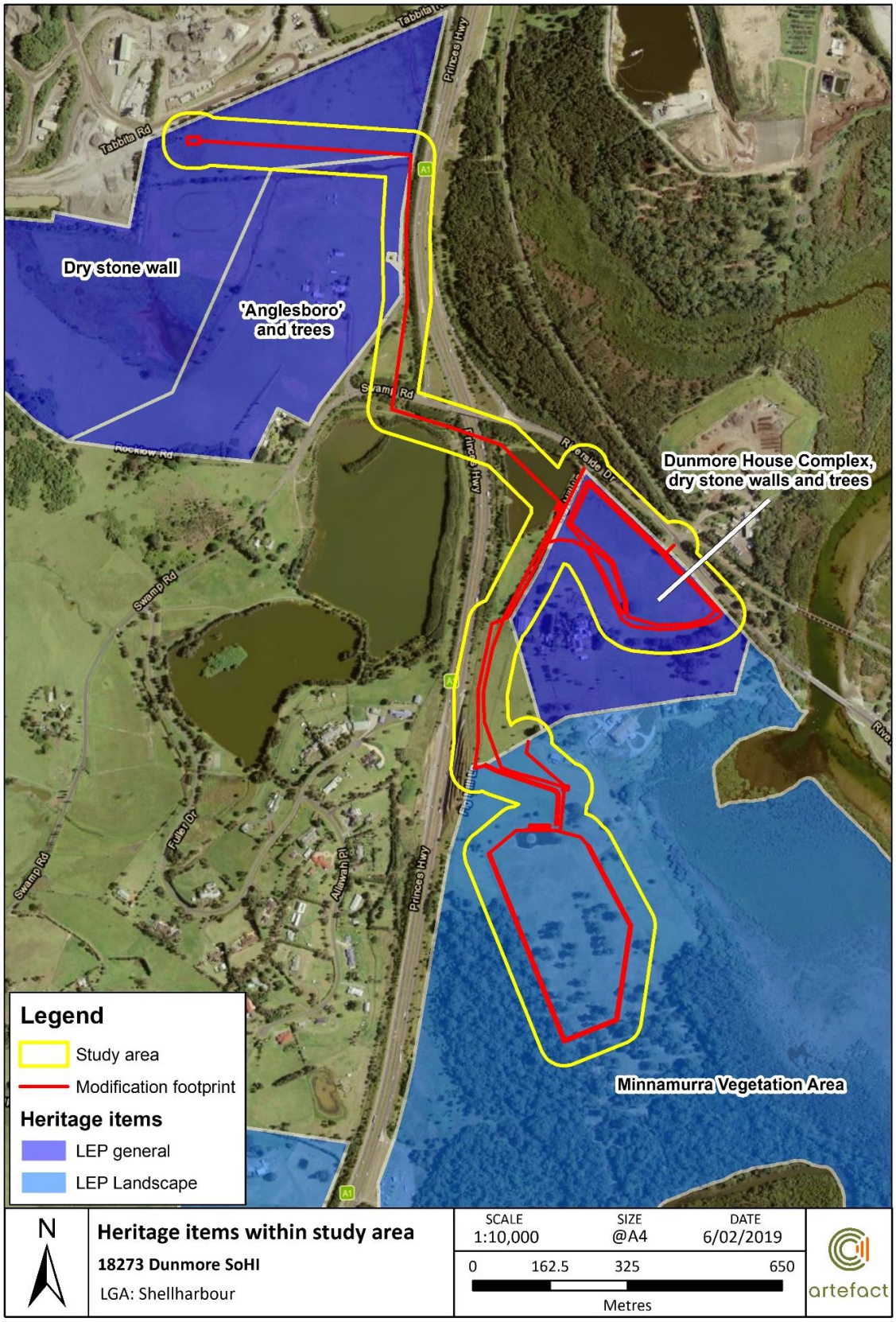
2.5 Heritage register search

As outlined above, statutory registers provide legal protection for heritage items. A search of all relevant registers was undertaken on 18 December 2018 of heritage items located within the study area. There are several heritage listings that are located within the study area. These items are identified in Table 4 and shown in Figure 3.

Table 4: Heritage listings within the study area

Item Name	Item/Listing Number	Address	Significance
Dunmore House Complex, Dry Stone Walls and Trees	SLEP 2013 I027	471 Riverside Drive, Dunmore	Local
Anglesboro and Trees	SLEP 2013 I028	4 Swamp Road, Dunmore	Local
Minnamurra Vegetation Area	SLEP 2013 I358	Dunmore	Local
Rocklow Road Dry Stone Wall	SLEP 2013 I253	Rocklow Road, Dunmore	Local

Figure 3: Heritage items within the study area.



Document Path: C:\Users\GIS\Desktop\GIS\GIS_Mapping\18273 Dunmore SOHI\MXD\Heritage items.mxd

3.0 HISTORICAL CONTEXT

3.1 Aboriginal histories of the locality

Aboriginal people traditionally lived in small family or clan groups that were associated with particular territories or places. The study area is located within the Dharawal language group area. The Dharawal language group was largely coastal and is thought to have extended from the Shoalhaven River in the south, to Botany Bay in the north and then inland to Camden.[6] The Dharawal language group was bordered to the north in the Botany Bay – southern Sydney region by the Darug and to the west in the Mittagong – Moss Vale region by the Gundungurra. The study area falls within the territory of the Dharawal-speaking Wodi Wodi people. Tindale (1974) described the territory of the Wodi Wodi as extending from north of the Shoalhaven River at Nowra to Wollongong and inland to Moss Vale.

Early interaction between the Dharawal and the British was intermittent and brief. The earliest sighting of British people by the Dharawal would most likely have been when they saw sailing ships along the coast. The records of Captain Cook and several of his crew document seeing numerous fires and occasional Aboriginal people on the coastline in the Illawarra region.[7] Several of the early British settlers in the Illawarra documented large gatherings of Aboriginal people. In 1836 a group of around 200 Aboriginal people were observed in the Illawarra area as they were preparing to travel to Cowpastures in south-west Sydney.[8]

A variety of flora and fauna resources were utilised in the Illawarra region for subsistence, personal ornament and tool requirements. The variety of subsistence resources in the Illawarra included marine, estuarine, freshwater and hinterland flora and fauna. Early British records documented torchlight spearing of bream and consumption of whale meat. The consumption of whale was documented as an important event linked to the spirits of their ancestors. Cabbage trees were used for various purposes, including utilisation of the fibre.[9] Other plant species utilised for food and tolls included bats-wing tree, grass tree, Gymea lily, various Eucalypt sp., mat-rush, sticky hop bush, Melaleuca and black wattle.[10] As Aboriginal people were mobile hunter-gatherers, it would be likely that they moved across the landscape between resources. It would also be likely that movement was related to socio/cultural factors such as gatherings and ceremonial obligations.

3.2 Development of Dunmore and Dunmore House

During the early 19th century, the area was exploited by European settlers for timber. Settlement proceeded throughout the 19th century following initial land grants, with farms providing wheat, dairying and pig farming. In 1821, Governor Lachlan Macquarie granted D'Arcy Wentworth, a prominent free settler who had arrived in the colony in 1790, 1,650 acres of land situated at what became Shellharbour and 1,500 acres at Dunster Hill and Mount Wentworth. The 1,650 acres included the site of the private town of 'Peterborough'.[11] On his death in 1827, Wentworth was one of the richest men in the colony, and his land holdings within the 'Peterborough Estate' totalled 13,050 acres.

In 1851, the private town of 'Peterborough' was laid out around the port of Shellharbour on part of the Peterborough Estate, and this town later became known as Shellharbour Village. The southern

[6] Attenbrow 2010: 34
[7] Organ 1993: 46
[8] Griffin 1986: 6, cited in AMBS 2010: 33
[9] Organ 1993: 155 and 262
[10] AMBS 2010: 35
[11] Shellharbour City Libraries

division of the Peterborough Estate of Shellharbour was advertised for sale in 1865. This included 2,560 acres on the Minnamurra River adjoining the Terry's Meadows Estate. George Laurence Fuller, who had arrived in Australia at the age of seven years with his family in 1839, bought the property and named the estate Dunmore after his old family home in Galway, Ireland. Fuller had settled in the Illawarra region in 1858, when he bought the Post Office store at Gerringong. On 20 April 1859, Fuller married Sarah Cunningham Miller of 'Renfrew Park' and purchased a new store in Kiama.

Figure 4: Historical map of Parish of Terragong, 1895.
(Source: Historical Land Records Viewer)

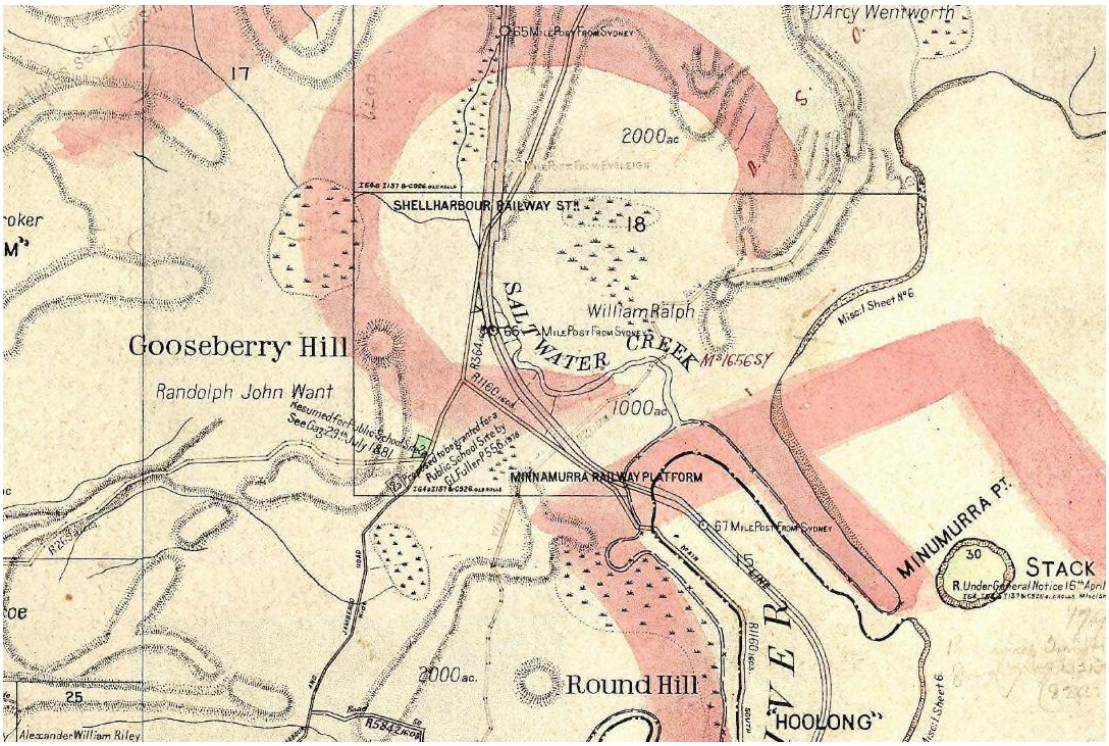
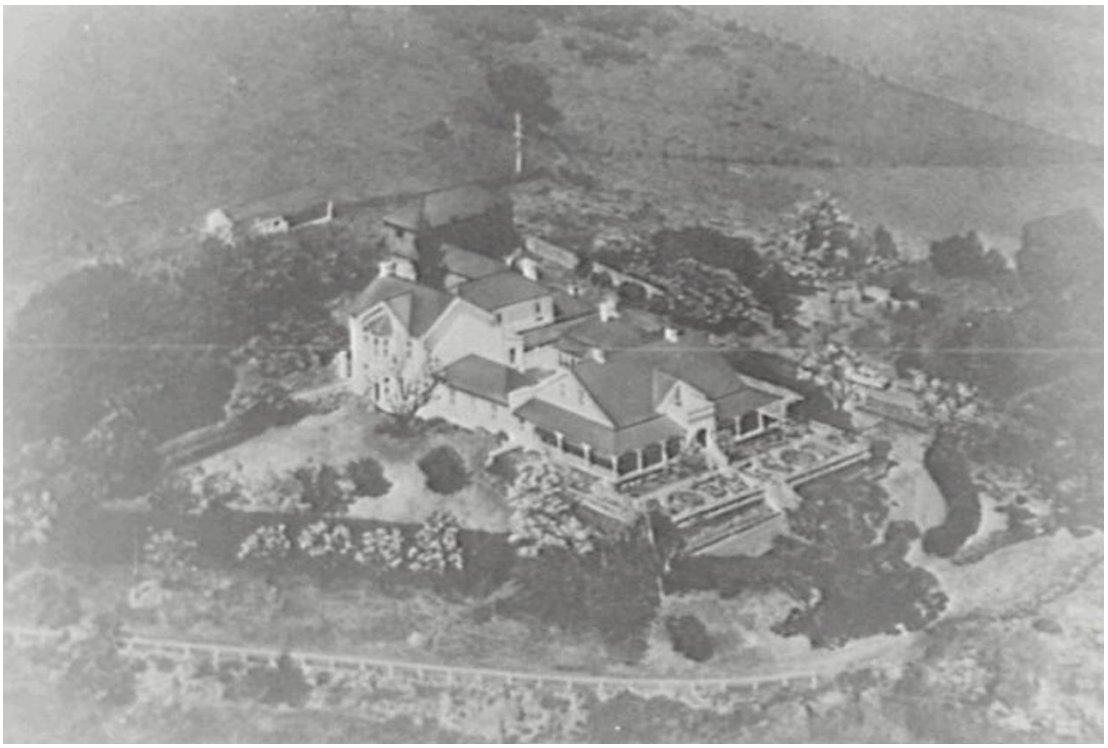


Figure 5: Historical photo circa 1890 showing the road to Dunmore.
(Source: Illawarra Mercury)

**Figure 6: Historical photograph of Dunmore House, c1900s.
(Source: Shellharbour Image Library)**

Having acquired part of the Peterborough Estate, Fuller subsequently constructed 'Dunmore House' in 1865. The house was built with locally obtained rubble blue metal and featured cedar interiors, and initially comprised a single storey residence with four rooms and attics. Gradually, a ballroom, barn and stables were added.

**Figure 7: Historical aerial photograph of Dunmore House, date unknown.
(Source: Wollongong City Libraries)**



By 1880, Fuller owned some 9,000 acres of the Peterborough Estate extending from Lake Illawarra to the Minnamurra River and west to Croom, Albion Park. He contributed largely to the development of the municipality, providing tenant farms for workers to cultivate the land during the early 1880s. This included establishment of the nearby 'Anglesboro' Victorian era homestead, which was built as a tenant farm house in the 1880s. From the mid to late 19th century, dry stone walls were established to denote the boundaries of properties in the Shellharbour area.

In 1883, Fuller gave two acres for a new school (Minnamurra School), which was built of local basalt at Swamp Road, Dunmore. Fuller expanded the blue metal trade in 1885, providing work and cottages to local quarrymen. Fuller also gave land for the Shellharbour General Cemetery and gifted a fully equipped operating theatre and ward at Kiama Hospital.

On 21 June 1887, the Illawarra railway line from Wollongong to Scarborough was opened as an isolated line, with an extension to Bombo (North Kiama) from Wollongong subsequently having opened on 9 November 1887. Finally, on 3 October 1888, the connection to the northern Sydney section was made. Dunmore (Shellharbour) Railway Station was completed as part of the section of the line that opened in November 1887.

In 1905, in celebration of the 50th anniversary of the marriage of George and Sarah Fuller, James Ford constructed the second storey to the Dunmore House residence. George Fuller passed away in 1917, and is buried in the Presbyterian section of Bombo Cemetery, Kiama.[12] In 1966, Dunmore House was modernised by master builder Mr Tom Hughes. Dairying activities prospered in the area into the 20th century.

**Figure 8: Historical photograph of Dunmore House, c1920.
(Source: Shellharbour Image Library)**

[12] http://www.shellharbour.nsw.gov.au/default.aspx?WebPage=1166#dunmore. Viewed 1 August 2013.

4.0 SITE INSPECTION

A site inspection of the study area was undertaken on 17 December 2018 by Charlotte Simons (Senior Heritage Consultant, Artefact Heritage) and Jennifer Norfolk (Heritage Consultant, Artefact Heritage). The aim of the inspection was to identify and assess potential impacts of the proposed works to surrounding heritage items, including impacts to potential archaeological deposits with the study area, and historic views and vistas. The inspection was undertaken on foot and a photographic record was made.

4.1 Setting and context

The study area is characterised by a semi-rural alluvial coastal flood plain setting, comprising a flat to gently sloping landscape that has been historically cleared for grazing, and is dissected by roads and large rural lots. The study area contains and is bound by several roads and natural features including Riverside Drive, Swamp Road, Princes Highway, Fig Hill Lane and Rocklow Creek, and is adjacent to the tidal reaches of the Minnamurra River.

The northern portion of the study area features existing sand extraction activities, and is bound by Tabbita Road to the north and the Princes Highway to the east. Further south, the study area is within the agricultural landscape of the historic 'Anglesboro' homestead complex, which is demarcated by a timber post and rail fence adjacent to the Princes Highway. The study area continues south east across Princes Highway, Swamp Road and Riverside Drive to the 'Dunmore House' estate, which features significant buildings, plantings and dry stone walls within an intact historic agricultural landscape. Along Fig Hill Lane and an unsealed road, the study area continues to its southern extent, which covers a portion of the Minnamurra Vegetation Area, a significant ecological feature adjoining a wetland landscape.

The distant landscape surrounding the study area comprises a combination of agricultural land, commercial and industrial development including the Dunmore Hard Rock Quarry to the north west and Dunmore Resource and Recycling Facility to the north, low density residential development including the Dunmore Lakes Estate to the south west and Minnamurra to the east, and infrastructure development including the Princes Highway and the South Coast Rail Line.

Figure 9: View south west from the Minnamurra Recycling Depot towards Dunmore House and site of proposed Stage 5A dredge pond.

Figure 10: View south west from Riverside Drive across site of proposed Stage 5A dredge pond towards Dunmore House.

Figure 11: View north west along Riverside Drive alongside Dunmore House, site of proposed Stage 5A dredge pond to left.

Figure 12: View south east along Riverside Drive towards original driveway entrance to Dunmore House.

Figure 13: View south from Riverside Drive to entry gates to Dunmore House alongside Fig Hill Lane.

Figure 14: View west across the site of the proposed Stage 5A dredge pond towards Fig Hill Lane and entry drive to Dunmore House.

Figure 15: View west across the site of the proposed Stage 5A dredge pond towards Fig Hill Lane and entry drive to Dunmore House.

Figure 16: View north west across the site of the proposed Stage 5A dredge pond towards the entry gates to Dunmore House.

Figure 17: View south east across the site of the proposed Stage 5A dredge pond.

Figure 18: View south east across the site of the proposed Stage 5A dredge pond, Dunmore House seen on hill in distance.

Figure 19: View north west east across the site of the proposed Stage 5A dredge pond towards entry drive.

Figure 20: View south west up hill towards the Dunmore House main homestead building (screened by plantings).

Figure 21: View north from near Dunmore House across the site of the proposed Stage 5A dredge pond towards Riverside Drive and Princes Highway in distance.

Figure 22: View north east from near Dunmore House across the site of the proposed Stage 5A dredge pond towards Riverside Drive.

Figure 23: View south east along the boundary of the Dunmore House gardens.

Figure 24: View north east from near Dunmore House towards site of proposed Stage 5A dredge pond.

Figure 25: View south west from site of proposed Stage 5A dredge pond towards Dunmore House, bamboo plantings in centre.

Figure 26: View east to bamboo plantings and rubble located within the site of the proposed Stage 5A dredge pond.

Figure 27: View north to concrete livestock trough located within site of the proposed Stage 5A dredge pond.

Figure 28: View north west across site of the proposed Stage 5A dredge pond (Dunmore House entry drive in distance).

Figure 29: View south east towards burn pile located near original entry drive to Dunmore House, within site of the proposed Stage 5A dredge pond.

Figure 30: View north west across site of the proposed Stage 5A dredge pond (Riverside Drive to right and Dunmore House entry drive in distance).

Figure 31: View north from gardens at Dunmore House towards the site of the proposed Stage 5A dredge pond.

Figure 32: View north from gardens at Dunmore House towards the site of the proposed Stage 5A dredge pond.

Figure 33: View west across gardens at Dunmore House, site of the proposed pipeline in the distance.

Figure 34: View north west across gardens at Dunmore House, site of the proposed pipeline in the distance.

Figure 35: View north from gardens at Dunmore House towards the site of the proposed Stage 5A dredge pond.

Figure 36: View north from entry path to Dunmore House towards the site of the proposed Stage 5A dredge pond.

Figure 37: View north east from entry path to Dunmore House towards the site of the proposed Stage 5A dredge pond.

Figure 38: View north from south-east boundary of the Dunmore House property towards the site of the proposed Stage 5A dredge pond.

Figure 39: Distant view north from the southern boundary and dry stone wall at the rear of the Dunmore House property towards the proposed Stage 5A dredge pond.

Figure 40: Distant view north west from the southern boundary and dry stone wall at the rear of the Dunmore House property towards the proposed Stage 5A dredge pond.

Figure 41: View north along Fig Hill Lane, site of the proposed pipeline route to the right.

Figure 42: View north from Fig Hill Lane to site of proposed pipeline route.

Figure 43: View south east across the Minnamurra Vegetation Area towards the site of the proposed Stage 5B dredge pond, site of proposed pipeline route in foreground.

Figure 44: View south across the Minnamurra Vegetation Area towards the site of the proposed Stage 5B dredge pond.

Figure 45: View south west across the Minnamurra Vegetation Area.

Figure 46: View east along existing dam within the Minnamurra Vegetation Area at site of proposed Stage 5B dredge pond.

Figure 47: View south east across the Minnamurra Vegetation Area towards the site of the proposed Stage 5B dredge pond.

Figure 48: View south east across the Minnamurra Vegetation Area towards the site of the proposed Stage 5B dredge pond.

Figure 49: View east across the Minnamurra Vegetation Area towards the site of the proposed Stage 5B dredge pond.

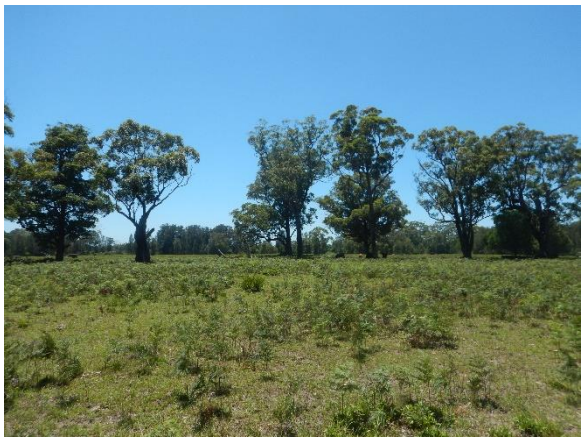


Figure 50: View north west across the Minnamurra Vegetation Area towards the site of the proposed Stage 5B dredge pond.

Figure 51: View west across the Minnamurra Vegetation Area towards the site of the proposed Stage 5B dredge pond.

Figure 52: View east across the Minnamurra Vegetation Area towards the site of the proposed Stage 5B dredge pond.

Figure 53: View south east across the Minnamurra Vegetation Area towards the site of the proposed Stage 5B dredge pond.

Figure 54: View of timber fence posts with concrete footings located within the site of the proposed Stage 5B dredge pond.

Figure 55: View of timber chair located within the site of the proposed Stage 5B dredge pond.

Figure 56: View east across the Minnamurra Vegetation Area towards the site of the proposed Stage 5B dredge pond.

Figure 57: View east from Swamp Road towards Princes Highway, site of proposed pipeline route.

Figure 58: View south east within the 'Anglesboro and Trees' heritage item towards site of proposed pipeline route.

Figure 59: View north west to main homestead building within the 'Anglesboro and Trees' heritage item.

Figure 60: View south east from main homestead building within the 'Anglesboro and Trees' heritage item towards proposed pipeline route.

Figure 61: View east from main homestead building within the 'Anglesboro and Trees' heritage item towards proposed pipeline route.

Figure 62: View north east from main homestead building within the 'Anglesboro and Trees' heritage item towards proposed pipeline route.

Figure 63: View north east from main homestead building within the 'Anglesboro and Trees' heritage item towards proposed pipeline route.

Figure 64: View north from main homestead building within the 'Anglesboro and Trees' heritage item towards proposed pipeline route.

Figure 65: View north east within the 'Anglesboro and Trees' heritage item towards proposed pipeline route.

Figure 66: View north east within the 'Anglesboro and Trees' heritage item towards proposed pipeline route near fence boundary.

Figure 67: View north east within the 'Anglesboro and Trees' heritage item towards proposed pipeline route near fence boundary.

Figure 68: View north east towards proposed pipeline route near fence boundary within the 'Anglesboro and Trees' heritage item, Princes Highway adjacent.

Figure 69: View south along fence line within the 'Anglesboro and Trees' heritage item towards proposed pipeline route.

Figure 70: View north from northern boundary of 'Anglesboro and Trees' towards the site of the 'Dry Stone Wall' heritage item, showing dredge pond within the adjoining property.

Figure 71: View north from Rocklow Road towards the study area, showing the wall within the 'Dry Stone Wall' heritage item located along Rocklow Road.

Figure 72: Detail shot of stone wall within the 'Dry Stone Wall' heritage item on Rocklow Road.

5.0 BUILT HERITAGE ASSESSMENT

5.1 Assessment of significance

The following section provides an overview description and assessment of significance of heritage items that are located within the study area. Information for each item has been extracted from their respective State Heritage Inventory (SHI) database listings on the OEH website.[13]

5.1.1 Dunmore House Complex, Dry Stone Walls and Trees (SLEP 2013 Item No. I027)

Figure 73: View south to front (north) elevation of Dunmore House.

5.1.1.1 Description

The 'Dunmore House Complex, Dry Stone Walls and Trees' heritage item comprises a rural 19th century homestead complex sited on a prominent hillside overlooking the surrounding Shellharbour landscape. The main residence is a two-storey U-shaped house with a symmetrical front, constructed of locally sourced basalt rubble and sandstone. The original portion of the house was built in 1865, with the second storey being added later in 1905. The house contains significant interiors including original cedar joinery and plaster cornices. Several outbuildings constructed of basalt rubble are sited near the house. The property is surrounded by dense plantings, features several Moreton Bay figs and early dry stone walls.

5.1.1.2 Assessment of significance

The following assessment of significance of the 'Dunmore House Complex, Dry Stone Walls and Trees' heritage item has been adapted from its SHI listing, and is presented in Table 5 below.

[13] NSW Office of Environment & Heritage, 'Cottage' 2001. Accessed online at: http://www.environment.nsw.gov.au/heritageapp/ViewHeritageItemDetails.aspx?id=1740002

Table 5: Significance assessment for the 'Dunmore House Complex, Dry Stone Walls and Trees'

Criterion	Explanation
A – Historical Significance	The Dunmore House complex is historically significant as evidence of the 19th century prosperity of the locality. The house itself remains as an outstanding 19th century residence within an intact historic landscape setting. Boundary and other improvements such as dry stone walls, demonstrate the network of tenant farms, provision of housing and community projects. The item has **local** significance under this criterion.
B – Associative Significance	The Dunmore House complex retains strong local historic associations with George Warburton Fuller, Premier of NSW from 1922 to 1925. His father, George Laurence Fuller, constructed the residence, and named it and the surrounding locality 'Dunmore' after his Irish hometown. George Laurence Fuller managed tenant farms on his estate and initiated several locally significant farm houses in the Dunmore area, and the family retain many historic connections and associations within the local district. The item has **local** significance under this criterion.
C – Aesthetic or Technical Significance	The Dunmore House homestead is of considerable architectural merit for its fine external appearance, which makes a strong contribution to the surrounding historic agricultural landscape, and also for its significant interior work and architectural features including ornate ceiling plasterwork and cedar joinery. The house is an excellent example of a Victorian era manor house and the only one of its kind in the area. The excellent use of local materials for the construction of the house further enhances its aesthetic values. The historic Dunmore House complex remains as a distinctive and important landmark within the important Dunmore valley cultural landscape. The landmark importance of the property is demonstrated by the relocation the bypass around it in circa 2006. The drystone walls and plantings are visually and technically significant locally, and considerably enhance and support the intactness and integrity of the homestead complex. It is noted that the fig plantings on the property also provide an increasingly scarce native fauna habitat. The item has **local** significance under this criterion.
D – Social Significance	Dunmore House homestead and other outbuildings and structures were constructed using locally available materials such as basalt, sandstone and cedar, and is similar in colour and texture to a number of local buildings. The house has further significance through its associations with the Fuller family and the early settlement and economic development of the area. The item has **local** significance under this criterion.
E – Research Potential	The construction of Dunmore House, its use of materials and dry stone walls demonstrate techniques of its era, and provide a source of research potential. The item has **local** significance under this criterion.
F – Rarity	Dunmore House is rare at both a local and State context. The dry stone walls that are within the homestead complex are locally rare and a distinctive historic element in the surrounding region. Figs on the property remain as an increasingly scarce natural feature and as increasingly rare native habitat. The item has **local** significance under this criterion.
G – Representativeness	Dunmore House is an outstanding example of a substantial 19th century country residence. The dry stone walls are representative of both their type and their construction within the local setting. Tree plantings are representative of their species. The item has **local** significance under this criterion.

5.1.1.3 Statement of significance

'Dunmore House' possesses an individual architectural style and makes use of materials that were readily available in the surrounding area; basalt rubble and cedar.

The home has strong associations with the early 1920s Premier of NSW, George Warburton Fuller, and is therefore of significance to the development of NSW.

It has links with early industry and Shellharbour (quarrying, shipping, dairying) and the Fuller family who were prominent citizens in the locality and large landholders of the 19th century (SHR statement). Also noteworthy is the setting of the impressive early colonial house, built by George Laurence Fuller, on a prominent hilltop site beside the Princes Highway.

It is surrounded by large mature trees including substantial Moreton Bay figs 'Ficus Macrophyla' that contribute to the wide cultural landscape, and dry stone walls that were instigated by Fuller for his surrounding tennant farms.

5.1.2 Minnamurra Vegetation Area (SLEP 2013 Item No. I358)

Figure 74: View east within the Minnamurra Vegetation Area. (Source: Artefact Heritage 2018)

5.1.2.1 Description

The ‘Minnamurra Vegetation Area’ heritage item adjoins the significant wetland of the Minnamurra River estuary, and contains endangered populations and threatened ecological communities of flora and fauna species within an area of around 120m^2. The landscape heritage item contains a variety of ecological communities including Bangalay-Banksia forest, Wattle forest, Swamp oak forest, Saltmarsh, Mangrove shrubland, Mangrove forest and Redgum Stringybark forest.

5.1.2.2 Assessment of significance

The following assessment of significance of the ‘Minnamurra Vegetation Area’ heritage item has been adapted from its SHI listing, and is presented in Table 6 below.

Table 6: Significance assessment for the 'Minnamurra Vegetation Area'

Criterion	Explanation
A – Historical Significance	The Minnamurra Vegetation Area is listed for its values as an important remnant ecological landscape, and as such is not considered to retain historical significance. The item is not considered to reach the threshold for **local** significance under this criterion.
B – Associative Significance	The Minnamurra Vegetation Area is listed for its values as an important remnant ecological landscape, and as such is not considered to retain any important associations or associative significance. The item is not considered to reach the threshold for **local** significance under this criterion.
C – Aesthetic or Technical Significance	The Minnamurra Vegetation Area is listed for its values as an important remnant ecological landscape, and as such is not considered significant for its aesthetic qualities. The item is not considered to reach the threshold for **local** significance under this criterion.
D – Social Significance	Whilst the Minnamurra Vegetation Area is an important landscape item, it does not appear to retain any substantial social significance within the local community. The item is not considered to reach the threshold for **local** significance under this criterion.
E – Research Potential	The Minnamurra Vegetation Area remains as a major marine habitat and hatchery, and is considered to have research potential associated with this value. The item has **local** significance under this criterion.
F – Rarity	The Minnamurra Vegetation Area remains as an increasingly rare habitat supporting threatened flora and fauna species. This rarity contributes to the high conservation value of the item. The item has **local** significance under this criterion.
G – Representativeness	The Minnamurra Vegetation Area is representative of the environment that would have once dominated this coastal floodplain area adjoining the Minnamurra River. These environments are becoming increasingly at risk, enhancing the representative values of the item. The item has **local** significance under this criterion.

5.1.2.3 Statement of significance

Bordering and supporting the nationally important wetland of the Minnamurra River estuary, the vegetative area has very high conservation value for both terrestrial and aquatic biodiversity. It contains endangered populations, endangered threatened ecological communities, and threatened flora and fauna species.

Significant mangrove and salt marsh communities support several vulnerable and migratory bird species protected under international agreement, and nationally recognised threatened fish species.

5.1.3 'Anglesboro' and Trees (SLEP 2013 Item No. I028)

Figure 75: View west to front (east) elevation of 'Anglesboro' cottage. (Source: Artefact Heritage 2018)

5.1.3.1 Description

The 'Anglesboro' and Trees heritage item comprises a 19th century Victorian era brick homestead within a rural complex setting with landmark qualities on the brow of a hill alongside Princes Highway. The cottage features a hipped roof with detached wrap around verandah, and is set amongst significant mature plantings with various outbuildings. A low post and rail timber fence borders the property.

5.1.3.2 Assessment of significance

The following assessment of significance of the 'Anglesboro' and Trees heritage item has been adapted from its SHI listing, and is presented in Table 7 below.

Table 7: Significance assessment for the 'Anglesboro' and Trees heritage item

Criterion	Explanation
A – Historical Significance	The 'Anglesboro' house and farm complex retain historic significance as evidence of the early division of the Dunmore estate into smaller holdings, and the evolution of the dairying industry in the region. The house remains as an important landmark in the area. The item has **local** significance under this criterion.
B – Associative Significance	'Anglesboro' maintains local historic associations with the locally influential Fuller family and Dunmore estate. The property also has local historic associations with 'Mayfield' and early pioneers and long-term owners the Creagan family, who have continuously occupied the property for over 130 years. The item has **local** significance under this criterion.
C – Aesthetic or Technical Significance	The Victorian era 'Anglesboro' house has local aesthetic value for its architectural style and use of materials. The house has landmark qualities, which are supported by its pleasing topographical setting on the ridge line between several mature trees. The item has **local** significance under this criterion.

Criterion	Explanation
D – Social Significance	'Anglesboro' is noted in documents and has been the subject of research by members of the local community, which demonstrates the item's social values. The item has **local** significance under this criterion.
E – Research Potential	The 'Anglesboro' property has been the subject of research by members of the local community, which demonstrates the item's research potential. The item has **local** significance under this criterion.
F – Rarity	The 'Anglesboro' property, including the house and tree plantings, remain as locally rare and distinctive historic elements in the surrounding region, which is undergoing an increasing degree of change and development. The item has **local** significance under this criterion.
G – Representativeness	The 'Anglesboro' house is representative for its Victorian era, and the selected tree plantings are representative of their species and historic integration in homestead complexes in the area. The item has **local** significance under this criterion.

5.1.3.3 Statement of significance

Anglesboro is a pleasing brick Victorian era farm house located on the brow of the hill ridge with historic connections at a local level with the early settlement of the significant Dunmore valley.

The home has historical associations with owner of Dunmore House, George Laurence Fuller and his Dunmore tenant farms. It also has link with the local dairying industry, and links with the Creagan family.

5.1.4 Rocklow Road Dry Stone Wall (SLEP 2013 Item No. I253)

Figure 76: View north from Rocklow Road to significant dry stone wall. (Source: Artefact Heritage 2018)

5.1.4.1 Description

The Rocklow Road Dry Stone Wall heritage item comprises a typical dry stone wall dating from the mid-19th century that is constructed without mortar or cement, using traditional dry packing methods. The stone is locally derived. The stone wall is located along the southern boundary of the lot and runs along the length of Rocklow Road.

5.1.4.2 Assessment of significance

The following assessment of significance of the Rocklow Road Dry Stone Wall heritage item has been adapted from its SHI listing, and is presented in Table 8 below.

Table 8: Significance assessment for the Rocklow Road Dry Stone Wall heritage item

Criterion	Explanation
A – Historical Significance	The Rocklow Road Dry Stone Wall has local significance for its historical association with the 19th century pioneering settlers and the rural activities of agriculture and pastoralism which shaped the Shellharbour landscape, was the basis of the economy and encouraged early growth in the locality. These walls remain as tangible evidence of the industries that have continued to the present day. The item has **local** significance under this criterion.
B – Associative Significance	The Rocklow Road Dry Stone Wall is associated with pioneering settlers from Britain, Ireland and more broadly from other parts of Europe, who introduced stone walling techniques to Shellharbour during the early settlement and development of the area. The item has **local** significance under this criterion.
C – Aesthetic or Technical Significance	The Rocklow Road Dry Stone Wall is of local significance for its aesthetic and scenic qualities, which suggest historical ruins and provide a distinctive sense of age in the district. The strong sculptural forms visually define the landscape, and are a strong contributing landscape feature in the Shellharbour area. The item has **local** significance under this criterion.
D – Social Significance	The Rocklow Road Dry Stone Wall is noted by the local community and has been a subject of research, which demonstrates the item's social values. The item has **local** significance under this criterion.
E – Research Potential	The Rocklow Road Dry Stone Wall has local significance for the potential to yield information about stone walling techniques and historical land use in the area. The item has **local** significance under this criterion.
F – Rarity	The once common stone walls are becoming increasingly rare in the locality as they have been progressively replaced with other fencing materials, especially timber and wire. The item has **local** significance under this criterion.
G – Representativeness	The Rocklow Road Dry Stone Wall is representative of dry stone walls in the Shellharbour area. The item has **local** significance under this criterion.

5.1.4.3 Statement of significance

These remnant stone walls are historically significant as evidence of early settlement patterns, farming techniques and prominent early industries in the locality which shaped the local landscape.

Also significant are associations with the pioneering settlers from Britain, Ireland and other parts of Europe who brought their stone walling techniques with them to Shellharbour.

Now a rare feature in the local landscape, these stone walls are aesthetically significant for their scenic qualities which suggest age and their strong forms visually define the landscape. They run the entire length of Rocklow Road.

6.0 ARCHAEOLOGICAL ASSESSMENT

6.1 Introduction

Non-Aboriginal archaeological potential is defined as the potential of a site to contain historical archaeological relics, as classified under the Heritage Act. Non-Aboriginal archaeological potential is assessed by identifying former land uses and associated features through historical research, and evaluating whether subsequent actions (either natural or human) may have impacted on evidence for these former land uses. The following section constitutes a preliminary archaeological assessment within the project modification site, where ground disturbing activities are anticipated.

6.2 Discussion of archaeological potential and significance

6.2.1 Methodological framework

The potential for the survival of archaeological relics in a particular place is significantly affected by activities which may have caused ground disturbance. These processes include the physical development of the site (for example, phases of building construction) and the activities that occurred there. The likelihood for the survival of these relics (i.e. their archaeological potential) is distinct from the archaeological/heritage significance of these remains, should any exist. For example, there may be 'low potential' for certain relics to survive, but if they do, they may be assessed as being of State significance.

Identification of the potential historical archaeological resource of the study area is based on the review and understanding of its land use and development (site formation processes) through historical research, and evaluating whether subsequent actions (either natural or human) may have impacted on evidence of former land use phases.

Table 9: Grades of archaeological potential

Grading	Justification
Nil	No evidence of historical development or use, or where previous impacts such as deep basement structures would have removed all archaeological potential
Low	Research indicates little or low intensity historical development, or where there have been substantial previous impacts, disturbance and truncation in locations where some archaeological remains such as deep subsurface features may survive
Moderate	Analysis demonstrates known historical development and some previous impacts, but it is likely that archaeological remains survive with some localised truncation and disturbance
High	Evidence of multiple phases of historical development and structures with minimal or localised 20th century development impacts, and it is likely the archaeological resource would be largely intact

Assessing significance for archaeological sites can be difficult, in that the extent and nature of the remains is generally unknown and value judgements based on potential or expected attributes need to be made. Heritage significance in NSW is assessed using the Heritage Council of NSW's seven specific criteria based on the principles of the *Burra Charter*. How these apply to archaeological heritage assessment is further explained in Assessing Significance for Historical Archaeological Sites

and Relics.[14] Consideration of the research potential of an archaeological resource is necessary in determining archaeological significance. In addition, the expected intactness or integrity of an archaeological resource influences the evaluation of research potential and significance.

6.2.2 Overview of previous and current structures

The modification site has retained a rural character from the time of initial land grants in the early decades of the 19th century, including Wentworth's large Peterborough Estate landholding. Analysis of historic plans and aerial photographs indicate that the study area has always been on the periphery of settlement within the Shellharbour region. As a result, structural development within the modification site has been limited and mainly associated with the historic Dunmore House and associated 'Anglesboro' rural properties, both of which were established in the mid to late-19th century.

At the time of this assessment, no historical subdivision plans or maps were located that show the location of early development within the study area. The first known buildings within the modification site were Dunmore House constructed in 1865, and 'Anglesboro' which was established as a tennant farm associated with Dunmore House during the early 1880s.

The earliest historical aerial photography of the area taken in 1948 indicate that the study area remained a predominantly undeveloped semi-cleared agricultural landscape at this time. Several small structures located around 140m to the west of Dunmore House appear in the 1948 aerial. These structures were likely agricultural outbuildings within the Dunmore House property, or otherwise possibly a small residence within an associated tennant farm. No other structures appear within the project modification site.

An historical aerial photograph taken of the area in 1961 indicates that by this time, a circular pond and plantings had been added at Dunmore House to the north east of the main homestead, along with a series of fence lines. No other structures appear within the modification site at this time.

The modification site does not contain any structures at present, and is predominantly used as agricultural land to graze livestock.

6.2.3 Assessment of historical archaeological potential

The following is a list of the typical types of archaeological remains that have been found in early to mid-nineteenth century residential archaeological sites.

- Structural remains associated with earlier buildings may include;
  - footings
  - early in ground services including sandstone, timber, brick and ceramic drains.
- Other types of structures, typically found in the rear yards of early houses and generally not included on early plans (and therefore difficult to locate within certainty), may include;
  - wells
  - cesspits
  - rubbish pits
  - reservoirs
  - cisterns
  - sheds.
- Other types of archaeological remains often found in agricultural contexts may include;
  - evidence for gardens, layout and use of the yard areas

[14] Heritage Branch, Department of Planning NSW, Heritage Manual 2009 – 'Assessing Significance for Historical Archaeological Sites and 'Relics''.

- fence lines which may assist with clarification of lot boundaries and indicate the internal use of lots
- evidence of land clearing or modification
- evidence of outbuildings and sheds (postholes)
- rubbish dumps
- other occupational debris.

A series of gradations of potential have been identified and mapped to indicate the degree to which archaeological remains are likely to survive within the project modification site. The identified levels of archaeological potential are:

Nil Potential: significant subsurface impacts have occurred within the area that are likely to have removed deeper sub-surface features such as wells, cesspits and their artefact-bearing deposits may survive and/or no known structures have occupied the area, nor have any significant activities taken place within it.

Low Potential: while there is likely to be quite high impacts in these areas, deeper sub-surface features such as wells, cesspits and their artefact-bearing deposits may survive.

Moderate Potential: while there are impacts in this area a range of archaeological remains are likely to survive across the site, including building footings and shallower remains as well as deeper sub-surface features.

High Potential: substantially intact archaeological remains could survive in these areas.

6.2.3.1 Phase 1: Early land use and grants 1810-1865

Phase 1 may contain archaeological evidence of early land grants, settlement patterns and development of the land within the modification site. This includes former access ways, fence lines, and evidence of early farming practices. The removal of vegetation, and preparation of the land for agricultural use, would have been the earliest land-use. Potential archaeological remains typically associated with nineteenth century clearing and agricultural use are ephemeral in nature. Activities such as tree clearance, fence construction, the development of unsealed roads and agricultural planting leave little material evidence and are not likely to be identified.

Evidence of the original land grants within Wentworth's Peterborough Estate would be ephemeral and are unlikely to be visible in the archaeological record. The land was largely divided into paddocks and lots for agriculture, and later subdivisions within the modification site for housing were not known to be developed until Phase 2. There is no evidence that any structures were constructed on land within the study area during this phase, and any early residences associated with farmers are unlikely to have been substantial in the early years of settlement within the region.

There is nil-low potential for archaeological remains associated with this period of development to be present within the modification site.

6.2.3.2 Phase 2: Early subdivision and Dunmore House 1865-1880s

During this phase the land within Wentworth's Peterborough Estate was subdivided. Subdivisions for the Peterborough Estate would include ephermeal remains such as land divisons and possible remains of structures not identfied through early records. The first known structure within or near the modification site was established in 1865 with the construction of Dunmore House. Potential archaeological remains dating to the 1860s could include brick footings, outbuildings, evidence of sheds, postholes, rubbish deposits, yard scatters and artefact deposits associated with Dunmore House.

It is noted that the modification area is not within the homestead complex or near any of the extant buildings and structures within the Dunmore House Complex, Dry Stone Walls and Trees heritage item, which would have higher potential for archaeological remains and occupation deposits.

The remainder of the modification site has remained undeveloped over time, and primarily used for agricultural grazing. This includes former access ways, fence lines, and evidence of early farming practices. Structures for the shelter of livestock, sheds and outbuildings may have been located throughout the study area. These structures are rarely documented in contemporary plans or accounts. Rural structures were typically light-weight and constructed of locally sourced materials, timber or stone. Archaeological remains of these types of structures seldom survive intact in the archaeological record, as they were not intended to be permanent. Building materials were often re-used and removed to other locations. Agricultural buildings were not intensely inhabited and are therefore rarely associated with an artefactual resource. Therefore, there is low potential that archaeological remains associated with undocumented outbuildings and shelters would be located within the study area.

There is no evidence from available historical photographs and plans of former residences within the rest of the study area. It is therefore unlikely wells, rubbish pits or other artefact bearing deposits from this phase are located within the study area, although archaeological evidence could include former access ways and fences lines where disturbance to the land has been minimal.

There is low potential that remains of the buildings associated with this phase of use remain within the modification site. It is unlikely, however, that remains from this phase of use would reach the local significance threshold. This is discussed further in Section 6.3.

6.2.3.3 Phase 3: Continued development of local area 1880s-1960s

Phase 3 relates to the continued development of the modification site for agricultural pursuits and ongoing subdivisions. During the 1880s, portions of the Dunmore House estate within the study area were subdivided to establish tennant farms, including the nearby ‘Anglesboro’. Underfloor deposits are unlikely to be associated with a building post-dating 1880 due to construction techniques that were commonplace at this time. The introduction of tongue-and-groove flooring, for example, has been found to significantly reduce the amount of accumulated refuse under floorboards and therefore limit the potential for occupation deposits.

Evidence of land use during this phase could include former access ways, fence lines, and evidence of farming practices. Agricultural structures including sheds, outbuildings and informal huts may have been located throughout the modification site, as these structures are rarely documented in contemporary plans or accounts. Agricultural buildings were not intensely inhabited and are therefore rarely associated with an artefactual resource. The earliest available aerial photograph of the study area in 1948 shows a cluster of structures having been located to the west of Dunmore House, which are likely to have been associated agricultural outbuildings. An aerial photograph taken in 1961 shows that by this time, most of the structures had been removed. No other structures appear within the study area in the aerial imagery.

**Figure 77: Historical aerial photograph of the study area in 1948 showing outbuilding located within the project modification site
(Source: Shellharbour City Council)**

**Figure 78: Historical aerial photograph of the study area in 1961 showing outbuilding located within the project modification site
(Source: Shellharbour City Council)**

There is low to moderate potential for remains of the buildings associated with this phase of use to remain within the modification site. It is unlikely, however, that remains from this phase would reach the local significance threshold. This is discussed further in Section 6.3.

6.2.3.4 Phase 4: Modern development 1960s-present

Phase 4 relates to the continued development of the study area for agricultural and industrial pursuits. Historical aerial photography of the region from the 1960s onwards demonstrates the modification site was devoid of any built structures or major elements. An aerial photograph of the area in 2004 shows that by this time, a large horse barn had been added to the west of Dunmore House adjacent to Fig Hill Lane. During this phase, portions of the study area were resumed for extractive industry purposes and the area underwent an additional change with the construction of the Princes Highway bypass carriageway.

There is low to moderate potential for remains of the buildings associated with this phase of use to remain within the modification site. It is unlikely, however, that remains from this phase would reach the local significance threshold. This is discussed further in Section 6.3.

6.3 Assessment of archaeological significance

This section assesses the heritage significance of the known or potential archaeological remains outlined in Section 6.3. Similar to other types of heritage items, archaeological remains should be managed in accordance with their significance. Assessing the heritage value of archaeological remains is complicated by the fact that their extent and nature is often unknown. Judgement must therefore be based on expected or potential attributes.

The *NSW Heritage Manual* provides the framework for the following significance assessment of the study area. These guidelines incorporate the aspects of cultural heritage value identified in the *Burra Charter* (Australia ICOMOS 2013). The Heritage Branch (now Heritage Division) has also issued the 2009 *Assessing Significance for Historical Archaeological Sites and 'Relics* .[15] and the 1996 *Archaeological Assessment Guidelines*.[16]The assessment of historical archaeological sites requires a specialised framework in order to consider the range of values of an archaeological site.

6.3.1 Assessment against the NSW heritage assessment guidelines

The significance of the potential archaeological resource, defined as being all potential archaeological remains within a site as identified in Section 5.4, has been assessed using the NSW heritage assessment criteria and is outlined in Table 10.

Table 10: Consideration against NSW heritage assessment criteria

Criteria	Discussion
Associations with individuals, events or groups of historical importance NSW Heritage Criterion A, B and D	If an artefactual or structural archaeological resource associated with the earliest occupation of the modification site is identified, it may have the ability to provide information relating to the establishment of Wentworth's Peterborough Estate and early land uses during this time. If remains are found to be intact and substantial, they may contribute to our knowledge of the development of early rural settlement in the Shellharbour region, and potentially early agricultural practises in this region (including the extent of land clearance, crop types, range and use of outbuildings, etc). If the modification site contains the remains of former structures and features

[15] NSW Heritage Branch 2009
[16] NSW Heritage Office 1996: 25 – 27

Criteria	Discussion
	associated with a substantial artefactual resource, analysis may provide insight into the preferences and life-ways of the former inhabitants of the area. The modification site is likely to have associations with current and former residents of Dunmore and the wider Shellharbour district. There is likely to be local interest in the history and archaeology of the modification site. There is potential that archaeological remains in the modification site would be able to be linked directly to the locally influential Fuller or Creagan families. **A substantial and intact potential archaeological resource associated with Phase 1 and Phase 2 of the development of the modification site would have local significance under this criterion, although it is unlikely that an archaeological resource dating from this phase would remain.**
Aesthetic or technical significance NSW Heritage Criterion C	It is acknowledged that whilst exposed archaeological remains do have some aesthetic qualities, these are primarily due to a connection to the history of a place, or artefactual remains, and are not considered aesthetically significant in and of themselves. Remains are likely to be typical of early structures and deposits, and unlikely to demonstrate technical significance. **The potential archaeological resource does not meet the local significance threshold under this criterion.**
Ability to demonstrate the past through archaeological remains NSW Heritage Criterion A, C, F and G	The modification site has the potential to yield archaeological remains which may provide information regarding the evolving agricultural and pastoral activities during early settlement within the Shellharbour region. Archaeological remains associated with the earliest phase of occupation of the area may yield information relating to early 19th century construction techniques, and contain an artefactual resource associated with former residents. In particular, intact artefact-bearing structures or deposits, such as wells, rubbish pits and occupation deposits, may provide an archive of information that may not be able to be ascertained through other historical sources. Few examples of early 19th century residences from Dunmore and the surrounding towns in the Shellharbour region have been archaeologically investigated. It is possible that an intact and substantial archaeological resource associated with this early phase would have local significance under this criterion. **A substantial and intact potential archaeological resource associated with Phase 1 of the development of the modification site would have local significance under this criterion, although it is unlikely that an archaeological resource dating from this phase would remain.**
Archaeological research potential NSW Heritage Criterion E	Should artefact bearing deposits be identified (i.e. discarded within cesspits / wells, rubbish pits or occupation deposits) these remains have the potential to provide information unavailable elsewhere, particularly as little is known about the nature of the occupation of the study area in the early to mid nineteenth century. Artefact-rich deposits can provide data related to the preferences (ie food and drink), occupations, domestic activities and cultural practises (ie smoking, drinking, cottage industry, games) and socio-economic standing of the former inhabitants of the modification site. The archaeological recording, analysis and interpretation of the potential archaeological resource could be expected to contribute to research questions in the local history of the area, such as the development of agriculture, the development of local economies, the building of settlements and the development of domestic and cultural life. **A substantial and intact potential archaeological resource associated with Phase 1 of the development of the study area would have local significance under this criterion, although it is unlikely that an archaeological resource dating from this phase would remain.**

6.4 Overview of archaeological potential and significance

The modification site has nil-low potential to contain locally significant archaeological remains associated with the earliest European development of the study area and wider Shellharbour region under Phase 1, and low potential to contain locally significant archaeological remains associated with the subsequent development of the study area under Phase 2. If high-yield artefact-bearing deposits such as wells or rubbish dumps are encountered during works, they would reach the local significance threshold through their ability to provide information regarding the previous occupants of the site location, and potentially contribute to our knowledge of the early historical development of Dunmore and wider Shellharbour region.

The archaeological resource within the modification site with potential to meet the local significance threshold includes:

- Phase 1: Evidence of early land grants to D'Arcy Wentworth including the Peterborough Estate. Potential remains are likely to reach the threshold for local significance for historical, social, rarity and research potential
- Phase 2: Evidence of subdivision of the Peterborough Estate and establishment of Dunmore House. Potential remains are likely to reach the threshold for local significance for their social value.

Potential archaeological remains in the modification site that are not considered to meet the local significance threshold include those associated with:

- Phase 3: Evidence of 1880s development of the study area and continued development until the 1960s
- Phase 4: Late twentieth century development of the study area.

7.0 PROPOSED WORKS

The modification consists of a series of works which are detailed below.

7.1 Additional Stage 5 extraction areas

The modification seeks to establish additional extraction areas (Stage 5) on adjoining private property near the existing site which is to be leased by DSS. The Stage 5 extraction areas would be separated into two separate extraction areas including Stage 5A (immediately south of Riverside Drive), and Stage 5B (to the north of Minnamurra River).

7.1.1 Stage 5A

Sand extraction within Stage 5A would commence prior to Stage 5B operations and will involve clearing and grubbing of established groundcover vegetation. Topsoil will be stripped and stockpiled along the southern edge of the extraction area for later re-use in rehabilitation. A proposed flooding bund comprising an earth embankment would be established around the perimeter of the pond.

The sand would initially be extracted from Stage 5A via excavator to create a large enough pond to float a dredge and accommodate fresh water pumping from the dredge via overland pipeline to the processing plant in Stage 2.

The dredge will then progressively extract sand in an easterly direction. The approximate sand resource to be extracted from Stage 5A is estimated at 234,000 tonnes. Sand will be extracted to a maximum depth of approximately 12m below the water table.

7.1.2 Stage 5B

The commencement of operations within Stage 5B would not commence until approximately two weeks prior to the completion of extraction in Stage 5A. During the two week transition period, two dredges may be operating in tandem to minimise disruption to operations and ensure the supply of sand is not compromised during the transition between extraction areas. Sand would be extracted in the northern end of the Stage 5B extraction area, via excavator to create a large enough pond to float a dredge and accommodate fresh water pumping from the dredge via overland pipeline to the processing plant in Stage 2. A proposed flooding bund comprising an earth embankment would be established around the perimeter of the pond.

The dredge will then progressively extract sand in a southerly direction. The approximate sand resource to be extracted from Stage 5B is estimated at 1,123,000 tonnes. Sand will be extracted to a maximum depth of approximately 27m below the water table.

7.2 Utilities and infrastructure

7.2.1 Pipeline

An overland pipeline would be established from the Stage 5B extraction area to the Stage 2 processing area. The pipeline route would be approximately 2.1km in length, and would comprise two parallel 355mm PVC pipelines.

The pipeline would be temporary infrastructure that will be removed on completion of dredging in the Stage 5 extraction area. Therefore, where possible, the pipeline will be laid above ground to avoid excavation and vegetation clearing and will cross creeks through existing culverts.

7.2.2 Booster pump

Two booster pump stations would be constructed to pump the water and sand through the pipeline from the Stage 5 extraction areas to the processing plant located in the Stage 2 area adjacent to Tabbita Road. The pump stations would be constructed using colorbond materials and sit on an approximately 5m x 5m concrete pad. The water and sand will be pumped from the Stage 5B extraction area over the hill immediately north and will gravity feed to the Stage 2 processing plant. A second booster pump would be positioned at the junction between the pipelines from Stage 5A and Stage 5B to ensure enough pressure to pump the water to the Stage 2 processing area.

An overhead high voltage power line would also be constructed from the existing powerline at 69 Fig Hill Lane (Lot 51 DP 1012246) to the booster pump station. The overhead power line would require installation of power poles.

7.3 Access roads

Fig Hill Lane provides the existing access to the Stage 5 extraction areas. As this existing access is too close to the Princes Highway – Riverside Drive intersection, a new access road is proposed to the Stage 5A extraction area off Riverside Drive, opposite Saltwater Creek Road. The access road would join an unsealed haul road around the perimeter of the Stage 5A extraction area, which joins the existing Fig Hill Lane, a sealed road that heads southwards towards the Stage 5B extraction area. A new unsealed access track will need to be constructed down the slope from where Fig Hill Lane terminates, to the northern end of the Stage 5B extraction area. An unsealed haul road will also be constructed around the perimeter of the Stage 5B extraction area to enable access for maintenance.

The new access roads will be used by light vehicles accessing the site office and parking area adjacent to the Stage 5B extraction area and heavy vehicles delivering fill material to the site.

All existing access arrangements for residents along Fig Hill Lane and Riverside Drive would be maintained during the Stage 5 operations. Fig Hill Lane varies in width and may need to be widened along its entire length to allow safe access for trucks and light vehicles.

7.4 Site office and parking

A portable site office and associated parking area of approximately for 10 light vehicles would be established in the north western corner of the Stage 5B extraction area.

7.5 Rehabilitation

Upon completion, the Stage 5A extraction area would be backfilled, topsoils spread and groundcover vegetation re-established to return the land back to pasture at the request of the landowner. The Stage 5B extraction area would be left as a pond at the request of the landowner and provide future habitat for local fauna.

Figure 79: Proposed modification plan.
(Source: image provided by Element Environmental)

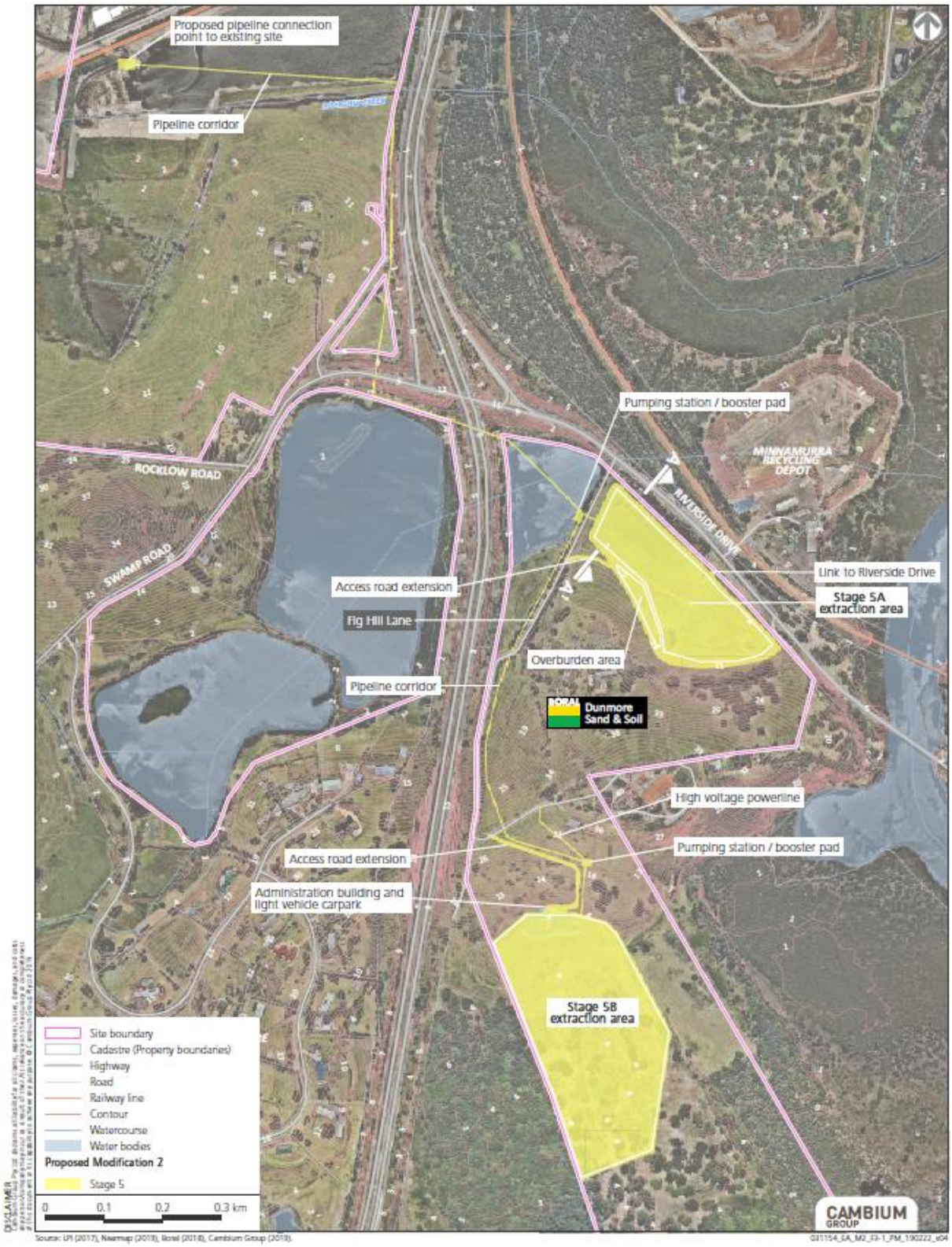
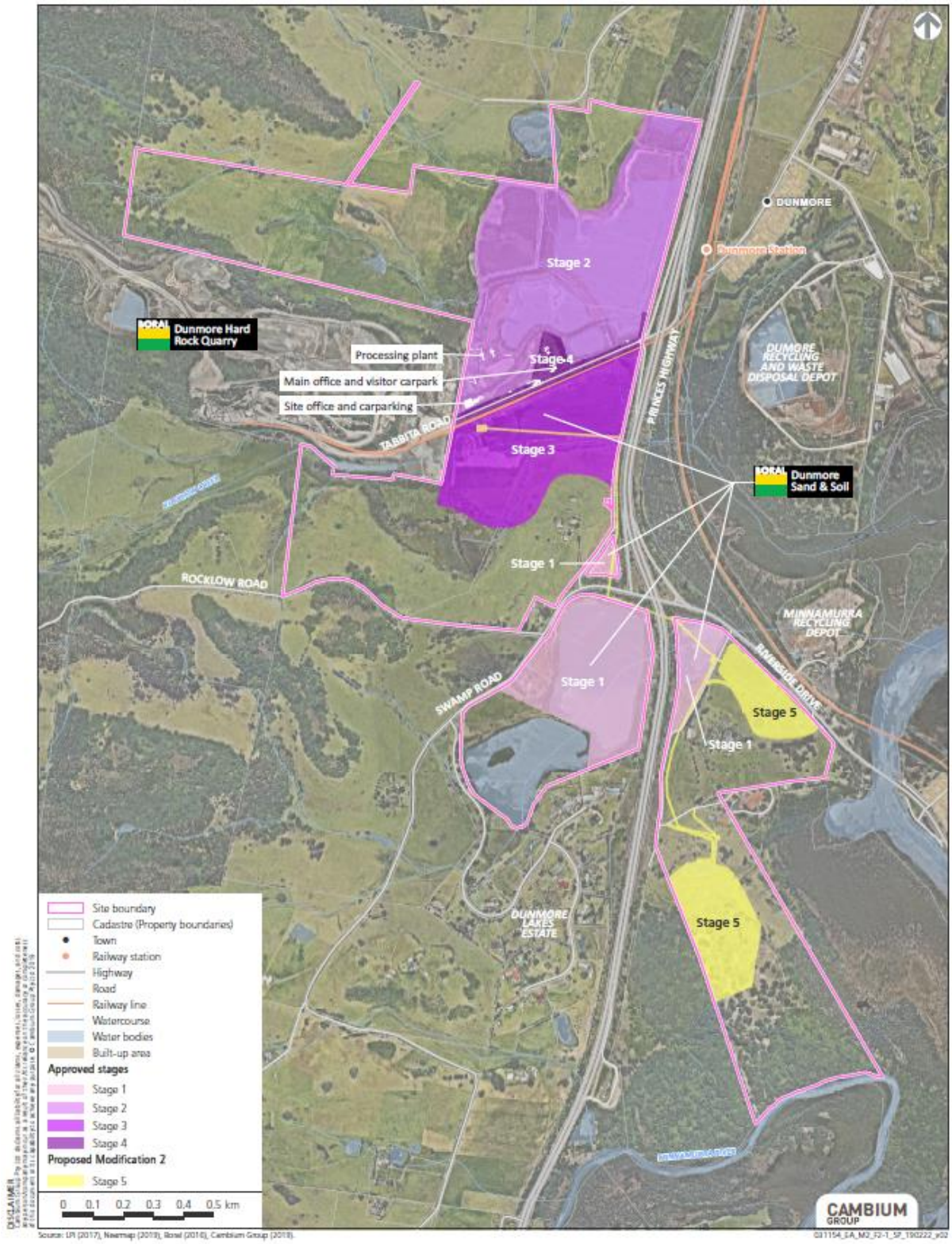


Figure 80: Proposed staging plan.
(Source: image provided by Element Environmental)



8.0 IMPACT ASSESSMENT

The objective of a SoHI is to evaluate and explain how the proposed development, rehabilitation or land use change will affect the heritage value of the site and/or place. A SoHI should also address how the heritage value of the site/place can be conserved or maintained, or preferably enhanced by the proposed works.

8.1 Heritage impact assessment

8.1.1 Dunmore House Complex, Dry Stone Walls and Trees (SLEP 2013 Item No. I027)

8.1.1.1 Physical impact

The modification would involve a range of works that would result in direct physical impact within a large area of the heritage curtilage of the Dunmore House Complex, Dry Stone Walls and Trees. The proposed Stage 5A extraction area, covering an area of 3.42ha, would be sited in the northern portion of the heritage item, adjacent to Riverside Drive and near the existing entry drive to the property. It is noted that this portion of the heritage item primarily comprises undeveloped land that has undergone previous impact by way of clearing and agricultural grazing.

A small area comprising bamboo, exotic plantings and stone rubble is located within the site of the proposed dredge pond, which are remnants of a Japanese style pond that was established circa 1960. A modern concrete livestock trough is also located within the site of the proposed dredge pond. The construction of the proposed Stage 5A extraction area would necessitate removal of these features, although these landscape elements are not considered to represent original or significant fabric within the Dunmore House Complex.

The temporary proposed link from the site of the Stage 5A extraction area connecting to Riverside Drive would result in localised impact to remove a portion of the existing timber post and rail fence located along the northern boundary of the item's heritage curtilage. This modern fence, while sympathetic to the aesthetic qualities of the rural property, does not constitute significant or original fabric within the homestead complex. It is understood that following the completion of the project, the affected portion of fencing would be reinstated. Establishment of the proposed link would also necessitate removal of one large tree located on the northern boundary of the site. While this mature native tree is not a planting that would constitute a significant heritage component within the homestead complex, the tree supports the setting and context of the historic property and its removal would represent an adverse physical impact.

Establishment of an overburden area adjoining the site of the dredge pond covering an area of 2,500m^2 within existing grazing land, along with requirement for an earth bund for flooding protection comprising an embankment around the perimeter of the pond, would be temporary and are not considered to result in any additional adverse heritage impact. A short length of a proposed pipeline connecting to the Stage 5A extraction area and leading north would also be located within the northern extent of the heritage curtilage of the property. It is understood this section of the proposed pipeline, the path of which travels across the existing entry drive and Fig Hill Lane, would be underground. The existing entry drive is not the original driveway to the property, with the original driveway having been formerly located to the east of the homestead complex. Private access to the property via the entry driveway and Fig Hill Lane would not be compromised by the modification.

Following completion of the project, the site of the Stage 5A dredge pond would be infilled to the natural ground level and the land rehabilitated and reverted back for use as agricultural pasture, which would continue the historical use of this part of the historic property. As such, physical impact from the dredge pond and associated infrastructure would be mainly temporary in nature. The

modification would involve construction activities in the vicinity of the heritage item, although as these would be more than 75m away from the nearest built element within the heritage item indirect physical impact by way of vibrations is not anticipated.

The modification would involve ground disturbing activities within the curtilage of Dunmore House Complex, Dry Stone Walls and Trees heritage item within an area that has been identified as having nil to low potential for locally significant archaeological remains, therefore archaeological impact is unlikely. It is also noted that no works are proposed within the homestead complex itself, which is likely to contain higher archaeological potential. Impact to archaeology is discussed in further detail in Section 8.3.

The modification would result in a **moderate** physical impact to the Dunmore House Complex, Dry Stone Walls and Trees heritage item.

8.1.1.2 Visual impact

The modification would involve establishment of the Stage 5A dredge pond, access roads, installation of a pipeline and associated works within the Dunmore House Complex, Dry Stone Walls and Trees heritage item. These works are associated with a range of visual changes and impacts that would occur within the item's heritage curtilage.

Figure 81: View looking north from the main homestead towards the modification site. Site of proposed extraction area and pipeline screened by existing garden plantings.

Figure 82: View looking north east from the homestead towards the modification site. Site of proposed extraction area (indicated by arrows) partially screened by garden plantings.

The proposed dredge pond would be located within the primary view catchment of the historic homestead, which is oriented north and north east. Dunmore House itself is prominently sited on a hill, and retains significant views of the surrounding floodplains and distant landscape setting. The dredge pond would be located to the north and north east of the homestead on the low-lying floodplain within the property. It is noted that while the dredge pond would likely be visible from glimpsed views within the homestead and surrounding garden on the hill, the pond would be largely screened by existing vegetation and plantings surrounding the house (see Figure 81 and Figure 82).

The proposed Stage 5A dredge pond would be visible in views looking towards Dunmore House from surrounding vantage points in the public domain, in particular for motorists travelling along the nearby Riverside Drive. For the duration of the project, the proposed dredge pond and associated infrastructure would detract from these existing views towards the landmark property, although this impact would be temporary in nature and affected views would be reinstated upon completion of the project following rehabilitation of the dredge pond back to ground level for grazing. It is also noted that the proposed flooding bund comprising an earth embankment around the pond would partially screen the extraction area from view for motorists travelling along Riverside Drive and from surrounding publicly accessible vantage points.

The proposed pipeline would be located within the north-eastern corner of the item's heritage curtilage leading from the Stage 5A dredge pond. Due to the unobtrusive location of the pipeline beneath the ridgeline and the low-rise profile of the pipes, it is anticipated that any visual changes would be minor and would not diminish the significant rural character and setting of the historic property.

Establishment of the access road from Riverside Drive to the Stage 5A extraction area would necessitate removal of a mature native tree located on the northern boundary of the site. This tree currently enhances the significant semi-rural setting and context of the historic property and its removal would therefore represent an adverse visual impact.

The visual impact of the modification, mainly relating to the proposed Stage 5A dredge pond and associated flooding bund and overburden area, would be largely temporary in nature. The site of the Stage 5A dredge pond would be infilled and the land reverted back for use as agricultural pasture, which would reinstate the existing rural character and appearance of this part of the property.

The modification would result in a **moderate** visual impact to the Dunmore House Complex, Dry Stone Walls and Trees heritage item.

8.1.2 Minnamurra Vegetation Area (SLEP 2013 Item No. I358)

8.1.2.1 Physical impact

The modification would involve a range of works that would result in direct physical impact within a large portion of the heritage curtilage of the Minnamurra Vegetation Area. The proposed Stage 5B dredge pond, covering an area of 8.12ha, would be sited approximately in the centre to northern portion of the heritage item. Construction of the pond would necessitate removal of all vegetation within this area and would affect the entirety of this part of the ecological item. It is noted that while this portion of the landscape heritage item has been subject to previous impact by way of clearing, agricultural grazing and an existing dam, the large trees in the southern portion of the modification site are contributing elements that support the overall integrity of the surrounding vegetation area.

The modification would also require establishment of a temporary access road and installation of an above ground pipeline with pumping station connecting to the Stage 5B extraction area and running north within the northern extent of the Minnamurra Vegetation Area heritage curtilage. It is understood the proposed route of the access road and pipeline would not impact on any existing trees in this

location or require removal of any vegetation, and the pipeline would be installed above ground for the duration of the project. Establishment of the access road, carpark and site offices within the northern extent of the heritage curtilage of the Minnamurra Vegetation Area would require localised ground disturbances, although this is largely cleared and is used as agricultural grazing land. Establishment of a flooding bund around the perimeter of the pond is not considered to result in any additional physical impact.

Following completion of the project, the Stage 5B dredge pond would be rehabilitated and adjoining pipeline and associated infrastructure decommissioned. Despite the temporary nature of the project, the removal of vegetation and trees within the Minnamurra Vegetation Area for the Stage 5B dredge pond would represent a permanent physical impact to this heritage item that would potentially compromise its identified significant ecological value.

The potential direct and indirect impacts of the proposed modification associated with biodiversity values have been assessed in a Biodiversity Assessment Report (BDAR) prepared in accordance with the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*, *NSW Biodiversity Conservation Act 2016*, *NSW Fisheries Management Act 1994*, and the *Biodiversity Assessment Method* (BAM), published by the OEH.

The BDAR identified that approximately 4.53ha of a Threatened Ecological Community (TEC), the Bangalay Sand Forest of the Sydney Basin and South East Corner bioregions, would be impacted by the proposed modification.

The BDAR found the modification would affect biodiversity, including threatened biodiversity through both direct and indirect impacts during construction and operation. Most impacts on biodiversity would occur during construction from clearing of native vegetation and removal of habitat for a limited range of flora and fauna, with the proposed modification affecting up to 4.53ha of native vegetation as described above within Stage 5B. The extent of direct impacts has been minimised through design (avoidance) and alignment.

It is understood preparation of a Biodiversity Management Plan (BMP) would inform and manage various activities for the duration of the modification to protect and manage important biodiversity values. The BDAR also identifies ecosystem and species offset credit requirements. It is understood an appropriate biodiversity offset strategy would be prepared to offset impacts to biodiversity in accordance with the NSW Biodiversity Offset Policy for Major Projects (NSW Office of Environment and Heritage, 2014).

The Minnamurra Vegetation Area comprises a landscape item devoid of any built elements or features, and as such any indirect impact by way of vibrations during construction and operational activities are not anticipated. As physical impacts within the heritage curtilage of the item would be able to be partially mitigated, the impact of the proposed modification would be moderate in nature.

The modification would result in a **moderate** physical impact to the Minnamurra Vegetation Area heritage item.

8.1.2.2 Visual impact

The establishment of the Stage 5B dredge pond and associated removal of trees and vegetation within over approximately 8 ha in the heritage item would result in permanent visual changes to the existing landscape qualities of the Minnamurra Vegetation Area. While it is noted that the landscape item is mainly of identified significance for its ecological value associated with its rarity, representativeness and research potential, the extent of visual changes within the heritage item and removal of trees and vegetation would still diminish its integrity and intactness.

Visual changes associated with the proposed pipeline, pumping station, carpark, site office and access road within the Minnamurra Vegetation Area would be localised within the overall context of the heritage item, although they would still be discernible from surrounding properties including from distant views within the adjoining Dunmore House Complex, Dry Stone Wall and Trees heritage item. It is noted the infrastructure associated with the Stage 5B dredge pond, including pipeline, access road, carpark and site office, would be temporary and would be removed at the end of the extraction.

The modification would result in a **moderate** visual impact to the Minnamurra Vegetation Area heritage item.

8.1.3 'Anglesboro' and Trees (SLEP 2013 Item No. I028)

8.1.3.1 Physical impact

The modification, while adjacent to the 'Anglesboro' and Trees heritage item, would not involve any works that would result in direct impacts within the heritage curtilage of the historic homestead complex. The modification would involve construction activities in the vicinity of the heritage item, although as these would be more than 75m away from the nearest built element within the heritage item, indirect physical impact by way of vibrations is not anticipated.

The modification would result in a **neutral** physical impact to the 'Anglesboro' and Trees heritage item.

8.1.3.2 Visual impact

The modification would involve installation of an above ground pipeline and associated works adjacent to the 'Anglesboro' and Trees heritage item. The proposed pipeline would be located beyond the existing timber post and rail fence along the item's front (eastern) boundary. Due to the unobtrusive location of the pipeline beneath the ridgeline and the low-rise profile of the proposed pipeline, it is anticipated that any visual changes would be minor and would not diminish the significant rural character and setting of the historic property. The existing fence would further screen any glimpsed views of the pipeline from the cottage.

It is understood the establishment of the proposed pipeline would not necessitate removal of any vegetation immediately adjacent to the item's eastern boundary, which would further maintain the visual character of the heritage item and ensure that views out from the property are not obstructed or diminished. It is noted that the proposed pipeline would be decommissioned and removed upon completion of the project, and as such any minor visual impacts in the locality would be temporary in nature.

The modification would result in a **negligible** (temporary) visual impact to the 'Anglesboro' and Trees heritage item.

8.1.4 Rocklow Road Dry Stone Wall (SLEP 2013 Item No. I253)

8.1.4.1 Physical impact

The modification would not involve any works that would result in direct impacts within the heritage curtilage of this heritage item. The significant fabric of the heritage item, comprising the stone wall that borders the northern side of Rocklow Road, is located a considerable distance from the proposed works location. As the modification would be more than 75m away from the stone wall, indirect physical impact by way of vibrations is not anticipated.

The modification would result in a **neutral** physical impact to the Rocklow Road Dry Stone Wall heritage item.

8.1.4.2 Visual impact

The modification, including establishment of a pipeline on the western side of Princes Highway, would be located a considerable distance from significant fabric within the Rocklow Road Dry Stone Wall, the heritage curtilage of which appears to be mapped off the boundary of the lot. The stone wall itself is located over 300m from the proposed pipeline. The pipeline would be low-rise in profile and screened by existing vegetation and development, and as such no visual impact is anticipated.

The modification would result in a **neutral** visual impact to the Rocklow Road Dry Stone Wall heritage item.

8.1.5 Summary of heritage impacts

A summary of impacts to the heritage items in the vicinity of the study area is provided in Table 11.

Table 11: Built heritage impact assessment summary.

Item Name	Listing No.	Direct (physical) impact	Visual impact	Indirect (vibration) impact
Dunmore House Complex, Dry Stone Walls and Trees	SLEP 2013 I027	Moderate	Moderate	Neutral
Minnamurra Vegetation Area	SLEP 2013 I358	Moderate	Moderate	Neutral
Anglesboro and Trees	SLEP 2013 I028	Neutral	Negligible (temporary)	Neutral
Rocklow Road Dry Stone Wall	SLEP 2013 I253	Neutral	Neutral	Neutral

8.2 Assessment of modification against management policies

The following sections will assess the modification against strategies and policies outlined in the following relevant heritage management plan:

- Shellharbour DCP 2013.

8.2.1 Shellharbour DCP 2013

Shellharbour DCP 2013 provides the following statements relating to character and heritage conservation that are relevant to this assessment, which are covered in the discussion that follows:

Objectives

1. To maintain scenic quality and manage visual impact.

2. To protect the heritage curtilage around heritage items.

3. To protect significant views to and from the heritage item.

4. To ensure that new structures are designed and located so they do not adversely impact the heritage significance of an item or its setting.

5. To design and locate new housing in the vicinity of heritage items to limit visual impact on item.

6. To conserve significant buildings, structures, and trees as visual landmarks.

7. To conserve the significant fabric and finishes of heritage items.

8. To reinforce traditional plantings in grounds of heritage items.

9. To retain the former Minnamurra school group in its setting.

10. To allow interpretation of important heritage values.

Development of heritage items

28.2.1 Development Applications for new structures or buildings must be accompanied by a heritage impact statement that includes an analysis of the heritage curtilage and a visual assessment.

28.2.2 No new structures or buildings are to be erected in the primary view catchment of the item. The primary view catchment is the principal view of the heritage item from the public domain unless it has been defined by a visual assessment and curtilage study that has been approved by Council.

28.2.3 New buildings or structures are not to be located in the saddle between two heritage items.

28.2.4 New buildings and structures are to be located so that they are not visually intrusive.

28.2.5 New buildings or structures must not be higher than the existing heritage item. Where there are a number of items on one property the new structure must be no higher than the lowest building.

28.2.6 New roads or driveways must follow the contours of the landscape with minimal cut and fill (rather than intersecting the contour).

28.2.7 Earthworks including cut and/or fill must be minimised in order to retain the natural contours of the lot.

28.2.8 New farm fences must be unpainted timber and steel post and wire. Painted post and rail fences are not permitted. For domestic fences around the homestead refer to general development advice.

28.2.11 Landscape design must ensure that existing significant trees are maintained as specimen trees.

28.2.12 Landscaping and development around trees must follow the advice in General development controls.

28.2.13 All dry stone walls must be retained. For dry stone wall advice refer to in General development advice.

In order to maintain the existing character and cultural landscape of the Dunmore area, the SDCP 2013 requires that places of recognised heritage significance are retained and conserved. This report provides a heritage impact assessment of the modification in accordance with the provisions of the SDCP 2013, including assessment of impact to heritage curtilage and visual impact. The assessment has identified impacts to several heritage items that are located within the study area.

The modification would result in permanent impacts to the locally listed Minnamurra Vegetation Area. Establishment of the proposed Stage 5B dredge pond would involve removal of all vegetation within this area and would affect the entirety of this part of the landscape item. It is noted that while this portion of the landscape heritage item has been subject to previous impact by way of clearing and agricultural grazing and an existing agricultural dam, the large mature trees are contributing elements that support the overall integrity of the ecology surrounding it.

The modification would result in temporary impacts to the locally listed Dunmore House Complex, Dry Stone Walls and Trees heritage item. The Stage 5A dredge pond, sited in the item's northern extent, is located within the primary view catchment of Dunmore House and would be visible from the public domain, particularly for motorists travelling along the adjacent Riverside Drive. It is noted that visual impact of the modification would be offset by the low-lying nature of the proposed work, absence of any proposed new structures or buildings, and the temporary nature of the project. Earthworks that would alter the natural contour of the floodplain within the historic property would be reinstated upon completion of the project, with the dredge pond being refilled and the grazing pastures rehabilitated. Moreover, it is noted that primary views looking out from the homestead would be maintained by way of visual screening offered by existing plantings surrounding Dunmore House.

The SDCP 2013 contains provisions to conserve and protect heritage listed dry stone walls, which are a distinctive landscape element in the region. The proposed works are located a considerable distance from dry stone walls located within affected heritage curtilages, and no impact to these significant landscape features are anticipated, either direct or indirect by way of vibrations.

8.3 Archaeological impact

The prevailing historic land use of the study area is agricultural. Activities with the potential to impact on the archaeological resource would include excavations required for the Stage 5A and 5B dredge ponds and associated infrastructure comprising access roads, carpark, site office, power poles, and any localised earth works required for the pipelines, although it is understood that most of the length of the pipeline would sit above ground. The potential for locally significant archaeology to be located within the study area has been assessed as nil-low, therefore the proposed works are not considered to result in an archaeological impact.

8.4 Statement of Heritage Impact

A Statement of Heritage Impact for the proposed works is provided in Table 12 below.

Table 12: Statement of heritage impact

Impact	Discussion
What aspects of the proposal respect or enhance the heritage significance of the study area?	The modification has been designed, where possible, to minimise direct impacts on heritage items. Aspects of the proposed modification are temporary in nature. Affected areas within the heritage curtilages of the Dunmore House Complex, Dry Stone Walls and Trees heritage item and 'Anglesboro' and Trees heritage item would be rehabilitated and reinstated upon completion of the project. However, it is noted that removal of vegetation within the heritage curtilages of several items and associated impacts would not respect or enhance the heritage significance of the study area, as discussed below.
What aspects of the proposal could have a detrimental impact on the heritage significance of the study area?	The proposed works, including construction of the Stage 5B dredge pond and associated infrastructure, would encroach upon a large portion of the Minnamurra Vegetation Area heritage curtilage (LEP 2012 Item No I358). This would result in removal of vegetation, movement of machinery, and excavations within the heritage item. Removal of vegetation within the Minnamurra Vegetation Area, which is listed for its landscape and ecological values, would represent permanent physical impacts within the heritage curtilage that would undermine the integrity and intactness of this item. The modification would involve impacts within the Dunmore House Complex, Dry Stone Walls and Trees heritage item associated with the establishment of the Stage 5A dredge pond including overburden area, flooding bund, access road and associated infrastructure, which would occur within around 25% of the item's heritage curtilage. Physical and visual impacts would be mainly temporary in nature, and the existing floodplain that is used for agricultural grazing would be reinstated upon completion of the project. It is noted the removal of a large native tree on the northern boundary of the heritage item for establishment of a proposed link between Riverside Drive and the Stage 5A extraction area would result in a permanent visual and physical impact. The modification would result in changes to the significant agricultural setting of the study area, and the relationship between this setting and existing heritage items including the Dunmore House Complex, Dry Stone Walls and Trees heritage item and the 'Anglesboro' and Trees heritage item, both of which remain as historic properties in the area. The study area retains a semi-rural character that is essential to the area's cultural landscape heritage values. The proposed dredge ponds and associated infrastructure would be visible from surrounding properties and from vantage points along Riverside Drive, although the proposed flooding bund around the perimeter of the pond would partially screen these views towards the property. While the modification would alter the cultural landscape heritage values of the study area, these impacts would be largely temporary and would be mitigated following completion of the project. The overall impact to setting within the broader landscape of Dunmore and the Shellharbour region is considered minor. As areas within the construction and excavation footprint of the modification site have been assessed as having nil-low potential for locally significant archaeology, archaeological impact from the modification is not anticipated. Recommendations contained in Section 9.2 provide guidance on obtaining relevant archaeological permits and procedures to be employed in the event that unexpected finds are encountered during the proposed work.

Have more sympathetic options been considered and discounted?	The proposed modification site provides a way to extract sand within an adequate resource that is in close range of the existing DSS processing facilities and transportation methods. It is noted the Stage 5B dredge pond was originally larger in area, and this area was reduced during design development in an effort to avoid direct impacts within the buffer zone of the coastal wetland that is protected under the Coastal Management SEPP. This reduced the requirement for clearing of ecologically significant vegetation within the listing.

9.0 CONCLUSIONS AND RECOMMENDATIONS

9.1 Conclusions

There are four listed heritage items within the study area. This includes:

- Dunmore House Complex, Dry Stone Walls and Trees (SLEP 2013 Item No. I027)
- 'Anglesboro' and Trees (SLEP 2013 Item No. I028)
- Minnamurra Vegetation Area (SLEP 2013 Item No. I358)
- Rocklow Road Dry Stone Wall (SLEP 2013 Item No. I253).

The proposed modification would have a **moderate** physical and visual impact on the following heritage items:

- Minnamurra Vegetation Area (SLEP 2013 Item No. I358)
- Dunmore House Complex, Dry Stone Walls and Trees (SLEP 2013 Item No. I027).

The proposed modification would have a **negligible** (temporary) visual impact on the following heritage items:

- 'Anglesboro' and Trees (SLEP 2013 Item No. I028).

The proposed modification would have a **neutral** physical impact on the following heritage items:

- 'Anglesboro' and Trees (SLEP 2013 Item No. I028)
- Rocklow Road Dry Stone Wall (SLEP 2013 Item No. I253).

The proposed modification would have a **neutral** visual impact on the following heritage items:

- Rocklow Road Dry Stone Wall (SLEP 2013 Item No. I253).

Indirect impact by way of vibrations during construction works is not anticipated for any heritage items located within the study area.

9.1.1 Non-Aboriginal archaeology

The project modification site has been assessed as having nil to low potential to contain locally significant archaeological remains, and as such archaeological impact is unlikely.

9.2 Recommendations

The following recommendations will aid in mitigating the impact of the modification on nearby heritage items and the wider Shellharbour cultural landscape:

- As the modification has been assessed as potentially resulting in a moderate physical and visual impact on the Minnamurra Vegetation Area (SLEP 2013 Item No. I358) and Dunmore House Complex, Dry Stone Walls and Trees (SLEP 2013 Item No. I027), consultation with Shellharbour

City Council would be required. It is noted that a consultation letter was provided to Shellharbour City Council on 4 December 2018

- Should significant amendments to the design of the proposed modification be made, this report should be updated to assess the potential heritage impact of the revised proposed modification
- Any unexpected archaeological remains within the modification site remain protected by the Heritage Act. If a potential relic is uncovered in the course of the works, work in the vicinity should cease, and the Heritage Division should be contacted for advice
- A heritage induction should be presented to workers before commencement of works in the vicinity of heritage items within the study area. The induction should include the heritage values of the place, avoidance procedure, and contacts for reporting unexpected archaeological finds or inadvertent impacts to heritage items.

10.0 REFERENCES

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APPENDIX H

AIR QUALITY IMPACT ASSESSMENT REPORT

AIR QUALITY ASSESSMENT

DUNMORE LAKES SAND PROJECT MODIFICATION 2

Element Environment

20 February 2019

Job Number 17040688

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Air Quality Assessment
Dunmore Lakes Sand Project Modification 2

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DRAFT - 002	29/01/2019	P Henschke	
FINAL - 001	20/02/2019	P Henschke	

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1 INTRODUCTION

Todoroski Air Sciences has prepared this report for Element Environment on behalf of Dunmore Sand & Soil Pty Ltd (DSS), a subsidiary of Boral Limited. The report presents an assessment of potential air quality impacts associated with the proposed modifications to the existing sand quarry located in Dunmore, New South Wales (NSW) (hereafter referred to as the Project).

To assess the potential air quality impacts associated with the proposed Project, this report incorporates the following aspects:

- A background and description of the Project;
- A review of the existing meteorological and air quality environment surrounding the Project site;
- Quantification of the potential dust emissions generated from the construction and operation of the Project; and,
- A qualitative assessment of potential air quality impacts associated with the Project.

This air quality assessment has been prepared with consideration of the NSW Environment Protection Authority (EPA) document *Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales* (**NSW EPA, 2017**). The assessment forms part of the environmental impact assessment prepared to accompany the modification application for the Project.

2 PROJECT BACKGROUND

2.1 Project setting

The Dunmore Lakes Sand Project (the existing site) is near Dunmore, approximately 3 kilometres (km) south-south west of Shellharbour and 7km north of Kiama, in the Illawarra region of New South Wales. The existing site covers approximately 88 hectares (ha) and is immediately west of the Princes Highway near Tabbita Road, Dunmore.

The proposed Project site is located approximately 1.1km south-southeast of the existing site and is bounded by Riverside Drive to the north and Princes Highway to the west.

The Project site covers an area of approximately 38ha and is on an alluvial coastal flood plain, adjacent to the tidal reaches of the Minnamurra River. The northern portion of the extraction area has been partially cleared and has historically been used for grazing.

Figure 2-1 presents the location of the Project. Land use in the vicinity of the Project site is characterised by existing sand quarry operations, the Dunmore Quarry hard rock extraction activities, residential development and agricultural land. The nearest identified receptor to the Project site is approximately 100 metres (m) to the southwest of Stage 5A (see **Figure 2-1**).

Figure 2-2 presents a pseudo three-dimensional visualisation of the topography in the general vicinity of the Project. The Project site can be characterised as relatively flat on the Illawarra coastal plain. The topography to the west of the site increases significantly in places and forms part of the Great Diving Range.

Figure 2-1: Project setting

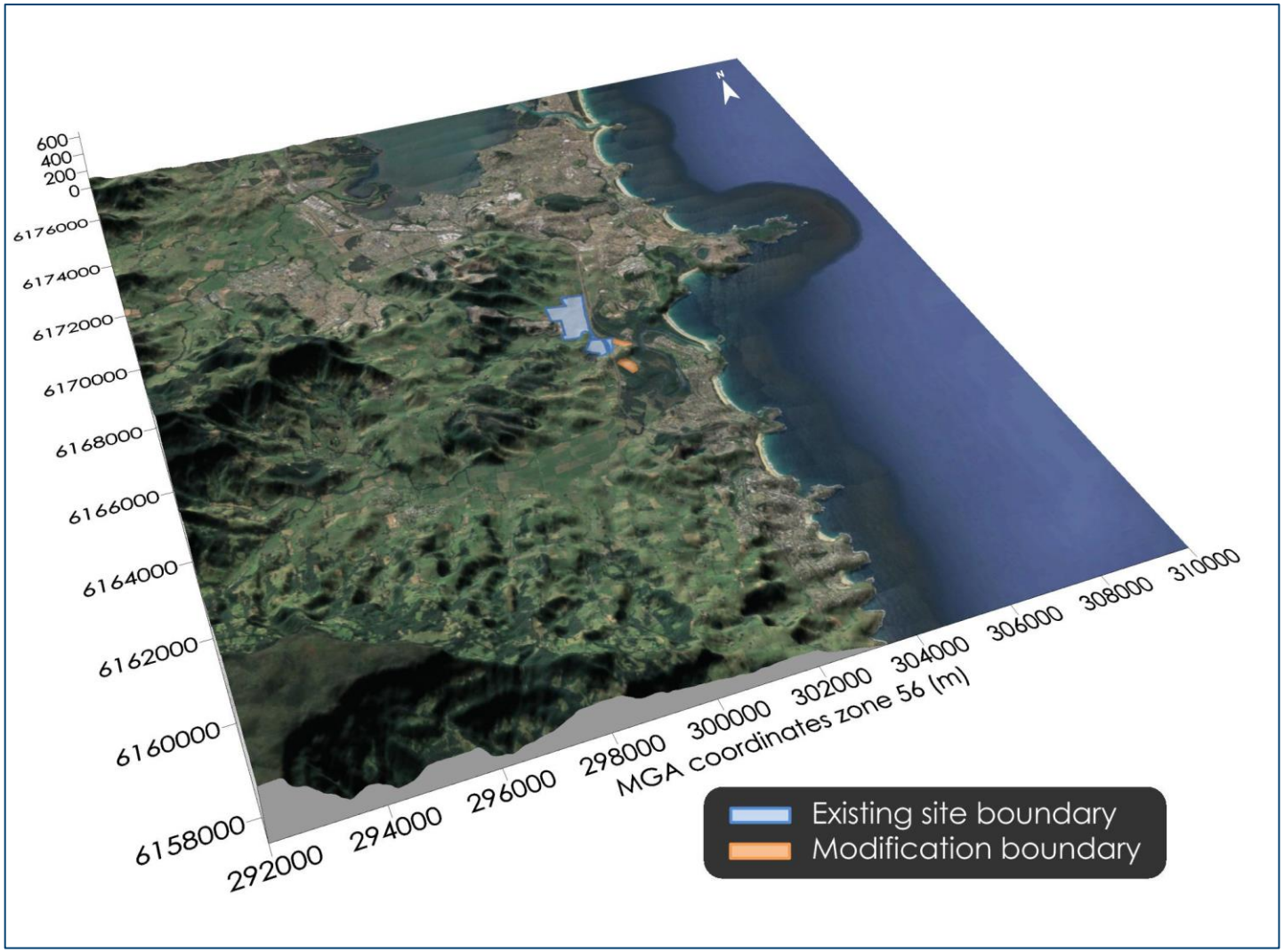

Figure 2-2: Representative visualisation of topography in the area surrounding the Project

2.2 Project description

2.2.1 Existing operations

The approved operations include extraction and transportation of up to 800,000 tonnes per annum (tpa) of sand products over a period of 25 years. The method of extraction of these resources includes both sand and soil extraction by excavator and dredge sand extraction, followed by washing, processing and material blending. The final product is then stockpiled on site until transported to local and regional markets.

Sand is extracted from Stage 3, with Stage 2 completed and Stage 4 yet to be dredged (refer to **Figure 2-1**).

The Stage 2 extraction area covers an area of 37 ha and adjoins the northern boundary of Tabbita Road. The area encompasses a large area of cleared and disturbed grassland and the footprint of existing sand extraction activities, which are nearing completion. Stage 2 also contains the sand processing infrastructure, which will continue to be utilised during sand extraction activities in Stage 3, 4 and eventually Stage 5 (which is the subject of the Project).

Stage 3, which covers an area of 21 ha, adjoins the southern boundary of Tabbita Road. Rocklow Creek transects Stage 3 and flows into a coastal wetland located to the east of the Princes Highway, and is conveyed by a culvert beneath the Highway.

Stage 4, covering five hectares, encompasses the Tabbita Road corridor, which includes the current road and rail access to Dunmore Hard Rock Quarry, located to the west of the site.

The screening and blending plants are located in the Stage 2 portion of the site and are mobile units comprising a hopper, conveyor belts, screens and delivery chute. The components for all blends are fed into the units by a front-end loader in their required proportions and a product stockpile is created. It is normal for at least ten different blended product stockpiles to be present at any one time.

The bulk of the sand that is extracted by dredge from Stages 2, 3 and 4 is processed to yield washed fine sand for direct sale or use in other products. The fine sand is ideally suited as a component of raw material for a wide range of sand-based products, including fine concrete sand or as a component of coarse sand blends. It is expected that between 30% and 50% of the fine washed sand would be used in the manufacture of the coarse sand blends. The grading of the coarse sands is designed to meet the customers' individual requirements.

The operating hours for the approved operations are outlined in **Table 2-1**.

Table 2-1: Approved operating hours

Activity	Day	Time
Dredging and processing	Monday-Saturday Sunday and public holidays	6:00 am to 6:00 pm 8:00 am to 4:00 pm
Excavator extraction	Monday-Saturday Sunday and public holidays	6:30 am to 6:00 pm None
Delivery, distribution and maintenance	Monday-Friday Saturday Sunday and public holidays	5:00 am to Midnight 6:00 am to 6:00 pm 8:00 am to 4:00 pm
Delivery and distribution via Shellharbour Road	Monday-Friday Saturday	7:00 am to 10:00 pm 7:00 am to 6:00 pm

Activity	Day	Time
	Sunday and public holidays	8:00 am to 4:00 pm
Maintenance (if inaudible at neighbouring residences)	Any time	Any time

2.2.2 Proposed modifications

The modification to the Approved Project seeks to establish additional extraction areas (Stage 5) on adjoining private property which is to be leased by DSS. The Stage 5 extraction areas would be separated into two separate extraction areas, namely Stage 5A (immediately south of Riverside Drive), and Stage 5B (to the north of Minnamurra River).

The approximate sand resource to be extracted from Stage 5A is estimated at 234,000 tonnes, whilst Stage 5B would extract approximately 1,123,000 tonnes. These resource volumes are the estimated sand resource only, and additional tonnage of soil (known as overburden) material will also be extracted in addition to the sand resource.

Mobile plant and equipment utilised at the site will be operated across both extraction areas within Stage 5. Extraction methods will be identical to those currently implemented in Stage 2 and 3.

No changes to the consented production volumes or operation hours are proposed as a result of the addition of the Stage 5 extraction area. The existing sand production facilities will process material extracted from the Stage 5 area, with no processing taking place within the Stage 5 site.

2.2.2.1 Stage 5A

Sand extraction within Stage 5A will commence prior to Stage 5B operations and will involve clearing and grubbing of established groundcover vegetation. Topsoil will be stripped and stockpiled along the southern edge of the extraction area for later re-use in rehabilitation.

The sand would initially be extracted from Stage 5A via excavator to create a large enough pond to float a dredge and accommodate fresh water pumping from the dredge, via overland pipeline to the processing plant in Stage 2.

The dredge will then progressively extract sand in an easterly direction.

Sand will be extracted to a maximum depth of approximately 12 m below the water table.

2.2.2.2 Stage 5B

The commencement of operations within Stage 5B will not occur until approximately two weeks prior to the completion of extraction in Stage 5A. During the two week transition period, two dredges may be operating in tandem to minimise disruption to operations and ensure the supply of sand is not compromised during the transition between extraction areas.

Sand will be extracted in the northern end of the Stage 5B extraction area, via excavator to create a large enough pond to float a dredge and accommodate fresh water pumping from the dredge, via overland pipeline to the processing plant in Stage 2.

The dredge will then progressively extract sand in a southerly direction.

Sand will be extracted to a maximum depth of approximately 27m below the water table.

2.2.2.3 Processing and dispatch

An overland pipeline will be established from the Stage 5 extraction area to the Stage 2 processing area, and will comprise two parallel 355 millimetres polyethylene pipelines with pump stations located at the junction of the 5A and 5B pipelines and at the Stage 5B area.

The sand and water pumped from the dredge in the Stage 5B extraction area (and possibly directly from the Stage 5A extraction area) will pass over an initial screen at the Stage 2 processing plant to separate oversize organic matter or debris and into a large wash tank to float out any fines (<75 micrometres [µm]). After washing, the sand will be pumped through a cyclone and stockpiled for further dewatering. Water removed through the dewatering process will drain to an existing fines pond and a secondary settling pond before being pumped back to the Stage 5A and Stage 5B dredge ponds.

Dewatered sand will then be loaded with a front end loader for dispatch by rail or road.

Water pumped from the Stage 5 extraction areas will be returned to these extraction areas via the pumping pipeline.

Sand processing and dispatch at the Stage 2 processing plant will be conducted in accordance with the Approved Project. The proposed modification does not involve any changes to the approved processing and dispatch activities.

2.2.2.4 Importation of fill material

DSS propose to import up to 325,000 tonnes of Virgin Excavated Natural Material (VENM) by road per annum to the Stage 5 extraction area.

The VENM fill is required to:

- backfill the Stage 5A extraction area to natural ground level; and
- stabilise the edges of the Stage 5B dredge pond and the upper portions of the natural batters that form underwater, to allow safe access for vehicles, plant and equipment around the pond's perimeter.

VENM will be transported to the site by road truck/truck and dog and will be tipped directly into the pit(s) and spread with a dozer.

3 AIR QUALITY CRITERIA

3.1 Particulate matter

Particulate matter consists of dust particles of varying size and composition. Air quality goals refer to measures of the total mass of all particles suspended in air defined as the Total Suspended Particulate matter (TSP). The upper size range for TSP is nominally taken to be 30 micrometres (µm) as in practice particles larger than 30 to 50µm will settle out of the atmosphere too quickly to be regarded as air pollutants.

Two sub-classes of TSP are also included in the air quality goals, namely PM_{10}, particulate matter with equivalent aerodynamic diameters of 10µm or less, and $PM_{2.5}$, particulate matter with equivalent aerodynamic diameters of 2.5µm or less.

Particulate matter, typically in the upper size range, that settles from the atmosphere and deposits on surfaces is characterised as deposited dust. The deposition of dust on surfaces may be considered a nuisance and can adversely affect the amenity of an area by soiling property in the vicinity.

3.1.1 NSW EPA impact assessment criteria

Table 3-1 summarises the air quality goals that are relevant to this assessment as outlined in the NSW EPA document *Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales* (**NSW EPA, 2017**).

The air quality goals for total impact relate to the total dust burden in the air and not just the dust from the Project. Consideration of background dust levels needs to be made when using these goals to assess potential impacts.

Table 3-1: NSW EPA air quality impact assessment criteria

Pollutant	Averaging Period	Impact	Criterion
TSP	Annual	Total	90µg/m^3
PM_{10}	Annual	Total	25µg/m^3
	24 hour	Total	50µg/m^3
$PM_{2.5}$	Annual	Total	8µg/m^3
	24 hour	Total	25µg/m^3
Deposited dust	Annual	Incremental	2g/m^2/month
		Total	4g/m^2/month

Source: NSW EPA, 2017

µg/m^3 = micrograms per cubic metre

g/m^2/month = grams per square metre per month

4 EXISTING ENVIRONMENT

This section describes the existing environment including the climate and ambient air quality in the area surrounding the Project.

4.1 Local climatic conditions

Long-term climatic data from the closest Bureau of Meteorology (BoM) weather station at Albion Park (Site No. 068241) were analysed to characterise the local climate in the proximity of the Project. The Albion Park (Wollongong Airport) weather station is located approximately 7km northwest of the Project.

Table 4-1 and **Figure 4-1** present a summary of data from the Albion Park (Wollongong Airport) weather station collected over an 11 to 19 year period for the various meteorological parameters.

The data indicate that January is the hottest month with a mean maximum temperature of 27.0 degrees Celsius (°C) and July is the coldest month with a mean minimum temperature of 6.3°C.

Rainfall varies throughout the year but is highest during the warmer months, with an annual average rainfall of 925.6 millimetres (mm) over 79.8 days. The data indicate that June is the wettest month with an average rainfall of 94.5mm over 6.3 days and September is the driest month with an average rainfall of 42.7mm over 5.1 days.

Relative humidity does not vary notably across the year and the spread between the 9am and 3 pm conditions is minor during the warmer months. Mean 9am relative humidity ranges from 57% in September to 76% in March. Mean 3pm relative humidity levels range from 49% in August to 67% in February.

Wind speeds decrease during the cooler months and peak in spring. There is a greater spread between the 9am and 3pm conditions during the warmer months, compared to the cooler months. Mean 9am wind speeds range from 8.1 kilometres per hour (km/h) in March to 15.3km/h in September. Mean 3pm wind speeds range from 17.1km/h in May to 22.6km/h in September.

Table 4-1: Monthly climate statistics summary – Albion Park (Wollongong Airport) weather station

Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann.
Temperature													
Mean max. temp. (°C)	27.0	26.3	25.3	23.1	20.6	18.1	17.6	18.8	21.4	23.1	24.0	25.6	22.6
Mean min. temp. (°C)	16.9	17.1	15.6	12.2	8.8	7.2	6.3	6.5	8.5	10.8	13.4	15.3	11.5
Rainfall													
Rainfall (mm)	72.9	140.5	122.3	76.9	58.1	94.5	51.4	55.3	42.7	64.5	83.1	67.0	925.6
No. of rain days (≥1mm)	7.8	8.6	7.9	7.3	4.8	6.3	4.8	4.5	5.1	6.4	8.2	8.1	79.8
9am conditions													
Mean temp. (°C)	22.5	22.0	20.2	19.2	15.8	13.0	12.5	14.0	17.1	19.0	19.7	21.4	18.0
Mean R.H. (%)	68	74	76	68	69	73	68	61	57	58	67	66	67
Mean W.S. (km/h)	11.6	9.8	8.1	10.7	12.4	13.6	14.4	15.0	15.3	14.4	12.9	12.7	12.6
3pm conditions													
Mean temperature (°C)	24.8	24.5	23.5	21.3	18.8	16.7	16.2	17.3	19.3	20.4	21.6	23.5	20.7
Mean R.H. (%)	63	67	64	61	58	57	54	49	53	58	63	61	59
Mean W.S. (km/h)	21.6	20.0	18.9	17.7	17.1	17.6	18.1	21.8	22.6	20.9	20.9	21.5	19.9

Source: **Bureau of Meteorology, 2018**

R.H. – Relative Humidity, W.S. – wind speed

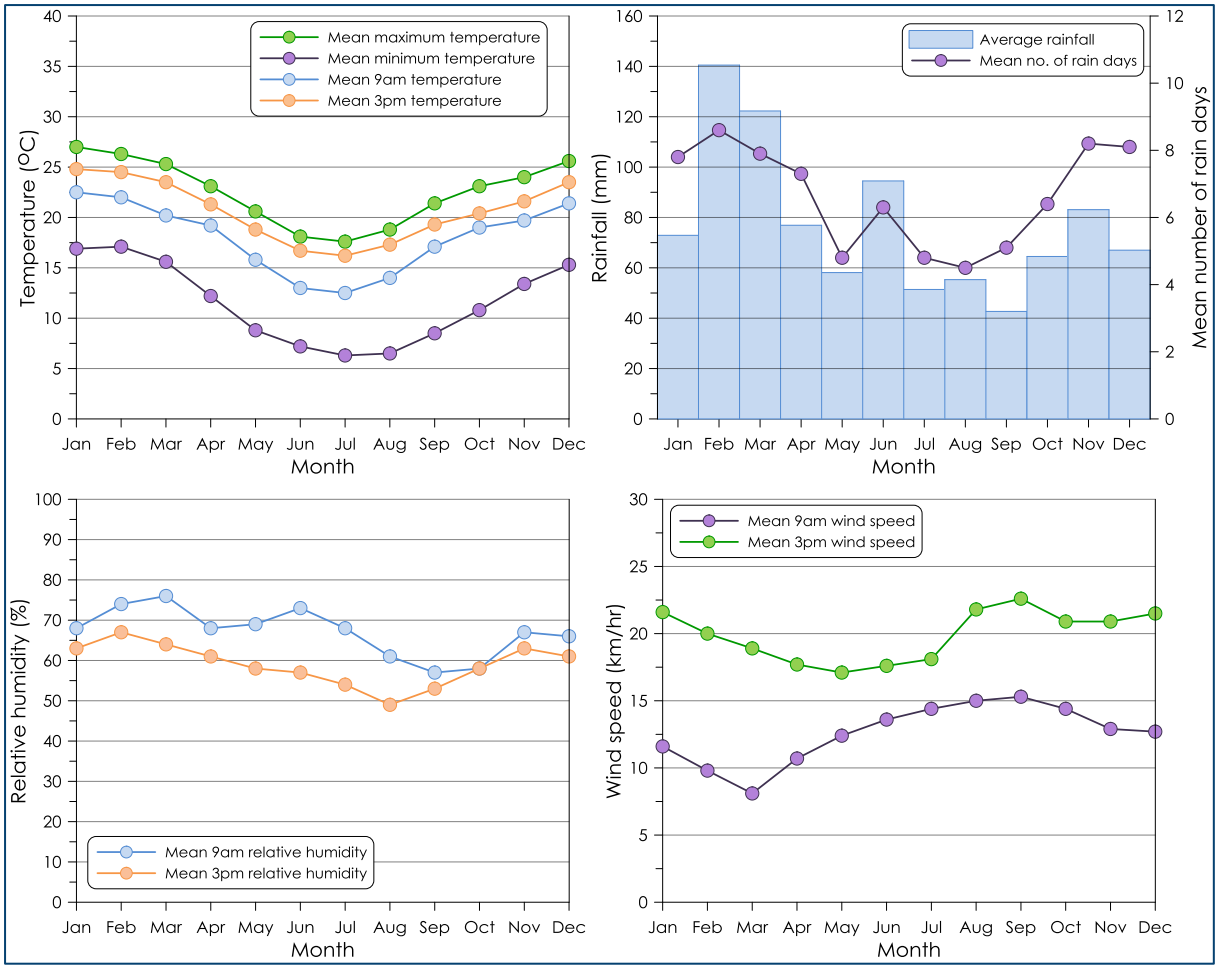

Figure 4-1: Monthly climate statistics summary – Albion Park (Wollongong Airport) weather station

4.2 Local meteorological conditions

Annual and seasonal windroses for the Albion Park (Wollongong Airport) weather station during the 2017 calendar period are presented in **Figure 4-2**. Stronger winds take place during summer and winter. On an annual basis, winds from the west are strongest and most frequent.

In summer, winds coming from the northeast are the most frequent and the strongest. The autumn distribution is similar to the annual distribution but with weaker winds. During winter, winds are typically from the west and the west-southwest. Spring experiences frequent winds from the west and the northeast.

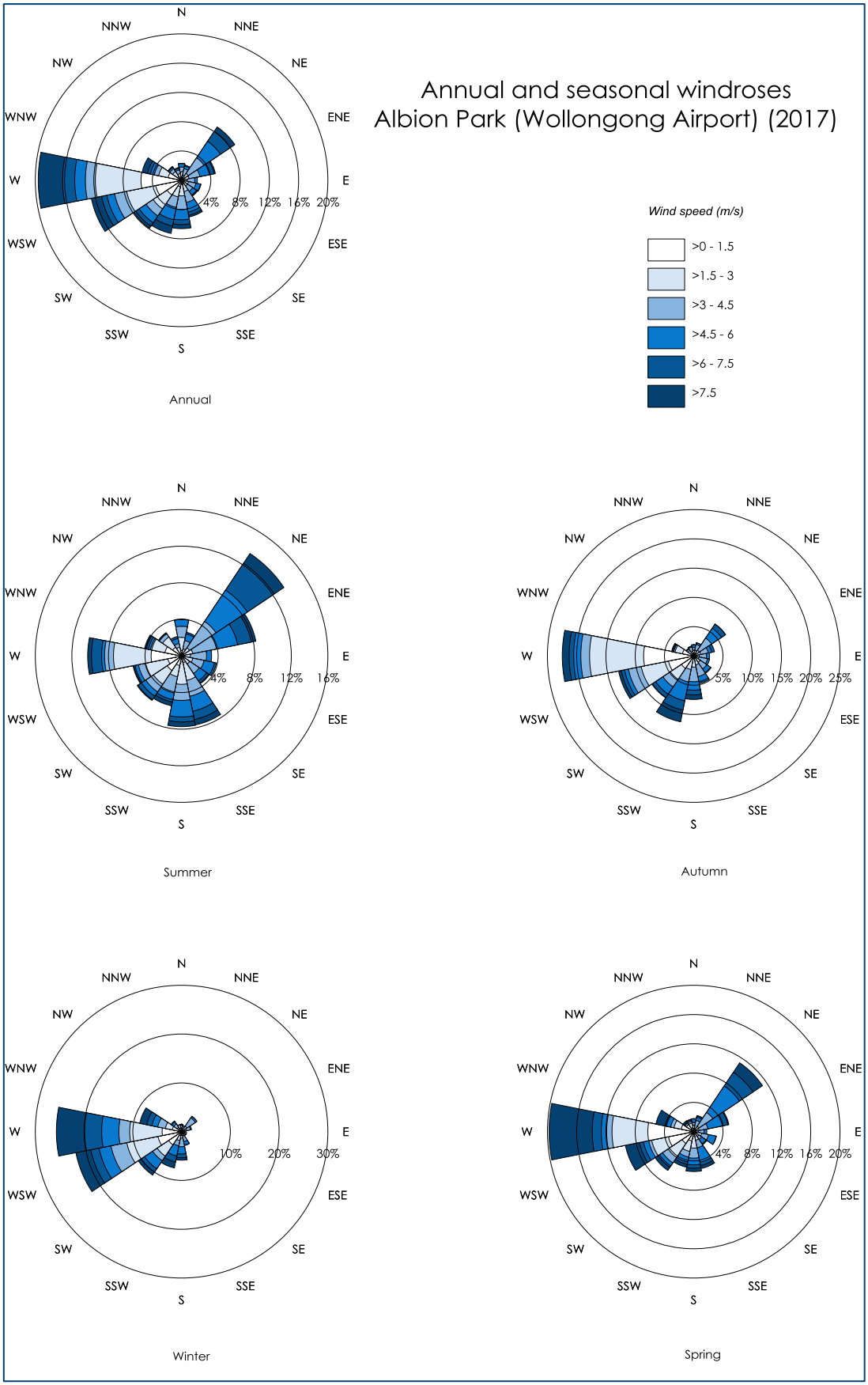

Figure 4-2 : Annual and seasonal windroses – Albion Park (Wollongong Airport) weather station (2017)

4.3 Local air quality monitoring

The main sources of air pollutants in the area surrounding the Project include emissions from local anthropogenic activities such as various commercial or industrial activities, motor vehicle exhaust (mainly from the Princes Highway) and domestic wood heaters.

Available ambient air quality monitoring data for the Project site and from the nearest air quality monitors operated by the NSW Office of Environment and Heritage (OEH) were used to quantify the existing background level for assessed pollutants at the Project site.

The air quality monitors for the Project site include a High Volume Air Sampler (HVAS) measuring PM_{10} and four dust deposition gauges. The NSW OEH air quality monitors include three Tapered Element Oscillating Microbalances (TEOMs) measuring PM_{10} and three Beta Attenuation Monitors (BAMs) measuring $PM_{2.5}$.

Figure 4-3 shows the approximate location of each of the monitoring stations for the Project. The NSW OEH air quality monitors at Wollongong, Kembla Grange and Albion Park South are not shown in the figure and are located approximately 22km, 15km and 6km from the site, respectively.

An additional dust gauge (DD8) located to the northwest of the existing site boundary has been excluded from this review. The dust monitoring at this location is conducted for internal dust management monitoring purposes and is not used for compliance purposes.

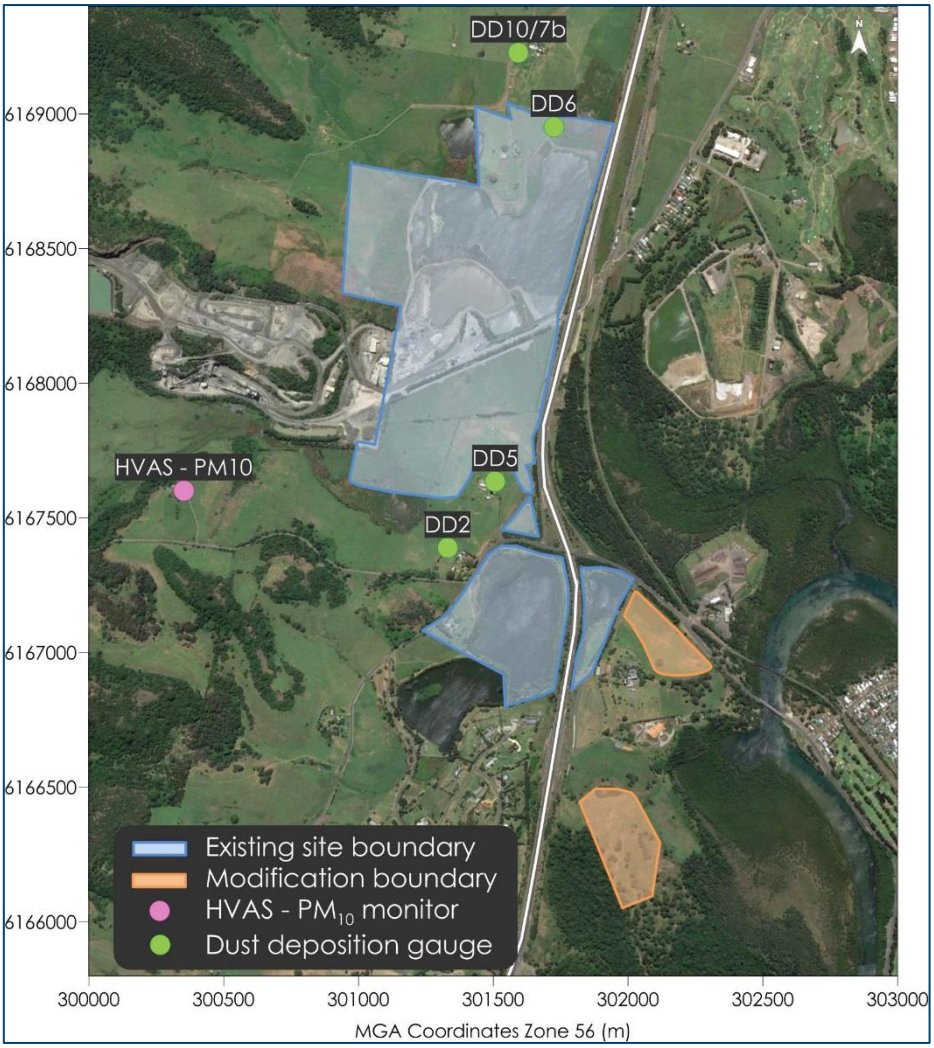

Figure 4-3: Monitoring locations

4.3.1 PM_{10} monitoring

A summary of the PM_{10} readings from the HVAS monitoring station operated at the Project is presented in **Table 4-2**. Recorded 24-hour average PM_{10} concentrations are presented in **Figure 4-4**.

The data in **Table 4-2** indicate that the annual average PM_{10} concentrations were below the relevant criterion of 25µg/m³ for the years reviewed. The maximum 24-hour average PM_{10} concentrations were found to exceed the relevant criterion of 50µg/m³ on one occasion during the review period. Some seasonal variation in the PM_{10} concentrations is seen in **Figure 4-4** with elevated days tending to occur in the warmer months.

Table 4-2: Summary of PM_{10} levels from HVAS monitoring (µg/m³)

Year	Annual average	Maximum 24-hour average
2013	11.9	35.8
2014	14.7	42.3
2015	11.0	37.9
2016	12.3	35.8
2017	10.7	**54.4**

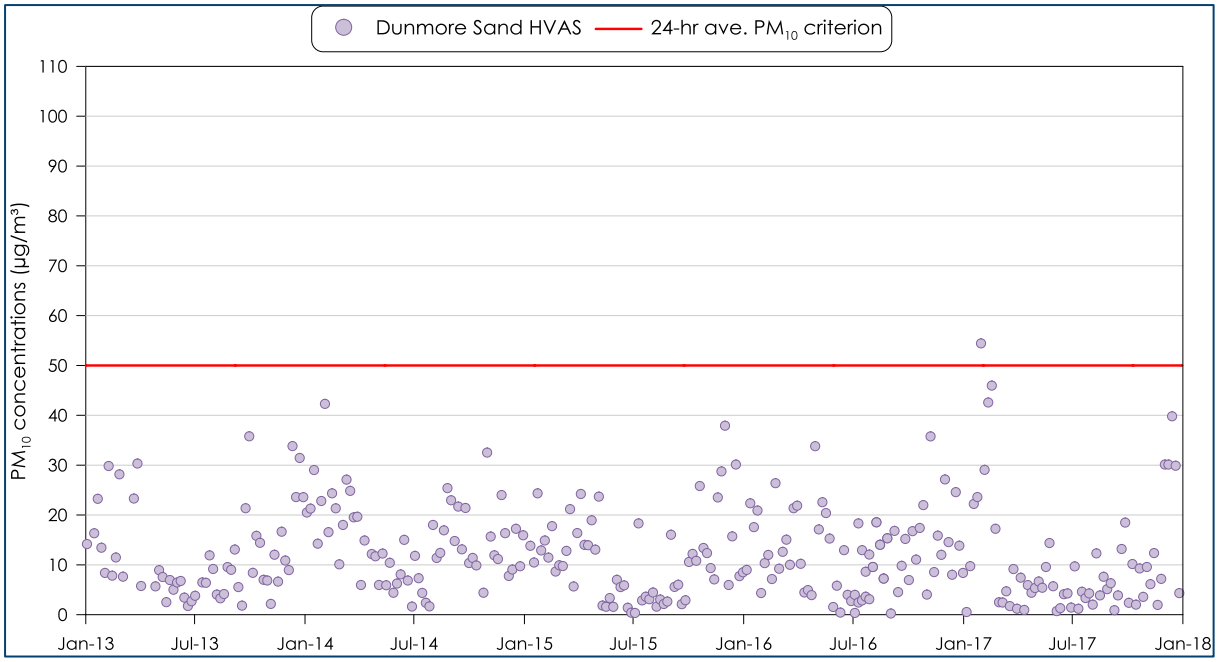

Figure 4-4: HVAS 24-hour average PM_{10} concentrations

A summary of the available data from the NSW OEH monitoring stations is presented in **Table 4-3**. Recorded 24-hour average PM_{10} concentrations are presented in **Figure 4-5**.

A review of **Table 4-3** indicates that the annual average PM_{10} concentrations for each monitoring station were below the relevant criterion of 25µg/m^3. The maximum 24-hour average PM_{10} concentrations recorded at these stations were found to exceed the relevant criterion of 50µg/m^3 during the review period (see **Figure 4-5**).

Table 4-3: Summary of PM_{10} levels from NSW OEH monitoring (µg/m³)

Year	Wollongong	Kembla Grange	Albion Park South
	Annual average		
2013	17.6	18.5	14.7
2014	17.7	17.3	16.2
2015	16.9	17.8	14
2016	17.3	20	14.9
2017	18.1	20.5	15.3
	Maximum 24-hour average		
2013	93.8	102.2	69
2014	45.3	99.2	48.3
2015	45.8	62.8	41.2
2016	52.9	56.3	43.1
2017	55.2	67.7	44.6

It can be seen from **Figure 4-5** that PM_{10} concentrations are nominally highest in the spring and summer months with the warmer weather raising the potential for drier ground, elevating the occurrence of windblown dust, bushfires and increased pollen levels.

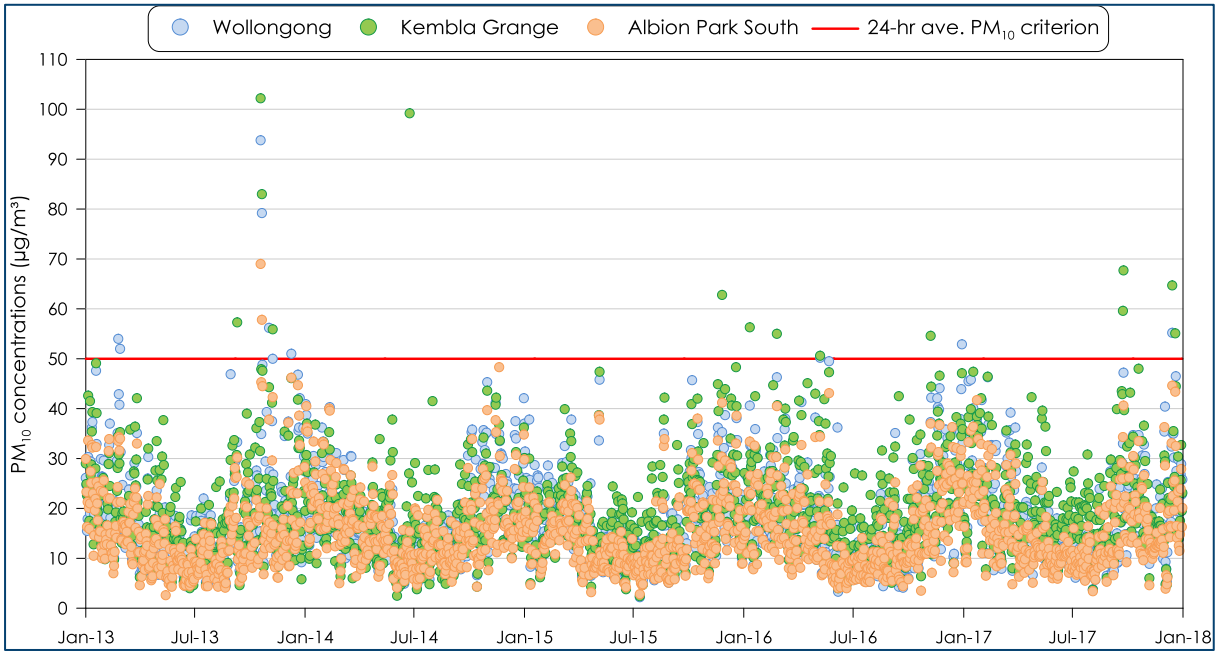

Figure 4-5: 24-hour average PM_{10} concentrations

4.3.2 $PM_{2.5}$ monitoring

A summary of the $PM_{2.5}$ readings from the NSW OEH monitoring stations is presented in **Table 4-4**. The recorded 24-hour average $PM_{2.5}$ concentrations are presented in **Figure 4-6**.

Table 4-4 indicates that the annual average $PM_{2.5}$ concentrations for the monitoring stations were below the annual average criterion of 8µg/m³ for every year, where data were available. The maximum 24-hour average $PM_{2.5}$ concentrations recorded at these stations were found to exceed the relevant criterion of 25µg/m³ during the review period (see **Figure 4-6**).

Table 4-4: Summary of $PM_{2.5}$ levels from NSW OEH monitoring (µg/m³)

Year	Wollongong	Kembla Grange[1]	Albion Park Sth[1]
	Annual average		
2013	7.7	-	-
2014	7	-	-
2015	7.6	6.7	6.4
2016	7.4	6.6	7.2
2017	7.1	6.9	6.6
	Maximum 24-hour average		
2013	88.4	-	-
2014	17.3	-	-
2015	31.6	23.8	21.1
2016	33.7	32	30.7
2017	24.7	21.3	19.3

[1]Data available from February 2015

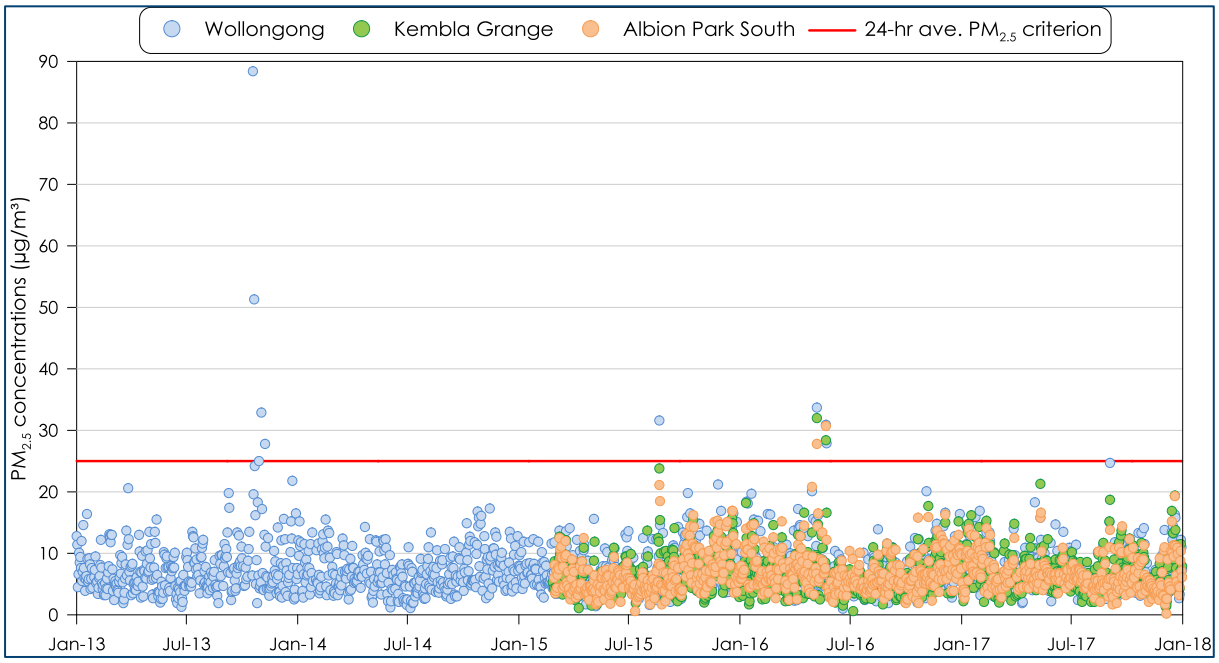

Figure 4-6: 24-hour average $PM_{2.5}$ concentrations

Bushfire events can have a significant impact on ambient air quality levels. Most noticeable was the bushfire event which occurred in late 2013 and impacted the majority of the Sydney basin. **Figure 4-7** presents satellite imagery showing the extent of the smoke plume on 21 October 2013, noting that the red patches in the images indicate the position of the active fire.

The elevated levels associated with bushfire events are included in the results, and do affect the 24-hour and annual average levels.

Source: **NASA, 2016**

Figure 4-7: Satellite imagery showing smoke plume from bushfires on 21 October 2013

4.3.3 Dust deposition monitoring

The locations of the dust deposition monitoring sites reviewed in this assessment are shown in **Figure 4-3**. **Table 4-5** summarises the annual average deposition levels at each gauge during Financial Year (FY) periods 2013 to 2017 and presents both the insoluble solids fraction and the ash fraction of the dust deposition.

Dust deposition is defined as the insoluble solids content of the deposited matter, which can include organic deposited material not associated with Boral operations such as pollen, bird droppings and insects. Due to the surrounding land uses of the site (wetlands and agriculture) a comparison with the ash fraction is used to determine any external contamination of the dust deposition values. The ash component excludes the organic deposited material recorded in the insoluble solids portion of a sample and is more indicative of the material processed on site which gives a better indication of potential contribution from the project.

All gauges recorded an annual average insoluble deposition level below the criterion of 4g/m^2/month, with the exception of DD2 in FY13. An investigation into this reading identified the increase in insoluble solids was due to the proximity of the monitor to nesting birds and their associated droppings resulting in contamination of several monthly samples during FY13. A comparison with the ash fraction of the reading (annual average level of 2.19g/m^2/month) indicates that the potential quarry contribution was not significant. A bird ring has since been installed at DD2 to reduce the instances of bird dropping contaminating the sample.

Table 4-5: Annual average dust deposition levels (g/m²/month)

Period	DD2		DD5		DD6		DD7b/10		Criteria
	Insoluble solids	Ash	Insoluble solids	Ash	Insoluble solids	Ash	Insoluble solids	Ash	
FY13	**4.19**	2.19	3.26	1.84	3.7	2.48	-	-	**4.0**
FY14	2.21	1.42	3.63	1.76	2.67	1.58	-	-	**4.0**
FY15	3.57	1.77	2.55	1.46	3.94	2.00	3.38	2.01	**4.0**
FY16	1.85	1.19	2.59	1.44	2.55	1.55	2.66	1.66	**4.0**
FY17	2.28	1.56	2.67	1.76	3.31	1.68	2.01	1.3	**4.0**

5 POTENTIAL OPERATIONAL DUST EMISSIONS

To investigate the potential effect that the Project may have on dust levels in the surrounding environment, an qualitative analysis is made of the dust levels associated with the proposed activities relative to other dust generating operations and the potential risk of impact occurring due to the proposed dust generating activities was evaluated.

The two components that comprise the Project, namely the sand extraction from Stage 5A and 5B and the importation of VEMN material, have been assessed using two different approaches as outlined in the following sections.

5.1 Proposed sand extraction

The amount of sand material proposed to be extracted from Stage 5A and Stage 5B is estimated at approximately 234,000 tonnes and 1,123,000 tonnes, respectively. Both Stage 5 areas require some initial topsoil removal to expose the resource and would be stockpiled adjacent to the extraction area for later re-use in the rehabilitation. Sand extraction would initially be conducted with an excavator to create a large enough pond to float a dredge, the sand resource would then be pumped to the existing processing area within Stage 2.

The timing of the operations would be staggered with Stage 5B only commencing two weeks prior to the completion of extraction in Stage 5A.

The Project does not seek to change the approved production rate or the existing processing activity within Stage 2 of the Approved Project, therefore there would be no change in the existing level of dust generation associated with the processing of the sand.

5.1.1 Emission estimation

The significant dust generating activities associated with sand extraction from Stage 5A and 5B are identified as handling of topsoil and transport of topsoil in the initial stages, wind erosion from stockpiles and diesel exhaust from trucks and plant. The activity of dredging sand from the extraction area and pumping of the sand to the Stage 2 area is a wet process and would not generate any significant level of emissions, noting that the wet sand is pumped via pipes to the processing area directly from the dredge.

In broad terms, the dust generating activities can be considered akin to construction effects in that they relate to short lived works necessary to allow the operations to commence.

Dust emission estimates for the Project have been calculated by analysing the various types of dust generating activities taking place and utilising suitable emission factors sourced from both locally developed and US EPA developed documentation **(US EPA, 1985 and Updates)**.

The estimated dust emissions for activities associated with the operation are presented in **Table 5-1**. Detailed calculations of the dust emission estimates are provided in **Appendix A**.

Table 5-1: Estimated annual dust emissions for the Project

Location	Activity	Emissions (kg/year)		
		TSP	PM_{10}	$PM_{2.5}$
Stage 5A	Excavator stripping topsoil and loading to haul truck	142	67	10
	Hauling topsoil to stockpile location on southern edge	794	202	20
	Emplacing at topsoil stockpile	142	67	10
	Wind erosion of topsoil stockpile	213	106	16
	Dredging sand (wet process - no emission)	-	-	-
	Pumping sand to processing area (wet process - no emission)	-	-	-
	Exhaust emissions	294	294	285
	Total TSP emissions (kg/yr)	**1,585**	**737**	**342**
Stage 5B	Excavator stripping topsoil and loading to haul truck	335	159	24
	Hauling to topsoil stockpile	2,492	635	64
	Emplacing at topsoil stockpile	335	159	24
	Wind erosion of topsoil stockpile	213	106	16
	Dredging sand (wet process - no emission)	-	-	-
	Pumping sand to processing area (wet process - no emission)	-	-	-
	Exhaust emissions	294	294	285
	Total TSP emissions (kg/yr)	**3,669**	**1,352**	**412**

5.1.2 Assessment of potential dust impacts

The estimated emissions in **Table 5-1** indicate that the majority of dust emissions in both stages arises from the initial preparation of the sites by the stripping and stockpiling of the topsoil material. These activities would not be prolonged over the life of the Project, with the only ongoing activity, the dredging of sand and pumping sand to the processing area, emitting negligible dust emissions. The estimated dust emissions presented in **Table 5-1** are considered conservative as they assume moderate values for the material variables, have not factored in all the potential operational dust mitigation options and represent a potential upper limiting scenario for the Project.

Given that the Project does not seek any change to the total production of sand from the operations (i.e. 800,000tpa) there would not be any additional impact associated with the existing processing activity.

As there is no change to the existing approved production rate and the proposed extraction method is identical to the approved operations using a dredge, it can be inferred that the Project would generate a similar level of dust emissions to the existing approved operations.

The only change associated with the approved Project is to allow the operations to expand into the proposed new Stage 5 extraction areas with minimal change to the existing overall dust levels in the wider area.

To gauge the extent of the Project related dust emissions to the existing dust levels in the wider area, the estimated emissions in **Table 5-1** have been compared against the total dust emissions from the identified significant dust generating operations in the surrounding area, namely the Dunmore Quarry.

The *Dunmore Quarry Air Quality Impact Assessment – Modification 9* (**Ramboll, 2016**) estimates a maximum annual TSP emission rate of 409,600kg/year. In comparison, the maximum estimated TSP emission rate for the Project equates to approximately 1% of this level and is considered minor in comparison, and would be difficult to discern beyond the existing background level.

It is noted that the existing air quality levels near the Project (refer to **Section 4.3**) indicate annual average PM_{10} levels well below the relevant impact assessment criterion and, given the scale of estimated emission associated with the Project relative to existing approved operations and other nearby operations, the likelihood of impacts arising due to the Project is unlikely.

Therefore, given that the total maximum emissions form the Project are approximately 1% of just one nearby source (quarry), would be short-lived, and that existing ambient levels are within criteria, it was considered that impacts would be minimal, and in accordance with the *Approved Method for the Modelling and Assessment of Air Pollutants in New South Wales* (**NSW EPA, 2017**) no air dispersion modelling would thus be required.

5.2 VENM importation

The potential air quality impacts due to the importation of VENM material to backfill and rehabilitate the extraction areas has been qualitatively assessed with consideration of the methodology outlined in the Institute of Air Quality Management (IAQM) document *Guidance on the Assessment of the Impacts of Construction on Air Quality and the Determination of their Significance* (**IAQM, 2011**).

The IAQM guidance document is aimed primarily for use in the United Kingdom, however, it is recognised that its applicability is international and has been accepted and applied to a number of projects in Australia.

The IAQM guidance methodology considers three separate dust effects due to construction activities, with the distance of the receptors that may experience these effects taken into account. The dust effects considered include:

- Annoyance due to dust deposition;
- Harm to ecological receptors, referring to direct impacts on vegetation or aquatic ecosystems, from dust deposition; and
- The risk of health effects due to a significant increase in exposure to PM_{10}.

A risk based assessment of the potential dust effects due to specific activities is determined by the scale and nature of the works, the proximity to sensitive receptors to identify the likelihood of an impact arising and the magnitude of specific mitigation required to ensure impacts are managed effectively.

The activities which have potential to generate dust impacts for the Project considered in the risk assessment include earthworks associated with the emplacement and shaping of the VENM material and potential track-out from unpaved roads onto public roads.

Table 5-2 presents the risk matrix for earthworks activity based on distance to the nearest receptors with no consideration of dust mitigation measures applied.

The volume of VENM material imported for the Project is 325,000 tonnes per annum, the entire area of Stage 5A is approximately 35,000m^2 and the distance to the nearest receptor is approximately 100m. For Stage 5B, the site area approximately 81,000m^2 and the distance to the nearest receptor is approximately 170m.

From the risk matrix in **Table 5-2**, the emplacement and shaping of the VENM activity for both stages is identified as a low to medium risk.

Table 5-2: Risk matrix for earthworks activity

Distance to Nearest Receptor (m)		Dust Emission Class (total building volume)		
Dust Deposition and PM_{10}	**Ecological**	**Large (Site area >10,000m² and >100,000 tonnes moved)**	**Medium (Site area >2,500m² - 10,000m² and 20,000 - 100,000 tonnes moved)**	**Small (Site area <2,500m² and <10,000 tonnes moved)**
<20	-	High Risk	High Risk	Medium Risk
20 – 50	-	High Risk	Medium Risk	Low Risk
50 – 100	<20	Medium Risk	Medium Risk	Low Risk
100 – 200	20 – 40	Medium Risk	Low Risk	Negligible
200 – 350	40 – 100	Low Risk	Low Risk	Negligible

Table 5-3 presents the risk matrix for potential track-out from unpaved roads onto public roads based on distance to the nearest receptors with no mitigation applied. The estimated daily number of VENM haul trucks is approximately 50 trucks/day and based on the distance from the nearest receptor (100m), there is a low risk from this activity.

Table 5-3: Risk matrix for track-out activity

Distance to Nearest Receptor (m)		Dust Emission Class (total building volume)		
Dust Deposition and PM_{10}	**Ecological**	**Large (>100 HDV per day)**	**Medium (25-100 HDV per day)**	**Small (<25 HDV per day)**
<20	-	High Risk	Medium Risk	Medium Risk
20 – 50	<20	Medium Risk	Medium Risk	Low Risk
50 – 100	20 – 100	Low Risk	Low Risk	Negligible

Based on the identified level of risk for the VENM importation activities, appropriate dust mitigation measures have been recommended in the following section to ensure potential dust impacts from this activity is minimised and managed appropriately.

6 DUST MITIGATION AND MANAGEMENT

The existing operations implement various dust mitigation and management measures to ensure air quality impacts are minimised in the surrounding environment.

The dust management performance of the existing operations are confirmed through the existing Air Quality Monitoring Program. The monitoring data presented in **Section 4.3** indicate the existing operations have generally been in compliance with the NSW EPA air quality criteria.

Relative to the existing operations, the proposed operations associated with the Project are unlikely to lead to any significant change in dust levels at private receptors and indicate that the operations are unlikely to generate any adverse air quality levels and that the existing dust mitigation and management measures would be effective for the Project.

To ensure activities associated with the Project continue to have a minimal effect on the surrounding environment and at sensitive receptor locations, the existing Air Quality Monitoring Program will be updated to incorporate the Project to ensure that the performance of the operations and appropriate operational and physical mitigation measures would continue to be implemented where feasible and reasonable.

Potential operational dust mitigation measures which complement existing measures applied at the operations are outlined in **Table 6-1**.

Table 6-1: Potential operational dust mitigation options

Source	Mitigation Measure
General	Activities to be assessed during adverse weather conditions and modified as required (e.g. cease activity where reasonable levels of dust cannot be maintained using the available means).
	Weather forecast to be checked prior to undertaking material handling or processing.
	Engines of on-site vehicles and plant to be switched off when not in use.
	Vehicles and plant are to be fitted with pollution reduction devices where practicable, with exhausts directed away from the ground so as to not stir up dust.
	Vehicles are to be maintained and serviced according to manufacturer's specifications.
	Visual monitoring of activities is to be undertaken to identify dust generation.
Material handling	Reduce drop heights from loading and handling equipment where practical.
	Dampen material when excessively dusty during handling.
	Practice careful handling to minimise spillage of material.
Hauling activities	Driveways and hardstand areas to be swept/cleaned regularly as required etc.
	Vehicle traffic is to be restricted to designated routes.
	Speed limits are to be enforced.
	Vehicle loads are to be covered when travelling off-site, with wheel wash facilities also utilised.
	Regular watering of active haul roads.
Exposed areas / stockpiles	The extent of exposed surfaces and stockpiles is to be kept to a minimum
	Exposed areas and stockpiles are either to be stabilised with vegetation, covered or are to be dampened with water as far as is practicable if dust emissions are visible, or there is potential for dust emissions outside operating hours.
	Minimise dust generation by undertaking rehabilitation earthworks when topsoil and subsoil stockpiles are moist and/or wind speed is below 10 m/s.
Incident and complaints management	Record all air/ dust incidents and breaches.
	Complaints are logged and investigated via site incident management system (SIMS).

7 SUMMARY AND CONCLUSIONS

This report has assessed the potential air quality impacts associated with the proposed sand extraction and rehabilitation of Stage 5 of the Dunmore Lakes Sand Project in Dunmore, NSW.

The assessment finds that the majority of dust emissions from the Project occur during the initial preparation stages and that ongoing operational activities would generate minimal dust emissions. As the Project will not increase the maximum total approved sand production rate, it is not expected to generate any additional dust beyond that already occurring associated with the approved operations.

Comparatively, the total dust generated from the Project would be approximately 1% of that from the neighbouring hard rock quarry operation, occur for only a short period, and thus would not have any significant or ongoing effect on the existing ambient dust levels.

Therefore it is considered reasonable to conclude that overall, the Project is unlikely to cause any discernible negative impact at any surrounding environment relative to the existing situation.

The potential risk of dust impact occurring due to the closure stages of the project associated with the importation of VENM is identified to be a low to medium dust risk based on the level of activity, area of activity and proximity to surrounding receptor locations. With the recommended mitigation and management measures, potential impacts associated with this activity would be managed effectively. The site's air quality monitoring program will be updated to include the Stage 5 area so that the effectiveness of these measures can be measured.

Overall, using conservative assumptions the assessment found that the Project can operate without causing any significant air quality impact at receptors in the surrounding environment.

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Appendix A

Emission Calculation

Emission Calculation

The quarry schedule and plans provided by the Proponent have been combined with emissions factor equations that relate to the quantity of dust emitted from particular activities based on intensity, the prevailing meteorological conditions, and composition of the material being handled.

Emission factors and associated controls have been sourced from the US EPA AP42 Emission Factors (**US EPA, 1985 and Updates**), the National Pollutant Inventory document *Emission Estimation Technique Manual for Mining, Version 3.1* (**NPI, 2012**) and the NSW EPA document, *NSW Coal Mining Benchmarking Study: International Best Practice Measures to Prevent and/or Minimise Emissions of Particulate Matter from Coal Mining*, prepared by Katestone Environmental (**Katestone Environmental, 2010**).

The emission factor equations used for each dust generating activity are outlined in **Table A-1** below. Detailed emission inventories for each stage are presented in **Table A-2**.

Control factors include the following:

- Hauling on unpaved surfaces – 75% control for watering of trafficked areas. Note the control factor is only applied to the mechanically generated emissions and not the contributions from the diesel exhaust emissions.

Air emissions associated with the operation of the diesel powered equipment have been estimated based on the number of equipment, power rating, hours of operation and emission factors sourced from the NSW EPA document *NSW Coal Mining Benchmarking Study Best-practice measures for reducing non-road diesel exhaust emissions* (**NSW EPA, 2014**).

Table A-1: Emission factor equations

Activity	Emission factor equation		
	TSP	PM_{10}	$PM_{2.5}$
Loading / emplacing overburden	$EF = 0.74 \times 0.0016 \times \left(\frac{U}{2.2}^{1.3} / \frac{M}{2}^{1.4}\right) kg/tonne$	$EF = 0.35 \times 0.0016 \times \left(\frac{U}{2.2}^{1.3} / \frac{M}{2}^{1.4}\right) kg/tonne$	$EF = 0.053 \times 0.0016 \times \left(\frac{U}{2.2}^{1.3} / \frac{M}{2}^{1.4}\right) kg/tonne$
Hauling on unsealed surfaces	$EF = \left(\frac{0.4536}{1.6093}\right) \times 4.9 \times (s/12)^{0.7} \times (1.1023 \times M/3)^{0.45} kg/VKT$	$EF = \left(\frac{0.4536}{1.6093}\right) \times 1.5 \times (s/12)^{0.9} \times (1.1023 \times M/3)^{0.45} kg/VKT$	$EF = \left(\frac{0.4536}{1.6093}\right) \times 0.15 \times (s/12)^{0.9} \times (1.1023 \times M/3)^{0.45} kg/VKT$
Wind erosion on exposed areas & conveyors	$EF = 850\, kg/ha/year$	$0.5 \times TSP$	$0.075 \times TSP$

EF = emission factor, U = wind speed (m/s), M = moisture content (%), s = silt content (%), VKT = vehicle kilometres travelled (km).

Table A-2: Emission inventory

Activities	TSP emission	PM10 emission	PM2.5 emission	Intensity	Units	Emission Factor TSP	Emission Factor PM10	Emission Factor PM2.5	Units	Var. 1	Units	Var. 1	Units	Size specific EF (TSP / PM10 / PM2.5)	Units	Var. 1	Units	Var. 1	Units	Var. 1	Units
Stage 5A																					
Excavator stripping topsoil and loading to haul truck	142	67	10	75,900	t/yr	0.00188	0.001	0.0001	kg/t	1.58	ave. $(WS/2.2)^{1.3}$	2	M.C. %								
Hauling topsoil to stockpile location on southern edge	794	202	20	75,900	t/yr	0.042	0.011	0.001	kg/t	40	t/load	0.6	km	2.8 / 0.7 / 0.1	kg/VKT	4.8	S.C. %	54	Ave GMV (t)	75	% Control
Emplacing at topsoil stockpile	142	67	10	75,900	t/yr	0.00188	0.001	0.0001	kg/t	1.58	ave. $(WS/2.2)^{1.3}$	2	M.C. %								
Wind erosion of topsoil stockpile	213	106	16	0.25	ha	850	425	64	kg/ha/yr												
Dredging sand (wet process - no emission)	-	-	-	-	t/yr																
Pumping sand to processing area (wet process - no emission)	-	-	-	-	t/yr																
Exhaust emissions	294	294	285																		
Total TSP emissions (kg/yr)	**1,585**	**737**	**342**																		
Stage 5B																					
Excavator stripping topsoil and loading to haul truck	335	159	24	178,640	t/yr	0.00188	0.001	0.0001	kg/t	1.58	ave. $(WS/2.2)^{1.3}$	2	M.C. %								
Hauling to topsoil stockpile	2,492	635	64	178,640	t/yr	0.056	0.014	0.001	kg/t	40	t/load	0.8	km	2.8 / 0.7 / 0.1	kg/VKT	4.8	S.C. %	54	Ave GMV (t)	75	% Control
Emplacing at topsoil stockpile	335	159	24	178,640	t/yr	0.00188	0.001	0.0001	kg/t	1.58	ave. $(WS/2.2)^{1.3}$	2	M.C. %								
Wind erosion of topsoil stockpile	213	106	16	0.25	ha	850	425	64	kg/ha/yr												
Dredging sand (wet process - no emission)	-	-	-	800,000	t/yr																
Pumping sand to processing area (wet process - no emission)	-	-	-	800,000	t/yr																
Exhaust emissions	294	294	285																		
Total TSP emissions (kg/yr)	**3,669**	**1,352**	**412**																		

APPENDIX I

NOISE IMPACT ASSESSMENT REPORT

ACOUSTICS AND AIR

DUNMORE LAKES SAND PROJECT - MODIFICATION 2

NOISE IMPACT ASSESSMENT

REPORT NO. 18156
VERSION B

MARCH 2019

PREPARED FOR

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APPENDIX A – Noise Measurement Results

GLOSSARY OF ACOUSTIC TERMS

Most environments are affected by environmental noise which continuously varies, largely as a result of road traffic. To describe the overall noise environment, a number of noise descriptors have been developed and these involve statistical and other analysis of the varying noise over sampling periods, typically taken as 15 minutes. These descriptors, which are demonstrated in the graph below, are here defined.

Maximum Noise Level (L_{Amax}) – The maximum noise level over a sample period is the maximum level, measured on fast response, during the sample period.

L_{A1} – The L_{A1} level is the noise level which is exceeded for 1% of the sample period. During the sample period, the noise level is below the L_{A1} level for 99% of the time.

L_{A10} – The L_{A10} level is the noise level which is exceeded for 10% of the sample period. During the sample period, the noise level is below the L_{A10} level for 90% of the time. The L_{A10} is a common noise descriptor for environmental noise and road traffic noise.

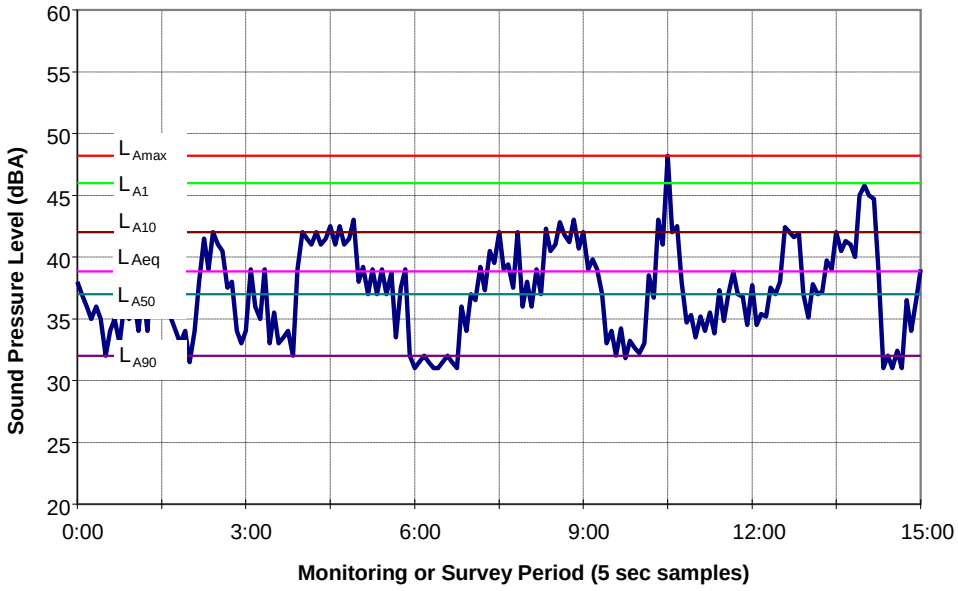
L_{A90} – The L_{A90} level is the noise level which is exceeded for 90% of the sample period. During the sample period, the noise level is below the L_{A90} level for 10% of the time. This measure is commonly referred to as the background noise level.

L_{Aeq} – The equivalent continuous sound level (L_{Aeq}) is the energy average of the varying noise over the sample period and is equivalent to the level of a constant noise which contains the same energy as the varying noise environment. This measure is also a common measure of environmental noise and road traffic noise.

ABL – The Assessment Background Level is the single figure background level representing each assessment period (daytime, evening and night time) for each day. It is determined by calculating the 10th percentile (lowest 10th percent) background level (L_{A90}) for each period.

RBL – The Rating Background Level for each period is the median value of the ABL values for the period over all of the days measured. There is therefore an RBL value for each period – daytime, evening and night time.

Typical Graph of Sound Pressure Level vs Time



1 INTRODUCTION

1.1 Background

Stage 1 of the Dunmore Lakes Sand Project (the 'Approved Project') was issued development consent from the then Minister for Planning in 1999. Stage 1 was on Swamp Road, Dunmore, and encompassed sand extraction by dredging of up to 500,000 tonnes per annum (tpa) for a period of 10 years. The Stage 1 consent included conditions requiring the proponent to lodge a further application for the remaining identified Stages of the Dunmore sand resource (being Stages 2 to 4).

The application for Stages 2 to 4 was lodged in 2004, and development consent was received from the Minister for Planning in June 2005. The consent approves extraction of up to 800,000 tpa of sand for a period of 25 years. Boral Resources (NSW) Pty Ltd (hereafter 'Boral') purchased Dunmore Sand & Soil Pty Ltd (DSS), including the Dunmore Lakes Sand Project in mid-2005. The Stage 1 consent has since lapsed following successful extraction of the approved sand resource and rehabilitation of the site in 2010.

Stages 2 to 4 commenced dredging in June 2007. Since then, due to high demand for sand in the Sydney market, the majority of sand in Stage 2 has been extracted with dredging recently moving into Stage 3. Given recent high demand, the sand resource in Stage 3 is expected to be exhausted in approximately 8 – 12 months. The last extraction stage (Stage 4) encompasses an area containing the site's road access and private rail line and supporting infrastructure for the Stage 2 to 4 operations and Boral's adjacent Dunmore hard rock quarry. This has led DSS to investigate other local sources of sand to continue operations beyond Stage 3.

DSS has been investigating a fine sand resource on an adjoining private property to the south. Investigative drilling has confirmed that there is sufficient sand resource to support three to four more years of extraction from two areas (Stage 5A and 5B).

As such, DSS is seeking to modify the current Project Approval (DA 195-8-2004) under Section 75W of the *Environmental Planning and Assessment Act 1979* (EP&A Act), to provide for an additional extraction area (Stage 5) on adjoining private land, encompassing two separate extraction areas, Stage 5A and Stage 5B (hereafter referred to as the 'modification').

The modification proposed above will constitute Modification 2 to the current Project Approval. The Minister for Planning is the consent authority for the modification.

1.2 The Applicant

DSS is a wholly owned subsidiary of Boral Limited (Boral) and is the applicant for the modification. Boral is an international building and construction materials group, headquartered in North Sydney, Australia. Boral's competitive position is underpinned by being a market leader in cement and construction materials in Australasia, Plasterboard in Australia and Asia and Cladding and Roof Tiles in the USA.

The Boral Australia division employs over 5,000 employees in its quarry, concrete, asphalt, concrete placing and cement operations. The business is a major supplier of products to the residential, commercial construction, and roads and engineering markets.

Boral operates over 110 quarries producing products such as concrete aggregates, crushed rock, asphalt and sealing aggregates, road base materials, sand and gravels for the Australian construction materials industry.

1.3 Purpose of this Report

Wilkinson Murray Pty Limited (WMPL) has been engaged by Element Environment (Element) on behalf of DSS to conduct a Noise Impact Assessment (NIA) for the proposed modification (the Proposal). This NIA provides a detailed assessment of potential operational noise impacts associated with the Proposal. The assessment has been conducted in general accordance with the *Noise Policy for Industry* (NPfI).

It should be noted that no significant sources of vibration have been identified for the Proposal. Therefore, a detailed assessment of potential vibration impacts is not considered necessary.

The Proposal would generate heavy vehicle movements along Riverside Drive between the Proposal site and the Princes Motorway, particularly during the importation of fill material for the backfill and rehabilitation of one of the two extraction areas. However, no sensitive land uses are located along this route. Therefore, a detailed assessment of road traffic noise is not considered necessary.

2 SITE DESCRIPTION

2.1 Site Location

Existing Site

The Dunmore Lakes Sand Project (the existing site) is near Dunmore, approximately 3 kilometres (km) south-south west of Shellharbour and 7 km north of Kiama, in the Illawarra region of New South Wales. The site is approximately 88 hectares (ha) and is immediately west of the Princes Highway near Tabbita Road, Dunmore. The site is within the Shellharbour Local Government Area (LGA).

Modification Site

The modification site is located approximately 1.1 km south-south-east of the existing site.

The modification site covers an area of approximately 38 ha and is on an alluvial coastal flood plain, adjacent to the tidal reaches of the Minnamurra River. The northern portion of the extraction area has been partially cleared and has historically been used for grazing.

The modification site is bound by Riverside Drive to the north and Princes Highway to the west.

2.2 Land Use and Ownership

Existing Site

Land holdings within Stages 2 to 4 include:

- Part Lot 6 DP 611159 (Stage 2);
- Part Lots 3, 4 and 5 DP 1030504 (Stage 2 and 4);
- Part Lot 6 DP 1001931 (Stage 3); and
- Lot 1 DP 213575 (Stage 4).

The existing site is characterised by existing sand extraction activities (i.e. in Stage 2 and 3) and agricultural land that has been predominantly cleared of native vegetation for the grazing of livestock. Land use in the surrounding locality includes:

- agricultural land to the north and south, primarily livestock grazing;
- commercial and industrial development, including Dunmore Hard Rock Quarry immediately to the west and Dunmore Resource and Recycling Facility to the east;
- residential development, including Dunmore Lakes Estate to the south, Shell Cove and Shellharbour to the north-east;
- infrastructure development, including the Princes Highway and the South Coast Rail Line to the east; and
- a wetland (afforded protection under State Environmental Planning Policy (Coastal Management) 2018) (Coastal SEPP) is on the eastern side of the Princes Highway, with the north western edge of the wetland approximately 350 m downstream of the site.

Access to the existing site is via the Princes Highway and Tabbita Road. The internal road network consists of several unsealed haul roads.

The local context of the site is shown in Figure 2-1.

Modification Site

The proposed Stage 5A extraction area is located on Lot 501 DP 1174897, whilst the proposed Stage 5B extraction area is located on Lot 51 DP 1012246.

The modification site is also characterised by agricultural land that has been predominantly cleared of native vegetation for the grazing of livestock. Land use in the surrounding locality of the modification includes:

- commercial and industrial development, including Dunmore Hard Rock Quarry to the north west and Dunmore Resource and Recycling Facility to the north;
- residential development, including Dunmore Lakes Estate to the south west and Minnamurra to the east;
- infrastructure development, including the Princes Highway to the west, and the South Coast Rail Line to the north-east; and
- Minnamurra River and associated wetland (afforded protection under State Environmental Planning Policy (Coastal Management) 2018) (Coastal SEPP) is located adjacent to the south of the modification.

Access to the modification site would be via Riverside Drive and internal road network consisting of several unsealed haul roads.

The owners of the land on which the modification is proposed have granted their consent to DSS establishing operations on their land via an agreement. The closest residential dwellings to the Stage 5 extraction areas include:

- 69 Fig Hill Lane, which is located on lot 51 DP 1012246, and is approximately 130 metres (m) to the north of the proposed booster pumping station associated with the Stage 5B extraction area. Boral has entered into an agreement with the owners of this property, and hence a noise agreement is in place. The proposed high voltage power line required to power the pumping station would connect to the existing electricity supply to this property;
- 71 Fig Hill Lane, which is approximately 290 m north-east of the booster pumping station. The dwelling at this address is derelict and is uninhabited. There is no valid development approval for this structure and has not been considered in this noise assessment;
- 471 Riverside Drive (Dunmore House), which is located on lot 501 DP 1174897, approximately 175 m to the south of the Stage 5A extraction area, 250 m to the east of the proposed haul road between the two extraction areas, and 750m north-north-east of the Stage 5B extraction area. Boral has entered into an agreement with the owners of this property, and hence a noise agreement is in place; and
- 431 Riverside Drive, which is located approximately 345 m south of the Stage 5A extraction area.

To the south-west of the Stage 5 extraction area, is the residential Dunmore Lakes Estate. The main access for these properties is via Riverside Road and Swamp Road. These properties are separated from the Stage 5A and 5B extraction area by the Princes Highway, with the closest approximately 495 m from the haul road linking the Stage 5A and 5B extraction areas. The township of Minnamurra is positioned approximately 865 m to the east of the Stage 5A extraction area. Sensitive receivers are shown in Figure 5-1.

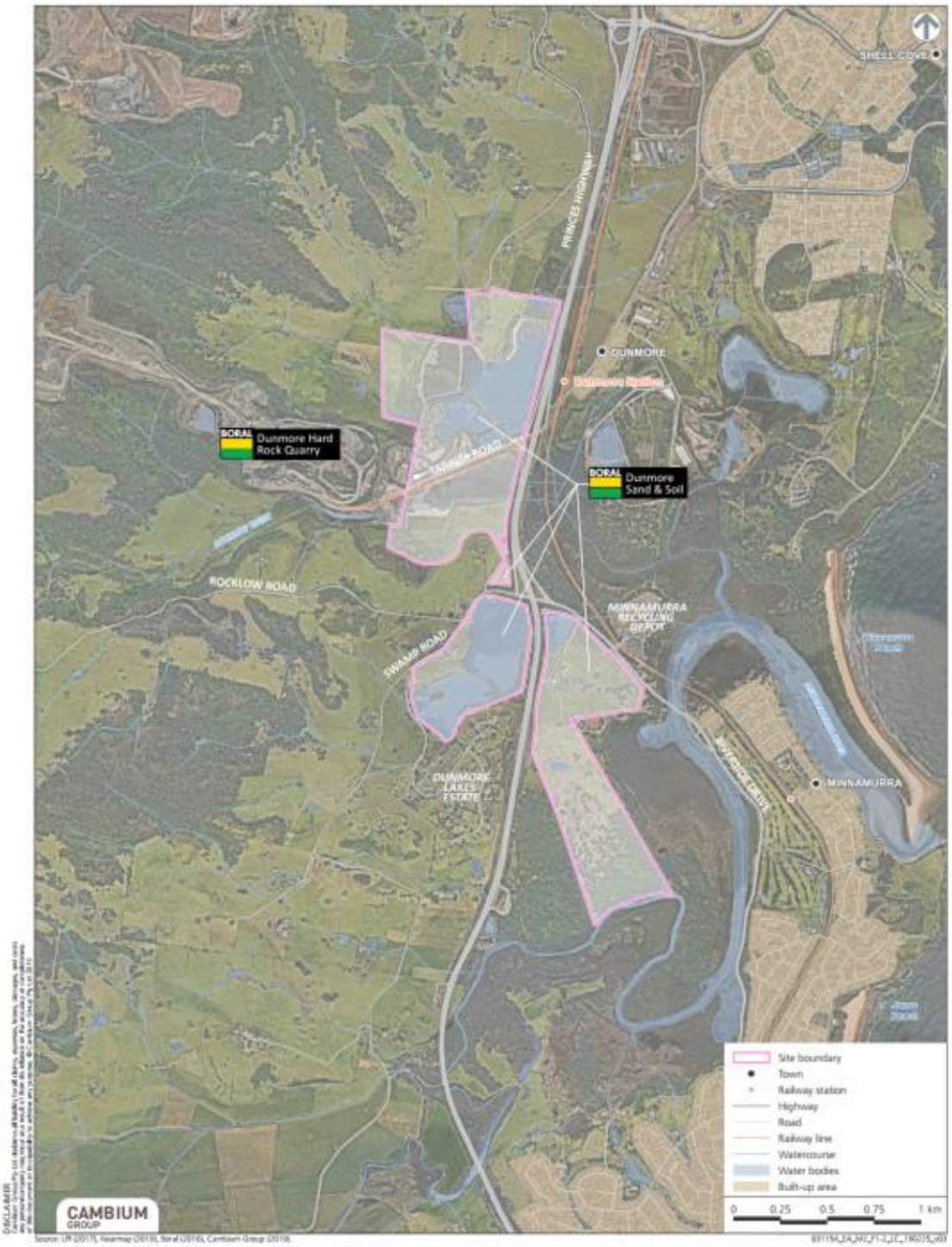
2.3 Zoning

The majority of the proposed modification site is zoned RU2 – Rural Landscape zone under the Shellharbour Local Environmental Plan (LEP) 2013. The southern portion of Stage 5B extraction area is zoned E3 – Environmental Management. Extractive industries are not permitted within these zones, however agricultural land uses are permitted with consent. By virtue of Section 7, Clause 3 (a) of State Environmental Planning Policy (Mining, Petroleum Production and Extractive Industries) 2007, extractive industries are permitted with consent on land where development for the purposes of agriculture or industry is permitted.

Land to the east and south of the modification site is zoned E2 – Environmental Conservation and E3 – Environmental Management, and this land is associated with environmental conservation areas of Minnamurra River and associated Coastal SEPP wetland.

The E2 zoning also runs along the northern fringe of Riverside Drive opposite the Stage 5A extraction area, whilst Riverside Drive and the Princes Highway are zoned as SP2 – Infrastructure.

Figure 2-1 Local Context



3 EXISTING OPERATIONS

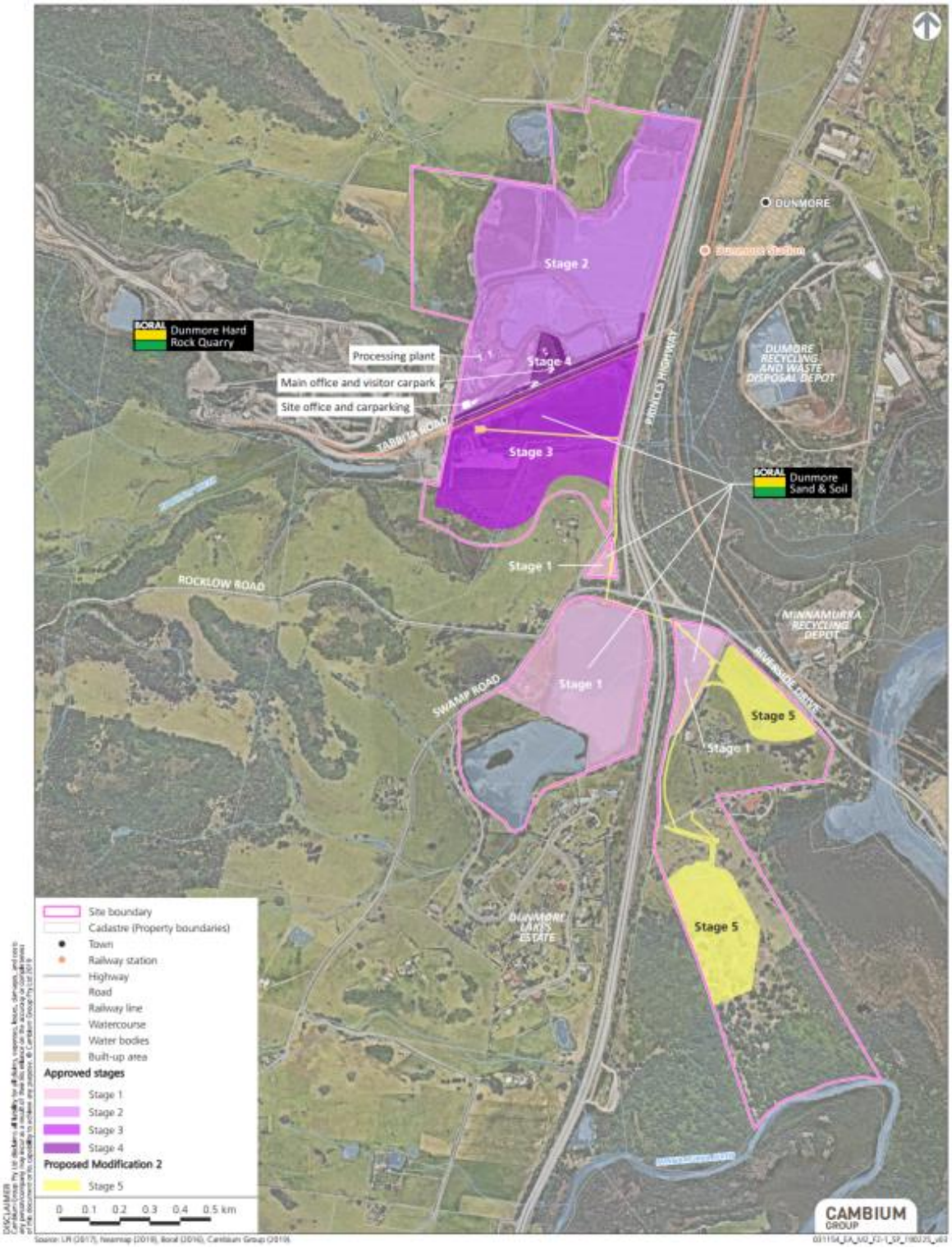
3.1 Approved Project

The approved operations include extraction and transportation of up to 800,000 tonnes of sand products per annum from Stage 2 to 4 over a period of 25 years.

The primary components of the Approved Project are outlined below and shown in Figure 3-1:

- Stage 2: Excavation of approximately 0.5 million tonnes of soil and extraction of approximately 3.6 million tonnes of sand by excavating from a 5 ha area around the margins of the Stage 2 area, and dredging from a 32 ha area of land within the Stage 2 area;
- Stage 3: Excavation of approximately 0.3 million tonnes of soil and extraction of approximately 2.2 million tonnes of sand by excavating from a 2 ha area around the margins and dredging from a 16 ha area of land within the Stage 3 area;
- Stage 4B: Excavation of approximately 0.1 million tonnes of soil and dredging of 1.1 million tonnes of sand from a 3.1 ha area of land within the Stage 4 area. A further 0.3 million tonnes of sand would be recovered from Stage 4 as some boundary profile materials in Stages 2 and 3 would be extracted;
- processing of the dredged sand;
- processing of imported quarry fines and blending with washed fine sand and fine blue metal to yield coarse sand products for concrete manufacture and other applications;
- processing and sale of other quarry products, and when required, blending with proprietary materials to meet customers' individual specifications;
- blending of a range of natural materials with washed or unwashed sand to meet customers' individual specifications;
- progressive backfilling of pre-determined areas to create up to approximately 16 ha of useable, landscaped and mostly flood-free land. Approximately 16 ha of the area extracted would be backfilled to a level comparable with existing levels;
- progressive rehabilitation and landscaping of the lake foreshores and adjoining land in the Stage 2 and 3 areas to create a picturesque lake setting. The lake setting would comprise some wetland shallows and at least one near-shore bird nesting island; and
- the transportation of soil, sand, blended and other products from the site and backfill materials and product component materials to the site.

Figure 3-1 Staging Plan



3.1.1 Extraction Activities

Existing operations involve the sequential dredging and excavation of approximately eight million tonnes of sand and soil from Stage 2, 3 and 4. The method of extraction of these resources includes both sand and soil extraction by excavator and dredge sand extraction, followed by washing, processing and material blending. The final product is then stockpiled on site until transported to local and regional markets via road and rail.

Stage 2 covers an area of 37 ha and adjoins the northern boundary of Tabbita Road and encompasses a large area of cleared and disturbed grassland and the footprint of existing sand extraction activities, which are nearing completion. Stage 2 also contains the sand processing infrastructure, which will continue to be utilised during sand extraction activities in Stage 3, 4 and eventually Stage 5.

Stage 3, which covers an area of 21 ha, adjoins the southern boundary of Tabbita Road. Rocklow Creek transects Stage 3, which flows into the Coastal SEPP wetland located to the east of the Princes Highway, conveyed by a culvert beneath the Highway.

Stage 4, covering 5 ha, encompasses the Tabbita Road corridor, which includes the current road and rail access to Dunmore Hard Rock Quarry, located to the west of the site.

The general extraction process is summarised below:

Topsoil Removal

Topsoil and underlying sand to a maximum total depth of approximately one metre is removed by excavator with either direct loading into trucks or into draining stockpiles prior to loading.

The topsoil is either removed directly from site, stored within the processing area or placed on areas for use in site rehabilitation and/or in bund wall construction.

Excavator Extraction

Extraction of sand by excavator is undertaken on a campaign basis whereby a perimeter length of the nominated stage is extracted ahead of the associated dredging.

Dredging Extraction

The dredge moves progressively through the resource area generally following the nominated stages. In most cases, the sand within each extraction stage is fully extracted unless operational constraints are encountered.

The dredge moves backwards and forwards across the active dredge pond, cutting away against the underwater sand face. The sand/water slurry is pumped directly from the dredge via a pontoon-mounted pipeline to either an initial storage area or the fine sand washing plant located within the processing and stockpile area at Stage 2. The pipeline location constantly changes throughout the life of the operation but is positioned to minimise impacts on natural vegetation and the banks of man-made channels across the site. The dredges manoeuvre around the ponds and their position is stabilised with the assistance of either "spud" bars or tie ropes connected to the banks around the active pond.

3.1.2 Processing, Blending and Stockpiling

The screening and blending plants are located in the Stage 2 portion of the site and are mobile units comprising a hopper, conveyor belts, screens and delivery chute. The components for all blends are fed into the units by a front-end loader in their required proportions and a product stockpile created. It is normal for at least ten different blended product stockpiles to be present at any one time.

Each plant has a capacity to blend products ranging from 20 to 200 tonnes per hour.

Coarse Sand Plant

This plant produces the coarse sand products from a blend of the washed fine-grained sand and the quarry fines generated at the nearby Dunmore Hard Rock Quarry. The plant has a capacity to produce coarse sand components at a rate of up to 150 tonnes per hour.

Fine Sand Plant

The fine sand plant has a capacity of approximately 200 tonnes per hour. This plant is fitted with twin cyclones and can feed two draining stockpiles.

3.1.3 Sand Products

The bulk of the sand that is extracted by dredge from Stages 2, 3 and 4 is processed to yield washed fine sand for direct sale or use in other products.

The fine sand is ideally suited as a component raw material for a wide range of sand-based products, including concrete sand and similar products either as a fine concrete sand or as a component of coarse sand blends. It is expected that between 30% and 50% of the fine washed sand would be used in the manufacture of the coarse sand blends. The grading of the coarse sands is designed to meet the customers' individual requirements.

3.2 Operating Hours

The operating hours for the Approved Project are outlined in detail in Table 3-1.

Table 3-1 Approved Operating Hours

Activity	Day	Time
Dredging and processing	Monday – Saturday Sunday and public holidays	6:00 am to 6:00 pm 8:00 am to 4:00 pm
Excavator extraction	Monday – Saturday Sunday and public holidays	6:30 am to 6:00 pm None
Delivery, distribution and maintenance	Monday – Friday Saturday Sunday and public holidays	5:00 am to Midnight 6:00 am to 6:00 pm 8:00 am to 4:00 pm
Delivery and distribution via Shellharbour Road	Monday – Friday Saturday Sunday and public holidays	7:00 am to 10:00 pm 7:00 am to 6:00 pm 8:00 am to 4:00 pm
Maintenance (if inaudible at neighbouring residences)	Any time	Any time

3.3 Environment Protection Licence

The *Protection of the Environment Operations Act 1997* provides for an integrated system of licensing and contains a core list of activities requiring Environment Protection Licences (EPL) from the NSW Environment Protection Authority (EPA). The activities are called 'scheduled activities' and are listed in Schedule 1 of the Act.

The Approved Project currently operates under EPL No. 11147, for the scheduled activities of crushing, grinding and separating, and extractive activities.

3.4 Environmental Management

An Environmental Management Strategy and the following associated management plans were previously prepared in accordance with DA 195-8-2004:

- Environmental Management Strategy;
- Noise Management Plan;
- Air Quality Management Plan;
- Flora and Fauna Management Plan;
- Water Management Plan which includes:
  - Site Water Balance;
  - Surface Water Monitoring Program; and
  - Ground Water Monitoring Program.
- Waste Management Plan; and
- Rehabilitation Management Plan.

The Environmental Management Strategy and associated management plans will need to be reviewed, revised and submitted to the DP&E for approval, prior to commencing operations in the Stage 5 extraction areas.

4 PROPOSED MODIFICATION

4.1 Additional Stage 5 Extraction Areas

The modification to the Approved Project seeks to establish additional extraction areas (Stage 5) on adjoining private property which is to be leased by DSS. Extraction is proposed to occur in two separate extraction areas, namely Stage 5A (immediately south of Riverside Drive), and Stage 5B (to the north of Minnamurra River). The approximate sand resource to be extracted from Stage 5A is estimated at 234,000 tonnes, whilst Stage 5B would extract approximately 1,123,000 tonnes. The aforementioned quantities are the estimated sand resource only, and additional tonnage of soil material may also be extracted in addition to the sand resource.

Mobile plant and equipment utilised at the site would be operated across both extraction areas within Stage 5. Extraction methods would be identical to those currently implemented in Stage 2 and 3.

Details of the proposed modification are shown in Figure 4-1.

4.1.1 Stage 5A

Sand extraction within Stage 5A would commence prior to Stage 5B operations and will involve clearing and grubbing of established groundcover vegetation. Topsoil will be stripped and stockpiled along the southern edge of the extraction area for later re-use in rehabilitation.

The sand would initially be extracted from Stage 5A via excavator to create a large enough pond to float a dredge and accommodate fresh water pumping from the dredge via overland pipeline to the processing plant in Stage 2.

The dredge will then progressively extract sand in an easterly direction.

Sand will be extracted to a maximum depth of approximately 12 m below the water table.

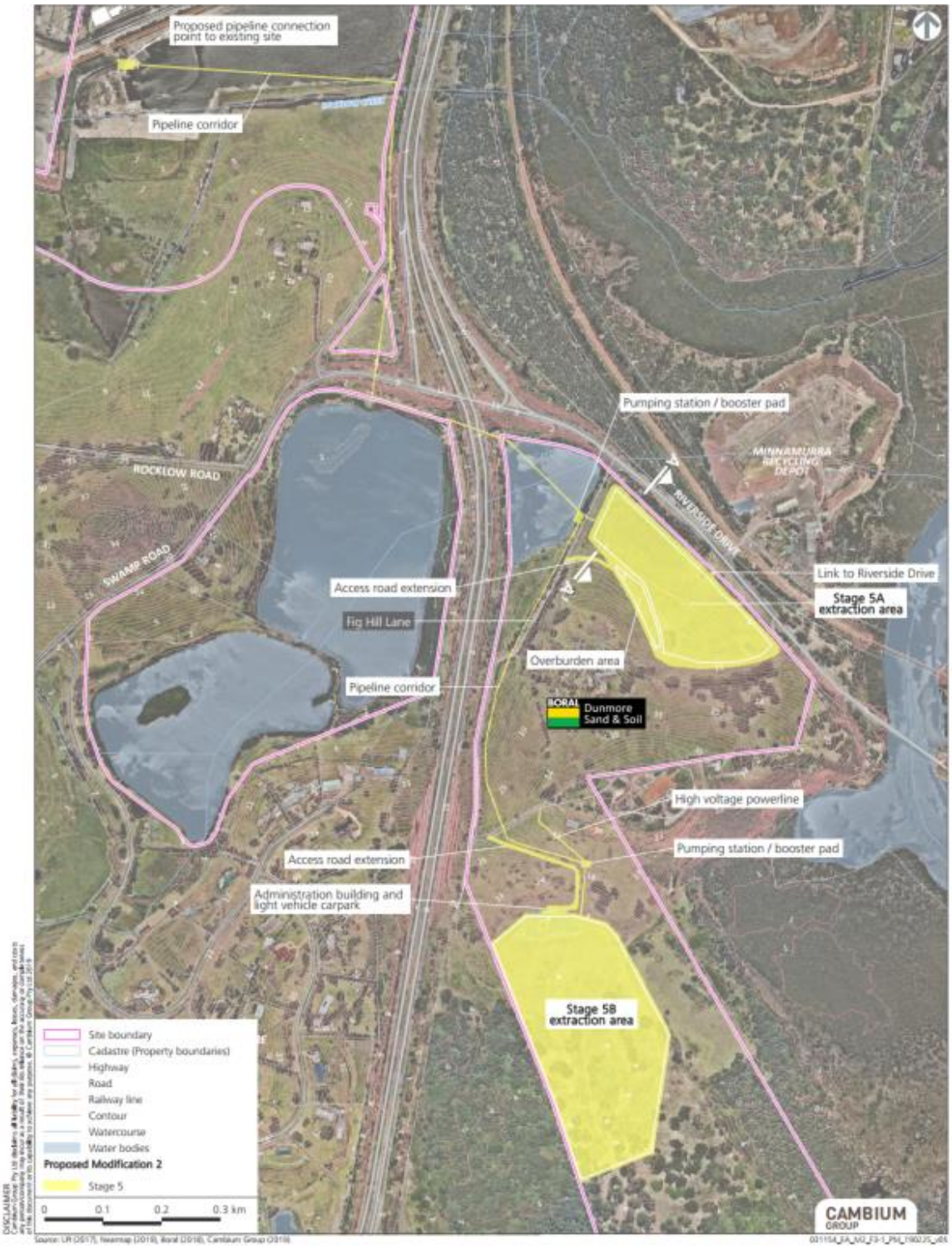
4.1.2 Stage 5B

Operations within Stage 5B would not commence until approximately two weeks prior to the completion of extraction in Stage 5A. During the two-week transition period, two dredges may be operating in tandem to minimise disruption to operations and ensure the supply of sand is not compromised during the transition between extraction areas. At the same time, earth mounds would be formed using a dozer to construct the flood bunding protection for the dredge pond.

Sand would be extracted in the northern end of the Stage 5B extraction area, via excavator to create a large enough pond to float a dredge and accommodate fresh water pumping from the dredge via overland pipeline to the processing plant in Stage 2.

The dredge will then progressively extract sand in a southerly direction. Sand will be extracted to a maximum depth of approximately 27 m below the water table.

Figure 4-1 Proposed Modification



4.2 Processing and Dispatch

An overland pipeline would be established from the Stage 5B extraction area to the existing Stage 2 processing area and would comprise two parallel 304 millimetre PVC pipelines.

The sand and water pumped from the dredge in the Stage 5B extraction area (and possibly directly from the Stage 5A extraction area) will pass over an initial screen at the Stage 2 processing plant to separate oversize organic matter or debris and into a large wash tank to float out any fines (<75 µm). After washing, the sand will be pumped through a cyclone and stockpiled for further dewatering. Water removed through the dewatering process will drain to an existing fines pond and a secondary settling pond before being pumped back to the Stage 5A and Stage 5B dredge ponds.

Dewatered sand will then be loaded with a front end loader for dispatch by rail and road.

Water pumped from the Stage 5 extraction areas will be returned to these extraction areas via the pumping pipeline. Pumped water volumes will be recorded by a flow meter and the same volume of water will be returned to the Stage 5 extraction areas to balance water extracted.

Sand processing and dispatch at the Stage 2 processing plant will be conducted in accordance with the Approved Project. The proposed modification does not involve any changes to the approved processing and dispatch activities.

4.3 Importation of Fill Material

DSS proposes to import up to 325,000 tonnes per annum of virgin excavated natural material (VENM) by road to the Stage 5 extraction area.

The VENM fill is required to:

- construct flood bunding and access roads in the Stage 5A extraction area;
- backfill the Stage 5A extraction area to natural ground level; and
- stabilise the edges of the Stage 5B dredge pond and the upper portions of the natural batters that form underwater, to allow safe access for vehicles, plant and equipment around the pond's perimeter.

VENM will be transported to the site by road truck/truck and dog and will be tipped directly into the pit(s) and spread with a dozer.

4.4 Access Roads

Fig Hill Lane provides the existing access to the Stage 5 extraction areas. As this existing access is too close to the Princes Highway – Riverside Drive intersection, a new access road is proposed to the Stage 5 extraction area off Riverside Drive, opposite Saltwater Creek Road. The access road would join a 3.5 m wide unsealed haul road around the perimeter of the Stage 5A extraction area, which joins the existing Fig Hill Lane, a sealed road that heads southwards towards the Stage 5B extraction area. A new 240 m long, 3.5 m wide unsealed access track will need to be constructed down the slope from where Fig Hill Lane terminates, to the northern end of the Stage 5B extraction area.

A 3.5 m wide unsealed haul road will also be constructed around the perimeter of the Stage 5B extraction area to enable access for maintenance.

The new access roads will be used by light vehicles accessing the site office and parking area adjacent to the Stage 5B extraction area and heavy vehicles delivering VENM fill material to the site.

All existing access arrangements for residents along Fig Hill Lane and Riverside Drive would be maintained during the Stage 5 operations.

4.5 Site Office and Parking

A portable site office and associated parking area for 10 light vehicles would be established in the north western corner of the Stage 5B extraction area.

4.6 Utilities and Infrastructure

4.6.1 Pipeline

An overland pipeline would be established from the Stage 5B extraction area to the Stage 2 processing area along the shortest possible route taking into account existing infrastructure, creeks and land ownership restrictions (refer to Figure 3-1). The approximately 2.1 km long pipeline is going to be temporary infrastructure that will be removed on completion of dredging in the Stage 5 extraction area. Therefore, where possible, the pipeline will be laid above ground to avoid excavation and vegetation clearing and will cross creeks through existing culverts.

The pipelines will be installed utilising a flatbed truck with hi-ab crane to unload the 12 m pipe segments into position. A small excavator may be required to position the pipe segments in position prior to welding of the segments together. The pipeline will be secured in place via a combination of star pickets and/or emplacement of fill over the pipelines. Any fill material used to secure the pipelines in position would be adequately stabilised with groundcover vegetation to minimise the potential for erosion and sedimentation impacts.

Where the pipelines traverse waterways, the pipeline will be secured to the side wall of the culvert via brackets and would sit well above the water column to mitigate against potential flood events.

4.6.2 Booster Pump

A booster pump station would be constructed to pump the water and sand through the pipeline from the Stage 5B extraction area to the processing plant located in the Stage 2 area adjacent to Tabbita Road. The water and sand will be pumped from the Stage 5B extraction area over the hill immediately north and will gravity feed to the Stage 2 processing plant. The water and sand will be pumped from the Stage 5B extraction area over the hill immediately north and will gravity feed to the Stage 2 processing plant. A second booster pump would also be required at the junction of the Stage 5A and Stage 5B pipelines to ensure sufficient pressure to transfer to the Stage 2 processing area.

The pump station would be constructed using Colorbond materials for noise attenuation and sit on an approximately 5 m x 5 m concrete pad. The pump station would comprise dimensions of approximately 3.5 m length by 3 m width and 2.5m height. The pumps would comprise dimensions of 3.2 m length by 2.65 m width and 2.2 m height.

An overhead high voltage power line would also be constructed from the existing powerline at 69 Fig Hill Lane (Lot 51 DP 1012246) to the booster pump station to the north of Stage 5B. The overhead power line would require installation of power poles.

4.7 Rehabilitation

DSS successfully backfilled and rehabilitated dredge ponds with VENM at previous stages of the operation. This experience and knowledge will be used in planning final rehabilitation options for the Stage 5 extraction area.

Prior to commencement of extraction in the Stage 5A area, topsoils would be stripped and stockpiled for future use in rehabilitation efforts.

Upon completion, the Stage 5A extraction area would be backfilled with VENM, topsoils spread, and groundcover vegetation re-established to return the land back to pasture at the request of the landowner. The Stage 5B extraction area would be left as a freshwater pond at the request of the landowner.

All rehabilitation initiatives at the site would be carried out in accordance with the principles contained in the approved Dunmore Sand and Soil Project Rehabilitation Management Plan (Arcadis, 2017). The Rehabilitation Management Plan would be updated to include the Stage 5 extraction area.

4.8 Comparison against Approved Project

No changes to the consented production volumes or operational hours are proposed as a result of the addition of the Stage 5 extraction area. The existing sand production facilities will process material extracted from the Stage 5 extraction areas, with no processing taking place within the modification site.

The modification would not increase the current hourly or daily traffic volumes associated with dispatch of processed sand products given that the production limit of the Approved Project would not be altered. However, the modification would introduce temporary additional heavy vehicle movements along the Princes Highway and Riverside Drive associated with importation of fill material to the Stage 5A extraction area.

5 EXISTING ENVIRONMENT

5.1 Sensitive Receivers

The nearest and most potentially affected receivers near the Proposal comprise:

- Isolated rural dwellings on and adjacent to the Proposal site;
- Residential dwellings in Minnamurra to the south-east;
- Residential dwellings in Dunmore Lakes Estate to the West; and,
- Two isolated rural dwellings to the north west.

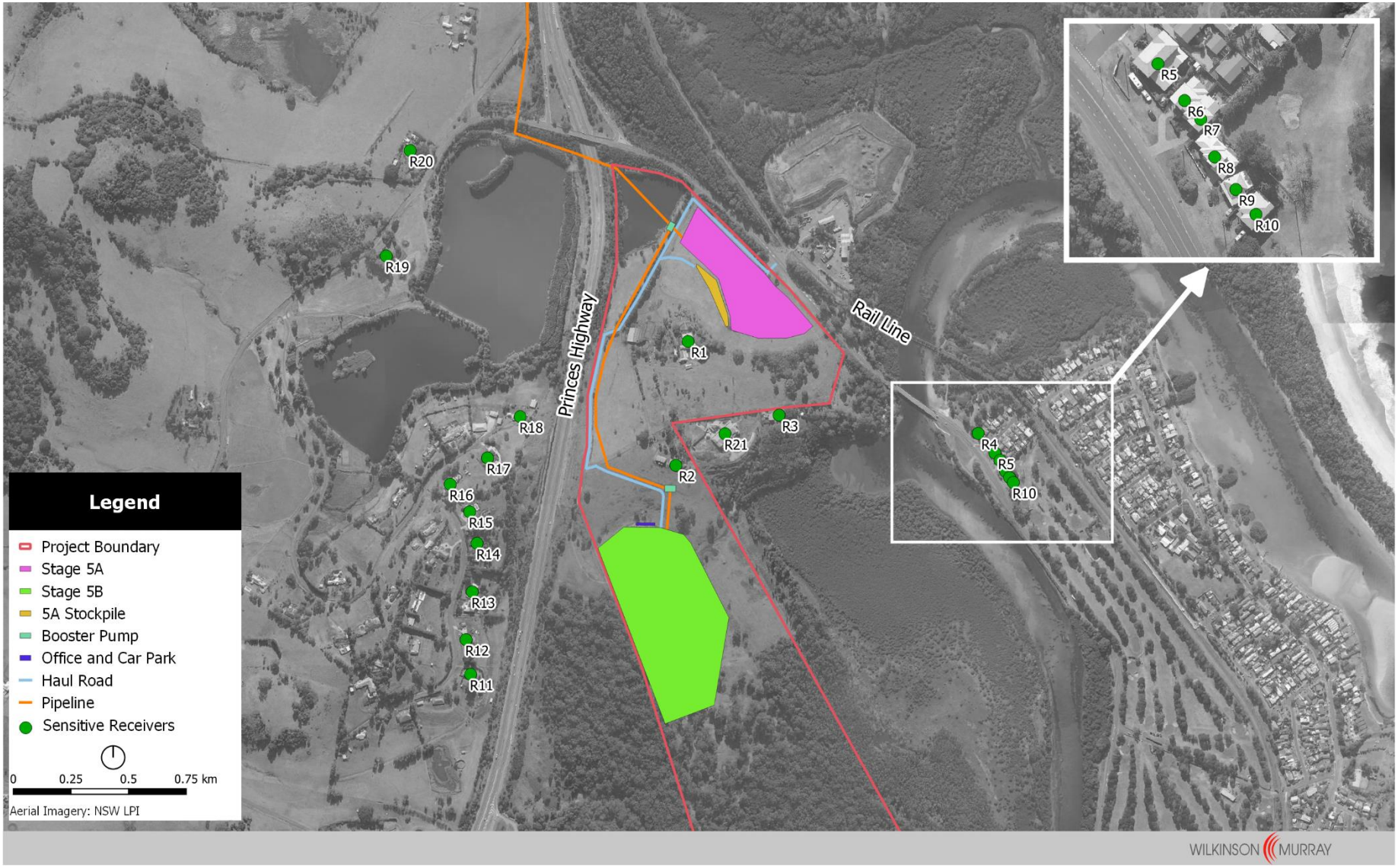
These receivers are described in Table 5-1 and shown in Figure 5-1.

Table 5-1 Sensitive Receivers

Receiver	Address	Lot/DP Number
R1	471 Riverside Drive, Dunmore	Lot 501 DP 1174897
R2	69 Fig Hill Lane, Dunmore	Lot 51 DP 1012246
R3	431 Riverside Drive, Dunmore	Lot 1 DP 219199
R4	2 The Village, Minnamurra	Lot 1 DP 225638
R5	1 The Village, Minnamurra	Lot 2 DP 1196150
R6	306 Riverside Drive, Minnamurra	Lot 2 DP 1192433
R7	304 Riverside Drive, Minnamurra	Lot 4 DP 1192433
R8	302 Riverside Drive, Minnamurra	Lot 1 DP 224542
R9	300 Riverside Drive, Minnamurra	Lot 2 DP 224542
R10	298 Riverside Drive, Minnamurra	Lot 3 DP 224542
R11	17 Allawah Place, Dunmore	Lot 32 DP 285417
R12	15 Allawah Place, Dunmore	Lot 33 DP 285417
R13	13 Allawah Place, Dunmore	Lot 18 DP 285417
R14	11 Allawah Place, Dunmore	Lot 19 DP 285417
R15	9 Allawah Place, Dunmore	Lot 20 DP 285417
R16	1 Allawah Place, Dunmore	Lot 21 DP 285417
R17	16 Fuller Drive, Dunmore	Lot 22 DP 285417
R18	18 Fuller Drive, Dunmore	Lot 34 DP 285417
R19	63 Swamp Road, Dunmore	Lot 17 DP 607791
R20	40 Swamp Road, Dunmore	Lot 1 DP 745632
R21	71 Fig Hill Lane, Dunmore	Lot 3 DP 717776

The landowners at receivers R1 and R2 have entered into a negotiated noise agreement with Boral. In addition, as R21 is an uninhabited structure without DA approval, noise levels at this receiver will not be considered further in this report.

Figure 5-1 Sensitive Receivers



5.2 Existing Ambient Noise Levels

Unattended noise monitoring was conducted between 13 August and 24 August 2018 to determine the existing ambient noise levels at the most potentially affected residential receivers in the area surrounding the Proposal. The monitoring was undertaken at three locations, each considered generally representative of nearby residential receivers, as shown in Figure 5-2 and described in Table 5-2.

Table 5-2 Noise Monitoring Locations

Location	Address
M1	471 Riverside Drive, Dunmore
M2	302 Riverside Drive, Minnamurra [a]
M3	40 Swamp Road, Dunmore

a. Noise logger deployed on Minnamurra Golf Course, at the rear of 302 Riverside Drive.

Noise monitoring location M1 is considered representative of the ambient noise environment at receiver R3. Existing noise levels measured at M1 have also been used for residential dwellings (receivers R11 to R18) in Dunmore Lakes Estate located east of Allawah Place due to proximity to the Princes Highway.

Location M2 is representative of receivers in Minnamurra, near the golf course. Location M3 represents the ambient noise environment at isolated rural residences to the north-east of the Proposal; however, it is noted that operational noise limits at 40 Swamp Road (M3) are already defined in the consent for DSS.

5.2.1 Ambient Noise Monitoring Results

The noise monitoring equipment used for these measurements consisted of an environmental noise logger set to A-weighted, fast response. This equipment is capable of remotely monitoring and storing noise level descriptors for later detailed analysis. The equipment calibration was checked before and after the survey and no significant drift was noted.

From the background noise levels (L_{A90}) the Rating Background Levels (RBLs) were determined using the methodology recommended in the NSW *Noise Policy for Industry* (NPfI). The existing operation was not audible during deployment or collection of unattended noise monitoring equipment and is unlikely to contribute significantly to background levels in the vicinity of the proposal. However, it should be noted that Appendix A1 of the NPfI addresses modifications to existing premises. The policy acknowledges that where the premises has been operating for a significant period of time, as is the case here, then it is considered a feature of the acoustic environment and may be included in the background noise assessment.

The existing ambient noise levels are presented in Table 5-3. Daily plots of the noise logger data are presented in **Appendix A**.

Table 5-3 Existing Ambient Noise Levels

Monitoring Location	Represented Receivers	Time of Day [a]	Noise Levels (dBA)	
			RBL	L_{Aeq}
M1	R1 – R3, R11 – R18	AM shoulder	46	54
		Day	47	55
		Evening	45	54
		Night	35	50
M2	R4 – R10	AM shoulder	38	57
		Day	42	64
		Evening	38	61
		Night	37	56
M3	R19	AM shoulder	41	52
		Day	42	53
		Evening	43	51
		Night	33	49

a. Day = 7:00 am – 6:00 pm; Evening = 6:00 pm – 10:00 pm; Night = 10:00 pm – 7:00 am.

Figure 5-2 Noise Monitoring Locations

6 OPERATIONAL NOISE ASSESSMENT

6.1 Operational Noise Trigger Levels

The *Noise Policy for Industry* (NPfI) (EPA, 2017) provides a framework for assessing environmental noise impacts from industrial premises and industrial development proposals in New South Wales.

The *NPfI* recommends the development of project noise trigger levels, which provide a benchmark for assessing a proposal or site. The project noise trigger levels should not be interpreted as mandatory noise criteria but, rather, as noise levels that, if exceeded, would indicate a potential noise impact on the community.

The project noise trigger level is the lower value of the project intrusiveness noise level and the project amenity noise level. The project intrusiveness noise level assesses the likelihood of noise being intrusive above the ambient noise level and is applied to residential receivers only. The project amenity noise level ensures the total industrial noise from all sources in the area does not rise above a maximum acceptable level.

The Proposal is located on land owned by 471 Riverside Drive (R1) and 69 Fig Hill Lane (R2). A negotiated agreement will form part of the extraction agreement and therefore, noise trigger levels are not established for these receivers.

6.1.1 Project Intrusiveness Noise Levels

The intrusiveness noise level is the noise level 5 dBA above the background noise level for each time period (daytime, evening or night time) of interest at a residential receiver. The background noise level is derived from the measured L_{A90} noise levels.

The *NPfI* stipulates that project intrusiveness noise levels should not be set below 40 dBA during the daytime and 35 dBA in the evening and night time. Additionally, the *NPfI* recommends that the project intrusiveness noise level for evening is set at no greater than that for the daytime, and that the project intrusiveness level for night time is set at no greater than that for the evening and daytime.

As the dredging is proposed to commence at 6:00 am in line with the existing approval, intrusiveness noise levels have been derived for the morning (AM) shoulder period.

Intrusiveness noise levels for the project are calculated from the RBLs in Section 5.2 of this report and are presented in Table 6-1. As the landowners at R1 and R2 have entered into a negotiated noise agreement with Boral, there are no project specific noise levels for these receivers.

Table 6-1 Project Intrusiveness Noise Levels

Receiver	Time of Day [a]	RBL	Project Intrusiveness Noise Level ($L_{Aeq,15min}$)
R3, R11 – R18	Morning shoulder	46	51
	Day	47	52
	Evening	45	50
	Night	35	40
R4 – R10	Morning shoulder	38	43
	Day	42	47
	Evening	38	43
	Night	37	42
R19	Morning shoulder	41	46
	Day	42	47
	Evening	43	47
	Night	33	38

a. Morning shoulder = 6:00 am – 7:00 am; Day = 7:00 am – 6:00 pm; Evening = 6:00 pm – 10:00 pm; Night = 10:00 pm – 7:00 am.

6.1.2 Project Amenity Noise Levels

Project amenity noise levels aim to set a limit on continuing increases in noise levels from all industrial noise sources affecting a variety of receiver types; that is, the ambient noise level in an area from all industrial noise sources remains below recommended amenity noise levels.

The amenity assessment is based on noise criteria specific to land use and associated activities. The criteria relate only to industrial-type noise and do not include transportation noise (when on public transport corridors), noise from motor sport, construction noise, community noise, blasting, shooting ranges, occupational workplace noise, wind farms, amplified music/patron noise.

The amenity noise level aims to limit continuing increases in noise levels which may occur if the intrusiveness level alone is applied to successive development within an area.

The recommended amenity noise level represents the objective for total industrial noise at a receiver location. The project amenity noise level represents the objective for noise from a single industrial development at a receiver location.

To prevent increases in industrial noise due to the cumulative effect of several developments, the project amenity noise level for each new source of industrial noise is set at 5dBA below the recommended amenity noise level.

The following exceptions apply to determining the project amenity noise level:

- For high-traffic areas the amenity criterion for industrial noise becomes the $L_{Aeq,period(traffic)}$ minus 15dBA.
- In proposed developments in major industrial clusters.

- If the resulting project amenity noise level is 10dB or more lower than the existing industrial noise level, the project amenity noise level can be set at 10dB below existing industrial noise levels if it can be demonstrated that existing industrial noise levels are unlikely to reduce over time.
- Where cumulative industrial noise is not a consideration because no other industries are present in, or likely to be introduced into the area, the relevant amenity noise level is assigned as the project amenity noise level for the development.

Amenity noise levels are not used directly as regulatory limits. They are used in combination with the project intrusiveness noise level to assess the potential impact of noise, assess mitigation options and determine achievable noise requirements.

The project amenity noise levels are calculated from the recommended amenity noise levels presented in Table 6-2.

Table 6-2 Recommended Amenity Noise Levels

Receiver	Noise Amenity Area	Time of Day [a]	Recommended Amenity Noise Level (dBA $L_{Aeq,period}$)
Residential	Rural	Day	50
		Evening	45
		Night	40
	Suburban	Day	55
		Evening	45
		Night	40
	Urban	Day	60
		Evening	50
		Night	45
Hotels, motels, caretakers' quarters, holiday accommodation, permanent resident caravan parks	See column 4	See column 4	5 dB(A) above the recommended amenity noise level for a residence for the relevant noise amenity area and time of day.
School classroom-internal	All	Noisiest 1-hour period when in use	35
Hospital ward internal external	All	Noisiest 1-hour	35
	All	Noisiest 1-hour	50
Place of worship-internal	All	When in use	40
Area specifically reserved for passive recreation (e.g. national park)	All	When in use	50
Active recreation area (e.g. school playground, golf course)	All	When in use	55

Receiver	Noise Amenity Area	Time of Day [a]	Recommended Amenity Noise Level (dBA $L_{Aeq,period}$)
Commercial premises	All	When in use	65
Industrial premises	All	When in use	65
Industrial interface (applicable only to residential noise amenity areas)	All	All	Add 5 dB(A) to recommended noise amenity area

a. Day = 7:00 am – 6:00 pm; Evening = 6:00 pm – 10:00 pm; Night = 10:00 pm – 7:00 am.

Recommended amenity noise levels presented in Table 6-2 above represent the objective for total industrial noise at a receiver location. In the case of a single new noise source being proposed, the project amenity noise level represents the objective for noise from a single industrial development at the receiver location. This is calculated as the recommended amenity noise level minus 5dBA.

Due to different averaging periods for the $L_{Aeq,15min}$ and $L_{Aeq,period}$ noise descriptors, the values of project intrusiveness and amenity noise levels cannot be compared directly when identifying noise trigger levels i.e.; the most stringent values of each category. In order to make a comparison between descriptors, the NPfI assumes that the $L_{Aeq,15min}$ equivalent of an $L_{Aeq,period}$ noise level is equal to the $L_{Aeq,15min}$ level plus 3dB.

Table 6-3 Project Amenity Noise Levels

Noise Amenity Area	Time of Day [a]	Recommended Amenity Noise Level ($L_{Aeq,period}$)	Project Amenity Noise Level ($L_{Aeq,15min}$ dBA)
Rural	Day	50	48
	Evening	45	43
	Night	40	38

a. Day = 7:00 am – 6:00 pm; Evening = 6:00 pm – 10:00 pm; Night = 10:00 pm – 7:00 am.

6.1.3 Project Noise Trigger Levels

Table 6-4 below shows the project noise levels for sensitive receivers, with the project noise trigger levels shown in bold.

Since the existing consent for DSS specifies $L_{Aeq,15min}$ noise limits for R20, the project noise trigger levels for this receiver are set to equal the consent noise limits. For consistency, the morning shoulder project noise trigger level for R3 and R11 to R18 are set at 48 dB, the same as the daytime project noise trigger level for these locations.

Table 6-4 Project Noise Trigger Levels

Receiver	Time of Day [a]	Project Intrusiveness Noise Levels ($L_{Aeq,15min}$ dBA)	Project Amenity Noise Levels ($L_{Aeq,15min}$ dBA)
R3, R11 – R18	Morning shoulder	51	**48**[c]
	Day	52	**48**
	Evening	50	**43**
	Night	40	**38**
R4 – R10	Morning shoulder	**43**	48[c]
	Day	**47**	48
	Evening	**43**	**43**
	Night	42	**38**
R19	Morning shoulder	**46**	48[c]
	Day	**47**	48
	Evening	47	**43**
	Night	**38**	**38**
R20[b]	Day	**49**	
	Evening	**44**	
	Night	**38**	

a. Morning shoulder = 6:00 am – 7:00 am; Day = 7:00 am – 6:00 pm; Evening = 6:00 pm – 10:00 pm; Night = 10:00 pm – 7:00 am.
b. Project noise trigger levels for R20 are set equal to the consent noise limits.
c. Project amenity noise levels are not specified for shoulder periods, therefore the day level has been adopted.

6.1.4 Maximum Noise Trigger Levels

Noise sources at night occurring over a short duration have the potential to cause sleep disturbance despite complying with project noise trigger levels. The dredge(s) are intended to operate from 6am, during the morning shoulder period. Therefore, maximum noise level events need to be considered for potential sleep disturbance.

The *NPfI* recommends that, where the night time L_{Amax} receiver noise levels from a development exceeds 52 dBA or the RBL plus 15 dBA, whichever is the greater, then a more detailed assessment of potential sleep disturbance impacts is warranted. Table 6-5 presents the maximum noise trigger levels for the receivers identified in this assessment. These noise levels are typically addressed at the façade of potentially affected dwellings and should consider multiple storey dwellings.

Table 6-5 Maximum Noise Trigger Levels

Receiver	RBL (dBA)	RBL + 15 dBA	Maximum Noise Trigger Level (dBA)
R3, R11 – R18	46	61	52
R4 – R10	38	53	52
R19	41	56	52

Additionally, in instances where night time $L_{Aeq,15min}$ noise levels exceed 40 dBA or the prevailing RBL plus 5 dBA, whichever is the greater, then a detailed assessment of potential sleep disturbance impacts is warranted.

6.2 Operational Noise Modelling Methodology

6.2.1 Computer Noise Model

Operational noise emissions associated with the Proposal were modelled using the CadnaA acoustic noise prediction software and the CONCAWE noise prediction algorithm. The CONCAWE noise propagation model is used around the world and is widely accepted as an appropriate model for predicting noise over significant distances. Factors addressed in the noise modelling are:

- Equipment noise level emissions and locations;
- Shielding from ground topography and structures;
- Noise attenuation due to geometric spreading;
- Ground absorption;
- Atmospheric absorption; and,
- Noise enhancing meteorology.

6.2.2 Ground Topography

Topographical data for the Proposal site and nearby surrounding area has been provided by DSS at 2 metre height intervals. Further afield, 2 metre ground contours from NSW Land and Property Information (LPI) have been incorporated in the model.

6.2.3 Ground Absorption

A ground absorption factor of 0.75 has been applied to the entire model. This global ground absorption value conservatively represents the mix of hard ground (absorption = 0) and soft ground (absorption = 1) on and around the site.

6.2.4 Meteorological Effects

At relatively large distances from a source, the resultant noise levels at receivers can be influenced by meteorological conditions, particularly temperature inversions and gradient winds. Where these factors are a feature of an area their effect on resultant noise levels should be taken into account.

Noise enhancing meteorology adopted in this assessment, denoted as "NE" in results tables, are described below.

Temperature Inversions

The *NPfI* requires that temperature inversion effects are modelled during the night time assessment period where they are a feature of the area. Temperature inversion effects have not been modelled for daytime operations, however, the morning shoulder has been modelled for dredge operation only with an F class inversion. Drainage wind is not considered a feature of the area and has not been assessed.

Wind

Prevailing winds have been identified in general accordance with "Fact Sheet D" of the *NPfI*, based on hourly wind speed and direction observations taken during the period 2013-2017 at the weather station located on the DSS site.

Table 6-6 presents the percentage of time where light winds up to 3.0 m/s are blowing from a particular direction, plus or minus 45 degrees, during the day, evening and night time in each season. Where the percentage is 30% or more, denoted in bold text, the winds are considered a feature of the area, and should be included in the assessment.

Table 6-6 Identification of Prevailing Winds

Direction	Percentage of Time											
	Summer			Autumn			Winter			Night		
	Day	Eve	Night	Day	Eve	Night	Day	Eve	Night	Day	Eve	Night
N	8	22	9	12	7	3	10	2	3	10	13	6
NNE	10	21	6	12	5	2	9	1	2	11	11	3
NE	11	16	3	11	3	1	8	1	1	12	7	2
ENE	10	9	2	10	1	1	8	1	1	11	4	2
E	10	8	2	9	1	1	7	1	1	9	3	2
ESE	9	9	3	9	2	1	7	1	2	7	4	2
SE	8	11	5	9	2	2	7	2	2	7	5	2
SSE	8	13	9	10	5	3	8	3	2	6	8	5
S	7	14	14	12	10	10	12	8	6	6	12	10
SSW	6	20	**30**	16	**34**	**31**	19	**35**	26	6	28	29
SW	4	23	**40**	18	**51**	**48**	24	**56**	**48**	6	**41**	**46**
WSW	3	22	**41**	17	**53**	**53**	25	**60**	**52**	5	**41**	**50**
W	3	20	**41**	15	**51**	**51**	24	**58**	**52**	6	**41**	**49**
WNW	4	13	28	11	**30**	**32**	18	**32**	**33**	5	25	**32**
NW	5	14	18	10	14	14	13	11	11	6	15	15
NNW	7	20	15	11	11	8	12	6	6	8	15	10

Table 6-6 indicates the potential for prevailing winds in the area surrounding the Proposal during the evening and night time assessment periods. Prevailing winds are not identified in the daytime assessment period. Therefore, in accordance with the *NPfI*, noise enhancing winds have not been incorporated into the noise model for daytime operations.

The following meteorological conditions have been incorporated into the noise model during the morning shoulder period:

- F-class stability; and
- D-class stability and 3 m/s wind.

Winds during the morning shoulder are modelled to result in the highest noise levels at each receiver. However, it is noted that winds from north-westerly to southerly are not prevalent in any period during any season. Therefore, noise enhancement due to prevailing winds is unlikely to occur at receivers located in an arc from south-easterly to north of the site.

6.3 Operational Noise Sources

6.3.1 Sources of Operational Noise

The major noise sources associated with the operation of the Proposal are:

- Mobile plant, such as excavator, dozer and dump trucks used during preparation and rehabilitation phases;
- The dredge;
- The booster pump; and,
- Road trucks importing VENM during rehabilitation.

Source sound power levels for mobile plant items, including road trucks, have been taken from previous measurements of similar equipment conducted by Wilkinson Murray on similar sites.

The dredge operating on the Proposal site would be similar to the dredge operating on the existing DSS site. Accordingly, the sound power level for this item has been taken from the previous EIS for Stages 2, 3 & 4 of DSS.

Detailed design of the booster pump is not yet complete. Therefore, it has conservatively been assumed that the continuous sound power level of the pump would be 105 dBA. The pump would be located in a Colorbond enclosure, reducing the apparent sound power level of the pump by approximately 15 dBA. Accordingly, the modelled sound power of the pump/enclosure combination is 90 dBA.

Table 6-7 summarises the operational noise sources associated with the Proposal and their respective SWL. Equipment used in each of the assessment scenarios is detailed in Section 6.4.

Table 6-7 Operational Noise Sources and Sound Power Levels

Item	Description	Quantity	SWL (dBA) per item
Dozer	Caterpillar D8	1	111
Excavator	60 tonne	1	113
Dump truck	Caterpillar 740	1	110
Road truck	Truck and dog	Up to 16 movements/hr	103
Dredge	-	1 [a]	104
Booster pump	-	1	90

a. Two dredges may be operating in tandem for up to two weeks.

A correction of +5 dBA (effectively an L_{Amax}) has been applied to trucks, both dump trucks and road trucks, travelling along the sloped section of the haul road to the Stage 5B extraction area.

6.4 Modelled Activities and Assessment Scenarios

Noise impacts associated with the operation of the Proposal would vary as the nature and location of the works change over the life of the Proposal. To present the range of potential noise impacts over the life of the Proposal, sand extraction activities have been modelled in multiple areas of each stage, as follows:

- Stage 5A East;
- Stage 5A West;
- Stage 5B North; and,
- Stage 5B South.

In each of these areas, both overburden removal (OB) and raw material extraction (RM) activities have been modelled.

As a worst-case, the pump at the north of the Stage 5A extraction area will be operating during all OB and RM activities for Stages 5A and 5B. The pump at the north of the Stage 5B extraction area will be operating during all Stage 5B extraction activities.

Finally, activities associated with the rehabilitation of the site have been modelled. More details on each activity are provided below.

6.4.1 Overburden Removal

Sand extraction within Stage 5A would commence prior to Stage 5B operations and will involve clearing and grubbing of established groundcover vegetation. Topsoil will be stripped and stockpiled along the southern edge of the extraction area for later re-use in rehabilitation. At the same time, earth mounds would be formed using a dozer to construct the flood bunding protection for the dredge pond.

During Stage 5B operations, overburden would be stripped with an excavator, transferred into a dump truck and hauled to the Stage 5A extraction area where it would be used in the rehabilitation phase.

Stripping would occur progressively for both Stage 5A and 5B to minimise dust and visual impacts. Typically, the area stripped would allow dredging to occur for approximately 1-2 months before the next area is stripped.

6.4.2 Raw Material Extraction

Sand extraction within Stage 5A would be achieved using the dredge, beginning in the west of the extraction area and progressing in an easterly direction. The sand would be pumped via overland pipeline to the processing plant in Stage 2.

Operations within Stage 5B would not commence until approximately two weeks prior to the completion of extraction in Stage 5A. During the two-week transition period, two dredges may be operating in tandem to minimise disruption to operations and ensure the supply of sand is not compromised during the transition between extraction areas. At the same time, earth mounds would be formed using a dozer to construct the flood bunding protection for the dredge pond.

Sand would be initially extracted in the northern end of the Stage 5B extraction area and would progress in a southerly direction. The sand would be pumped via overland pipeline to the processing plant in Stage 2 and would require the use of the booster pump to pump sand and water over the intervening topography.

6.4.3 Rehabilitation

Upon completion, the Stage 5A extraction area would be backfilled with VENM, topsoil spread, and groundcover vegetation re-established to return the land back to pasture at the request of the landowner. The VENM would be imported to the site via truck-and-dog and would be spread with a dozer. The rehabilitation of the Stage 5A extraction area would occur in parallel with material extraction from Stage 5B.

Upon completion, the Stage 5A extraction area would be backfilled with VENM, topsoils spread, and groundcover vegetation re-established to return the land back to pasture at the request of the landowner. The Stage 5B extraction area would be left as a freshwater pond at the request of the landowner. The edges of the Stage 5B extraction area would be stabilised with VENM. This stabilisation works would take between 6 months and 2 years.

6.4.4 Summary of Scenarios

Table 6-8 provides a summary of equipment used in each stage of extraction.

Table 6-8 Summary of Model Scenarios and Equipment

Extraction Stage	Activity	Location	Equipment
5A	OB	West	Pump (5A North)
			Dozer/excavator (5A North)
			Dozer (5A South)
	OB	East	Pump (5A North)
			Dozer
			Dredge
	RM	West	Pump (5A North)
			Dredge
	RM	East	Pump (5A North)
			Dredge
	Rehabilitation	-	Pump (5A North)
			Pump (5B North)
			Dozer
			Haul trucks
			Dredge (5B South)
5A / 5B Transition	RM	5A East / 5B North	Pump (5A North)
			Pump (5B North)
			Dredge (5A East)
			Dredge (5B North)
			Dozer (5B North)
5B	OB	North	Pump (5A North)
			Pump (5B North)
			Excavator
			Dump truck to 5A
	OB	South	Pump (5A North)
			Pump (5B North)
			Dredge
			Excavator
			Dump truck to 5A
	RM	North	Pump (5A North)
			Pump (5B North)
			Dredge
	RM	South	Pump (5A North)
			Pump (5B North)
			Dredge
	Rehabilitation	-	Dozer
			Haul trucks

6.5 Assessment of Impacts

Given the landowners at R1 and R2 have entered into a negotiated agreement, the project noise trigger level is not applicable (n/a) at these locations and only the predicted noise levels from the Proposal have been presented.

6.5.1 Predicted Daytime $L_{Aeq,15min}$ Operational Noise Levels

The predicted $L_{Aeq,15min}$ noise levels associated with the operation of the Proposal are presented in Table 6-9.

Review of Table 6-9 indicates that the predicted operational noise levels comply with the established project noise trigger levels at all receivers.

Table 6-9 Predicted Daytime $L_{Aeq,15min}$ Operational Noise Levels

Receiver	Project Noise Trigger Level	Predicted Noise Level (dBA)											Complies?
		5A West OB	5A West RM	5A East OB	5A East RM	5B North OB	5B North RM	5B South OB	5B South RM	5A Rehab	5B Rehab	5A / 5B Transition	
R1	n/a	55	46	57	47	41	28	41	28	56	41	47	**n/a**
R2	n/a	27	19	26	20	56	46	55	44	44	53	49	**n/a**
R3	48	46	32	43	37	33	24	36	26	45	32	38	**Yes**
R4	47	32	22	26	22	30	21	34	24	31	29	30	**Yes**
R5	47	30	20	25	20	32	23	37	28	31	32	33	**Yes**
R6	47	29	<20	24	<20	35	23	37	28	30	32	33	**Yes**
R7	47	29	<20	24	<20	35	23	37	28	30	32	33	**Yes**
R8	47	29	<20	23	<20	35	23	37	28	30	32	33	**Yes**
R9	47	28	<20	23	<20	35	27	37	28	30	32	33	**Yes**
R10	47	27	<20	23	<20	35	27	37	28	30	32	33	**Yes**
R11	48	<20	<20	<20	<20	38	30	40	29	29	39	39	**Yes**
R12	48	<20	<20	<20	<20	41	33	42	31	31	42	42	**Yes**
R13	48	<20	<20	<20	<20	42	34	42	30	30	43	43	**Yes**
R14	48	21	<20	<20	<20	46	39	45	34	34	47	47	**Yes**
R15	48	26	21	<20	<20	45	38	44	33	33	45	45	**Yes**
R16	48	28	22	20	<20	39	27	39	24	25	37	34	**Yes**
R17	48	29	24	22	<20	46	27	46	23	25	43	32	**Yes**
R18	48	29	24	23	<20	48	20	48	<20	23	46	26	**Yes**
R19	44	36	30	25	<20	35	<20	35	<20	27	33	21	**Yes**
R20	49	32	25	27	21	32	<20	32	<20	29	30	22	**Yes**

6.5.2 Predicted Morning Shoulder $L_{Aeq,15min}$ Operational Noise Levels

The predicted $L_{Aeq,15min}$ noise levels associated with the operation of the Proposal during meteorological enhancing conditions. Only the dredging will be conducted during the morning shoulder period.

The dredge operating in each of Stages 5A and 5B have been modelled under the following enhancing conditions:

- F-class stability, no wind speed. Results are presented in Table 6-10; and
- D-class stability and 3 m/s wind speed. Results are presented in Table 6-11.

Table 6-10 Predicted Morning Shoulder $L_{Aeq,15min}$ Operational Noise Levels – Temperature Inversion

Receiver	Project Noise Trigger Level	Predicted Noise Level (dBA)					
		5A West RM	5A East RM	5B North RM	5B South RM	5A / 5B Transition	Complies?
R1	n/a	49	49	31	31	49	**n/a**
R2	n/a	44	44	48	45	48	**n/a**
R3	48	36	39	26	29	39	**Yes**
R4	47	26	24	24	28	27	**Yes**
R5	47	23	22	26	32	28	**Yes**
R6	47	22	22	27	32	28	**Yes**
R7	47	22	22	27	32	28	**Yes**
R8	47	22	21	27	32	28	**Yes**
R9	47	21	21	31	32	32	**Yes**
R10	47	21	20	31	32	32	**Yes**
R11	48	21	20	34	33	34	**Yes**
R12	48	22	21	36	35	36	**Yes**
R13	48	24	23	37	34	37	**Yes**
R14	48	25	25	42	37	42	**Yes**
R15	48	27	25	41	36	41	**Yes**
R16	48	26	21	30	27	30	**Yes**
R17	48	27	22	29	26	29	**Yes**
R18	48	27	21	23	20	24	**Yes**
R19	44	34	22	18	18	22	**Yes**
R20	49	29	25	16	16	25	**Yes**

Table 6-11 Predicted Morning Shoulder $L_{Aeq,15min}$ Operational Noise Levels – Wind Enhancing

Receiver	Project Noise Trigger Level	Predicted Noise Level (dBA)					
		5A West RM	5A East RM	5B North RM	5B South RM	5A / 5B Transition	Complies?
R1	n/a	49	50	33	32	50	**n/a**
R2	n/a	44	44	48	45	48	**n/a**
R3	48	37	40	27	30	40	**Yes**
R4	47	27	25	25	29	28	**Yes**
R5	47	24	24	27	33	29	**Yes**
R6	47	23	23	27	33	29	**Yes**
R7	47	23	23	27	33	29	**Yes**
R8	47	23	22	28	33	29	**Yes**
R9	47	22	22	32	33	32	**Yes**
R10	47	22	22	32	33	32	**Yes**
R11	48	22	21	34	34	34	**Yes**
R12	48	23	22	37	36	37	**Yes**
R13	48	25	24	38	35	38	**Yes**
R14	48	26	26	43	38	43	**Yes**
R15	48	28	26	42	37	42	**Yes**
R16	48	27	22	31	28	31	**Yes**
R17	48	28	23	30	27	30	**Yes**
R18	48	28	22	24	21	25	**Yes**
R19	44	35	22	19	19	23	**Yes**
R20	49	30	26	17	17	26	**Yes**

Review of Table 6-10 and Table 6-11 indicates that the predicted morning shoulder operational noise levels comply with the established project noise trigger levels at all receivers during all noise enhancing meteorological conditions.

Winds during the morning shoulder are modelled to result in the highest noise levels at each receiver. Based on prevailing winds, noise enhancement is unlikely to occur at receivers located in an arc from south-easterly to north of the site.

6.5.3 L_{Amax} Operational Noise Levels

As the dredge is a relatively constant noise source limited to the operation of pumps and machinery, there are unlikely to be any maximum noise events with the potential to cause sleep disturbance. As detailed in Table 6-10, the predicted $L_{Aeq,15min}$ noise levels for the operation of dredges during the morning shoulder period are well below the project specific criterion at each receiver. Given this, the Proposal will also meet the maximum noise trigger levels detailed in Table 6-5. No further assessment of maximum noise levels is required.

6.5.4 Cumulative Noise Impacts

The noise assessment methodology recommended by the *NPfI* implicitly considers potential cumulative impacts from multiple industrial activities through the amenity noise levels. However, it is necessary to consider the potential for cumulative impacts from the combined operation of the existing Stage 2, 3 and 4 of DSS and the Proposal.

During a recent operational noise audit for DSS, it was found that noise from the existing DSS operations was inaudible at 40 Swamp Road (R20) and was estimated to be, at most, 38 dBA ($L_{Aeq,15min}$).

Since R20 is the closest of the receivers in this assessment to the existing DSS operations, it is reasonable to conclude that the $L_{Aeq,15min}$ operational noise levels at all receivers in this assessment due to the existing DSS operations would be not greater than 38 dBA. At receivers in Minnamurra, $L_{Aeq,15min}$ noise levels from existing DSS operations would be significantly less than 38 dBA.

Accordingly, the $L_{Aeq,15min}$ noise levels from existing DSS operations would be at least 10 dBA below the project noise trigger levels for all receivers in this assessment. Therefore, these existing noise levels would have a negligible contribution to the total $L_{Aeq,15min}$ noise levels from all DSS operations.

Similarly, the highest predicted $L_{Aeq,15min}$ noise level at R20 from the operation of the Proposal is 34 dBA and it is therefore reasonable to assume that $L_{Aeq,15min}$ operational noise levels from the Proposal at receivers further to the north are less than 34 dBA. The most stringent daytime $L_{Aeq,15min}$ noise limit in the existing DSS consent is 46 dBA, which applies to 183 James Road, Dunmore (Lot 6 DP 1030504). Therefore, operational noise levels from the Proposal would be at least 10 dBA below the most stringent noise limits for the existing DSS operations and would not contribute to total $L_{Aeq,15min}$ noise levels at receivers near the existing DSS site.

7 CONSTRUCTION NOISE

The following section presents an assessment of potential noise impacts associated with construction components of the Proposal.

7.1 Construction Noise Management Levels

The *Interim Construction Noise Guideline* (ICNG) (DECC, 2009) recommends noise management levels (NML) to reduce the likelihood of noise impacts arising from construction activities. The *ICNG* NML for residential receivers are shown in Table 7-1.

Table 7-1 Construction NMLs at Residences

Time of Day	Management Level $L_{Aeq,15min}$ (dBA)	How to Apply
Recommended Standard Hours: Monday to Friday 7am to 6pm Saturday 8am to 1pm No work on Sundays or Public Holidays	Noise affected RBL + 10dBA	The noise affected level represents the point above which there may be some community reaction to noise. Where the predicted or measured $L_{Aeq,(15min)}$ is greater than the noise affected level, the proponent should apply all feasible and reasonable work practices to minimise noise. The proponent should also inform all potentially impacted residents of the nature of works to be carried out, the expected noise levels and duration, as well as contact details.
	Highly noise affected 75dBA	The highly noise affected level represents the point above which there may be strong community reaction to noise. Where noise is above this level, the proponent should consider very carefully if there is any other feasible and reasonable way to reduce noise to below this level. If no quieter work method is feasible and reasonable, and the works proceed, the proponent should communicate with the impacted residents by clearly explaining the duration and noise level of the works, and by describing any respite periods that will be provided.
Outside recommended standard hours	Noise affected RBL + 5 dB	A strong justification would typically be required for works outside the recommended standard hours. The proponent should apply all feasible and reasonable work practices to meet the noise affected level. Where all feasible and reasonable practices have been applied and noise is more than 5dB(A) above the noise affected level, the proponent should negotiate with the community. For guidance on negotiating agreements see section 7.2.2.

It is expected that all construction activities will be conducted within standard construction hours.

Based on the established RBLs, construction noise management levels for residential receivers near the Proposal are presented in Table 7-2.

Table 7-2 Project-Specific Construction NML

Receivers	Noise Affected $L_{Aeq,15min}$ Level (Standard Daytime Construction hours)	Highly Affected Noise Level (dBA)
R3, R11 – R18	57	75
R4 – R10	52	75
R19, R20	52	75

7.2 Construction Activities and Plant

The main construction activities associated with the Proposal are as follows:

7.2.1 Access Road

A new 240 m long, 3.5 m wide unsealed access track will need to be constructed down the slope from where Fig Hill Lane terminates, to the northern end of the Stage 5B extraction area. This access road would require cut and fill earthworks to enable vehicles to safely traverse down the slope. It is assumed that equipment similar to that proposed for overburden removal and rehabilitation would be used during construction of the access road.

7.2.2 Pipeline

The overland pipeline to be established from the Stage 5B extraction area to the Stage 2 processing area will be installed utilising a flatbed truck with hi-ab crane to unload the 12 m pipe segments into position. A small excavator may be required to position the pipe segments in position prior to welding of the segments together. The pipeline will be laid above ground to avoid excavation and vegetation clearing and will cross creeks through existing culverts.

7.2.3 Booster Pumps

Booster pump stations would be required to pump the water and sand through the pipeline from:

- the Stage 5B extraction area to the processing plant located in the Stage 2 area adjacent to Tabbita Road; and
- the junction of the Stage 5A and Stage 5B pipelines to ensure sufficient pressure to transfer to the Stage 2 processing area.

The booster pump stations will involve construction of a concrete pad and Colorbond material for noise attenuation.

7.2.4 Site Office and Parking Area

A portable site office and associated parking area for 10 light vehicles would be established in the north western corner of the Stage 5B extraction area. It is assumed that equipment similar to that proposed for overburden removal and rehabilitation would be used during construction of the parking area.

7.3 Construction Timing

The construction activities outline above will occur prior to overburden removal and excavation of raw materials. It is anticipated that the construction timeframe for the above activities will be less than 3 weeks.

The construction of flood bunding during Stage 5A and 5B has also been modelled, however, these construction activities have been modelled as occurring concurrently with other site operations. The predicted LAeq,15min noise levels during overburden removal in Stage 5A West and during the 5A/5B dredge transition represent the worst-case cumulative noise levels from the Proposal.

7.4 Construction Sound Power Levels

The worst-case construction activity and noisiest plant items to be used are listed in Table 7-3. The table provides typical sound power levels of the equipment, based on measurements previously conducted by Wilkinson Murray, and the resultant total sound power.

Table 7-3 Sound Power Level for Worst-Case Construction Activity

Construction Activity	Plant	Individual Sound Power Level (dBA)	Activity Sound Power Level (dBA)
Construction of access road	Dozer	111	117
	Roller	109	
	Excavator	113	
	Trucks	110	

The activity sound power is considered to represent the typical worst-case level in a given 15-minute period. It is important to note that this sound power level is unlikely to be sustained at such a level for the duration of the activity. As a result, many 15-minute periods will be at lower levels.

7.5 Predicted Construction Noise Levels

The predicted $L_{Aeq,15min}$ construction noise levels at the nearest sensitive receivers are presented in Table 7-4 for the worst-case construction activity that will occur prior to operations.

Table 7-4 Predicted Daytime $L_{Aeq,15min}$ Construction Noise Levels

Receiver	Project Construction Noise Trigger Level (dBA)	Predicted Construction Noise Level (dBA)	Complies?
R1	n/a	58	**n/a**
R2	n/a	29	**n/a**
R3	57	47	**Yes**
R4	52	38	**Yes**
R5	52	37	**Yes**
R6	52	36	**Yes**
R7	52	36	**Yes**
R8	52	36	**Yes**
R9	52	35	**Yes**
R10	52	35	**Yes**
R11	52	<30	**Yes**
R12	52	<30	**Yes**
R13	52	<30	**Yes**
R14	52	<30	**Yes**
R15	52	<30	**Yes**
R16	52	<30	**Yes**
R17	52	<30	**Yes**
R18	52	<30	**Yes**
R19	52	35	**Yes**
R20	52	35	**Yes**

7.6 Construction Noise Mitigation

As outlined above, noise levels associated with the worst-case construction activity of the Proposal will not exceed the established NML. However, all reasonable and feasible measures should be applied to manage noise levels. These measures should be documented in a Construction Noise Management Plan (CNMP) and include:

- Identification of nearby residences and other sensitive land uses;
- Description of approved hours of work;
- Description and identification of construction activities, including work areas, equipment and duration;
- Description of what work practices (generic and specific) will be applied to minimise noise and vibration;

- Consider the selection of plant and processes with reduced noise emissions;
- A complaint handling process;
- Noise monitoring procedures;
- Overview of community consultation required for identified high impact works;
- Induction and training will be provided to relevant staff and sub- contractors outlining their responsibilities with regard to noise; and,
- Procedures for approval of any works undertaken outside of the following hours:
    - Standard hours of 07:00 am to 18:00 pm Monday to Friday, and 08:00 am to 13:00 pm Saturday.

8 CONCLUSION

DSS is seeking to modify the current Project Approval (DA 195-8-2004) under Section 75W of the *Environmental Planning and Assessment Act 1979* (EP&A Act), to provide for an additional extraction area (Stage 5) on adjoining private land, encompassing two separate extraction areas, Stage 5A and Stage 5B.

Wilkinson Murray Pty Limited (WMPL) has been engaged by Element Environment (Element) on behalf of DSS to conduct a Noise Impact Assessment (NIA) for the proposed modification. This NIA provides a detailed assessment of potential operational noise impacts associated with the Proposal. The assessment has been conducted in general accordance with the *Noise Policy for Industry* (NPfI).

Unattended noise monitoring was conducted to determine the existing ambient noise levels at the most potentially affected residential receivers in the area surrounding the Proposal.

Noise impacts associated with the operation of the Proposal have been assessed in accordance with the *NPfI*.

A computer noise model has been developed to predict the $L_{Aeq,15min}$ operational noise levels at sensitive receivers. Meteorological data from the weather station on the Dunmore site has been analysed to identify the potential for noise-enhancing meteorology. No such meteorology has been identified as a feature of the area.

Based on information from Boral and previous noise assessments for DSS, operating parameters, equipment and source sound power levels have been developed to describe several noise assessment scenarios for the Proposal.

$L_{Aeq,15min}$ operational noise levels have been predicted at sensitive receivers for each assessment scenario. The predicted noise levels comply with the established project noise trigger levels. In accordance with the *Noise Policy for Industry*, no receiver-based treatments or controls are warranted.

APPENDIX A

NOISE MEASUREMENT RESULTS

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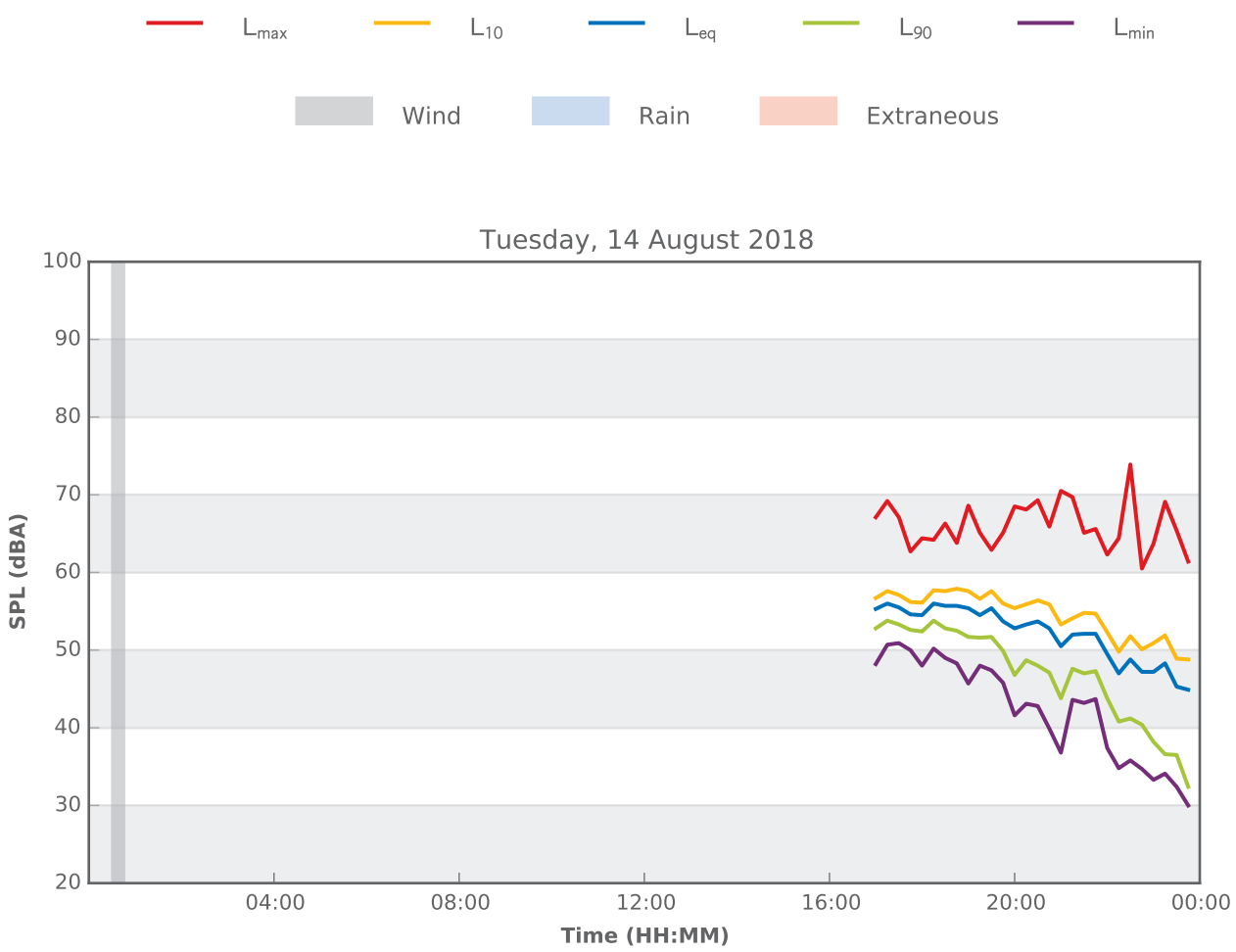

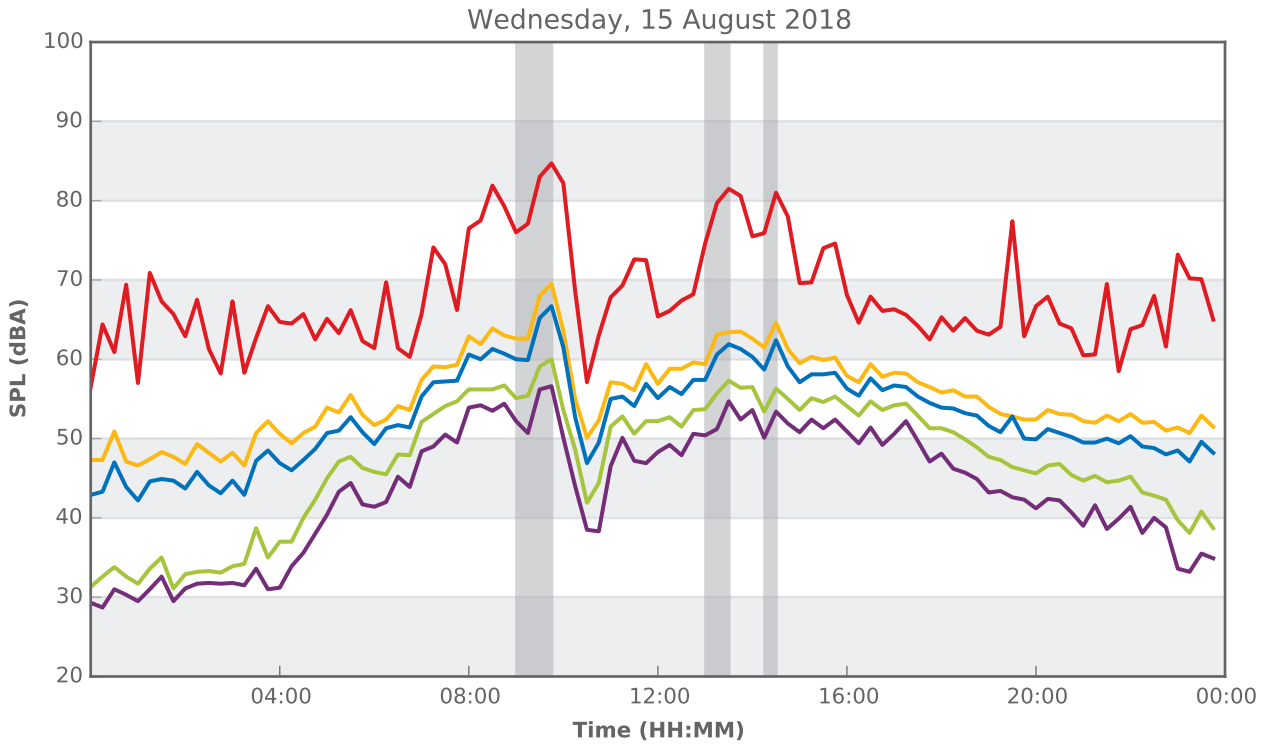

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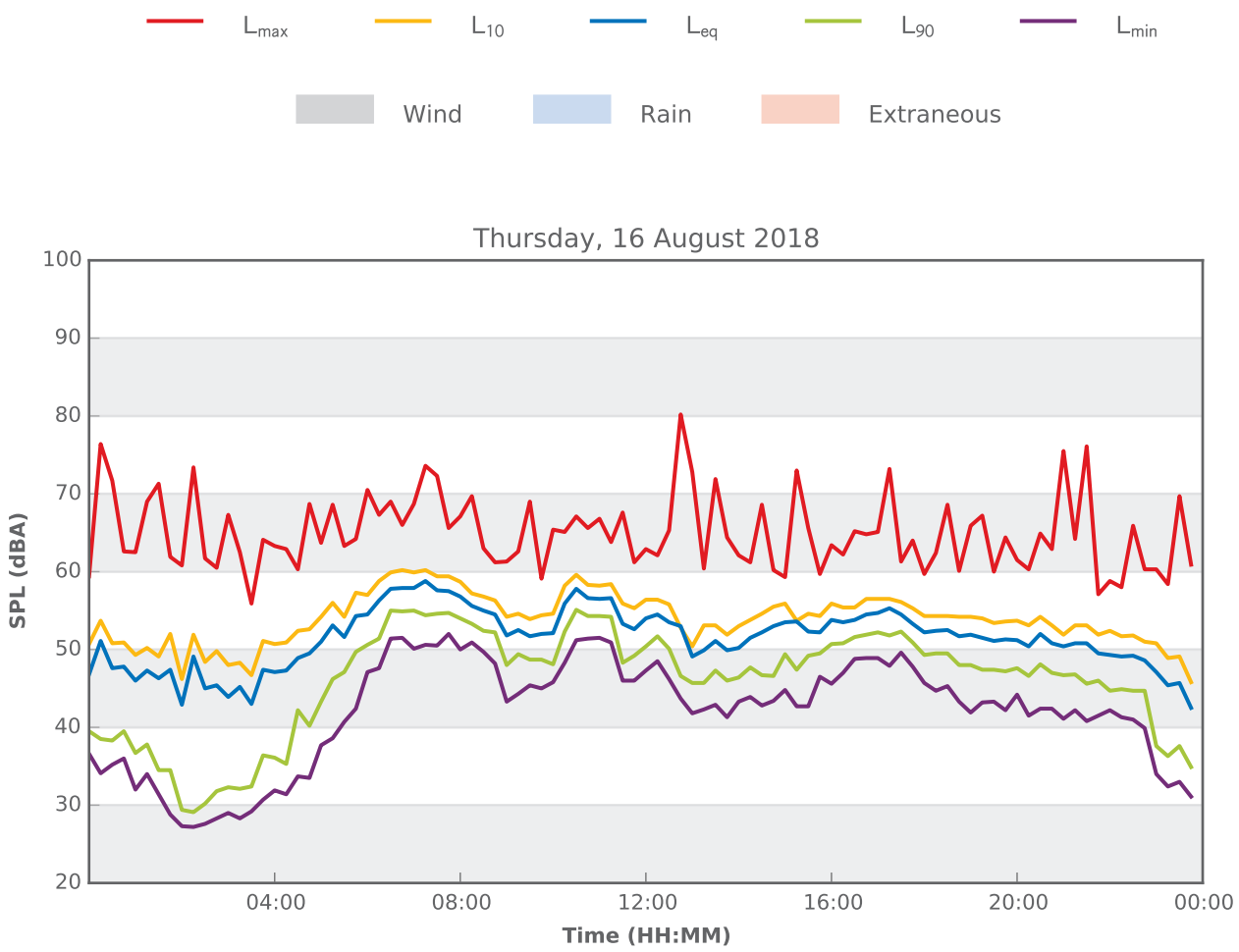

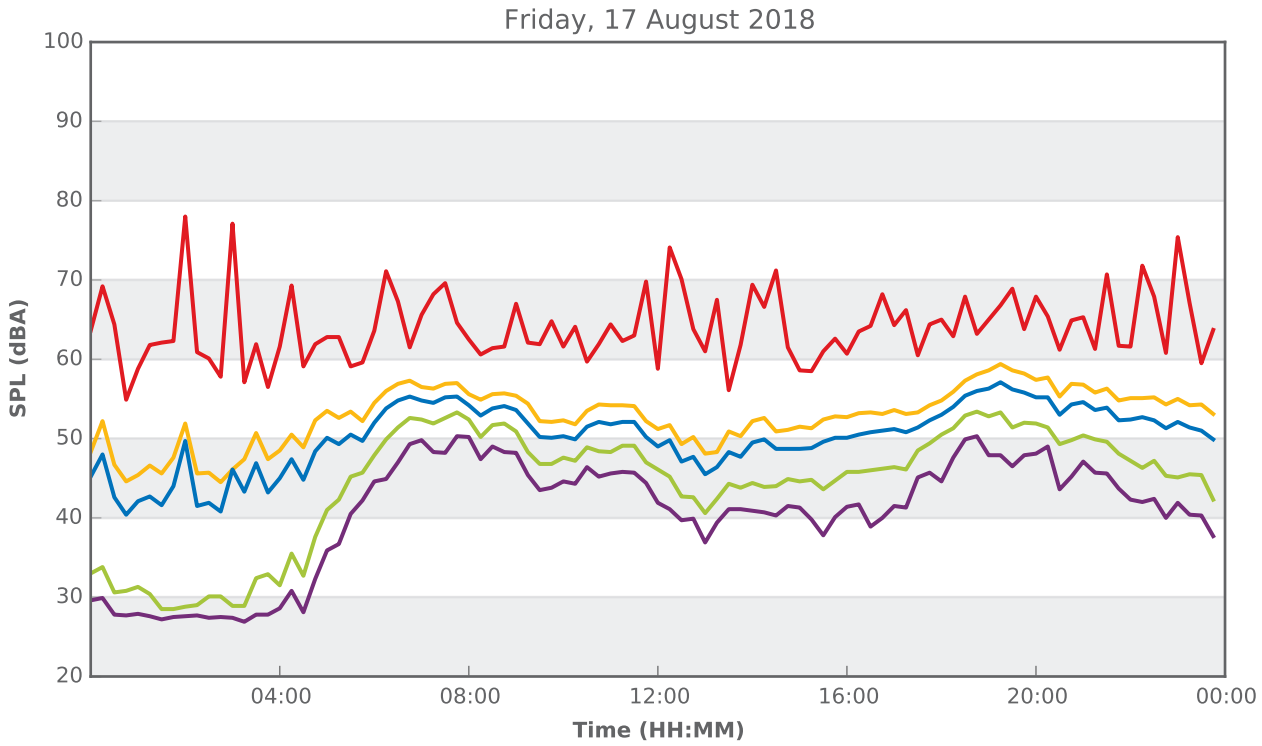

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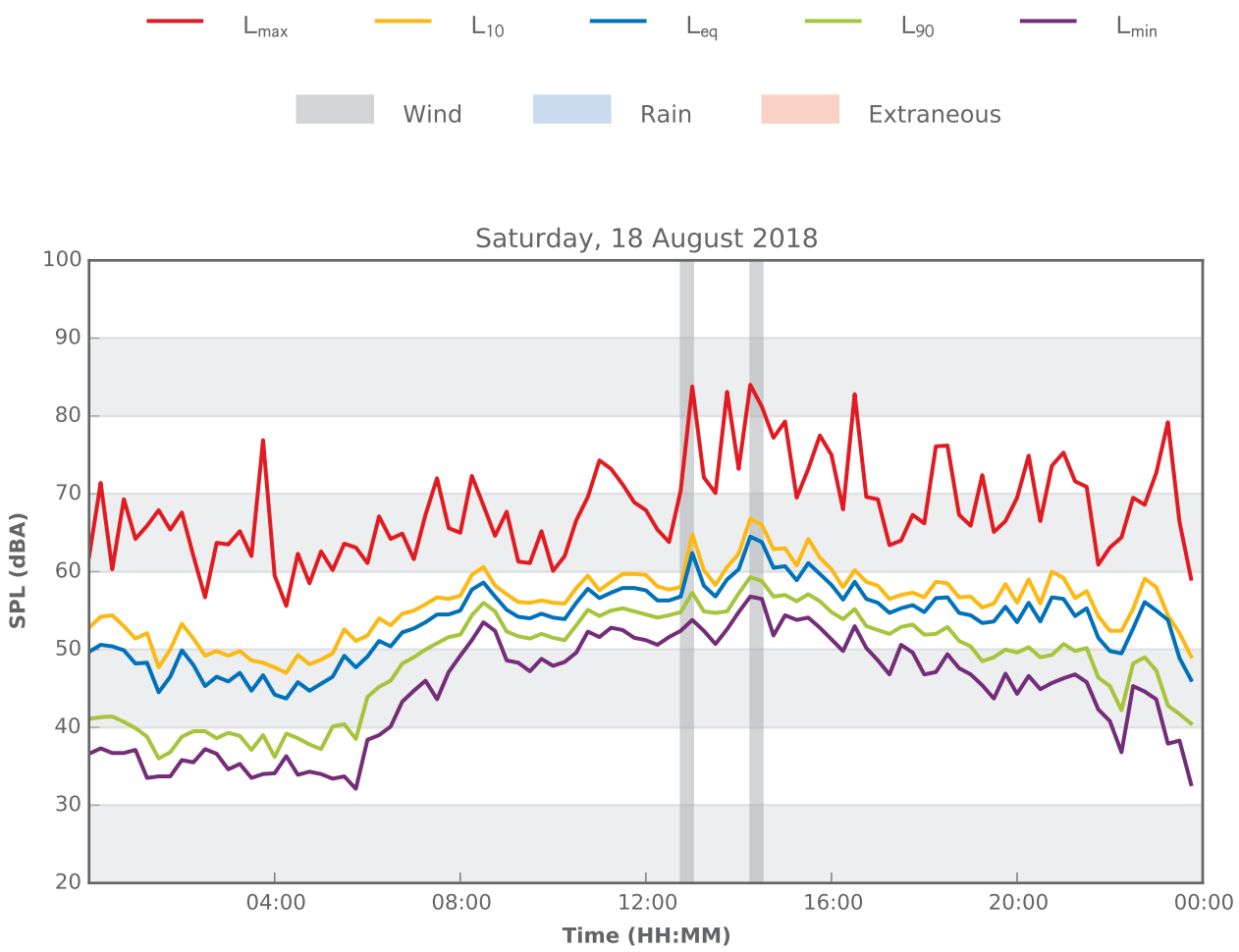

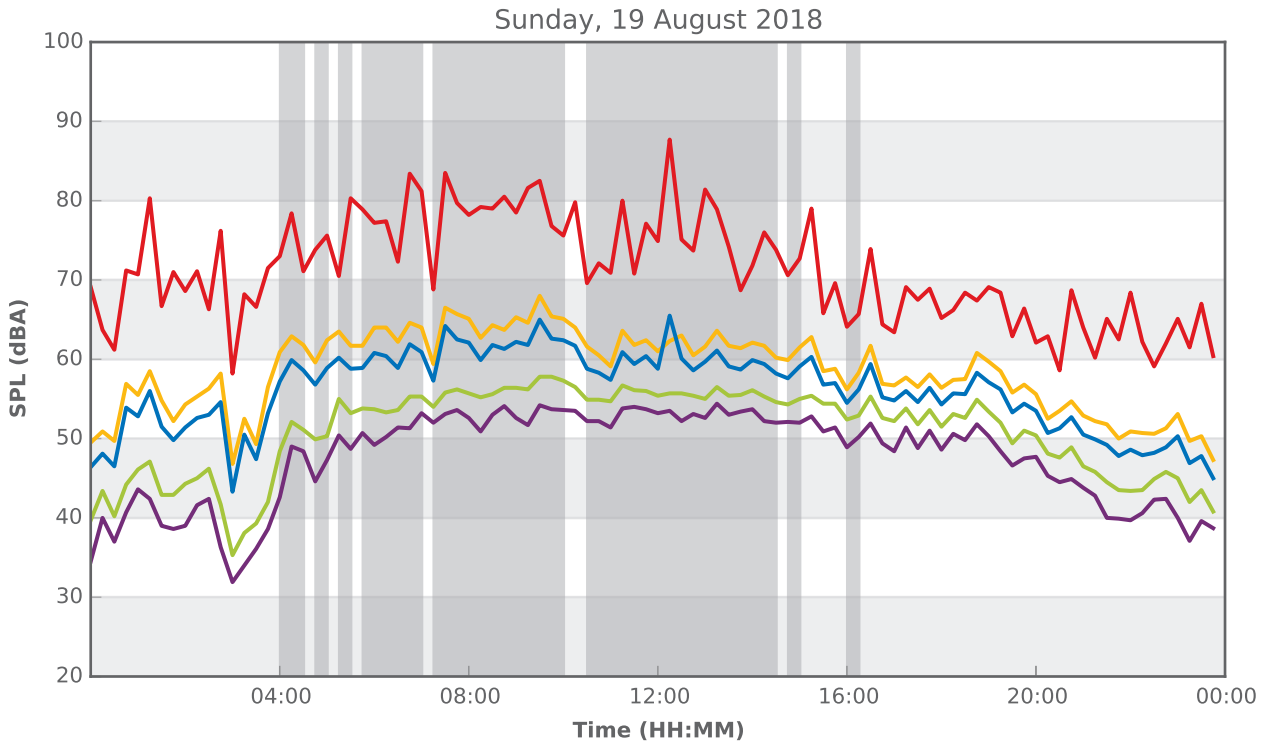

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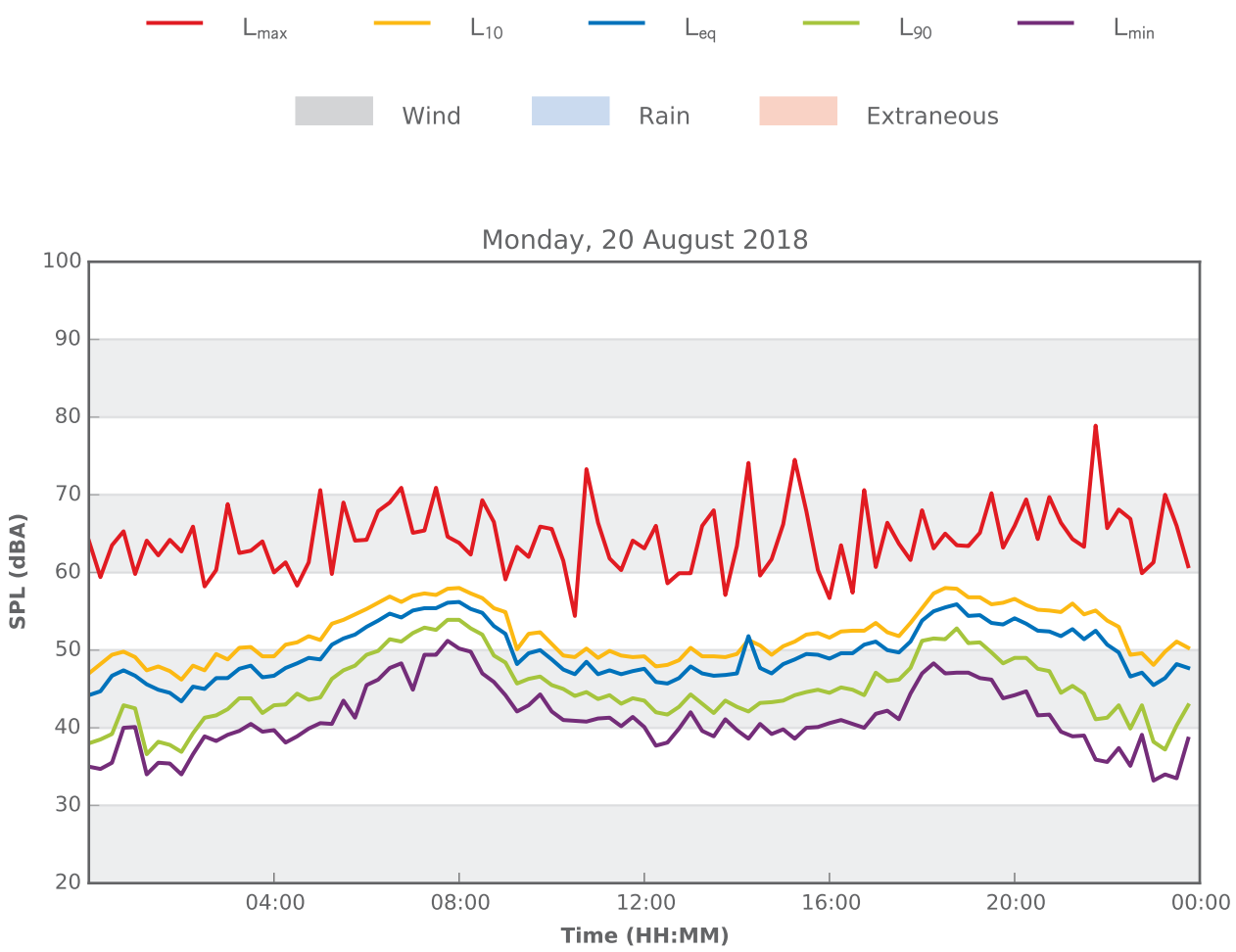

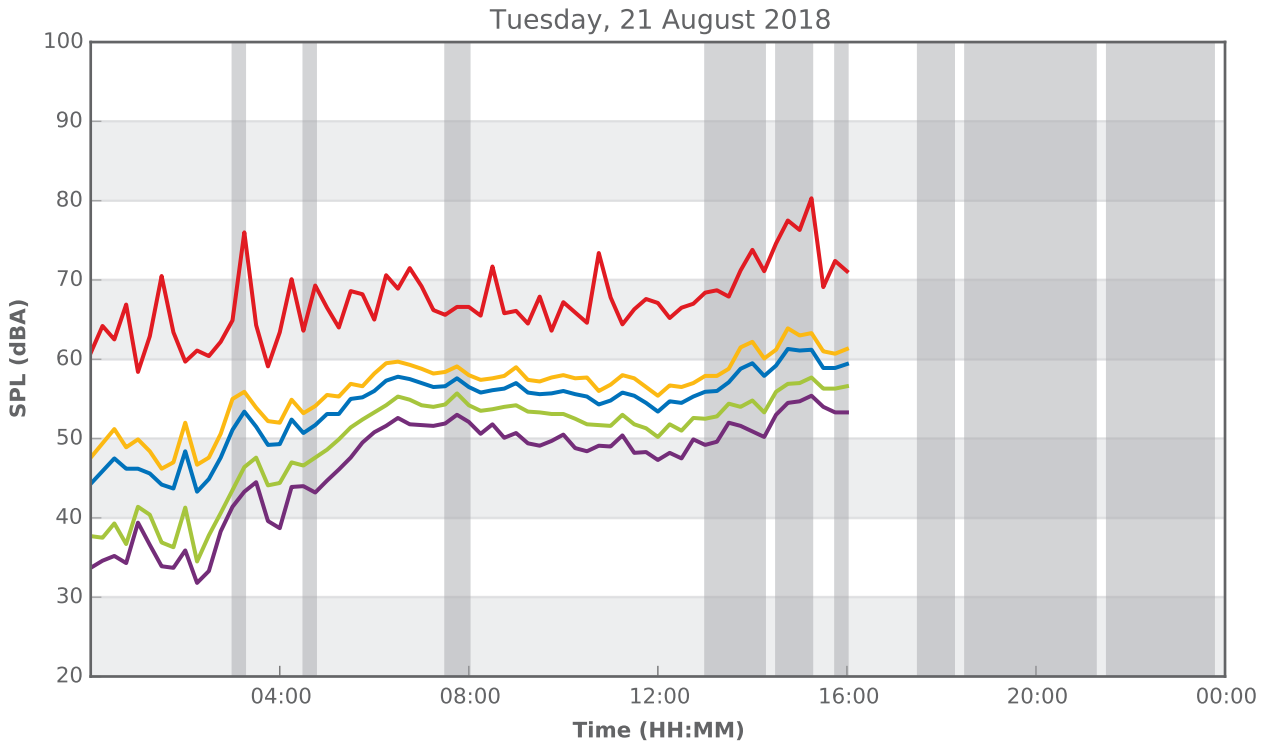

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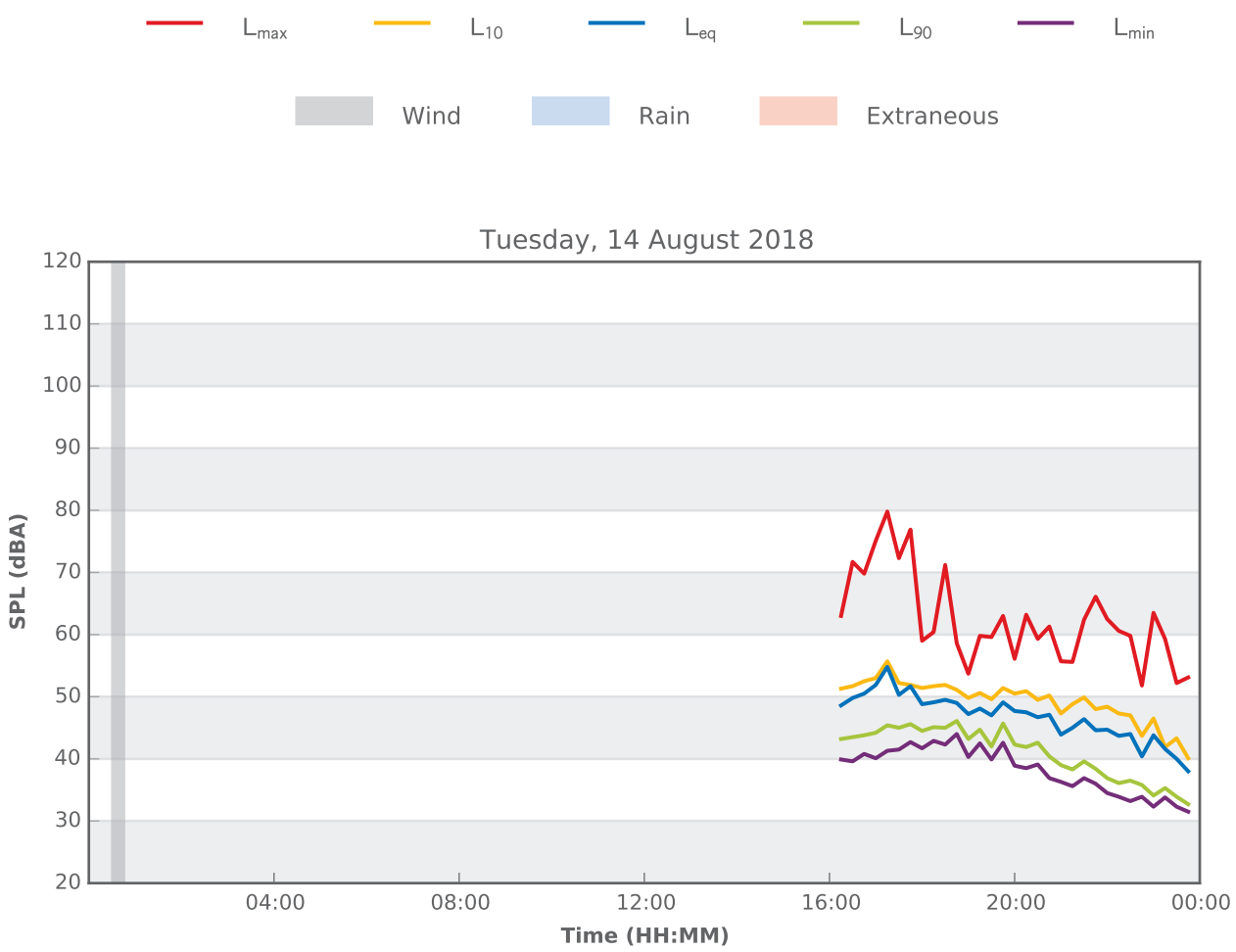

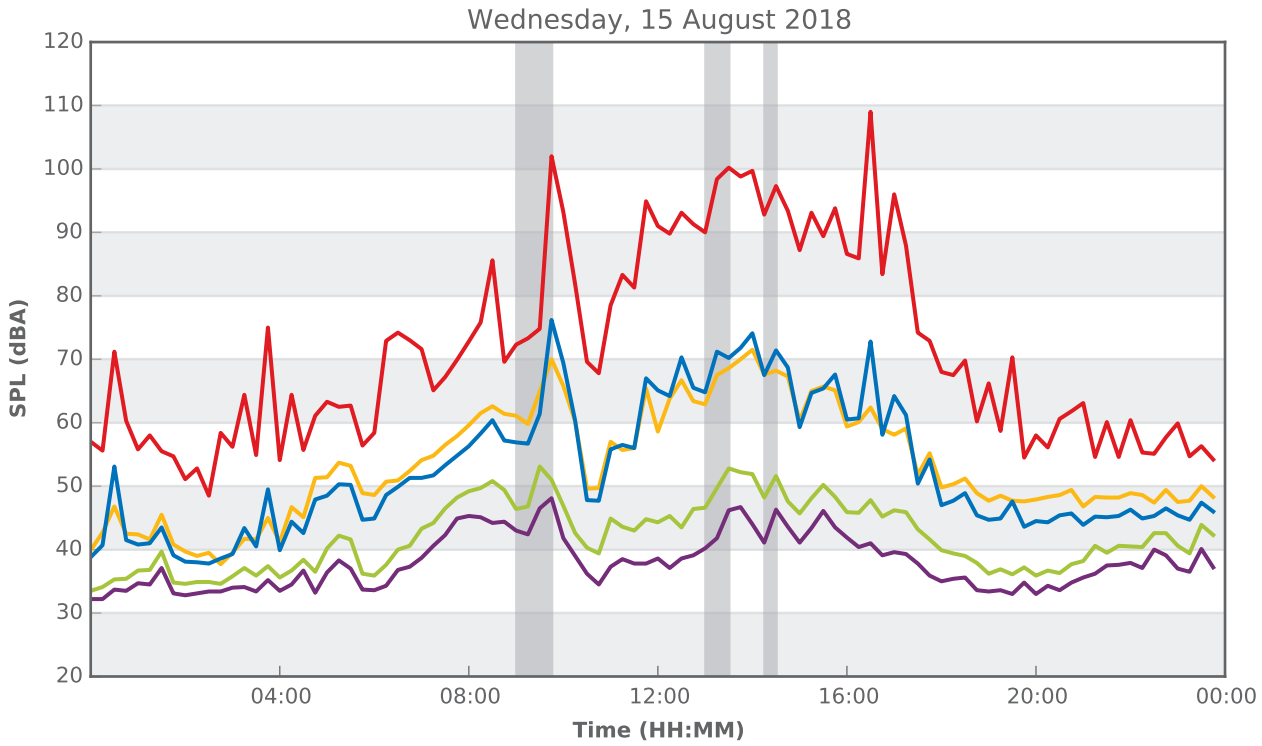

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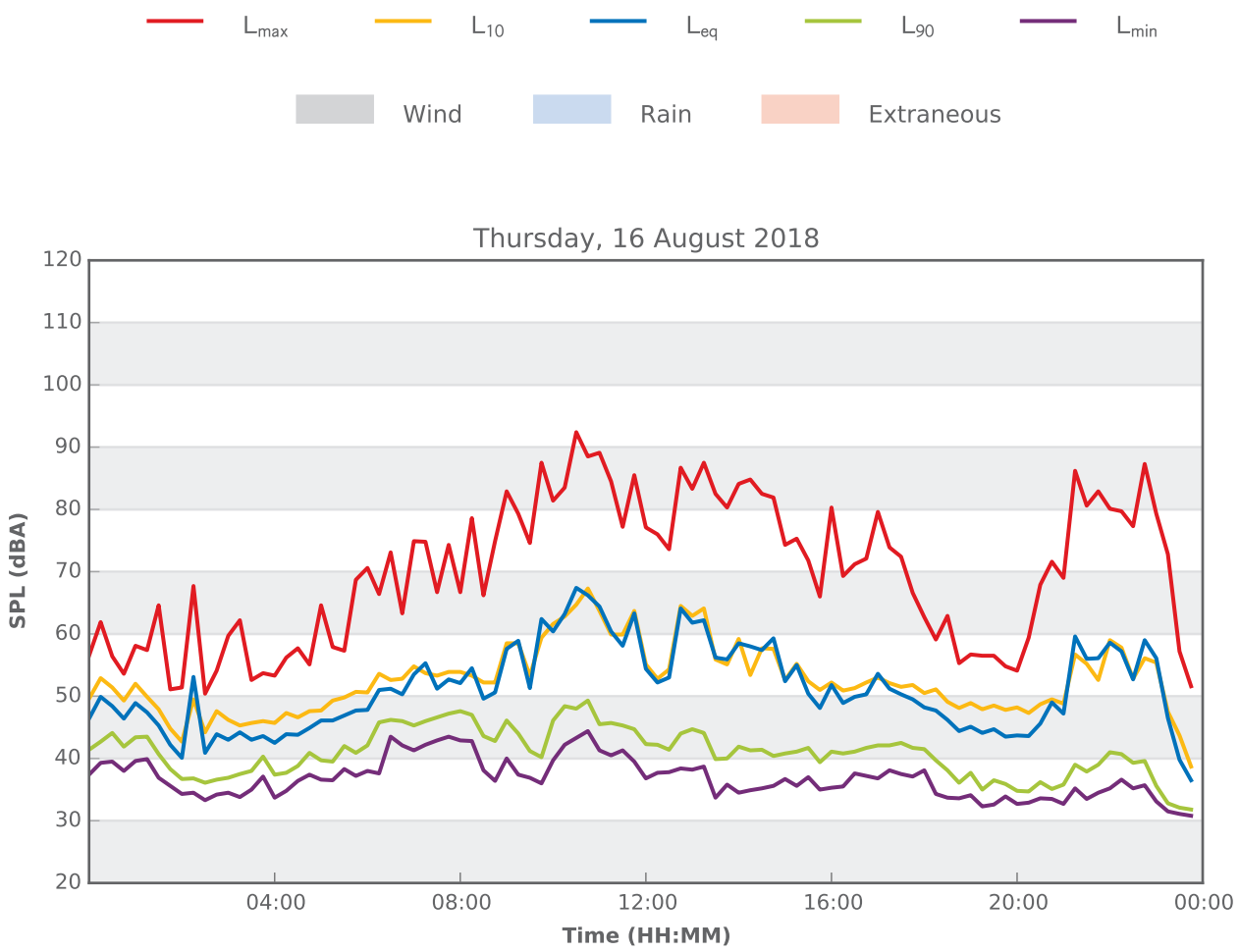

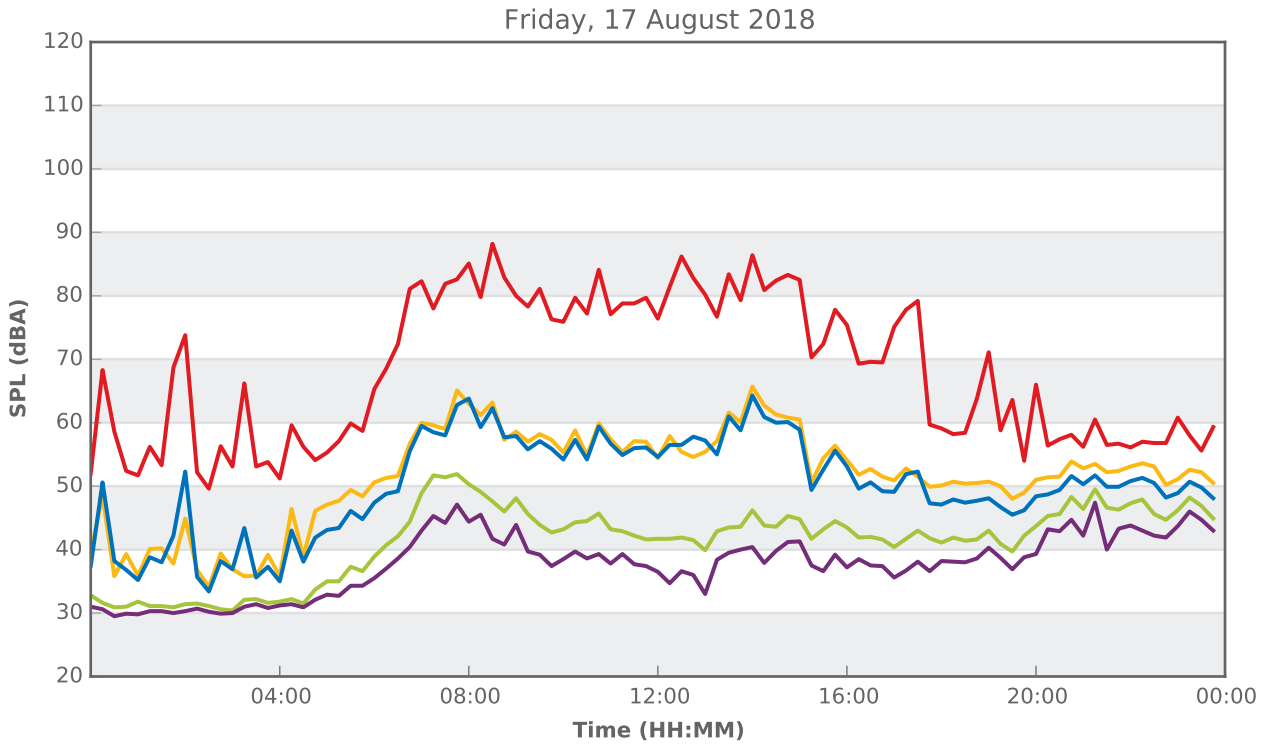

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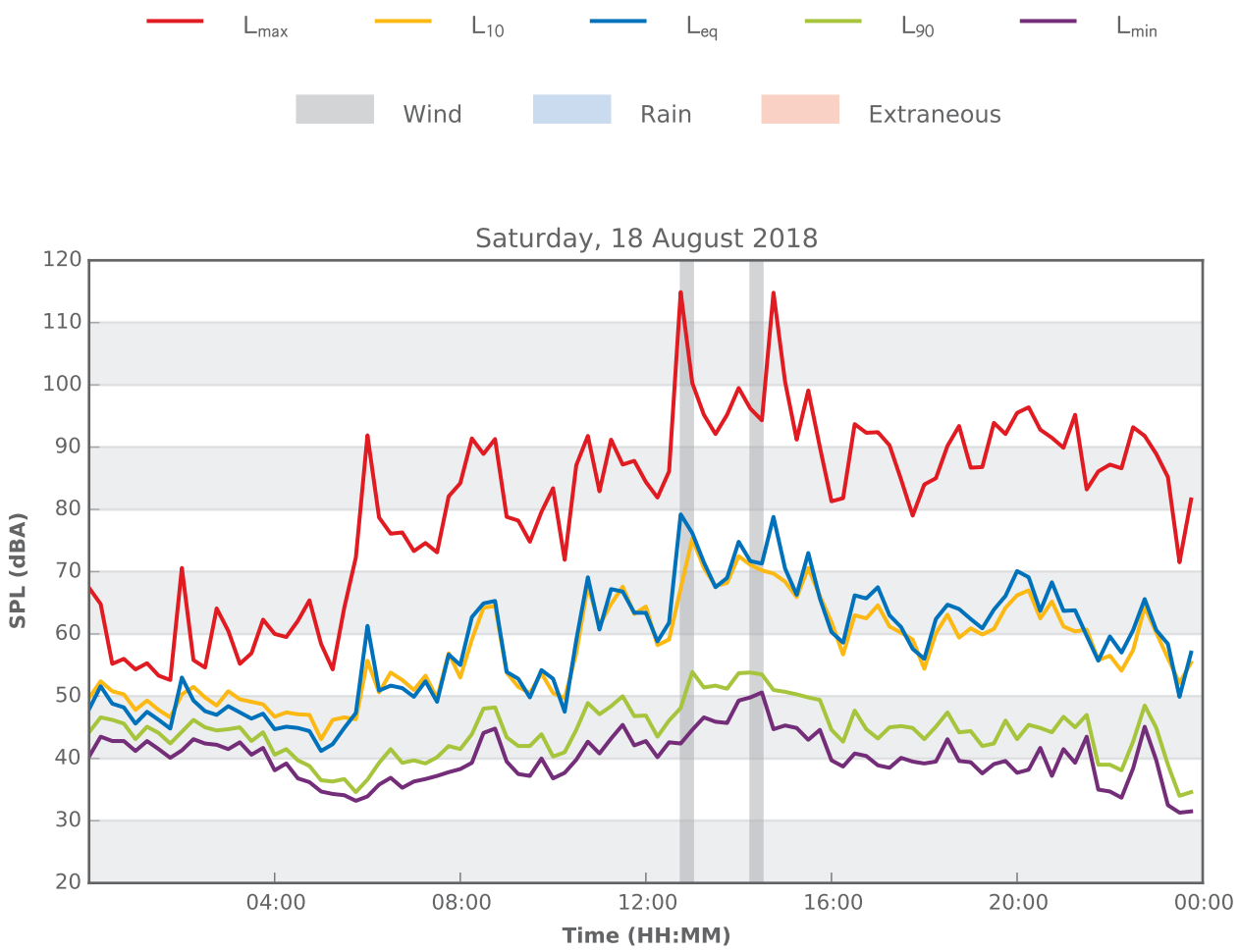

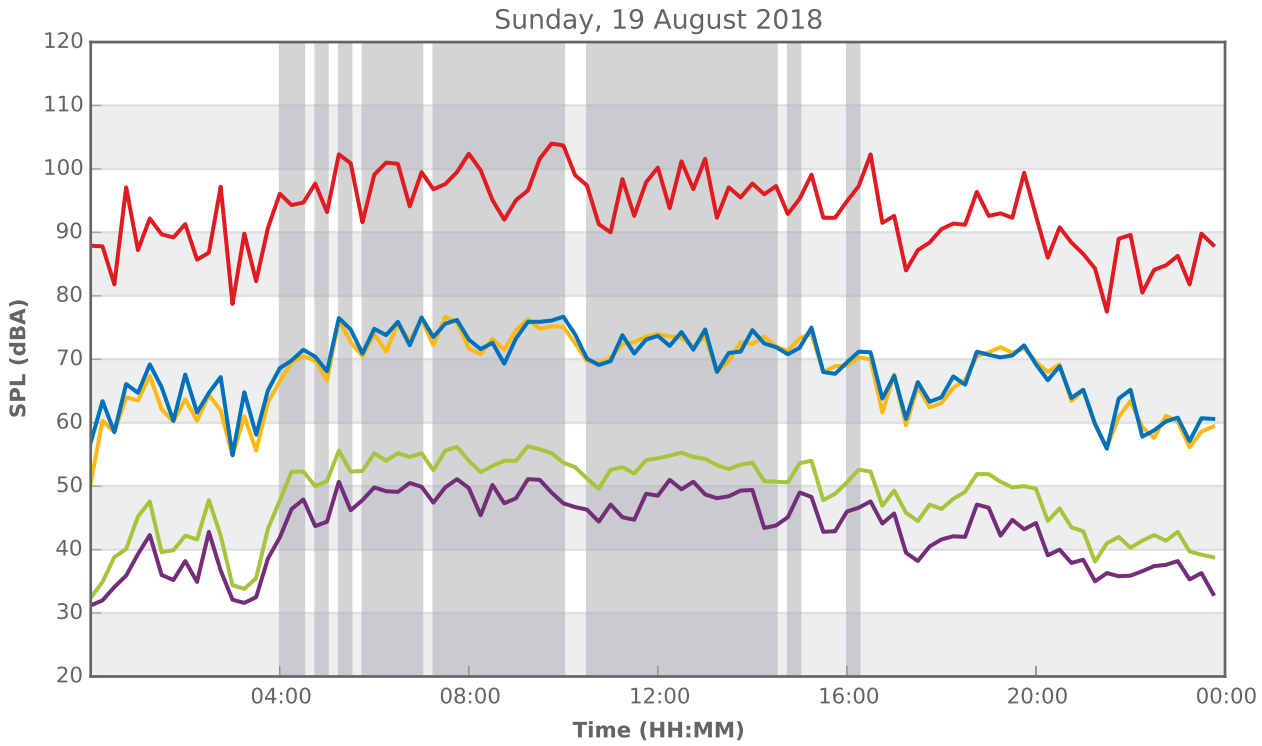

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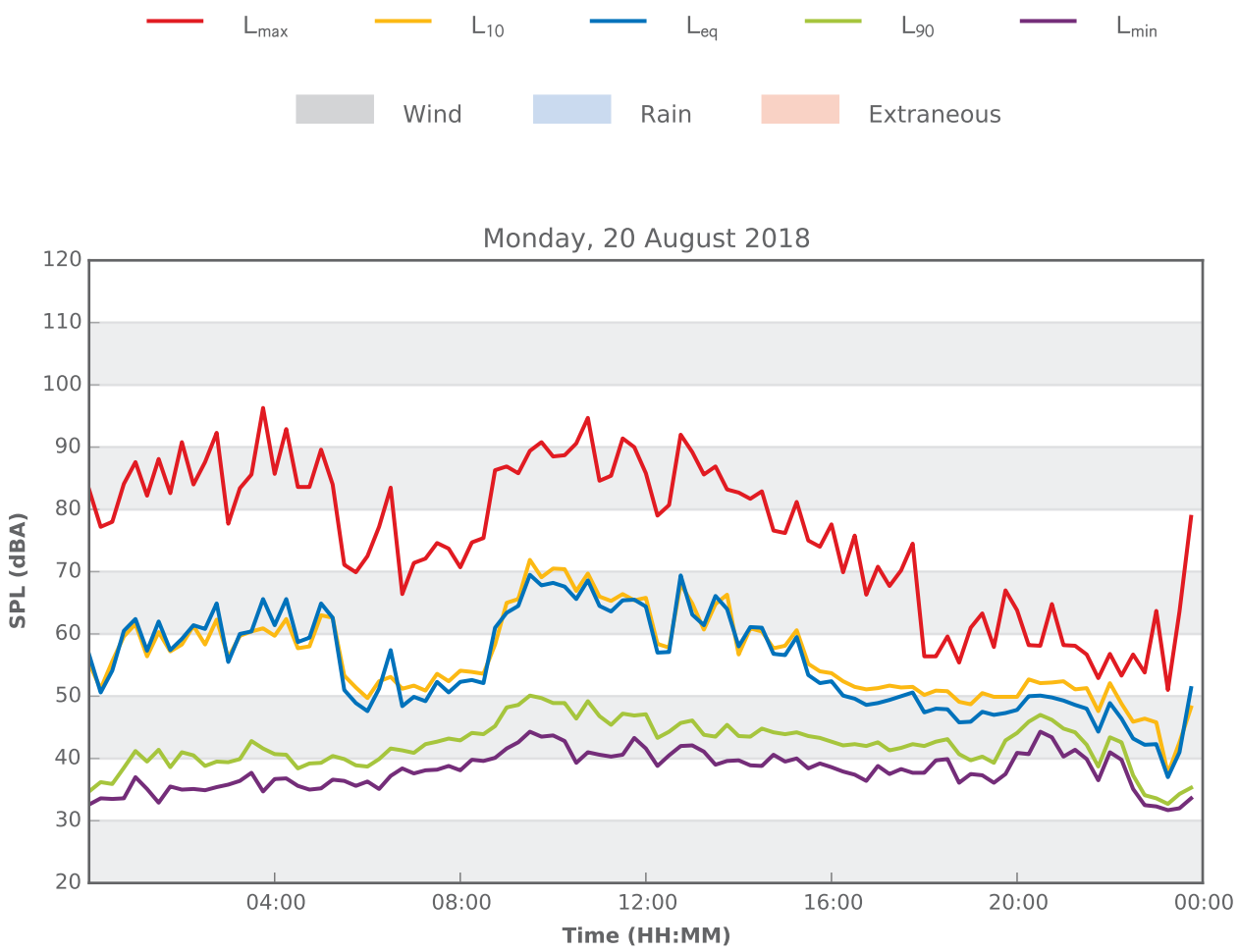

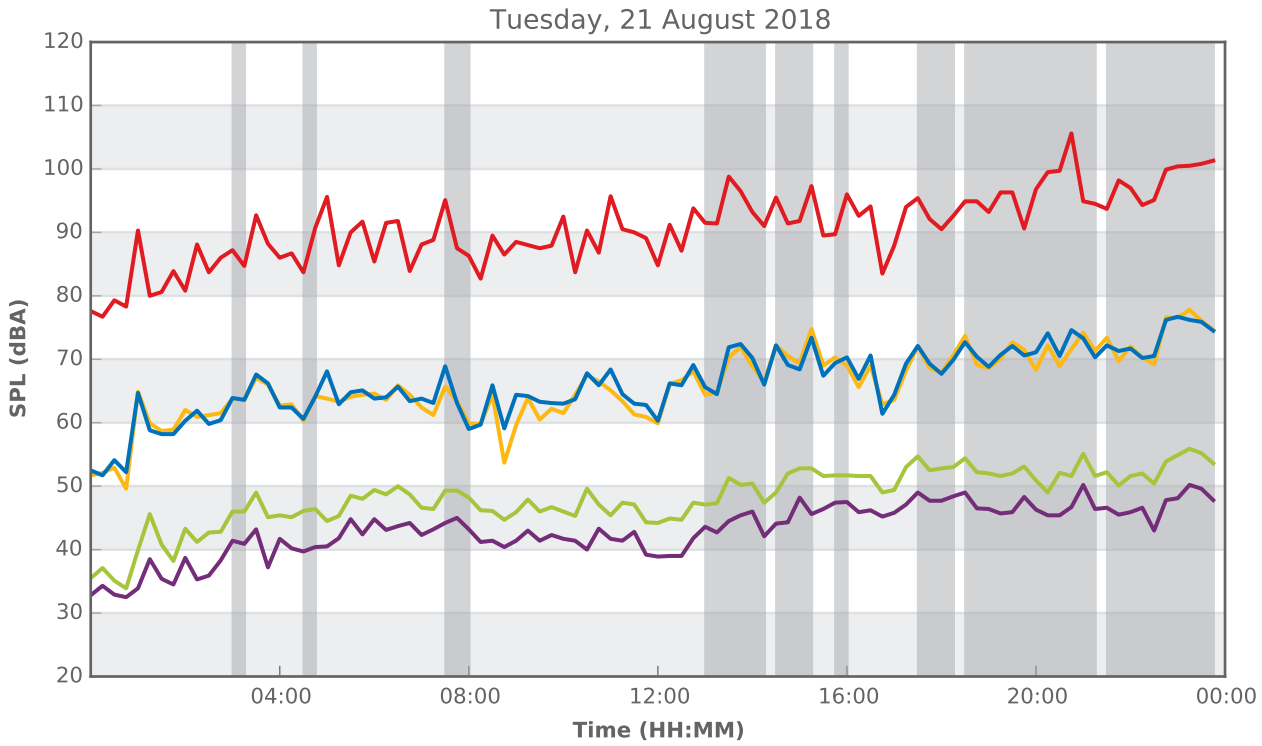

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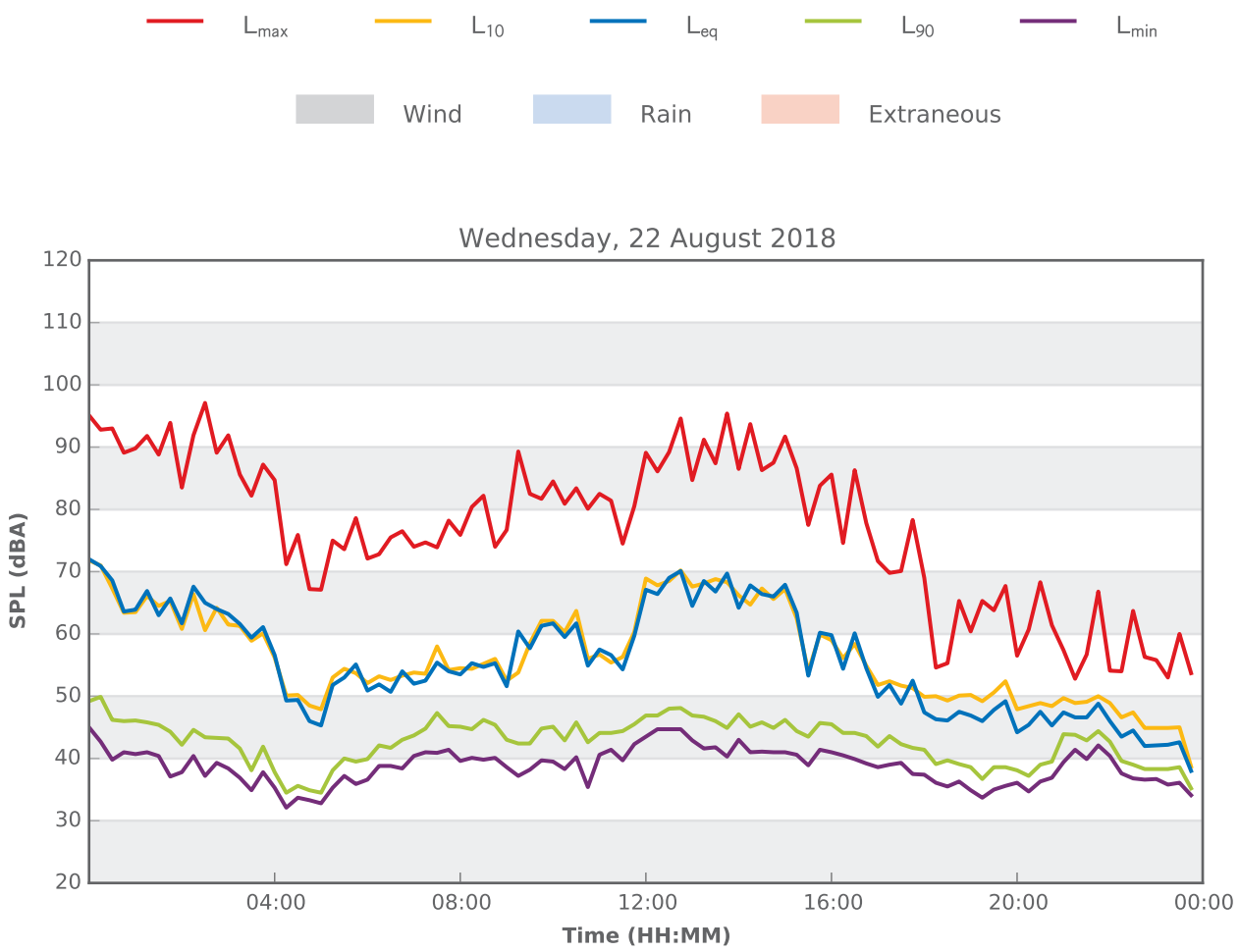

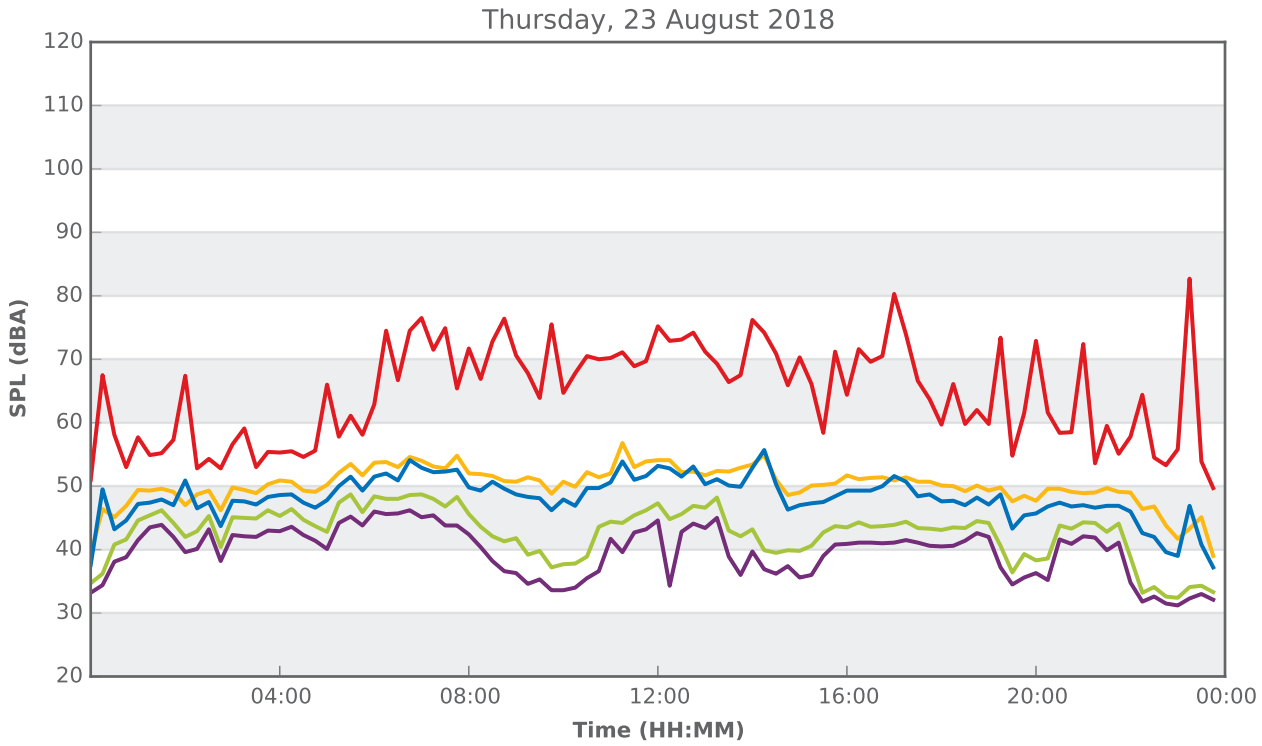

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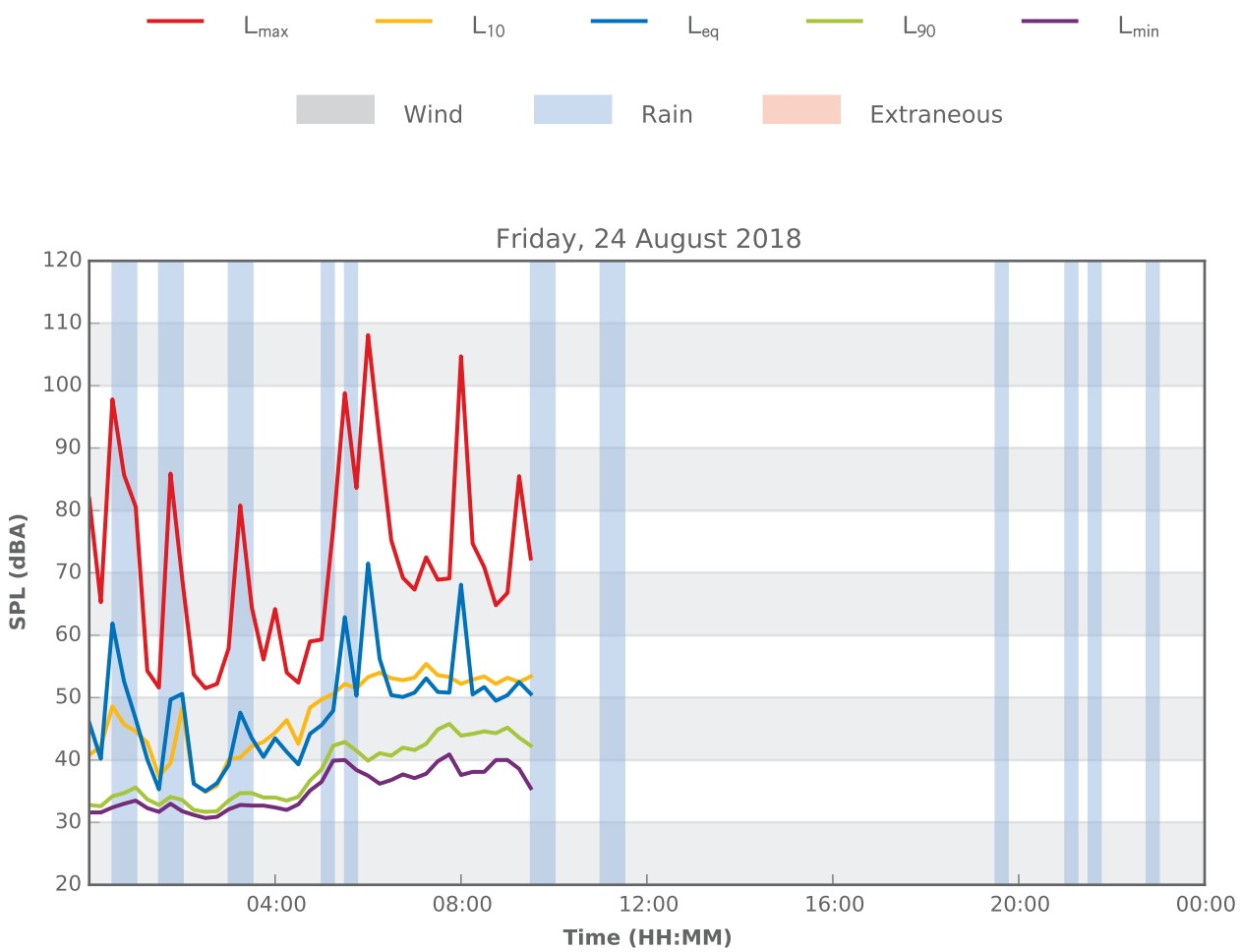

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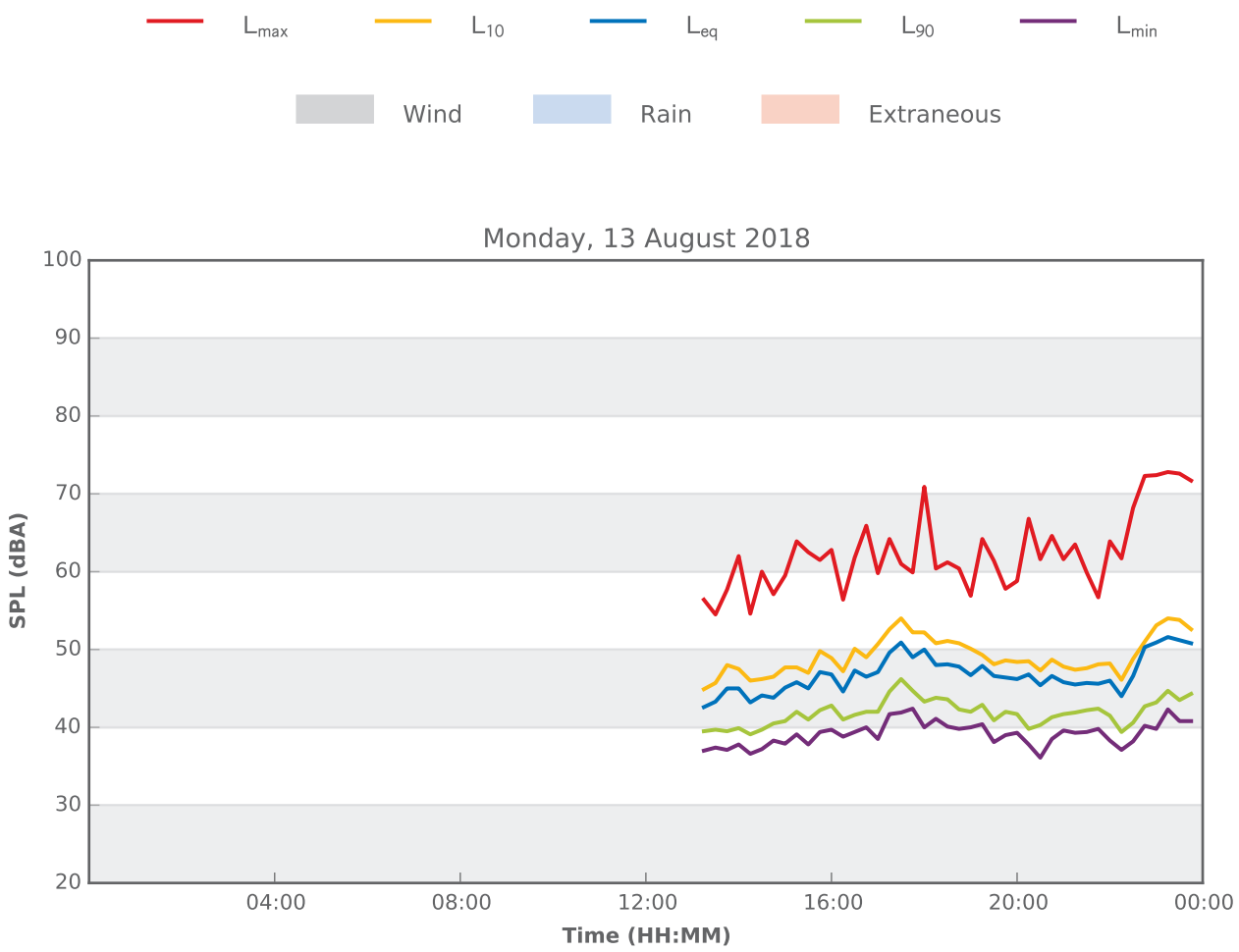

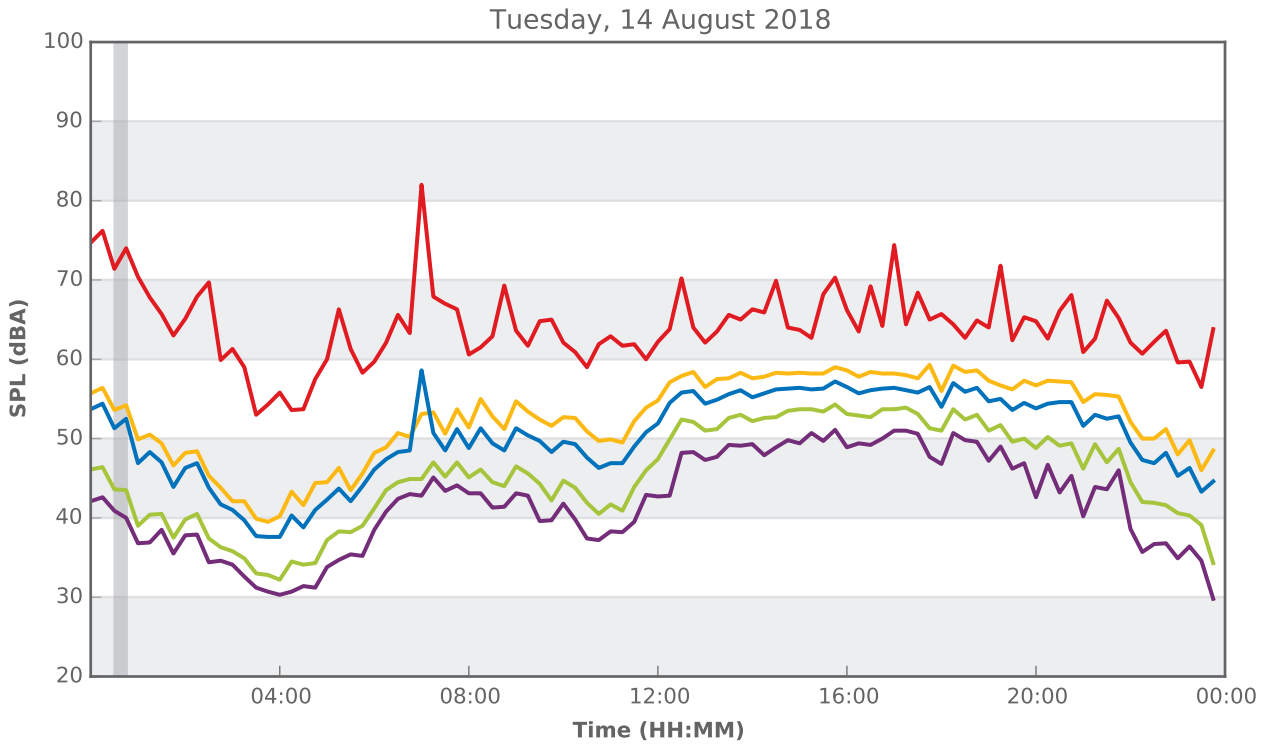

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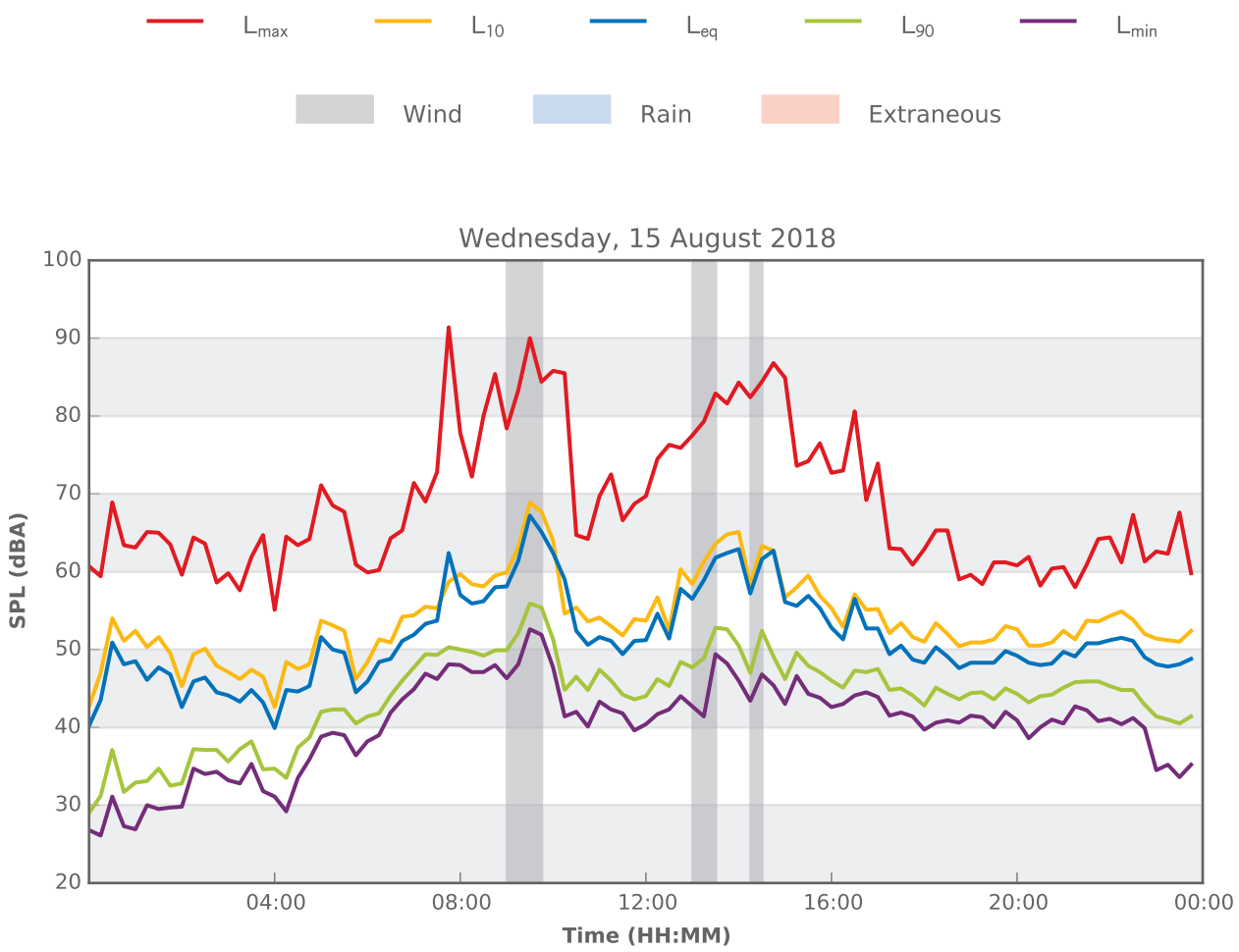

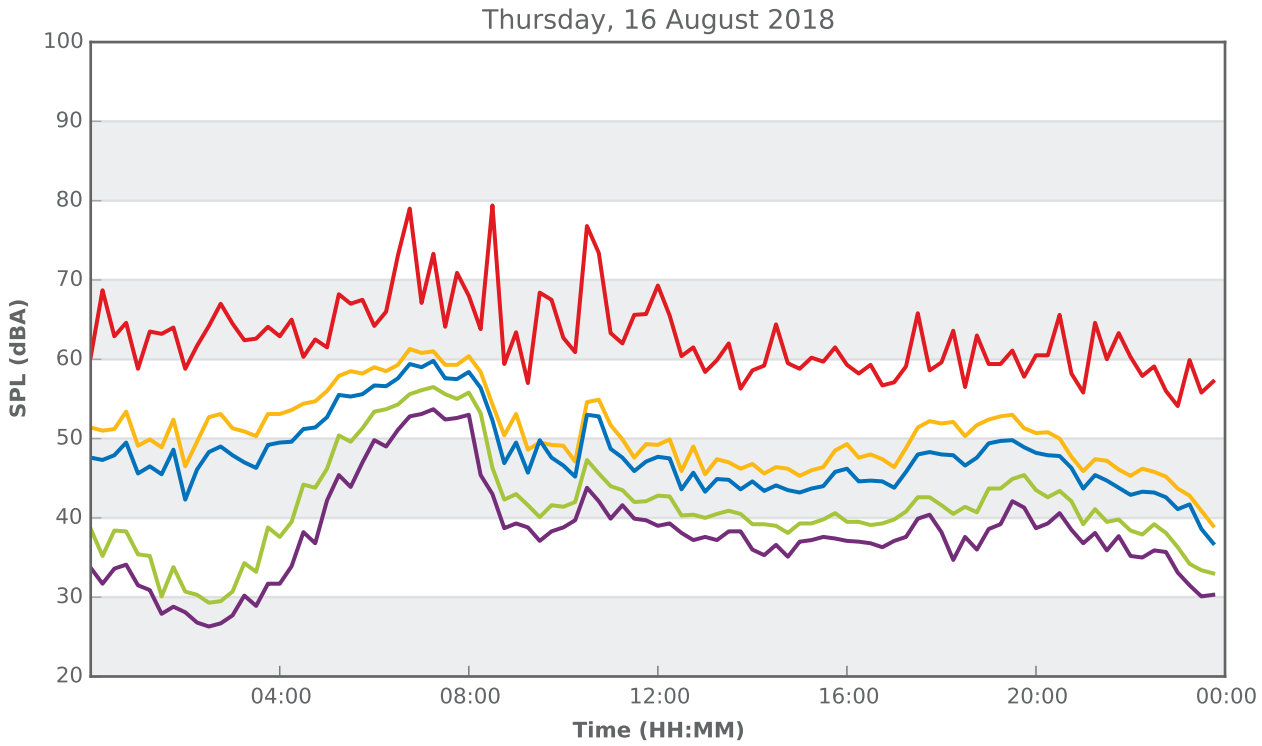

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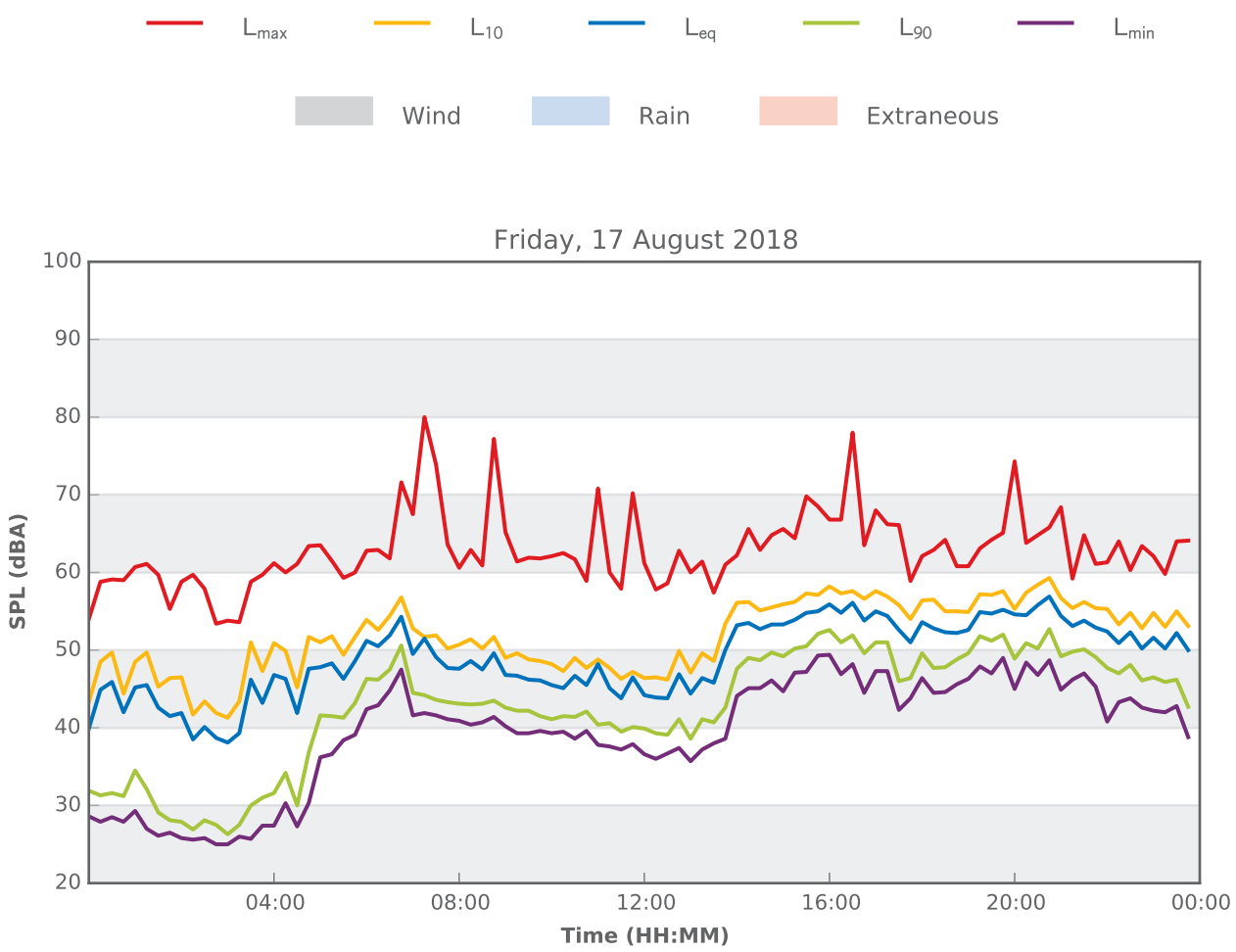

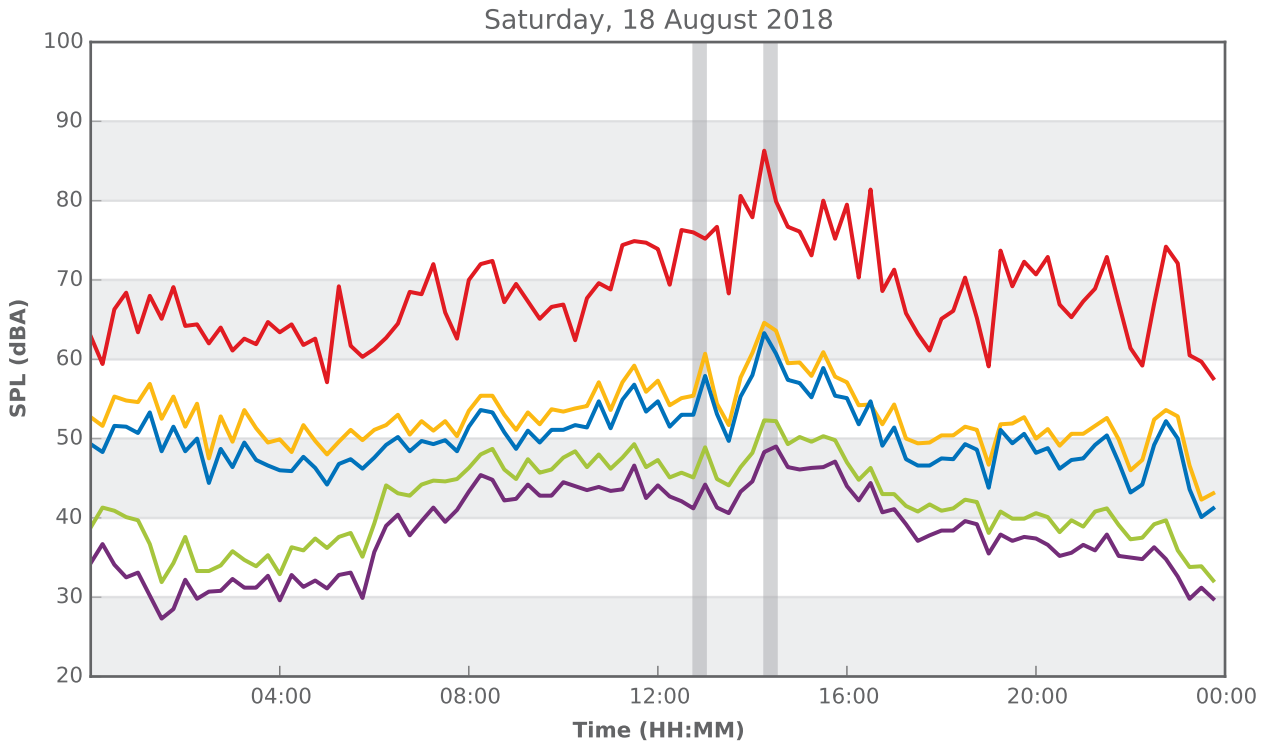

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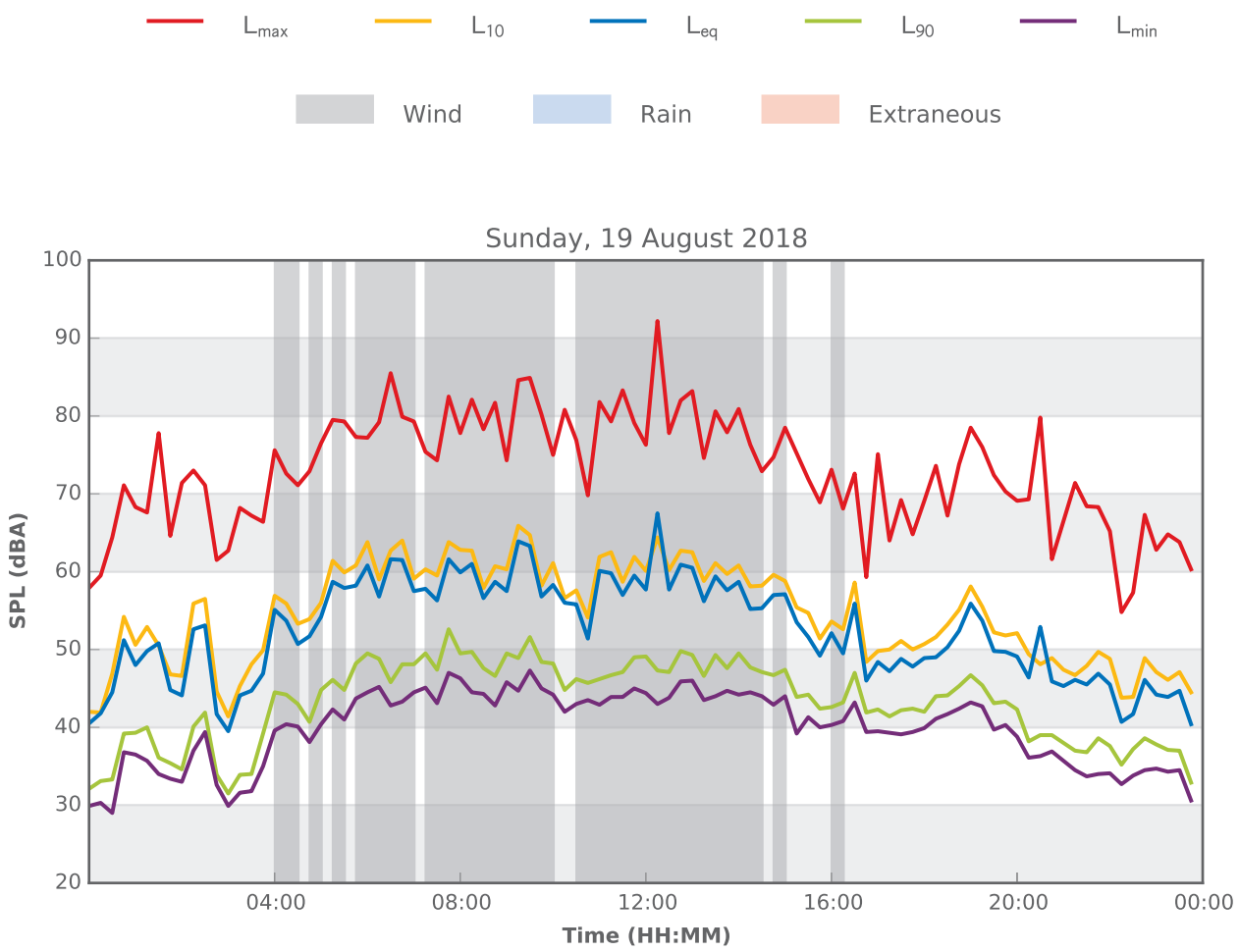

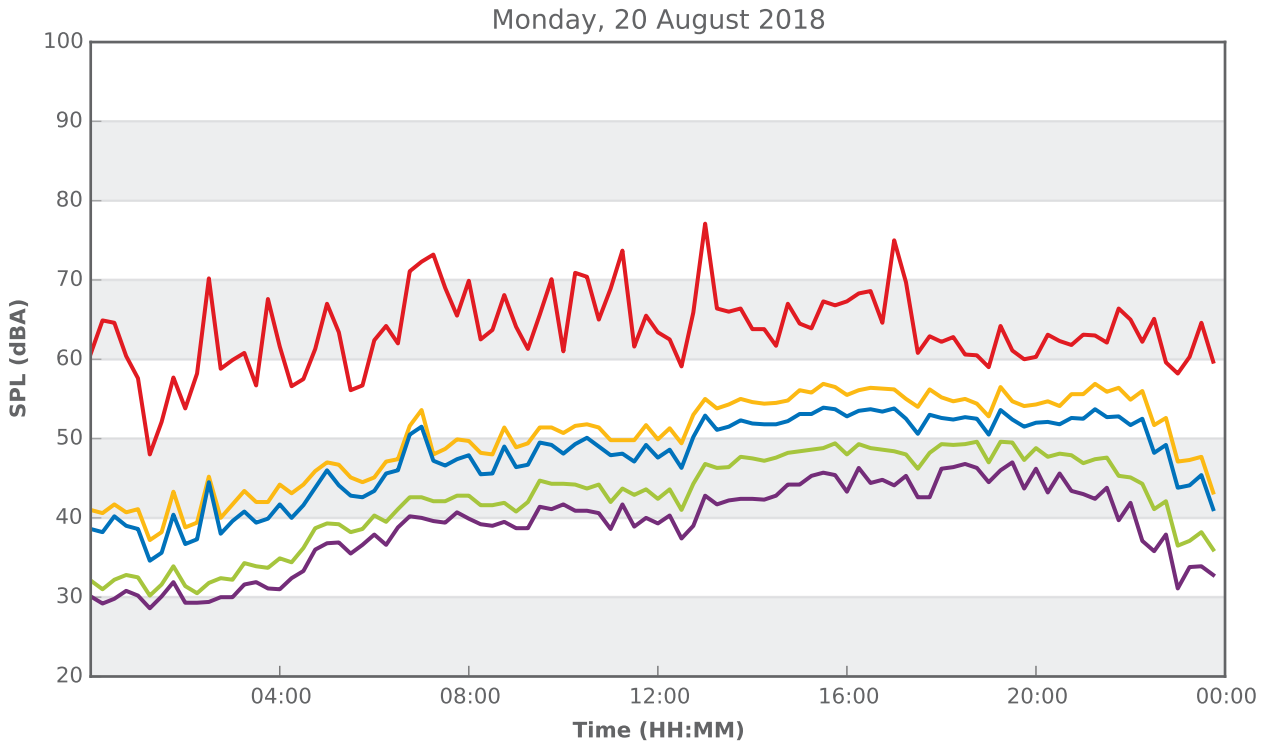

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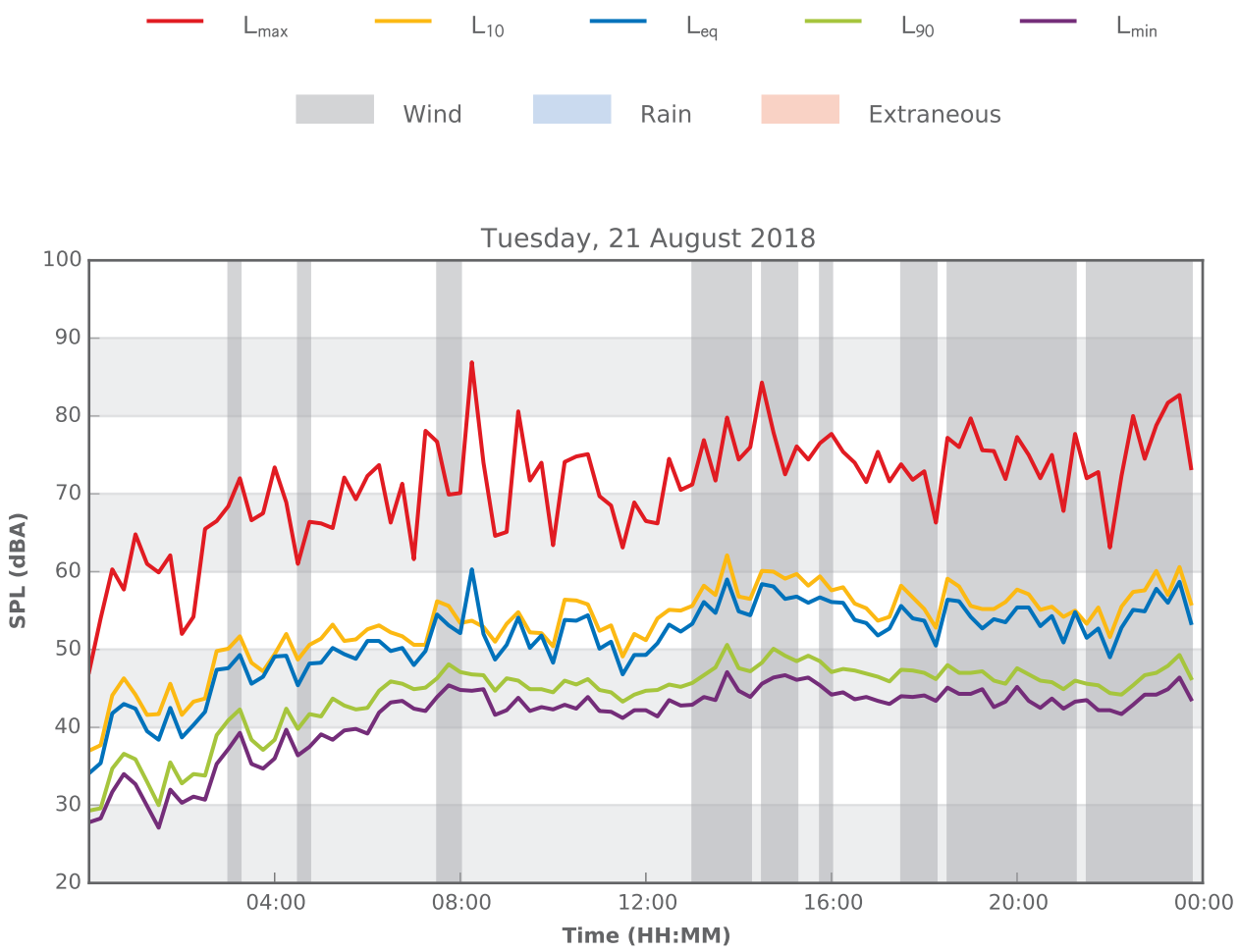

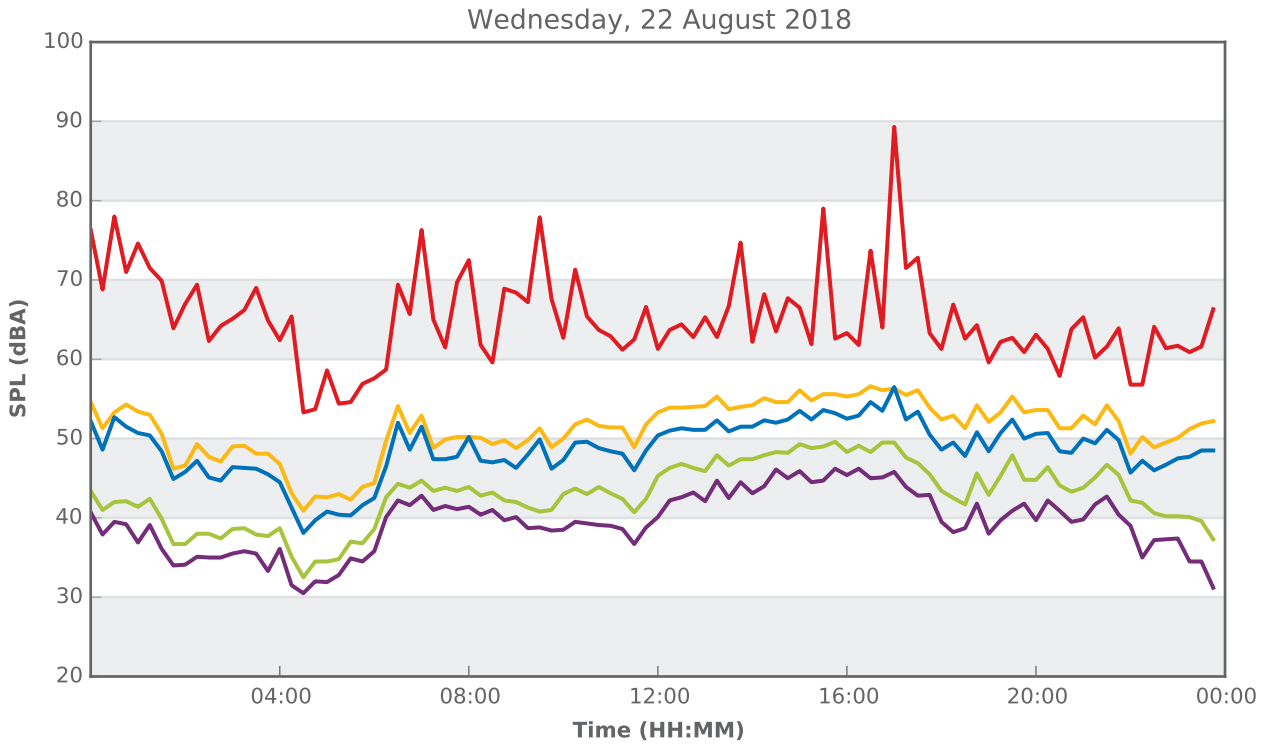

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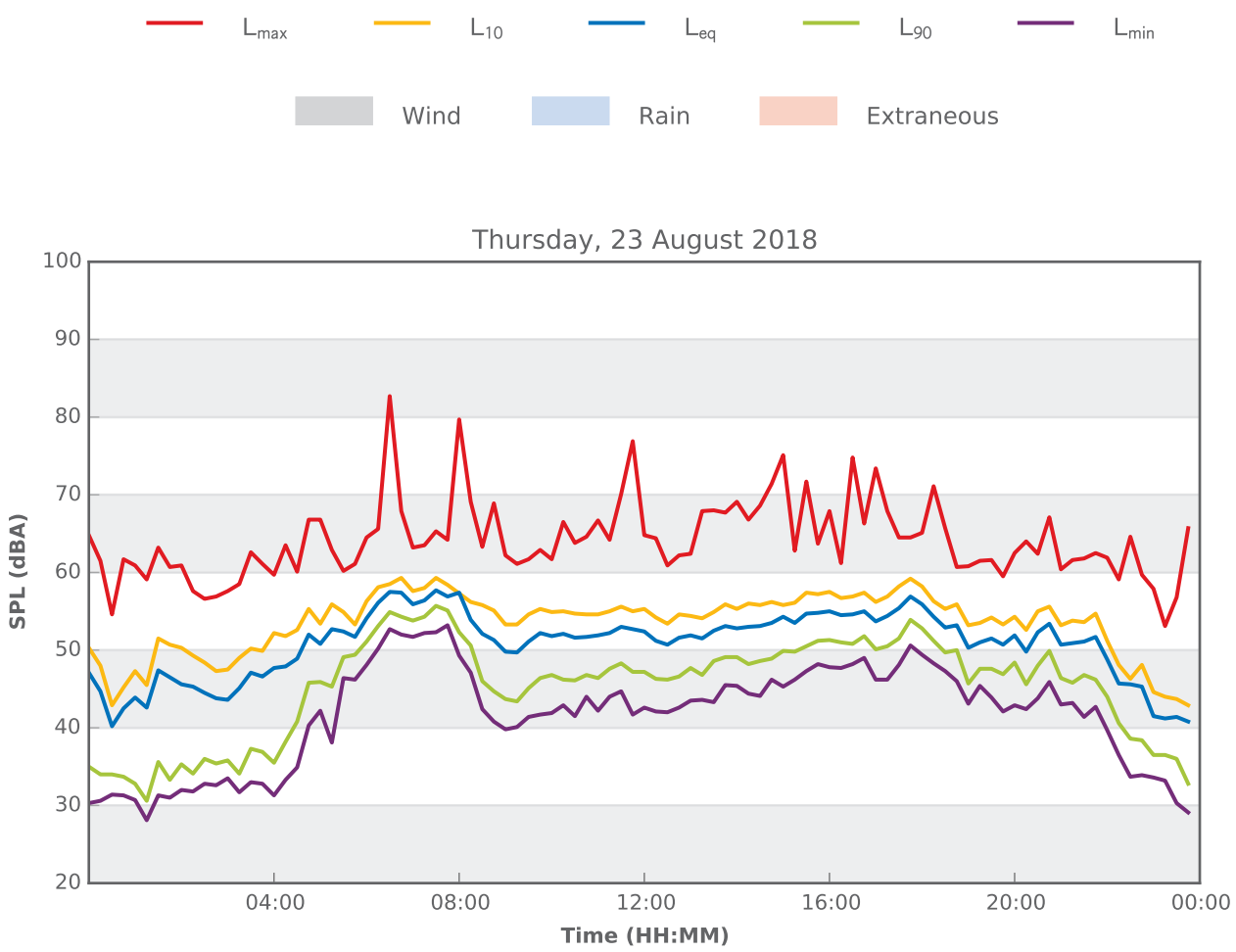

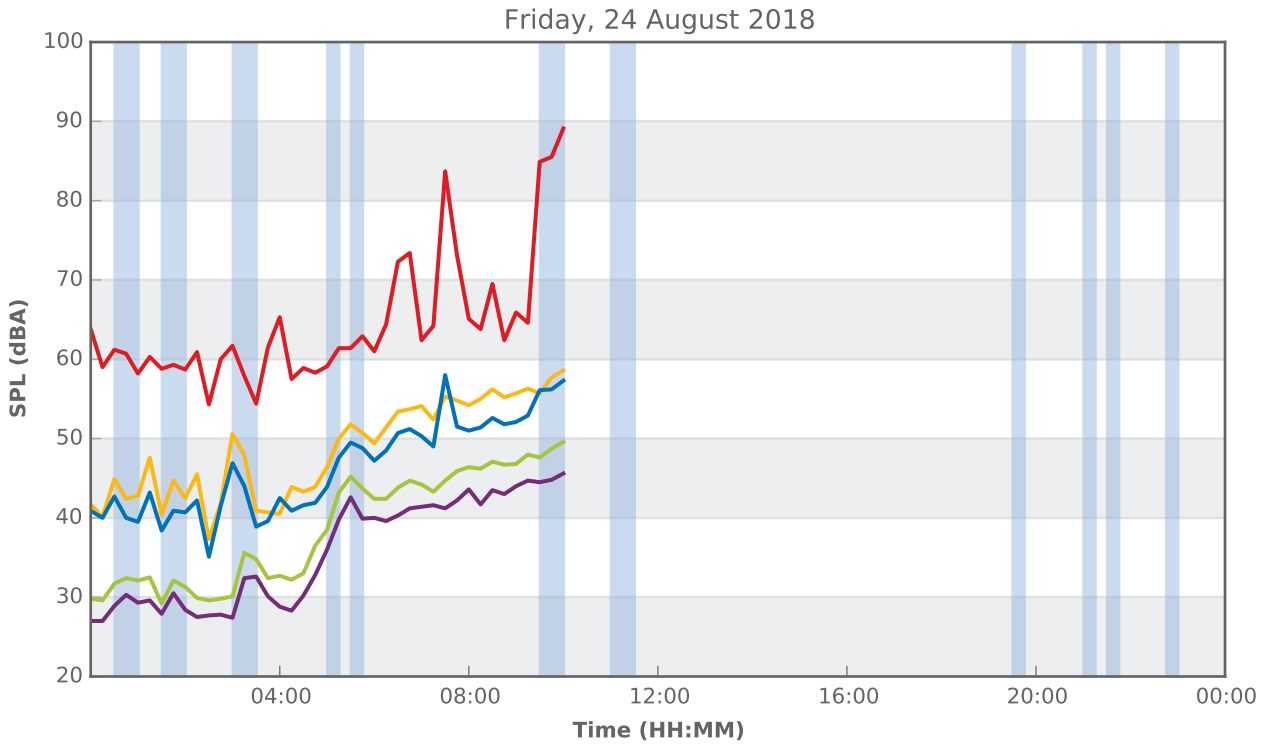

APPENDIX J

SURFACE WATER ASSESSMENT REPORT

Surface Water Assessment for Modification 2 of the Dunmore Lakes Sand Project.

Report Prepared for: Element Environment, on behalf of Dunmore Sand & Soil Pty Limited

February 2019

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1.0 INTRODUCTION

1.1. Background

Southeast Engineering and Environmental has been engaged by Element Environment (Element on behalf of Dunmore Sand & Soil Pty Ltd (DSS) to undertake a detailed surface water assessment report as part of a modification to the current Project Approval (195-8-2004) made under Section 75W of the *Environmental Planning and Assessment Act 1979* (EP&A Act). This modification will provide an additional extraction area (Stage 5) on adjoining private land, encompassing two separate extraction areas, Stage 5A and Stage 5B (hereafter referred to as the 'modification').

The objective of this assessment is to outline, and where possible, quantify the potential water quality and quantity impacts and issues associated with the modification and to develop management and mitigation measures as required.

1.2. Proposal

The modification seeks to establish additional extraction areas (Stage 5) on adjoining private property which is to be leased by DSS. The Stage 5 extraction areas would be separated into two, namely Stage 5A (immediately south of Riverside Drive), and Stage 5B (to the north of the Minnamurra River). The approximate sand resource to be extracted from Stage 5A is estimated at 234,000 tonnes, while Stage 5B would extract approximately 1,123,000 tonnes. The aforementioned quantities are the estimated sand resource only, and additional tonnage of soil material may also be extracted in addition to the sand resource. The current approval allows for a total extraction of 800,000 tonnes per annum (tpa).

Sand will be transferred from the Stage 5A and 5B dredge ponds to the Stage 2 area for processing via a transfer pipe. The transfer pipe will be laid on the ground surface, floated over existing pond areas, beneath roads within existing culverts and suspended over Rocklow Creek.

Mobile plant and equipment utilised at the site would be operated across both extraction areas within Stage 5. Extraction methods would be identical to those currently implemented in Stage 2 and 3 of the approved operations.

2.0 RELEVANT LEGISLATION, POLICY AND GUIDELINES

2.1. Planning context

The proposed works are sought via a modification to the current Project Approval (195-8-2004) made under Section 75W of the *Environmental Planning and Assessment Act 1979* (EP&A Act).Part 3A of the EP&A Act exempts a development from a range of approvals and legislation, including:

(a) the concurrence under Part 3 of the *Coastal Protection Act 1979* of the Minister administering that Part of the Act,

(b) a permit under section 201, 205 or 219 of the *Fisheries Management Act 1994*,

(h) a water use approval under section 89, a water management work approval under section 90 or an activity approval under section 91 of the *Water Management Act 2000*.

2.2. Legislation

2.2.1. Fisheries Management Act 1994

Permits to dredge, reclaim, harm marine vegetation or block fish passage are not required as the original development is considered to be approved under Part 3A of the EP&A Act. However, the objectives of the *Fisheries Management Act 1994*, particularly those associated with part 7, Protection of aquatic habitats, and part 7A, Threatened species conservation, need to be observed, and have been considered in the development of the proposed modification.

The *Policy and guidelines for fish habitat and conservation management* (DPI, 2013) have been incorporated into this assessment, in particular, the proximity of works to Type 1 Highly sensitive key fish habitat and Class 1 waterways and the potential impacts associated with the modification activities.

2.2.2. State Environmental Planning Policy 2018 (Coastal Management)

The aim of SEPP 2018 (Coastal Management) is to promote an integrated and coordinated approach to land use planning in the coastal zone in a manner consistent with the objects of the *Coastal Management Act 2016.* The proposed modification encroaches into the defined Coastal Environment Area, and Stage 5A of the modification encroaches into the Coastal Wetland proximity Area (Figure 3.8). The legislation requires that the development will not significant impacts ecological values, water quality and quantity, create adverse impacts on a range of ecological and social values associated with the coastal environment and mitigate adverse impacts where impacts are unavoidable. These requirements have been incorporated into the assessment and design of the modification, in particular the isolation as much as possible of the extraction areas from adjacent wetland and estuarine areas.

2.2.3. Water Management Act (WMA) 2000

The principles outlined in Section 5 of the WMA apply to the proposed modification, specifically:

(4) In relation to water use:

(a) water use should avoid or minimise land degradation, including soil erosion, compaction, geomorphic instability, contamination, acidity, waterlogging, decline of native vegetation or, where appropriate, salinity and, where possible, land should be rehabilitated, and

(b) water use should be consistent with the maintenance of productivity of land in the long term and should maximise the social and economic benefits to the community, and

(c) the impacts of water use on other water users should be avoided or minimised.

(6) In relation to floodplain management:

(a) floodplain management must avoid or minimise land degradation, including soil erosion, compaction, geomorphic instability, contamination, acidity, waterlogging, decline of native vegetation or, where appropriate, salinity and, where possible, land must be rehabilitated, and

(b) the impacts of flood works on other water users should be avoided or minimised, and

(c) the existing and future risk to human life and property arising from occupation of floodplains must be minimised.

(7) In relation to controlled activities:

(a) the carrying out of controlled activities must avoid or minimise land degradation, including soil erosion, compaction, geomorphic instability, contamination, acidity, waterlogging, decline of native vegetation or, where appropriate, salinity and, where possible, land must be rehabilitated, and

(b) the impacts of the carrying out of controlled activities on other water users must be avoided or minimised.

These objectives have been incorporated into the modification design and associated management and mitigation measures, in particular the bunding of extraction areas, assessment of floodplain impacts and proposed rehabilitation.

2.2.3.1. Controlled Activities

Controlled activity approval under the WMA is not required as the development is considered to be approved under Part 3A of the EP&A Act. Nevertheless, the guidelines managed by the Natural resources Access Regulator (NRAR) need to be followed. Relevant guidelines considered in this SWA are:

- *Guidelines for Controlled Activities on Waterfront Land - Riparian Corridors (NRAR, 2018)*
- *Guidelines for Instream Works on Waterfront Land (DPI Water, 2012a)*
- *Guidelines for Laying Pipes and Cables in Watercourses on Waterfront Land (DPI Water, 2012b)*
- *Guidelines for Outlet Structures on Waterfront Land (DPI Water, 2012c)*
- *Guidelines for Vegetation Management Plans on Waterfront Land (DPI Water, 2012d)* and
- *Guidelines for Watercourse Crossings on Waterfront Land (DPI Water, 2012e)*.

2.2.3.2. Surface Water Sharing Plans

The site is located within the Water Sharing Plan for the Greater Metropolitan Region Unregulated River Water Sources within the defined 'Illawarra Rivers' water source.

The current operation has a groundwater Water Access Licence (WAL24477) issued under the *Water Management Act 2000*. The licence permits the taking of 65ML/y of water from the Sydney Basin South Groundwater Source and is subject to a number of conditions. Associated 'work approvals' include 10WA106713 and 10WA106714.

The additional Stage 5 extraction area would require additional water demand for operations of the Dunmore Lakes Sand Project. The current water demand is at the threshold of licensed extraction volumes. This is discussed in section 4.0.

An additional Water Access Licence (WAL 42100) for 15ML has been obtained, at the time of preparing this report no Water Supply Work approval has been nominated in conjunction with this licence. A WAL for a further 20ML of allocation which has been secured is being applied for.

2.2.4. Protection of the Environment Operations Act 1997

The *NSW Protection of the Environment Operations Act 1997* (PoEO Act) and the NSW Protection of the Environment Operations (General) Regulation 2009 set out the general obligations for environmental protection. The PoEO Act is relevant to the Modification as it contains requirements relating to the prevention of the pollution of waters.

The current Environmental Protection Licence (EPL) has a range of surface water related controls relating to sediment management and flooding along with the approval conditions (refer to section 2.4).

2.3. Guidelines

2.3.1. Erosion and sediment control guidelines

Managing Stormwater: Soils and Construction, Volume 2E – Mines and Quarries (DECC, 2008) provides guidelines to specifically address requirements for erosion and sediment control on mines and quarries based on the principles set out in *Managing Stormwater: Soils and Construction, Volume 1* (Landcom 2004). In this case, the sand extraction process generates a sediment basin by default and is isolated from surrounding runoff. Fines management will occur in the existing fines management basin at Stage 2.

Chapter 6 of *Managing Stormwater: Soils and Construction, Volume 2A – Installation of services* (DECC, 2008) outlines a range of sediment and erosion controls applicable for the installation of the transfer pipeline, particularly where vegetation clearing is required. Refer to section 4.0.

Managing Urban Stormwater: soils and construction, Volume 1 and Volume 2C: Unsealed roads and 2D: main road construction (DECC 2008) provide guidance on road design and design of erosion and sediment control measures for the construction of the proposed unsealed access road from the end of the existing sealed Fig Hill Lane, the car parking area adjacent to the Stage 5B area, as well as the haul roads surrounding the Stage 5A and 5B areas. Refer to section 4.0.

2.3.2. NSW Floodplain Development Manual

The *NSW floodplain development manual* (DIPNR) outlines a merit based approach for the assessment of development within the floodplain, including the risks associated with development to determine whether that use of the floodplain is appropriate and sustainable. Section 4.0 outlines the potential floodplain impacts of the proposed development.

2.3.3. NSW State Rivers and Estuaries Policy (1993)

The *NSW State Rivers and Estuaries Policy* (NSW Water Resources Council, 1993) contains state-wide objectives for the protection and enhancement of watercourses. The proposed surface water management should be consistent with the *NSW State Rivers and Estuaries Policy* objectives which are to:

- *manage the rivers and estuaries of NSW in ways which slow, halt or reverse the overall rate of degradation in their systems*
- *ensure the long term sustainability of their essential biophysical functions and*
- *maintain the beneficial use of these resources.*

The surface water management of the modification has been designed in accordance with the objectives of the Policy. The key aspect is to demonstrate that there is no degradation of adjacent unnamed tributaries, Rocklow Creek, the Minnamurra River and associated estuaries.

2.4. Environment Protection Licence and Current approval conditions relating to surface water management

This proposal is a modification to an existing approval. Controls within the existing EPL that relate to surface water management are as follows:

L1.1 Except as may be expressly provided in any other condition of this licence, the licensee must comply with section 120 of the Protection of the Environment Operations Act 1997.

O5.1 TRUCK WASH

All vehicles must pass through the truck wash facility prior to leaving the premises.

O5.2 STORMWATER/SEDIMENT CONTROL - CONSTRUCTION AND OPERATIONAL PHASES

O5.3 Any pond subject to dredging, or containing turbid water due to recent dredging, must be maintained and operated to prevent discharges of any water from these ponds.

O5.4 Backfilling of the dredge ponds must not take place when they are overflowing.

O5.5 The fines return pond(s) must be bunded to an elevation that prevents inundation by floodwaters caused in a 1:100 year flood level. Note: The predicted 1:100 year flood level for the site is 3.7 m AHD.

The current development consent contains the following conditions relating to water quality control, stormwater management and floodplain management for the ponds and for discharges from the site:

SCHEDULE 3 – SPECIFIC ENVIRONMENTAL CONDITIONS

Pollution of waters

22. Except as may be expressly provided by an Environment Protection Licence, the Applicant must comply with section 120 of the Protection of the Environment Operations Act 1997 during the carrying out of the development.

Water Discharge Limit

23. Except as may be expressly provided by an Environmental Protection Licence, the Applicant must ensure that the discharges from any licenced discharge point/s do not cause additional exceedances of the criteria in Table 6:

Table 6: Water Discharge Pollution Limits

Pollutant	Unit of Measure	100 Percentile Concentration Limit
Total Suspended Solids	mg/L	50
pH	pH	± 1.0

Water Quality Objectives

24. The Applicant must ensure that water quality in the dredge ponds and in groundwater comply with the water quality objectives in Table 7, or other such level as approved by the Secretary:

Table 7: Water Quality Objectives

Pollutant	Unit of Measure	Water Quality Objective
Turbidity	NTU	5-20
pH	pH	6.5 – 8.5
Salinity	µS/cm	<1,500
Dissolved oxygen	mg/L	>6
Total phosphorus	µg/L	5-50
Total nitrogen	µg/L	100-500
Chorophyll-a	µg/L	2-10
Faecal coliforms	Median No./100mL	<1000
Enterococci	Median No./100mL	<230
Algae and blue-green algae	No.cells/mL	<15,000
Sodium	mg/L	400
Potassium ion	mg/L	50
Magnesium ion	mg/L	50
Chloride ion	mg/L	300
Sulphate ion	mg/L	250
Bicarbonate ion	mg/L	750
Soluble Iron ion	mg/L	6
Ammonium ion	mg/L	20

Notes:

- *The objectives for dissolved oxygen, turbidity and algae are relevant to surface water only;*
- *The Department acknowledges that short term exceedances of these objectives may occur during natural events such as heavy rainfall or tidal saline water inflow.*

Stormwater Management

25. The Applicant must ensure that any pond subject to dredging or backfilling, or containing turbid water due to recent dredging or backfilling, must be maintained and operated to prevent discharges of any turbid water (as defined in Tables 6 and 7) from these ponds.

26. The Applicant must cease backfilling activities not less than 12 hours prior to the commencement of overflow from any dredge pond. No backfilling must occur when the dredge ponds are overflowing.

Flood Management

27. The Applicant must ensure that the flood storage capacity of the site is no less than the pre-existing flood storage capacity at all stages of the development. Details of the available flood storage capacity must be reported in the Annual Review.

28. The access road entrance off Tabbita Road, processing and stockpile area, and the fines return pond(s) must be constructed and maintained so as to prevent inundation by floodwaters caused by the 1 in 100 year ARI flood level. Prior to the commissioning of the

processing area, the Applicant must provide certification to the Secretary that this condition has been complied with.

29. Following the cessation of dredging and backfilling operations, the Applicant must commission a suitably qualified hydrologist to define the flood-related limits of the final landform. The flood study must be undertaken in consultation with the Department and Shellharbour Council, and to the satisfaction of the Secretary.

3.0 SURFACE WATER CONTEXT

3.1. Overall catchment

The Stage 5A and Stage 5B extraction areas are located between the Minnamurra River to the south, an unnamed tributary almost directly west, and Rocklow Creek to the north (Figure 3.1 and Figure 3.2).

The existing processing area is located within the Stage 2 area of the DSS operations, extending over a portion of the floodplain of Rocklow Creek, and associated tributaries to the north of the Stage 5A area. Much of the catchment information outlined below is taken from the Surface Water Assessment of the Dunmore Lakes Sand Extraction Proposal: Stages 2, 3 and 4 prepared by Bewsher Consulting (Bewsher Consulting, 2004).

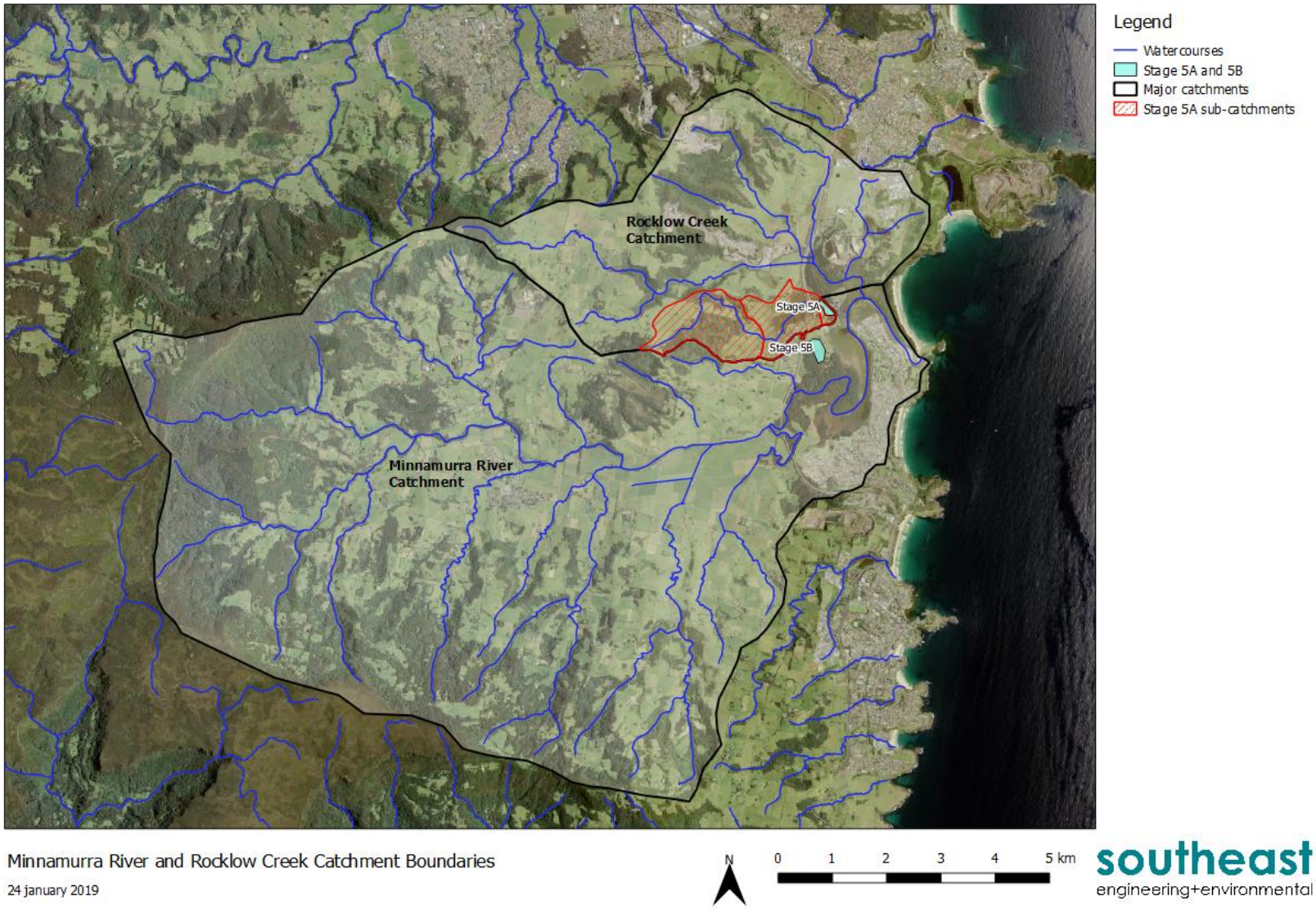


Figure 3.1 Proposal and catchment context

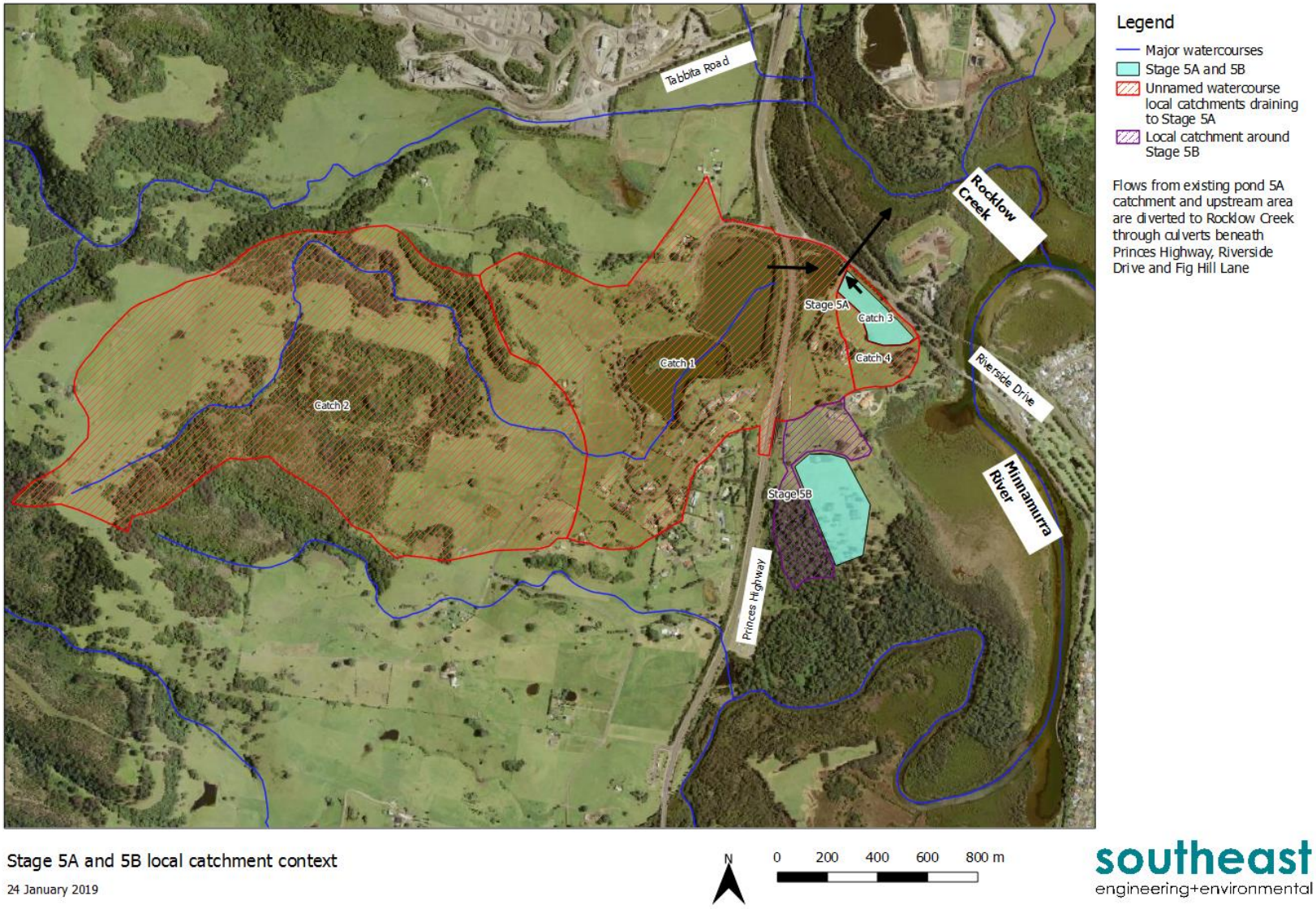


Figure 3.2 Local catchments draining directly to Stages 5A and 5B

3.2. Stage 5A

Stage 5A comprises an area of approximately 4 hectares (ha) and is located on the northern side of a hill with relief from approximately 9m Australian Height Datum (AHD) to about 1.3m AHD close to the driveway entrance to Dunmore House. Much of the Stage 5A extraction area is currently low lying with current ground surface generally below 3.0m AHD. The area is influenced by three main surface flow behaviours; surface flows from the adjacent hillside, runoff associated with the catchment to the west, and backwater flooding associated with Rocklow Creek and ultimately the Minnamurra River.

Local flows from the small hillside catchment (approximately 6 ha) to the south drain to the proposed Stage 5A extraction area. Currently, runoff from this local catchment traces existing low points and a constructed drainage channel along the southern boundary of Riverside Drive, making its way to the twin 900mm culverts beneath Fig Hill Lane in the northern corner to the adjacent pond, then beneath Riverside Drive via three 2.7m wide x 2.4m high culverts to Rocklow Creek and ultimately the Minnamurra River (Figure 3.3).

The pond system immediately to the west of the Stage 5A extraction area drains a catchment of approximately 315 ha (Figure 3.2), extending west approximately 3 km. The catchment is a mixture of cleared farmland and forested areas over the steeper slopes, with a relatively incised and steep sided watercourse through the mid catchment, opening out into pond areas in the lower catchment created as part of previous dredging operations.

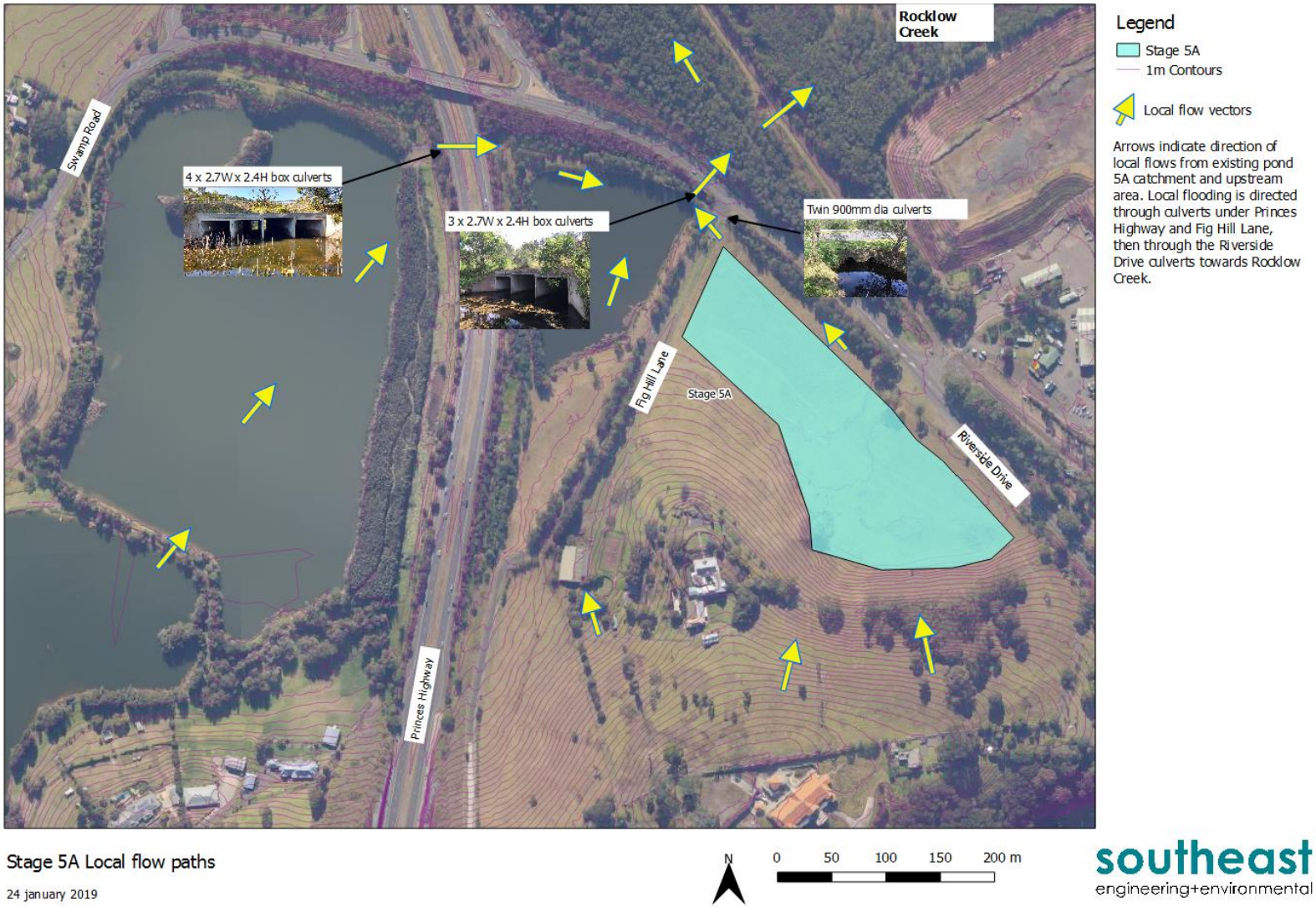


Figure 3.3 Surface flows around Stage 5A

3.3. Stage 5B

The Stage 5B extraction area is located on a flat area at the southern base of a hill with elevations ranging from 2.5 - 4m AHD. The area is located on the floodplain within a large meander of the Minnamurra River with the channel approximately 400m to the south and 500m to the east of the extraction area.

Local drainage, including the small catchment on the hillside to the north drains down to a sequence of small depressions which drain to the Minnamurra River estuary to the east (Figure 3.4).

The Minnamurra River catchment covers approximately 96 km^2, extending about 13km west to the Illawarra Range escarpment. The catchment is a mixture of steeper forested areas in the upper to mid catchment with undulating cleared rural land trending to cleared agricultural floodplains in the lower catchment. Within the lower alluvial plains of the catchment, known as the Terragong Swamp, the River and floodplain have been drained and the River straightened to improve agricultural productivity. From approximately the Princes Highway east, the River becomes more estuarine as it meanders to the north and east where it meets the ocean at Minnamurra Point. The estuary is characterised as a wave dominated barrier estuary (i.e. the opening of the estuary is highly influenced by wave action and longshore sediment transport). The entrance is permanently open and is not a trained (rock walls) entrance.

Figure 3.4 Surface flows around Stage 5B

3.4. Transfer pipeline and booster pumps

An overland transfer pipeline would be established from the Stage 5A extraction area and Stage 5B extraction areas to the Stage 2 processing area (Figure 3.5). The pipeline would consist of twin 355mm diameter polyethylene pipes, one to transfer dredged material to Stage 2 for processing and one to return treated water to ponds 5A and 5B.

Water transfer volumes will be measured by recording pump operation times to check extracted volumes and the equivalent treated water returned to the ponds to ensure a neutral water balance is maintained. Booster pumps would be located above the Stage 5B dredge pond and adjacent to the Stage 5A dredge pond.

The proposed pipeline route starts at the edge of the Stage 5B pond and travels over the Dunmore House hill to the Stage 5A dredge pond (adjacent to the existing access road for much of the way). The pipeline will then run across the existing pond to the north of Stage 5A and through existing culverts beneath the Princes Highway and Swamp Road.

The culverts beneath the Princes Highway are 4m x 2.7mW x 2.4mH box culverts which connect the upstream catchment of about 205ha to downstream. The 1% AEP flood level in these culverts is estimated at 2.9m AHD, the invert of the culvert is approximately 1.7m AHD.

The Swamp Road culvert is a single 2.7mW x 2.4mH box culvert primarily installed to incorporate infrastructure that led to the previous wash plant located to the north of Swamp Road, and to provide a hydraulic connection to this area.

The transfer pipeline will also traverse Rocklow Creek then connect to the Stage 2 processing area.

The pipeline is temporary infrastructure that will be removed on completion of dredging in the Stage 5 extraction area.

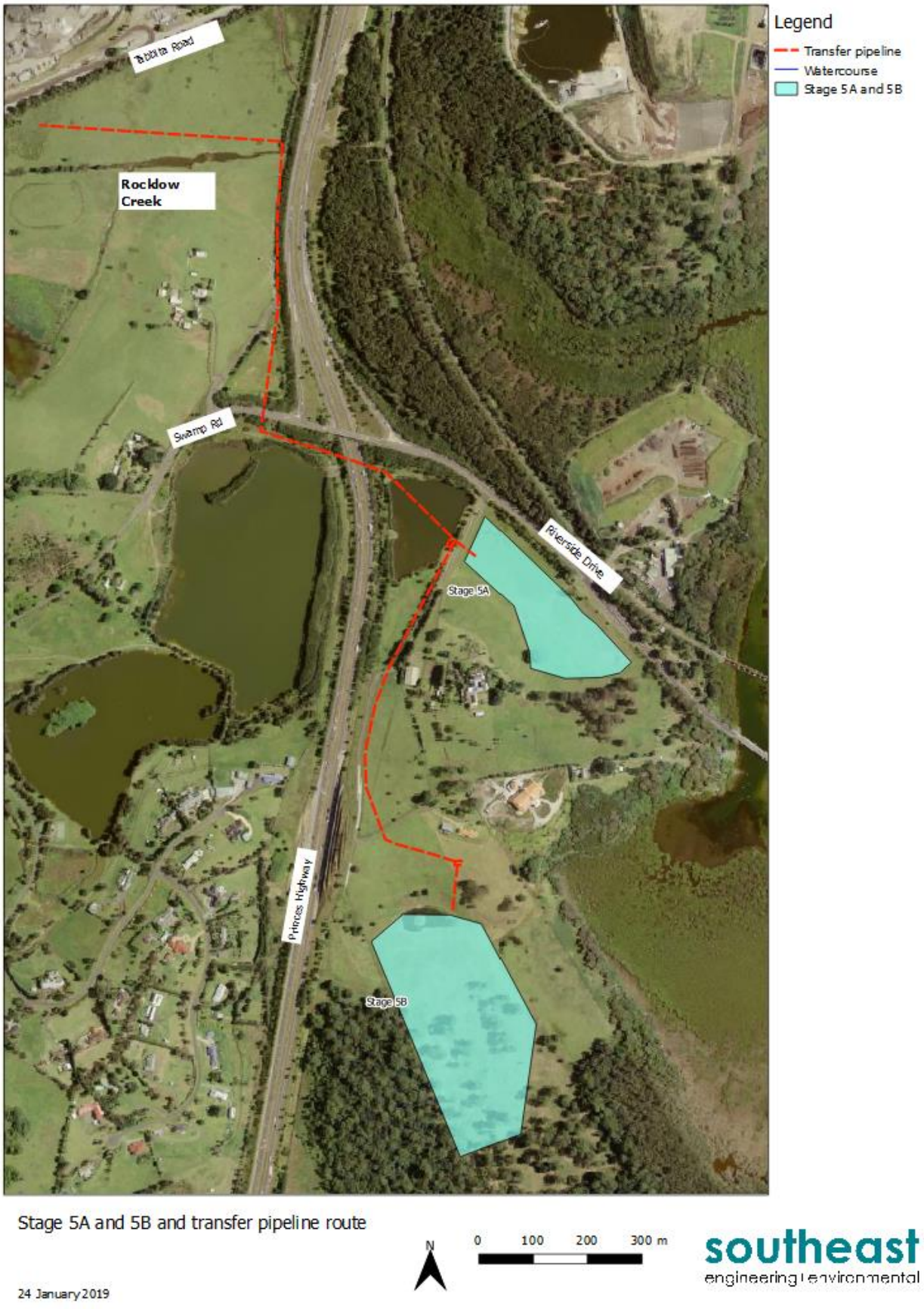


Figure 3.5 Transfer pipeline location

3.5. Local catchment flooding – Stage 5A

Along with backwater flooding from Rocklow Creek, the Stage 5A extraction area also experiences inundation associated with local catchment flooding. Runoff from the catchment to the west drains into the Stage 5A extraction area prior to discharge to Rocklow Creek, controlled by culverts beneath Riverside Drive and the Railway embankment. As previously outlined, the catchment draining to this area is approximately 315 ha. Flows from this catchment and the smaller catchment upslope from the Stage 5A extraction area were modelled in XP-RAFTS using 2016 Australian Rainfall and Runoff (ARR) rainfall intensity data. The peak flows for each sub-catchment and the entire catchment, draining through Riverside Drive culverts towards Rocklow Creek, are outlined in Table 3.1.

Table 3.1 1% AEP peak flows

Catchment	Area (ha)	1% AEP (m^3/s) Duration and median storm
1	114.6	37.5 (3hr – Storm 9)
2	190.0	25.5 (3hr – Storm 10)
3	4.5	2.0 (3hr –Storm 2)
4	5.9	1.5 (1.5hr – Storm 6)

A 2D hydraulic model (HEC RAS) has been prepared around the Stage 5A extraction area to estimate locally driven flood levels and velocities, and to compare existing and proposed surface conditions (Figure 3.6).

Key assumptions used in both the hydrologic and hydraulic models are outlined in Appendix A.

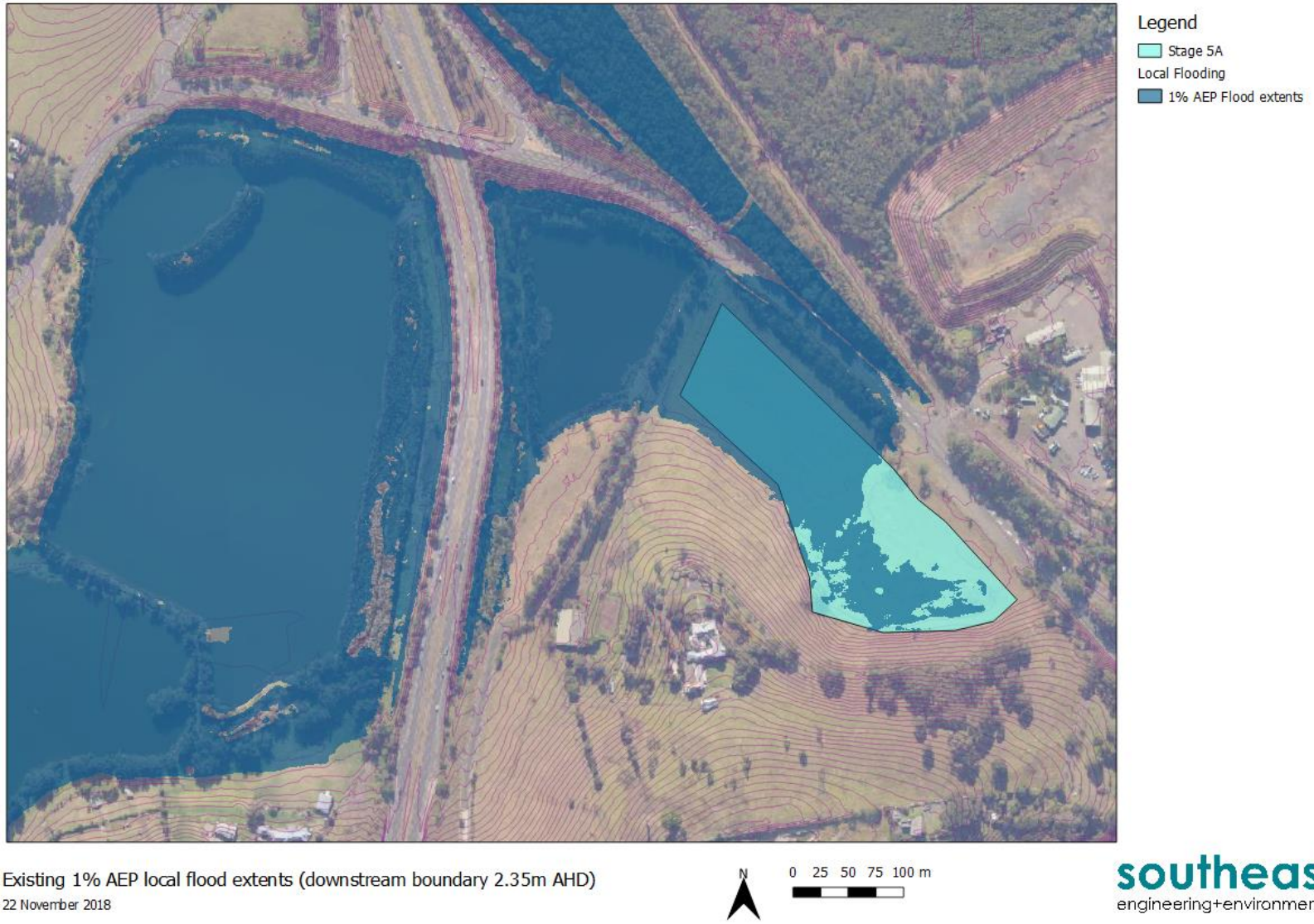


Figure 3.6 Existing 1% AEP flood extents for local 5A flooding (2.35m AHD backwater in Rocklow Creek)

3.6. Rocklow Creek and Minnamurra River Flooding

3.6.1. Rocklow Creek

A number of flood and surface water investigations have been carried out on Rocklow Creek and reviewed in the Surface Water Assessment of the Dunmore Lakes Sand Extraction Proposal: Stages 2, 3 and 4 (Bewsher Consulting, 2004). Backwater flooding levels extracted from that review and assumed for the existing Dunmore extraction areas are listed in Table 3.2.

The backwater flooding levels assumed for Stages 2 to 4 are reasonable proxies for backwater flood levels from Rocklow Creek for the Stage 5A extraction area, given the similar catchment configuration. Given the location of Stage 5A downstream of Stages 2 to 4 these levels are slightly conservative.

Backwater flows from Rocklow Creek into the Stage 5A extraction area are controlled to a certain extent by the railway embankment and culverts (estimated Invert Level (IL) 1.0m AHD) and Riverside Drive road surface and culverts (estimated IL 1.3m AHD).

Most of the Stage 5A extraction area is below 2m AHD, and as such backwater flooding from Rocklow Creek would inundate almost all of Stage 5A extraction area in a 1% AEP event, with about 60% of the disturbance footprint inundated in a 10% AEP event. The low lying nature of the Stage 5A extraction area comprising a significant portion below 1.5m AHD means that backwater flooding over this surface area is likely to be below the 50% AEP backwater flood level for Rocklow Creek meaning that inundation is estimated to occur every two years or so.

The High Water Solstice Springs tide level (HHWSS) ("king tide", approx. 3 times per year) at the confluence of the Minnamurra River and Rocklow Creek is 0.94m AHD (OEH, 2012).

Table 3.2 Estimated backwater flooding levels for Stages 2, 3 and 4 and proxy for 5A. (Bewsher, 2004)

Event	Flood level (m AHD)
1% AEP	3.6
5% AEP	3.3
10% AEP	3.2

3.6.2. Minnamurra River

Connell Wagner Pty Ltd carried out a flood study on the Minnamurra River as part of impact assessment for the North Kiama Bypass Environmental Impact Statement (Connell Wagner, 1990). The study undertook simple hydraulic calibration using historical anecdotal flood levels upstream of the Princes Highway and assessed the impact of the proposed North Kiama Bypass crossing on Minnamurra River flooding, concluding:

Comparison of the 1 in 100 year event indicates an afflux of approximately 10mm… hydraulic analysis undertaken indicates that encroachments of up to 300 metres into the south side of the Minnamurra flood plain along the route proposed, will not have a significant effect on flood heights, flow distributions and velocities within the catchment.

Based on this study, the 1% AEP Minnamurra River flood level around the Stage 5B extraction area ranges from 4.14m AHD at the southern end, to 3.67m AHD at the eastern side (Figure 3.7). For the 5% AEP the flood level ranges from 3.78m AHD at the southern end to about 3.3m AHD at the eastern end.

Figure 3.7 Extract from Nth Kiama Bypass Flood Study, 1% AEP Flood Levels (Approximatel location of Stage 5B extraction area in red) (Connell Wagner, 1990)

Surface levels over the Stage 5B extraction area range from 4.0 to 2.2m AHD along the eastern face. The northern quarter of the extraction area sits between 3.0 and 4.0m AHD, with the reminder at about 4.0m AHD. Accordingly, across most of the site, flood depth in the 1% AEP event would be relatively shallow (100-200mm).

In more frequent events most of the Stage 5B extraction area will remain flood free, apart from the lower areas (2 to 3m AHD) at the base of the hillside at the northern end of the site which may experience backwater inundation in events as frequent as the 20% to 10% AEP events.

3.7. Interface between surface and sub-surface flows

The permeable nature of soils over the proposed modification areas (3.0-3.5m/d), the generally high water table (nominal 0.6m below ground surface), low hydraulic gradient, and estimated high rainfall recharge all combine to create a strong hydraulic connection between surface and sub-surface flows (Environmental and Earth Sciences, 2004).

For light to moderate rainfall events, little runoff is expected, given the permeable nature of surface soils. In heavier rainfall events, or periods of prolonged rainfall, the high water table places a limit on soil storage, and extensive areas of waterlogging and ponding will occur over the low lying areas, exacerbated by the shallow hydraulic gradients which limit discharge and prolong surface water retention. It is possible that in the case of heavy rain and high recharge, some areas will experience localised flooding due to the piezometric head associated with groundwater recharge. In flood events, areas isolated hydraulically on the surface can experience similar flood levels for this reason.

3.8. Water quality and receiving environments

Rocklow Creek the Minnamurra River Estuary are the receiving waters for the currently approved operations area, and the proposed modification. The Stage 5A extraction area currently drains to the mangrove wetlands surrounding Rocklow Creek, whilst the area over Stage 5B drains to the mangrove wetlands between the extraction footprint and the Minnamurra River. These wetlands are classified as coastal wetlands in the Coastal Management SEPP 2018 (Figure 3.8) and contain Type 1 Highly sensitive key fish habitat and Class 1 waterways as defined in the Policy and guidelines for fish habitat conservation and management (DPI, 2013).

Figure 3.8 Stages 5A and 5B location in relation to Coastal management SEPP boundaries

The Coastal Zone Management Plan for the Minnamurra River Estuary (Hydrosphere, 2015) summarises the recent historical and current estuary conditions, pressures on the estuary and water quality data recorded within the estuary and upstream. Key findings of relevance to the proposed modification are:

- Based on the NSW Natural Resources Monitoring, Evaluation and Reporting (MER) program, the overall condition rating for the Minnamurra River Estuary was assessed as "Good" from an average of all scores which ranged from poor for seagrass (due to a loss in area) to very good ratings for turbidity and saltmarsh.
- The key pressures on the estuary are increased sediment and nutrient inputs, with an estimated increase of approximately 500% from natural conditions. The overall pressure score for the estuary was 'Moderate' as assessed in the MER.
- Analysis of water quality data (2006/2007, 2007/2008 and 2011/2012) shows median water quality values that exceed guideline nutrient levels (<0.03mg/L for Total Nitrogen (TN) and <0.03mg/l for Total Phosphorus (TP)) throughout the catchment, including the receiving water areas close to proposed Stages 5A and 5B which have median values over the sampling period of 0.52 mg/L TN and 0.05 mg/L TP at Sample sites M3 (Mid Estuary Minamurra River) and 1.5 mg/L TN and 0.2mg/L at R1 (Rocklow Creek). As well as median turbidity values (12.1 NTU) above estuarine guideline level of <10 NTU at R1 (Rocklow Creek).

In summary, the Minnamurra River is in a good condition, however there are significant land use pressures that increase the risk of condition degradation. Water quality monitoring results for Rocklow Creek and the Minnamurra estuary exceed ANZECC trigger values for a range of parameters, and in some periods Rocklow Creek shows highly eutrophic conditions (Hydrosphere, 2015). Eutrophic conditions are an indication of likely algal blooms, the result of high nutrient availability.

3.9. Water quality monitoring

As part of the existing Dunmore Lakes Sand Project approval conditions, water quality monitoring is carried out monthly and after 20mm or more of rainfall within a 24 hour period. Water quality samples are collected at five Environment Protection licence (EPL) sites (see Figure 3.9) along with a range of other pond sampling sites and inflow points to the site to provide background water quality data. During high flow and flood events, additional sampling is taken upstream from normally dry watercourses to improve upstream and downstream water quality comparison.

The existing water quality monitoring objectives reflect the NSW ANZECC Water Quality Objectives (WQOs) for lowland rivers and estuaries in the Illawarra region.

Figure 3.9 Current EPL monitoring points

Table 3.3 shows the average monitored results for the five EPL monitoring points over the 2017 and 2018 financial years, including pH, turbidity (NTU), total suspended solids (TSS) and electrical conductivity (EC) (salinity). Note that DW-20 is the only point directly influenced by the existing site activities, and the other points are used as baseline conditions. For DW20 in 2017, measured turbidity levels exceeded the limit 5 times; however on average were significantly lower than DW12 and DW11, both upstream of the Site. In 2018, EC levels were exceeded 3 times at DW20 and the average of samples taken was above the threshold. This is an indication of saline influence into the stage 3 pond over time.

The proposed modification will necessitate an expansion of the water quality monitoring program, as discussed below.

Table 3.3 Financial year average water quality results, (number of exceedances), red denotes average above threshold.

Monitoring point	Location characteristics	Fin year	pH	NTU	TSS	EC
DW12 (EPL11)	Upstream of Site. Highly influenced by farming and also by a different quarry	2017	6.9 (1)	478.8 (1)	161.6 (1)	242
		2018	-	-	-	-
DW11 (EPL12)	Upstream of Site. Highly influenced by farming and also by a different quarry	2017	7.76	61.68 (2)	46.62 (2)	596
		2018	-	-	-	-
DW21 (EPL10)	Downstream of Site. Influenced by Princes Highway runoff. Not influenced by Site activities	2017	7.44	14.6 (1)	19.72	4676 (5)
		2018	7.5	11.6 (1)	15.9 (2)	27107 (13)
DW18 (EPL13)	Upstream of Site. Influenced by farming and discharged water from an unrelated Boral quarry	2017	7.3	26.1 (6)	19.2 (3)	1907 (2)
		2018	7.3	22.7 (3)	34.5 (1)	10617 (5)
DW20(a) (EPL9)	Downstream of Site. Influenced by stage 2 water discharge and Princes Highway runoff	2017	7.68	34.33 (5)	21.4 (1)	667 (1)
		2018	7.5	17.4 (1)	24.8 (1)	4341 (3)
WQO			6.5-8.5	5-20	<50	<1500

3.10. Existing Water Balance

As part of the development consent, DSS are required to provide a water balance outlining the following:

a) include details of all water extracted and used by the development; and

b) provide for the reporting of annual water extraction and maximum instantaneous pumping rates to the Department in accordance with the licence under the Water Act 1912.

The latest Annual Review from DSS for 2017/2018 contains the following information relating to water use on site:

Water is used for dust suppression and sand processing and is sourced from the fines pond and dredge pond under a groundwater Water Access Licence (WAL24477) issued under the Water Management Act 2000. The licence permits the taking of 65ML of water from the Sydney Basin South Groundwater Source and is subject to a number of conditions. Associated 'work approvals' include 10WA106713 and 10WA106714.

Surface water enters the site ponds from the Western Eastern and Northern Tributaries and flows out of the ponds back into the re-aligned Western Tributary. The influence of surface water on the site water balance is therefore considered to be neutral. Water extracted from the ponds is measured and considered in relation to the applicable groundwater licence.

Figure 3.10 outlines water movement around the existing operations areas.

The two extractive water uses on site are dust suppression and water exported from the site as moisture content in sand products.

Dust suppression

Boral estimates that for the current Stage 2 to 4 operations, up to five 30,000L tanker loads are used on non-rain days during the year and that on average there are about 200 non-rain days.

An interrogation of local climate data collected from the Bureau of Meteorology (Foxground Road rainfall gauge 68197 1945-2018), approximately 14km from the extraction area, suggests that on average the number of non-rain days is about 230 per year. Assuming 230 days, this would equate to 34.5 ML/y of water required for dust suppression.

Water used in processing and exported

Based on DSS records, approximately 19.5ML/d (7.1 GL/y) is used for sand processing, including dredge pumping (10.8ML/d), pumping to the sand wash bin for dust washing (6.5ML/d) and water use in the oversize screen sprayers (2.2ML/d). The average moisture content of sand leaving the site is around 8%. Based on the 2017 production of 401,582 tonnes, approximately 32.12ML/y currently leaves the site. The remainder (7.07GL/y) returns to the surrounding landscape ponds as runoff or as infiltration to groundwater.

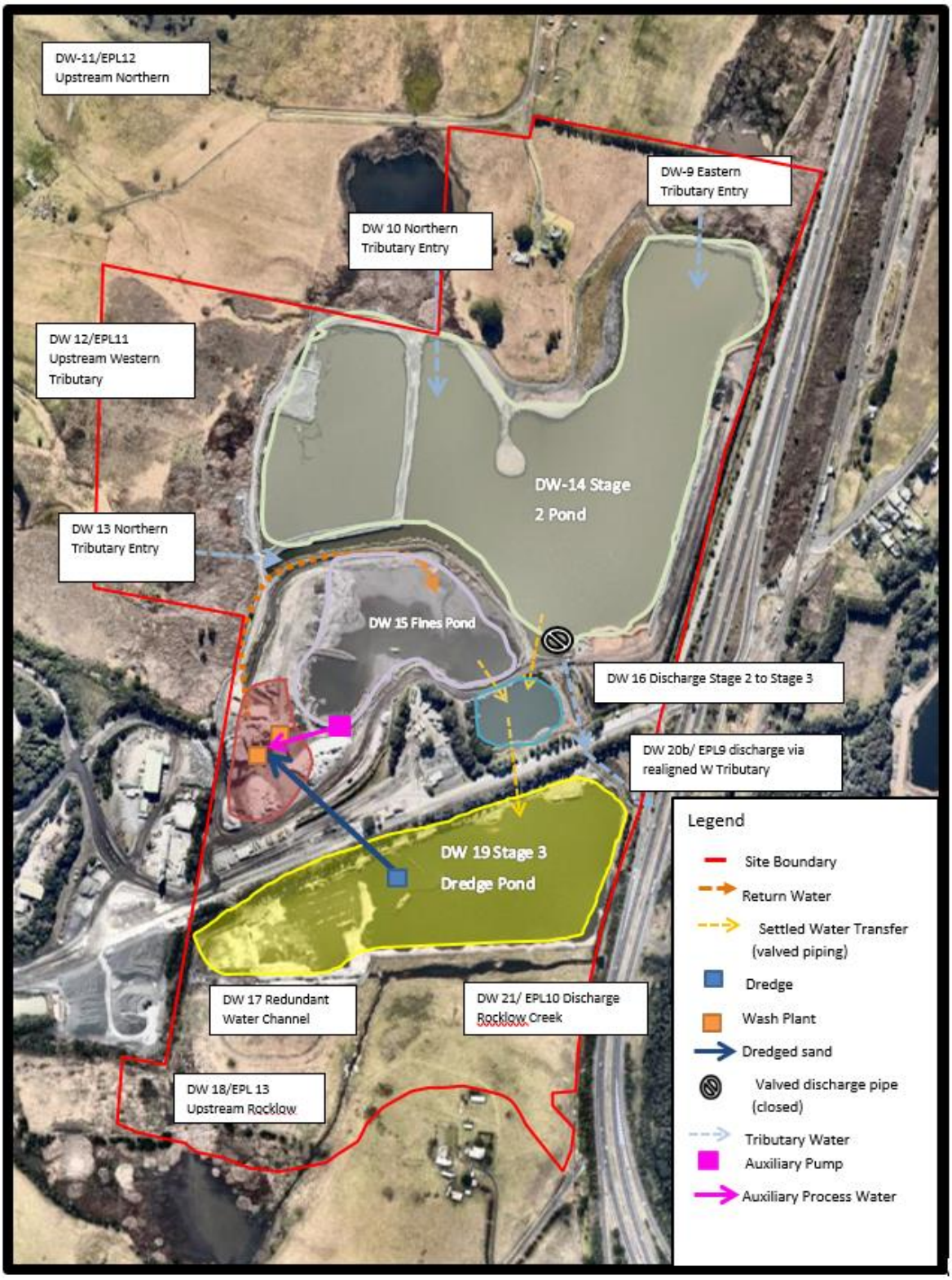


Figure 3.10 Current water transfers over Stages 2 to 4.

4.0 SURFACE WATER IMPACTS AND MANAGEMENT

4.1. Water quality management – Construction phase

Construction impacts at the site are predominantly associated with the earthworks required to establish the extraction areas and infrastructure for material movements.

4.1.1. Access Roads, site office and parking

Fig Hill Lane will need to be extended to the south to provide access to the Stage 5B extraction area, this includes an unsealed road running down the hillside to the site office facilities and parking area.

Exposed soils generated through the construction of the access roads, site office and parking will be managed through standard sediment and erosion controls, refer to *Managing Urban Stormwater: soils and construction, Volume 1 and Volume 2C: Unsealed roads and 2D: main road construction* (DECC 2008) for the preparation of Soil and Water Management Plans (SWMPs) for the construction phase of the project.

Maintenance tracks will also be required around both of the Stage 5A and 5B extraction areas. Additional unsealed areas and sealed areas will need to be constructed for site office facilities at the northern part of the Stage 5B extraction area. These areas can be diverted to the dredge pond which will act as a sediment basin.

4.1.2. Dredge Ponds, stockpile areas and haul roads

The Stage 5A and Stage 5B dredge ponds are to be bunded to prevent interaction with surface flows and floodwaters, and to prevent the associated potential water quality risks to adjacent receiving waters. Bunds are to be constructed in conjunction with the initial site clearing. These bunded areas will function as sediment basins for surrounding cleared areas.

Bunds will need to be engineered, and will likely require either VENM imported to the site or material other than excavated sands to ensure their structural integrity.

Clearing and grubbing of the proposed extraction areas and construction of water diversion structures and flood protection bunds will generate areas of exposed materials increasing the potential for erosion and transfer of material to receiving waters. In particular, the outer batter slopes of the flood protection bunds should be adequately stabilized with vegetation to limit erosion and sediment transport off site. Refer to *Managing Urban Stormwater, Soils and Construction, Volume 2E Mines and Quarries (DECC, 2008)* for specific information on batter treatment and diversion drain design.

In addition to the isolation of the dredge ponds from surrounding surface and river flows, the bunds provide significant freeboard of up to 2 to 3m from the normal operating water level (likely to be close to local groundwater surface levels of around 1m AHD) (Environmental Earth Sciences, 2019). The freeboard will reduce the possibility of basin overflows in flood and high rainfall events and also allow the ponds to act as sediment basins through the provision of detention storage. As a comparison, sediment basin sizing using the *Managing Urban Stormwater* Soils *and Construction Volume 1* has been used. Assuming 5 day, 95th percentile rainfall capture, as recommended in *Managing Urban Stormwater, Soils and Construction, Volume 2E Mines and Quarries (DECC, 2008),* the calculated sediment basin volume against the available storage volume within the bunded dredge ponds are outlined in Table 4.1. The available storage within the dredge ponds will exceed the recommended sediment basin volumes outlined in for the catchments draining to them.

Table 4.1 Comparison of available retention volume in dredge ponds against sediment basin sizing calculations

	Catchment Area (ha)	**Storage volume**		
		Bunded dredge pond (above local groundwater level of 1m AHD) (m^3)	**Type D/F basin storage based on catchment (m^3)**	**Type C basin storage calculation (m^3)**
Stage 5A dredge pond and surrounds.	4.3	78000	3000	2500
Stage 5B dredge pond and surrounds.	11.1	270000	6000	5000

4.1.3. Transfer pipeline

For the majority of the transfer pipeline alignment, the pipe will be placed on the surface and secured to the ground. Some clearing will be necessary along the edges of the existing ponds to accommodate the transfer pipeline. Clearing will be confined to limited shrub removal, with groundcover vegetation to remain. Surface water impacts are limited to temporary impacts associated with machinery access and will be minor. Erosion and sediment controls shall be installed where required. Refer to *Managing Urban Stormwater, Soils and Construction, Volume 2A Installation of Services (DECC, 2008)* for specific information on mitigating erosion and sedimentation for linear construction as well as *Guidelines for Laying Pipes and Cables in Watercourses on Waterfront Land (DPI Water, 2012b)*

4.2. Water quality management - Operational phase

4.2.1. Stage 5A and Stage 5B

For Stage 5A, the haul road surrounding the dredge pond and stockpile area shall drain to the dredge pond. The dredge pond will provide the water quality treatment for these areas during dredge pond operations.

For Stage 5B, part of the unsealed access road, the car-park, office and amenities area shall drain to the dredge pond, along with the haul road surrounding the dredge pond to provide for water quality treatment during operations.

The available storage in both dredge ponds exceeds the sediment basin volumes outlined in *Managing Urban Stormwater, Soils and Construction, Volume 2E Mines and Quarries* (DECC, 2008) for sensitive receiving waters. Refer to section 4.1 for a discussion on sediment basin volume and treatment.

4.2.1. Processing

Once site preparation is complete, sand from Stage 5A and 5B will initially be extracted using an excavator and stockpiled adjacent to the extraction area until a pond is sufficiently large enough to float a dredge. These stockpiles will then be dredged with the underlying sand and pumped as a sand/water mix to the Stage 2 processing area.

Primary water quality impacts associated with processing consist of the water use during the pumping and washing of the sand material, and the management of fines from the dewatering process at the Stage 2 area. In accordance with the approved operations, water removed through the dewatering process will drain to an existing fines pond and a secondary settling pond, before being pumped back to the Stage 5A and Stage 5B dredge ponds.

Water pumped from the Stage 5 extraction areas will be returned to these extraction areas via the pumping pipeline. Pumped water volumes will be recorded by a flow meter and the same volume of water will be returned to the Stage 5 extraction areas to balance water extracted.

4.3. Protection of aquatic and coastal environment

Stage 5A is located within the Coastal Wetland proximity area (Figure 4.1) and within about 150m of mangrove areas within the Minnamurra River and 250m of mangrove areas within Rocklow Creek. Stage 5B is located about 160m from saltmarsh and mangrove areas on the tidal flats of the Minnamurra River. These adjacent aquatic areas are considered 'Type 1 – Highly sensitive key fish habitat' due to their coastal wetland characterisation and the presence of mangrove, saltmarsh and seagrass communities. Table 4.2 contains a summary of key risks to aquatic habitats and recommended management measures to mitigate these risks.

The recommended riparian buffer to provide protection for these sensitive communities is a minimum of 100m. The proposed disturbance areas for Stage 5A and 5B are beyond 100m from these sensitive areas.

The transfer pipeline will be floated over the pond to the northwest of Stage 5A, and suspended from the roof of culverts beneath the Princes Highway and Swamp Road. The pipeline is flexible and can be installed without tree removal, some clearing of smaller, shrub riparian vegetation will be necessary to allow for machinery access for installation.

The pipeline will cross Rocklow Creek. A gangway is proposed to support the pipeline above the creek. Gangway supports will be located on the overbanks. No works are required in-stream.

In these cases there is no discernable impact on impact on aquatic habitat, or fish passage.

There is a risk of pipeline leakage or failure, either through mechanical failure or damage from an external cause. System monitoring and maintenance shall be incorporated into operational procedures for the transfer pipeline to limit the possibility of failure, and allow for the swift identification of failure, should it occur.

Table 4.2 Risks to aquatic habitat and management

Key risks associated with the construction and operation of the dredge ponds	**Management and mitigation**
Erosion of exposed areas and sediment transfer to adjacent waterways during construction	Prepare and implement a SWMP for the construction phase of various components.
Erosion and sediment transfer during operational phase	Direct runoff from unsealed areas to dredge ponds. Ensure surface diversion drains and outer bund batters are stable and well vegetated.
Transfer of sediment and fines through inflow and overflow from dredge ponds	Dredge pond areas are to be bunded to the nominal 1% AEP flood level to isolate them from local river and estuarine flooding and prevent uncontrolled discharge.
Failure of sand/water pipe resulting in sand entering water courses	Double skinned pipe at watercourse crossings and regular inspection of the pipe. Mechanisms to shut down pumping system during high risk periods (flooding), and when a leak occurs.
Failure of outer bunds resulting in sediment entering the water courses	Design and construction with appropriate geotechnical expertise and materials.
Impacts of water extraction associated with sand slurry transfers	Water volume extracted to be measured and returned from Stage 2 processing area to dredge ponds to maintain local water balance.

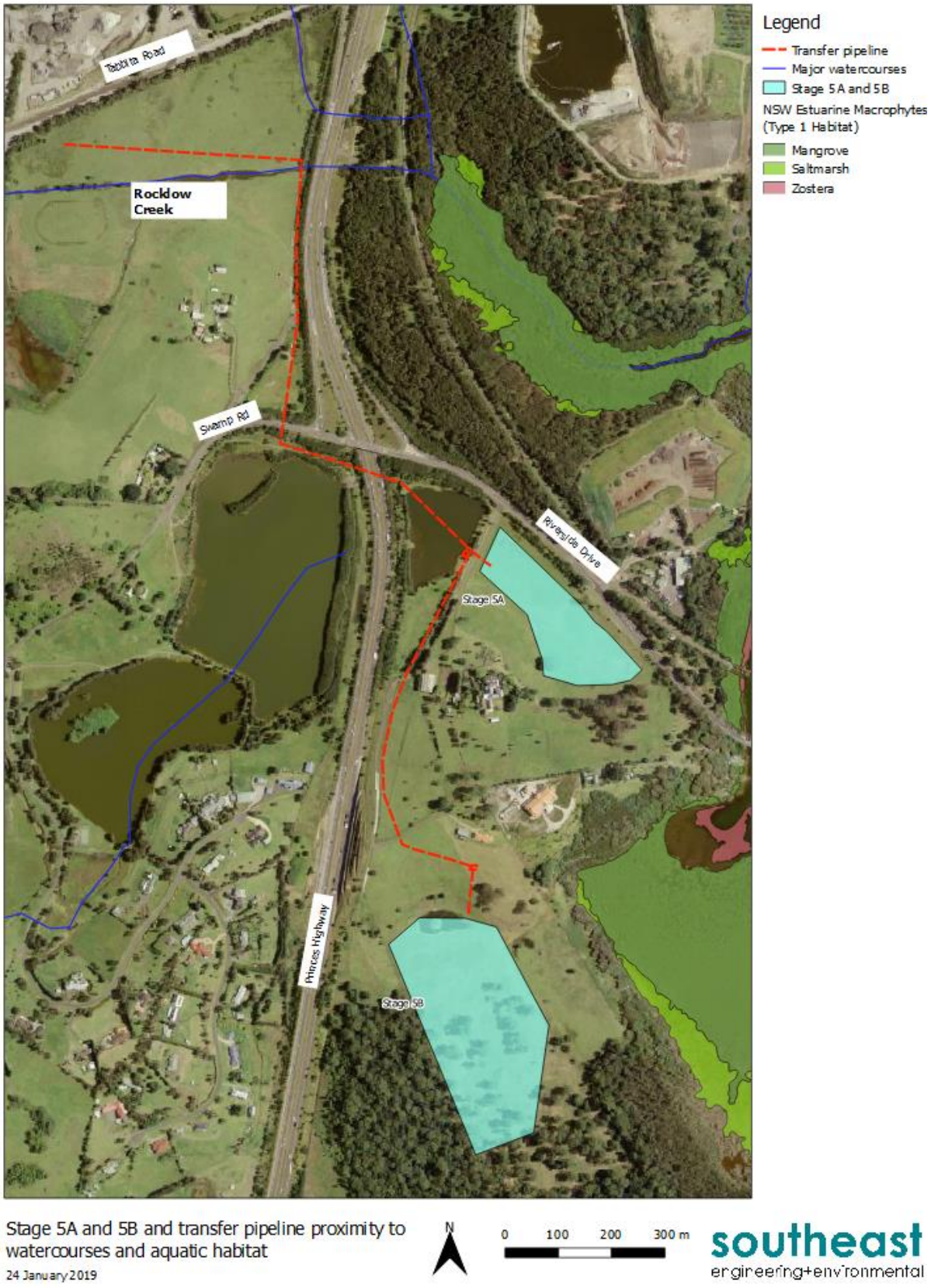


Figure 4.1 Stage 5A and 5B and transfer pipeline Proximity to aquatic habitat

4.4. Local surface flows and flooding

4.4.1. Stage 5A

The area currently receives surface flows from the adjacent hillside, flood flows from the unnamed watercourse to the west and backwater flooding from Rocklow Creek and the Minnamurra River estuary. Runoff from Riverside Drive and parts of the western edge of the site is captured in an open drain that runs along the boundary with Riverside Drive.

Flows from the hillside catchment to the south can be diverted around the proposed Stage 5A extraction area. This will consist of a series of diversion drains to divert flows around the extraction area. (Figure 4.2). The VENM stockpile area and surrounding haul road shall drain to the dredge pond, where sediment can settle out. As outlined above, the available storage exceeds the recommended volumes to manage sediment.

Flows and flooding from the unnamed watercourse to the west pass through the adjacent existing ponds, prior to discharge though the culverts beneath Riverside Drive. The existing 1% AEP flood level for this local catchment is around 2.45m AHD over the proposed Stage 5A extraction area (Figure 3.6) and backwater flooding from Rocklow Creek and the Minnamurra River is estimated at 3.6m AHD. These floods cover most of the proposed Stage 5A extraction area.

To limit potential water quality impacts or turbid water from the active Stage 5A extraction area entering Rocklow Creek and ultimately the Minnamurra River during flooding events, it is proposed to provide an earth bund around the 5A extraction area up to the 1% AEP backwater flood level, plus 100mm freeboard (3.7m AHD) to isolate dredging activities from the local floodwaters and surface flows.

Bunding of the Stage 5A extraction area effectively removes the extraction area and associated access roads from floodplain storage. The impact of this on local flood flows has been assessed for the local 1% AEP event by comparing an existing hydraulic model with a model of the modified terrain. There are very small localised increases in flood depth as a result of the temporary removal of floodplain storage in the order of 1 to 5cm over Riverside Drive for the local 1% AEP event (Figure 4.3).

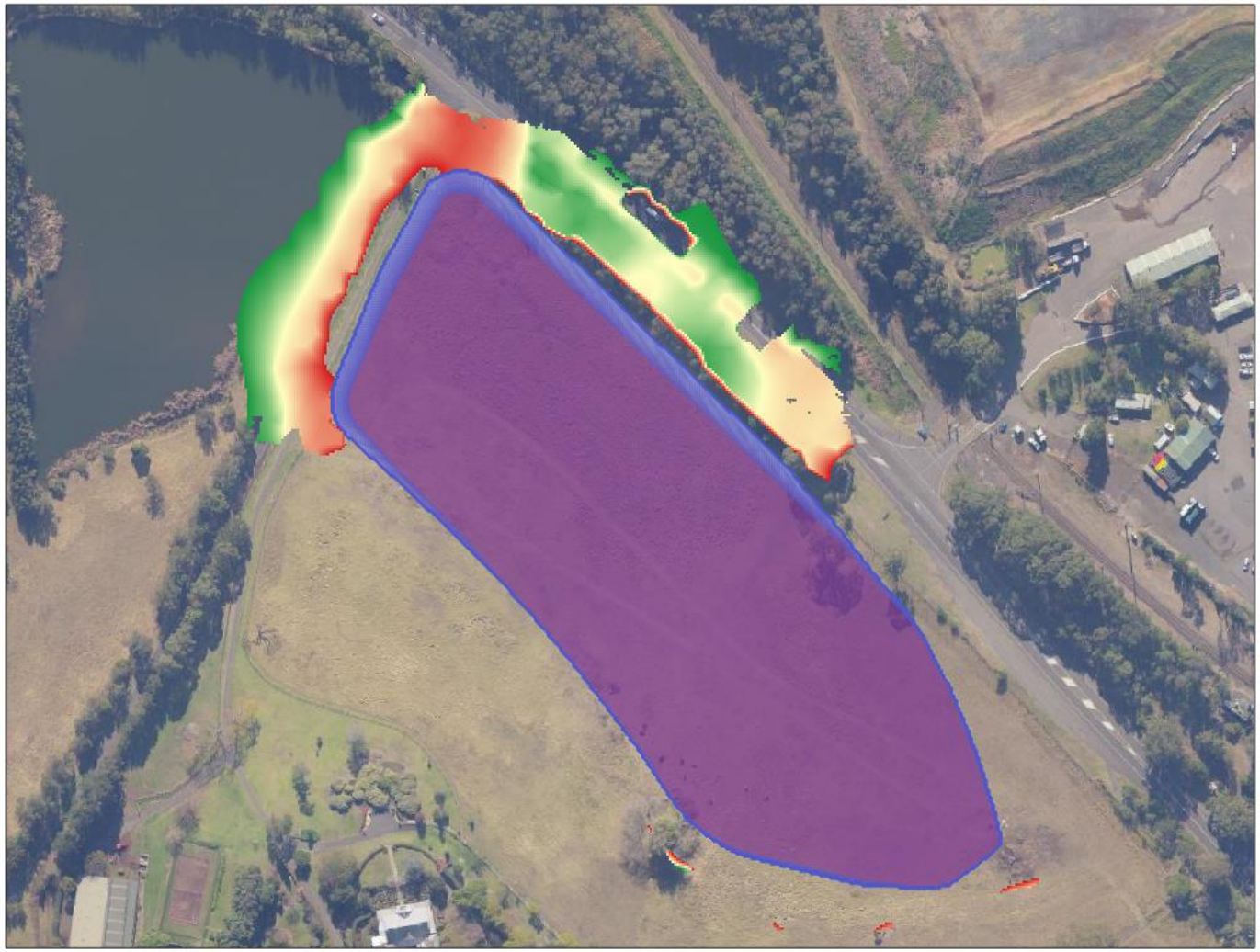
Given the temporary nature of the works, estimated at three to five years, and the limited impact on local 1% AEP flood levels, the temporary loss of floodplain storage on flood levels is not significant. The impact of minor flood changes are outweighed by the water quality benefits associated with isolating the dredge areas from external flows and potential discharge.

To accommodate the possibility of inundation of the Stage 5A extraction area due to water levels within the extraction area either through rising groundwater levels, local catchment flows draining to the dredge pond, or large flood events in excess of the bund level a preferential flow path into and out of the extraction area is recommended. An armoured spillway 100mm lower than the bund height (3.6m AHD) and 20m long will allow for the basin to drain to the spillway crest over about 1 hour, allowing the upper storage to drain in line with the falling flood wave.

There is the potential for a significant difference in water level inside and outside of the bunded areas of up to 2.5m in areas. This may occur if surrounding floodwaters have drained, and the dredge pond remains full, or in the opposite case where floodwaters are much higher than water levels within the pond. Bund design will need to allow for the appropriate hydrostatic pressures, along with the potential for internal erosion through the bund material.

Once resource extraction is complete, reinstatement of floodplain storage shall be undertaken through the removal of the bund, backfilling of the Stage 5A extraction area and associated site rehabilitation.

Figure 4.2 Stage 5A Surface water management



HEC-RAS Results - Impact on Riverside Drive for local 1% AEP flood

05 February 2019

southeast
engineering+environmental

Figure 4.3 HEC-RAS modelling results showing change in flood depth as a result of the temporary removal of floodplain storage

4.4.1. Stage 5B

Surface flows from the hillside to the north will drain down towards the proposed 5B extraction area. The 1% AEP flood levels (4.1m to 3.7m AHD) from the Minnamurra River (Connell Wagner, 1990) (Figure 3.7) extend over the extraction area at shallow depths of around 100mm or so over most of the site, apart from the low lying parts in the north east corner of the site where flood depths are up to 2m.

As for Stage 5A, an earth bund up to the estimated 1% AEP flood level (4.1m AHD) is to be established around the Stage 5B extraction area to isolate it from local surface flows and flood flows from the Minnamurra River.

Most of the Stage 5B extraction area is at or only slightly below the 1% AEP flood level of around 4.1 to 3.7m AHD and is located in a backwater area of low velocity. The bunded area is either on what would be classified as the flood fringe, or at most flood storage area, as such impacts on flood levels are likely to be minimal.

As for Stage 5A, given the temporary nature of the works, estimated at three to five years, and the limited impact on local 1% AEP flood levels the temporary loss of floodplain storage on flood levels is not significant.

The location of the Stage 5B extraction area within an active part of the floodplain does create the possibility of water levels within the extraction area either through rising groundwater levels, local catchment flows draining to the dredge pond, or large flood events in excess of the bund level.

For this reason an emergency inflow and outflow spillway is recommended. The spillway will provide a preferential armoured flow path for flows in and out of the extraction area in large flood events (approx. 1% AEP and greater). Spillway dimensions should be approximately 60m long and 200mm deep. This allows for the basin to be drained to the spillway crest over about 1 hour, and roughly match the falling limb of a flood wave through the Minnamurra River.

On completion of the resource extraction, floodplain storage shall be reinstated through the removal of the bund, and necessary reshaping and revegetation. The pond will be retained as an open water area.

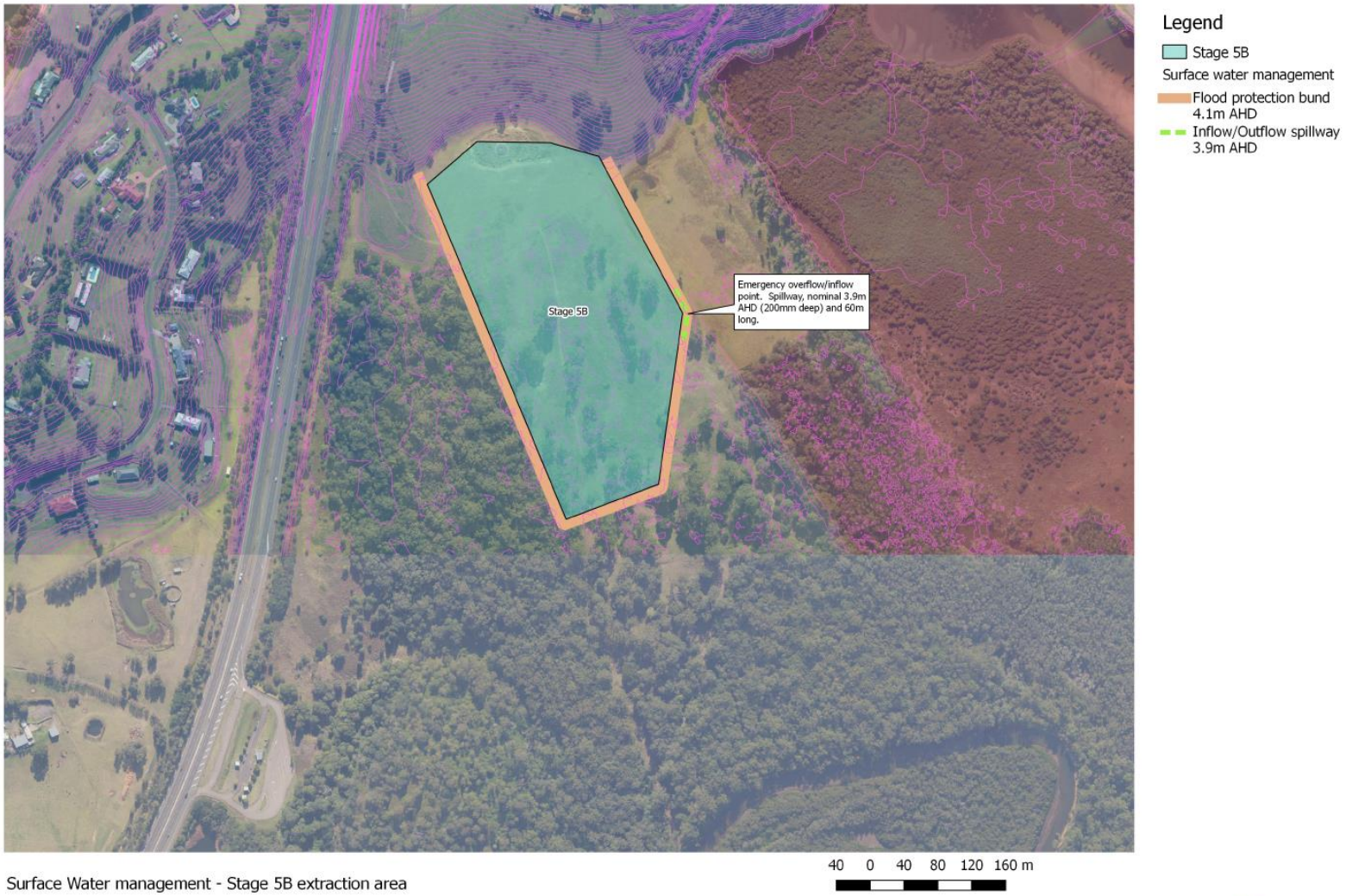


Figure 4.4 Stage 5B surface water management.

4.4.2. Transfer pipeline

The nominal 355mm diameter sand slurry transfer pipes travel from the Stage 5B extraction area to Stage 5A and then to the Stage 2 processing area as described in Section 3.4.

The pipe will be secured to the ground and clearing will be required where vegetation prevents access for machinery and placement of the pipe, along with excavation necessary to install the booster pumping stations. The pipe will need to be secured to existing culverts beneath the Princes Highway and Swamp Road and will cross Rocklow creek.

Where clearing is required, standard erosion and sediment controls shall be applied, refer to *Managing Stormwater: Soils and Construction, Volume 2A – Installation of services* (DECC, 2008) when preparing sediment and erosion controls for this component. *Guidelines for Laying Pipes and Cables in Watercourses on Waterfront Land (DPI Water, 2012b)* should be considered when designing and constructing the pipelines.

The transfer pipeline will be floated across the pond adjacent to dredge pond 5A. maximum velocities in a 1% AEP event across this pond are approximately 0.5m/s. Design of the floatation and the fixing system where the pipeline connects back to the pond banks will need to consider the hydraulic forces associated with flood flows along with the variation in water levels.

To traverse the roadways it is proposed to attach them to the side of existing culverts in the upper corner. At the Princes Highway the existing culverts are 2.7m wide by 2.4m high (Figure 4.5) with invert level at approximately 1.7m AHD at the upstream end. The culverts provide a flow area of about 26m^2. The installation of the transfer pipes will require about 0.25m^2 of potential flow area, reducing culvert capacity by about 1%.

Additionally, local 1% AEP flood levels are about 2.9m AHD, about 1.2m below the culvert obvert. Backwater flooding from broader catchment flooding from Rocklow Creek and the Minnamurra River may inundate the culverts. Given the small flow area removed and low flow velocity the hydraulic capacity impacts of the transfer pipeline on the Princes Highway culverts are not considered significant.

Figure 4.5 Culverts beneath Princes Highway

The transfer pipe will also pass through the culvert beneath Swamp Road. This culvert was installed primarily for infrastructure that connected the previous sand extraction area with the previous processing plant (Figure 4.6). The culvert also allows for the movement of flows from a catchment of about 2ha. The addition of the transfer pipes to the side of this culvert will not have an impact on hydraulic capacity.

Figure 4.6 Swamp Road culvert

The transfer pipe will also cross Rocklow Creek. To limit riparian and hydraulic impacts, the transfer pipe will be installed on a gangway approximately 1.5m above the creek banks and a span of about 12m. The gangway construction will consist of concrete footings beyond the existing top of bank. No piers within the watercourse will be required. Design and construction management should be undertaken in compliance with:

- *Guidelines for Controlled Activities on Waterfront Land - Riparian Corridors (NRAR, 2018)*
- *Guidelines for Instream Works on Waterfront Land (DPI Water, 2012a)*

There is a risk of pipeline leakage or failure, either through mechanical failure or damage from an external cause. Risks are mitigated through the use of a double skinned HDPE pipeline. System monitoring and maintenance shall be incorporated into operational procedures for the transfer pipeline to limit the possibility of failure, and allow for the swift identification of failure, should it occur.

4.5. Water balance and water licence

As outlined in Section 3.10, water leaving the existing Dunmore Lakes Sand Project operations includes water used for dust suppression for roads and stockpile areas as well as water exported from the site as moisture content in the outgoing sand product.

Water used to transfer the sand slurry from Stages 5A and 5B will be metered and the same volume returned to ensure the local surface and groundwater balance is maintained.

The current approval allows for the removal of 800,000tpa. Current, and expected extraction averages around 400,000 to 500,000tpa. It is expected that this demand will remain in this range.

Average moisture content of material leaving the site is around 8%. Assuming an average extraction of 450,000tpa, approximately 36ML of water will leave the Site with sand products.

The current dust suppression water use is about 4.5ML/ha/y and covers about 7.6 ha (Pers comm Ben Williams, DSS Environmental Co-ordinator).

The Stage 5A and 5B access roads and stockpile areas cover about 0.7ha. Applying the same rate will increase current dust suppression water use from about 34.2ML/y to about 38ML/y.

Total water use for a production level of 450,000tpa is 74ML/y (36ML/year as moisture content in exported material and 38ML/year for dust suppression).

Currently DSS has a Water Access Licence (WAL) and associated Water Supply Work (WSW) approval for 65ML/y from the Sydney Basin South Groundwater source. DSS also have a WAL for an additional 15ML/y from the Metropolitan Coastal Sands Groundwater source, however are yet to obtain a WSW for this allocation. Once a WSW is nominated, likely over the Stage 5 extraction areas, and approved DSS will have a total of 80ML/y available for extraction which will nominally allow for extraction up to 525,000tpa, based on existing assumptions.

A further allocation of 20ML has been secured from the Metropolitan Coastal Sands Groundwater source however both a WAL and WSW are pending for this allocation.

4.6. Water quality objectives and monitoring

The current water quality and discharge controls for the existing operations are outlined in Section 2.4, and include water quality targets for water discharged at licenced discharge points, and water quality objectives for the basins themselves.

It is proposed that the same water quality objectives are applied to the Stage5A and 5B extraction areas, apart from conductivity objectives, as interaction with more saline groundwater in these areas is possible

Current groundwater monitoring notes that salinity of groundwater to the east of the Princes Highway is consistently higher than that to the west and increases at depth, with values potentially exceeding currently consented water quality objectives for conductivity. (EES, 2018). In the currently approved Groundwater Management Plan, Environmental Earth Sciences (EES, 2018) have recommended that trigger values for groundwater salinity be increased from <1500 to 33000µS/cm for groundwater monitoring sites to the east of the Princes Highway to reflect the saline influence on groundwater in this area.

The Stage 3 dredge pond currently experiences elevated electrical conductivity due to this saline tidal inflow which is above the current consented limit of 1500µS/cm. Rocklow Creek is tidal in this area. Adjacent bore holes (BHF and BHD) also reported elevated electrical conductivity levels in May 2018 (EES, 2018). Saline intrusion is a possible cause, particularly given the depth of dredge pond excavation is up to 15m deep and extends into the deeper aquifer which has higher salinity levels (EES, 2018).

Surface water salinity in the channel to the northwest of Stage 5A, on the eastern side of Riverside Drive is brackish Recent groundwater assessment in the northern corner the Stage 5A area (bore MW5A3) reports TDS levels around the current objective level at a depth of around 0.6m AHD and that the tidal effect on groundwater is typically between 5 and 50 m from a tidal creek, depending on soil permeability (EES, 2019).

The proximity of the Stage 5A and 5B dredge ponds to tidally influenced and saline watercourses, and the groundwater salinity levels measured in the vicinity, creates the potential for saline groundwater intrusion into these ponds. The likelihood increases as pond excavation deepens as well as during periods of pond draw-down either through extraction or evaporation. Further, the transfer of water from Stage 5A and 5B to the processing facility (Stage 2) and return flows mean that salinity levels in the Stage 2 fines pond will be influenced by Stages 5A and 5B and vice versa.

As this is possible, an increase to the current surface water electroconductivity trigger from <1500µS/cm should be considered. Some water quality characterisation will be necessary to assist in determining any new objectives.

The expanded operation associated with the modification will continue to make use of the existing EPL provisions for wastewater (effluent) and discharge from ponds associated with the extraction activities and crushing, grinding and separating activities. No additional discharge points are proposed for the modification, and all processing will be undertaken at the existing facility in the Stage 2 processing area, along with water quality management in the existing fines and settling ponds.

Uncontrolled discharges from the Stage 5A or Stage 5B extraction areas are unlikely as the proposed confinement bunds would provide protection of receiving waters by:

- Protecting interaction with external flood flows; and
- Providing storage (nominally 2m depth) within the basins to allow for local rainfall and variations in flow transfer to these ponds.

In the event of overtopping of the bunds in a large flood (>1% AEP), water quality of the dredge ponds unlikely to be significantly different to water quality within floodwaters themselves, additionally, significant dilution of dredge pond overflows would occur.

The current monitoring locations outlined in the EPL should be maintained. In addition, four new monitoring points, along with the new Stage 5A and 5B dredging ponds themselves should be added to the existing water quality monitoring program.

The new monitoring points are recommended to be located upstream and downstream of the extraction areas to allow for comparison. For Stage 5A, an upstream monitoring point should be positioned at the pond west of the Princess Highway and a downstream monitoring point positioned upstream of the Riverside Drive culvert crossing. Similarly, for the Stage 5B extraction area, water quality monitoring shall be undertaken at sites upstream, and downstream within the Minnamurra River. Refer to Figure 4.7 for locations of proposed water quality monitoring locations.

Monitoring at these four points, along with the Stage 5A and 5B dredging ponds themselves should be carried out in accordance with the current monitoring program.

Figure 4.7 Proposed water quality monitoring points upstream (U/S) and downstream (D/S) of Stage 5A and 5B extraction areas.

4.7. Rehabilitation

The 5A dredge pond will be filled once resource extraction is complete. Surface water protection bunds will be removed and surface levels restored to similar pre-extraction levels and revegetated.

The 5B dredge pond will be retained as an open water area. Flood protection bunds will be removed and the site revegetated. Water levels in the pond will be driven by groundwater andlocal catchment flows. The primary connection to the Minnamurra River will be in the north east corner of the pond, where the existing point is at about 2.1m AHD. When floodwaters exceed this level in the Minnamurra River (approximately 20% AEP event) backwater flows will enter the rehabilitated pond.

Rehabilitation plans for both dredge ponds will need to be prepared and should take into consideration surface flow movements after surface reshaping.

5.0 SUMMARY

The proposed modification will open up additional areas for resource extraction and make use of the existing processing and water management facilities located in Stage 2 of the approved operations. The following summary outlines the key surface water impacts, along with their mitigation and management measures.

5.1. Floodplain impacts

The proposed extraction areas are located on the local floodplains. The isolation of these areas from surface and flood flows by establishing bunds, removes storage from the floodplain. This removal is temporary. The impact of the loss of floodplain storage is not large, a maximum of about a 5cm increase in flood level across Riverside Drive for the 1% AEP event for the Stage 5A area and limited impacts are expected for the Stage 5B extraction area.

Armoured spillways are proposed for both Stage 5 extraction areas to allow for the potential inundation in large flood events and controlled inflow and outflow of floodwaters.

On completion of resource extraction, bunds shall be removed to reinstate floodplain storage. The Stage B dredge pond is likely to remain as open water.

5.2. Water quality

SWMPs will be required for the construction phase of both stages, for all components of infrastructure. Key aspects will be:

- Design of diversion drains for surface flow diversion; and
- Surface treatment of external bund batters to prevent erosion.

Bund and diversion drains will isolate the extraction areas from local surface flows and surrounding flood flows to reduce the possibility of uncontrolled discharges from the extraction areas.

The existing Stage 2 processing area will process all materials from Stage 5A and Stage 5B, with waste process water managed through the existing fines and settling ponds.

Additional water quality monitoring locations are to be established upstream and downstream of Stages 5A and 5B, as well as monitoring of the new dredging ponds themselves. Monitoring frequency and parameters shall be maintained as per the current approval.

The current licenced discharge points shall be maintained along with discharge pollutant limits. An increase to the salinity water quality objective from <1500µS/cm should be considered given the potential influence of saline groundwater on the Stage 5 dredge ponds.

The Stage 5B dredge pond will remain as open water once extraction is complete. With the bund removed, floodwaters from the Minnamurra River will interact with the pond at levels of around 2.1m AHD and higher. The location of the 5B pond in a backwater and flood storage area means that flood velocities will be low, and sediment resuspension unlikely given the depth and volume of the pond.

5.3. Water Use and Water balance

Water extracted from Stages 5A and 5B is to be measured, and the same volume returned to maintain the local water balance.

The additional extraction areas will require additional water, primarily for dust suppression over the additional exposed areas. Water exported from the site as moisture content in exported sand product may also increase, depending on export rates. Based on an average extraction of 450,000tpa and the additional dust suppression, total water use is 74ML/y (36ML/year as moisture content in exported material and 38ML/year for dust suppression). The current water access licence is for 65ML/y.

The current Water Access Licence will need to be increased to accommodate the expected annual extraction at the site.

5.4. Legislation

Relevant clauses from pertinent legislation are summarised in Table 5.1 Table 5.2 and Table 5.3 below.

Table 5.1 State Environmental Planning Policy 2018 (Coastal Management)

Relevant clauses	Key management and mitigation measures
Clause 11 (1) Development consent must not be granted unless the consent authority is satisfied that the proposed development will not significantly impact on: a) the biophysical, hydrological or ecological integrity of the adjacent coastal wetland, or b) the quantity and quality of surface and ground water flows to and from the adjacent coastal wetland. In order to not significantly impact the biophysical, hydrological or ecological integrity of the adjacent coastal wetland it is important to as much as possible maintain the existing runoff regime from the wetlands contributing catchment. Maintaining the existing runoff regime includes maintaining: • existing runoff flow paths and discharge points; and • runoff quality and quantity (a function of land use and imperviousness)	• The extraction areas are to be isolated from the local floodplain up to the 1% AEP flood level. Uncontrolled discharge from the extraction areas to adjacent wetland areas is unlikely. • The water balance within each proposed extraction area is to be maintained. Water extracted as part of the sand slurry transfer is to be measured and returned to limit modification to groundwater flows and levels. • Surface diversion drains are to be stable and well vegetated where slopes allow and existing discharge points to be maintained where possible. • Bund batter slopes shall be well vegetated to limit runoff and protect against erosion.

Table 5.2 Fisheries Management Act 1994 and Policy and guidelines for fish habitat conservation and management 2013

Relevant clauses	Key management and mitigation measures
Section 201 - permit to carry out works of dredging or reclamation (i.e. any excavation within, or filling or draining of, water land or the removal of woody debris, snags, rocks or freshwater native aquatic vegetation or the removal of any other material from water land that disturbs, moves or harms these in-stream habitats), Section 219 – permit to obstruct the free passage of fish. NSW DPI will generally require riparian buffer zones to be established and maintained for developments or activities in or adjacent to TYPE 1 or 2 habitats or CLASS 1-3 waterways	Although no permits are required for this modification, an assessment of extraction impacts and fish passage impacts are incorporated into this assessment. Extraction activities are undertaken beyond the recommended buffer distances (100m) for adjacent Type 1 habitats and Class 1 waterways. Obstruction of fish passage impacts associated with the transfer pipe have been assessed, and are negligible. Water quality during construction will be managed based on relevant sediment and erosion control guidelines. Operation water quality management will continue to be controlled through the operations EPL and consent conditions.

Table 5.3 Water Management Act 2000

Relevant section	Key management and mitigation measures
5. Water management principles (6) In relation to floodplain management: (a) floodplain management must avoid or minimise land degradation, including soil erosion, compaction, geomorphic instability, contamination, acidity, waterlogging, decline of native vegetation or, where appropriate, salinity and, where possible, land must be rehabilitated, and (b) the impacts of flood works on other water users should be avoided or minimised, and (c) the existing and future risk to human life and property arising from occupation of floodplains must be minimised. (7) In relation to controlled activities: (a) the carrying out of controlled activities must avoid or minimise land degradation, including soil erosion, compaction, geomorphic instability, contamination, acidity, waterlogging, decline of native vegetation or, where appropriate, salinity and, where possible, land must be rehabilitated, and (b) the impacts of the carrying out of controlled activities on other water users must be avoided or minimised.	• The extraction areas will require clearing of the floodplain during operation. For Stage 5A backfilling with VENM, and revegetation of the floodplain will be undertaken once resource extraction is complete. For 5B, bunds will be removed and an open water area retained. • Bunding of the extraction areas will temporarily remove some floodplain storage. The impact is small in a 1% AEP event. Bunding will be removed once resource extraction is complete and floodplain storage will be restored. • The existing and future risk to human life and property from the works on the floodplain is very low and temporary. • Temporary crossings of existing ponds and Rocklow Creek are required. These are to be undertaken in accordance with controlled activity guidelines: o *Guidelines for Controlled Activities on Waterfront Land - Riparian Corridors (NRAR, 2018)* o *Guidelines for Instream Works on Waterfront Land (DPI Water, 2012a)* o *Guidelines for Laying Pipes and Cables in Watercourses on Waterfront Land (DPI Water, 2012b)* • Soil and water management plans are to be prepared for all aspects of construction. • Rehabilitation of the floodplain will be undertaken on completion of the resource extraction.

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APPENDIX A – HYDROLOGIC AND HYDRAULIC MODEL ASSUMPTIONS

XP RAFTS was used to estimate peak flows from the unnamed watercourse to the west of Stage 5A. The following assumptions were used:

IFD and rainfall increments taken from the ARR data hub.

Losses based on ARR 2016; initial losses 61mm and continuing losses of 4.3mm/h.

Routing between catchment outlets based on average flow velocity of 1.5m/s.

Surface roughness of 0.04 for pervious areas and 0.014 for impervious areas.

Catchment details:

Catchment	Area (ha)	Slope %	% impervious
1	114.6	0.2	25.6
2	190.0	6	0.6
3	4.5	1	0.5
4	5.9	10	0.5

Hydraulic model summary

HEC-RAS 5.0.5 was used to model the 1% flood event at 5A to compare existing and post-development flood levels. Two upstream boundary conditions were used in the model, based on hydrographs from the RAFTS model at Catchment 1 and Catchment 3. The study area of the model extended from the western boundary of the Stage 1 ponds, to a downstream boundary between Riverside Drive and the railway embankment. On the downstream boundary, the 5% peak design ocean level was used to represent backwater flows. For the Minnamurra River, which has a Waterway Entrance Type C, the NSW OEH Floodplain Risk Management Guide 2015 recommends a peak design level at 2.35m AHD for the 5% AEP ocean event.

The invert levels of culverts beneath the Princes Highway, Riverside Drive and Fig Hill Lane were estimated, based on surrounding levels and Rocklow Creek water levels. Manning's n values of 0.08 for thick bush areas, 0.025 for pastures, 0.015 for ponds and 0.06 for remaining areas were used across the study area.

Surface terrain was modified to reflect the addition of the bunded areas and re-modelled.

APPENDIX K

TRAFFIC IMPACT ASSESSMENT REPORT

Dunmore Lakes Sand Project – MOD 2

Stage 5 – Traffic Impact Assessment

Prepared for:

Dunmore Sand & Soil Pty Ltd

9 April 2019

The Transport Planning Partnership

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Dunmore Lakes Sand Project – MOD 2

Stage 5 – Traffic Impact Assessment

Client: Dunmore Sand & Soil Pty Ltd

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1 Introduction

1.1 Background

Dunmore Sand and Soil Pty Ltd (DSS) operates an approved sand extraction facility near Dunmore in the Illawarra region of New South Wales. The facility is referred to hereafter as the 'Dunmore Lakes Sand Project' or the 'existing site'.

Stage 1 of the Dunmore Lakes Sand Project (the 'Approved Project') was issued development consent from the then Minister for Planning in 1999. Stage 1 was on Swamp Road, Dunmore, and encompassed sand extraction by dredging of up to 500,000 tonnes per annum (tpa) for a period of 10 years. The Stage 1 consent included conditions requiring the proponent to lodge a further application for the remaining identified Stages of the Dunmore sand resource (being Stages 2 to 4).

The application for Stages 2 to 4 was lodged in 2004, and development consent was received from the Minister for Planning in June 2005. The consent approves extraction of up to 800,000 tpa of sand for a period of 25 years. Boral Resources (NSW) Pty Ltd (hereafter 'Boral') purchased DSS, including the Dunmore Lakes Sand Project in mid 2005. The Stage 1 consent has since lapsed following successful extraction of the approved sand resource and rehabilitation of the site in 2010.

Stages 2 to 4 commenced dredging in June 2007. Since then, due to the high demand for sand in the Sydney market, the majority of sand in Stage 2 has been extracted with dredging recently moving into Stage 3.

Given recent high demand, the sand resource in Stage 3 is expected to be exhausted in approximately 3-5 months. The last extraction stage (Stage 4) encompasses an area containing the site's road access and private rail line and supporting infrastructure for the Stage 2 to 4 operations and Boral's adjacent Dunmore hard rock quarry. Given this, Stage 4 cannot be extracted until these activities are relocated. This has led DSS to investigate other local sources of sand to continue operations beyond Stage 3.

DSS has been investigating a fine sand resource on an adjoining private property to the south. Investigative drilling has confirmed that there is sufficient sand resource to support three to four more years of extraction from two areas (Stage 5A and 5B).

As such, DSS is seeking to modify the current Project Approval (DA 195-8-2004) under Section 75W of the *Environmental Planning and Assessment Act 1979* (EP&A Act), to provide for an additional extraction area (Stage 5) on adjoining private land, encompassing two separate extraction areas, Stage 5A and Stage 5B (hereafter referred to as the 'modification').

1.2 Purpose of this Report

As will be set out further in more detail in following sections of this report, the proposed modification to the approved development will seek approval to expand the extent of sand extraction into the area referred to as Stage 5.

With regard to traffic and transport aspects, the proposed modification associated with Stage 5 will not change the approved extraction and transportation of 800,000 tpa of sand from the existing processing facility.

As such the proposed modification will not alter the existing method of sand transportation from the site and delivery routes to market. That is, for sand extracted from the site the same mode of transport (road and rail), haulage routes and train / truck volumes to and from the site will remain unchanged.

Road haulage of sand product is currently via Tabbita Road and the interchange with the Princes Highway.

However, the proposed modification will involve the generation of additional heavy vehicles associated with the importation of up to 325,000 tpa of Virgin Excavated Natural Material (VENM) to the site.

The importation of VENM is required to:

- fill the Stage 5A extraction area to natural ground; and
- stabilise the edges of the Stage 5B dredge pond and the upper portions of the natural batters that form underwater, to allow safe access for vehicles, plant and equipment around the ponds perimeter.

Therefore, the purpose of this report is to assess the potential traffic implications associated with the importation of VENM to the Stage 5 area and identify any suitable infrastructure required to ameliorate traffic and safety impacts associated with the proposed modification.

In assessing the potential traffic implications of the proposed modification, consultation has been undertaken with NSW Roads and Maritime Services (RMS) and Shellharbour City Council. Feedback received from these agencies has been considered within this assessment report.

2 Overview of Proposed Modification

2.1 Site Location

The Dunmore Lakes Sand Project (the existing site) is near Dunmore, approximately 3 kilometres (km) south-south west of Shellharbour and 7 km north of Kiama, in the Illawarra region of New South Wales.

The existing site (Stages 2-4) is approximately 88 hectares (ha) and is immediately west of the Princes Highway near Tabbita Road, Dunmore. The site is within the Shellharbour Local Government Area (LGA).

The modification site (Stage 5) is located approximately 1.1 km south-south east of the existing site on the eastern side of the Princes Highway. The modification site is bound by Riverside Drive to the north and Princes Highway to the west. The location of Stage 5 relative to the sand processing plant (Stage 2) is shown in Figure 2.1.

2.2 Stage 5 Extraction Areas

The proposed modification seeks to establish additional extraction areas (Stage 5) on adjoining private property which is to be leased by DSS.

The Stage 5 extraction areas would be separated into two separate extraction areas, namely Stage 5A (immediately south of Riverside Drive), and Stage 5B (to the north of Minnamurra River). The approximate sand resource to be extracted from Stage 5A is estimated at 234,000 tonnes, whilst Stage 5B would extract approximately 1,123,000 tonnes.

The aforementioned quantities are the estimated sand resource only, and additional tonnage of soil material may also be extracted in addition to the sand resource.

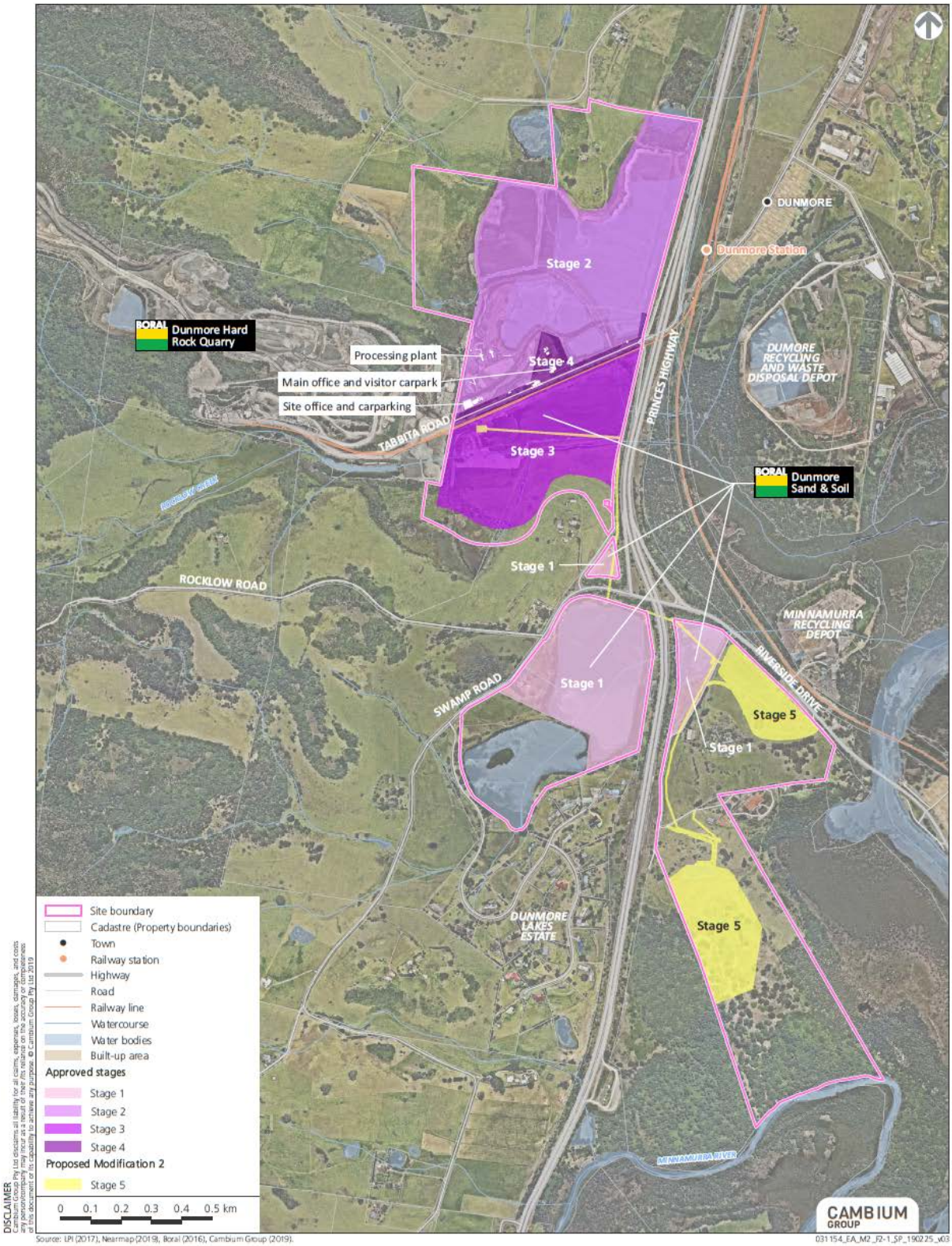
2.3 Stage 5 Sand Processing and Dispatch

The extraction of sand from Stage 5 would commence in Stage 5A and then once complete move onto Stage 5B.

The sand extracted from Stage 5A and Stage 5B would be transferred via overland pipelines from Stage 5 to the existing processing site (Stage 2). From the processing plant, product sand will be dispatched to markets via road or rail in accordance with the existing Approved Project.

For clarity, the proposed modification does not involve any changes to the approved processing and dispatch activities associated with product sand.

Figure 2.1: Site Location (Indicative Location of Stage 5)



Source: Dunmore Lakes Sand Extraction Project, Modification 2, Environmental Impact Assessment (prepared by Element Environment, February 2019)

2.4 Stage 5 Importation of VENM (Fill) Material

2.4.1 Overview

DSS propose to import up to 325,000 tonnes of Virgin Excavated Natural Material (VENM) by road per annum to the Stage 5 extraction area.

The VENM fill is required to:

- backfill the Stage 5A extraction area to natural ground level; and
- stabilise the edges of the Stage 5B dredge pond and the upper portions of the natural batters that form underwater, to allow safe access for vehicles, plant and equipment around the ponds perimeter.

VENM will be transported to the site by road truck / truck and dog and will be tipped directly into the pit(s) and spread with a dozer.

2.4.2 Vehicle Access to Stage 5

Fig Hill Lane provides the existing access to the Stage 5 extraction areas. As this existing access is considered to be too close to the Princes Highway / Riverside Drive intersection for the purpose of accommodating trucks delivering VENM to the site, a new access road is proposed to the Stage 5 extraction area off Riverside Drive, opposite Saltwater Creek Road (access to the Kiama Waste Recycling Depot).

The concept design for the proposed new vehicle access is shown in Appendix A. The new access would include the provision of a dedicated right turn lane from Riverside Drive into the site.

The new site access road would join to internal haul roads within the Stage 5 site.

All existing access arrangements for residents along Fig Hill Lane and Riverside Drive would be maintained during the Stage 5 operations.

2.4.3 VENM Haulage Routes

The importation of VENM to Stage 5A will be undertaken via prescribed haulage routes. It is proposed that all VENM haulage will occur to / from the Princes Highway via the interchange with Riverside Drive and the new site access at Riverside Drive.

While the exact source locations of VENM for Stage 5A are not yet known, it is likely that the majority of fill material will be sourced to the north of the site and thus approach the site in a south bound direction and utilise the Princes Highway off ramps at Riverside Drive.

Fill deliveries approaching Stage 5 from the south will travel north along the Princes Highway and utilise the Shellharbour Road interchange to turn around and head south to the site via the Riverside Drive interchange.

2.4.4 VENM Truck Volumes

Additional truck volumes generated by the importation of VENM to Stage 5A will not commence until the extraction of sand from Stage 5A has been completed. As such additional heavy vehicle traffic will not commence on Day 1 of Stage 5 operations.

The commencement of VENM importation will be dependent upon market conditions, namely the demand for sand products and the availability of VENM.

Once VENM importation commences the time taken to complete the filling and rehabilitation works will be dependent upon the ability to source appropriate quality and quantities of fill. Given existing market conditions, it is expected that the importation of VENM is likely to take several years to complete.

Notwithstanding the above, for the purpose of this assessment, it has been conservatively assumed that all VENM filling works will be completed within a 2 year period.

It is anticipated that the importation of VENM for the filling of Stage 5A will occur on a project by project basis with most project typically of a small scale, meaning that importation will not be constant. As such the importation of VENM will not occur every day of the site's operation with no vehicles generated in the period between projects.

Notwithstanding the above, the average, peak hour and maximum daily truck volumes expected to be generated by the importation of VENM to Stage 5A is set out in Table 2.1.

Should the period of filling be greater than 2 years, then the average daily and hourly truck volumes will be lower the shown in Table 2.1 and the number of days with no VENM trucks greater than expected for a 2 year fill scenario.

Table 2.1: Stage 5 VENM Importation – Estimated Truck Volumes (Fill within 2 Year)

	Volume / Tonnes
Total VENM Imported to Stage 5	325,000 tonnes
Average Truck Load	30 tonnes / truck
Total Trucks Importing VENM	10,833 trucks
VENM Haulage Weeks / Year	48 weeks
VENM Haulage Days / Week	5 days
VENM Haulage Hours / Day	9 hours
Average Truck Volumes	
Average Daily VENM Trucks	23 trucks / day (23 in + 23 out)
Average Hourly VENM Trucks	3 trucks / hour (3 in + 3 out)
Peak Truck Volumes	
Peak Hourly VENM Trucks	5 trucks / hour (5 in + 5 out)
Maximum Daily VENM Trucks [1.]	45 trucks / day (45 in + 45 out)

Notes: 1. Maximum Daily Trucks = Peak Hourly Volumes x No. of Daily Operating Hours (ie. 5 trucks x 9 hours)

3 Assessment of Proposed Modifications

3.1 Existing Traffic Conditions

3.1.1 Surrounding Road Network

The Stage 5 site is located with a vehicle accessible frontage to Riverside Drive. At the site, Riverside Drive provides a single travel lane in each direction with sealed road shoulders and a posted speed limit of 80km/hr.

Riverside Drive provides a north – south road connection between the Princes Highway and the localities of Minnamurra and Kiama Downs via the Princes Highway interchanges at Dunmore (north) and Bombo (south).

The Princes Highway / Riverside Drive interchange at Dunmore is serviced by north facing ramps which allow vehicles travelling south along the Princes Highway to exit onto Riverside Drive and vehicles travelling along Riverside Drive to enter (northbound) onto the Princes Highway.

The interchange to the north at Princes Highway / Shellharbour Road accommodates both northbound and southbound entry and exit movements at the Princes Highway.

3.1.2 Existing Road Network Traffic Flows

Observations undertaken by TTPP at various time of the day and week at the Princes Highway / Riverside Drive interchange at Dunmore, indicate that the interchange operates satisfactorily with no vehicle delays or congestions. Vehicle queuing for the entry to or from the Princes Highway were not observed to exceed a single vehicle.

A classified traffic count was undertaken along Riverside Drive at the existing Stage 5 site access driveway between 14 June 2018 and 21 June 2018. The results of the classified count are presented in Appendix B.

Based the classified traffic counts, Riverside Drive at the Stage 5 site access currently carries approximately 6,670 vehicles per weekday. The daily traffic flows are summarised in Table 3.1.

A summary of the hourly traffic flow profiles along Riverside Drive as surveyed is shown in Figure 3.1. The summary indicates a distinctive morning (AM) and afternoon (PM) peak period of 8am-9am and 4-5pm with westbound peak flows in the AM and eastbound flows peaking in the PM period.

The classified counts indicated that approximately 5-6% of vehicles travelling along Riverside Drive at the site are heavy vehicles.

Table 3.1: Riverside Drive Daily Traffic Flows (June 2018)

	Two Way	Eastbound	Westbound
Average Weekday (veh / day)	6,670	3,392	3,278
7 Day Average (veh / day)	6,349	3,227	3,122
85th Percentile Speed	85 km / hr	86 km / hr	87 km/ hr
% Heavy Vehicles	5.6%	5.4%	5.9%

3.2 Site Access Arrangements

Stage 5 is currently accessed via Fig Hill Lane. As shown in Figure 3.2, the existing driveway access (Fig Hill Lane) intersects with Riverside Drive some 40 metres to the east of the end of the merge lane from the Princes Highway exit ramp.

TTPP has considered the geometric implications of a proposed VEMN delivery truck standing in Riverside Drive waiting to turn right into the Stage 5 site at the existing access (Fig Hill Lane). It is considered that the location of the standing vehicle relative within the travel and the use of the shoulder for through traffic at the end of the merge lane would not provide a desirable outcome.

The alignment of Riverside Drive at the Fig Hill Lane driveway is slightly curved both horizontally and vertically driveway.

Given the alignment and proximity to the end of the merge lane, it is not considered practical to upgrade the existing site access to incorporate a designed right turn lane for VEMN trucks entering the site.

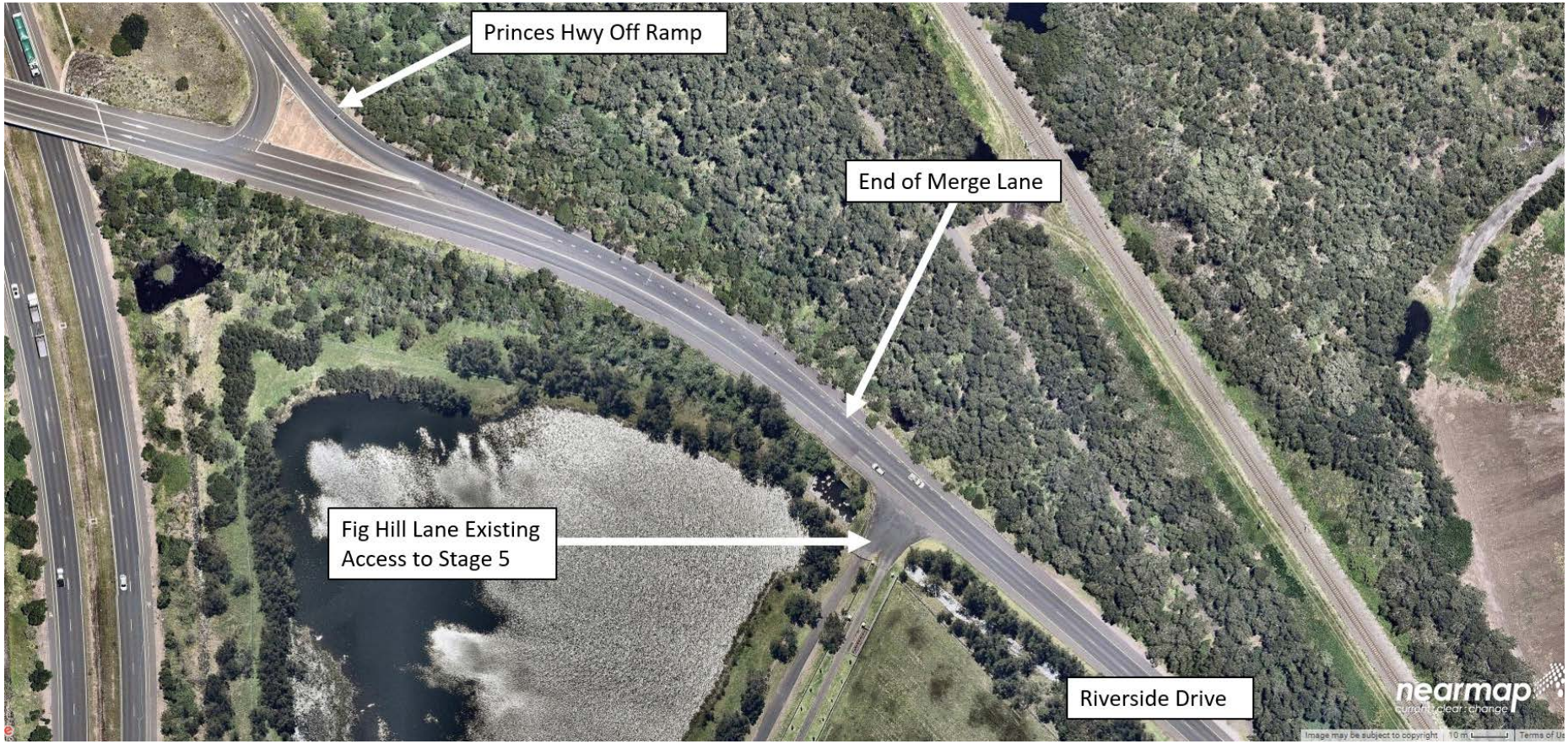
Thus it is proposed that a new vehicle access be constructed at the intersection of Riverside Drive and the entrance to the Kiama Waste Recycling Centre (see Figure 3.3). This new access would be utilised by all heavy vehicle movement entering and exiting the Stage 5 site. It is noted that the existing driveway at Fig Hill Lane will be retained for emergency and ad hoc access by light vehicles. Similarly access to the private driveway adjacent to Fig Hill Lane will be retained and provide unaffected access to Dunmore House.

The design concept is shown in Appendix A.

It is noted that the proposed site access arrangements would be temporary for the duration of Stage 5 works. The access would be removed upon completion of the Stage 5 works.

Figure 3.1: Riverside Drive Hourly Weekday Traffic Flows (vehicle / hour)
Count Location: East of Princes Highway Off Ramp

Figure 3.2: Existing Fig Hill Lane Access at Riverside Drive



Source: Nearmap (2019)

Figure 3.3: Location of Proposed Stage 5 Site Access

Source: Nearmap (2019)

The proposed access arrangement would facilitate a designated right turn lane form Riverside Drive into the site and would be located at a relatively flat grade with good sight lines for exiting vehicles to approaching vehicles.

3.3 Road Network Operation

3.3.1 Princes Highway

As outlined in Section 2 of this report, it is estimated that the proposed Stage 5 modification will generate a peak of 5 additional inbound and 5 outbound truck movements per hour associated with the importation of VENM to the Stage 5 site. If this peak hour volume was to be maintained over the whole day (ie. site's operating hours) then this would represent a maximum of 45 trucks per day.

The addition of 5 truck movements per hour to each the Princes Highway off ramp and on ramp at Riverside Drive will not generate a discernible adverse impact on the operation of the Princes Highway.

It is noted that sufficient sealed road shoulder is available for through traffic on Riverside Drive to proceed westbound unaffected should a truck / vehicle be required to stand awaiting to turn right onto the Princes Highway on ramp.

It is also noted that RMS correspondence requested a SIDRA analysis of the Princes Highway / Riverside Drive interchange operation with the proposed Stage 5 modification. However, given the low additional traffic flows associated with the proposed modification, existing good operation and adequate road geometry, it is not considered necessary to undertake detailed SIDRA modelling for Princes Highway intersections.

It is considered that the impacts of additional VENM trucks will be most noticeable at Riverside Drive / Site access intersection. A SIDRA analysis for this intersection has been undertaken as set out below.

In summary, the regional road network (ie. Princes Highway) can adequately accommodate an additional 10 vehicle movements per hour (5 in + 5 out) without the need for improvements. This would apply to existing and future (+10 year) scenarios.

3.3.2 Riverside Drive / Proposed Site Access Intersection

A SIDRA intersection modelling assessment has been undertaken for the proposed new site access at Riverside Drive.

As noted above, the importation of VENM will not commence until the completion of sand extraction from Stage 5A.

For the purpose of this assessment it is assumed that the importation of VENM will:

- occur over a 2 year period;
- commence in 2027 and be completed by 2028.

While the commencement year of 2027 is unrealistic with filling likely to commence much earlier, this commencement year has been used in the traffic assessment to consider the implications of VENM importation at a future time (+10 years) in line with the RMS comments received as part of the consultation process.

With regard to the +10 year scenario, the traffic assessment has, without the benefit of historical data, assumed a 2% per annum growth in background traffic flows along Riverside Drive.

In summary the SIDRA assessment has considered the following scenarios:

- Future (+10years) without Stage 5 modification works; and
- Future (+10 years) with Stage 5 modification works with an estimated peak of 5 truck in + 5 truck out per hour; and

SIDRA Intersection 8 modelling software has been used to analysis and ascertain the existing intersection capacity and operational performance of the Riverside Drive / Depot / Site Access intersection during the AM and PM peak hour periods of the surrounding road network. As such the analysis has assessed the scenario where the road network and site peaks occur simultaneously.

RMS uses the performance measure level of service (LoS) to define how efficient an intersection is operating under given prevailing traffic conditions.

Level of service is directly related to the delays experienced by traffic travelling through the intersection. Level of service ranges from LoS A to LoS F. LoS A indicates the intersection is operating with spare capacity, while LoS F indicates the intersection is operating above capacity. LoS D is the long term desirable level of service.

Table 3.2 shows the criteria that SIDRA Intersection adopts in assessing the level of service.

The existing operation of the surveyed intersections are presented in Table 3.3. Detailed SIDRA outputs are provided in Appendix C.

As shown in Table 3.3, the proposed site access intersection is expected to continue to operate satisfactorily with the proposed addition of the Stage 5 site access approach in the future (2028).

Table 3.2: RMS Level of Service Criteria

Level of Service (LoS)	Average Delay per vehicle (secs/veh)	Traffic Signals, Roundabout	Give Way & Stop Sign
A	Less than 14	Good operation	Good operation
B	15 to 28	Good with acceptable delays and spare capacity	Acceptable delays and spare capacity
C	29 to 42	Satisfactory	Satisfactory, but accident study required
D	43 to 56	Near capacity	Near capacity, accident study required
E	57 to 70	At capacity; at signals incidents will cause excessive delays. Roundabouts require other control mode	At capacity, requires other control mode
F	Greater than 70	Unsatisfactory, requires additional capacity	Unsatisfactory, requires other control mode or major treatment

Table 3.3: Proposed Site Access Operation (2028)

Scenario / Peak	Level of Service	Degree of Saturation	Average Delay Intersection (seconds / vehicle)	Average Delay Worst Movement (seconds / vehicle)	95% Queue (no. of Veh)
Without Stage 5 Modification					
AM Peak	B	0.27	0.3 sec / veh	22 sec	0.1
PM Peak	B	0.29	0.4 sec / veh	26 sec	0.1
With Stage 5 Modification Peak Operation (5 trucks in + 5 trucks out / hour)					
AM Peak	C	0.27	0.6 sec / veh	39 sec	0.2
PM Peak	D	0.29	0.7 sec / veh	49 secs	0.2

The proposed location of the Stage 5 site access will afford satisfactory sight distances for vehicles approaching the intersection on all approaches.

In particular the sight lines from the Stage 5 access to the east are in excess of 300 metres. Given the able sight distances it is considered that, like the Waste Depot access, a dedicated left turn acceleration lane for vehicles exiting the Stage 5 site to Riverside Drive is not required.

3.4 Crash Study

It is acknowledged that the SIDRA modelling results indicate that for one of the future peaks, the site access intersection at Riverside Drive will operate at a LoS D, albeit with low degrees of saturation (DoS - 0.29) and minimum queues.

Notwithstanding the above, RMS guidelines recommend that an accident study be undertaken were LoS D are expected.

RMS Crash Data was obtained for the period 2013 -2017 for Riverside Drive in the immediate vicinity of the proposed site access intersection (see Appendix D).

A review of the crash data indicates that there was one recorded crash for the period at the Riverside Drive / Fig Hill Lane intersection. This was a non-casualty rear end crash at the intersection. While one accident in 5 years is a low incident level, the one accident supports the proposed location of the site access away from Fig Hill Lane due to the potential for rear end crashes.

No accidents have been recorded at the proposed site access intersection, indicating that the satisfactory sight lines and intersection geometry available at this location assist in mitigating potential conflicts. The proposed site access arrangements would not adversely impact on these satisfactory sight lines and intersection geometry.

4 Conclusions

The traffic impact assessment of the proposed Stage 5 Modification (MOD 2) of the approved Dunmore Lakes Sand project has concluded that:

- There would be no alteration to the existing hours of operation associated with the addition of the Stage 5 extraction area.
- Similarly, the current output limit of sand product 800,000 tpa would continue following approval of the modification.
- The modification would not increase the current hourly or daily traffic volumes associated with dispatch of processed sand products given that the production limit of the Approved Project would not be altered.
- The proposed modification would introduce temporary additional heavy vehicle movements along the Princes Highway and Riverside Drive associated with importation of fill material to the Stage 5 extraction area.
- During peak periods of VENM importation to the Stage 5 site, it is estimated that an additional 10 trucks per hour (5 in + 5 out) would be generated.
- The generation of 10 additional truck movements can be adequately accommodated by the surrounding road network when considering future (+10 year) background traffic growth.
- A new vehicle access arrangement is proposed for Stage 5 to safely and efficiently accommodate VENM truck access to and from the Stage 5 site.

Appendix A

Proposed Site Access Concept Design (Riverside Drive)

REV.	DESCRIPTION	DRAWN	CHECK	APP'D	DATE
A	ISSUE FOR DISCUSSION	KM	JR	JR	10/05/18

The Transport Planning Partnership

Suite 402, 22 Atchison Street
St. Leonards NSW 2065
Tel: 02 8437 7800
Email: info@tpp.net.au

PROJECT: DUNMORE LAKES SAND QUARRY

TITLE: INTERSECTION CONCEPT DESIGN

DWG No.: FIGURE 1

DATE STAMP: 10 MAY 2018

PROJECT No.: 18117

SCALE: NTS

REV.: A

Filename: 18117CAD02-CONCEPT DESIGN-180511.dwg Date: 10 May 2018 By: Karl magistrado

Appendix B

Classified Traffic Count Results – Riverside Drive

TRANS TRAFFIC SURVEY
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Site Riverside Drive

Direction Westbound

Back to Site Summary Page

Day	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday	7 days		Weekday		Weekend	
Date	18/06/2018	19/06/2018	20/06/2018	14/06/2018	15/06/2018	16/06/2018	17/06/2018	Total	Average	Total	Average	Total	Average
AM Peak	07:00	07:00	07:00	08:00	07:00	09:00	10:00	N/A	08:00	N/A	07:00	N/A	10:00
PM Peak	13:00	16:00	15:00	15:00	15:00	12:00	12:00	N/A	15:00	N/A	15:00	N/A	12:00
00:00	2	2	2	3	5	12	15	41	6	14	3	27	14
01:00	3	2	1	8	4	8	5	31	4	18	4	13	7
02:00	2	4	3	5	5	5	8	32	5	19	4	13	7
03:00	10	13	8	9	11	10	6	67	10	51	10	16	8
04:00	49	37	45	41	41	30	17	260	37	213	43	47	24
05:00	111	123	119	120	120	41	29	663	95	593	119	70	35
06:00	227	218	249	256	218	74	50	1292	185	1168	234	124	62
07:00	401	435	413	398	388	138	72	2245	321	2035	407	210	105
08:00	374	395	393	415	376	267	121	2341	334	1953	391	388	194
09:00	231	257	250	256	289	294	263	1840	263	1283	257	557	279
10:00	187	209	220	209	230	294	299	1648	235	1055	211	593	297
11:00	178	181	192	211	201	280	240	1483	212	963	193	520	260
12:00	166	161	177	199	191	266	238	1398	200	894	179	504	252
13:00	185	161	178	170	202	238	191	1325	189	896	179	429	215
14:00	185	175	201	195	197	203	201	1357	194	953	191	404	202
15:00	182	185	233	214	241	207	160	1422	203	1055	211	367	184
16:00	167	219	181	206	193	210	173	1349	193	966	193	383	192
17:00	146	161	189	202	176	161	125	1160	166	874	175	286	143
18:00	97	102	116	112	132	87	83	729	104	559	112	170	85
19:00	60	54	70	71	59	66	49	429	61	314	63	115	58
20:00	42	31	30	60	39	35	36	273	39	202	40	71	36
21:00	20	29	30	47	35	34	51	246	35	161	32	85	43
22:00	12	10	17	19	26	48	16	148	21	84	17	64	32
23:00	11	4	11	9	14	17	6	72	10	49	10	23	12
Total	3048	3168	3328	3435	3393	3025	2454	21851	3122	16372	3278	5479	2746
% Heavy	7.41%	6.94%	6.16%	5.65%	6.07%	4.50%	3.75%	5.85%		6.42%		4.16%	

TRANS TRAFFIC SURVEY
trafficsurvey.com.au

Site Riverside Drive

Direction Eastbound

Back to Site Summary Page

Day	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday	7 days		Weekday		Weekend	
Date	18/06/2018	19/06/2018	20/06/2018	14/06/2018	15/06/2018	16/06/2018	17/06/2018	Total	Average	Total	Average	Total	Average
AM Peak	10:00	11:00	10:00	11:00	11:00	11:00	11:00	N/A	11:00	N/A	11:00	N/A	11:00
PM Peak	16:00	17:00	16:00	17:00	16:00	12:00	14:00	N/A	16:00	N/A	17:00	N/A	13:00
00:00	10	20	15	26	15	36	33	155	22	86	17	69	35
01:00	2	13	9	14	15	14	12	79	11	53	11	26	13
02:00	7	6	7	3	2	10	11	46	7	25	5	21	11
03:00	7	7	8	8	7	3	5	45	6	37	7	8	4
04:00	7	6	5	8	8	10	9	53	8	34	7	19	10
05:00	22	24	27	32	31	14	10	160	23	136	27	24	12
06:00	53	54	64	81	61	45	31	389	56	313	63	76	38
07:00	98	105	114	119	118	74	38	666	95	554	111	112	56
08:00	140	155	156	155	168	105	57	936	134	774	155	162	81
09:00	137	168	166	156	177	142	98	1044	149	804	161	240	120
10:00	168	128	182	167	172	218	155	1190	170	817	163	373	187
11:00	168	189	172	188	215	283	241	1456	208	932	186	524	262
12:00	191	195	198	217	200	289	231	1521	217	1001	200	520	260
13:00	198	233	211	175	239	273	256	1585	226	1056	211	529	265
14:00	260	252	251	271	277	249	272	1832	262	1311	262	521	261
15:00	350	358	420	386	411	284	233	2442	349	1925	385	517	259
16:00	428	367	424	428	415	276	251	2589	370	2062	412	527	264
17:00	416	435	388	452	403	208	208	2510	359	2094	419	416	208
18:00	181	218	234	232	216	156	145	1382	197	1081	216	301	151
19:00	114	117	126	147	110	116	79	809	116	614	123	195	98
20:00	81	88	110	103	99	83	58	622	89	481	96	141	71
21:00	61	72	95	98	69	67	46	508	73	395	79	113	57
22:00	37	27	38	56	64	93	34	349	50	222	44	127	64
23:00	33	33	18	26	52	36	10	208	30	162	32	46	23
Total	3169	3270	3438	3548	3544	3084	2523	22576	3227	16969	3392	5607	2810
% Heavy	6.18%	5.47%	5.99%	5.95%	5.70%	3.66%	3.92%	5.34%		5.86%		3.78%	

TRANS TRAFFIC SURVEY
trafficsurvey.com.au

Site Riverside Drive

Direction Combined

Back to Site Summary Page

Day	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday	7 days		Weekday		Weekend	
Date	18/06/2018	19/06/2018	20/06/2018	14/06/2018	15/06/2018	16/06/2018	17/06/2018	Total	Average	Total	Average	Total	Average
AM Peak	08:00	08:00	08:00	08:00	08:00	11:00	11:00	N/A	08:00	N/A	08:00	N/A	11:00
PM Peak	16:00	17:00	15:00	17:00	15:00	12:00	14:00	N/A	16:00	N/A	16:00	N/A	12:00
00:00	12	22	17	29	20	48	48	196	28	100	20	96	48
01:00	5	15	10	22	19	22	17	110	16	71	14	39	20
02:00	9	10	10	8	7	15	19	78	11	44	9	34	17
03:00	17	20	16	17	18	13	11	112	16	88	18	24	12
04:00	56	43	50	49	49	40	26	313	45	247	49	66	33
05:00	133	147	146	152	151	55	39	823	118	729	146	94	47
06:00	280	272	313	337	279	119	81	1681	240	1481	296	200	100
07:00	499	540	527	517	506	212	110	2911	416	2589	518	322	161
08:00	514	550	549	570	544	372	178	3277	468	2727	545	550	275
09:00	368	425	416	412	466	436	361	2884	412	2087	417	797	399
10:00	355	337	402	376	402	512	454	2838	405	1872	374	966	483
11:00	346	370	364	399	416	563	481	2939	420	1895	379	1044	522
12:00	357	356	375	416	391	555	469	2919	417	1895	379	1024	512
13:00	383	394	389	345	441	511	447	2910	416	1952	390	958	479
14:00	445	427	452	466	474	452	473	3189	456	2264	453	925	463
15:00	532	543	653	600	652	491	393	3864	552	2980	596	884	442
16:00	595	586	605	634	608	486	424	3938	563	3028	606	910	455
17:00	562	596	577	654	579	369	333	3670	524	2968	594	702	351
18:00	278	320	350	344	348	243	228	2111	302	1640	328	471	236
19:00	174	171	196	218	169	182	128	1238	177	928	186	310	155
20:00	123	119	140	163	138	118	94	895	128	683	137	212	106
21:00	81	101	125	145	104	101	97	754	108	556	111	198	99
22:00	49	37	55	75	90	141	50	497	71	306	61	191	96
23:00	44	37	29	35	66	53	16	280	40	211	42	69	35
Total	6217	6438	6766	6983	6937	6109	4977	44427	6349	33341	6668	11086	5546
% Heavy	6.79%	6.20%	6.07%	5.80%	5.88%	4.08%	3.84%	5.59%		6.13%		3.97%	

Appendix C

SIDRA Model Outputs

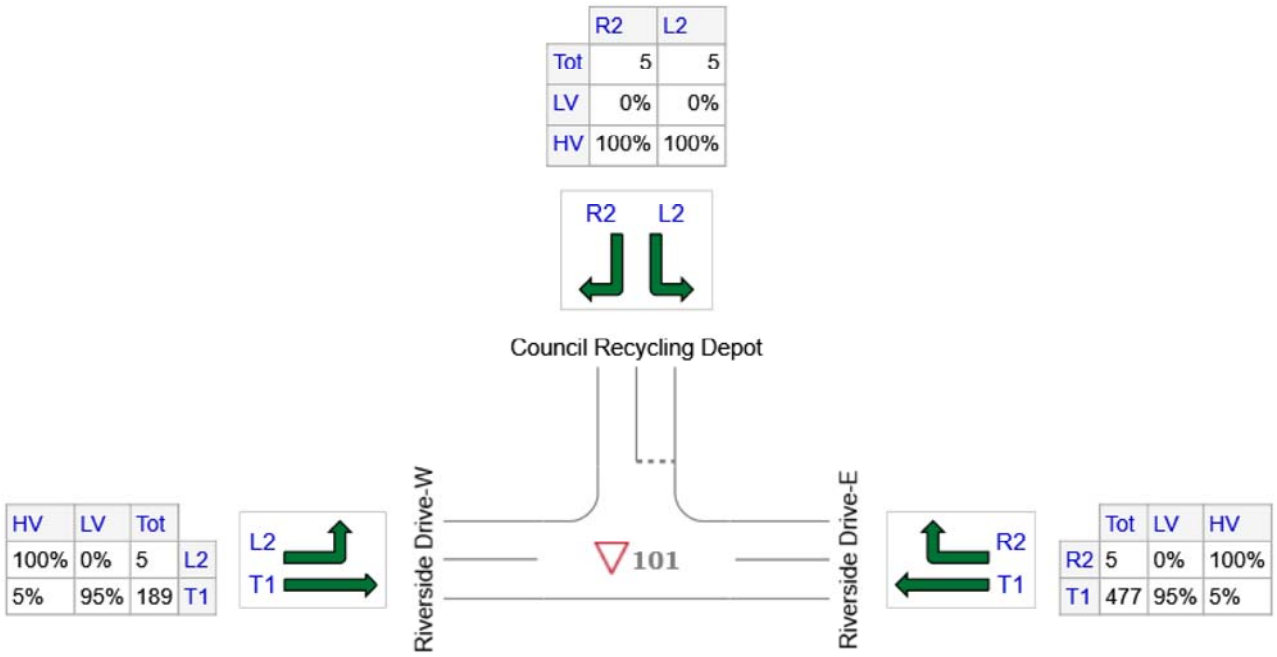
INPUT VOLUMES

Vehicles and pedestrians per 60 minutes

Site: 101 [AM Riverside Dr West Fig Tree Ln Base Case]

18117 Dunmore Lakes Sand Quarry MOD 2
2028 Base Case
Site Category: 2018+10years (2028) Base
Giveway / Yield (Two-Way)

Volume Display Method: Total and %



	All MCs	Light Vehicles (LV)	Heavy Vehicles (HV)
E: Riverside Drive-E	482	453	29
N: Council Recycling Depot	10	0	10
W: Riverside Drive-W	194	180	14
Total	686	633	53

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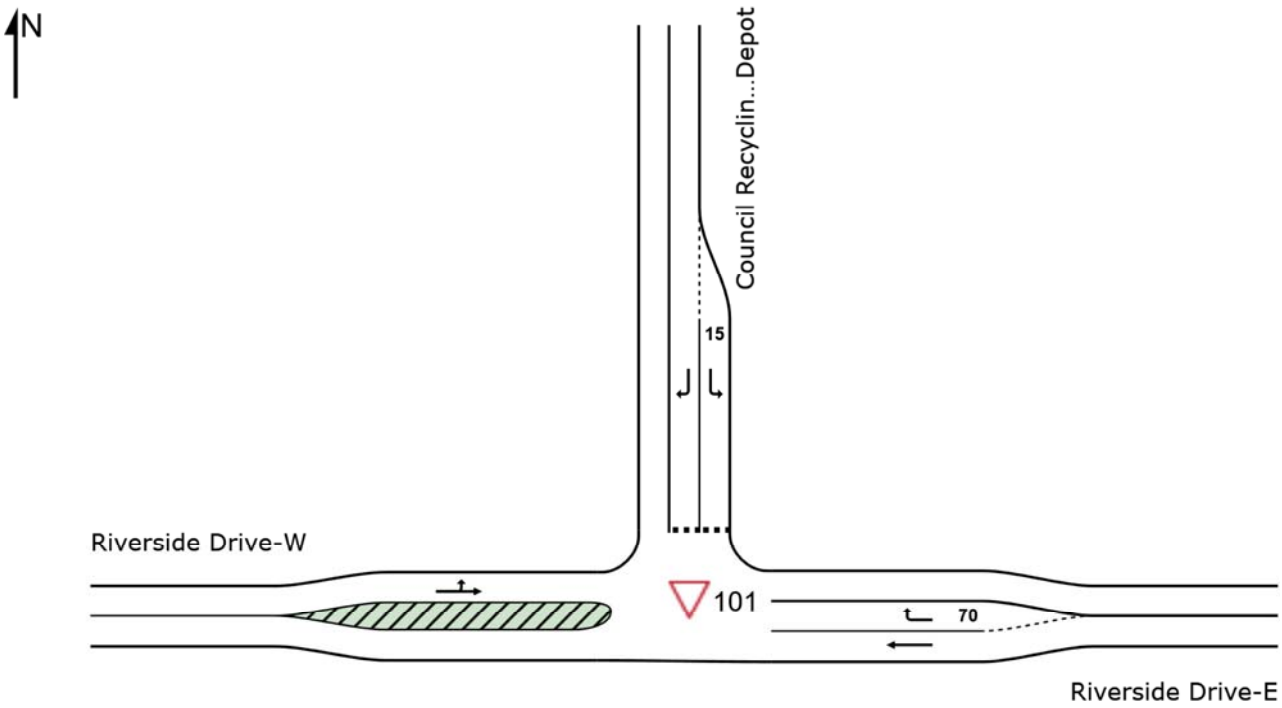
SITE LAYOUT

Site: 101 [AM Riverside Dr West Fig Tree Ln Base Case]

18117 Dunmore Lakes Sand Quarry MOD 2
2028 Base Case
Site Category: 2018+10years (2028) Base
Giveway / Yield (Two-Way)



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Organisation: TTPP - THE TRANSPORT PLANNING PARTNERSHIP | Created: Monday, 18 February 2019 4:07:09 PM
Project: \\TTPPSRV\Projects\18117 Dunmore Lakes Sand Quarry MOD 2\07 Modelling Files\190124_Results 3 HV Case\18117_2018 +10 year case_ Riverside Dr West Fig Tree Ln.sip8

MOVEMENT SUMMARY

Site: 101 [AM Riverside Dr West Fig Tree Ln Base Case]

18117 Dunmore Lakes Sand Quarry MOD 2
2028 Base Case
Site Category: 2018+10years (2028) Base
Giveway / Yield (Two-Way)

Movement Performance - Vehicles												
Mov ID	Turn	Demand Flows Total veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	Distance m	Prop. Queued	Effective Stop Rate	Aver. No. Cycles	Average Speed km/h
East: Riverside Drive-E												
22	T1	502	5.0	0.266	0.0	LOS A	0.0	0.0	0.00	0.00	0.00	79.9
23	R2	5	100.0	0.006	9.2	LOS A	0.0	0.3	0.38	0.58	0.38	47.5
Approach		507	6.0	0.266	0.1	NA	0.0	0.3	0.00	0.01	0.00	79.3
North: Council Recycling Depot												
24	L2	5	100.0	0.006	5.1	LOS A	0.0	0.3	0.35	0.47	0.35	39.9
26	R2	5	100.0	0.029	21.7	LOS B	0.1	1.2	0.78	0.89	0.78	33.4
Approach		11	100.0	0.029	13.4	LOS A	0.1	1.2	0.56	0.68	0.56	36.4
West: Riverside Drive-W												
27	L2	5	100.0	0.110	7.9	LOS A	0.0	0.0	0.00	0.03	0.00	57.2
28	T1	199	5.0	0.110	0.0	LOS A	0.0	0.0	0.00	0.03	0.00	79.6
Approach		204	7.4	0.110	0.4	NA	0.0	0.0	0.00	0.03	0.00	78.8
All Vehicles		722	7.8	0.266	0.3	NA	0.1	1.2	0.01	0.02	0.01	77.9

Site Level of Service (LOS) Method: Delay (RTA NSW). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
Vehicle movement LOS values are based on average delay per movement.
Minor Road Approach LOS values are based on average delay for all vehicle movements.
NA: Intersection LOS and Major Road Approach LOS values are Not Applicable for two-way sign control since the average delay is not a good LOS measure due to zero delays associated with major road movements.
SIDRA Standard Delay Model is used. Control Delay includes Geometric Delay.
Gap-Acceptance Capacity: SIDRA Standard (Akçelik M3D).
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.

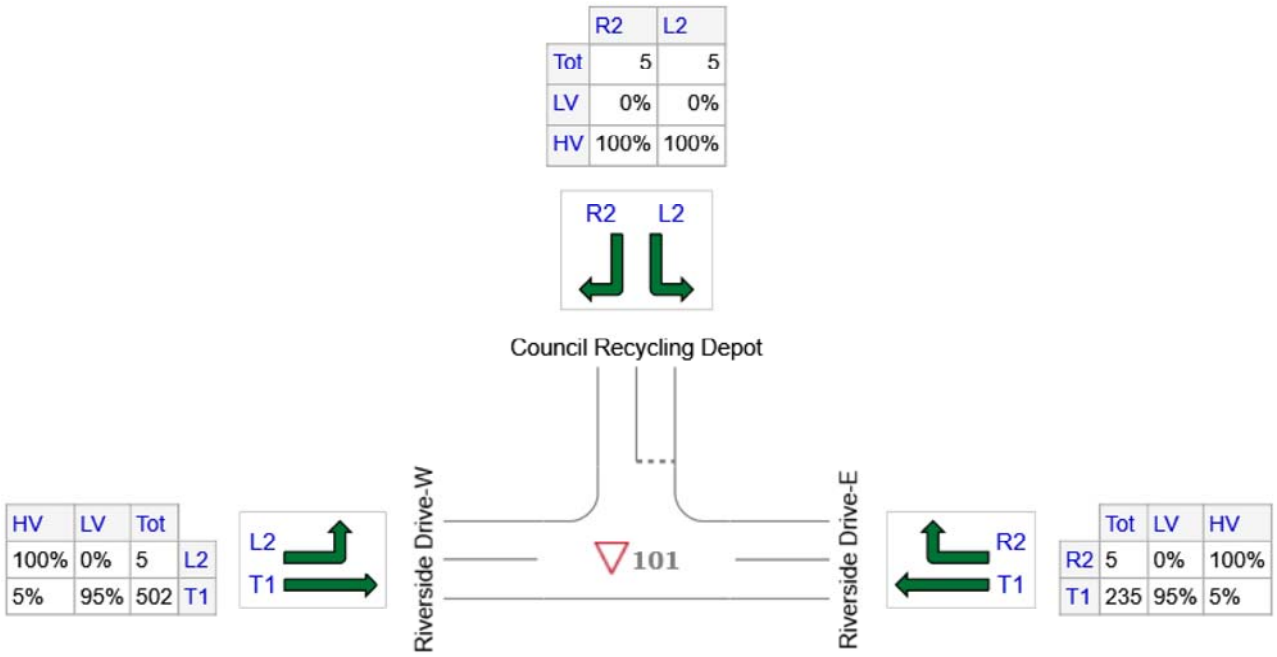
INPUT VOLUMES

Vehicles and pedestrians per 60 minutes

Site: 101 [PM Riverside Dr West Fig Tree Ln Base Case]

18117 Dunmore Lakes Sand Quarry MOD 2
2028 Base Case
Site Category: 2018+10years (2028) Base
Giveway / Yield (Two-Way)

Volume Display Method: Total and %



	All MCs	Light Vehicles (LV)	Heavy Vehicles (HV)
E: Riverside Drive-E	240	223	17
N: Council Recycling Depot	10	0	10
W: Riverside Drive-W	507	477	30
Total	757	700	57

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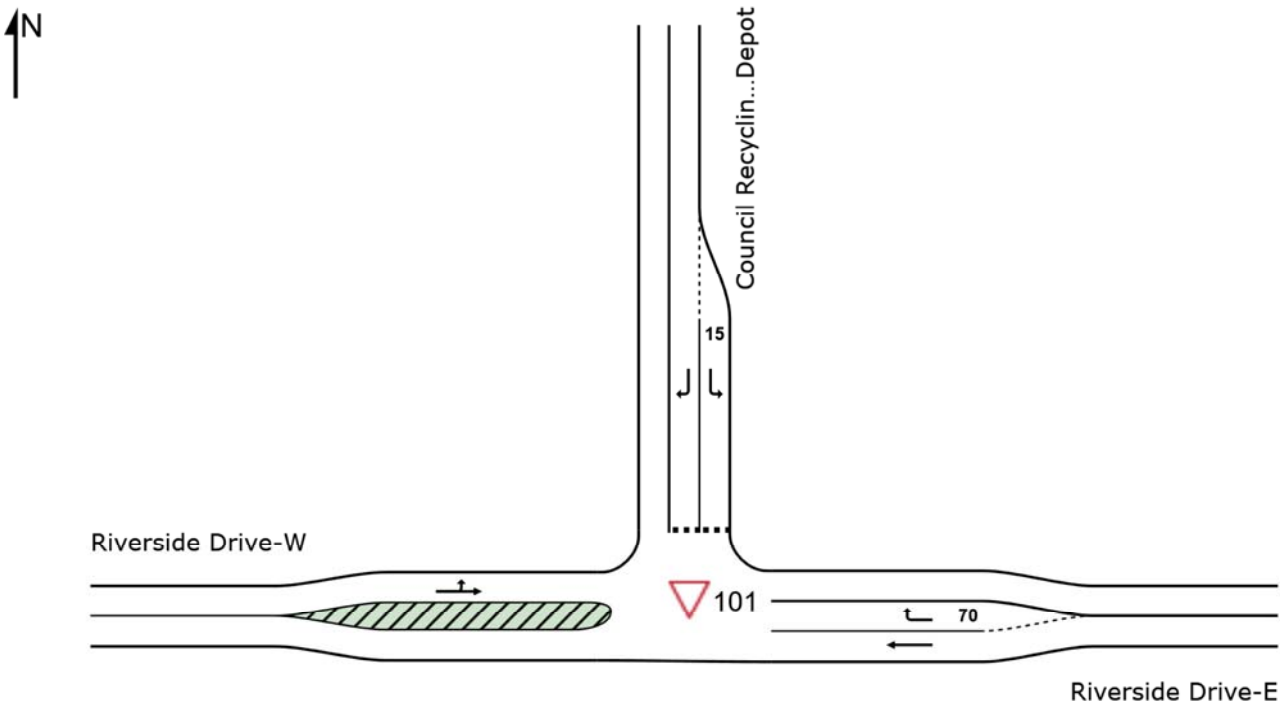
SITE LAYOUT

Site: 101 [PM Riverside Dr West Fig Tree Ln Base Case]

18117 Dunmore Lakes Sand Quarry MOD 2
2028 Base Case
Site Category: 2018+10years (2028) Base
Giveway / Yield (Two-Way)



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Organisation: TTPP - THE TRANSPORT PLANNING PARTNERSHIP | Created: Monday, 18 February 2019 4:07:21 PM
Project: \\TTPPSRV\Projects\18117 Dunmore Lakes Sand Quarry MOD 2\07 Modelling Files\190124_Results 3 HV Case\18117_2018 +10 year case_ Riverside Dr West Fig Tree Ln.sip8

MOVEMENT SUMMARY

Site: 101 [PM Riverside Dr West Fig Tree Ln Base Case]

18117 Dunmore Lakes Sand Quarry MOD 2
2028 Base Case
Site Category: 2018+10years (2028) Base
Giveway / Yield (Two-Way)

Movement Performance - Vehicles												
Mov ID	Turn	Demand Flows Total veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	Distance m	Prop. Queued	Effective Stop Rate	Aver. No. Cycles	Average Speed km/h
East: Riverside Drive-E												
22	T1	247	5.0	0.131	0.0	LOS A	0.0	0.0	0.00	0.00	0.00	80.0
23	R2	5	100.0	0.011	13.4	LOS A	0.0	0.5	0.61	0.72	0.61	45.1
Approach		253	7.0	0.131	0.3	NA	0.0	0.5	0.01	0.01	0.01	78.7
North: Council Recycling Depot												
24	L2	5	100.0	0.011	9.2	LOS A	0.0	0.5	0.58	0.64	0.58	38.2
26	R2	5	100.0	0.035	26.0	LOS B	0.1	1.5	0.82	0.91	0.82	32.1
Approach		11	100.0	0.035	17.6	LOS B	0.1	1.5	0.70	0.77	0.70	34.9
West: Riverside Drive-W												
27	L2	5	100.0	0.285	7.9	LOS A	0.0	0.0	0.00	0.01	0.00	57.2
28	T1	528	5.0	0.285	0.0	LOS A	0.0	0.0	0.00	0.01	0.00	79.8
Approach		534	5.9	0.285	0.2	NA	0.0	0.0	0.00	0.01	0.00	79.4
All Vehicles		797	7.5	0.285	0.4	NA	0.1	1.5	0.01	0.02	0.01	77.9

Site Level of Service (LOS) Method: Delay (RTA NSW). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
Vehicle movement LOS values are based on average delay per movement.
Minor Road Approach LOS values are based on average delay for all vehicle movements.
NA: Intersection LOS and Major Road Approach LOS values are Not Applicable for two-way sign control since the average delay is not a good LOS measure due to zero delays associated with major road movements.
SIDRA Standard Delay Model is used. Control Delay includes Geometric Delay.
Gap-Acceptance Capacity: SIDRA Standard (Akçelik M3D).
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.

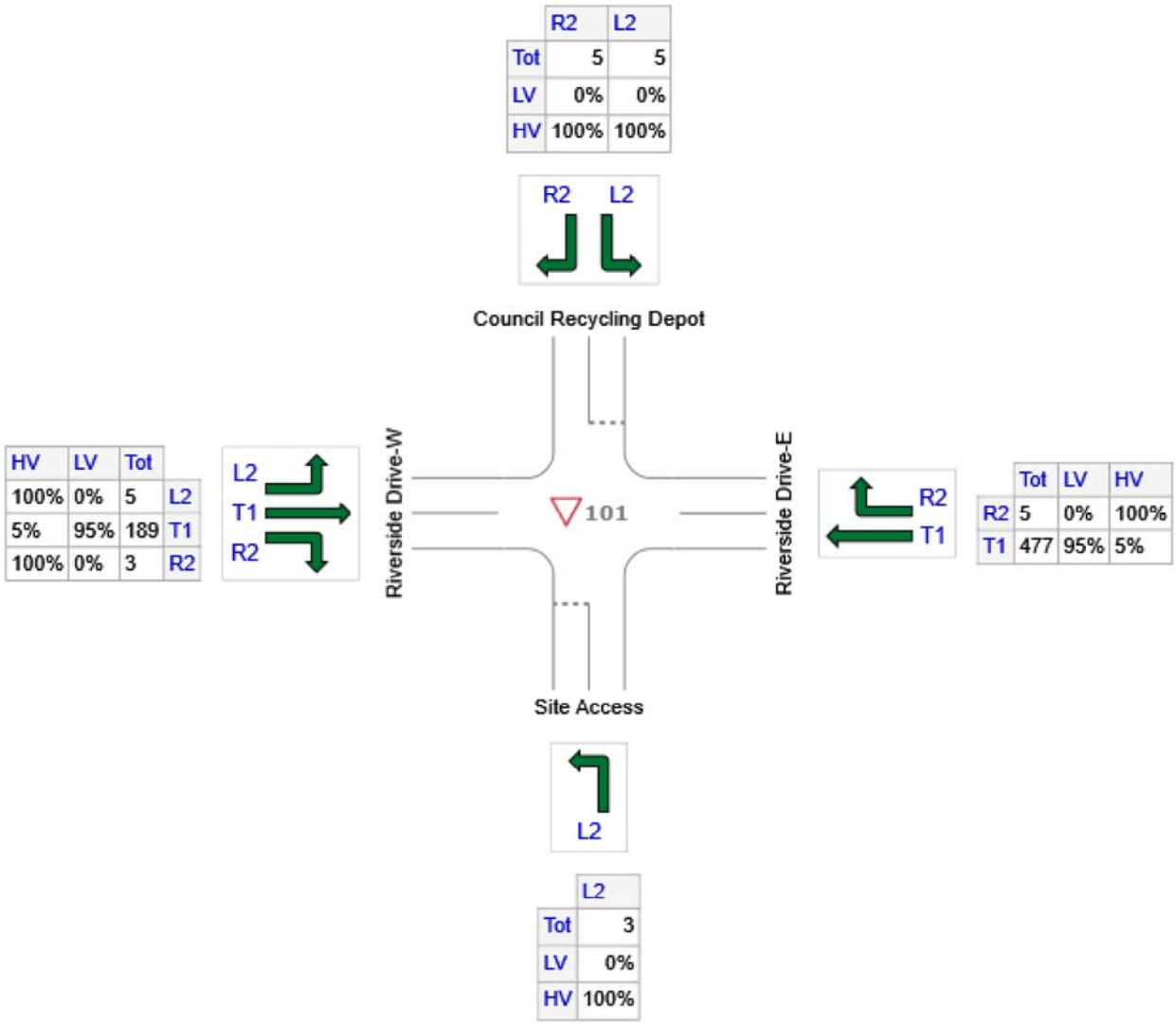
INPUT VOLUMES

Vehicles and pedestrians per 60 minutes

Site: 101 [AM Riverside Dr West Fig Tree Ln]

18117 Dunmore Lakes Sand Quarry MOD 2
2028 3HV Case
Site Category: 2018+10years (2028) 3HV Case
Giveway / Yield (Two-Way)

Volume Display Method: Total and %



	All MCs	Light Vehicles (LV)	Heavy Vehicles (HV)
S: Site Access	3	0	3
E: Riverside Drive-E	482	453	29
N: Council Recycling Depot	10	0	10
W: Riverside Drive-W	197	180	17
Total	692	633	59

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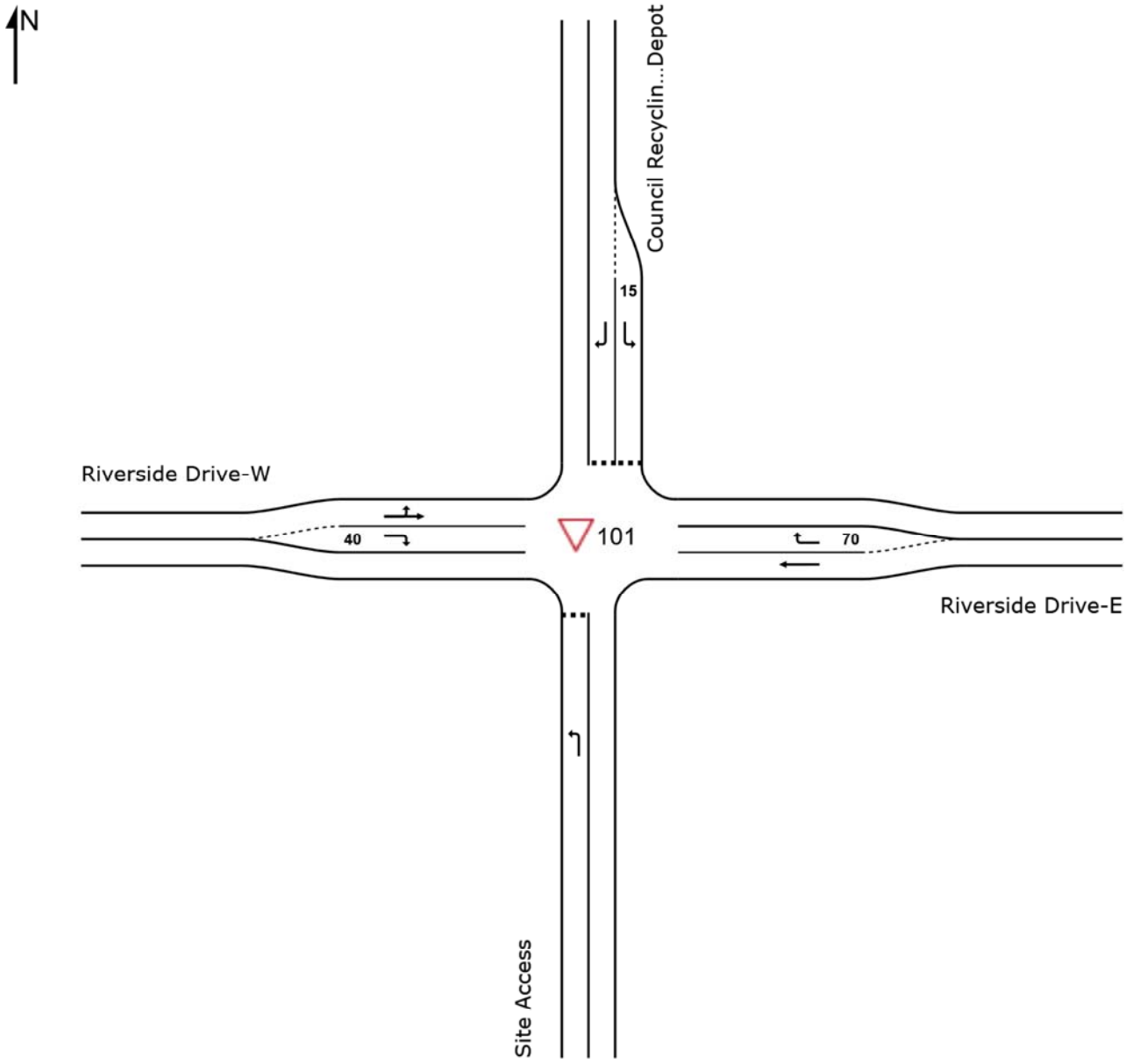
SITE LAYOUT

Site: 101 [AM Riverside Dr West Fig Tree Ln]

18117 Dunmore Lakes Sand Quarry MOD 2
2028 3HV Case
Site Category: 2018+10years (2028) 3HV Case
Giveway / Yield (Two-Way)



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MOVEMENT SUMMARY

Site: 101 [AM Riverside Dr West Fig Tree Ln]

18117 Dunmore Lakes Sand Quarry MOD 2
2028 3HV Case
Site Category: 2018+10years (2028) 3HV Case
Giveway / Yield (Two-Way)

Movement Performance - Vehicles

Mov ID	Turn	Demand Flows Total veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	Distance m	Prop. Queued	Effective Stop Rate	Aver. No. Cycles	Average Speed km/h
South: Site Access												
30	L2	3	100.0	0.009	10.4	LOS A	0.0	0.4	0.59	0.65	0.59	37.7
Approach		3	100.0	0.009	10.4	LOS A	0.0	0.4	0.59	0.65	0.59	37.7
East: Riverside Drive-E												
22	T1	502	5.0	0.266	0.0	LOS A	0.0	0.0	0.00	0.00	0.00	79.9
23	R2	5	100.0	0.006	9.2	LOS A	0.0	0.3	0.38	0.58	0.38	47.5
Approach		507	6.0	0.266	0.1	NA	0.0	0.3	0.00	0.01	0.00	79.3
North: Council Recycling Depot												
24	L2	5	100.0	0.008	5.5	LOS A	0.0	0.4	0.35	0.48	0.35	39.7
26	R2	5	100.0	0.052	37.9	LOS C	0.2	2.1	0.85	0.92	0.85	29.2
Approach		11	100.0	0.052	21.7	LOS B	0.2	2.1	0.60	0.70	0.60	33.7
West: Riverside Drive-W												
27	L2	5	100.0	0.110	7.9	LOS A	0.0	0.0	0.00	0.03	0.00	57.2
28	T1	199	5.0	0.110	0.0	LOS A	0.0	0.0	0.00	0.03	0.00	79.6
29	R2	3	100.0	0.006	12.5	LOS A	0.0	0.3	0.59	0.68	0.59	45.2
Approach		207	8.9	0.110	0.6	NA	0.0	0.3	0.01	0.04	0.01	78.0
All Vehicles		728	8.6	0.266	0.6	NA	0.2	2.1	0.02	0.03	0.02	77.1

Site Level of Service (LOS) Method: Delay (RTA NSW). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
Vehicle movement LOS values are based on average delay per movement.
Minor Road Approach LOS values are based on average delay for all vehicle movements.
NA: Intersection LOS and Major Road Approach LOS values are Not Applicable for two-way sign control since the average delay is not a good LOS measure due to zero delays associated with major road movements.
SIDRA Standard Delay Model is used. Control Delay includes Geometric Delay.
Gap-Acceptance Capacity: SIDRA Standard (Akçelik M3D).
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.

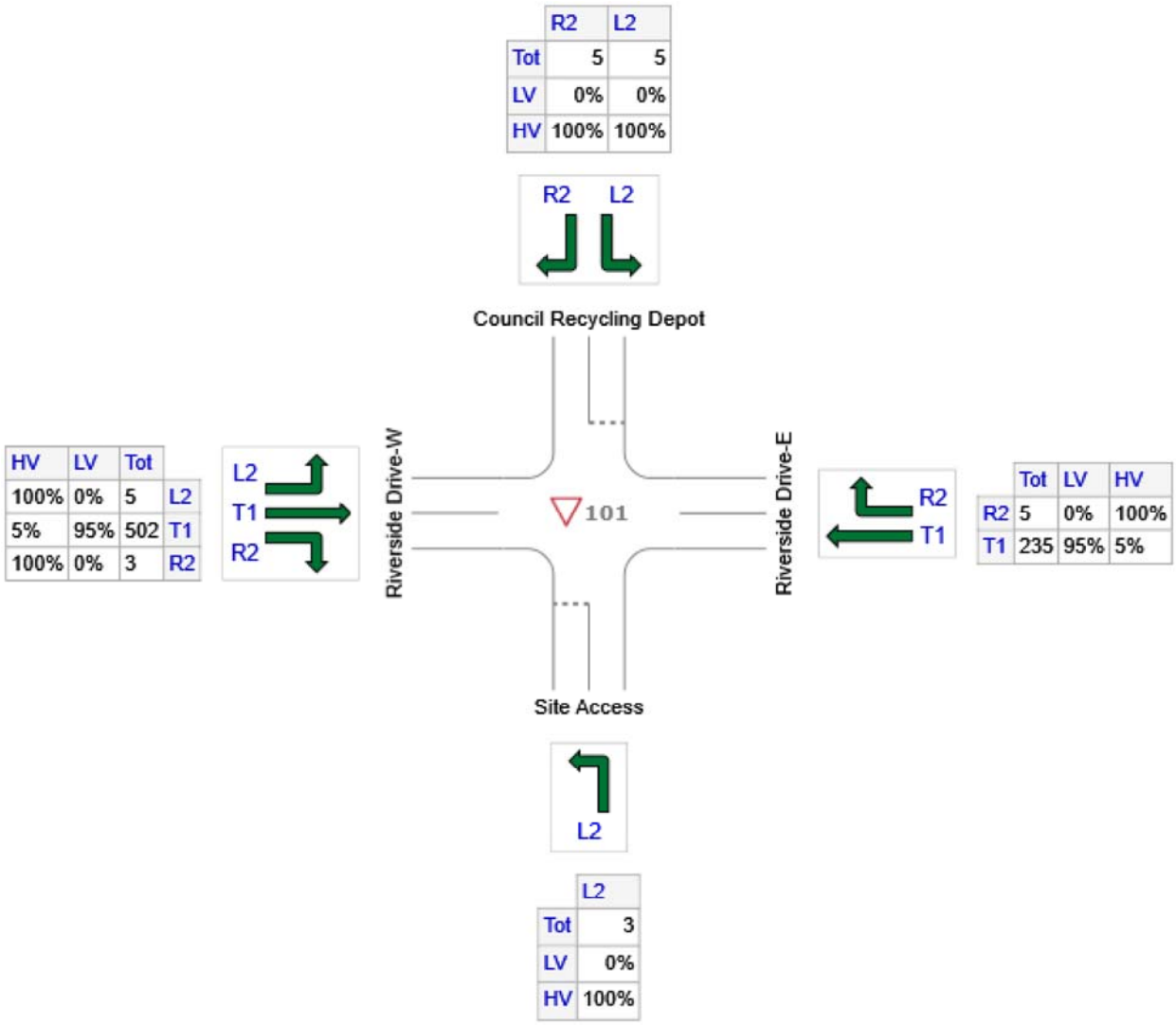
INPUT VOLUMES

Vehicles and pedestrians per 60 minutes

Site: 101 [PM Riverside Dr West Fig Tree Ln]

18117 Dunmore Lakes Sand Quarry MOD 2
2028 3 HV Case
Site Category: 2018+10years (2028) 3HV Case
Giveway / Yield (Two-Way)

Volume Display Method: Total and %



	All MCs	Light Vehicles (LV)	Heavy Vehicles (HV)
S: Site Access	3	0	3
E: Riverside Drive-E	240	223	17
N: Council Recycling Depot	10	0	10
W: Riverside Drive-W	510	477	33
Total	763	700	63

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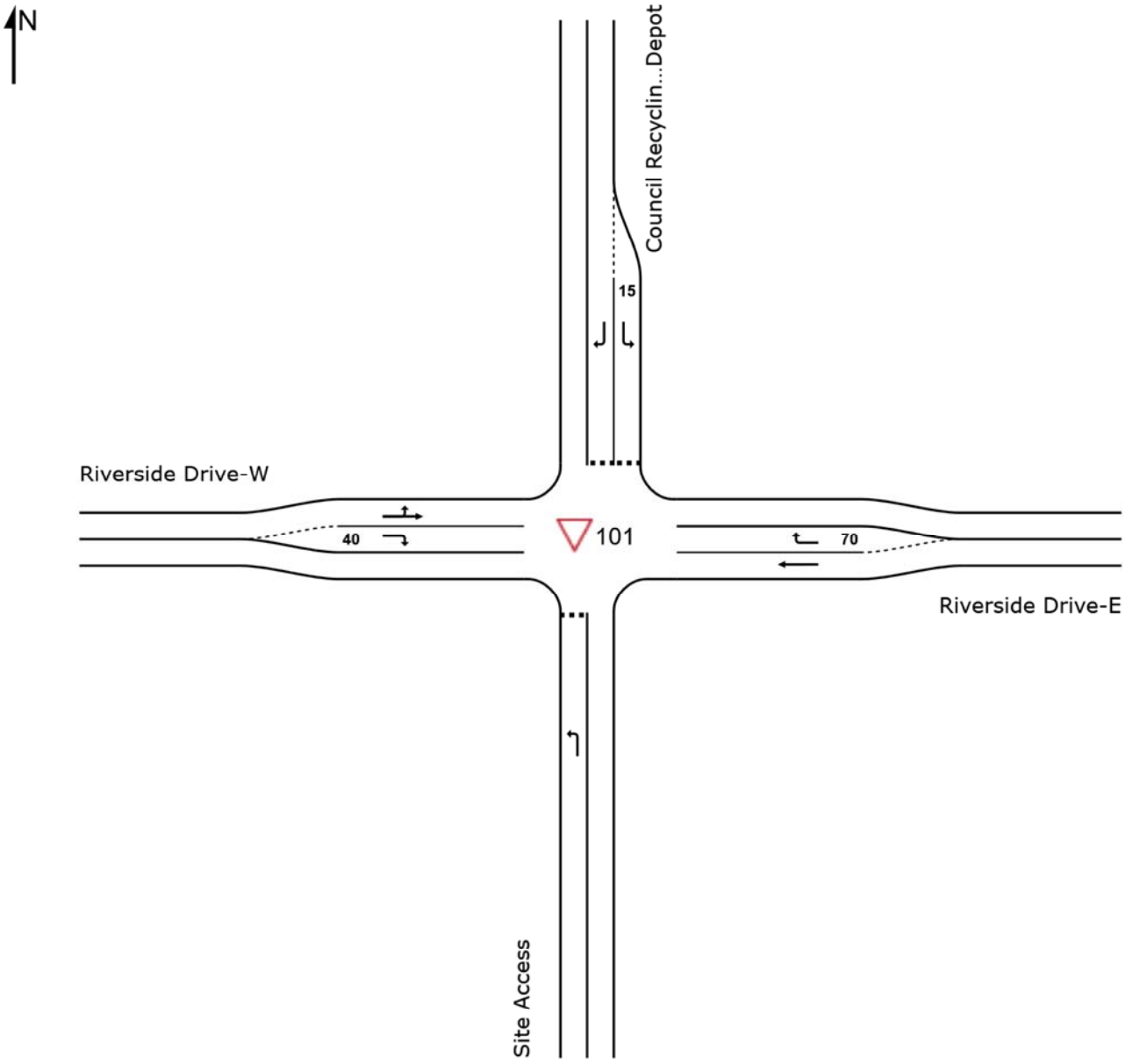
SITE LAYOUT

Site: 101 [PM Riverside Dr West Fig Tree Ln]

18117 Dunmore Lakes Sand Quarry MOD 2
2028 3 HV Case
Site Category: 2018+10years (2028) 3HV Case
Giveway / Yield (Two-Way)



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MOVEMENT SUMMARY

Site: 101 [PM Riverside Dr West Fig Tree Ln]

18117 Dunmore Lakes Sand Quarry MOD 2
2028 3 HV Case
Site Category: 2018+10years (2028) 3HV Case
Giveway / Yield (Two-Way)

Movement Performance - Vehicles

Mov ID	Turn	Demand Flows Total veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	Distance m	Prop. Queued	Effective Stop Rate	Aver. No. Cycles	Average Speed km/h
South: Site Access												
30	L2	3	100.0	0.005	6.0	LOS A	0.0	0.2	0.40	0.50	0.40	39.5
Approach		3	100.0	0.005	6.0	LOS A	0.0	0.2	0.40	0.50	0.40	39.5
East: Riverside Drive-E												
22	T1	247	5.0	0.131	0.0	LOS A	0.0	0.0	0.00	0.00	0.00	80.0
23	R2	5	100.0	0.011	13.4	LOS A	0.0	0.5	0.61	0.72	0.61	45.1
Approach		253	7.0	0.131	0.3	NA	0.0	0.5	0.01	0.01	0.01	78.7
North: Council Recycling Depot												
24	L2	5	100.0	0.015	11.1	LOS A	0.0	0.6	0.61	0.70	0.61	37.4
26	R2	5	100.0	0.066	47.7	LOS D	0.2	2.6	0.88	0.94	0.88	27.1
Approach		11	100.0	0.066	29.4	LOS C	0.2	2.6	0.75	0.82	0.75	31.4
West: Riverside Drive-W												
27	L2	5	100.0	0.285	7.9	LOS A	0.0	0.0	0.00	0.01	0.00	57.2
28	T1	528	5.0	0.285	0.0	LOS A	0.0	0.0	0.00	0.01	0.00	79.8
29	R2	3	100.0	0.004	9.4	LOS A	0.0	0.2	0.42	0.59	0.42	47.0
Approach		537	6.5	0.285	0.2	NA	0.0	0.2	0.00	0.02	0.00	79.1
All Vehicles		803	8.2	0.285	0.6	NA	0.2	2.6	0.02	0.03	0.02	77.2

Site Level of Service (LOS) Method: Delay (RTA NSW). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
Vehicle movement LOS values are based on average delay per movement.
Minor Road Approach LOS values are based on average delay for all vehicle movements.
NA: Intersection LOS and Major Road Approach LOS values are Not Applicable for two-way sign control since the average delay is not a good LOS measure due to zero delays associated with major road movements.
SIDRA Standard Delay Model is used. Control Delay includes Geometric Delay.
Gap-Acceptance Capacity: SIDRA Standard (Akçelik M3D).
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.

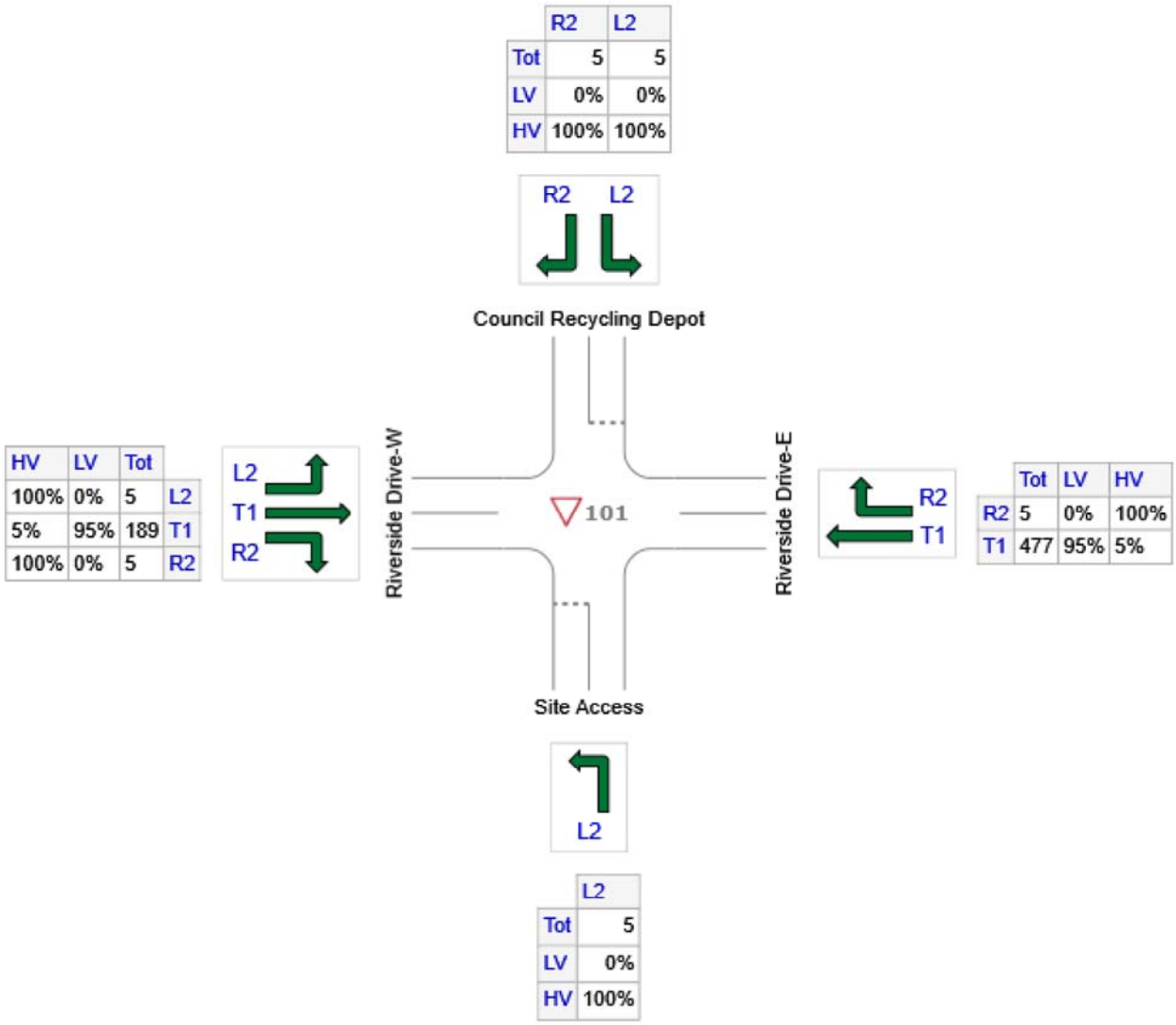
INPUT VOLUMES

Vehicles and pedestrians per 60 minutes

Site: 101 [AM Riverside Dr West Fig Tree Ln]

18117 Dunmore Lakes Sand Quarry MOD 2
2028 5 HV Case
Site Category: 2018+10years (2028) 5 HV Case
Giveway / Yield (Two-Way)

Volume Display Method: Total and %



	All MCs	Light Vehicles (LV)	Heavy Vehicles (HV)
S: Site Access	5	0	5
E: Riverside Drive-E	482	453	29
N: Council Recycling Depot	10	0	10
W: Riverside Drive-W	199	180	19
Total	696	633	63

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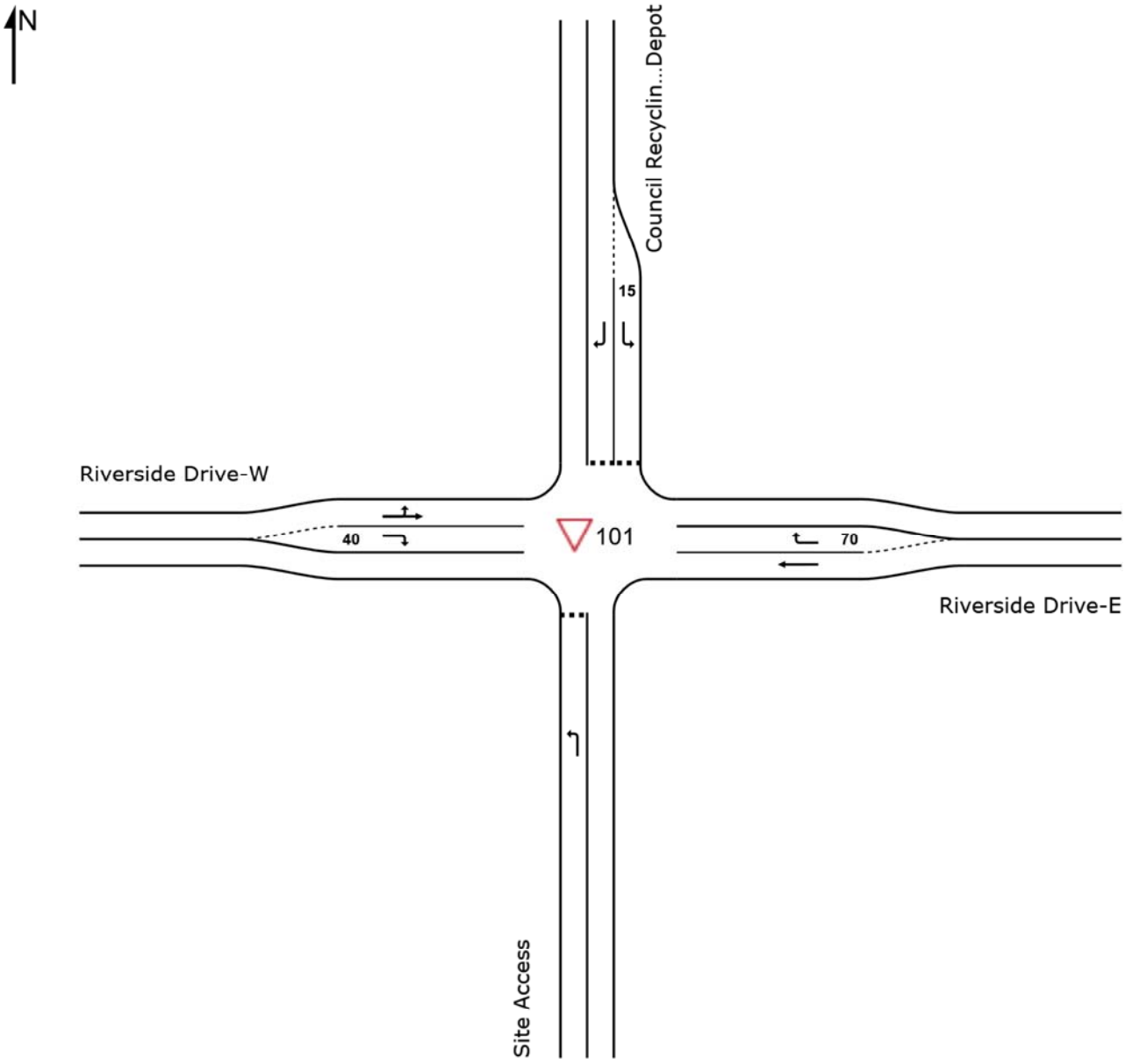
SITE LAYOUT

Site: 101 [AM Riverside Dr West Fig Tree Ln]

18117 Dunmore Lakes Sand Quarry MOD 2
2028 5 HV Case
Site Category: 2018+10years (2028) 5 HV Case
Giveway / Yield (Two-Way)



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MOVEMENT SUMMARY

Site: 101 [AM Riverside Dr West Fig Tree Ln]

18117 Dunmore Lakes Sand Quarry MOD 2
2028 5 HV Case
Site Category: 2018+10years (2028) 5 HV Case
Giveway / Yield (Two-Way)

Movement Performance - Vehicles

Mov ID	Turn	Demand Flows Total veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	Distance m	Prop. Queued	Effective Stop Rate	Aver. No. Cycles	Average Speed km/h
South: Site Access												
30	L2	5	100.0	0.014	10.5	LOS A	0.0	0.6	0.59	0.68	0.59	37.7
Approach		5	100.0	0.014	10.5	LOS A	0.0	0.6	0.59	0.68	0.59	37.7
East: Riverside Drive-E												
22	T1	502	5.0	0.266	0.0	LOS A	0.0	0.0	0.00	0.00	0.00	79.9
23	R2	5	100.0	0.006	9.2	LOS A	0.0	0.3	0.38	0.58	0.38	47.5
Approach		507	6.0	0.266	0.1	NA	0.0	0.3	0.00	0.01	0.00	79.3
North: Council Recycling Depot												
24	L2	5	100.0	0.008	5.5	LOS A	0.0	0.4	0.35	0.48	0.35	39.7
26	R2	5	100.0	0.053	38.7	LOS C	0.2	2.2	0.86	0.92	0.86	29.1
Approach		11	100.0	0.053	22.1	LOS B	0.2	2.2	0.60	0.70	0.60	33.6
West: Riverside Drive-W												
27	L2	5	100.0	0.111	7.9	LOS A	0.0	0.0	0.00	0.03	0.00	57.2
28	T1	199	5.0	0.111	0.0	LOS A	0.0	0.0	0.00	0.03	0.00	79.6
29	R2	5	100.0	0.010	12.6	LOS A	0.0	0.5	0.59	0.71	0.59	45.2
Approach		209	9.8	0.111	0.7	NA	0.0	0.5	0.01	0.05	0.01	77.4
All Vehicles		733	9.1	0.266	0.6	NA	0.2	2.2	0.02	0.03	0.02	76.7

Site Level of Service (LOS) Method: Delay (RTA NSW). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
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Minor Road Approach LOS values are based on average delay for all vehicle movements.
NA: Intersection LOS and Major Road Approach LOS values are Not Applicable for two-way sign control since the average delay is not a good LOS measure due to zero delays associated with major road movements.
SIDRA Standard Delay Model is used. Control Delay includes Geometric Delay.
Gap-Acceptance Capacity: SIDRA Standard (Akçelik M3D).
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.

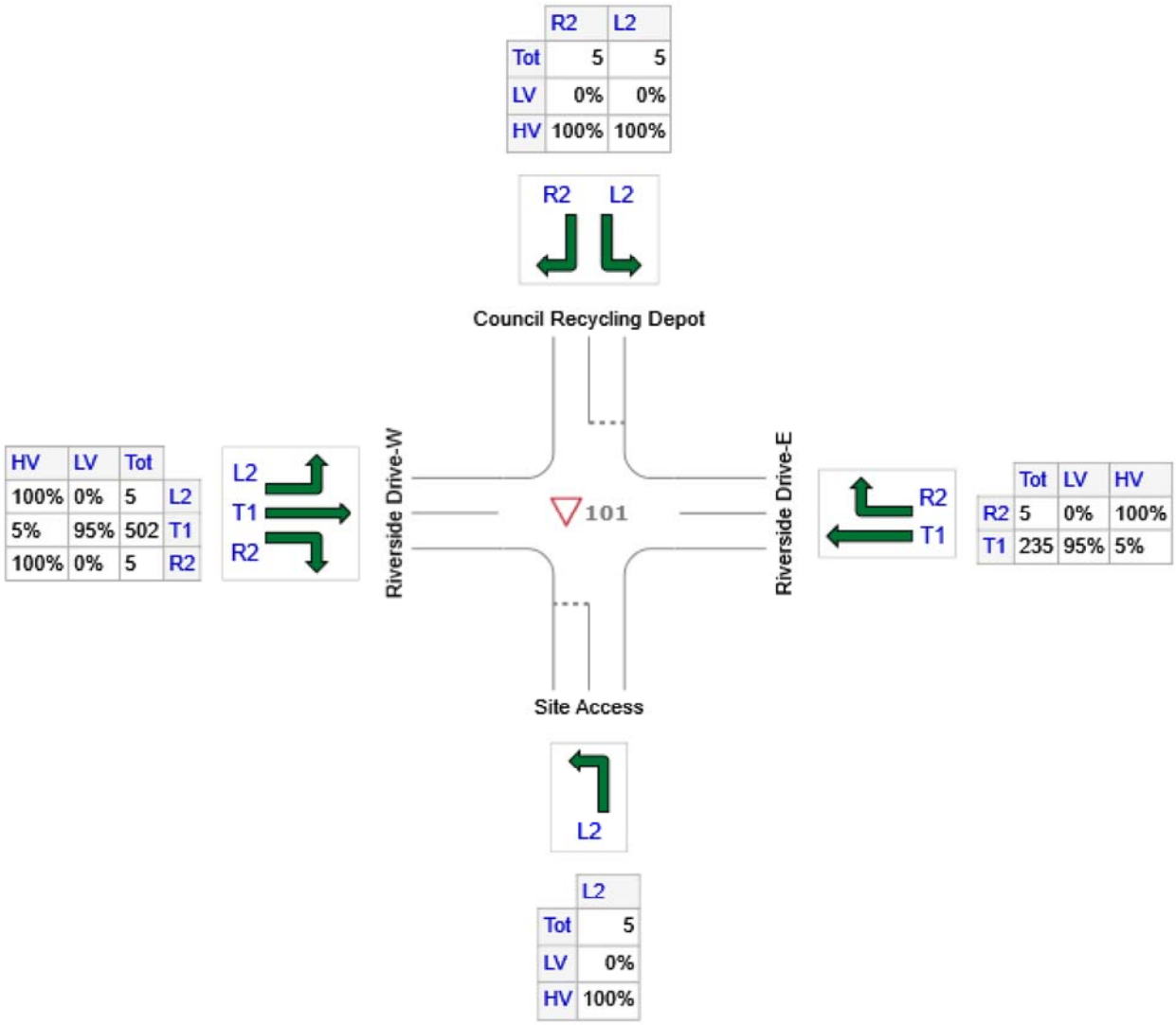
INPUT VOLUMES

Vehicles and pedestrians per 60 minutes

Site: 101 [PM Riverside Dr West Fig Tree Ln]

18117 Dunmore Lakes Sand Quarry MOD 2
2028 5 HV Case
Site Category: 2018+10years (2028) 5 HV Case
Giveway / Yield (Two-Way)

Volume Display Method: Total and %



	All MCs	Light Vehicles (LV)	Heavy Vehicles (HV)
S: Site Access	5	0	5
E: Riverside Drive-E	240	223	17
N: Council Recycling Depot	10	0	10
W: Riverside Drive-W	512	477	35
Total	767	700	67

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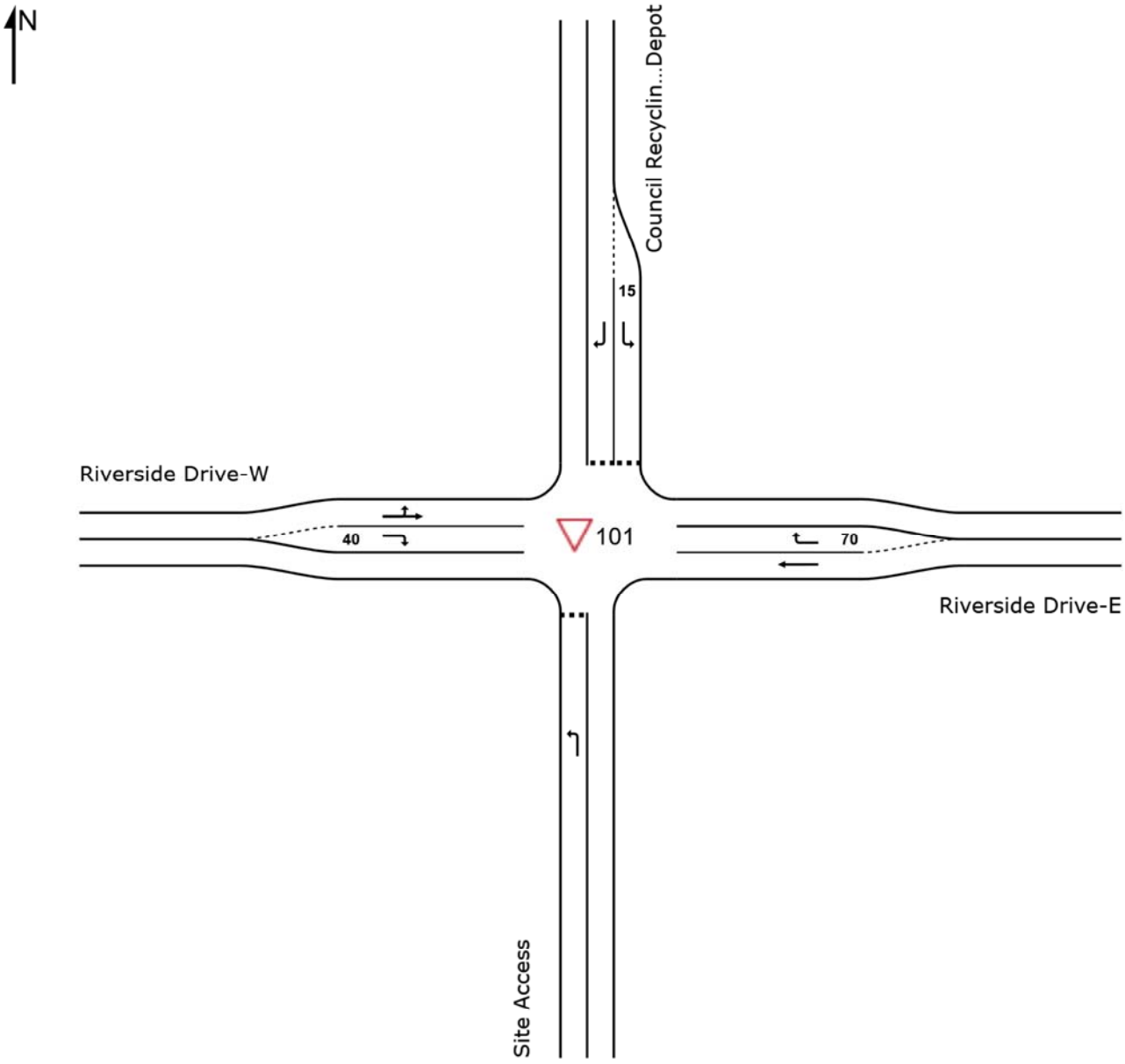
SITE LAYOUT

Site: 101 [PM Riverside Dr West Fig Tree Ln]

18117 Dunmore Lakes Sand Quarry MOD 2
2028 5 HV Case
Site Category: 2018+10years (2028) 5 HV Case
Giveway / Yield (Two-Way)



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MOVEMENT SUMMARY

Site: 101 [PM Riverside Dr West Fig Tree Ln]

18117 Dunmore Lakes Sand Quarry MOD 2
2028 5 HV Case
Site Category: 2018+10years (2028) 5 HV Case
Giveway / Yield (Two-Way)

Movement Performance - Vehicles

Mov ID	Turn	Demand Flows Total veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	Distance m	Prop. Queued	Effective Stop Rate	Aver. No. Cycles	Average Speed km/h
South: Site Access												
30	L2	5	100.0	0.009	6.0	LOS A	0.0	0.4	0.40	0.51	0.40	39.5
Approach		5	100.0	0.009	6.0	LOS A	0.0	0.4	0.40	0.51	0.40	39.5
East: Riverside Drive-E												
22	T1	247	5.0	0.131	0.0	LOS A	0.0	0.0	0.00	0.00	0.00	80.0
23	R2	5	100.0	0.011	13.4	LOS A	0.0	0.5	0.61	0.72	0.61	45.1
Approach		253	7.0	0.131	0.3	NA	0.0	0.5	0.01	0.01	0.01	78.7
North: Council Recycling Depot												
24	L2	5	100.0	0.015	11.1	LOS A	0.0	0.6	0.61	0.70	0.61	37.4
26	R2	5	100.0	0.068	48.6	LOS D	0.2	2.7	0.89	0.94	0.89	26.9
Approach		11	100.0	0.068	29.9	LOS C	0.2	2.7	0.75	0.82	0.75	31.3
West: Riverside Drive-W												
27	L2	5	100.0	0.286	7.9	LOS A	0.0	0.0	0.00	0.01	0.00	57.2
28	T1	528	5.0	0.286	0.0	LOS A	0.0	0.0	0.00	0.01	0.00	79.8
29	R2	5	100.0	0.006	9.4	LOS A	0.0	0.3	0.42	0.61	0.42	47.0
Approach		539	6.9	0.286	0.3	NA	0.0	0.3	0.00	0.02	0.00	78.9
All Vehicles		807	8.7	0.286	0.7	NA	0.2	2.7	0.02	0.03	0.02	76.8

Site Level of Service (LOS) Method: Delay (RTA NSW). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
Vehicle movement LOS values are based on average delay per movement.
Minor Road Approach LOS values are based on average delay for all vehicle movements.
NA: Intersection LOS and Major Road Approach LOS values are Not Applicable for two-way sign control since the average delay is not a good LOS measure due to zero delays associated with major road movements.
SIDRA Standard Delay Model is used. Control Delay includes Geometric Delay.
Gap-Acceptance Capacity: SIDRA Standard (Akçelik M3D).
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.

Appendix D

RMS Crash History Data

Transport for NSW | Centre for Road Safety

Search | Google™ Custom Search

Home | About the centre | Staying safe | Campaigns | Statistics | Speeding | Research | Contact us

NSW Centre for Road Safety > Statistics > Interactive crash statistics > Crash and casualty statistics - LGA view

Crash and casualty statistics - LGA view

Listen

LGA Summary | Crashes - characteristics | Crashes - contributing factors | Crashes - map | Casualties - characteristics | Casualties - contributing factors | MVCs - characterist

Transport for NSW

Crashes Map - Kiama

Navigation and Help

Select your LGA:

Kiama

Reporting year: (All)

Degree of crash: (All)

Type of crash: All

Speed limit: (All)

RUM code group: (All)

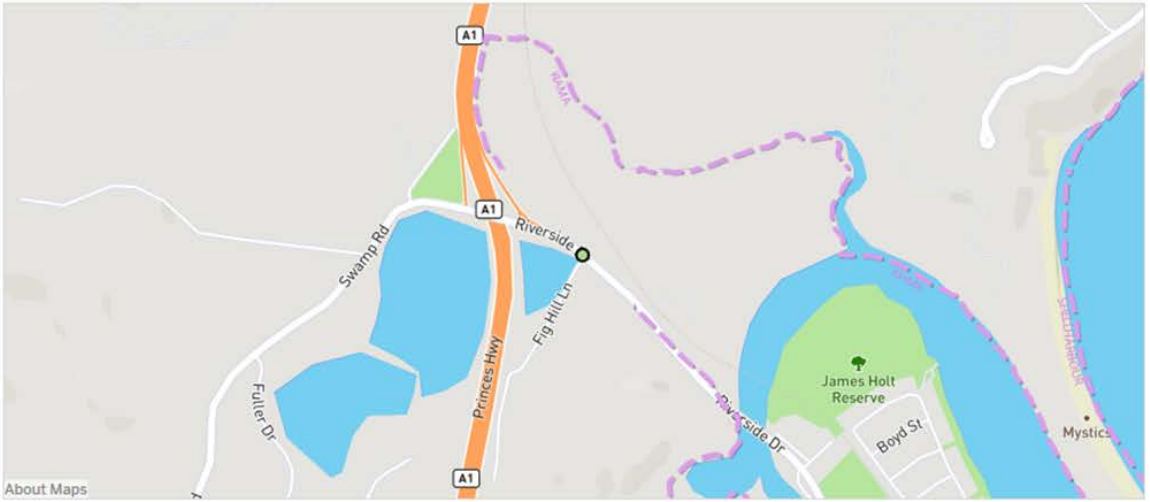
Type of location group: (All)

Speeding involved in crash: (All)

Fatigue involved in crash: (All)

Road classification: (All)

DATA AVAILABILITY
Finalised data is available for the 5 year period 2013



Degree of crash: Fatal | Serious Injury | Moderate Injury | Minor/Other Injury | Non-casualty (towaway)

Repo..	Crash ID	Degree of crash	RUM - code	RUM - descripti..	Type of location	Natural l..	Longitude	Lattitude	No ..	No Inju..
2015	1061909	Non-casualty (t..	30	Rear end	T-junction	Daylight	150.840689	-34.617333	-	-

The Transport Planning Partnership
Suite 402 Level 4, 22 Atchison Street
St Leonards NSW 2065

P.O. Box 237
St Leonards NSW 1590

02 8437 7800

info@ttpp.net.au

www.ttpp.net.au

APPENDIX L

ACID SULFATE SOIL ASSESSMENT REPORT

ENVIRONMENTAL EARTH SCIENCES
CONTAMINATION RESOLVED

REPORT NO. **118044_PASS**

POTENTIAL ACID SULFATE SOIL ASSESSMENT

DUNMORE LAKES SAND EXTRACTION PROJECT MODIFICATION 2 (STAGE 5), DUNMORE NSW

ENVIRONMENTAL EARTH SCIENCES NSW
REPORT TO ELEMENT ENVIRONMENT
25 FEBRUARY 2019
VERSION 3

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Glaeba (02) Pty Ltd trading as Environmental Earth Sciences NSW
82 – 84 Dickson Avenue, Artarmon, NSW. 2064 PO BOX 380 North Sydney, NSW 2059
P. 61 2 99221777 F. 61 2 99221010 E. eesnsw@environmentalearthsciences.com
www.environmentalearthsciences.com

ENVIRONMENTAL EARTH SCIENCES
CONTAMINATION RESOLVED

25 February 2019

Element Environment
PO Box 1563
Warriewood NSW 2120

Attention: **Luke Farrell**

Acid Sulfate Soils Impact Assessment at Boral Dunmore Sand & Soil - Stage 5, NSW

Please find enclosed a copy of our report entitled as above. Thank you for the opportunity to undertake this work. If you have any queries concerning the investigation or the report, please contact the undersigned.

For and on behalf of
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118044 Dunmore Lakes Sand MOD2 ASS Assessment V3

EXECUTIVE SUMMARY

Dunmore Sand and Soil (DSS) is seeking to modify the current Project Approval (DA 195-8-2004) under Section 75W of the Environmental Planning and Assessment Act 1979 (EP&A Act), to provide for an additional extraction area (Stage 5) on adjoining private land, encompassing two separate extraction areas, Stage 5A located at 471 Riverside Drive, and Stage 5B located at 69 Fig Hill Lane, Dunmore (hereafter referred to as the 'Site').

It is understood that following approval of the proposed modification, up to 800,000 tpa of sand will continue to be extracted across the DSS operations via dredging for commercial sale. The Proposal consists of an area to be disturbed of approximately 12 hectares. The excavation formed would be rehabilitated on completion of the sand extraction activities. Following extraction of the sand in Stage 5A, it is proposed that the excavation would be rehabilitated with appropriately characterised material, it is intended that Stage 5B area remain as a pond and be rehabilitated for wetland purposes.

The objective of this report to identify if actual or potential Acid Sulfate Soils (AASS / PASS) are present within the designated dredge zones associated with Stage 5and assess the potential impacts of ASS or PASS on sensitive receptors.

The following scope of works was undertaken to meet the objectives:

- desktop study, including the area's hydrology, geology and ASS risk;
- installation of seven representative bores to a maximum of 18 m below ground level (m BGL);
- field study including detailed borelogs and field pH and peroxide testing;
- laboratory analysis of selected samples for ASS; and,
- provision of an acid sulfate soil assessment across the areas of disturbance in Stage 5A and Stage 5B.

The full extent of the proposed dredging profile was examined at eight locations across the site. The results of the field screening and laboratory analysis corroborated the results of the desktop study, which indicated a low probability for acid sulfate soils (ASS) in the Stage 5B area of the site, with localised areas of high probability for ASS in the Stage 5A area.

Two locations (5A2 and 5A3) in Stage 5A reported a moderate to high risk for potential ASS. All soil samples analysed within the Stage 5B area were classified as 'not acid sulfate soils' (NASS) or 'no risk non-reactive' (NRNR). It is reasonable to extrapolate that a buffering ability exists across Stage 5B due to the presence of shell grit within sand deposits.

Regular monitoring as part of an ASS Management Plan is recommended for a proactive monitoring regime so that early indications of localised acid generation could trigger appropriate management. Further testing at the time of extraction is recommended to confirm the assessment.

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1 INTRODUCTION

1.1 Background

Stage 1 of the Dunmore Lakes Sand Project was issued development consent from the (then) Minister for Planning in 1999. Stage 1 was located on Swamp Road, Dunmore, and included sand extraction by dredging for up to 500,000 tonnes per annum (tpa) for a period of 10 years. The Stage 1 consent included conditions requiring the proponent to lodge a further application for the remaining identified Stages of the Dunmore sand resource (being Stages 2 to 4).

The application for Stages 2 to 4 was lodged in 2004, and development consent was received from the (then) Minister for Planning in June 2005. The consent approves extraction of up to 800,000 tpa (tons per annum) of sand for a period of 25 years. Boral Resources (NSW) Pty Ltd (hereafter 'Boral') purchased DSS, including the Dunmore Lakes Sand Project in mid - 2005. The Stage 1 consent has since lapsed following successful extraction of the approved sand resource and rehabilitation of the site in 2010.

Stages 2 to 4 commenced dredging in June 2007. Since then, due to the high demand for sand in the Sydney market, the majority of sand in Stage 2 has been extracted with dredging recently moving into Stage 3. Given recent high demand, the sand resource in Stage 3 is expected to be exhausted within 8-12 months. This has led DSS to investigate other local sources of sand to continue operations beyond Stage 4.

DSS had been investigating a fine sand resource on an adjoining private property to the south of existing approved stages on adjoining private land (Stage 5A and 5B), with findings confirming sufficient sand resources exist to support 3 - 4 more years of extraction.

As such, DSS is seeking to modify the current Project Approval (DA 195-8-2004) under Section 75W of the *Environmental Planning and Assessment Act 1979* (EP&A Act), to provide for an additional extraction area (Stage 5) on adjoining private land, encompassing two separate extraction areas, Stage 5A and Stage 5B (hereafter referred to as the 'modification').

Stage 5A is located at 471 Riverside Drive, Dunmore and Stage 5B is located at 69 Fig Hill Lane, Dunmore (the Site). See **Figure 1** for location. It is understood that following approval of the proposed modification, up to 800,000 tonnes per annum of sand will continue to be extracted across the DSS operations via dredging for commercial sale.

Environmental Earth Sciences were commissioned by Element Environment, on behalf of Boral Dunmore Sand and Soil Pty Ltd (DSS), to undertake an assessment of the sulfidic sediments of proposed Stage 5A and Stage 5B extraction areas

A resource exploration report undertaken by Boral (Boral, April 2016) estimated that approximately 234,000 tonnes from Stage 5A and 1,123,000 tonnes from Stage 5B of sand is available for commercial sale.

1.2 Acid Sulfate Soil (ASS)

Acid Sulfate Soils (ASS) is the generic name given to soils and sediments which are rich in iron sulfides (pyrite). They have formed naturally, commonly in estuarine areas along the

east coast of Australia as well as other parts of the continent and throughout the world. If permanently deprived of oxygen, the sulfidic minerals in ASS cause no environmental harm and the materials are referred to as Potential Acid Sulfate Soils (PASS).

Coastal ASS (CASS) occurs predominantly below 5 metres Australian Height Datum (AHD) and up to 10m AHD in some instances. If exposed to atmospheric oxygen (eg through excavation or drainage, the sulfidic minerals in the soil oxidise and can produce excess sulfuric acid. Such soils are referred to as Actual Acid Sulfate Soils (AASS).

2 OBJECTIVES AND SCOPE OF WORKS

The objective of this report is to identify if actual acid sulfate soils or potential acid sulfate soils (AASS / PASS) are present at the modification area with findings determining whether additional management of health and ecological risk may be required.

A hydrogeological impact assessment has been provided by Environmental Earth Sciences (Environmental Earth Sciences, 2019). The results of the report are not duplicated herein. It is recommended that this report be read in conjunction with the hydrogeological impact report.

The following scope of works was undertaken to meet the objectives:

- Desktop study, including review of the site environmental setting (hydrology, hydrogeology, geology and potential for ASS risk);
- Detailed PASS assessment including:
    - Installation of eight representative bores to a maximum depth of 18 metres below ground level (mBGL) to refine the conceptual site model (CSM) for PASS risk;
    - Field measurements during drilling including pH and peroxide testing;
    - Preparation of detailed bore logs of material type and PASS characteristics;
- Laboratory analysis of selected samples for indicators of PASS; and
- Presentation of findings and provision of the following PASS management advice associated with acid generation effects:
    - from potential lowering of the water table;
    - on groundwater-dependant ecosystems (GDEs);
    - on extracted sand for commercial sale; and
    - on general management / remediation (where required).

Specific details of the works program are described throughout the report and are discussed in the following sections.

3 SITE SETTING

3.1 Description of the proposal

The approved operations include extraction and transportation of up to 800,000 tonnes of sand products per annum from Stage 2 to 4 over a period of 25 years. The project forms a modification to the approved project through the establishment of additional extraction areas (Stage 5) on adjoining private property which is to be leased by DSS.

The project would involve establishment of the sand extraction site, extraction of sand from Stages 5A and 5B area by excavator and dredge and pumping it to the existing processing area on Stage 2 for washing, stockpiling and dispatch.

Fines from the washing process would continue to be placed in the Stage 2 fines pond, however, return water would be pumped back to the Stage 5 ponds. Although there would be an increase in the disturbance footprint of the Project and inclusion of additional land, there will be no changes sought to the annual production limit or consent life.

3.2 Site location and details

The Dunmore Lakes Sand Project is near Dunmore, approximately 3 kilometres (km) south-south west of Shellharbour and 7 km north of Kiama, in the Illawarra region of NSW. The site is approximately 88 hectares (ha) and is immediately west of the Princes Highway near Tabbita Road, Dunmore. The site is within the Shellharbour Local Government Area (LGA).

The Stage 5 extraction area is located approximately 1.1 km south-south east of the existing site, covers an area of approximately 38 ha and is on an alluvial coastal flood plain, adjacent to the tidal reaches of the Minnamurra River. The northern portion of the Stage 5 extraction area has been partially cleared and has historically been used for grazing. The Stage 5 extraction area is bound by Riverside Drive to the north and Princes Highway to the west. The site location and context is illustrated on **Figure 1** and **Figure 2**. Key identification features of the project area are summarised in **Table 1**.

Table 1 Site identification

Item	Details Stage 5A	Details Stage 5B
Site Owner	Private landowner	Private landowner
Address	471 Riverside Drive, Dunmore NSW	69 Fig Hill Lane, Dunmore NSW
Lot & Plan number	Lot 501 DP1174897	Lot 51 DP1012246
Area	Approximately 3.32 hectares	Approximately 7.85 hectares
Size of sand resource	234,000 tonnes	1,123,000 tonnes
Zoning	RU2 – Rural Landscape	Part RU2 – Rural Landscape Part E3 – Environmental Management
Proposed land use	Extraction of natural resources (sand)	Extraction of natural resources (sand)
Local Government Authority	Shellharbour City Council	Shellharbour City Council

Item	Details Stage 5A	Details Stage 5B
Site Location and Layout	Figure 1 and Figure 2	Figure 1 and Figure 2

3.3 Site history

The Site is situated in a predominantly rural area and has been used for cattle grazing throughout its reported history, however, there is an increasing residential and industrial presence in the Shellharbour-Dunmore-Kiama region.

Activities surrounding the Site include two municipal waste depots to the north-east, sand extraction operations, and a hard rock quarry to the north-west of the site (**Figure 1**).

3.4 Landform and topography

The Stage 5 area is bordered to the south and within close proximity to the east by the Minnamurra River. As such, these estuarine and alluvial tidal flats are low-lying with water-logging issues due to the permanently high water-tables.

Elevation within the subject site area is typically very low lying and is typically between <1 – 5 metres above Australian Height Datum (mAHD). An outcrop of latitie forms a hill separating Stage 5A and 5B with elevations as high as 44 mAHD.

3.5 Soil and geology

The local geology has been described in the Kiama 1:250 000 Geological series sheet 9028 (1974) as comprising of Quaternary alluvium, including, gravel, beach and dune sand.

The geology around the perimeter of the Project Site forms the sides of a valley which also extends to the east. separating Stage 5A and Stage 5B as a result of Bumbo Latite outcropping along the edge of a ‘drowned’ river valley. The valley is in-filled with unconsolidated sediments being Quaternary aged and consisting of gravels, swamp deposits and sand dunes.

The sand resource consists of predominantly tsunami deposits of a typically fine to medium grained sand underlain by columnar latite deposits which make up the surrounding undulating hills. The sand contains varying quantities of shells and shell fragments, and in places clay lenses. The extent to which underlying latite is weathered ranges from fresh rock to metres of latitic clay deposits.

Soil landscape information was sourced from eSPADE v2.0 published by the NSW Office of Environment & Heritage (2018) (espade.environment.nsw.gov.au/, verified 2 November 2018) and the Department of conservation and land management 1:100,000 scale Soil Landscape Series Sheet (Kiama, 9028). The soil landscape group identified in the Stage 5 area is called Mangrove Creek, which typically features:

- Vegetated tidal flats in estuarine areas on Holocene sediments on the Coastal Plain;
- Holocene sediments consist of silty to peaty quartz sand, silt and clay. Common shell layers in sandy mud and muddy sand; and,
- Soil that tends to feature strongly saline, strongly sodic and strongly acid characteristics with acid sulphate potential.

Refer to **Appendix A** for soil landscape reports.

3.6 Acid Sulfate Soils

For PASS risk the Stage 5 area is included in the Albion Park 1:25,000 Acid Sulfate Soils Map (1997) produced by NSW Department of Land and Water Conservation. The southern area of the Stage 5 area (5B) is considered low probability for ASS in general, however the north-eastern area of Stage 5A is considered to have a high probability of occurrence of acid sulfate soil materials within the soil profile at or near the surface, associated with estuarine plain deposits

PASS risk mapping information was sourced from eSPADE v2.0 published by the NSW Office of Environment & Heritage (2018) (espade.environment.nsw.gov.au/, verified 2 November 2018). The Stage 5A area was considered to have a high probability for ASS between <1 m BGL whilst the Stage 5B area was considered high probability for ASS >3 mBGL.

Review of the Shellharbour Local Environmental Plan (LEP) 2013 identifies Class 2 risk for PASS in the Stage 5A area and Class 4 risk of PASS in the Stage 5B area. As such development consent is required for any works below the natural ground surface in the Stage 5A area and >2 mBGL in the Stage 5B area.

As per *Clause 6.1 subclause 4(a)* and *4(b)* of the LEP, the requisite development consent can be avoided if:

- a preliminary assessment for the proposed works is prepared in accordance with the PASS Manual indicating no ASS management plan is required; and,
- the preliminary assessment is provided to and approved by the consent authority.

However, this modification comes under section 75W of the *Environmental Planning and Assessment Act 1979*, thereby superseding the provisions of the LEP. A summary of information regarding the low probability for PASS is provided in **Table 2** below.

Table 2 Summary of PASS in the Stage 5 area

Locally High Probability for PASS[1]		
PASS MAP Class Description[1]	The environment of deposition is suitable for the formation of PASS, particularly in the north-eastern area of Stage 5A. No known occurrence of PASS in the Stage 5B area.	
Environmental Risk[2]	These estuarine and alluvial landforms have a high probability to contain PASS. Land management is generally required for PASS. Environmental risk will vary with elevation and depth of disturbance.	
Typical Landform Types[2]	Estuarine (Stage 5A area)	Alluvial (Stage 5B area)
Depth to sulfidic soil[2]	High probability <1 m BGL	High probability >3 m BGS
Shellharbour LEP (2013) class of land[3]	**Class 2** Development consent required for any works below ground surface	**Class 4** Development consent required for: Works >2 m BGL.

Locally High Probability for PASS[1]		
		Works by which the water table is likely to be lowered >2 m BGL.
Soil Landscape[3]	Mangrove Creek	Mangrove Creek

Notes:

1. Sourced from the Albion Park 1:25 000 Acid Sulfate Soils Map (1997) produced by NSW Department of Land and Water Conservation.
2. Sourced from eSPADE v2.0 published by the NSW Office of Environment & Heritage (2018) (espade.environment.nsw.gov.au/, verified 2 November 2018).
3. Sourced from Shellharbour Local Environmental Plan 2013; Part 7 Clause 6.1 – Acid Sulfate Soils.

3.7 Hydrology

Rocklow Creek lies approximately 500 m to the north of the Stage 5A area, whilst Stage 5B is bordered to the south by the Minnamurra River which discharges into the Pacific Ocean approximately 1 km to the east of site.

The Minnamurra River is a large catchment approximately 120 km^2 in area. The site is located on the boundary between the estuarine and marine zones of the Minnamurra River before it discharges into the Pacific Ocean to the east (Panayotou, 2004).

The predominant land uses are grazing and other rural activities (Environmental Earth Sciences, 2004).

3.8 Hydrogeology and groundwater use

The site is underlain by a shallow, unconfined sand aquifer that is likely connected to the Minnamurra River and potentially partially influenced by the Rocklow Creek to the north of Stage 5A area. Permanently high-water tables are dominant on the site with rainfall considered to be the primary recharge source for the aquifer via percolation. The area is prone to high rainfall events that result in periodic flooding.

Groundwater usage in the vicinity of the site is generally located on private property for stock water and / or irrigation, and for monitoring purposes at nearby DSS and Dunmore Landfill.

3.9 Land-use

Land use over the 2,200 hectares comprising the Rocklow catchment is varied and ranges from grazing cattle and horses on small lot holdings, mining (quarries), industrial (landfilling), commercial and residential.

Similar land uses are identified within the 10,000 hectares comprising the Minnamurra River Catchment. Large areas of native remnant vegetation are found around Rocklow Creek and Minnamurra River and on the upper slopes of the catchment.

4 ACID SULFATE SOIL ASSESSMENT METHODOLOGY

4.1 Background information

Before conducting the field assessment, an initial understanding of the different types of soils and landscapes across the Stage 5 area was developed. These desktop investigations included a review of available:

- Topographic, geological, soil and acid sulfate soil maps.
- Aerial photography for the purpose of delineating landscape features and geomorphic processes within the Stage 5 area.
- Climatic data.

This information provided a preliminary understanding of the potential distribution of PASS across the Stage 5 area which informed the field activities and reporting components of the scope of works. Intrusive field work was then used to validate this information and assess ASS within the Stage 5 area and the potential impacts.

4.2 Rationale and regime

According to the NSW Acid Sulfate Soils Management Advisory Committee (1998), *Acid Sulfate Soils Planning Guidelines* the sampling depth for intrusive investigations should be at least one metre beyond the depth of the proposed excavation. Thus, we proposed to excavate boreholes to a maximum depth of 18 metres below ground level.

The intrusive investigation was advanced with the following considerations to:

- obtain representative coverage of the Stage 5 area;
- target the lower-lying areas where possible;
- advance boreholes to a maximum of depth 18 mBGL, to assess the full extent of the proposed dredging profile and the underlying sediments;
- conducting qualitative pH_F and pH_{FOX} ASS field screening on likely ASS samples; and
- conducting quantitative laboratory analysis – chromium reducible sulfur (S_{CR}) suite on samples that indicated highest risk within the upper 1.5 metres in accordance with the scope.

A summary of soil borehole locations and rationale is provided in **Table 3**.

Table 3 Summary of locations and rationale

Location	Sampled Media	Rationale
MW_5A1	Soil	Stage 5A area coverage; southeast
MW_5A1	Soil	Stage 5A area coverage; southwest
MW_5A1	Soil	Stage 5A area coverage; northeast
MW_5B1	Soil	Stage 5B area coverage; northwest

Location	Sampled Media	Rationale
MW_5B2	Soil	Stage 5B area coverage; southwest
MW_5B3	Soil	Stage 5B area coverage; southeast
MW_5B4	Soil	Stage 5B area coverage; northeast
MW_5B5	Soil	Bore log only, no samples analysed

4.2.1 Field pH Screening

The following field assessment was undertaken to determine potential impacts of PASS and determine sample selection for laboratory analysis:

- soil texture (proportion of sand, silt and clay);
- pH_F and temperature (1:5 soil/water);
- pH_{FOX} and temperature (30% H_2O_2); and
- level of effervescence following H_2O_2 addition.

Field pH screening equipment was calibrated before and after each borehole. For calibration records, refer to **Appendix B** for calibration certificates.

4.2.2 Soil sampling

Investigation works were carried out between and 13 July 2018 by Environmental Earth Sciences using sonic drilling technique to advance seven boreholes within the proposed sand extraction area, to depths of between 9 - 13 mBGL in Stage 5A area, and between 9 – 18 mBGL in Stage 5B area.

Soil samples were obtained, and field pH and peroxide tests were undertaken, at 0.25 m intervals. Soil samples were collected in a zip-lock bag and stored on ice within a cool box. Full details of field hydrogen peroxide test are included in **Appendix F**.

4.2.3 Ground conditions

The profiles of bores in the Stage 5A area (bores MW_5A1 to MW_5A3) were typically described as fine to medium grained grey, cream and brown sand with occasional shell grit in the sand aquifer portion of the profiles.

In the Stage 5A area, this was generally underlain by weathered bedrock (latite), whereas the Stage 5B area was underlain by estuarine clay deposits over weathered bedrock. A summary of the stratigraphy encountered at the site is included in **Table 4**. Refer to **Appendix C** for detailed borelogs.

4.2.4 Groundwater

During drilling, groundwater was encountered within all boreholes at shallow depths ranging between 0.92 and 3.45 mBGL. Borehole MW5A3 recorded the shallowest groundwater level at 0.92 mBGL.

Table 4 Stratigraphy summary

Area	Strata	From (min / max)	To (min / max)	Min / max thickness	Groundwater (min / max)	Comments
Stage 5A	Fine to medium SAND with occasional shell	0.0	5.00 / 12.25 m	5.00 / 12.25 m	0.92 / 3.45 mbgl	-
	Clayey SAND	5.00 / 7.25 m	6.00 / 8.50 m	1.00 / 1.25 m		Not encountered in MW5A3
	CLAY	6.00 / 12.25	9.00 / 13.00 m	0.75 / >1.50 m		Base not proven in MW5A1
	Latite BEDROCK	9.00 / 13.00 m	Not proven	-		-
Stage 5B	Fine to medium SAND with occasional shell	0.00 m	6.25 /11.25 m	6.25 / 11.25 m	1.84 / 2.70 mbgl	-
	Clayey SAND with shell	6.25 / 11.25 m	7.00 / 13.25 m	0.75 / 2.00 m		-
	Clayey SAND	7.00 / 13.25 m	14.50 m / not proven	2.00 / -		Extended beyond maximum depth in MW5B3 (16.0 m) and MW5B4 (9.0 m)
	Clayey SAND with shell	14.50 m	15.00 m	0.50 m		MW5B2 only
	CLAY with shell	15.00 m	18.00 m	3.00 m		MW5B2 only

5 LABORATORY ANALYSIS

A total of 50 primary soil samples were scheduled for laboratory of the following analytes:

- Chromium Reducible Sulfur (CRS) suite (EA033-A, -B, -C and -E), to determine the on-site potential for the presence of potential, actual or partially oxidised acid sulfate soils including:
  - total actual acidity (TAA) (including pH_{KCl});
  - potential acidity (S_{CR}) using the Chromium Reducible Sulfur (CRS) method;
  - retained acidity as Net Acid Soluble Sulfur (S_{NAS}) when pH_{KCl} ≤4.5;
  - Acid Neutralising Capacity (ANC) – when pH_{KCl} ≥6.5; and
  - Acid Base Accounting (ABA) based on the above results.
- seven samples were selected for further testing for ANC (EA033-C).

Three intra-laboratory field duplicate samples were schedule for testing for quality assurance/ quality control (QA/QC) purposes. Laboratory transcripts and chain of custody documentation are presented in **Appendix D**. Samples were analysed by ALS Environmental (ALS), accredited with the National Association of Testing Authorities (NATA) for the methods used.

5.1 Analytical schedule

The final analytical schedule was chosen in consideration of field observations and the results of the field test for soils. The final analytical schedule is summarised in **Table 5**. Laboratory transcripts are provided in **Appendix D**.

Table 5 Analytical schedule

Soil	No. of samples	No. of intra-lab duplicates	Total
CRS (EA033-A, EA033-B and EA033-E)	50	3	53
ANC (EA033-C)	41	0	41

5.2 Assessment criteria

The term acid sulfate soil includes both AASS and PASS, where AASS is defined as soil "containing highly acidic soil horizons" producing "hydrogen ions in excess of the sediments capacity to neutralise the acidity, resulting in soil pH of 4 or less when measured in dry season conditions". PASS is defined as soil "that contains sulfidic material that has not been oxidised and poses a considerable environmental risk, as they will become extremely acid when exposed to air and oxidised."

Hazard classes are a means to define material based on impact to the environment, and are based on soil sulfide (S) and net acidity (NA) values. Net acidity refers to acid-base accounting (ABA), as it includes assessment of the natural buffering capacity of soil, usually present as carbonates measured as acid neutralising capacity (ANC) in the laboratory. Risk classes normally used to determine the degree of management and remediation required (if any) are no risk - no sulfur, no risk - non-reactive, moderate risk, and high risk.

5.3 No risk-no sulfur and no risk – non-reactive

The no risk – no sulfur (NRNS) classification is based solely on the presence of sulfides measured by the CRS, S_{POS} or TOS methods (Ahern, *et al*. 2004).

Soils classified as 'no sulfur' are not acid sulfate soils (NASS), while 'non-reactive' soils are completely self-buffering and do not require management through neutralization if oxidized (although they do require monitoring).

No risk - non-reactive is based on NA and is defined as having S values greater than the no risk – no sulfur threshold but NA values below three times that of the no risk – no sulfur values. Thus: for sand, NA <3 kg H_2SO_4/ tonne of soil; for sandy silts and silts, NA <6 kg H_2SO_4/ tonne of soil; and for sandy clays, silty clays and clays, NA <9 kg H_2SO_4/tonne of soil (**Table 6**). Though it is noted in cement using sand with sulfides above 0.05% kg H_2S0_4, iron spots may appear regardless of the buffering capacity.

Note that these levels are based on consideration of buffering agents in the soil, as per the equation:

- NA (kg H_2SO_4/tonne) = sulfur (S) + acidity (TAA) + retained acidity (S_{RAS} at pH_{KCl}<4.5) – buffering (ANC/Ca+Mg)

These levels are also based on Environmental Earth Sciences experience with PASS and require consideration and trialling on a site-specific basis to define the exact value, as soil texture variation can cause deviation by up to 30% from the anticipated value.

5.4 Moderate risk and high-risk ASS

Moderate risk and high-risk sediment and soil could potentially cause a significant adverse risk to the environment. Essentially, moderate risk will generate a small amount of acid slowly while high risk will either generate acid quickly, in large volumes or both. Values for moderate or high-risk sediments must be derived by either field trials or accelerated weathering experiments, but broad class groups are presented in **Table 6**. These are the only two classes that are considered ASS from a management point of view.

Soil sulfide hazard classes which rank the net acidity of a soil against its texture are presented also in **Table 6**. This reflects the buffering capacity of the soil, which is generally lower in coarser (sandier) soils (i.e. sands have limited ability to offset acid generation).

Table 6 Soil sulfide hazard classes

	No Risk				Risk			
Hazard Class	**'No-sulfur'**		**'Non-reactive'**		**'Moderate Risk'**		**'High Risk'**	
Texture Group	**Sulfur**	**NA**	**Sulfur**	**NA**	**Sulfur**	**NA**	**Sulfur**	**NA**
1 – SAND	1	N/A	>1 (<10)[4]	<3	>1	>3	>10	>5
2 – Light CLAY	2	N/A	>2 (<20)[4]	<6	>2	>6	>20	>10
3 – m-heavy CLAY	3	N/A	>3 (<30)[4]	<9	>3	>9	>30	>15

Note(s): 1. all units in kg H_2SO_4 generated per tonne of soil
2. NA net acidity (sulfur + acid – buffering capacity)

3. Texture groups are: 1. Coarse: sand; 2. Medium: loams/silt-light clay; 3. Fine: medium to heavy clay, silty clay
4. [4] sulfur levels exceeding the values in brackets require confirmation through incubation tests or weathering trials
5. shaded values indicate relevant texture group and associated criteria for Stage 5 area.

5.5 Procedures for quality control and quality assurance

Quality control is achieved by using NATA registered laboratories using ASTM standard methods supported by internal duplicates, the checking of high, abnormal or otherwise anomalous results against background and other chemical results for the sample concerned.

Quality assurance is achieved by confirming that field results, or anticipated results based upon comparison with field observations, are consistent with laboratory results. Also, that sampling methods are uniform and decontamination is thorough. In addition, the laboratory undertakes additional duplicate analysis as part of their internal quality assurance program on the basis of one duplicate analysis for every 20 samples analysed.

Field observations are compared with laboratory results when they are not as expected. Confirmation, re-sampling and re-analysis of a sample are undertaken if the results are not consistent with field observations and/or measurements. In addition, field duplicate sample results have to be within the acceptable range of reproducibility. A discussion of the quality of internal laboratory results and field duplicate relative percentage difference (RPD) calculations are presented in **Appendix E**.

6 DISCUSSION OF RESULTS

6.1 Field pH_F and pH_{FOX} screening

A total of 301 field samples were tested for acidity at 0.25 m intervals along the soil profile at each location. Findings of the field testing are summarised in **Table 7**. Full results are included in results summary tables (**Table 10** at rear of report).

The net acidity (NA) for the majority of the samples from Stage 5A area fell below the screening criteria indicating either a NASS or NRNR. However, soils between 3.25 - 4.00 m depth in MW5A2 and soils between 1.25 - 4.00 m depth in MW5A3 and were classified as moderate to high risk acid sulfate soils.

Table 7 Field oxidation summary

Area	Total field samples	$pH_{1:5}$ (min/max)	pH_F (min/max)	Number of samples with effervescence		
				none	mild	strong
Stage 5A	104	4.8 - 8.7	1.7 - 8.1	25	38	41
Stage 5B	198	5.2 – 9.7	2.6 – 7.7	46	138	13

The pH_F ranged from neutral to acidic across the site. A total of 176 samples recorded mild effervescence to peroxide testing, however, 54 soil samples recorded strong effervescence, predominantly in the bores of MW5A2 and MW5A3 from the area of Stage 5A.

The pH_{FOX} ranged from mildly alkaline to strongly acid across the site. The most acidic soil was reported in Stage 5A area at MW5A2 and particularly MW5A3 where pH_{FOX} was generally reported as <2.5.

The average pH_{FOX} in the Stage 5 area was mildly acidic at pH 5.3. The most alkaline result of field pH_{FOX} testing was pH 8.1 (MW5A3 at 12.25m depth) whilst the most acidic was pH 1.7 (MW5A1 at 4.00 depth), both located within the Stage 5A area.

6.2 Laboratory Results

Out of the 53 samples submitted for laboratory analysis, 20 originated form the Stage 5A area whilst 31 came from Stage 5B area. A brief summary of the laboratory results for each of the areas is provided in **Table 8** and **Table 9** respectively. A detailed summary is provided in the results summary tables (**Table 10** at rear of report). Refer to **Appendix D** for full laboratory transcripts.

6.2.1 Stage 5A area

Table 8 Summary of acidity results – Stage 5A area

	Minimum	Maximum	Screening Criteria[1]	Samples exceeding criteria
pH_{KCl} (1:5)	4.5	9.8	<5	1
pH_F (1:5)	4.8	8.2	<5	0
pH_{FOX} (H_2O_2)	1.7	5.7	<2.5	15
Potential Acidity (CRS)[2]	0.28	19.30	1	15
Actual Acidity (TAA)[2]	<0.049	0.931	1	0
Buffering Capacity (ANC)[2]	0.19	95.45	-	-
Net acidity (NA)	-86.53	20.0	3	7

1. Based on texture group – Sand
2. As kg H_2SO_4

The net acidity (NA) for the majority of the samples from Stage 5A area fell below the screening criteria indicating either a NASS or NRNR. However, soils between 3.25 and 4.0m depth in MW5A2 and soils between 1.25 - 4.00 m depth in MW5A3 were classified as moderate to high risk acid sulfate soils.

6.2.2 Stage 5B area

Table 9 Summary of acidity results – Stage 5B area

	Minimum	Maximum	Screening Criteria[1]	Samples exceeding criteria
pH_{KCl} (1:5)	5.5	9.8	<5	0
pH_F (1:5)	8.0	9.4	<5	0

	Minimum	Maximum	Screening Criteria[1]	Samples exceeding criteria
pH_{FOX} (H_2O_2)	2.6	6.9	<2.5	0
Potential Acidity (CRS)[2]	0.08	19.91	1	20
Actual Acidity (TAA)[2]	<0.049	0.098	1	0
Buffering Capacity (ANC)[2]	0.49	540.96	-	-
Net acidity (NA)	-440.7	0.17	3	0

1. Based on texture group – Sand
2. As kg H_2SO_4

Whilst 20 soil samples from Stage 5B area reported a Potential Acidity (CRS) greater than 1 kg H_2SO_4 per tonne of soil, the NA value for all of the samples analysed in Stage 5B were below the 3 kg H_2SO_4 threshold and therefore may be considered to have suitable buffering capacity to be considered either NRNR or NASS in all cases.

It should be considered, however that the presence of NASS and NRNR could still cause iron speckling in cement render. Though testing is required to confirm, we assume removal of the fines from the sands will remove these low-level sulfides.

7 CONCLUSION & RECOMMENDATIONS

7.1 General

The objective of this report was to identify if PASS were present within the designated dredge zones associated with Stage 5 and assess the potential impacts of PASS on sensitive receptors / uses. As such Environmental Earth Sciences undertook *in-situ* and laboratory characterisation assessment of soils within the proposed area of sand extraction.

Field tests were generally undertaken at 0.25 m intervals along eh soil profile in each borehole, with laboratory analyses scheduled according to results of field testing.

Ground conditions assessed in the Stage 5A area typically comprised of sand overlying a thin band of sandy clay, then underlain by Latite bedrock. The Stage 5B area typically comprised sands with interbedded layers of shell, underlain by shelly clay from approximately 15 mBGL.

Groundwater was encountered in all boreholes advanced across the site at depths between 0.92 - 3.45 mBGL.

No observations of fine sediments (e.g. clays, silts, or estuarine muds) were made in shallow soil profiles at any location in the Stage 5A or Stage 5B areas. As sulphides typically reside in the finer grained sediments, this observation further reduces the risk for PASS present and furthermore having a potential to oxidise.

Based on the results of the investigation, soils between 3.25 - 4.00 mBGL in MW5A2 and soils between 1.25 - 4.00 mBGL in MW5A3 in the Stage 5A area were identified as moderate to high risk acid sulfate soils.

All soil samples analysed within the Stage 5B area were classified as NASS or NRNR. It is reasonable to extrapolate that a natural buffering capacity does exist across Stage 5B due to the presence of shell grit ($CaCO_3$) within sand deposits. To the north of the Latite outcrop which separates Stages 5A and 5B, the Stage 5A area is anticipated to have a somewhat lower buffering capacity in relation.

7.2 Mitigation measures

It is understood that the extracted sands will pass through a sluicing device whereby finer grained material (if present), will drain into the Stage 2 fines pond, reducing the risk of any localised finer grained sediments oxidising into PASS.

We recommend all sand be sluiced (or similarly screened) to remove the fines. This would also remove the PASS risk to the final commercial sand product intended for sale. It should be considered, however, that the presence of NASS and NRNR could still cause iron speckling in any cement render. Though testing is required to confirm this, Environmental Earth Sciences assumes removal of finer particles from the sands will reduce any sulphides that may be occurring at low-levels.

As dredging activities will see the majority of the water drain back into the dredge pond, there is low risk from the oxidation of potentially localised instances of PASS. Returning the water to the dredge pond also prevents a lowering the groundwater table.

This assessment did not encounter any other specific management considerations for PASS in the Stage 5A and 5B areas, however continual monitoring of pH is required during further works to confirm the classification and ensure that the procedures for any treatment or remediation of PASS is undertaken appropriately.

7.3 Acid sulfate soil management plan

Boral have requested that an Acid Sulfate Soil Management Plan (ASSMP) be prepared to establish to properly mitigate any health and environmental harm during material extraction / dredging within the Stage 5 area, with particular focus on the Stage 5A area (vicinity of samples 5A2 and 5A3 which reported a moderate-high PASS risk. This would allow a proactive monitoring regime to be employed so that early indications of acid generation could trigger appropriate management. The monitoring should proceed immediately prior, during and at the conclusion of dredging and filling activities.

The ASSMP is recommended to be prepared in accordance with Ahern, C R, Stone, Y, and Blunden, B (1998) – *Acid Sulfate Soils Management Guidelines*, Acid Sulfate Soil Management Advisory Committee NSW (August 1998).

8 LIMITATIONS

This report has been prepared by Environmental Earth Sciences NSW ABN 109 404 006 in response to and subject to the following limitations:

1. The specific instructions received from Element Environment on behalf of the client Boral Limited;

2. The specific scope of works set out in PO117066 issued by Environmental Earth Sciences for and on behalf of Element Environment;
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6. The report only relates to the site referred to in the scope of works being located at Boral Dunmore Sand & Soil - Stage 5, NSW
7. The report relates to the site as at the date of the report as conditions may change thereafter due to natural processes and/or site activities;
8. No warranty or guarantee is made in regard to any other use than as specified in the scope of works and only applies to the depth tested and reported in this report;
9. Fill, soil, groundwater and rock to the depth tested on the site may be fit for the use specified in this report. Unless it is expressly stated in this report, the fill, soil and/or rock may not be suitable for classification as clean fill if deposited off site; and
10. Our General Limitations set out at the back of the body of this report.

9 REFERENCES

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ENVIRONMENTAL EARTH SCIENCES GENERAL LIMITATIONS

Scope of services

The work presented in this report is Environmental Earth Sciences response to the specific scope of works requested by, planned with and approved by the client. It cannot be relied on by any other third party for any purpose except with our prior written consent. Client may distribute this report to other parties and in doing so warrants that the report is suitable for the purpose it was intended for. However, any party wishing to rely on this report should contact us to determine the suitability of this report for their specific purpose.

Data should not be separated from the report

A report is provided inclusive of all documentation sections, limitations, tables, figures and appendices and should not be provided or copied in part without all supporting documentation for any reason, because misinterpretation may occur.

Subsurface conditions change

Understanding an environmental study will reduce exposure to the risk of the presence of contaminated soil and or groundwater. However, contaminants may be present in areas that were not investigated, or may migrate to other areas. Analysis cannot cover every type of contaminant that could possibly be present. When combined with field observations, field measurements and professional judgement, this approach increases the probability of identifying contaminated soil and or groundwater. Under no circumstances can it be considered that these findings represent the actual condition of the site at all points.

Environmental studies identify actual sub-surface conditions only at those points where samples are taken, when they are taken. Actual conditions between sampling locations differ from those inferred because no professional, no matter how qualified, and no sub-surface exploration program, no matter how comprehensive, can reveal what is hidden below the ground surface. The actual interface between materials may be far more gradual or abrupt than an assessment indicates. Actual conditions in areas not sampled may differ from that predicted. Nothing can be done to prevent the unanticipated. However, steps can be taken to help minimize the impact. For this reason, site owners should retain our services.

Problems with interpretation by others

Advice and interpretation is provided on the basis that subsequent work will be undertaken by Environmental Earth Sciences NSW. This will identify variances, maintain consistency in how data is interpreted, conduct additional tests that may be necessary and recommend solutions to problems encountered on site. Other parties may misinterpret our work and we cannot be responsible for how the information in this report is used. If further data is collected or comes to light we reserve the right to alter their conclusions.

Obtain regulatory approval

The investigation and remediation of contaminated sites is a field in which legislation and interpretation of legislation is changing rapidly. Our interpretation of the investigation findings should not be taken to be that of any other party. When approval from a statutory authority is required for a project, that approval should be directly sought by the client.

Limit of liability

This study has been carried out to a particular scope of works at a specified site and should not be used for any other purpose. This report is provided on the condition that Environmental Earth Sciences NSW disclaims all liability to any person or entity other than the client in respect of anything done or omitted to be done and of the consequence of anything done or omitted to be done by any such person in reliance, whether in whole or in part, on the contents of this report. Furthermore, Environmental Earth Sciences NSW disclaims all liability in respect of anything done or omitted to be done and of the consequence of anything done or omitted to be done by the client, or any such person in reliance, whether in whole or any part of the contents of this report of all matters not stated in the brief outlined in Environmental Earth Sciences NSW's proposal number and according to Environmental Earth Sciences general terms and conditions and special terms and conditions for contaminated sites.

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FIGURES

0 1000

Scale in Metres

Source: © Google Maps

ENVIRONMENTAL EARTH SCIENCES
CONTAMINATION RESOLVED

Title:	**Site Locality Map**
Location:	**Boral Dunmore Sand and Soil - Stage 5**
Client:	**Element Environmental**
Job No:	**118044**
Project Man:	**EG**
Scale:	**As Shown**
Drawn By:	**LB**
Date:	**November 2018**
	Figure 1

Source: © NSW Globe 2018

LEGEND:

- Lot boundary
- Monitoring well location
- Latite

0 250

Scale in Metres

ENVIRONMENTAL EARTH SCIENCES
CONTAMINATION RESOLVED

Title:	**Site Layout and Borehole Locations**
Location:	**Boral Dunmore Sand and Soil - Stage 5**
Client: **Element Environmental**	Job No: **118044**
Project Man: **EG**	Scale: **As Shown**
Drawn By: **LB**	Date: **November 2018**
	Figure 2

TABLES

Table 10 Summary of laboratory acidity results

Sample ID (depth m BGL)	Texture Group[1]	pH_{KCl} (1:5)	pH_F (1:5)	pH_{FOX} (H_2O_2)	Potential Acidity (CRS)[1]	Actual Acidity (TAA)[1]	Buffering Capacity (ANC)[1]	Net acidity (NA)[1]	Risk Level
Criteria	1 - Sand	<5	<5	<2.5	1	1	-	3	
	2 - Clay	<5	<5	<2.5	2	2	-	6	
5A1_4.00	SAND	5.3	6.7	1.7	0.98	0.098	-	1.08	NASS
5A1_4.50	SAND	5.6	6.5	2.3	1.65	<0.049	-	1.70	NRNR
5A1_6.00	SAND	9.8	8.3	5.7	2.00	<0.049	74.97	-72.93	NRNR
5A1_7.00	SAND	9.4	8.3	5.6	8.87	<0.049	95.45	-86.53	NRNR
5A1_7.50	Clayey SAND	7.0	8.7	5.7	0.21	<0.049	1.18	-0.91	NASS
5A2_3.25	SAND	5.1	5.7	2.0	8.01	0.343	0.19	8.16	Moderate Risk
5A2_3.75	SAND	5.1	5.8	1.8	7.03	0.343	1.59	5.81	Moderate Risk
5A2_4.00	SAND	4.5	6.0	1.8	19.30	0.931	0.19	20.00	High Risk
5A2_5.00	Clayey SAND	5.3	5.8	2.2	0.28	0.147	-	0.422	NASS
5A2_6.00	Clayey SAND	5.3	5.6	4.6	0.31	0.294	-	0.60	NASS
5A3_1.25	SAND	5.1	5.8	1.9	12.33	0.49	0.69	12.13	High Risk
5A3_1.75	SAND	5.0	4.8	1.9	7.89	0.441	0.88	7.45	Moderate Risk
5A3_2.75	SAND	5.6	5.8	2.0	8.93	0.049	1.67	7.45	Moderate Risk
5A3_4.00	SAND	5.4	7.5	1.9	7.43	0.098	2.16	5.37	Moderate Risk
5A3_5.75	SAND	6.2	8.2	2.3	2.69	<0.049	-	2.74	NRNR
5A3_7.00	SAND	5.4	7.6	2.1	2.66	0.098	-	2.7	NRNR
5A3_8.75	SAND	6.0	6.0	2.3	2.20	<0.049	-	2.25	NRNR
5A3_9.50	SAND	5.8	6.0	2.2	2.02	<0.049	-	2.06	NRNR
5A3_12.50	CLAY	7.9	8.2	2.4	1.93	<0.049	10.49	-8.51	NRNR
5B1_1.00	SAND	5.5	8.0	4.6	0.10	0.098	-	0.17	NASS
5B1_3.50	SAND	9.6	9.4	6.2	6.18	<0.049	445.90	-439.7	NRNR
5B1_4.25	SAND	9.7	9.4	6.2	5.02	<0.049	261.66	-256.59	NRNR
5B1_7.00	SAND	8.6	8.8	6.2	0.28	<0.049	5.00	-4.67	NASS

Sample ID (depth m BGL)	Texture Group[1]	pH_{KCl} (1:5)	pH_F (1:5)	pH_{FOX} (H_2O_2)	Potential Acidity (CRS)[1]	Actual Acidity (TAA)[1]	Buffering Capacity (ANC)[1]	Net acidity (NA)[1]	Risk Level
Criteria	1 - Sand	<5	<5	<2.5	1	1	-	3	
	2 - Clay	<5	<5	<2.5	2	2	-	6	
5B2_1.75	SAND	7.3	5.8	5.2	0.25	<0.049	0.49	-0.19	NASS
5B2_3.00	SAND	9.7	8.0	6.3	0.28	<0.049	205.80	-205.5	NASS
5B2_5.00	SAND	9.7	9.0	6.6	3.30	<0.049	175.42	-172.1	NRNR
5B2_6.00	SAND	9.7	9.4	6.5	4.59	<0.049	351.82	-347.2	NRNR
5B2_7.25	SAND	9.4	9.0	5.7	9.45	<0.049	428.26	-419	NRNR
5B2_8.50	SAND	9.6	9.1	6.2	4.34	<0.049	180.32	-175.9	NRNR
5B2_9.25	SAND	9.7	8.7	6.2	4.01	<0.049	52.23	-48.18	NRNR
5B2_10.75	Clayey SAND	9.1	9.0	6.9	19.91	<0.049	102.90	-82.94	NRNR
5B2_12.00	Clayey SAND	9.2	9.4	5.9	7.46	<0.049	26.17	-18.653	NRNR
5B2_14.50	Clayey SAND	8.9	9.3	2.6	9.05	<0.049	31.95	-22.84	NRNR
5B2_15.00	Clayey SAND	8.9	9.4	6.4	0.64	<0.049	223.44	-222.75	NASS
5B3_2.00	SAND	9.7	8.0	6.2	3.06	<0.049	392.98	-389.9	NRNR
5B3_3.25	SAND	9.3	8.0	6.1	6.70	<0.049	207.76	-201	NRNR
5B3_4.00	SAND	9.7	8.6	6.0	4.04	<0.049	114.66	-110.6	NRNR
5B3_7.25	SAND	9.5	8.8	5.8	7.07	<0.049	447.86	-440.7	NRNR
5B3_7.75	SAND	9.6	9.0	5.8	2.91	<0.049	32.34	-29.4	NRNR
5B3_10.00	SAND	9.6	9.2	6.0	3.92	<0.049	43.71	-39.74	NRNR
5B3_12.25	Clayey SAND	9.1	9.4	5.9	1.22	<0.049	7.64	-6.37	NRNR
5B3_14.00	Clayey SAND	7.3	8.4	5.4	1.41	<0.049	6.86	-5.40	NASS
5B4_1.50	SAND	9.8	9.0	5.9	0.08	<0.049	161.70	-161.58	NASS
5B4_2.00	SAND	9.8	8.8	5.8	0.86	<0.049	223.44	-222.53	NASS
5B4_3.25	SAND	9.8	8.5	5.7	1.93	<0.049	206.78	-204.8	NRNR
5B4_4.50	SAND	9.8	8.6	6.1	1.59	<0.049	103.88	-102.24	NRNR
5B4_5.25	SAND	9.4	8.3	6.6	10.46	<0.049	540.96	-530.44	NRNR
5B4_6.50	Clayey SAND	9.0	8.5	5.9	2.81	<0.049	16.268	-13.40	NRNR

Sample ID (depth m BGL)	Texture Group[1]	pH_{KCl} (1:5)	pH_F (1:5)	pH_{FOX} (H_2O_2)	Potential Acidity (CRS)[1]	Actual Acidity (TAA)[1]	Buffering Capacity (ANC)[1]	Net acidity (NA)[1]	Risk Level
Criteria	1 - Sand	<5	<5	<2.5	1	1	-	3	
	2 - Clay	<5	<5	<2.5	2	2	-	6	
5B4_7.25	Clayey SAND	8.3	8.5	5.8	0.15	<0.049	7.056	-6.85	NASS
5B4_8.25	Clayey SAND	6.4	8.5	5.6	0.08	<0.049	-	0.13	NASS

Notes:

1. Texture groups are: 1. Coarse: sand; 2. Medium: loams/silt-light clay; this has been taken to include 'clayey sand'
2. As kg H_2SO_4 per tonne of soil
3. NASS indicates Not Acid Sulfate Soils; NRNR indicates No Risk – Non-Reactive;
4. Shaded cells indicate exceeds criteria; shaded and bold cells indicate Moderate or High Risk (requires management if disturbed); and
5. – indicates no data available.

APPENDIX A SOIL LANDSCAPE REPORTS

mc MANGROVE CREEK

Landscape—vegetated tidal flats in estuarine areas on Holocene sediments. Relief <3 m. Slopes <3%. Mangrove open-scrub, saltmarsh herbland, sedgeland and low open-forest.

Soils—deep (>150 cm) Siliceous Sands (Uc1.21) and Calcareous Sands (Uc1.11) and Solonchaks (Uc1.11) occur on mangrove flats. Humic Gley Soils (Uc4.53) and Solonchaks (Uc1.11) occur on saltmarshes.

Limitations—regular tidal flooding and waterlogging, saline soil, very low soil fertility.

LOCATION

Vegetated tidal flats in estuarine areas on Holocene sediments on the Coastal Plain. Examples occur at Mangrove Island, Minnamurra River and Crookhaven River and Greenwell Point.

LANDSCAPE

Geology

Holocene sediments—silty to peaty quartz sand, silt and clay. Common shell layers in sandy mud and muddy sand.

Topography

Local relief <3 m and slopes <3%. These tidal flats and creeks in coastal inlets and estuaries are regularly inundated by brackish tidal waters. Four shore parallel zones are recognised, each zone with a different drainage and inundation pattern. At the lowest elevation is the mudflat zone. In order of increasing elevation are the mangrove zone, the saltmarsh zone and littoral forest zone. Minor differences in topography often result in a mosaic of zones.

The mudflat zone is inundated except at low tide. It is characterised by rapidly migrating, shallow (<70 cm), non-directional, meandering channels with reversible flows which widen rapidly in the downstream direction.

The mangrove zone is inundated only during high tide, and the saltmarshes are inundated only during spring flood tides. These zones have non-directional, often interrupted drainage. The forest zone is rarely flooded and has interrupted or absent drainage. Clarke and Hannon (1967, 1969, 1970 and 1971) have described the plant ecology of tidal flat communities.

Vegetation

Mainly open-scrub where the common species are grey mangrove (*Avicennia marina*), river mangrove (*Aegiceras corniculatum*) and scattered decorative paperbark (*Melaleuca decora*).

Shoreward of the mangroves the low open-forest is dominated by swamp oak (*Casuarina glauca*) and less commonly swamp mahogany (*Eucalyptus robusta*), forest red gum (*Eucalyptus tereticornis*) and bangalay (*Eucalyptus botryoides*). This open-forest often has an understorey of sand couch (*Sporobolus virginicus*).

Saltmarsh is found in areas less frequently inundated. Common species of saltmarsh include sea-blite (*Suaeda australis*), glasswort (*Salicornia quinqueflora*), sand couch (*Sporobolus virginicus*), streaked arrowgrass (*Triglochin striata*) and sea rush (*Juncus kraussi*).

Land Use

Mangroves and saltmarshes are recognised as important breeding areas for commercial fish and crustaceans (West 1985) and for some species of water birds. Oyster leases are located on the seaward edges of tidal flats at Minnamurra and Greenwell Point.

Existing Erosion

There is little appreciable erosion. Minor wave erosion is caused by powerboats (Scholar 1974). Sediments eroded from surrounding catchments are often deposited on this unit, enlarging the mangrove communities (West 1985).

SOILS

Dominant Soils Materials

mc1—Greasy smelly organic mottled dark brown silty loam (topsoil)

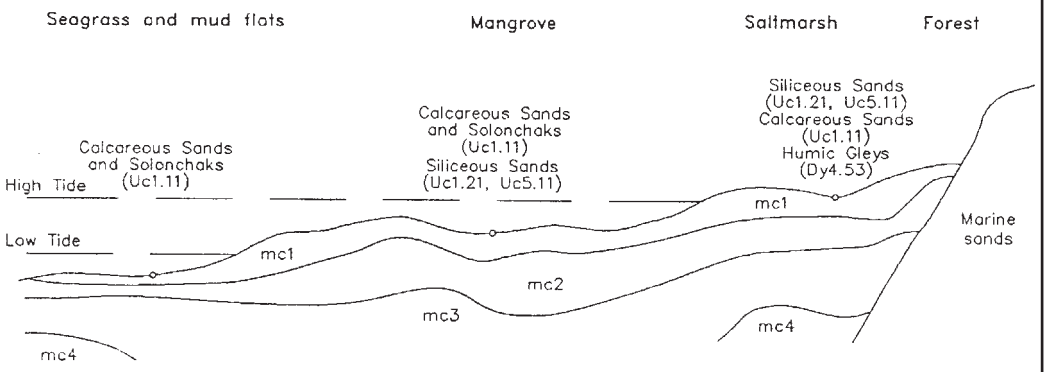
Colour	dark brown (10YR 3/3) to yellowish grey (2.5Y 4/1) with dark red mottles (50%)
Texture	silty loam
Structure	apedal massive
Fabric	earthy
pH	7.0–8.5
Stones	nil
Roots	nil

mc2—Shelly organic black sandy loam (subsoil)

Colour	black (10YR 2/1) to dull yellowish brown (10YR 4/3)
Texture	sandy loam
Structure	apedal massive
Fabric	sandy
pH	5.0–8.5
Stones	nil
Roots	common

mc3—Shelly greyish yellow sand (subsoil)

Colour	dark greyish yellow
Texture	sand
Structure	apedal single-grained
Fabric	sandy
pH	6.5–9.0
Stones	quartz pebbles common
Roots	rare



■ ***Schematic cross-section of Mangrove Creek soil landscape illustrating the occurrence and relationship of the dominant soil materials.***

mc4—Gleyed mottled sandy clay (subsoil)

Colour	grey (5Y 5/1) with orange brown mottles (40%)
Texture	sandy clay
Structure	apedal massive
Fabric	sandy
pH	7.5–9.0
Stones	nil
Roots	rare

Associated Soil Materials

Charcoal Sands. Up to 80% charcoal fragments within a sandy loam matrix

Midden Materials. Large quantities of oyster and other mollusc shells occur in the soil materials. These are Aboriginal sites and should not be disturbed.

Occurrence and Relationships

Mangrove Flats. Up to 30 cm greasy smelly organic mottled dark brown silty loam **(mc1)** overlies <50 cm shelly organic black sandy loam **(mc2)** and >100 cm shelly greyish yellow sand **(mc3).** The boundaries are gradual to diffuse [Siliceous Sands (Uc1.21, Uc5.11), Calcareous Sands (Uc1.11) and Solonchaks (Uc1.11)]. Total soil depth is >200 cm.

Saltmarshes. Up to 20 cm **mc1** overlies <20 cm **mc2** and <50 cm **mc3** which in turn overlies >200 cm gleyed mottled sandy clay **(mc4).** Boundaries are gradual to diffuse [Humic Gley Soils (Uc4.53) and Calcareous Sands (Uc1.11)]. Total soil depth is >300 cm.

LIMITATIONS TO DEVELOPMENT

Soil Limitations

mc1 Low wet bearing strength
Strongly saline
Low permeability
High organic matter
Very low fertility
Acid sulphate potential
Strongly sodic

mc2 High organic matter
Strongly sodic
Strongly saline
Low wet bearing strength
Very low fertility
Very strongly acid
Acid sulphate potential
Potential aluminium toxicity

mc3 High organic matter
Strongly saline
Strongly sodic
Very low fertility
Strongly acid
Acid sulphate potential
Low wet bearing strength

mc4 Low wet bearing strength
Strongly saline
Strongly sodic
Low permeability
Low available water-holding capacity
Low fertility
Acid sulphate potential
Moderately alkaline

Fertility

The general fertility is very low. The soil materials are strongly saline and are frequently inundated by tidal waters. These soils should not be drained as this will result in organic sulphur compounds being oxidised. The sulphuric acid produced results in the soils becoming extremely acid.

Erodibility

mc1 and **mc2** have very low erodibility. They consist of sands strongly bound by abundant organic fibrous matter. **mc3** has very low erodibility consisting predominantly of well-drained coarse sands. **mc4** has a moderate erodibility as it has a low organic matter content and consists of fine and coarse sand grains imbedded in a clay matrix. **mc4** clays are highly dispersible in freshwater, where they are highly erodible.

Erosion Hazard

The erosion hazard for non-concentrated flows is low. Calculated soil loss for the first 12 months of urban development ranges up to 10 t/ha of topsoil and 20 t/ha of exposed subsoil. The erosion hazard for wave and concentrated flows is also low.

Surface Movement Potential

These materials become highly reactive following draining and leaching. Both drained *in situ* material and deposited fill composed of these materials should be tested to determine surface movement potential prior to construction.

Landscape Limitations

Flood hazard
Waterlogging
Permanently high watertable
Wave erosion hazard

Urban Capability

Generally high to severe limitations for urban development.

Rural Capability

Generally high to severe limitations for regular cultivation and grazing.

APPENDIX B CALIBRATION CERTIFICATES

ENVIRONMENTAL EARTH SCIENCES
THE KNOW AND THE HOW

Equipment Calibration Record – Hanna pH

This equipment calibration record is to be stored in your job folder

Equipment Type: Hanna pH HI9025

Equipment Number: _____

Date Calibrated: 11/9/18

Calibrated By: LV (name)

Job Number: 118044

Details of Calibration:

Electrode Checked (Condition): _____

pH at 4.01 Reading: 4.0

pH at 7.01 Reading: 7.0

pH at 6.88 Reading: _____

ENVIRONMENTAL EARTH SCIENCES
THE KNOW AND THE HOW

Equipment Calibration Record – Hanna pH

This equipment calibration record is to be stored in your job folder

Equipment Type: Hanna pH HI9025

Equipment Number: _____

Date Calibrated: 11/7/18

Calibrated By: _____ (name)

Job Number: 109046

Details of Calibration:

Electrode Checked (Condition): _____

pH at 4.01 Reading: 4.0

pH at 7.01 Reading: 7.0

pH at 6.88 Reading: _____

ENVIRONMENTAL
EARTH SCIENCES
THE KNOW AND THE HOW

Equipment Calibration Record – Hanna pH

This equipment calibration record is to be stored in your job folder

Equipment Type: Hanna pH HI9025

Equipment Number: _____

Date Calibrated: 11/7/18

Calibrated By: CW (name)

Job Number: CC8044

Details of Calibration:

Electrode Checked (Condition): _____

pH at 4.01 Reading: 4.0

pH at 7.01 Reading: 7.0

pH at 6.88 Reading: _____

ENVIRONMENTAL EARTH SCIENCES
THE KNOW AND THE HOW

Equipment Calibration Record – Hanna pH

This equipment calibration record is to be stored in your job folder

Equipment Type: Hanna pH HI9025

Equipment Number: _____

Date Calibrated: 17/07/18

Calibrated By: NE (name)

Job Number: 118044

Details of Calibration:

Electrode Checked (Condition): _____

pH at 4.01 Reading: 4.0

pH at 7.01 Reading: 7.0

pH at 6.88 Reading: _____

ENVIRONMENTAL EARTH SCIENCES
THE KNOW AND THE HOW

Equipment Calibration Record – Hanna pH

This equipment calibration record is to be stored in your job folder

Equipment Type: Hanna pH HI9025

Equipment Number: _____

Date Calibrated: 17/07/18

Calibrated By: NE (name)

Job Number: 118044

Details of Calibration:

Electrode Checked (Condition): _____

pH at 4.01 Reading: 4.0

pH at 7.01 Reading: 7.0

pH at 6.88 Reading: _____

ENVIRONMENTAL
EARTH SCIENCES
THE KNOW AND THE HOW

Equipment Calibration Record – Hanna pH

This equipment calibration record is to be stored in your job folder

Equipment Type: Hanna pH HI9025

Equipment Number: _____

Date Calibrated: 18/07/18

Calibrated By: NE (name)

Job Number: 118044

Details of Calibration:

Electrode Checked (Condition): _____

pH at 4.01 Reading: 4.0

pH at 7.01 Reading: 7.0

pH at 6.88 Reading: _____

ENVIRONMENTAL EARTH SCIENCES
THE KNOW AND THE HOW

Equipment Calibration Record – Hanna pH

This equipment calibration record is to be stored in your job folder

Equipment Type: Hanna pH HI9025

Equipment Number: _____

Date Calibrated: 18/07/18

Calibrated By: NE (name)

Job Number: 118044

Details of Calibration:

Electrode Checked (Condition): _____

pH at 4.01 Reading: 4.0

pH at 7.01 Reading: 7.0

pH at 6.88 Reading: _____

ENVIRONMENTAL EARTH SCIENCES
THE KNOW AND THE HOW

Equipment Calibration Record – Hanna pH

This equipment calibration record is to be stored in your job folder

Equipment Type: Hanna pH HI9025

Equipment Number: _____

Date Calibrated: 19/07/18

Calibrated By: NE (name)

Job Number: 118044

Details of Calibration:

Electrode Checked (Condition): _____

pH at 4.01 Reading: 4.0

pH at 7.01 Reading: 7.0

pH at 6.88 Reading: _____

APPENDIX C GEOLOGICAL BORELOGS

Geological Borelog

ENVIRONMENTAL EARTH SCIENCES
CONTAMINATION RESOLVED

LOCATION: Dunmore Sand and Soil - Stage 5		Borehole Log: MW5A1	Logged by: LV
SURFACE ELEVATION:	JOB NUMBER: 118044		
GROUNDWATER: 3.45m BGL	DATUM:	PROJECT: Dunmore	Proj. Manager: LV
DRILL METHOD: sonic drill	DATE DRILLED: 11/07/18		

STRATIGRAPHY	GRAPHIC LOG	Depth metres	Sample Depth	Moisture Content	PID/FID Background	PID/FID Reading	pH - soil	pH - water	Construction Details	Comments
NATURAL Loose, light brown/grey, medium grained SAND.		0.5		DM					Concrete Bentonite	
NATURAL Loose, brown, medium to fine grained SAND.		1.0		DM						
NATURAL Loose, cream, medium to fine grained SAND.		1.5 2.0 2.5							Casing	
NATURAL Loose, cream medium to fine grained SAND.		3.0		DM						
NATURAL Loose, brown, medium to fine grained, silty SAND.		3.5		M M						SWL at 3.45mBGL Roots and organic plant matter.
NATURAL Loose, cream, medium to fine grained, silty SAND.				M						
NATURAL Loose, brownish grey, medium to coarse grained, SAND.		4.0 4.5 5.0		M					Screen	

NOTE: This bore log is for environmental purposes only and is not intended to provide geotechnical information.

Geological Borelog

ENVIRONMENTAL EARTH SCIENCES
CONTAMINATION RESOLVED

LOCATION: Dunmore Sand and Soil - Stage 5		Borehole Log: MW5A1	Logged by: LV
SURFACE ELEVATION:	JOB NUMBER: 118044		
GROUNDWATER: 3.45m BGL	DATUM:	PROJECT: Dunmore	Proj. Manager: LV
DRILL METHOD: sonic drill	DATE DRILLED: 11/07/18		

STRATIGRAPHY	GRAPHIC LOG	Depth metres	Sample Depth	Moisture Content	PID/FID Background	PID/FID Reading	pH - soil	pH - water	Construction Details	Comments
NATURAL Loose, grey, fine to medium grained, SAND, fine shell grit throughout.		5.5 6.0		M						Sulfuric odour
NATURAL Loose, grey, fine to medium grained, SAND, fine shell grit throughout.		6.5 7.0		M						
NATURAL Loose, grey, coarse, SAND, coarse shell grit and organic plant matter.										Weathered bedrock?
NATURAL Firm, brown/grey,fine to medium grained, clayey SAND, no shells.		7.5 8.0		M					Bentonite Plug	
NATURAL Firm, grey/brown, fine to medium grained, clayey SAND, no shells.		8.5		M					Backfill	
NATURAL Firm, grey, fine grained, sandy CLAY, no shells.		9.0		M						
End of hole		9.5 10.0								

NOTE: This bore log is for environmental purposes only and is not intended to provide geotechnical information.

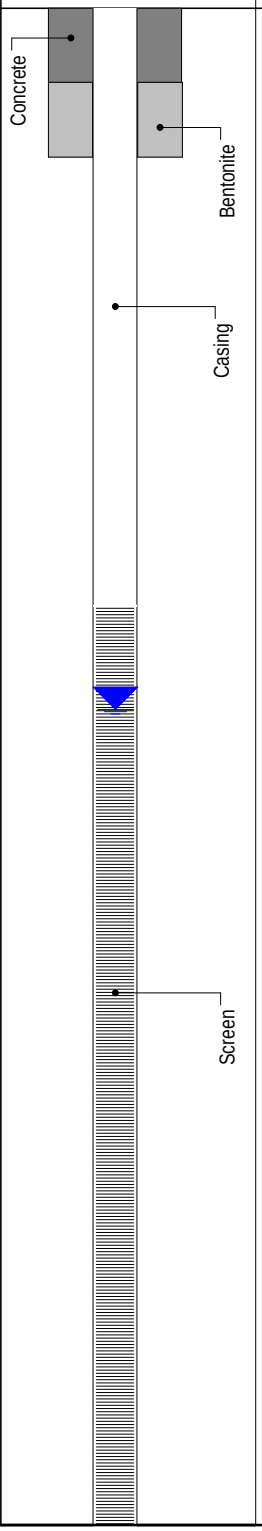
Geological Borelog

ENVIRONMENTAL EARTH SCIENCES
CONTAMINATION RESOLVED

LOCATION: Dunmore Sand and Soil Stage 5		Borehole Log: MW5A2	Logged by: LV
SURFACE ELEVATION:	JOB NUMBER: 118044		
GROUNDWATER: 2.35 mBGL	DATUM:	PROJECT: Dunmore	Proj. Manager: LV
DRILL METHOD: sonic drill	DATE DRILLED: 11/07/18		

STRATIGRAPHY	Depth metres	Sample Depth	Moisture Content	PID/FID Background	PID/FID Reading	pH - soil	pH - water	Comments
FILL/REWORKED NATURAL Firm, dark brown, sandy CLAY, with gravels and latite cobble, plant matter (roots).	0.5		DM			6.4	5.8	Latite and clay fallen from hill weathered surface?
NATURAL Loose, dark brown, fine to medium grained, silty SAND.	1.0		DM			6.5 6.6	5.6 5.6	
NATURAL Loose, dark grey/brown, fine to medium grained, silty SAND.	1.5		DM			6.6 6.5 6.7	5.7 5.4 5.8	
NATURAL Loose, grey/brown, fine to medium grained, SAND.	2.0		M			6.8 6.8	5.7 5.8 5.6	Water level at 2.35 mBGL
NATURAL Loose, grey, medium grained, SAND.	2.5		M			6.9 6.8	5.6 5.6	
NATURAL Loose, dark grey, medium grained, SAND.	3.0		M			6.8 6.9 6.7	5.6 6.8 5.1	
NATURAL Loose, dark grey, medium grained, SAND, 25 % sub-angular gravel, cobble, rounded gravel.	3.5 4.0		M			6.7 6.7 6.4	5.3 1.7 2.4	Alluvium? Paleochannel?
NATURAL Loose, grey/brown fine to medium grained, SAND.	4.5 5.0		M			6.5 6.6 7.3	2.3 5.1 6	

Construction Details



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Geological Borelog

ENVIRONMENTAL EARTH SCIENCES
CONTAMINATION RESOLVED

LOCATION: Dunmore Sand and Soil Stage 5		Borehole Log: MW5A2	Logged by: LV
SURFACE ELEVATION:	JOB NUMBER: 118044		
GROUNDWATER: 2.35 mBGL	DATUM:	PROJECT: Dunmore	Proj. Manager: LV
DRILL METHOD: sonic drill	DATE DRILLED: 11/07/18		

STRATIGRAPHY	GRAPHIC LOG	Depth metres	Sample Depth	Moisture Content	PID/FID Background	PID/FID Reading	pH - soil	pH - water	Construction Details	Comments
NATURAL Firm, brown/grey, clayey SAND, no shells				M			7.7	5.7		Weathered bedrock
Becoming grey.		5.5					7.9	6		
							8	5.9		
		6.0					8.3	5.7		
NATURAL Very dense, grey, CLAY.				M			7.9	5.8	Bentonite	End of well at 6 mBGL
		6.5					8	5.8		Weathered bedrock, extremely hard, difficult to cut/sample.
							8.3	5.6		
		7.0					8.5	5.6		
							8.6	5.6		
		7.5					8.7	5.7	Backfill	
							8.4	5.7		
		8.0					8.4	5.6		
							8.3	5.8		
		8.5					8.2	5.8		
							8.2	5.9		
		9.0					8.1	5.8		
End of hole @ 9m (Latite)										
		9.5								
		10.0								

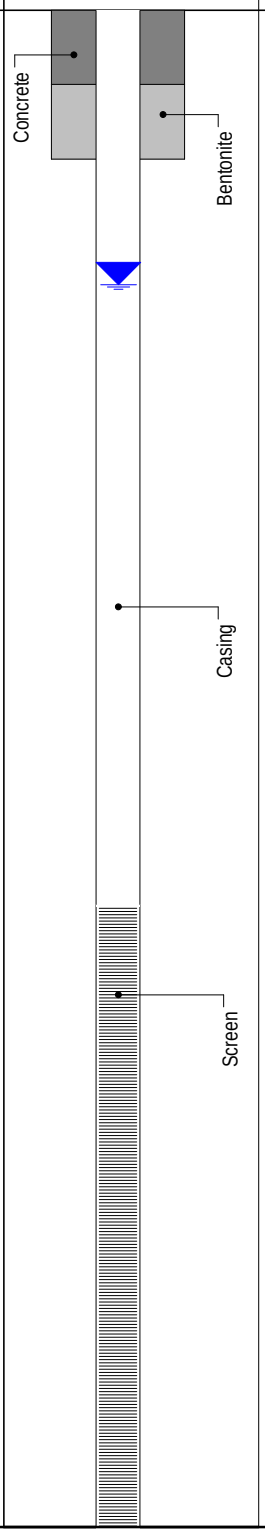
NOTE: This bore log is for environmental purposes only and is not intended to provide geotechnical information.

Geological Borelog

ENVIRONMENTAL EARTH SCIENCES
CONTAMINATION RESOLVED

LOCATION: Dunmore Sand and Soil Stage 5		Borehole Log: MW5A3	Logged by: LV
SURFACE ELEVATION:	JOB NUMBER: 118044		
GROUNDWATER: 0.92 mBGL	DATUM:	PROJECT: Dunmore	Proj. Manager: LV
DRILL METHOD: sonic drill	DATE DRILLED: 11/07/18		

STRATIGRAPHY	GRAPHIC LOG	Depth metres	Sample Depth	Moisture Content	PID/FID Background	PID/FID Reading	pH - soil	pH - water	Construction Details	Comments
NATURAL Loose, dark brown, fine to medium grained, silty SAND, with roots and plant matter.		0.5		DM			6.8	4.6		
NATURAL Loose, light brown, medium grained, SAND.		1.0		DM			6.3	4.1		
NATURAL Loose, dark grey, medium grained, SAND.		1.5		M			5.9	4.4		SWL
		2.0					5.9	4		
		2.5					5.8	1.9		
		3.0					5.5	2		
		3.5					4.8	1.9		
NATURAL Becoming, fine to medium grained SAND.		4.0		M			5.3	2		
		4.5					5.3	2		
NATURAL Becoming, medium grained SAND.		5.0		M			5.5	2		
								2		
							5.6	2.1		
							7.3	2.1		
							7.2	1.8		
							7.2	1.9		
							7.5	1.9		
							7	1.9		
								1.8		
							7.1	1.8		
							7	5.5		



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Geological Borelog

ENVIRONMENTAL EARTH SCIENCES
CONTAMINATION RESOLVED

LOCATION: Dunmore Sand and Soil Stage 5		Borehole Log: MW5A3	Logged by: LV
SURFACE ELEVATION:	JOB NUMBER: 118044		
GROUNDWATER: 0.92 mBGL	DATUM:	PROJECT: Dunmore	Proj. Manager: LV
DRILL METHOD: sonic drill	DATE DRILLED: 11/07/18		

STRATIGRAPHY	GRAPHIC LOG	Depth metres	Sample Depth	Moisture Content	PID/FID Background	PID/FID Reading	pH - soil	pH - water	Construction Details	Comments
NATURAL Loose, dark grey, medium grained, SAND with very coarse shell grit (75%).				M			7.6	6.9		
		5.5					7.9	2.3		
NATURAL Loose, dark grey, medium to coarse grained, SAND.				M			8.2	2.3		
		6.0					7.9	2.2		
NATURAL Loose, fawn, medium grained, SAND. some fawn/sandy clay (10%).				M			7.9	2.4		
		6.5					7.9	2.2		
							7.7	2.2		
		7.0					7.6	2.1		
NATURAL Loose, fawn/grey, medium grained, SAND.				M			7.8	3.9		Sandy clay lense <5cm @7.25 mBGL
		7.5					7.7	2.3		
							7.7	2.2		
		8.0					7.3	2.2		
NATURAL Loose, grey, medium grained, SAND.				M			6.7	2.4		
		8.5					6	2.2		
							6	2.3		
		9.0					6	2.3		
		9.5					6	2.2		
		10.0					6	2.3		

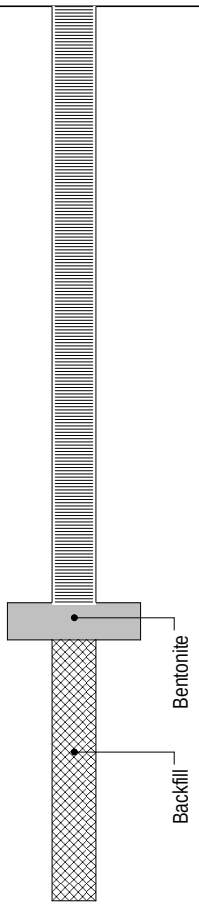
NOTE: This bore log is for environmental purposes only and is not intended to provide geotechnical information.

Geological Borelog

ENVIRONMENTAL EARTH SCIENCES
CONTAMINATION RESOLVED

LOCATION: Dunmore Sand and Soil Stage 5		Borehole Log: MW5A3	Logged by: LV
SURFACE ELEVATION:	JOB NUMBER: 118044		
GROUNDWATER: 0.92 mBGL	DATUM:	PROJECT: Dunmore	Proj. Manager: LV
DRILL METHOD: sonic drill	DATE DRILLED: 11/07/18		

STRATIGRAPHY	GRAPHIC LOG	Depth metres	Sample Depth	Moisture Content	PID/FID Background	PID/FID Reading	pH - soil	pH - water	Construction Details	Comments
		10.5					6.7	3.5		
		11.0					6.3	4.4		
		11.5					6.9	6.3		
		12.0					7	6.6		
NATURAL Loose, grey, medium grained, SAND, very coarse shell grit (90%).				M			8.6	8.1		
NATURAL Firm, grey, CLAY. No shells.		12.5		D			8.2	2.4		Assumed Weathered bedrock until end of hole
End of hole @ 13m (Refusal on Latite)		13.0								
		13.5								
		14.0								
		14.5								
		15.0								



NOTE: This bore log is for environmental purposes only and is not intended to provide geotechnical information.

Geological Borelog

ENVIRONMENTAL EARTH SCIENCES
CONTAMINATION RESOLVED

LOCATION: Dunmore Sand and Soil - Stage 5		Borehole Log: MW5B1	Logged by: LV
SURFACE ELEVATION:	JOB NUMBER: 118044		
GROUNDWATER: 2.45 mBGL	DATUM:	PROJECT: Dunmore	Proj. Manager: LV
DRILL METHOD: sonic drill	DATE DRILLED: 12/07/18		

STRATIGRAPHY	GRAPHIC LOG	Depth metres	Sample Depth	Moisture Content	PID/FID Background	PID/FID Reading	pH - soil	pH - water	Construction Details	Comments
NATURAL Loose, dark brown/grey, silty SAND, with roots.				D			8.8		Cement, Bentonite, Casing, Screen	
NATURAL Loose, grey/brown, medium grained, SAND.		0.5		D			8.7			
							5.2			
NATURAL Loose, dark brown, fine to medium grained, silty SAND.		1.0		DM			8			
		1.5					7.4			
							7.3			
							6.9			
NATURAL Loose, brown, fine to medium grained, silty SAND.		2.0		M			6.8			
							6.6			
		2.5					6.6			SWL
							6.4			
NATURAL Loose, grey, fine grained, SAND, with shell grit throughout.		3.0		M			6.4			
							8.9			
		3.5					9.4			
							7.1			
		4.0					8.8			
							9.4			
		4.5					9.4			
							9.3			
		5.0					9.1			

NOTE: This bore log is for environmental purposes only and is not intended to provide geotechnical information.

Geological Borelog

ENVIRONMENTAL EARTH SCIENCES
CONTAMINATION RESOLVED

LOCATION: Dunmore Sand and Soil - Stage 5		Borehole Log: MW5B1	Logged by: LV
SURFACE ELEVATION:	JOB NUMBER: 118044		
GROUNDWATER: 2.45 mBGL	DATUM:	PROJECT: Dunmore	Proj. Manager: LV
DRILL METHOD: sonic drill	DATE DRILLED: 12/07/18		

STRATIGRAPHY	GRAPHIC LOG	Depth metres	Sample Depth	Moisture Content	PID/FID Background	PID/FID Reading	pH - soil	pH - water	Construction Details	Comments
							9.1			
		5.5					9			
Shell grit increasing from medium to coarse.				M			9			
		6.0					8.9			
NATURAL Firm, grey, clayey, fine grained SAND, no shells. Extremely weathered bedrock.				D			8.9		Bentonite	Assumed extremely weathered bedrock until end of hole.
		6.5					8.9			
							8.9			
		7.0					8.8		Backfill	
							-			
		7.5					8.5			
							8.5			
		8.0					8.9			
		8.5								
NATURAL Latitie.				D						
		9.0								
End of hole @ 9m (Refusal on latite)										
		9.5								
		10.0								

NOTE: This bore log is for environmental purposes only and is not intended to provide geotechnical information.

Geological Borelog

ENVIRONMENTAL EARTH SCIENCES
CONTAMINATION RESOLVED

LOCATION: Dunmore Sand and Soil - Stage 5		Borehole Log: MW5B2	Logged by: LV
SURFACE ELEVATION:	JOB NUMBER: 118044		
GROUNDWATER: 2.7 mBGL	DATUM:	PROJECT: Dunmore	Proj. Manager: LV
DRILL METHOD: sonic drill	DATE DRILLED: 12/07/18		

STRATIGRAPHY	GRAPHIC LOG	Depth metres	Sample Depth	Moisture Content	PID/FID Background	PID/FID Reading	pH - soil	pH - water	Construction Details	Comments
NATURAL becoming fawn in colour.				D			6.6	3.3	Cement	
		0.5		D			6.2	4.4	Bentonite	
NATURAL Loose, brown, medium grained, silty SAND.							5.9	4.1		
		1.0		DM			5.6	4.6	Casing of deep groundwater bore	
NATURAL Loose, brown, medium grained, SAND. Becoming lighter in colour.							5.9	4.8	Casing of shallow groundwater bore	
		1.5					5.8	5.3		
							5.8	5.2		
		2.0		M			5.8	5.3		
NATURAL becoming fawn in colour.							5.8	5.5		
		2.5		M			5.8	5.7	Screen	
NATURAL Loose, grey, fine to medium grained, SAND, with very fine grained shell grit throughout.							7	6.3		SWL
		3.0					8			
							8.5	6.6		
		3.5					8.9	7		
shell grit becoming fine to medium grained							8.8	6.7		
		4.0					9	6.6		
becoming dark grey in colour							8.8	6.8		
		4.5					8.9	6.6		
							8.8	6.5		
		5.0					9	6.6		

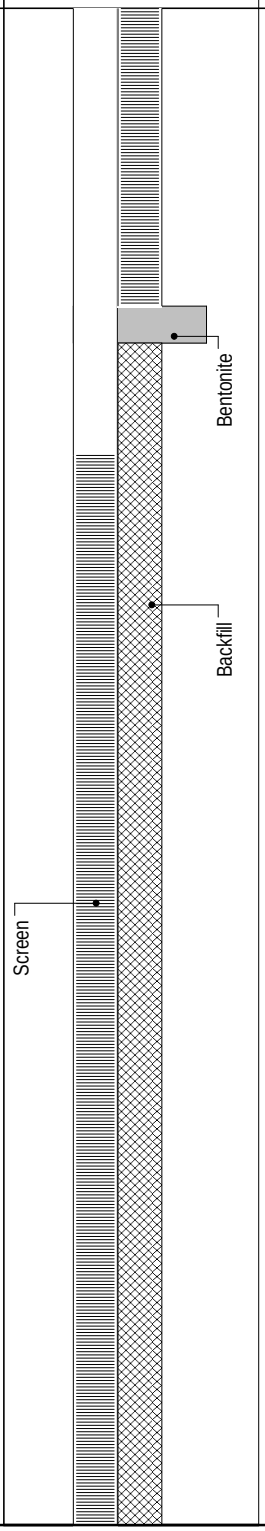
NOTE: This bore log is for environmental purposes only and is not intended to provide geotechnical information.

Geological Borelog

ENVIRONMENTAL EARTH SCIENCES
CONTAMINATION RESOLVED

LOCATION: Dunmore Sand and Soil - Stage 5		Borehole Log: MW5B2	Logged by: LV
SURFACE ELEVATION:	JOB NUMBER: 118044		
GROUNDWATER: 2.7 mBGL	DATUM:	PROJECT: Dunmore	Proj. Manager: LV
DRILL METHOD: sonic drill	DATE DRILLED: 12/07/18		

STRATIGRAPHY	GRAPHIC LOG	Depth metres	Sample Depth	Moisture Content	PID/FID Background	PID/FID Reading	pH - soil	pH - water	Construction Details	Comments
intact shell pieces							8.9	6.8		
		5.5					9	6.6		
							9	6.4		
		6.0					9.4	6.5		
							9.2	6.6		
		6.5					9.2	7.2		
							9.1	6.6		
		7.0					9.1	6.9		
							9	5.7		
		7.5					9.1	6.5		
occasional whole shells							8.9	6.4		
		8.0					9	6		
NATURAL Loose, grey, medium grained, SAND, with coarse shell grit throughout.				M			8.7	6.3		
		8.5					9.1	6.2		
				M			8.7	6.3		
NATURAL Loose, grey, fine to medium grained, SAND, with fine shell grit throughout.		9.0					8.6	6.3		
							8.7	6.2		
becoming medium grained.										
		9.5					9	6.4		
							9.3	6.3		
		10.0		M			8.9	6.2		



NOTE: This bore log is for environmental purposes only and is not intended to provide geotechnical information.

Geological Borelog

ENVIRONMENTAL EARTH SCIENCES
CONTAMINATION RESOLVED

LOCATION: Dunmore Sand and Soil - Stage 5		Borehole Log: MW5B2	Logged by: LV
SURFACE ELEVATION:	JOB NUMBER: 118044		
GROUNDWATER: 2.7 mBGL	DATUM:	PROJECT: Dunmore	Proj. Manager: LV
DRILL METHOD: sonic drill	DATE DRILLED: 12/07/18		

STRATIGRAPHY	GRAPHIC LOG	Depth metres	Sample Depth	Moisture Content	PID/FID Background	PID/FID Reading	pH - soil	pH - water	Construction Details	Comments
NATURAL Loose, dark grey, fine grained, SAND, with medium grained shell grit throughout.							8.5	6.9	Bentonite	
NATURAL Soft, dark grey, fine grained, clayey SAND, with fine grained shell grit (5%).		10.5		M			8.6	6.7		Assumed esturine clays
NATURAL Soft, dark grey, fine grained, clayey SAND, with shell grit (5%).							9	6.9		
		11.0					9.1	6.9		
							9	7.4		
		11.5					9.2	7.3	Backfill	
							9.4	6.3		
		12.0					9.4	5.9		
							9.1	6.3		
		12.5		M			9	6.4		
NATURAL Soft, grey, fine grained, clayey SAND, with no shells, homogenous.							9.3	6.8		
		13.0					8.8	6.3		
							9.2	6.1		
		13.5					9.3	6.1		
							9.3	5.7		
		14.0					9.4	5.5		
							9.3	5.8		
		14.5		DM			9.3	2.6		Assumed esturine
NATURAL Soft, dark grey, fine grained, clayey SAND, with fine grained shell grit (5%).							9.4	4.7		
		15.0		DM			9.4	6.4		

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Geological Borelog

ENVIRONMENTAL EARTH SCIENCES
CONTAMINATION RESOLVED

LOCATION: Dunmore Sand and Soil - Stage 5		Borehole Log: MW5B2	Logged by: LV
SURFACE ELEVATION:	JOB NUMBER: 118044		
GROUNDWATER: 2.7 mBGL	DATUM:	PROJECT: Dunmore	Proj. Manager: LV
DRILL METHOD: sonic drill	DATE DRILLED: 12/07/18		

STRATIGRAPHY	GRAPHIC LOG	Depth metres	Sample Depth	Moisture Content	PID/FID Background	PID/FID Reading	pH - soil	pH - water	Construction Details	Comments
NATURAL Firm, grey, CLAY, with shell grit (5%).		15.5					9.5	6.8		
							9.4	6.5		
							9.7	6.6		
		16.0					9.6	6.9		
		16.5								
		17.0					9.6	7.4		
		17.5								
		18.0					18.5	7.7		
End of hole @ 18 m.		18.5								
		19.0								
		19.5								
		20.0								

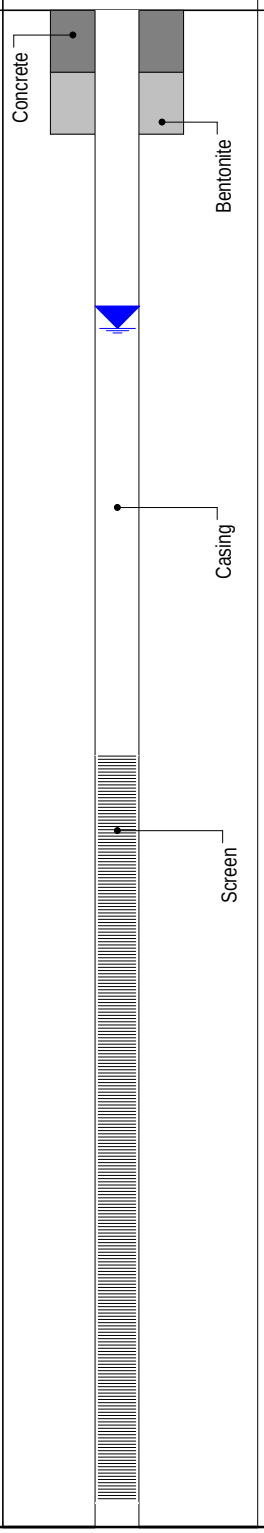
NOTE: This bore log is for environmental purposes only and is not intended to provide geotechnical information.

Geological Borelog

ENVIRONMENTAL EARTH SCIENCES
CONTAMINATION RESOLVED

LOCATION: Dunmore Sand and Soil - Stage 5		Borehole Log: MW5B3	Logged by: LV
SURFACE ELEVATION:	JOB NUMBER: 118044		
GROUNDWATER: 1.28 mBGL	DATUM:	PROJECT: Dunmore	Proj. Manager: LV
DRILL METHOD: sonic drill	DATE DRILLED: 16/07/18		

STRATIGRAPHY	Depth metres	Sample Depth	Moisture Content	PID/FID Background	PID/FID Reading	pH - soil	pH - water	Comments
NATURAL Firm, dark brown, LOAMY TOPSOIL, with roots..	0.5		D			7.9	6.2	
NATURAL Loose, tan, fine grained, clayey SAND (5%).	1.0		DM			8.1	6.3	
NATURAL Loose, tan, fine grained, SAND. becoming grey	1.5		M			8.1	6.3	
NATURAL Loose, grey, fine grained, SAND, with very fine grained shell grit throughout.	2.0		M			8.3	6.4	
	2.5		M			8	6.3	SWL
NATURAL Loose, grey, medium grained SAND, with medium grained shell grit.	3.0		M			8	6.2	
NATURAL Loose, dark grey, medium grained, SAND, with medium grained shell grit with coarse shells, timber, marine barnacles.	3.5		M			8	6.2	
NATURAL Loose, dark grey, fine grained, SAND, with fine grained shell grit throughout.	4.0		M			7.6	6.2	
	4.5					7.6	5.9	
	5.0					7.8	6.2	
	5.5					8	6	
	6.0					8	6.1	
						8	6.1	Barnacles + timber
						8.1	6.1	
						8.6	6	
						8.6	6.3	
						8.5	6.2	
						8.4	6.3	
						8.4	6.3	
						8.5	6.3	
						8.4	6.1	
						8.5	6	
						8.5	6.2	



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Geological Borelog

ENVIRONMENTAL EARTH SCIENCES
CONTAMINATION RESOLVED

LOCATION: Dunmore Sand and Soil - Stage 5		Borehole Log: MW5B3	Logged by: LV
SURFACE ELEVATION:	JOB NUMBER: 118044		
GROUNDWATER: 1.28 mBGL	DATUM:	PROJECT: Dunmore	Proj. Manager: LV
DRILL METHOD: sonic drill	DATE DRILLED: 16/07/18		

STRATIGRAPHY	GRAPHIC LOG	Depth metres	Sample Depth	Moisture Content	PID/FID Background	PID/FID Reading	pH - soil	pH - water	Construction Details	Comments
NATURAL Loose, dark grey, medium grained, SAND, with coarse shell grit throughout.		6.5					8.6	5.8		
							8.7	6	Casing	
NATURAL Loose, dark grey, coarse grained, SAND, with coarse grain shell grit (90%).		7.0		M			8.6	6.1		
							8.7	5.9		
NATURAL Loose, grey, medium grained, SAND, no shell grit.		7.5		M			8.8	5.8		
							8.9	6		
		8.0					9	5.8		
							8.6	6		
		8.5					8.8	6		
							8.8	6		
		9.0					8.7	6		
							8.6	6.3		
		9.5					9.1	6.1		
							9.1	6.1	Screen	
		10.0					9	6.1		
							9.2	6		
		10.5					9.1	6.2		
							9	6.1		
		11.0					9.1	6.4		
							9.3	6.3		
NATURAL Loose, brown/grey, medium grained, clayey SAND, with shell grit (5%).		11.5		DM			9.1	6.2	Bentonite	Assumed esturine clayey sand.
							9.1	6.2		
							9	6.3	Backfill	
		12.0					9.1	6.2		

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Geological Borelog

ENVIRONMENTAL EARTH SCIENCES
CONTAMINATION RESOLVED

LOCATION: Dunmore Sand and Soil - Stage 5		Borehole Log: MW5B3	Logged by: LV
SURFACE ELEVATION:	JOB NUMBER: 118044		
GROUNDWATER: 1.28 mBGL	DATUM:	PROJECT: Dunmore	Proj. Manager: LV
DRILL METHOD: sonic drill	DATE DRILLED: 16/07/18		

STRATIGRAPHY	GRAPHIC LOG	Depth metres	Sample Depth	Moisture Content	PID/FID Background	PID/FID Reading	pH - soil	pH - water	Construction Details	Comments
		12.5					9.4	5.9		
							8.9	6.1		
							8.7	6.2		
		13.0					8.6	6.4		
NATURAL Soft, brown, fine grained, clayey SAND, with no shell grit.				DM			8.2	6		Assumed weathered bedrock, homogeneous until end of hole
		13.5		DM			8.3	5.9	Backfill	
NATURAL Soft, grey, fine grained, clayey SAND, with no shell grit.							8.2	5.6		
		14.0					8.4	5.4		
							7.5	5.8		
		14.5					7.5	5.5		
							7.2	5.7		
		15.0					7.3	5.7		
							7.3	5.6		
		15.5					7.7	5.4		
							7.6	5.5		
		16.0					7.3	6.2		
End of hole @ 16m.										
		16.5								
		17.0								
		17.5								
		18.0								

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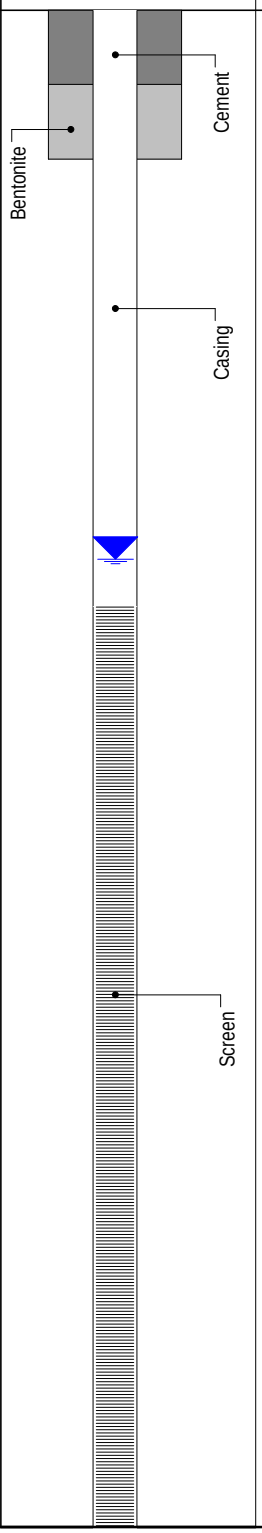
Geological Borelog

ENVIRONMENTAL EARTH SCIENCES
CONTAMINATION RESOLVED

LOCATION: Dunmore Sand and Soil - Stage 5		Borehole Log: MW5B4	Logged by: LV
SURFACE ELEVATION:	JOB NUMBER: 118044		
GROUNDWATER: 1.84 mBGL	DATUM:	PROJECT: Dunmore	Proj. Manager: LV
DRILL METHOD: sonic drill	DATE DRILLED: 16/07/18		

STRATIGRAPHY	GRAPHIC LOG	Depth metres	Sample Depth	Moisture Content	PID/FID Background	PID/FID Reading	pH - soil	pH - water	Construction Details	Comments
NATURAL Loose, brown, fine grained, silty SAND.							6.7	6.2		
NATURAL Loose, cream, fine grained, SAND.		0.5					8.2	6.2		5 % clay.
							8.5	6.3		
		1.0					8.8	6.4		
							9	6		
NATURAL Loose, fawn, fine grained, SAND.		1.5					9	5.9		
							8.7	6		SWL
NATURAL Loose, grey, fine grained, SAND.		2.0					8.8	5.8		
							8.6	5.8		
NATURAL Loose, grey, fine grained, SAND, with very fine grained shell grit throughout.		2.5					8.7	6.1		
							8.7	5.9		
		3.0					8.6	5.9		
							8.5	5.7		
		3.5					8.2	6.5		
							8	6.6		
NATURAL Loose, grey, medium grained, SAND.		4.0					8.6	6.9		
							8.6	6.7		
		4.5					8.6	6.1		
							8.5	7		
		5.0					8.7	6.3		



NOTE: This bore log is for environmental purposes only and is not intended to provide geotechnical information.

Geological Borelog

ENVIRONMENTAL EARTH SCIENCES
CONTAMINATION RESOLVED

LOCATION: Dunmore Sand and Soil - Stage 5		Borehole Log: MW5B4	Logged by: LV
SURFACE ELEVATION:	JOB NUMBER: 118044		
GROUNDWATER: 1.84 mBGL	DATUM:	PROJECT: Dunmore	Proj. Manager: LV
DRILL METHOD: sonic drill	DATE DRILLED: 16/07/18		

STRATIGRAPHY	GRAPHIC LOG	Depth metres	Sample Depth	Moisture Content	PID/FID Background	PID/FID Reading	pH - soil	pH - water	Construction Details	Comments
							8.3	6.6		
NATURAL Loose, grey, medium grained SAND, with grey, very coarse, shell grit.		5.5					8.5	6.3	Screen	
							8.4	6.4		
NATURAL Loose, grey, medium grained, SAND.		6.0					8.4	6.36.3		
NATURAL Loose, grey, medium grained, clayey SAND, with shell (5%).							8.6	5.9	Bentonite	Assumed esturine clay.
		6.5					8.5	5.9		
NATURAL Loose, grey, medium grained, clayey SAND, with coarse shell (20%) and latite cobble.							8.4	6.4		
		7.0					8.5	6		
NATURAL Loose, brown, fine grained, clayey SAND.							8.5	5.8	Backfill	Assumed weathered bedrock.
		7.5					8.2	6		
							8.3	5.8		
		8.0					8.3	5.8		
NATURAL Loose, grey, fine grained, clayey SAND.							8.5	5.6		Assumed extremely weathered bedrock
		8.5					8.2	5.6		
							8.2	6		
End of hole @ 9.0 m.		9.0					7.6	5.8		
		9.5								
		10.0								

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Geological Borelog

ENVIRONMENTAL EARTH SCIENCES
CONTAMINATION RESOLVED

LOCATION: Dunmore Sand and Soil - Stage 5		Borehole Log: MW5B5	Logged by: LV
SURFACE ELEVATION:	JOB NUMBER: 118044		
GROUNDWATER: 2.15 mBGL	DATUM:	PROJECT: Dunmore	Proj. Manager: LV
DRILL METHOD: sonic drill	DATE DRILLED: 13/07/18		

STRATIGRAPHY	GRAPHIC LOG	Depth metres	Sample Depth	Moisture Content	PID/FID Background	PID/FID Reading	pH - soil	pH - water	Construction Details	Comments
NATURAL Loose, dark brown, silty SAND, with organic plant matter and roots.										
NATURAL Loose, brown, coarse, silty SAND, with organic plant matter and roots.		0.5								
NATURAL Loose, orange/brown, medium grained, SAND. becoming light brown.		1.0 1.5 2.0 2.5							Bentonite Cement Casing	SWL
NATURAL Loose, cream, medium grained, SAND, with medium grained shell grit throughout.		3.0 3.5 4.0							Screen	
NATURAL Loose, grey, fine to medium grained, SAND, with very fine grained shell grit throughout.		4.5 5.0 5.5								
NATURAL Loose, grey, fine to medium grained, SAND, with medium grained shell grit.										
NATURAL		6.0								

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Geological Borelog

ENVIRONMENTAL EARTH SCIENCES
CONTAMINATION RESOLVED

LOCATION: Dunmore Sand and Soil - Stage 5		Borehole Log: MW5B5	Logged by: LV
SURFACE ELEVATION:	JOB NUMBER: 118044		
GROUNDWATER: 2.15 mBGL	DATUM:	PROJECT: Dunmore	Proj. Manager: LV
DRILL METHOD: sonic drill	DATE DRILLED: 13/07/18		

STRATIGRAPHY	GRAPHIC LOG	Depth metres	Sample Depth	Moisture Content	PID/FID Background	PID/FID Reading	pH - soil	pH - water	Construction Details	Comments
		6.5								
		7.0							Casing	
		7.5								
NATURAL Loose, grey, fine to medium grained, clayey SAND (5%).		8.0								
		8.5								
NATURAL Loose, grey, medium grained, SAND, with medium grained shell grit.		9.0								
		9.5								
		10.0								
		10.5							Casing	
		11.0								
		11.5								
		12.0							Bentonite	

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Geological Borelog

ENVIRONMENTAL EARTH SCIENCES
CONTAMINATION RESOLVED

LOCATION: Dunmore Sand and Soil - Stage 5		Borehole Log: MW5B5	Logged by: LV
SURFACE ELEVATION:	JOB NUMBER: 118044		
GROUNDWATER: 2.15 mBGL	DATUM:	PROJECT: Dunmore	Proj. Manager: LV
DRILL METHOD: sonic drill	DATE DRILLED: 13/07/18		

STRATIGRAPHY	GRAPHIC LOG	Depth metres	Sample Depth	Moisture Content	PID/FID Background	PID/FID Reading	pH - soil	pH - water	Construction Details	Comments
NATURAL Loose, grey, fine to medium grained, SAND, with fine grained shell grit throughout.		12.5 13.0 13.5 14.0 14.5 15.0 15.5 16.0							Bentonite Backfill	
End of hole @ 16.0 m.		16.5 17.0 17.5 18.0								

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APPENDIX D LABORATORY TRANSCRIPTS AND CHAIN OF CUSTODY FORMS

ALS Environmental

CERTIFICATE OF ANALYSIS

Work Order	: **EB1819629**	Page	: 1 of 13
Amendment	: **1**		
Client	: **ENVIRONMENTAL EARTH SCIENCES**	Laboratory	: Environmental Division Brisbane
Contact	: L VISINTIN	Contact	: Peter Ravlic
Address	: 82-84 Dickson Avenue ARTARMON NSW, AUSTRALIA 2064	Address	: 2 Byth Street Stafford QLD Australia 4053
Telephone	: (02)9922 1777	Telephone	: +61-7-3243 7222
Project	: 118044	Date Samples Received	: 14-Aug-2018 11:20
Order number	:	Date Analysis Commenced	: 17-Aug-2018
C-O-C number	: ----	Issue Date	: 28-Sep-2018 15:01
Sampler	: LVI		
Site	: Dunmore		
Quote number	: EN/010/18		
No. of samples received	: 54		
No. of samples analysed	: 53		

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. 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 the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by 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
- Amendment (28/09/2018): This report has been amended and re-released to allow the reporting of additional analytical data. EA033-C (ANC) has been added to samples 5A2_3.25, 5A2_3.75, 5A2_4.0, 5A3_1.25, 5A3_1.75, 5A3_2.75 and 5A3_4.0.
- 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)			Client sample ID	5A1_4.0	5A1_4.5	5A1_6.0	5A1_7.0	5A1_7.5
			Client sampling date / time	11-Jul-2018 00:00	11-Jul-2018 00:00	11-Jul-2018 00:00	11-Jul-2018 00:00	11-Jul-2018 00:00
Compound	CAS Number	LOR	Unit	EB1819629-001	EB1819629-002	EB1819629-003	EB1819629-004	EB1819629-005
				Result	Result	Result	Result	Result
EA033-A: Actual Acidity								
pH KCl (23A)	----	0.1	pH Unit	5.3	5.6	9.8	9.4	7.0
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	0.032	0.054	0.065	0.290	0.007
acidity - Chromium Reducible Sulfur (a-22B)	----	10	mole H+ / t	20	34	41	181	<10
EA033-C: Acid Neutralising Capacity								
Acid Neutralising Capacity (19A2)	----	0.01	% CaCO3	----	----	7.65	9.74	0.12
acidity - Acid Neutralising Capacity (a-19A2)	----	10	mole H+ / t	----	----	1530	1950	25
sulfidic - Acid Neutralising Capacity (s-19A2)	----	0.01	% pyrite S	----	----	2.45	3.12	0.04
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	0.04	0.06	<0.02	<0.02	<0.02
Net Acidity (acidity units)	----	10	mole H+ / t	22	35	<10	<10	<10
Liming Rate	----	1	kg CaCO3/t	2	3	<1	<1	<1
Net Acidity excluding ANC (sulfur units)	----	0.02	% S	0.04	0.06	0.06	0.29	<0.02
Net Acidity excluding ANC (acidity units)	----	10	mole H+ / t	22	35	41	181	<10
Liming Rate excluding ANC	----	1	kg CaCO3/t	2	3	3	14	<1

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	5A2_3.25	5A2_3.75	5A2_4.0	5A2_5.0	5A2_6.0
			Client sampling date / time	11-Jul-2018 00:00	11-Jul-2018 00:00	11-Jul-2018 00:00	11-Jul-2018 00:00	11-Jul-2018 00:00
Compound	CAS Number	LOR	Unit	EB1819629-006	EB1819629-007	EB1819629-008	EB1819629-009	EB1819629-010
				Result	Result	Result	Result	Result
EA033-A: Actual Acidity								
pH KCl (23A)	----	0.1	pH Unit	**5.1**	**5.1**	**4.5**	**5.3**	**5.3**
Titratable Actual Acidity (23F)	----	2	mole H+ / t	**7**	**7**	**19**	**3**	**6**
sulfidic - Titratable Actual Acidity (s-23F)	----	0.02	% pyrite S	<0.02	<0.02	**0.03**	<0.02	<0.02
EA033-B: Potential Acidity								
Chromium Reducible Sulfur (22B)	----	0.005	% S	**0.262**	**0.230**	**0.630**	**0.009**	**0.010**
acidity - Chromium Reducible Sulfur (a-22B)	----	10	mole H+ / t	**164**	**144**	**393**	<10	<10
EA033-C: Acid Neutralising Capacity								
Acid Neutralising Capacity (19A2)	----	0.01	% CaCO3	**0.02**	**0.16**	**0.02**	**----**	**----**
acidity - Acid Neutralising Capacity (a-19A2)	----	10	mole H+ / t	<10	**31**	<10	**----**	**----**
sulfidic - Acid Neutralising Capacity (s-19A2)	----	0.01	% pyrite S	<0.01	**0.05**	<0.01	**----**	**----**
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	**0.27**	**0.24**	**0.66**	<0.02	**0.02**
Net Acidity (acidity units)	----	10	mole H+ / t	**170**	**151**	**411**	<10	**13**
Liming Rate	----	1	kg CaCO3/t	**13**	**11**	**31**	<1	<1
Net Acidity excluding ANC (sulfur units)	----	0.02	% S	**0.27**	**0.24**	**0.66**	<0.02	**0.02**
Net Acidity excluding ANC (acidity units)	----	10	mole H+ / t	**170**	**151**	**411**	<10	**13**
Liming Rate excluding ANC	----	1	kg CaCO3/t	**13**	**11**	**31**	<1	<1

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Client sample ID	5B1_1.0	5B1_3.5	5B1_4.25	5B1_7.0	5B2_1.75
				Client sampling date / time	12-Jul-2018 00:00	12-Jul-2018 00:00	12-Jul-2018 00:00	12-Jul-2018 00:00	12-Jul-2018 00:00
Compound	CAS Number	LOR	Unit		EB1819629-011	EB1819629-012	EB1819629-013	EB1819629-014	EB1819629-015
					Result	Result	Result	Result	Result
EA033-A: Actual Acidity									
pH KCl (23A)	----	0.1	pH Unit		**5.5**	**9.6**	**9.7**	**8.6**	**7.3**
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		<0.005	**0.202**	**0.164**	**0.009**	**0.008**
acidity - Chromium Reducible Sulfur (a-22B)	----	10	mole H+ / t		<10	**126**	**102**	<10	<10
EA033-C: Acid Neutralising Capacity									
Acid Neutralising Capacity (19A2)	----	0.01	% CaCO3		**----**	**45.5**	**26.7**	**0.51**	**0.05**
acidity - Acid Neutralising Capacity (a-19A2)	----	10	mole H+ / t		**----**	**9090**	**5330**	**102**	<10
sulfidic - Acid Neutralising Capacity (s-19A2)	----	0.01	% pyrite S		**----**	**14.6**	**8.55**	**0.16**	**0.01**
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	<0.02	<0.02	<0.02	<0.02
Net Acidity (acidity units)	----	10	mole H+ / t		<10	<10	<10	<10	<10
Liming Rate	----	1	kg CaCO3/t		<1	<1	<1	<1	<1
Net Acidity excluding ANC (sulfur units)	----	0.02	% S		<0.02	**0.20**	**0.16**	<0.02	<0.02
Net Acidity excluding ANC (acidity units)	----	10	mole H+ / t		<10	**126**	**102**	<10	<10
Liming Rate excluding ANC	----	1	kg CaCO3/t		<1	**9**	**8**	<1	<1

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	5B2_3.0	5B2_5.0	5B2_6.0	5B2_7.25	5B2_8.5
			Client sampling date / time	12-Jul-2018 00:00	12-Jul-2018 00:00	12-Jul-2018 00:00	12-Jul-2018 00:00	12-Jul-2018 00:00
Compound	CAS Number	LOR	Unit	EB1819629-016	EB1819629-017	EB1819629-018	EB1819629-019	EB1819629-020
				Result	Result	Result	Result	Result
EA033-A: Actual Acidity								
pH KCl (23A)	----	0.1	pH Unit	9.7	9.7	9.7	9.4	9.6
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	0.009	0.108	0.150	0.309	0.142
acidity - Chromium Reducible Sulfur (a-22B)	----	10	mole H+ / t	<10	67	94	193	89
EA033-C: Acid Neutralising Capacity								
Acid Neutralising Capacity (19A2)	----	0.01	% CaCO3	21.0	17.9	35.9	43.7	18.4
acidity - Acid Neutralising Capacity (a-19A2)	----	10	mole H+ / t	4200	3570	7180	8740	3670
sulfidic - Acid Neutralising Capacity (s-19A2)	----	0.01	% pyrite S	6.73	5.73	11.5	14.0	5.88
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	<0.02	<0.02	<0.02	<0.02
Net Acidity (acidity units)	----	10	mole H+ / t	<10	<10	<10	<10	<10
Liming Rate	----	1	kg CaCO3/t	<1	<1	<1	<1	<1
Net Acidity excluding ANC (sulfur units)	----	0.02	% S	<0.02	0.11	0.15	0.31	0.14
Net Acidity excluding ANC (acidity units)	----	10	mole H+ / t	<10	67	94	193	89
Liming Rate excluding ANC	----	1	kg CaCO3/t	<1	5	7	14	7

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	5B2_10.75	5B2_12.0	5B2_14.5	5B2_15.0	5B3_2.0
			Client sampling date / time	12-Jul-2018 00:00	12-Jul-2018 00:00	12-Jul-2018 00:00	12-Jul-2018 00:00	16-Jul-2018 00:00
Compound	CAS Number	LOR	Unit	EB1819629-022	EB1819629-023	EB1819629-024	EB1819629-025	EB1819629-026
				Result	Result	Result	Result	Result
EA033-A: Actual Acidity								
pH KCl (23A)	----	0.1	pH Unit	**9.1**	**9.2**	**8.9**	**8.9**	**9.7**
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	**0.651**	**0.244**	**0.296**	**0.021**	**0.100**
acidity - Chromium Reducible Sulfur (a-22B)	----	10	mole H+ / t	**406**	**152**	**185**	**13**	**62**
EA033-C: Acid Neutralising Capacity								
Acid Neutralising Capacity (19A2)	----	0.01	% CaCO3	**10.5**	**2.67**	**3.26**	**22.8**	**40.1**
acidity - Acid Neutralising Capacity (a-19A2)	----	10	mole H+ / t	**2090**	**534**	**652**	**4560**	**8020**
sulfidic - Acid Neutralising Capacity (s-19A2)	----	0.01	% pyrite S	**3.35**	**0.86**	**1.04**	**7.31**	**12.8**
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	<0.02	<0.02	<0.02	<0.02
Net Acidity (acidity units)	----	10	mole H+ / t	<10	<10	<10	<10	<10
Liming Rate	----	1	kg CaCO3/t	<1	<1	<1	<1	<1
Net Acidity excluding ANC (sulfur units)	----	0.02	% S	**0.65**	**0.24**	**0.30**	**0.02**	**0.10**
Net Acidity excluding ANC (acidity units)	----	10	mole H+ / t	**406**	**152**	**185**	**13**	**62**
Liming Rate excluding ANC	----	1	kg CaCO3/t	**30**	**11**	**14**	**1**	**5**

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	5B3_3.25	5B3_4.0	5B3_7.25	5B3_7.75	5B3_10.0
			Client sampling date / time	16-Jul-2018 00:00	16-Jul-2018 00:00	16-Jul-2018 00:00	16-Jul-2018 00:00	16-Jul-2018 00:00
Compound	CAS Number	LOR	Unit	EB1819629-027	EB1819629-028	EB1819629-029	EB1819629-030	EB1819629-031
				Result	Result	Result	Result	Result
EA033-A: Actual Acidity								
pH KCl (23A)	----	0.1	pH Unit	9.3	9.7	9.5	9.6	9.6
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	0.219	0.132	0.231	0.095	0.128
acidity - Chromium Reducible Sulfur (a-22B)	----	10	mole H+ / t	137	82	144	59	80
EA033-C: Acid Neutralising Capacity								
Acid Neutralising Capacity (19A2)	----	0.01	% CaCO3	21.2	11.7	45.7	3.30	4.46
acidity - Acid Neutralising Capacity (a-19A2)	----	10	mole H+ / t	4240	2340	9130	659	891
sulfidic - Acid Neutralising Capacity (s-19A2)	----	0.01	% pyrite S	6.80	3.75	14.6	1.06	1.43
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	<0.02	<0.02	<0.02	<0.02
Net Acidity (acidity units)	----	10	mole H+ / t	<10	<10	<10	<10	<10
Liming Rate	----	1	kg CaCO3/t	<1	<1	<1	<1	<1
Net Acidity excluding ANC (sulfur units)	----	0.02	% S	0.22	0.13	0.23	0.10	0.13
Net Acidity excluding ANC (acidity units)	----	10	mole H+ / t	137	82	144	59	80
Liming Rate excluding ANC	----	1	kg CaCO3/t	10	6	11	4	6

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	5B3_12.25	5B3_14.0	5B4_1.5	5B4_2.0	5B4_3.25
			Client sampling date / time	16-Jul-2018 00:00	16-Jul-2018 00:00	16-Jul-2018 00:00	16-Jul-2018 00:00	16-Jul-2018 00:00
Compound	CAS Number	LOR	Unit	EB1819629-032	EB1819629-033	EB1819629-034	EB1819629-035	EB1819629-036
				Result	Result	Result	Result	Result
EA033-A: Actual Acidity								
pH KCl (23A)	----	0.1	pH Unit	**9.1**	**7.3**	**9.8**	**9.8**	**9.8**
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	**0.040**	**0.046**	<0.005	**0.028**	**0.063**
acidity - Chromium Reducible Sulfur (a-22B)	----	10	mole H+ / t	**25**	**29**	<10	**17**	**40**
EA033-C: Acid Neutralising Capacity								
Acid Neutralising Capacity (19A2)	----	0.01	% CaCO3	**0.78**	**0.70**	**16.5**	**22.8**	**21.1**
acidity - Acid Neutralising Capacity (a-19A2)	----	10	mole H+ / t	**156**	**139**	**3290**	**4560**	**4210**
sulfidic - Acid Neutralising Capacity (s-19A2)	----	0.01	% pyrite S	**0.25**	**0.22**	**5.28**	**7.31**	**6.75**
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	<0.02	<0.02	<0.02	<0.02
Net Acidity (acidity units)	----	10	mole H+ / t	<10	<10	<10	<10	<10
Liming Rate	----	1	kg CaCO3/t	<1	<1	<1	<1	<1
Net Acidity excluding ANC (sulfur units)	----	0.02	% S	**0.04**	**0.05**	<0.02	**0.03**	**0.06**
Net Acidity excluding ANC (acidity units)	----	10	mole H+ / t	**25**	**29**	<10	**17**	**40**
Liming Rate excluding ANC	----	1	kg CaCO3/t	**2**	**2**	<1	**1**	**3**

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	5B4_4.5	5B4_5.25	5B4_6.5	5B4_7.25	5B4_8.25
			Client sampling date / time	16-Jul-2018 00:00	16-Jul-2018 00:00	16-Jul-2018 00:00	16-Jul-2018 00:00	16-Jul-2018 00:00
Compound	CAS Number	LOR	Unit	EB1819629-037	EB1819629-038	EB1819629-039	EB1819629-040	EB1819629-041
				Result	Result	Result	Result	Result
EA033-A: Actual Acidity								
pH KCl (23A)	----	0.1	pH Unit	**9.8**	**9.4**	**9.0**	**8.3**	**6.4**
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	**0.052**	**0.342**	**0.092**	**0.005**	<0.005
acidity - Chromium Reducible Sulfur (a-22B)	----	10	mole H+ / t	**32**	**214**	**58**	<10	<10
EA033-C: Acid Neutralising Capacity								
Acid Neutralising Capacity (19A2)	----	0.01	% CaCO3	**10.6**	**55.2**	**1.66**	**0.72**	**----**
acidity - Acid Neutralising Capacity (a-19A2)	----	10	mole H+ / t	**2120**	**11000**	**331**	**145**	**----**
sulfidic - Acid Neutralising Capacity (s-19A2)	----	0.01	% pyrite S	**3.41**	**17.7**	**0.53**	**0.23**	**----**
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	<0.02	<0.02	<0.02	<0.02
Net Acidity (acidity units)	----	10	mole H+ / t	<10	<10	<10	<10	<10
Liming Rate	----	1	kg CaCO3/t	<1	<1	<1	<1	<1
Net Acidity excluding ANC (sulfur units)	----	0.02	% S	**0.05**	**0.34**	**0.09**	<0.02	<0.02
Net Acidity excluding ANC (acidity units)	----	10	mole H+ / t	**32**	**214**	**58**	<10	<10
Liming Rate excluding ANC	----	1	kg CaCO3/t	**2**	**16**	**4**	<1	<1

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	5A3_1.25	5A3_1.75	5A3_2.75	5A3_4.0	5A3_5.75
			Client sampling date / time	11-Jul-2018 00:00	11-Jul-2018 00:00	11-Jul-2018 00:00	11-Jul-2018 00:00	11-Jul-2018 00:00
Compound	CAS Number	LOR	Unit	EB1819629-042	EB1819629-043	EB1819629-044	EB1819629-045	EB1819629-046
				Result	Result	Result	Result	Result
EA033-A: Actual Acidity								
pH KCl (23A)	----	0.1	pH Unit	5.1	5.0	5.6	5.4	6.2
Titratable Actual Acidity (23F)	----	2	mole H+ / t	10	9	<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	0.403	0.258	0.292	0.243	0.088
acidity - Chromium Reducible Sulfur (a-22B)	----	10	mole H+ / t	251	161	182	151	55
EA033-C: Acid Neutralising Capacity								
Acid Neutralising Capacity (19A2)	----	0.01	% CaCO3	0.07	0.09	0.17	0.22	----
acidity - Acid Neutralising Capacity (a-19A2)	----	10	mole H+ / t	14	18	34	43	----
sulfidic - Acid Neutralising Capacity (s-19A2)	----	0.01	% pyrite S	0.02	0.03	0.05	0.07	----
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	0.42	0.27	0.29	0.25	0.09
Net Acidity (acidity units)	----	10	mole H+ / t	261	170	182	154	55
Liming Rate	----	1	kg CaCO3/t	20	13	14	12	4
Net Acidity excluding ANC (sulfur units)	----	0.02	% S	0.42	0.27	0.29	0.25	0.09
Net Acidity excluding ANC (acidity units)	----	10	mole H+ / t	261	170	182	154	55
Liming Rate excluding ANC	----	1	kg CaCO3/t	20	13	14	12	4

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	5A3_7.0	5A3_8.75	5A3_9.5	5A3_12.5	FD1
			Client sampling date / time	11-Jul-2018 00:00	11-Jul-2018 00:00	11-Jul-2018 00:00	11-Jul-2018 00:00	11-Jul-2018 00:00
Compound	CAS Number	LOR	Unit	EB1819629-047	EB1819629-048	EB1819629-049	EB1819629-050	EB1819629-051
				Result	Result	Result	Result	Result
EA033-A: Actual Acidity								
pH KCl (23A)	----	0.1	pH Unit	5.4	6.0	5.8	7.9	5.5
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	0.087	0.072	0.066	0.063	0.054
acidity - Chromium Reducible Sulfur (a-22B)	----	10	mole H+ / t	54	44	41	39	34
EA033-C: Acid Neutralising Capacity								
Acid Neutralising Capacity (19A2)	----	0.01	% CaCO3	----	----	----	1.07	----
acidity - Acid Neutralising Capacity (a-19A2)	----	10	mole H+ / t	----	----	----	214	----
sulfidic - Acid Neutralising Capacity (s-19A2)	----	0.01	% pyrite S	----	----	----	0.34	----
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	0.07	0.07	<0.02	0.05
Net Acidity (acidity units)	----	10	mole H+ / t	56	45	41	<10	34
Liming Rate	----	1	kg CaCO3/t	4	3	3	<1	2
Net Acidity excluding ANC (sulfur units)	----	0.02	% S	0.09	0.07	0.07	0.06	0.05
Net Acidity excluding ANC (acidity units)	----	10	mole H+ / t	56	45	41	39	34
Liming Rate excluding ANC	----	1	kg CaCO3/t	4	3	3	3	2

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Client sample ID	FD2	FD4	5B2_9.75	----	----
				Client sampling date / time	11-Jul-2018 00:00	11-Jul-2018 00:00	12-Jul-2018 00:00	----	----
Compound	CAS Number	LOR	Unit		EB1819629-052	EB1819629-053	EB1819629-055	--------	--------
					Result	Result	Result	----	----
EA033-A: Actual Acidity									
pH KCl (23A)	----	0.1	pH Unit		**5.0**	**5.8**	**9.7**	**----**	**----**
Titratable Actual Acidity (23F)	----	2	mole H+ / t		**7**	<2	<2	**----**	**----**
sulfidic - Titratable Actual Acidity (s-23F)	----	0.02	% pyrite S		<0.02	<0.02	<0.02	**----**	**----**
EA033-B: Potential Acidity									
Chromium Reducible Sulfur (22B)	----	0.005	% S		**0.193**	**0.061**	**0.131**	**----**	**----**
acidity - Chromium Reducible Sulfur (a-22B)	----	10	mole H+ / t		**121**	**38**	**82**	**----**	**----**
EA033-C: Acid Neutralising Capacity									
Acid Neutralising Capacity (19A2)	----	0.01	% CaCO3		**----**	**----**	**5.33**	**----**	**----**
acidity - Acid Neutralising Capacity (a-19A2)	----	10	mole H+ / t		**----**	**----**	**1060**	**----**	**----**
sulfidic - Acid Neutralising Capacity (s-19A2)	----	0.01	% pyrite S		**----**	**----**	**1.71**	**----**	**----**
EA033-E: Acid Base Accounting									
ANC Fineness Factor	----	0.5	-		**1.5**	**1.5**	**1.5**	**----**	**----**
Net Acidity (sulfur units)	----	0.02	% S		**0.20**	**0.06**	<0.02	**----**	**----**
Net Acidity (acidity units)	----	10	mole H+ / t		**128**	**38**	<10	**----**	**----**
Liming Rate	----	1	kg CaCO3/t		**10**	**3**	<1	**----**	**----**
Net Acidity excluding ANC (sulfur units)	----	0.02	% S		**0.20**	**0.06**	**0.13**	**----**	**----**
Net Acidity excluding ANC (acidity units)	----	10	mole H+ / t		**128**	**38**	**82**	**----**	**----**
Liming Rate excluding ANC	----	1	kg CaCO3/t		**10**	**3**	**6**	**----**	**----**

ALS Environmental

QUALITY CONTROL REPORT

Work Order	: **EB1819629**	Page	: 1 of 6
Amendment	: **1**		
Client	: **ENVIRONMENTAL EARTH SCIENCES**	Laboratory	: Environmental Division Brisbane
Contact	: L VISINTIN	Contact	: Peter Ravlic
Address	: 82-84 Dickson Avenue ARTARMON NSW, AUSTRALIA 2064	Address	: 2 Byth Street Stafford QLD Australia 4053
Telephone	: (02)9922 1777	Telephone	: +61-7-3243 7222
Project	: 118044	Date Samples Received	: 14-Aug-2018
Order number	:	Date Analysis Commenced	: 17-Aug-2018
C-O-C number	: ----	Issue Date	: 28-Sep-2018
Sampler	: LVI		
Site	: Dunmore		
Quote number	: EN/010/18		
No. of samples received	: 54		
No. of samples analysed	: 53		

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. 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 the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by 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

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	*Client sample ID*	*Method: Compound*	*CAS Number*	*LOR*	*Unit*	*Original Result*	*Duplicate Result*	*RPD (%)*	*Recovery Limits (%)*
EA033-A: Actual Acidity (QC Lot: 1877207)									
EB1819629-001	5A1_4.0	EA033: sulfidic - Titratable Actual Acidity (s-23F)	----	0.02	% pyrite S	<0.02	<0.02	0.00	No Limit
		EA033: Titratable Actual Acidity (23F)	----	2	mole H+ / t	2	<2	0.00	No Limit
		EA033: pH KCl (23A)	----	0.1	pH Unit	5.3	5.5	3.70	0% - 20%
EB1819629-011	5B1_1.0	EA033: sulfidic - Titratable Actual Acidity (s-23F)	----	0.02	% pyrite S	<0.02	<0.02	0.00	No Limit
		EA033: Titratable Actual Acidity (23F)	----	2	mole H+ / t	2	<2	0.00	No Limit
		EA033: pH KCl (23A)	----	0.1	pH Unit	5.5	5.5	0.00	0% - 20%
EA033-A: Actual Acidity (QC Lot: 1877208)									
EB1819629-022	5B2_10.75	EA033: sulfidic - Titratable Actual Acidity (s-23F)	----	0.02	% pyrite S	<0.02	<0.02	0.00	No Limit
		EA033: Titratable Actual Acidity (23F)	----	2	mole H+ / t	<2	<2	0.00	No Limit
		EA033: pH KCl (23A)	----	0.1	pH Unit	9.1	9.1	0.00	0% - 20%
EB1819629-032	5B3_12.25	EA033: sulfidic - Titratable Actual Acidity (s-23F)	----	0.02	% pyrite S	<0.02	<0.02	0.00	No Limit
		EA033: Titratable Actual Acidity (23F)	----	2	mole H+ / t	<2	<2	0.00	No Limit
		EA033: pH KCl (23A)	----	0.1	pH Unit	9.1	9.1	0.00	0% - 20%
EA033-A: Actual Acidity (QC Lot: 1877209)									
EB1819629-042	5A3_1.25	EA033: sulfidic - Titratable Actual Acidity (s-23F)	----	0.02	% pyrite S	<0.02	<0.02	0.00	No Limit
		EA033: Titratable Actual Acidity (23F)	----	2	mole H+ / t	10	10	0.00	No Limit
		EA033: pH KCl (23A)	----	0.1	pH Unit	5.1	5.1	0.00	0% - 20%
EB1819629-052	FD2	EA033: sulfidic - Titratable Actual Acidity (s-23F)	----	0.02	% pyrite S	<0.02	<0.02	0.00	No Limit
		EA033: Titratable Actual Acidity (23F)	----	2	mole H+ / t	7	7	0.00	No Limit
		EA033: pH KCl (23A)	----	0.1	pH Unit	5.0	5.0	0.00	0% - 20%
EA033-A: Actual Acidity (QC Lot: 1889880)									
EB1819629-055	5B2_9.75	EA033: sulfidic - Titratable Actual Acidity (s-23F)	----	0.02	% pyrite S	<0.02	<0.02	0.00	No Limit
		EA033: Titratable Actual Acidity (23F)	----	2	mole H+ / t	<2	<2	0.00	No Limit
		EA033: pH KCl (23A)	----	0.1	pH Unit	9.7	9.7	0.00	0% - 20%

Sub-Matrix: **SOIL**

				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	*Client sample ID*	*Method: Compound*	*CAS Number*	*LOR*	*Unit*	*Original Result*	*Duplicate Result*	*RPD (%)*	*Recovery Limits (%)*
EA033-A: Actual Acidity (QC Lot: 1889880) - continued									
EB1820175-010	Anonymous	EA033: sulfidic - Titratable Actual Acidity (s-23F)	----	0.02	% pyrite S	0.07	0.08	0.00	No Limit
		EA033: Titratable Actual Acidity (23F)	----	2	mole H+ / t	46	47	2.29	0% - 20%
		EA033: pH KCl (23A)	----	0.1	pH Unit	4.3	4.3	0.00	0% - 20%
EA033-B: Potential Acidity (QC Lot: 1877207)									
EB1819629-001	5A1_4.0	EA033: Chromium Reducible Sulfur (22B)	----	0.005	% S	0.032	0.032	0.00	No Limit
		EA033: acidity - Chromium Reducible Sulfur (a-22B)	----	10	mole H+ / t	20	20	0.00	No Limit
EB1819629-011	5B1_1.0	EA033: Chromium Reducible Sulfur (22B)	----	0.005	% S	<0.005	<0.005	0.00	No Limit
		EA033: acidity - Chromium Reducible Sulfur (a-22B)	----	10	mole H+ / t	<10	<10	0.00	No Limit
EA033-B: Potential Acidity (QC Lot: 1877208)									
EB1819629-022	5B2_10.75	EA033: Chromium Reducible Sulfur (22B)	----	0.005	% S	0.651	0.655	0.680	0% - 20%
		EA033: acidity - Chromium Reducible Sulfur (a-22B)	----	10	mole H+ / t	406	409	0.680	0% - 20%
EB1819629-032	5B3_12.25	EA033: Chromium Reducible Sulfur (22B)	----	0.005	% S	0.040	0.039	3.08	No Limit
		EA033: acidity - Chromium Reducible Sulfur (a-22B)	----	10	mole H+ / t	25	24	0.00	No Limit
EA033-B: Potential Acidity (QC Lot: 1877209)									
EB1819629-042	5A3_1.25	EA033: Chromium Reducible Sulfur (22B)	----	0.005	% S	0.403	0.403	0.00	0% - 20%
		EA033: acidity - Chromium Reducible Sulfur (a-22B)	----	10	mole H+ / t	251	251	0.00	0% - 20%
EB1819629-052	FD2	EA033: Chromium Reducible Sulfur (22B)	----	0.005	% S	0.193	0.194	0.00	0% - 20%
		EA033: acidity - Chromium Reducible Sulfur (a-22B)	----	10	mole H+ / t	121	121	0.00	0% - 50%
EA033-B: Potential Acidity (QC Lot: 1889880)									
EB1819629-055	5B2_9.75	EA033: Chromium Reducible Sulfur (22B)	----	0.005	% S	0.131	0.126	4.08	0% - 20%
		EA033: acidity - Chromium Reducible Sulfur (a-22B)	----	10	mole H+ / t	82	79	4.08	No Limit
EB1820175-010	Anonymous	EA033: Chromium Reducible Sulfur (22B)	----	0.005	% S	<0.005	<0.005	0.00	No Limit
		EA033: acidity - Chromium Reducible Sulfur (a-22B)	----	10	mole H+ / t	<10	<10	0.00	No Limit
EA033-C: Acid Neutralising Capacity (QC Lot: 1877208)									
EB1819629-022	5B2_10.75	EA033: Acid Neutralising Capacity (19A2)	----	0.01	% CaCO3	10.5	10.5	0.344	0% - 20%
		EA033: sulfidic - Acid Neutralising Capacity (s-19A2)	----	0.01	% pyrite S	3.35	3.37	0.344	0% - 20%
		EA033: acidity - Acid Neutralising Capacity (a-19A2)	----	10	mole H+ / t	2090	2100	0.344	0% - 20%
EB1819629-032	5B3_12.25	EA033: Acid Neutralising Capacity (19A2)	----	0.01	% CaCO3	0.78	0.88	11.4	0% - 20%
		EA033: sulfidic - Acid Neutralising Capacity (s-19A2)	----	0.01	% pyrite S	0.25	0.28	11.4	0% - 20%

Sub-Matrix: **SOIL**

				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	*Client sample ID*	*Method: Compound*	*CAS Number*	*LOR*	*Unit*	*Original Result*	*Duplicate Result*	*RPD (%)*	*Recovery Limits (%)*
EA033-C: Acid Neutralising Capacity (QC Lot: 1877208) - continued									
EB1819629-032	5B3_12.25	EA033: acidity - Acid Neutralising Capacity (a-19A2)	----	10	mole H+ / t	156	175	11.4	0% - 50%
EA033-C: Acid Neutralising Capacity (QC Lot: 1877209)									
EB1819629-042	5A3_1.25	EA033: Acid Neutralising Capacity (19A2)	----	0.01	% CaCO3	0.07	0.04	54.4	No Limit
		EA033: sulfidic - Acid Neutralising Capacity (s-19A2)	----	0.01	% pyrite S	0.02	0.01	0.00	No Limit
		EA033: acidity - Acid Neutralising Capacity (a-19A2)	----	10	mole H+ / t	14	<10	36.2	No Limit
EA033-C: Acid Neutralising Capacity (QC Lot: 1889880)									
EB1819629-055	5B2_9.75	EA033: Acid Neutralising Capacity (19A2)	----	0.01	% CaCO3	5.33	5.41	1.55	0% - 20%
		EA033: sulfidic - Acid Neutralising Capacity (s-19A2)	----	0.01	% pyrite S	1.71	1.73	1.55	0% - 20%
		EA033: acidity - Acid Neutralising Capacity (a-19A2)	----	10	mole H+ / t	1060	1080	1.55	0% - 20%

Method Blank (MB) and Laboratory Control Spike (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 Spike (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 (%)	Recovery Limits (%)	
Method: Compound	CAS Number	LOR	Unit	Result	Concentration	LCS	Low	High
EA033-A: Actual Acidity (QCLot: 1877207)								
EA033: pH KCl (23A)	----	----	pH Unit	----	4.6 pH Unit	104	70	130
EA033: Titratable Actual Acidity (23F)	----	2	mole H+ / t	<2	17.7 mole H+ / t	83.7	70	130
EA033: sulfidic - Titratable Actual Acidity (s-23F)	----	0.02	% pyrite S	<0.02	----	----	----	----
EA033-A: Actual Acidity (QCLot: 1877208)								
EA033: pH KCl (23A)	----	----	pH Unit	----	4.6 pH Unit	104	70	130
EA033: Titratable Actual Acidity (23F)	----	2	mole H+ / t	<2	17.7 mole H+ / t	79.0	70	130
EA033: sulfidic - Titratable Actual Acidity (s-23F)	----	0.02	% pyrite S	<0.02	----	----	----	----
EA033-A: Actual Acidity (QCLot: 1877209)								
EA033: pH KCl (23A)	----	----	pH Unit	----	4.6 pH Unit	104	70	130
EA033: Titratable Actual Acidity (23F)	----	2	mole H+ / t	<2	17.7 mole H+ / t	86.8	70	130
EA033: sulfidic - Titratable Actual Acidity (s-23F)	----	0.02	% pyrite S	<0.02	----	----	----	----
EA033-A: Actual Acidity (QCLot: 1889880)								
EA033: pH KCl (23A)	----	----	pH Unit	----	4.6 pH Unit	104	70	130
EA033: Titratable Actual Acidity (23F)	----	2	mole H+ / t	<2	17.7 mole H+ / t	81.7	70	130
EA033: sulfidic - Titratable Actual Acidity (s-23F)	----	0.02	% pyrite S	<0.02	----	----	----	----
EA033-B: Potential Acidity (QCLot: 1877207)								
EA033: Chromium Reducible Sulfur (22B)	----	0.005	% S	<0.005	0.25483 % S	84.3	70	130
EA033: acidity - Chromium Reducible Sulfur (a-22B)	----	10	mole H+ / t	<10	----	----	----	----
EA033-B: Potential Acidity (QCLot: 1877208)								
EA033: Chromium Reducible Sulfur (22B)	----	0.005	% S	<0.005	0.25483 % S	87.3	70	130
EA033: acidity - Chromium Reducible Sulfur (a-22B)	----	10	mole H+ / t	<10	----	----	----	----
EA033-B: Potential Acidity (QCLot: 1877209)								
EA033: Chromium Reducible Sulfur (22B)	----	0.005	% S	<0.005	0.25483 % S	87.3	70	130
EA033: acidity - Chromium Reducible Sulfur (a-22B)	----	10	mole H+ / t	<10	----	----	----	----
EA033-B: Potential Acidity (QCLot: 1889880)								
EA033: Chromium Reducible Sulfur (22B)	----	0.005	% S	<0.005	0.25483 % S	95.9	70	130
EA033: acidity - Chromium Reducible Sulfur (a-22B)	----	10	mole H+ / t	<10	----	----	----	----
EA033-C: Acid Neutralising Capacity (QCLot: 1877207)								
EA033: Acid Neutralising Capacity (19A2)	----	0.01	% CaCO3	<0.01	10 % CaCO3	102	70	130
EA033: acidity - Acid Neutralising Capacity (a-19A2)	----	10	mole H+ / t	<10	----	----	----	----
EA033: sulfidic - Acid Neutralising Capacity (s-19A2)	----	0.01	% pyrite S	<0.01	----	----	----	----
EA033-C: Acid Neutralising Capacity (QCLot: 1877208)								
EA033: Acid Neutralising Capacity (19A2)	----	0.01	% CaCO3	<0.01	10 % CaCO3	102	70	130

Sub-Matrix: **SOIL**

Method: Compound	CAS Number	LOR	Unit	Method Blank (MB) Report	Laboratory Control Spike (LCS) Report			
					Spike	Spike Recovery (%)	Recovery Limits (%)	
				Result	Concentration	LCS	Low	High
EA033-C: Acid Neutralising Capacity (QCLot: 1877208) - continued								
EA033: acidity - Acid Neutralising Capacity (a-19A2)	----	10	mole H+ / t	<10	----	----	----	----
EA033: sulfidic - Acid Neutralising Capacity (s-19A2)	----	0.01	% pyrite S	<0.01	----	----	----	----
EA033-C: Acid Neutralising Capacity (QCLot: 1877209)								
EA033: Acid Neutralising Capacity (19A2)	----	0.01	% CaCO3	<0.01	10 % CaCO3	104	70	130
EA033: acidity - Acid Neutralising Capacity (a-19A2)	----	10	mole H+ / t	<10	----	----	----	----
EA033: sulfidic - Acid Neutralising Capacity (s-19A2)	----	0.01	% pyrite S	<0.01	----	----	----	----
EA033-C: Acid Neutralising Capacity (QCLot: 1889880)								
EA033: Acid Neutralising Capacity (19A2)	----	0.01	% CaCO3	<0.01	10 % CaCO3	106	70	130
EA033: acidity - Acid Neutralising Capacity (a-19A2)	----	10	mole H+ / t	<10	----	----	----	----
EA033: sulfidic - Acid Neutralising Capacity (s-19A2)	----	0.01	% pyrite S	<0.01	----	----	----	----

Matrix Spike (MS) Report

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

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

ALS Environmental

QA/QC Compliance Assessment to assist with Quality Review

Work Order	: **EB1819629**	Page	: 1 of 8
Amendment	: **1**		
Client	: **ENVIRONMENTAL EARTH SCIENCES**	Laboratory	: Environmental Division Brisbane
Contact	: L VISINTIN	Telephone	: +61-7-3243 7222
Project	: 118044	Date Samples Received	: 14-Aug-2018
Site	: Dunmore	Issue Date	: 28-Sep-2018
Sampler	: LVI	No. of samples received	: 54
Order number	:	No. of samples analysed	: 53

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

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

Summary of Outliers

Outliers : Quality Control Samples

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

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

Outliers : Analysis Holding Time Compliance

- **NO Analysis Holding Time Outliers exist.**

Outliers : Frequency of Quality Control Samples

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

Analysis Holding Time Compliance

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

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

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

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

Matrix: **SOIL**

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

Method / Container / Client Sample ID(s)	Sample Date	Extraction / Preparation			Analysis		
		Date extracted	Due for extraction	Evaluation	Date analysed	Due for analysis	Evaluation
EA033-A: Actual Acidity							
Snap Lock Bag - frozen (EA033)							
5A1_4.0, 5A1_4.5, 5A1_6.0, 5A1_7.0, 5A1_7.5, 5A2_3.25, 5A2_3.75, 5A2_4.0, 5A2_5.0, 5A2_6.0, 5A3_1.25, 5A3_1.75, 5A3_2.75, 5A3_4.0, 5A3_5.75, 5A3_7.0, 5A3_8.75, 5A3_9.5, 5A3_12.5, FD1, FD2, FD4	**11-Jul-2018**	**17-Aug-2018**	11-Jul-2019	✓	**17-Aug-2018**	15-Nov-2018	✓
Snap Lock Bag - frozen (EA033)							
5B1_1.0, 5B1_3.5, 5B1_4.25, 5B1_7.0, 5B2_1.75, 5B2_3.0, 5B2_5.0, 5B2_6.0, 5B2_7.25, 5B2_8.5, 5B2_10.75, 5B2_12.0, 5B2_14.5, 5B2_15.0	**12-Jul-2018**	**17-Aug-2018**	12-Jul-2019	✓	**17-Aug-2018**	15-Nov-2018	✓
Snap Lock Bag - frozen (EA033)							
5B2_9.75	**12-Jul-2018**	**23-Aug-2018**	12-Jul-2019	✓	**23-Aug-2018**	21-Nov-2018	✓
Snap Lock Bag - frozen (EA033)							
5B3_2.0, 5B3_3.25, 5B3_4.0, 5B3_7.25, 5B3_7.75, 5B3_10.0, 5B3_12.25, 5B3_14.0, 5B4_1.5, 5B4_2.0, 5B4_3.25, 5B4_4.5, 5B4_5.25, 5B4_6.5, 5B4_7.25, 5B4_8.25	**16-Jul-2018**	**17-Aug-2018**	16-Jul-2019	✓	**17-Aug-2018**	15-Nov-2018	✓

Matrix: **SOIL**

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

Method / Container / Client Sample ID(s)	Sample Date	Extraction / Preparation			Analysis		
		Date extracted	Due for extraction	Evaluation	Date analysed	Due for analysis	Evaluation
EA033-B: Potential Acidity							
Snap Lock Bag - frozen (EA033)							
5A1_4.0, 5A1_4.5, 5A1_6.0, 5A1_7.0, 5A1_7.5, 5A2_3.25, 5A2_3.75, 5A2_4.0, 5A2_5.0, 5A2_6.0, 5A3_1.25, 5A3_1.75, 5A3_2.75, 5A3_4.0, 5A3_5.75, 5A3_7.0, 5A3_8.75, 5A3_9.5, 5A3_12.5, FD1, FD2, FD4	**11-Jul-2018**	**17-Aug-2018**	11-Jul-2019	✓	**17-Aug-2018**	15-Nov-2018	✓
Snap Lock Bag - frozen (EA033)							
5B1_1.0, 5B1_3.5, 5B1_4.25, 5B1_7.0, 5B2_1.75, 5B2_3.0, 5B2_5.0, 5B2_6.0, 5B2_7.25, 5B2_8.5, 5B2_10.75, 5B2_12.0, 5B2_14.5, 5B2_15.0	**12-Jul-2018**	**17-Aug-2018**	12-Jul-2019	✓	**17-Aug-2018**	15-Nov-2018	✓
Snap Lock Bag - frozen (EA033)							
5B2_9.75	**12-Jul-2018**	**23-Aug-2018**	12-Jul-2019	✓	**23-Aug-2018**	21-Nov-2018	✓
Snap Lock Bag - frozen (EA033)							
5B3_2.0, 5B3_3.25, 5B3_4.0, 5B3_7.25, 5B3_7.75, 5B3_10.0, 5B3_12.25, 5B3_14.0, 5B4_1.5, 5B4_2.0, 5B4_3.25, 5B4_4.5, 5B4_5.25, 5B4_6.5, 5B4_7.25, 5B4_8.25	**16-Jul-2018**	**17-Aug-2018**	16-Jul-2019	✓	**17-Aug-2018**	15-Nov-2018	✓

Matrix: **SOIL**

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

Method / Container / Client Sample ID(s)		Sample Date	Extraction / Preparation			Analysis		
			Date extracted	Due for extraction	Evaluation	Date analysed	Due for analysis	Evaluation
EA033-C: Acid Neutralising Capacity								
Snap Lock Bag - frozen (EA033)								
5A1_4.0,	5A1_4.5,	**11-Jul-2018**	**17-Aug-2018**	11-Jul-2019	✓	**17-Aug-2018**	15-Nov-2018	✓
5A1_6.0,	5A1_7.0,							
5A1_7.5,	5A2_3.25,							
5A2_3.75,	5A2_4.0,							
5A2_5.0,	5A2_6.0,							
5A3_1.25,	5A3_1.75,							
5A3_2.75,	5A3_4.0,							
5A3_5.75,	5A3_7.0,							
5A3_8.75,	5A3_9.5,							
5A3_12.5,	FD1,							
FD2,	FD4							
Snap Lock Bag - frozen (EA033)								
5B1_1.0,	5B1_3.5,	**12-Jul-2018**	**17-Aug-2018**	12-Jul-2019	✓	**17-Aug-2018**	15-Nov-2018	✓
5B1_4.25,	5B1_7.0,							
5B2_1.75,	5B2_3.0,							
5B2_5.0,	5B2_6.0,							
5B2_7.25,	5B2_8.5,							
5B2_10.75,	5B2_12.0,							
5B2_14.5,	5B2_15.0							
Snap Lock Bag - frozen (EA033)								
5B2_9.75		**12-Jul-2018**	**23-Aug-2018**	12-Jul-2019	✓	**23-Aug-2018**	21-Nov-2018	✓
Snap Lock Bag - frozen (EA033)								
5B3_2.0,	5B3_3.25,	**16-Jul-2018**	**17-Aug-2018**	16-Jul-2019	✓	**17-Aug-2018**	15-Nov-2018	✓
5B3_4.0,	5B3_7.25,							
5B3_7.75,	5B3_10.0,							
5B3_12.25,	5B3_14.0,							
5B4_1.5,	5B4_2.0,							
5B4_3.25,	5B4_4.5,							
5B4_5.25,	5B4_6.5,							
5B4_7.25,	5B4_8.25							

Matrix: **SOIL**

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

Method / Container / Client Sample ID(s)		Sample Date	Extraction / Preparation			Analysis		
			Date extracted	Due for extraction	Evaluation	Date analysed	Due for analysis	Evaluation
EA033-D: Retained Acidity								
Snap Lock Bag - frozen (EA033)								
5A1_4.0,	5A1_4.5,	**11-Jul-2018**	**17-Aug-2018**	11-Jul-2019	✓	**17-Aug-2018**	15-Nov-2018	✓
5A1_6.0,	5A1_7.0,							
5A1_7.5,	5A2_3.25,							
5A2_3.75,	5A2_4.0,							
5A2_5.0,	5A2_6.0,							
5A3_1.25,	5A3_1.75,							
5A3_2.75,	5A3_4.0,							
5A3_5.75,	5A3_7.0,							
5A3_8.75,	5A3_9.5,							
5A3_12.5,	FD1,							
FD2,	FD4							
Snap Lock Bag - frozen (EA033)								
5B1_1.0,	5B1_3.5,	**12-Jul-2018**	**17-Aug-2018**	12-Jul-2019	✓	**17-Aug-2018**	15-Nov-2018	✓
5B1_4.25,	5B1_7.0,							
5B2_1.75,	5B2_3.0,							
5B2_5.0,	5B2_6.0,							
5B2_7.25,	5B2_8.5,							
5B2_10.75,	5B2_12.0,							
5B2_14.5,	5B2_15.0							
Snap Lock Bag - frozen (EA033)								
5B2_9.75		**12-Jul-2018**	**23-Aug-2018**	12-Jul-2019	✓	**23-Aug-2018**	21-Nov-2018	✓
Snap Lock Bag - frozen (EA033)								
5B3_2.0,	5B3_3.25,	**16-Jul-2018**	**17-Aug-2018**	16-Jul-2019	✓	**17-Aug-2018**	15-Nov-2018	✓
5B3_4.0,	5B3_7.25,							
5B3_7.75,	5B3_10.0,							
5B3_12.25,	5B3_14.0,							
5B4_1.5,	5B4_2.0,							
5B4_3.25,	5B4_4.5,							
5B4_5.25,	5B4_6.5,							
5B4_7.25,	5B4_8.25							

Matrix: **SOIL**

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

Method / Container / Client Sample ID(s)	Sample Date	Extraction / Preparation			Analysis		
		Date extracted	Due for extraction	Evaluation	Date analysed	Due for analysis	Evaluation
EA033-E: Acid Base Accounting							
Snap Lock Bag - frozen (EA033)							
5A1_4.0, 5A1_4.5, 5A1_6.0, 5A1_7.0, 5A1_7.5, 5A2_3.25, 5A2_3.75, 5A2_4.0, 5A2_5.0, 5A2_6.0, 5A3_1.25, 5A3_1.75, 5A3_2.75, 5A3_4.0, 5A3_5.75, 5A3_7.0, 5A3_8.75, 5A3_9.5, 5A3_12.5, FD1, FD2, FD4	**11-Jul-2018**	**17-Aug-2018**	11-Jul-2019	✓	**17-Aug-2018**	15-Nov-2018	✓
Snap Lock Bag - frozen (EA033)							
5B1_1.0, 5B1_3.5, 5B1_4.25, 5B1_7.0, 5B2_1.75, 5B2_3.0, 5B2_5.0, 5B2_6.0, 5B2_7.25, 5B2_8.5, 5B2_10.75, 5B2_12.0, 5B2_14.5, 5B2_15.0	**12-Jul-2018**	**17-Aug-2018**	12-Jul-2019	✓	**17-Aug-2018**	15-Nov-2018	✓
Snap Lock Bag - frozen (EA033)							
5B2_9.75	**12-Jul-2018**	**23-Aug-2018**	12-Jul-2019	✓	**23-Aug-2018**	21-Nov-2018	✓
Snap Lock Bag - frozen (EA033)							
5B3_2.0, 5B3_3.25, 5B3_4.0, 5B3_7.25, 5B3_7.75, 5B3_10.0, 5B3_12.25, 5B3_14.0, 5B4_1.5, 5B4_2.0, 5B4_3.25, 5B4_4.5, 5B4_5.25, 5B4_6.5, 5B4_7.25, 5B4_8.25	**16-Jul-2018**	**17-Aug-2018**	16-Jul-2019	✓	**17-Aug-2018**	15-Nov-2018	✓

Quality Control Parameter Frequency Compliance

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

Matrix: **SOIL**

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

Quality Control Sample Type		Count		Rate (%)			Quality Control Specification
Analytical Methods	*Method*	*QC*	*Regular*	***Actual***	***Expected***	*Evaluation*	
Laboratory Duplicates (DUP)							
Chromium Suite for Acid Sulphate Soils	EA033	8	72	**11.11**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Laboratory Control Samples (LCS)							
Chromium Suite for Acid Sulphate Soils	EA033	4	72	**5.56**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Method Blanks (MB)							
Chromium Suite for Acid Sulphate Soils	EA033	4	72	**5.56**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard

Brief Method Summaries

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

Analytical Methods	Method	Matrix	Method Descriptions
Chromium Suite for Acid Sulphate Soils	EA033	SOIL	In house: Referenced to Ahern et al 2004. This method covers the determination of Chromium Reducible Sulfur (SCR); pHKCl; titratable actual acidity (TAA); acid neutralising capacity by back titration (ANC); and net acid soluble sulfur (SNAS) which incorporates peroxide sulfur. It applies to soils and sediments (including sands) derived from coastal regions. Liming Rate is based on results for samples as submitted and incorporates a minimum safety factor of 1.5.

Preparation Methods	Method	Matrix	Method Descriptions
Drying at 85 degrees, bagging and labelling (ASS)	EN020PR	SOIL	In house

CHAIN OF CUSTODY - ANALYSIS REQUEST FORM

Job No: 118044

Laboratory: ALS

Project Manager: Lvi

Sampler: Lvi

Site Location: Dunmore

Sheet: 1 of 3

No. of samples	Sample ID/ Depth	Anticipated Result (PID)/EC reading	Date sampled	Time sampled	Sample Matrix: Soil	Water	Sediment	Analysis Required: Chromium Reducible Sulfur Suite	Sample-specific instructions/ notes
1	5A1_4.0				x			x	
1	5A1_4.5				x			x	
1	5A1_6.0				x			x	
1	5A1_7.0				x			x	
1	5A1_7.5				x			x	
1	5A2_3.25				x			x	
1	5A2_3.75				x			x	
1	5A2_4.0				x			x	
1	5A2_4.5				x			x	
1	5A2_4.75				x			x	
1	5A2_5.0				x			x	
1	5A2_6.0				x			x	
1	5B1_1.0				x			x	
1	5B1_3.5				x			x	
1	5B1_4.25				x			x	
1	5B1_7.0				x			x	
1	5B2_1.75				x			x	
1	5B2_3.0				x			x	
1	5B2_5.0				x			x	
1	5B2_6.0				x			x	
	TOTAL 18/53	0							

Environmental Division
Brisbane
Work Order Reference
EB1819629

Telephone : + 61-7-3243 7222

10/10/18 14/8/18.

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Comments/ Instructions:

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	Name	Signature	Date	Time
Sent off Site/Office by:	Nat Eldridge.	Eldridge	10/8/18.	
Receiving Lab:	ALS Sothepha		10/8/18 1537	-07C
Receiving Lab:				

ENVIRONMENTAL EARTH SCIENCES
CONTAMINATION RESOLVED
Phone: (02) 9922 1777
Fax: (02) 9922 1010
PO Box: 380, North Sydney NSW 2059
Email: eesNSW@eesigroup.com

CHAIN OF CUSTODY - ANALYSIS REQUEST FORM

Job No: 118044 | Laboratory: ALS

Project Manager: Lvi | Sampler: Lvi | Site Location: Dunmore | Sheet: 2 of 34

No. of samples	Sample ID/ Depth	Anticipated Result (PID)/EC reading	Date sampled	Time sampled	Sample Matrix: Soil	Water	Sediment	Analysis Required: Chromium Reducible Sulfur Suite												Sample-specific instructions/ notes
1	5B2_7.25				x			x												
1	5B2_8.5				x			x												
1	5B2_9.75				x			x												
1	5B2_10.75				x			x												
1	5B2_12.0				x			x												
1	5B2_14.5				x			x												
1	5B2_15.0				x			x												
1	5B3_2.0				x			x												
1	5B3_3.25				x			x												
1	5B3_4.0				x			x												
1	5B3_7.25				x			x												
1	5B3_7.75				x			x												
1	5B3_10.0				x			x												
1	5B3_12.25				x			x												
1	5B3_14.0				x			x												
1	5B4_1.5				x			x												
1	5B4_2.0				x			x												
1	5B4_3.25																			
1	5B4_4.5																			
1	5B4_5.25																			
	Total	20/53																		

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Receiving Lab:	ALS		ALS 10/8/18	-070
Receiving Lab:				

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Phone: (02) 9922 1777
Fax: (02) 9922 1010
PO Box: 380, North Sydney NSW 2059
Email: eesNSW@eesigroup.com

CHAIN OF CUSTODY - ANALYSIS REQUEST FORM

Job No: 118044 | Laboratory: ALS

Project Manager: Lvi | Sampler: Lvi | Site Location: Dunmore | Sheet: 3 of 3

	No. of samples	Sample ID/ Depth	Anticipated Result (PID)/EC reading	Date sampled	Time sampled	Sample Matrix: Soil	Water	Sediment	Analysis Required: Chromium Reducible Sulfur Suite													Sample-specific instructions/ notes
39	1	5B4_6.5				x			x													
40	1	5B4_7.25				x			x													
41	1	5B4_8.25				x			x													
42	1	5A3_1.25				x			x													
43	1	5A3_1.75				x			x													
44	1	5A3_2.75				x			x													
45	1	5A3_4.0				x			x													
46	1	5A3_5.75				x			x													
47	1	5A3_7.0				x			x													
48	1	5A3_8.75				x			x													
49	1	5A3_9.5				x			x													
50	1	5A3_12.5				x			x													
51	1	FD1				x			x													
52	1	FD2				x			x													
53	1	FD4				x			x													
54	1	582_7.0 extra sample.				x			x													
						x			x													
						x			x													
						x			x													
						x			x													
		15/53																				

Turn Around *(circle)*:

Lab Quotation No. *(if applicable)*: EN/010/17

Comments/ Instructions:

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Cc: report to *(email address)*:

Cc: invoice to *(email address)*: accounts@eesigroup.com

	Name	Signature	Date	Time
Sent off Site/Office by:	Nat Eldridge		10/8/18	
Receiving Lab:	ALS SOO SHE	yes	10/8/18 1537	-07
Receiving Lab:				

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Fax: (02) 9922 1010
PO Box: 380, North Sydney NSW 2059
Email: eesNSW@eesigroup.com

APPENDIX E QUALITY ASSURANCE AND QUALITY CONTROL PROCEDURES

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1 DATA QUALITY OBJECTIVES

Development of data quality objectives (DQOs) for each project is a requirement of the National Environment Protection (Assessment of Site Contamination) Amendment Measure (NEPC 2013). Specific discussion in the development of the DQO's has been included in the main report.

Based on the DQOs the following measurement data quality indicators (MDQIs) are provided in Table 1.

TABLE 1 MEASUREMENT DATA QUALITY INDICATORS (MDQIS)

Parameter	Procedure	Minimum Frequency	Criteria	
			(5 to 10x LOR[4])	>10x LOR
Precision	Field Duplicates	1 in 20 - metals	<80 RPD	<50 RPD
		1 in 20 - semi-volatiles	<100 RPD	<80 RPD
		1 in 20 - volatiles	<150 RPD	<130 RPD
	Lab Replicate*	1 in 20	<50 RPD	<30 RPD
Accuracy*	Reference Material	1 in 10	60% to 140%R	80% to 120%R
	Matrix spikes			
	Surrogate spikes			
Representativeness*	Reagent Blanks	1 per batch	No detection	
	Holding Times*	Every sample	-	
Blanks**	Trip Blank	1 per batch	No detection	
	Rinsate Blanks			
Sensitivity	Limit of Reporting	Every sample	LOR < ½ site criteria	

Notes:

1. RPD – relative percentage difference;
2. %R – percent recovery;
3. LOR – limit of reporting;
4. [4] no limit at <5x LOR;
5. * the MDQI is usually specified in the standard method. If not, use the default values set out in this table; and
6. ** only necessary when measuring dissolved metals and volatile organic compounds in water samples.

It should be noted that Standards Australia (i.e. AS4482.1) specify that typical MDQIs for precision should be ≤50% RPD, however it should be noted that low concentrations and organic compounds can be acceptable if reported outside of this range. As the standard suggests, an RPD of >50% has been used as a 'trigger' and values above this level of repeatability have also been noted and explained.

Our adopted MDQIs for precision acknowledge the intrinsic heterogeneity of metal and semi volatile chemical concentrations in disturbed soil that may potentially cause large variations in results between laboratory subsamples (although all efforts are made to homogenise non-volatile duplicate samples). Similarly, large variations in volatile chemical concentrations between duplicates may be unavoidable even when using best practice sampling

methodology, especially as we seek to minimise the disturbance to the sample while splitting it which means a high degree of inherent heterogeneity is expected.

As such, our adopted RPD criteria are considered to be a suitable measure for the reproducibility of results within a naturally heterogeneous media such as soil. A ≤50% RPD trigger value will be used, with any exceedance discussed and assessed for acceptability.

2 FIELD QA/QC PROGRAM

2.1 Sample collection, preservation, transportation and storage

Soil samples were collected and placed in appropriate sample containers as supplied by the nominated National Association of Testing Authorities (NATA) laboratory. Samples were labelled with the corresponding field/sample identification number, site reference and date in accordance with Environmental Earth Science sample procedures. Samples were placed in an iced container prior to transport to the nominated laboratory.

Soil samples were supplied to NATA accredited laboratories (ALS Laboratory) under a completed chain of custody (CoC). Copies of the CoC documentation and laboratory transcripts are provided in Appendix D of the main report.

2.2 Calibration of field equipment

The calibration of field equipment (hand held pH reader) was undertaken before and after each bore hole during the soil sampling program. The calibration records can be found within Attachment B.

2.3 Intra (blind) duplicate sampling

2.3.1 Soil

Four intra (blind) samples were collected during collection of soil samples. The relative percentage differences (RPD) calculations of the collected intra duplicate samples are presented in Table 2 below.

Calculated RPDs between the primary sample and their corresponding duplicate samples were all within the acceptable limits (MQDIS), as such, we consider the data set to be reliable.

TABLE 2 SOIL FIELD INTRA DUPLICATE RESULTS

Sample			Primary Sample	Intra duplicate sample	RPD%	Primary Sample	Inter duplicate sample	RPD%	Primary Sample	Inter duplicate sample	RPD%
Analyte	**units**	**LOR**	**5A1_4.5**	**FD1**		**5A2_3.75**	**FD2**		**5A3_9.5**	**FD4**	
Depth (m)			4.5	4.5		3.75	3.75		9.5	9.5	
pH KCl	pH Unit	0.1	5.6	5.5	1.8	5.1	5.0	6.2	5.8	5.8	5.3
Titratable Actual Acidity	mole H+/t	2	nd	nd	nd	7	7	0.0	nd	nd	-
sulfidic - Titratable Actual Acidity	% pyrite S	0.02	nd	nd	nd	nd	nd	-	nd	nd	-
Chromium Reducible Sulfur	% S	0.005	0.054	0.054	0.0	0.230	0.193	17.5	0.066	0.061	7.8
acidity - Chromium Reducible Sulfur	mole H+/t	10	34	34	0.0	144	121	17.3	41	38	7.6
Acid Neutralising Capacity	% CaCO3	0.01	-	-	-	0.16	-	-	-	-	-
acidity - Acid Neutralising Capacity	mole H+/t	0.5	-	-	-	31	-	-	-	-	-
sulfidic - Acid Neutralising Capacity	% pyrite S	0.01	-	-	-	0.05	-	-	-	-	-
ANC Fineness Factor		0.5	1.5	1.5	0.0	1.5	1.5	0.0	1.5	1.5	0.0
Net Acidity	% S	0.02	0.06	0.05	18	0.24	0.2	18.1	0.07	0.06	15.4
Net Acidity	mole H+/t	10	35	34	2.9	151	128	16.4	41	38	7.6
Liming Rate	kg CaCO3/t	1	3	2	40	11	10	9.5	3	3	0.0
Net Acidity excluding ANC	% S	0.02	0.06	0.05	18	0.24	0.2	18.1	0.07	0.06	15.4
Net Acidity excluding ANC	mole H+/t	10	35	34	2.9	151	128	16.4	41	38	7.6

Sample			Primary Sample	Intra duplicate sample	RPD%	Primary Sample	Inter duplicate sample	RPD%	Primary Sample	Inter duplicate sample	RPD%
Analyte	**units**	**LOR**	**5A1_4.5**	**FD1**		**5A2_3.75**	**FD2**		**5A3_9.5**	**FD4**	
Liming Rate excluding ANC	kg CaCO3/t	1	3	2	40	11	10	9.5	3	3	0.0

Notes:

1. LOR level of reporting
2. RPD relative percentage difference
3. - not analysed, or RPD not calculable
4. nd – not detected above the Laboratory LOR

3 LABORATORY QUALITY CONTROL

3.1 Holding time

Analysed samples were extracted and analysed within acceptable holding times as defined in AS4482.1-2005.

3.2 Laboratories and analytical procedures

Laboratory analysis of primary and intra (blind) duplicate samples for this project was completed by ALS. The laboratory is accredited by NATA for the methods used, details of this accreditation can be viewed at http://www.nata.asn.au/, while details of the samples sent to each laboratory and the analysis requested are contained in the chain of custody documentation held in Appendix D of the main report. The analytical methods are noted on the laboratory transcripts.

3.3 Required limits of reporting

Acceptable limits of reporting (LOR) were provided by the analytical laboratory to allow the results to be compared against the soil investigation levels.

3.4 Laboratory method blanks

Reported results for laboratory method blank samples were acceptable or lower than laboratory LORs.

3.5 Laboratory duplicates

Laboratory duplicate results can be found in the analytical laboratory reports. The RPD between analytical results for primary samples and their corresponding laboratory soil duplicates were within acceptable limits.

4 ASSESSMENT OF DATA QUALITY

Based on information presented above, it can be confidently stated that the MDQO's for this project have been met and the data set is considered to be reliable for interpretative use.

5 QA/QC APPENDIX REFERENCES

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APPENDIX F FIELD PEROXIDE SCREENING

Field Hydrogen Peroxide Test Logs – Acid Sulfate Soils

ENVIRONMENTAL EARTH SCIENCES
CONTAMINATION RESOLVED

Job No: 118044	Date: 11/07/2018	Sampled By: LV	Client: Element Environment	Site: Stage 5

Sample ID	Sample Depth	$pH_{1:5}$	Temperature 1:5	pH_{fox}	Temperature fox	Level of Effervescence
5A1	0.25	6.4	6.8	5.8	6.4	none
5A1	0.50	6.5	6.9	5.6	5.7	none
5A1	0.75	6.6	7.1	5.6	5.5	none
5A1	1.00	6.6	7.1	5.7	5.4	none
5A1	1.25	6.5	7.0	5.7	5.2	none
5A1	1.50	6.7	7.1	5.8	5.1	none
5A1	1.75	6.8	7.2	5.7	5.4	none
5A1	2.0	6.8	7.3	5.8	5.5	none
5A1	2.25	6.8	7.2	5.6	5.4	none
5A1	2.50	6.9	7.1	5.6	5.9	none
5A1	2.75	6.8	7.3	5.6	6.0	none
5A1	3.0	6.8	7.4	5.6	6.0	none
5A1	3.25	6.9	13.2	6.8	14.9	none
5A1	3.50	6.7	12.0	5.1	14.6	none
5A1	3.75	6.7	13.8	5.3	14.7	none
5A1	4.0	6.7	13.9	1.7	26.3	none
5A1	4.25	6.4	14.3	2.4	16.8	mild
5A1	4.50	6.5	14.3	2.3	16.3	none
5A1	4.75	6.6	14.2	5.1	20.3	none
5A1	5.0	7.3	15.4	6.0	26.4	none
5A1	5.25	7.7	15.1	5.7	18.6	mild
5A1	5.50	7.9	14.5	6.0	18.2	mild
5A1	5.75	8.0	14.2	5.9	18.8	mild
5A1	6.0	8.3	16.3	5.7	25.8	mild
5A1	6.25	7.9	16.6	5.8	16.0	mild
5A1	6.50	8.0	16.5	5.8	17.3	mild
5A1	6.75	8.3	16.6	5.6	19.2	mild
5A1	7.0	8.5	15.2	5.6	22.6	mild
5A1	7.25	8.6	16.4	5.6	21.9	mild
5A1	7.50	8.7	16.8	5.7	21.1	mild
5A1	7.75	8.4	17.1	5.7	21.1	mild
5A1	8.0	8.4	16.4	5.6	22.1	mild

Field Hydrogen Peroxide Test Logs – Acid Sulfate Soils

ENVIRONMENTAL EARTH SCIENCES
CONTAMINATION RESOLVED

Job No: 118044	Date: 11/07/2018	Sampled By: LV	Client: Element Environment	Site: Stage 5

Sample ID	Sample Depth	$pH_{1:5}$	Temperature 1:5	pH_{fox}	Temperature fox	Level of Effervescence
5A1	8.25	8.3	17.5	5.8	23.6	strong
5A1	8.50	8.2	18.0	5.8	25.1	mild
5A1	8.75	8.2	17.8	5.9	24.9	mild
5A1	9.00	8.1	16.4	5.8	23.9	mild

Field Hydrogen Peroxide Test Logs – Acid Sulfate Soils

ENVIRONMENTAL EARTH SCIENCES
CONTAMINATION RESOLVED

Job No: 118044	Date: 11/07/2018	Sampled By: LV	Client: Element Environment	Site: Stage 5

Sample ID	Sample Depth	$pH_{1:5}$	Temperature 1:5	pH_{fox}	Temperature fox	Level of Effervescence
5A2	0.25	7.8	20.5	6.5	79.0	strong
5A2	0.50	7.6	20.8	6.1	79.0	strong
5A2	0.75	7.8	21.4	5.8	28.9	mild
5A2	1.00	8.0	22.7	5.1	30.7	mild
5A2	1.25	7.8	21.7	5.2	25.2	none
5A2	1.50	7.8	21.0	5.4	23.1	mild
5A2	1.75	7.8	21.1	5.3	22.7	none
5A2	2.00	7.7	21.8	5.4	27.9	none
5A2	2.25	7.5	21.7	5.6	21.9	none
5A2	2.50	7.4	20.8	5.7	21.8	none
5A2	2.75	7.3	20.7	5.6	21.8	none
5A2	3.00	7.4	20.9	5.1	27.5	mild
5A2	3.25	5.7	21.2	2.0	85.6	strong
5A2	3.50	5.9	19.5	2.0	85.6	strong
5A2	3.75	5.8	19.1	1.8	29.2	mild
5A2	4.00	6.0	19.1	1.8	86.5	strong
5A2	4.25	6.0	19.5	1.9	81.6	strong
5A2	4.50	5.9	19.3	3.0	25.3	strong
5A2	4.75	5.8	18.7	3.5	19.2	mild
5A2	5.00	5.8	18.8	2.2	37.8	mild
5A2	5.25	5.7	19.0	3.9	89.4	strong
5A2	5.50	5.7	19.2	4.1	32.1	mild
5A2	5.75	5.6	19.0	4.0	28.5	mild
5A2	6.00	5.6	18.9	4.6	26.2	mild

Field Hydrogen Peroxide Test Logs – Acid Sulfate Soils

ENVIRONMENTAL EARTH SCIENCES
CONTAMINATION RESOLVED

Job No: 118044	Date: 11/07/2018	Sampled By: LV	Client: Element Environment	Site: Stage 5

Sample ID	Sample Depth	$pH_{1:5}$	Temperature 1:5	pH_{fox}	Temperature fox	Level of Effervescence
5A3	0.25	6.8	19.0	4.6	20.0	mild
5A3	0.50	6.3	19.0	4.1	20.0	mild
5A3	0.75	5.9	20.0	4.4	20.0	mild
5A3	1.00	5.9	19.0	4.0	29.0	mild
5A3	1.25	5.8	21.0	1.9	74.5	strong
5A3	1.50	5.5	21.0	2.0	88.0	strong
5A3	1.75	4.8	21.0	1.9	45.0	mild
5A3	2.00	5.3	21.0	2.0	35.0	mild
5A3	2.25	5.3	21.0	2.0	92.3	strong
5A3	2.50	5.5	21.0	2.0	91.0	strong
5A3	2.75	5.8	21.0	2.0	88.8	strong
5A3	3.00	5.6	21.0	2.1	91.0	strong
5A3	3.25	7.3	20.0	2.1	90.0	strong
5A3	3.50	7.2	20.0	1.8	91.0	strong
5A3	3.75	7.2	20.0	1.9	91.0	strong
5A3	4.00	7.5	20.0	1.9	90.0	strong
5A3	4.25	7.0	20.0	1.9	90.0	strong
5A3	4.50	7.1	20.0	1.8	93.0	strong
5A3	4.75	7.1	2.0	1.8	93.1	strong
5A3	5.00	7.0	20.0	5.5	90.0	strong
5A3	5.25	7.6	19.6	6.9	95.0	strong
5A3	5.50	7.9	19.6	2.3	90.0	strong
5A3	5.75	8.2	19.6	2.3	80.0	strong
5A3	6.00	7.9	19.6	2.2	93.0	strong
5A3	6.25	7.9	19.6	2.4	90.0	strong
5A3	6.50	7.9	19.6	2.2	93.0	strong
5A3	6.75	7.7	19.6	2.2	93.0	strong
5A3	7.00	7.6	19.6	2.1	91.0	strong
5A3	7.25	7.8	19.6	3.9	40.0	mild
5A3	7.50	7.7	19.6	2.3	90.0	strong
5A3	7.75	7.7	19.6	2.2	30.0	mild
5A3	8.00	7.3	19.6	2.2	90.0	strong

Field Hydrogen Peroxide Test Logs – Acid Sulfate Soils

ENVIRONMENTAL EARTH SCIENCES
CONTAMINATION RESOLVED

Job No: 118044	Date: 11/07/2018	Sampled By: LV	Client: Element Environment	Site: Stage 5		
Sample ID	Sample Depth	$pH_{1:5}$	Temperature 1:5	pH_{fox}	Temperature fox	Level of Effervescence
5A3	8.25	6.7	22.8	2.4	88.0	strong
5A3	8.50	6.0	22.8	2.2	91.0	strong
5A3	8.75	6.0	23.0	2.3	90.0	strong
5A3	9.00	6.0	23.0	2.3	87.8	strong
5A3	9.50	6.0	23.0	2.2	90.0	strong
5A3	10.00	6.0	23.0	2.3	90.0	strong
5A3	10.50	6.7	18.5	3.5	19.0	mild
5A3	11.00	6.3	23.0	4.4	27.2	mild
5A3	11.50	6.9	18.5	6.3	19.0	mild
5A3	12.00	7.0	23.0	6.6	30.7	mild
5A3	12.25	8.6	23.0	8.1	85.6	strong
5A3	12.50	8.2	23.0	2.4	83.4	strong

Field Hydrogen Peroxide Test Logs – Acid Sulfate Soils

ENVIRONMENTAL EARTH SCIENCES
CONTAMINATION RESOLVED

Job No: 118044	Date: 11/07/2018	Sampled By: LV	Client: Element Environment	Site: Stage 5		
Sample ID	Sample Depth	$pH_{1:5}$	Temperature 1:5	pH_{fox}	Temperature fox	Level of Effervescence
5B1	0.25	8.8	16.5	4.8	17.8	mild
5B1	0.50	8.7	16.8	4.9	17.4	mild
5B1	0.75	85.2	16.8	4.3	17.9	mild
5B1	1.00	8.0	16.8	4.6	18.1	mild
5B1	1.25	7.4	16.8	4.6	18.1	mild
5B1	1.50	7.3	16.8	4.6	18.1	mild
5B1	1.75	6.9	16.8	4.6	17.8	mild
5B1	2.00	6.8	16.8	4.9	18.2	mild
5B1	2.25	6.6	16.8	4.8	17.8	mild
5B1	2.50	6.6	16.8	4.9	17.6	mild
5B1	2.75	6.4	16.8	4.9	17.3	mild
5B1	3.00	6.4	16.8	6.1	21.0	mild
5B1	3.25	8.9	17.4	6.4	20.8	mild
5B1	3.50	9.4	17.2	6.2	19.2	mild
5B1	3.75	7.1	17.1	6.2	19.6	mild
5B1	4.00	8.8	17.1	6.4	18.5	mild
5B1	4.25	9.4	17.1	6.2	20.5	mild
5B1	4.50	9.4	17.1	6.3	19.1	mild
5B1	4.75	9.3	17.1	6.4	20.2	mild
5B1	5.00	9.1	17.1	6.3	19.2	mild
5B1	5.25	9.1	17.1	6.4	19.1	mild
5B1	5.50	9.0	17.1	6.3	19.2	mild
5B1	5.75	9.0	17.1	6.3	19.8	mild
5B1	6.00	8.9	17.1	6.2	21.0	mild
5B1	6.25	8.9	17.9	6.4	24.3	mild
5B1	6.50	8.9	17.9	6.6	23.5	mild
5B1	6.75	8.9	17.9	7.0	23.2	mild
5B1	7.00	8.8	17.9	6.2	20.8	mild
5B1	7.25	Missed				
5B1	7.50	8.5	17.6	6.3	20.9	mild
5B1	7.75	8.5	17.6	6.1	19.2	mild
5B1	8.00	8.9	17.6	6.1	19.1	mild

Field Hydrogen Peroxide Test Logs – Acid Sulfate Soils

ENVIRONMENTAL EARTH SCIENCES
CONTAMINATION RESOLVED

Job No: 118044	Date: 11/07/2018	Sampled By: LV	Client: Element Environment	Site: Stage 5

Sample ID	Sample Depth	$pH_{1:5}$	Temperature 1:5	pH_{fox}	Temperature fox	Level of Effervescence
5B2	0.25	6.6	19.5	3.3	18.6	none
5B2	0.50	6.2	19.1	4.4	18.0	mild
5B2	0.75	5.9	19.1	4.1	18.6	none
5B2	1.00	5.6	19.2	4.6	18.0	none
5B2	1.25	5.9	19.2	4.8	18.0	none
5B2	1.50	5.8	19.2	5.3	18.0	none
5B2	1.75	5.8	19.2	5.2	18.0	none
5B2	2.00	5.8	19.2	5.3	18.0	none
5B2	2.25	5.8	19.2	5.5	18.0	mild
5B2	2.50	5.8	19.2	5.7	18.0	none
5B2	2.75	7.0	19.2	6.3	18.0	none
5B2	3.00	8.0	19.2	6.3	18.0	none
5B2	3.25	8.5	17.0	6.6	18.0	none
5B2	3.50	8.9	17.0	7.0	18.0	none
5B2	3.75	8.8	17.0	6.7	19.0	none
5B2	4.00	9.0	17.0	6.6	19.0	none
5B2	4.25	8.8	17.0	6.8	19.0	none
5B2	4.50	8.9	17.0	6.6	19.0	none
5B2	4.75	8.8	17.0	6.5	19.0	none
5B2	5.00	9.0	17.0	6.6	19.0	none
5B2	5.25	8.9	18.0	6.8	20.0	none
5B2	5.50	9.0	18.0	6.6	20.0	none
5B2	5.75	9.0	18.0	6.4	20.0	none
5B2	6.00	9.4	18.0	6.5	20.0	none
5B2	6.25	9.2	18.0	6.6	20.0	none
5B2	6.50	9.2	18.0	7.2	20.0	none
5B2	6.75	9.0	18.0	6.6	20.0	mild
5B2	7.00	9.1	18.0	6.9	20.0	mild
5B2	7.25	9.0	18.0	5.7	24.0	mild
5B2	7.50	9.1	18.0	6.5	20.0	mild
5B2	7.75	8.9	18.0	6.4	20.0	mild
5B2	8.00	9.0	18.0	6.0	20.0	mild

Field Hydrogen Peroxide Test Logs – Acid Sulfate Soils

ENVIRONMENTAL EARTH SCIENCES
CONTAMINATION RESOLVED

Job No: 118044	Date: 11/07/2018	Sampled By: LV	Client: Element Environment	Site: Stage 5

Sample ID	Sample Depth	$pH_{1:5}$	Temperature 1:5	pH_{fox}	Temperature fox	Level of Effervescence
5B2	8.25	8.7	17.4	6.3	19.6	mild
5B2	8.50	9.1	17.4	6.2	19.6	mild
5B2	8.75	8.7	17.4	6.3	22.2	mild
5B2	9.00	8.6	17.4	6.3	20.4	mild
5B2	9.25	8.7	17.4	6.2	20.6	mild
5B2	9.50	9.0	17.4	6.4	20.0	mild
5B2	9.75	9.3	17.4	6.3	20.8	mild
5B2	10.00	8.9	17.4	6.2	20.7	mild
5B2	10.25	8.5	17.4	6.9	65.4	strong
5B2	10.50	8.6	17.4	6.7	86.4	strong
5B2	10.75	9.0	17.4	6.9	93.8	strong
5B2	11.00	9.1	17.4	7.1	94.0	strong
5B2	11.25	9.0	17.8	7.4	95.0	strong
5B2	11.50	9.2	17.8	7.3	95.0	strong
5B2	11.75	9.4	17.5	6.3	50.0	strong
5B2	12.00	9.4	17.6	5.9	21.0	mild
5B2	12.25	9.1	17.6	6.3	38.0	mild
5B2	12.50	9.0	17.6	6.4	24.0	mild
5B2	12.75	9.3	17.6	6.8	28.0	mild
5B2	13.00	8.8	17.6	6.3	22.0	mild
5B2	13.25	9.2	17.6	6.1	20.0	mild
5B2	13.50	9.3	17.6	6.1	20.0	mild
5B2	13.75	9.3	17.6	5.7	19.0	mild
5B2	14.00	9.4	17.6	5.5	21.0	mild
5B2	14.25	9.3	17.6	5.8	19.0	mild
5B2	14.50	9.3	17.6	2.6	85.0	strong
5B2	14.75	9.4	17.6	4.7	90.0	strong
5B2	15.00	9.4	17.6	6.4	24.0	mild

Field Hydrogen Peroxide Test Logs – Acid Sulfate Soils

ENVIRONMENTAL EARTH SCIENCES
CONTAMINATION RESOLVED

Job No: 118044	Date: 11/07/2018	Sampled By: LV	Client: Element Environment	Site: Stage 5

Sample ID	Sample Depth	$pH_{1:5}$	Temperature 1:5	pH_{fox}	Temperature fox	Level of Effervescence
5B2	15.25	9.5	18.4	6.8	40	mild
5B2	15.50	9.4	17.6	6.5	27.0	mild
5B2	15.75	9.7	17.5	6.6	30.0	mild
5B2	16.00	9.6	17.5	6.9	50.0	mild
5B2	17.00	9.6	18.4	7.4	93.2	strong
5B2	18.00	9.5	18.5	7.7	89.1	strong

Field Hydrogen Peroxide Test Logs – Acid Sulfate Soils

ENVIRONMENTAL EARTH SCIENCES
CONTAMINATION RESOLVED

Job No: 118044	Date: 11/07/2018	Sampled By: LV	Client: Element Environment	Site: Stage 5

Sample ID	Sample Depth	$pH_{1:5}$	Temperature 1:5	pH_{fox}	Temperature fox	Level of Effervescence
5B3	0.25	7.9	17.8	6.2	23.7	strong
5B3	0.50	8.1	17.4	6.3	20.2	mild
5B3	0.75	8.1	17.4	6.3	19.4	none
5B3	1.00	8.3	17.6	6.4	20.4	none
5B3	1.25	8.0	17.4	6.3	18.4	none
5B3	1.50	8.0	17.4	6.2	18.1	none
5B3	1.75	8.2	17.4	6.4	18.6	none
5B3	2.00	8.0	17.4	6.2	18.6	none
5B3	2.25	7.6	17.4	6.2	19.1	none
5B3	2.50	7.6	17.4	5.9	18.3	none
5B3	2.75	7.8	17.4	6.2	18.7	none
5B3	3.00	8.0	17.4	6.0	19.9	mild
5B3	3.25	8.0	16.7	6.1	21.4	mild
5B3	3.50	8.0	17.7	6.1	21.7	mild
5B3	3.75	8.1	17.9	6.1	21.3	mild
5B3	4.00	8.6	18.0	6.0	21.3	mild
5B3	4.25	8.6	17.8	6.3	19.2	mild
5B3	4.50	8.5	17.8	6.2	19.5	mild
5B3	4.75	8.4	17.8	6.3	19.9	mild
5B3	5.00	8.4	17.8	6.3	20.3	mild
5B3	5.25	8.5	17.8	6.3	20.3	mild
5B3	5.50	8.5	17.8	6.1	20.3	mild
5B3	5.75	8.5	17.8	6.0	20.4	mild
5B3	6.00	8.5	17.8	6.2	21.6	mild
5B3	6.25	8.6	17.8	5.8	20.1	mild
5B3	6.50	8.7	18.0	6.0	21.6	mild
5B3	6.75	8.6	17.9	6.1	22.6	mild
5B3	7.00	8.7	18.0	5.9	23.2	mild
5B3	7.25	8.8	18.1	5.8	21.5	mild
5B3	7.50	8.9	18.1	6.0	20.0	mild
5B3	7.75	9.0	17.8	5.8	20.1	mild
5B3	8.00	8.6	18.1	6.0	20.5	mild

Field Hydrogen Peroxide Test Logs – Acid Sulfate Soils

ENVIRONMENTAL EARTH SCIENCES
CONTAMINATION RESOLVED

Job No: 118044	Date: 11/07/2018	Sampled By: LV	Client: Element Environment	Site: Stage 5

Sample ID	Sample Depth	$pH_{1:5}$	Temperature 1:5	pH_{fox}	Temperature fox	Level of Effervescence
5B3	8.25	8.8	18	6	20.7	mild
5B3	8.50	8.8	17.9	6.0	20.7	mild
5B3	8.75	8.7	18.2	6.0	20.8	mild
5B3	9.00	8.6	18.1	6.3	21.2	mild
5B3	9.25	9.1	17.5	6.1	18.5	mild
5B3	9.50	9.1	17.5	6.1	18.2	mild
5B3	9.75	9.0	17.4	6.1	18.3	mild
5B3	10.00	9.2	17.5	6.0	18.6	mild
5B3	10.25	9.1	17.5	6.2	18.5	mild
5B3	10.50	9.2	17.5	6.1	19.0	mild
5B3	10.75	9.1	17.5	6.4	19.0	mild
5B3	11.00	9.3	17.5	6.3	18.9	mild
5B3	11.25	9.1	19.2	6.2	19.5	mild
5B3	11.50	9.1	18.5	6.2	23.9	mild
5B3	11.75	9.0	18.2	6.3	23.3	mild
5B3	12.00	9.1	18.2	6.2	20.0	mild
5B3	12.25	9.4	18.2	5.9	22.7	mild
5B3	12.50	8.9	18.2	6.1	25.5	mild
5B3	12.75	8.7	18.2	6.2	24.1	mild
5B3	13.00	8.6	18.2	6.4	30.7	mild
5B3	13.25	8.2	19.0	6.0	22.8	mild
5B3	13.50	8.3	18.5	5.9	22.7	mild
5B3	13.75	8.2	18.9	5.6	21.4	mild
5B3	14.00	8.4	18.7	5.4	20.8	mild
5B3	14.25	7.5	18.9	5.8	19.0	mild
5B3	14.50	7.5	18.8	5.5	19.7	mild
5B3	14.75	7.2	18.2	5.7	20.1	mild
5B3	15.00	7.3	18.4	5.7	20.6	mild

Field Hydrogen Peroxide Test Logs – Acid Sulfate Soils

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Sample ID	Sample Depth	$pH_{1:5}$	Temperature 1:5	pH_{fox}	Temperature fox	Level of Effervescence
5B3	15.25	7.3	18.8	5.6	21.6	mild
5B3	15.50	7.7	18.8	5.4	21.6	mild
5B3	15.75	7.6	18.5	5.5	21.5	mild
5B3	16.00	7.3	18.2	6.2	22.3	mild

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Sample ID	Sample Depth	$pH_{1:5}$	Temperature 1:5	pH_{fox}	Temperature fox	Level of Effervescence
5B4	0.25	6.7	16.5	6.2	17.5	mild
5B4	0.50	8.2	16.5	6.2	15.9	mild
5B4	0.75	8.5	16.5	6.3	15.8	mild
5B4	1.00	8.8	16.5	6.4	15.8	mild
5B4	1.25	9.0	16.5	6.0	15.6	none
5B4	1.50	9.0	16.5	5.9	15.4	none
5B4	1.75	8.7	16.5	6.0	15.3	none
5B4	2.00	8.8	16.5	5.8	15.4	mild
5B4	2.25	8.6	16.5	5.8	15.6	none
5B4	2.50	8.7	16.5	6.1	17.2	mild
5B4	2.75	8.7	16.5	5.9	17.1	none
5B4	3.00	8.6	16.5	5.9	17.0	mild
5B4	3.25	8.5	17.6	5.7	18.3	mild
5B4	3.50	8.2	17.2	6.5	19.8	none
5B4	3.75	8.0	16.6	6.6	19.4	none
5B4	4.00	8.6	16.8	6.9	20.6	none
5B4	4.25	8.6	17.0	6.7	19.2	none
5B4	4.50	8.6	17.5	6.1	19.5	none
5B4	4.75	8.5	17.4	7.0	19.7	none
5B4	5.00	8.7	17.2	6.3	24.0	mild
5B4	5.25	8.3	17.3	6.6	49.3	strong
5B4	5.50	8.5	17.2	6.3	22.6	mild
5B4	5.75	8.4	17.0	6.4	22.6	mild
5B4	6.00	8.4	17.4	6.3	21.7	mild
5B4	6.25	8.6	17.4	5.9	24.8	none
5B4	6.50	8.5	17.4	5.9	23.7	none
5B4	6.75	8.4	17.4	6.4	23.6	mild
5B4	7.00	8.5	17.4	6.0	22.7	mild
5B4	7.25	8.5	17.4	5.8	23.1	mild
5B4	7.50	8.2	17.2	6.0	35.0	mild
5B4	7.75	8.3	17.2	5.8	23.3	mild
5B4	8.00	8.3	17.2	5.8	21.8	mild

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5B4	8.50	8.2	17.2	5.6	20.2	mild
5B4	8.75	8.2	17.2	6.0	23.4	mild
5B4	9.00	7.6	17.2	5.8	21.3	mild