Coastal Process Assessment
&
Dune Management Report

4226 Nelson Bay Road, Anna Bay

Prepared for

Hay Enterprises (NSW) Pty. Ltd.

EXECUTIVE SUMMARY

Hay Enterprises (NSW) Pty. Ltd. proposes to establish a sand extraction facility on Lot 591 DP 1191380, 4226 Nelson Bay Road, Anna Bay. The construction of an ancillary Site Office and Manager's Residence is also proposed at the site.

The proposed operations seek to remove wind deposited sand to natural ground level within an existing 33kV electrical easement and land immediately south of this easement. The proposal seeks to extract and remove up to 50,000 cubic metres (maximum) of sand per year over a 30-year period.

This report has been prepared to detail the impact of the proposed development on the locality's coastal environmental values and natural coastal processes and to prescribe the methods to minimise and mitigate this impact

The proposed sand extraction facility will provide a sand resource suitable for general purposes in the construction industry. Importantly, removal of windblown sand will also ensure that the 33KV electricity easement within the site is kept clear of sand and can be accessed for maintenance purposes.

The transgressive sand dune system is migrating north at a rate of approximately 4 to 5m per year onto the subject site. Excavation of this material will impact the coastal process of dune migration by stalling the northwards progression of the system but will not impact the overall dune system. This impact is already occurring at several nearby mine sites and has occurred at the subject site as part of emergency maintenance of the existing Ausgrid Electrical Easement.

With regard to impacts on long term stability, a geotechnical assessment determined the batter associated with the sand mine. It is recommended that when the mine is not actively loading out that batters be limited to a maximum of 1.5H:1V and for long term stability against mass failure that the slopes be battered at a maximum 2H:1V giving a factor of safety against ravelling failure of 1.3 and mass rotational failure of 1.5.

Final rehabilitation will ensure that slopes are battered for long term stability against mass failure. The dune faces will be mass planted with Spinifex beach strand grassland and the excavated areas will be planted with Smooth-barked Apple - Blackbutt heathy open forest of the Tomaree Peninsula.

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1 INTRODUCTION

1.1 Site Description and Report Context

Tattersall Lander Pty Limited is engaged by Hay Enterprises (NSW) Pty. Ltd to prepare a Coastal Process Assessment & Dune Management Report for a proposed sand extraction enterprise at 4226 Nelson Bay Road, Anna Bay. An ancillary Site Office and associated Manager's residence is also proposed.

The site is located on the landward edge of the Stockton mobile transgressive dune system. The mobile dune sheet is encroaching northwards into the currently vegetated sections of land at a rate of approximately 5 to 10m per year (Thom et. al. 1992).

The proposed operations seek to remove wind deposited sand to the natural ground level, prior to the current stage of dune migration, within an existing 33kV electrical easement and land immediately south of this easement. Operations seek to extract and remove up to 50,000 cubic metres (maximum) of sand per year over a 30-year period.

Importantly, removal of windblown sand will also ensure that the 33KV electricity easement within the site is kept clear of sand and can be accessed for maintenance purposes. Figure 1-1 below shows the toe of the sand dunes encroaching into the cleared electrical easement.

This report has been prepared to detail the impact of the proposed development on the locality's coastal environmental values and natural coastal processes and to prescribe the methods to minimise and mitigate this impact.

Figure 1-1: View East along 33kV Electricity Network: Poles, Wires, Easement and Part of Sand Incursion

From Figure 1-2 below it can be seen that the height of the dune system approaches the top of the electricity network poles.

Figure 1-2: View North-West from Distant Sand Dunes: 33kV Electricity Network in Background

The section of the site with dune encroachment where proposed sand mining is to occur is mapped as a Coastal Environment Area in *SEPP (Coastal Management) 2018* as shown in Figure 1-3 below.

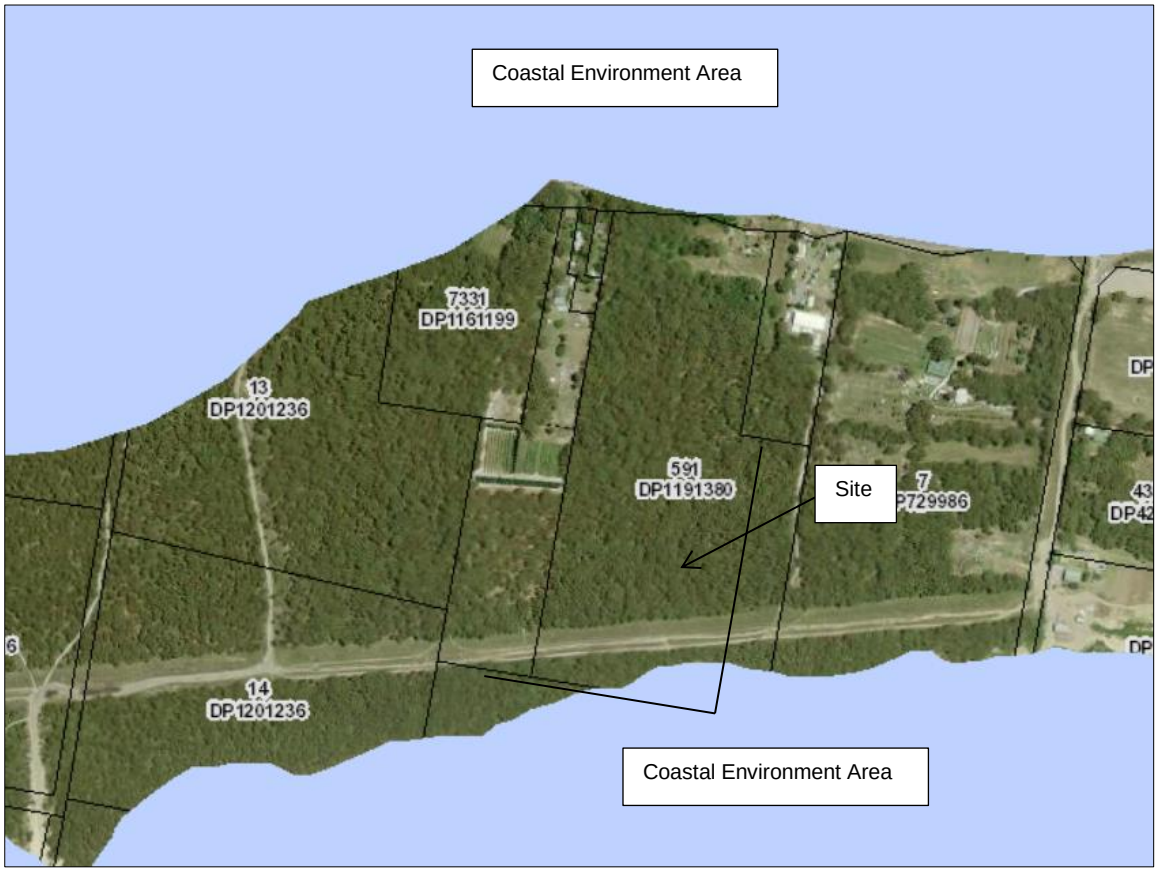


Figure 1-3: Coastal Environment Area Map and Relevance to Subject Land

Clause 13 (1) and (2) of the SEPP is relevant for the purposes of the proposed development of the land.

Clause 13 (1) states that consent must not be granted to development within the coastal environment area unless the consent authority has considered whether the proposed development is likely to cause an adverse impact on the following:

(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.

Clauses 13(1)(a), (c), (d), (e), (f) and (g) are assessed in other reports associated with the development.

This report considers 13 (1) (b) the coastal environmental values and natural coastal processes

Clause 13(2) stipulates that development consent must not be granted to development on land to which this clause applies 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.

2 Coastal Processes

As described in section 1 of this report the proposed sand extraction activities are to occur on the landward edge of the Stockton mobile transgressive dune system.

This system is the most recent of three transgressive dune systems shown as ridge III in Figure 2-1 below, with the first two systems (Ridge I & II) stabilising approximately 4000 and 1200 years ago with the current mobile transgressive system commencing 300 to 500 years ago (Thom et al. 1992).

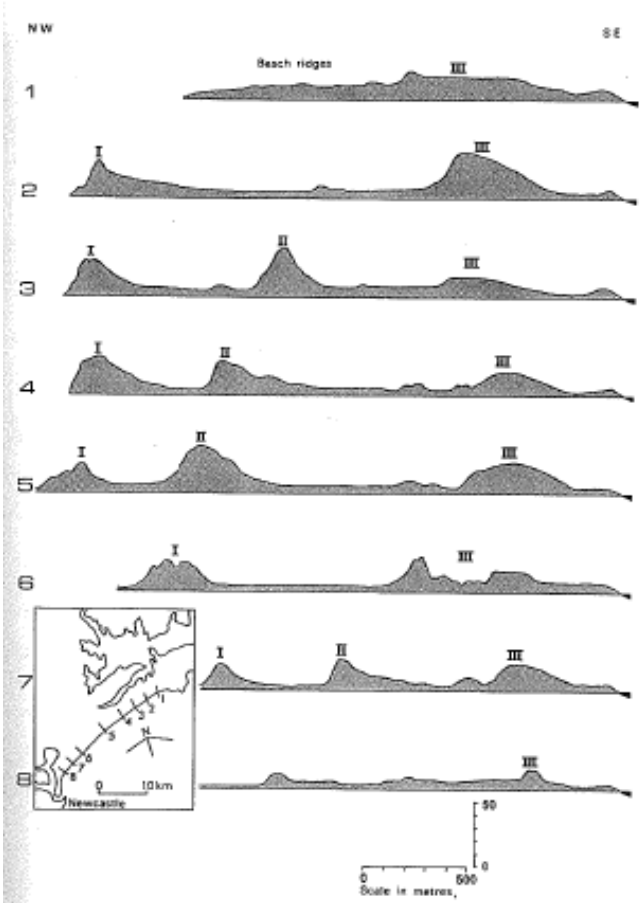


Figure 4-5: Topographic sections across the Outer Barrier of Newcastle Bight (see inset map for general location of each section). Section 1 traverses the beach-ridge (or strand plain) at the northeast end of the embayment. Roman numerals, I, II, III identify transgressive dune ridges. Ridges I and II are stable but Ridge III is mobile. The sea is on the right.

Figure 2-1: Newcastle Bight Ridges

Source: Thom et. al. (1992)

Figure 2-2 below shows the geomorphology of the Newcastle Bight region (Thom et. al.). (1992). The features on the subject site are the outer barrier strand plain and the mobile sand with transverse ridges.

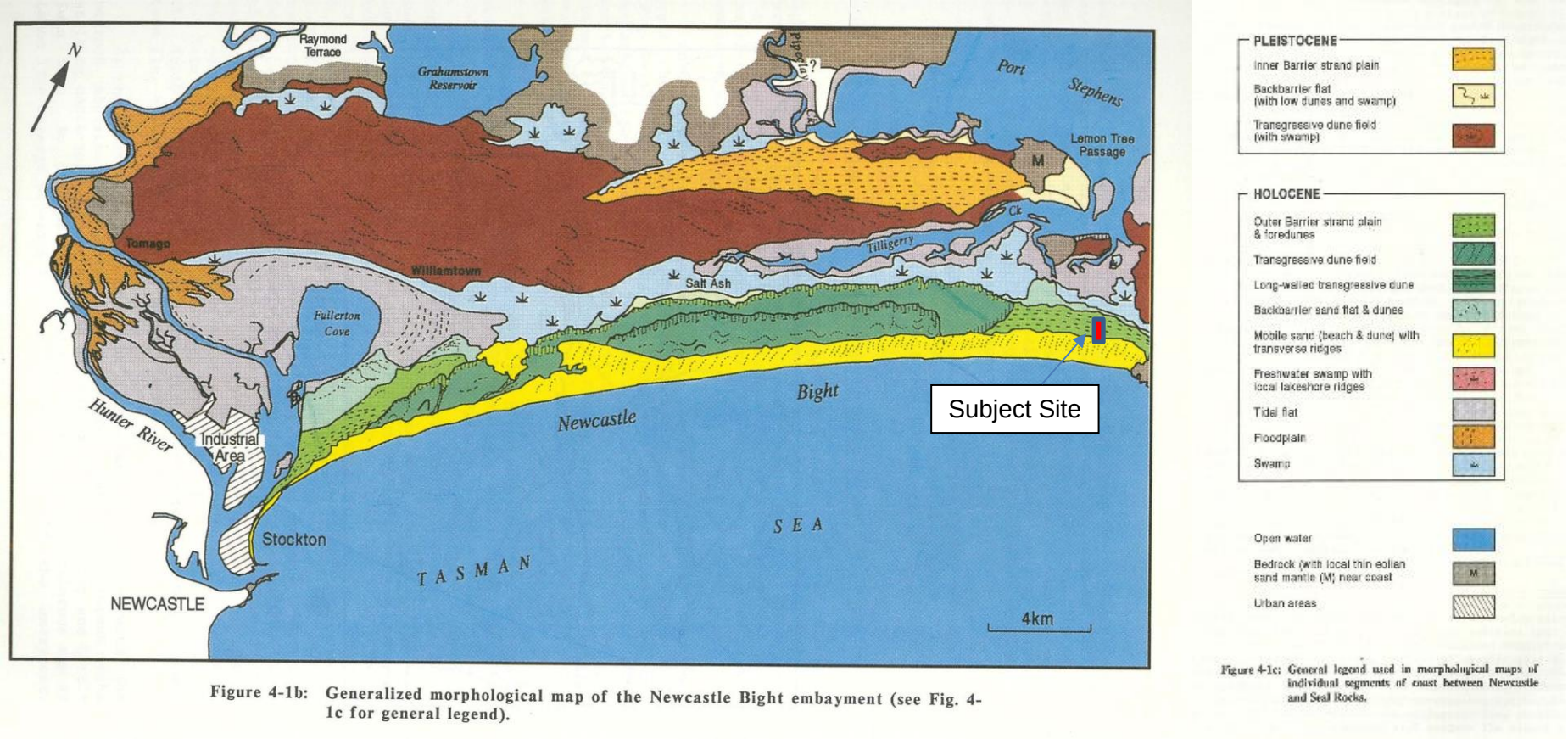


Figure 4-1b: Generalized morphological map of the Newcastle Bight embayment (see Fig. 4-1c for general legend).

Figure 4-1c: General legend used in morphological maps of individual segments of coast between Newcastle and Seal Rocks.

Figure 2-2 Newcastle Bight Geomorphology

Source: Thom et. al. (1992)

The mobile sand dunes can be broken into four main sections:

1 Transgressive Dune Sheet
2 Deflation Basin
3 Foredune
4 Beach

Figure 2-3: Coastal Dune System Sections

The beach and foredune are subject to numerous onshore and offshore coastal processes depending on wind and ocean conditions. Due to the prevailing south easterly and south westerly wind, sand that reaches the transgressive dune sheet is essentially lost from the foredune and beach system, as such the processes of the foredune, beach and deflation basin have not been considered in this report only the transgressive dune sheet.

The prevailing onshore winds and lack of vegetation cause the sand dunes to develop and migrate through aeolian transportation as shown in Figure 2-4. The width of the transgressive dune sheet south of the subject site is approximately 750m if supply of sediment from the beach and foredune systems is not taken into account the sand resource would not be exhausted for approximately 150 years which is outside the planning scope for this development

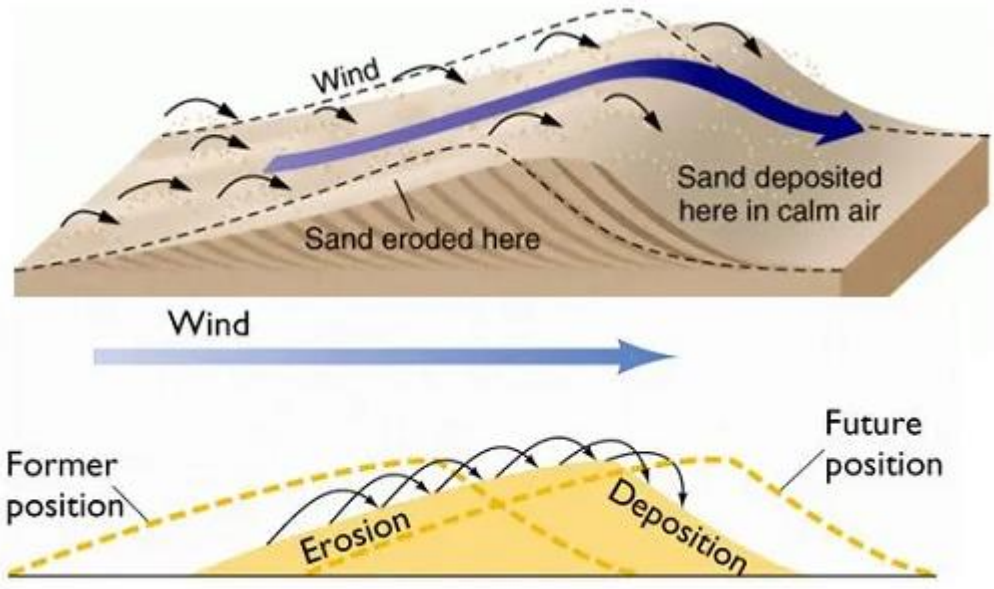


Figure 2-4: Dune Migration through Aeolian Transport

Source: GeoCon https://geologyconcepts.com/3334/

Dune transgression onto the subject site is relatively recent when considering the timescale of the coastal dune system. Figure 2-5 shows a series of satellite images from 1966 to 2018 with the property boundary of the proposed site highlighted to demonstrate the transgressive nature of the dune system. It can be seen that the face of the dune system is south of the site boundary in 1966 and encroachment over the boundary has just started by 1987. By 2016 the sand dune has started to encroach on the cleared section of the Ausgrid Power easement Emergency works to remove sand within the Ausgrid easement were undertaken during 2018.

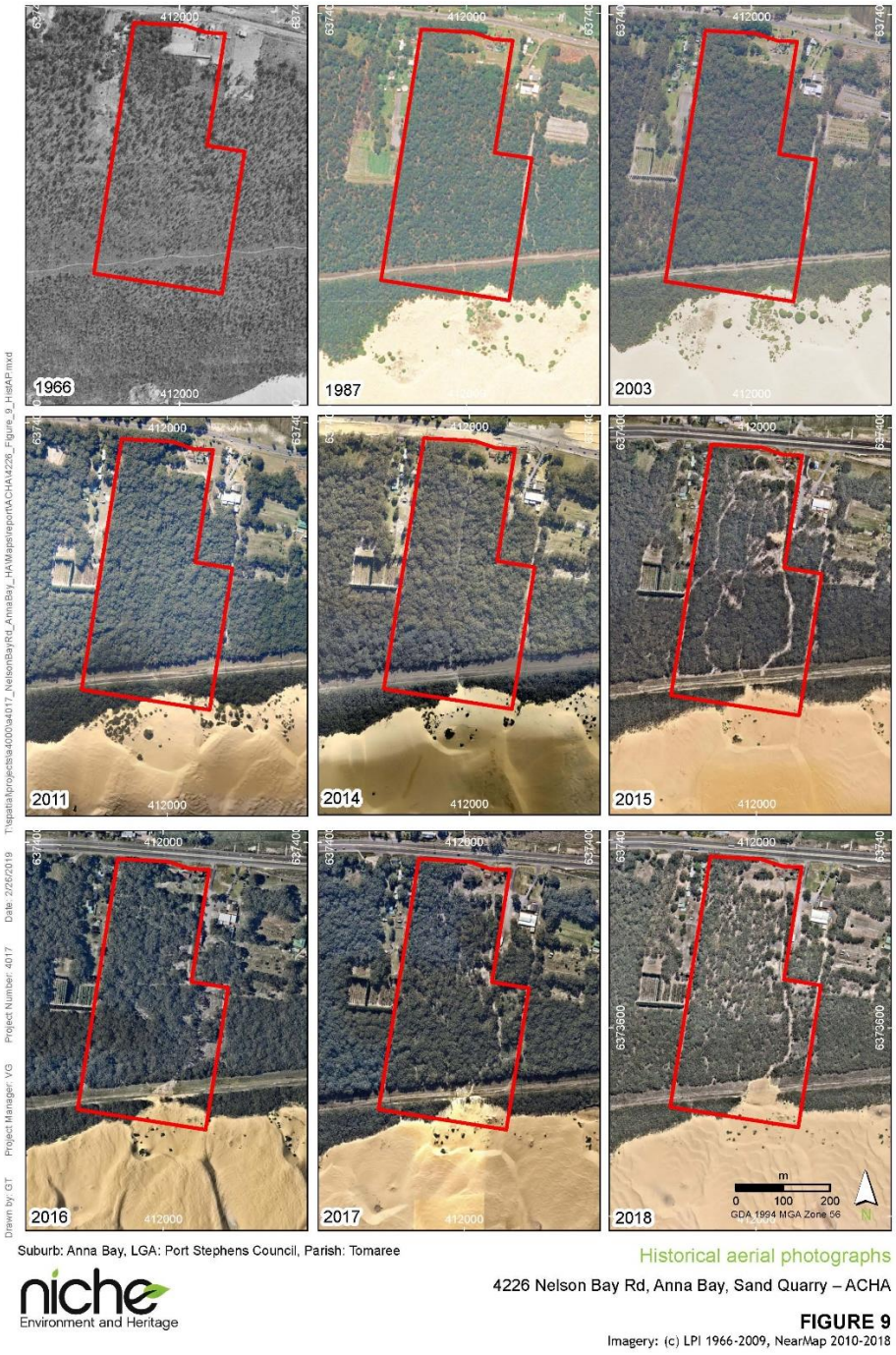


Figure 2-5: Depiction of Historical Wind-Blown Sand Incursion Over Time (1966-2018)

Source: Niche Environment & Heritage 2018

3 Assessment of Dune Transgression

3.1 Aerial Photography Analysis

A series of satellite images were obtained from Nearmap(2019) showing the landward margin of the transgressive dune system in the vicinity of the site from 2010 to 2019. These images were aligned to survey measurements of the power lines in the Ausgrid Easement and the toe of the dunes were traced for each image. Figure 3-1 shows a sample image with the toe of the dune face traced. Images for each year have been included in higher resolution in Appendix A.

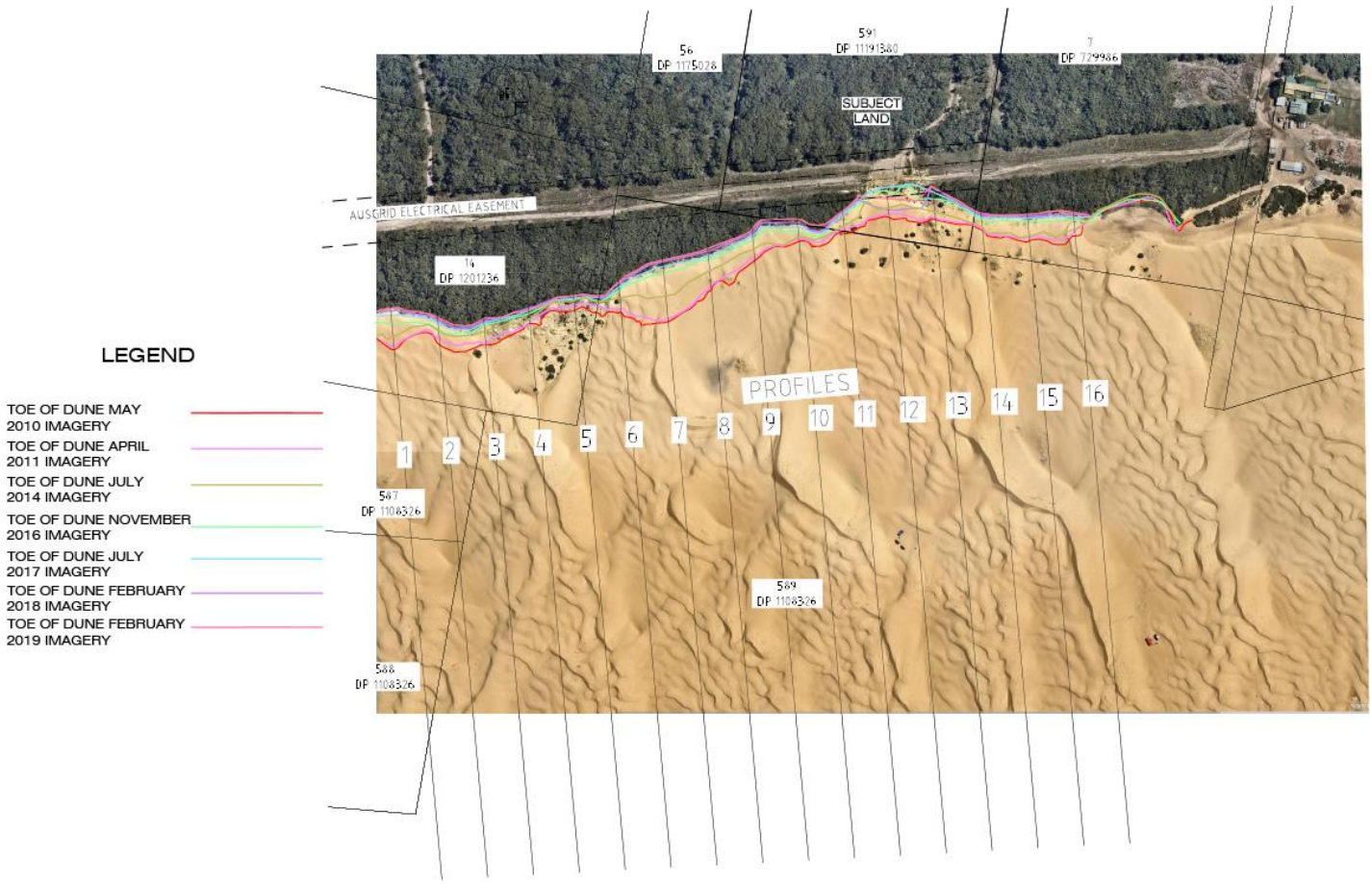


Figure 3-1: 2019 Satellite Imagery with Toe of Dune Measured.

A series of sixteen profiles between the Ausgrid Easement and the beach at 50m spacings were used to measure the distance from the toe of the dune to the Ausgrid Easement As shown in Table 3-1 and

Table 3-2 these distances were averaged over the time between image capture to give a rate of dune transgression.

Table 3-1 Distance Between Transgressive Dune Toe and Power Easement (m)

Profile	8/05/2010	9/04/2011	5/07/2014	2/11/2016	5/07/2017	16/02/2018	12/02/2019
1	117.8	114.5	104.0	89.7	80.4	75.5	72.6
2	117.3	108.1	101.8	99.9	93.2	89.4	86.9
3	121.1	120.4	106.7	100.1	97.8	96.2	93.1
4	102.8	101.3	97.6	91.7	88.3	87.5	86.1
5	92.7	86.8	82.0	80.7	79.7	77.3	77.0
6	100.1	95.5	83.7	75.4	71.8	67.7	66.6
7	114.2	110.9	86.2	60.6	53.9	48.6	47.0
8	83.6	79.1	63.2	51.0	47.2	41.6	38.7
9	56.3	52.6	43.5	34.0	28.4	25.6	22.3
10	40.1	37.5	35.4	29.4	24.3	20.5	15.7
11	35.7	31.0	28.0	14.6	13.8	11.9	11.5
12	22.7	19.0	12.1	-6.6	-10.2	14.1	2.2
13	29.5	27.8	21.3	7.4	-0.5	-5.7	-5.7
14	46.1	45.1	42.6	35.0	31.8	29.0	27.1
15	61.8	57.9	56.6	40.3	36.8	35.3	32.9
16	60.9	56.1	53.4	43.6	40.3	37.3	35.3

Table 3-2 Rate of dune progression between image dates (m/yr)

Profile	2011	2014	2016	2017	2018	2019	Average
1	3.7	3.2	6.1	13.8	8.0	2.9	6.3
2	9.9	2.0	0.8	10.0	6.1	2.6	5.2
3	0.7	4.2	2.9	3.4	2.6	3.1	2.8
4	1.6	1.2	2.5	5.1	1.3	1.4	2.2
5	6.4	1.5	0.5	1.5	4.0	0.3	2.4
6	4.9	3.6	3.6	5.3	6.7	1.2	4.2
7	3.6	7.6	11.0	9.9	8.6	1.7	7.1
8	4.9	4.9	5.2	5.7	9.1	2.8	5.4
9	4.0	2.8	4.1	8.3	4.7	3.3	4.5
10	2.8	0.7	2.6	7.6	6.1	4.8	4.1
11	5.2	0.9	5.8	1.1	3.1	0.4	2.8
12	4.0	2.1	8.0	NA	NA	NA	4.7
13	1.9	2.0	5.9	11.7	8.4	0.0	5.0
14	1.1	0.8	3.3	4.8	4.5	1.9	2.7
15	4.2	0.4	7.0	5.2	2.4	2.4	3.6
16	5.2	0.8	4.2	4.9	4.9	2.0	3.7
Average	3.9	2.5	4.6	6.7	5.4	2.1	4.1

Averaging the rates of dune progression over the 16 profiles and 9 years of satellite imagery gives a rate of 4.1m/year. At this rate, the section of easement on the subject site (Between profiles 8 and 14) would have an active dune face within the next 6 years.
The leeward face of the dune at profile 12 transgressed on the easement in 2016 and limited excavations of the face have been conducted locally in this area in subsequent years and have as such have been removed from the calculation for the average rate of transgression and labelled Not Applicable

Note that the rate of transgression between the 2018 imagery and 2019 imagery was 12.1m/yr. This is potentially due to the lack of vegetation resisting the transgression.

3.2 Contour Analysis and Photogrammetry

Ground elevation information was sourced from Geoscience Australia's elevation information system web portal - Port Stephens 2012-12-14 1 metre resolution digital elevation model.
Land to the south of the subject land is held in separate ownership, Permission to enter lot 589 DP 1108326 would be required to conduct photogrammetry survey of the approaching dune system. The owners of lot 589 are the Worimi Local Aboriginal Land Council (Worimi LALC). The Worimi LALC was contacted seeking permission to access the site for the purposes of the photogrammetry survey.
At the time of this report no response has been received.

Photogrammetry survey for a nearby site (Figure 3-2) on the same dune system has been used to compare the height of the dune systems and their progression towards the Ausgrid elecricity easement. Whilst this data was not collected originally for this use and as such does not include the landward margin of the dune system, it is approximately 800m west of the subject site and can be used to make some comparisons between 2012 and 2020.

Figure 3-2: Photogrammetry Location with respect to Subject Site

Remotely Piloted Aerial System (RPAS) Photogrammetry Survey

On the 9th July 2019 and 7th January 2020, photogrammetric missions were flown over the nearby site at Anna Bay for monitoring of the sand dunes These missions cover the dunes from the deflation basin to the edge of vegetation.

These missions take near vertical (referred to as Nadir) photos of the sand dune in a grid pattern at pre-calculated intervals designed to ensure 80% overlap between adjacent photos.

The photos were coordinated using a navigational (accurate to 2m) Global Navigation Satellite System (GNSS) receiver. Additionally, up to 9 Ground Control Points (GCPs) for each flight were placed and surveyed using survey-grade differential GNSS receivers (accurate to 50mm) using corrections from CORSnet.

Photos were then processed in Agisoft Photoscan photogrammetry software which uses Structure in Motion algorithms to detect both GCPs and common points between photos. From this, Photoscan ran a bulk adjustment of the photos to position and align them
After the initial alignment, a set of parabolic lens parameters were best fit to the coordinated targets to correct for the lens distortions on the day of the survey. The bulk adjustment was then updated with the new lens parameters to create a sparse point cloud of the dunes.

To fill in the gaps in the sparse point cloud, the Structure in Motion algorithm was used again to detect additional common points between photos and by intersection from the now known camera positions create a dense point cloud. This dense point cloud was then used to create a raster Digital Elevation Model (DEM – a raster image that stores heights of a pixel instead of colours) of the dunes and an Orthophoto (Virtual satellite photo).

All processing and coordination were conducted on Map Grid of Australia 1994 (MGA94) zone 56 using AusGEOID09 to simulate Australian Height Datum 1971

(AHD71) and truthed to Survey Control Information Management System (SCIMS) coordinated marks near the site.

Geographic Information System (GIS) Analysis

Using QGIS GIS software, the 2012 DEM from LIDAR was compared to the 2020 DEM from Photogrammetry by use of a subtractive algorithm (difference = 2020 Elevation – 2012 Elevation). The result of the algorithm is shown in false colour below in Figure 3-3 where; positive values denote accretion, and negative values denote erosion.

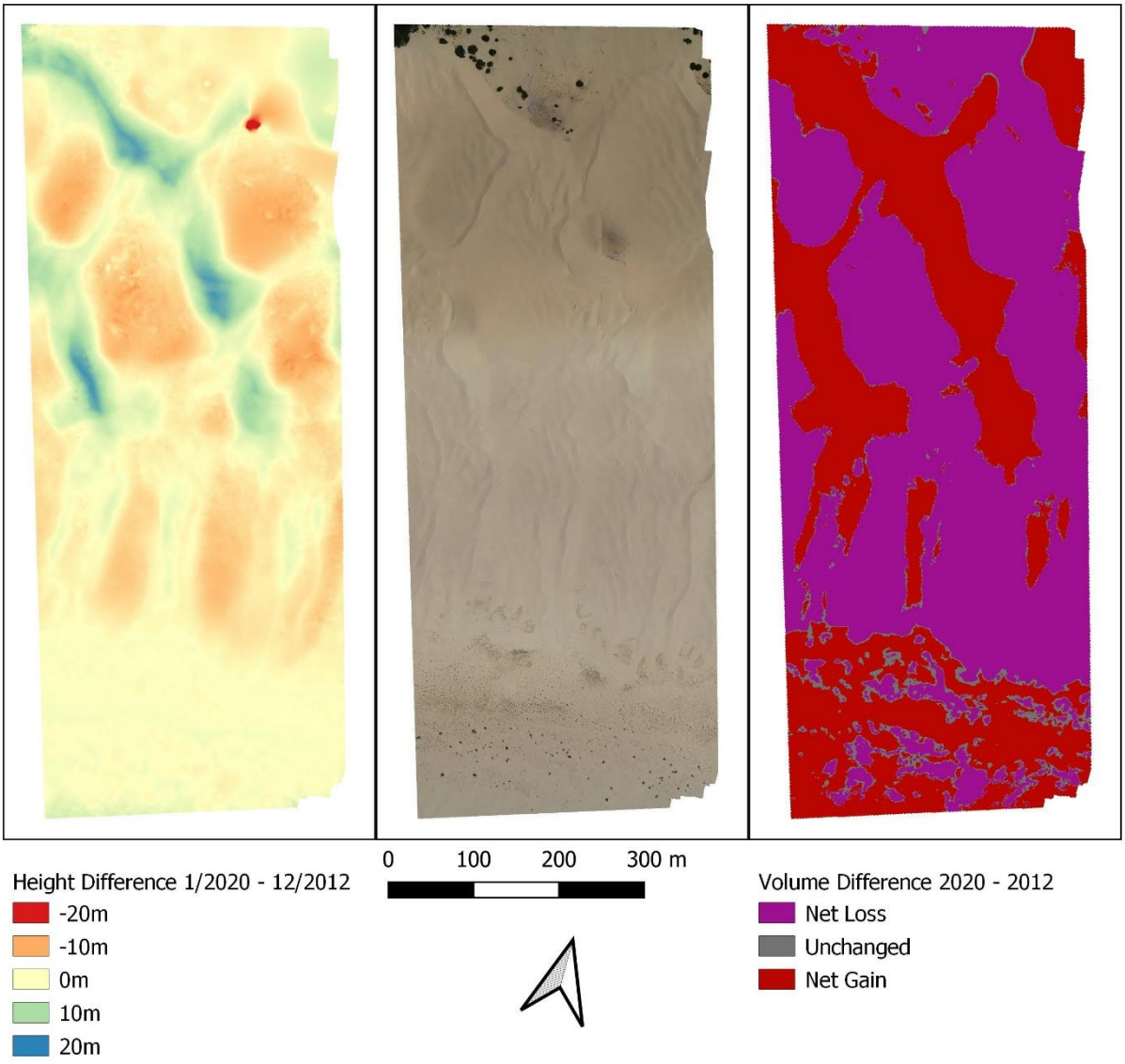


Figure 3-3: QGIS Subtractive Analysis (2012-2020)

This image shows the general northward trend of the dune system with the ridges eroding and accreting whilst maintaining a similar profile in a NNE direction. Sections through the photogrammetry site show the northward progression of the dune faces. Figure 3-4 shows that the dune faces are maintaining elevation as they migrate northwards at a rate of 5 to 7.5m per year. This is consistent with the rate of transgression identified in Section 3.1 of this report and other literature. Section D is from our site towards the beach and only has data from the 2012 LiDAR information. Whilst the height of the current transgressive face is approximately 16m AHD the next ridge of the system is approximately 25m AHD. If the profile here matches the profiles of the nearby site this face could join the proposed face of the mine site within the next 30 years. This would be significantly higher than the current high voltage transmission lines which are approximately 19m AHD.

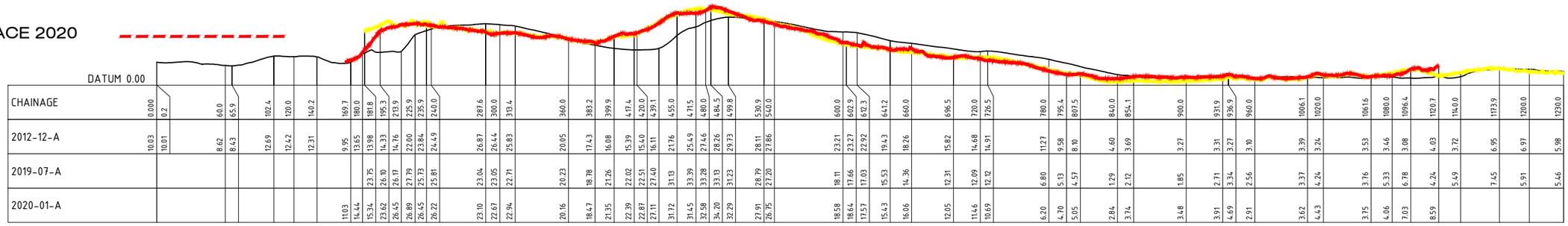
DUNE SURFACE 2012

DUNE SURFACE 2019

DUNE SURFACE 2020

Easement Approach A

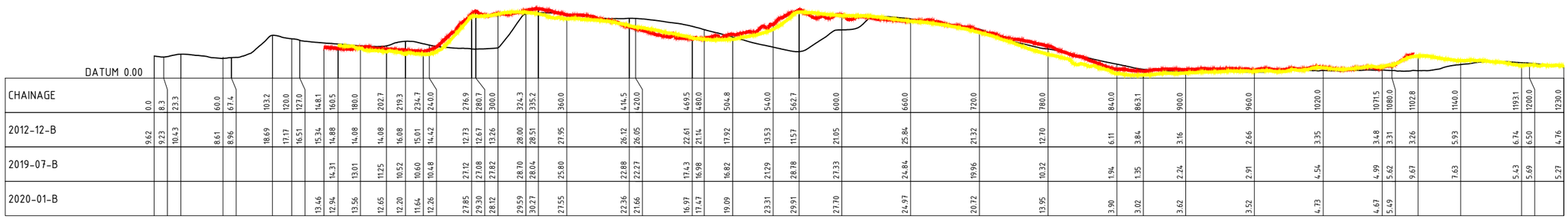
SCALES: HORIZONAL 1:4000 VERTICAL 1:2000



CHAINAGE	0.000	0.2	60.0	65.9	102.4	120.0	140.2	169.7	180.0	181.8	195.3	213.9	225.9	235.9	240.0	287.6	300.0	310.4	360.0	383.2	399.9	417.4	420.0	439.1	455.0	471.5	480.0	484.5	499.8	530.9	540.0	600.0	602.9	612.3	622.9	641.2	660.0	696.5	720.0	726.5	780.0	795.4	807.5	840.0	854.1	900.0	931.9	936.9	960.0	1006.1	1020.0	1066.16	1080.0	1096.4	1120.7	1140.0	1173.9	1200.0	1230.0
2012-12-A	10.03	10.01	8.62	8.43	12.69	12.42	12.31	9.95	13.65	13.98	14.33	14.76	22.00	23.84	24.49	26.87	26.44	25.83	20.05	17.43	16.08	15.39	15.60	16.11	21.76	25.49	27.46	28.26	29.73	28.11	27.86	23.21	23.27	22.92	19.43	18.26	15.82	14.68	14.91	11.27	9.58	8.10	4.60	3.69	3.27	3.31	3.27	3.10	3.39	3.24	3.53	3.46	3.08	4.03	3.72	6.95	6.97	5.98
2019-07-A									23.75	26.90	27.79	25.73	25.81			23.04	23.05	22.71	20.23	18.78	21.26	22.02	22.51	27.40	31.13	33.39	33.28	33.13	31.23	28.79	27.20	18.11	17.66	17.03	15.53	14.36	12.31	12.09	12.12	6.80	5.13	4.57	1.29	2.12	1.85	2.71	3.34	2.56	3.37	4.24	3.76	5.33	6.78	4.24	5.49	7.45	5.91	5.46
2020-01-A								11.03	14.44	15.34	23.62	26.45	26.89	26.45	26.22	23.10	22.67	22.94	20.16	18.47	21.35	22.39	22.87	27.11	31.72	31.45	32.58	34.20	32.29	27.91	26.75	18.58	18.64	17.57	15.43	16.06	12.05	11.46	10.69	6.20	4.70	5.05	2.84	3.74	3.48	3.91	4.69	2.91	3.62	4.43	3.75	4.06	7.03	8.59				

Easement Approach B

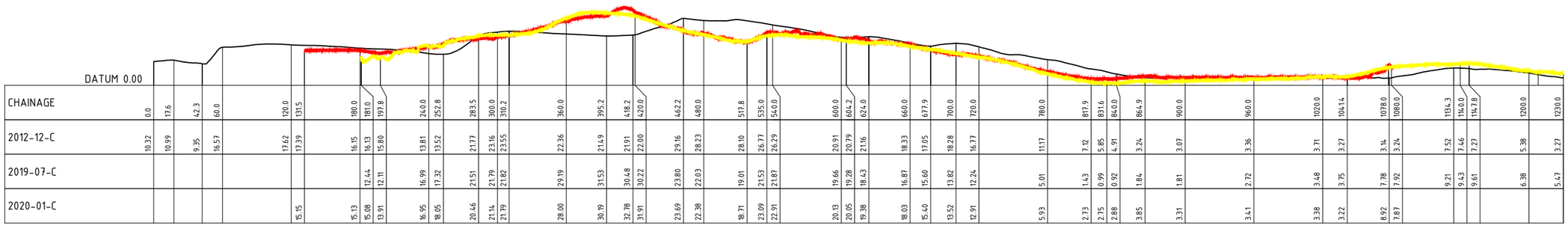
SCALES: HORIZONAL 1:4000 VERTICAL 1:2000



CHAINAGE	0.0	8.3	23.3	60.0	67.4	103.2	120.0	127.0	148.1	160.5	180.0	202.7	219.3	234.7	240.0	276.9	280.7	300.0	324.3	335.2	360.0	414.5	420.0	469.5	480.0	504.8	540.0	562.7	600.0	660.0	720.0	780.0	840.0	863.1	900.0	960.0	1020.0	1071.5	1080.0	1102.8	1140.0	1193.1	1200.0	1230.0
2012-12-B	9.62	9.23	10.43	8.61	8.96	18.69	17.17	16.51	15.34	14.88	14.08	14.08	16.08	15.01	14.42	12.73	12.67	13.26	28.00	28.51	27.95	26.12	26.05	22.61	21.14	17.92	13.53	11.57	21.05	25.84	21.32	12.70	6.11	3.84	3.16	2.66	3.35	3.48	3.31	3.26	5.93	6.74	6.50	4.76
2019-07-B										14.31	13.01	11.25	10.52	10.60	10.48	27.12	27.08	27.82	28.70	28.04	25.80	22.88	22.27	17.43	16.98	16.82	21.29	28.78	27.33	24.84	19.96	10.32	1.94	1.35	2.24	2.91	4.54	4.99	5.62	9.67	7.63	5.43	5.69	5.27
2020-01-B									13.46	12.94	13.56	12.65	12.20	11.64	12.26	27.85	29.30	28.12	29.59	30.27	27.55	22.36	21.66	16.97	17.47	19.09	23.31	29.91	27.70	24.97	20.72	13.95	3.90	3.02	3.62	3.52	4.73	4.67	5.49						

Easement Approach C

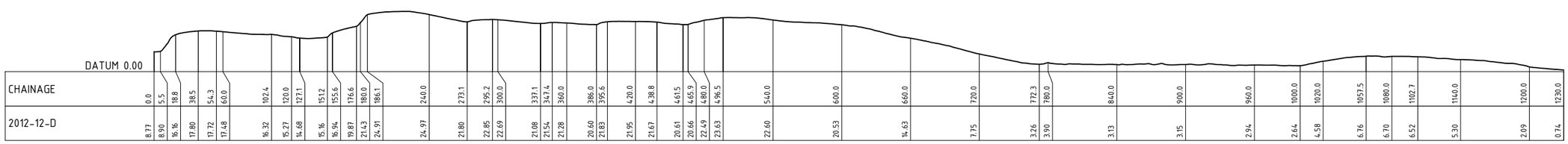
SCALES: HORIZONAL 1:4000 VERTICAL 1:2000



CHAINAGE	0.0	17.6	42.3	60.0	120.0	131.5	180.0	181.0	197.8	240.0	252.8	283.5	300.0	310.2	360.0	395.2	418.2	420.0	462.2	480.0	517.8	535.0	540.0	600.0	604.2	624.0	660.0	677.9	700.0	720.0	780.0	817.9	831.6	840.0	864.9	900.0	960.0	1020.0	1041.4	1078.0	1080.0	1134.3	1140.0	1141.8	1200.0	1230.0
2012-12-C	10.32	10.99	9.35	16.57	17.62	17.39	16.15	16.13	15.80	13.81	13.52	21.77	23.16	23.55	22.36	21.49	21.91	22.00	29.16	28.23	28.10	26.77	26.29	20.91	20.79	21.16	18.33	17.05	18.28	16.77	11.17	7.12	5.85	4.91	3.24	3.07	3.36	3.71	3.27	3.14	3.24	7.52	7.46	7.27	5.38	3.27
2019-07-C							12.44	12.11		16.99	17.32	21.51	21.79	21.82	29.19	31.53	30.48	30.22	23.80	22.03	19.01	21.53	21.87	19.66	20.05	19.28	18.43	16.87	15.60	13.82	12.24	5.01	1.43	0.99	0.92	1.84	1.81	2.72	3.48	3.75	7.78	7.92	9.21	9.43	9.61	6.38	5.47
2020-01-C					15.15	15.08	15.13	13.91		16.95	18.05	20.46	21.14	21.79	28.00	30.19	32.78	31.91	23.69	22.38	18.71	23.09	22.91	20.13	20.05	19.38	18.03	15.40	13.52	12.91	5.93	2.73	2.75	2.88	3.85	3.31	3.41	3.38	3.22	8.92	7.87					

Easement Approach D

SCALES: HORIZONAL 1:4000 VERTICAL 1:2000



CHAINAGE	0.0	5.5	18.8	38.5	54.3	60.0	102.4	120.0	127.1	151.2	155.6	176.6	180.0	186.1	240.0	273.1	295.2	300.0	331.1	347.4	360.0	386.0	395.6	420.0	438.8	461.5	465.9	480.0	496.5	540.0	600.0	660.0	720.0	772.3	780.0	840.0	900.0	960.0	1000.0	1020.0	1057.5	1080.0	1102.7	1140.0	1200.0	1230.0
2012-12-D	8.77	8.90	16.16	17.80	17.72	17.48	16.32	15.27	14.68	15.16	16.94	19.87	21.43	24.91	24.97	21.80	22.85	22.69	21.08	21.54	21.28	20.60	21.83	21.95	21.67	20.61	20.66	22.49	23.63	22.60	20.53	14.63	7.75	3.26	3.90	3.13	3.15	2.94	2.64	4.58	6.16	6.70	6.52	5.30	2.09	0.74

Figure 3-4: Sections Through nearby dunes (2012-2020)

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DUNE PROFILES FROM 2012 TO 2020

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4 STABILITY

4.1 Impacts of Extraction on Long Term Stability

As described in section 2 of this report the dunes are migrating north at a rate of approximately 4.1m/year. A geotechnical report was conducted to determine the appropriate slopes for excavation. The investigation determined that during operational works the face of excavation should be limited to 1.5H:1V which is the natural angle of repose for the existing dune face. Figure 4-1 shows the process of saltating sand accumulating on the crest of the dune and avalanching down the face, maintaining a slip face of 33 to 34 degrees.

The proposed extraction will halt the northward progression of the face but will have no impact on this natural process. The face will continue to develop at the angle of repose and avalanche past the 5m buffer zone until the sand resources to the south of the site are exhausted or stabilised.

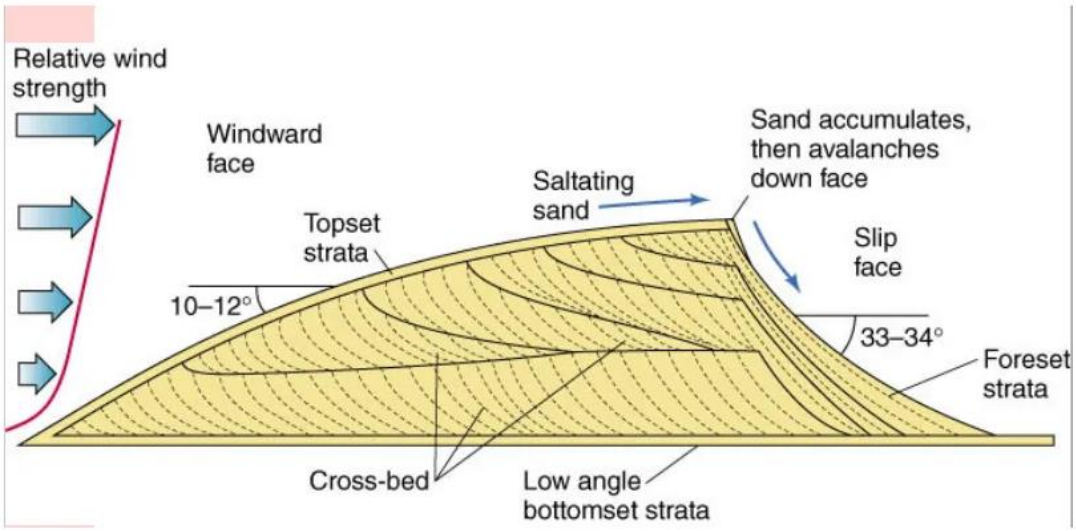

Figure 4-1: Dune Face Stability

Source: https://geologyconcepts.com/695/

4.2 Impacts of Sand Dune Movement on Ongoing Operations

The proposed sand extraction operation will remove windblown sand to 9mAHD which is the approximate ground level before the current phase of the dune encroachment. As outlined on sheet 3 of the Tattersall Lander design plans (reference 21800003), Stage 3 of the mine operation is to maintain a stable slope to the 5m buffer from the property boundary and excavate new windblown

material once enough has accumulated for removal to be viable. This method of extraction will only result in mining occurring for short spans throughout the year.

If the dune were to become stabilised on Lot 589 DP1108326 during the lifespan of extraction, operations would cease and the final rehabilitation outlined in section 4 of this report would proceed.

4.3 Management Measures to Ensure Long-term Stability

During operation, the dune face is to be managed by the following thresholds:

- Limiting extraction to the pre dune encroachment levels.
- Limiting batter slopes to 1.5H:1V as outlined in the geotechnical investigation. This limitation keeps the face of the dune system at the naturally formed angle of repose so as not to accelerate the dune transgression.
- Limiting extraction to a 5m buffer from the boundary of the site. this limitation ensures that extraction does not cause a slip face other than the naturally occurring dune accumulation outside the subject site.

Once sand extraction operations have ceased, long-term stability is to be provided by:

- Increasing the batter from 1.5H:1V to 2H:1V to provide a factor of safety against sand ravelling down the slope of 1.3 and a factor of safety against mass rotational slump of 1.5. This is an acceptable solution for the proposal as outlined in the geotechnical investigation.
- Planting binding vegetation into the dune face as per the rehabilitation plan
- Construction of dune forming fences to provide additional stability whilst vegetation establishes.

  Dune forming fences are typically used on the windward side of a blowout in a dune for repair purposes.. In this instance they are to be used to increase the angle of the slip face whilst vegetation establishes. As noted in "*Dune Management Options Study for Transgressive Dune Sheet South of Dark Point*"(2010) the vegetation on the landward face of the dune temporarily allows a steeper face until the strength of vegetation is decreased as a result of dieback.
  As the dieback has extended to the Ausgrid easement on the subject site this is currently not occurring and the northward movement of the dune face appears to have been accelerated at the subject site as a result. The

dune forming fences are to provide this increased slope stability whilst vegetation establishes.

Unless the dune system to the south of the subject site has been vegetated and the transgressive system has been halted during the lifespan of the sand extraction operations, the northward progression of the dune sheet will continue once sand extraction operations cease.

At this point there will be three options to manage the ongoing incursion of sand into the site and within the Ausgrid easement:

- Allow the dunes to encroach into the Ausgrid easement with Ausgrid to use their rights over the easement to remove sand that threatens power security in the Nelson Bay region. This is a maintenance impost for Ausgrid.
- Relocate the Ausgrid network and allow the dunes to continue further North towards existing dwellings and community facilities. This is a major financial impost for Ausgrid and is impractical.
- Recommence and maintain sand extraction operations for the duration of any development consent and EPA license.

5 POST OPERATIONAL REHABILITATION

A post operation rehabilitation plan has been developed by Wildthing Environmental Consultants (see Appendix B) The rehabilitation is proposed to be completed in two stages.

The initial rehabilitation is to occur during Stage 2 of sand extractions (Figure 5-1) where currently inundated areas that aren't required for ongoing maintenance and operation are to be revegetated with Smooth-barked Apple - Blackbutt heathy open forest (once the sand currently within these areas has been removed)
Final rehabilitation is to occur prior to closure of extraction operations. Final rehabilitation includes establishment of Smooth-barked Apple - Blackbutt heathy open forest on the flat areas of the site and Spinifex beach strand grassland on the battered slopes with dune stabilisation techniques including dune fencing to allow proposed vegetation to establish.

The staging of the rehabilitation allows as much of the proposed vegetation to establish and return to the open forest that existed on the site prior to dune inundation as possible. The proposed management zones for the rehabilitation are shown in Figure 5-1.

The management zones are described as:

- Zone 1 – Existing vegetation to be protected from dune inundation by the proposed sand extraction operation
- Zone 2 – Existing Vegetation that will be subject to sand extraction operations pending dune inundation
- Zone 3 – Proposed initial rehabilitation area
- Zone 4 – Final rehabilitation area: Smooth-barked Apple - Blackbutt heathy open forest
- Zone 5 – Final Rehabilitation Area: Spinifex beach strand grassland

Figure 5-1: Rehabilitation Management Zones

6 REFERENCES

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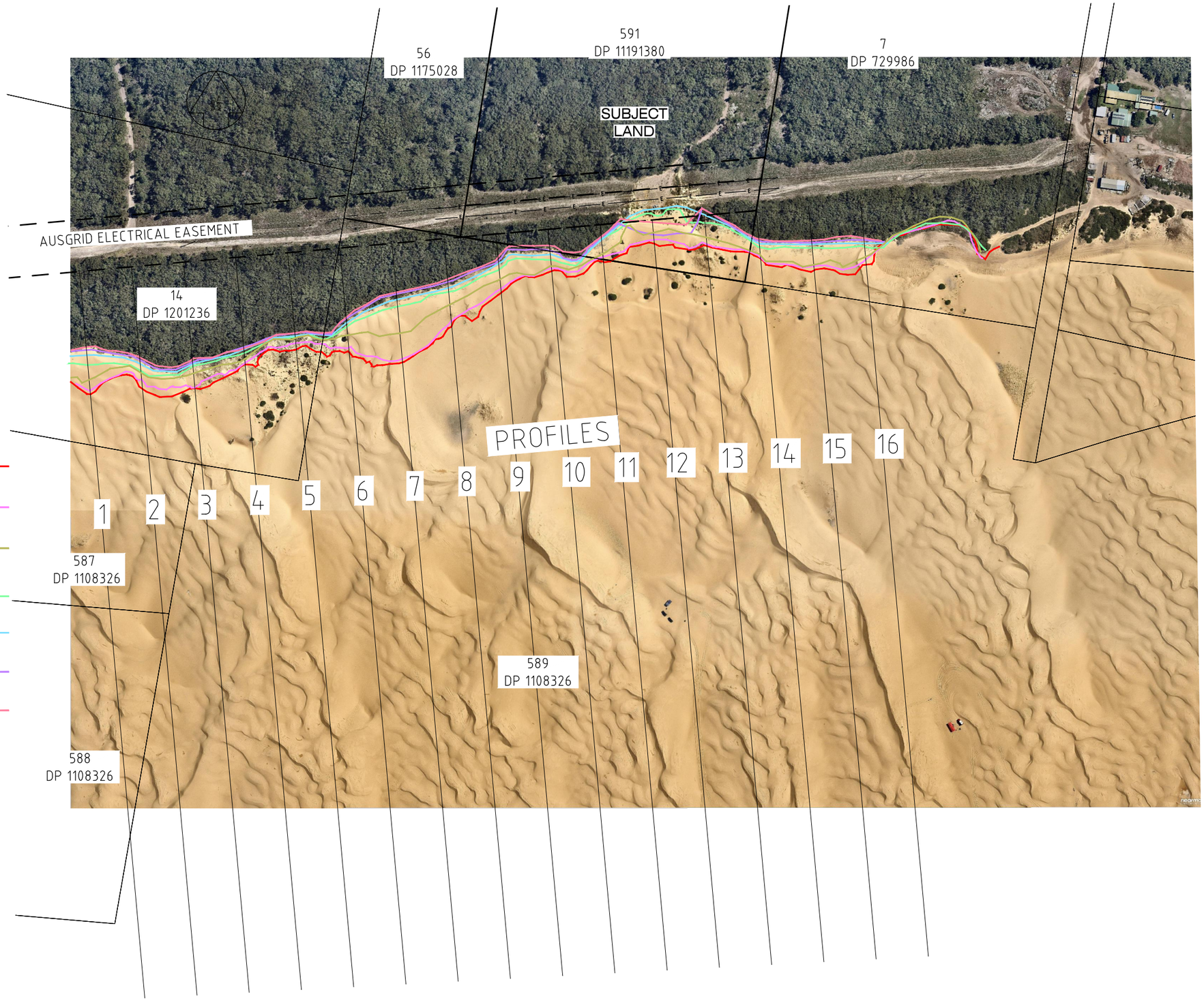
7 APPENDICES

APPENDIX A: SATELLITE IMAGERY



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AERIAL IMAGERY ANALYSIS
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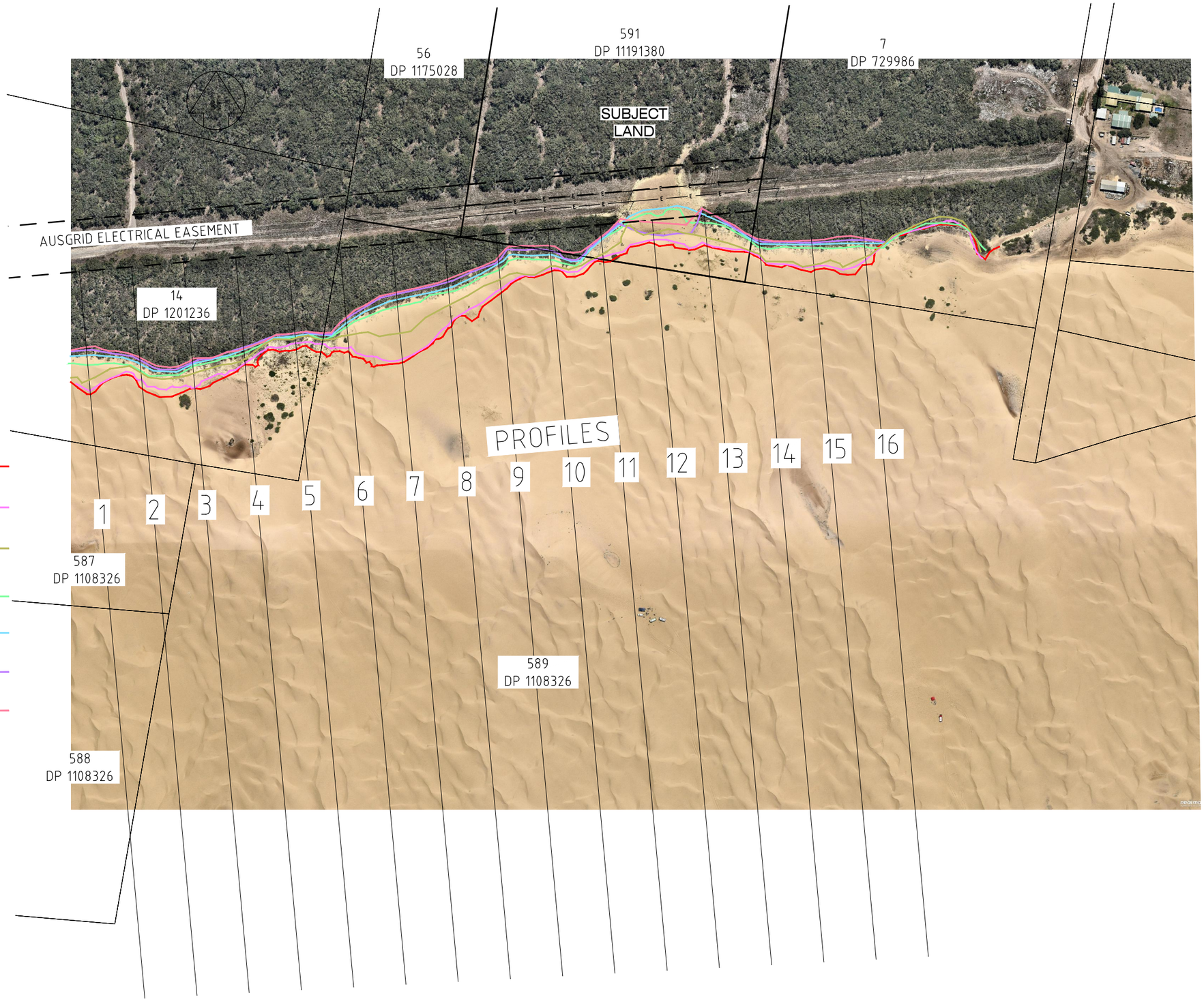

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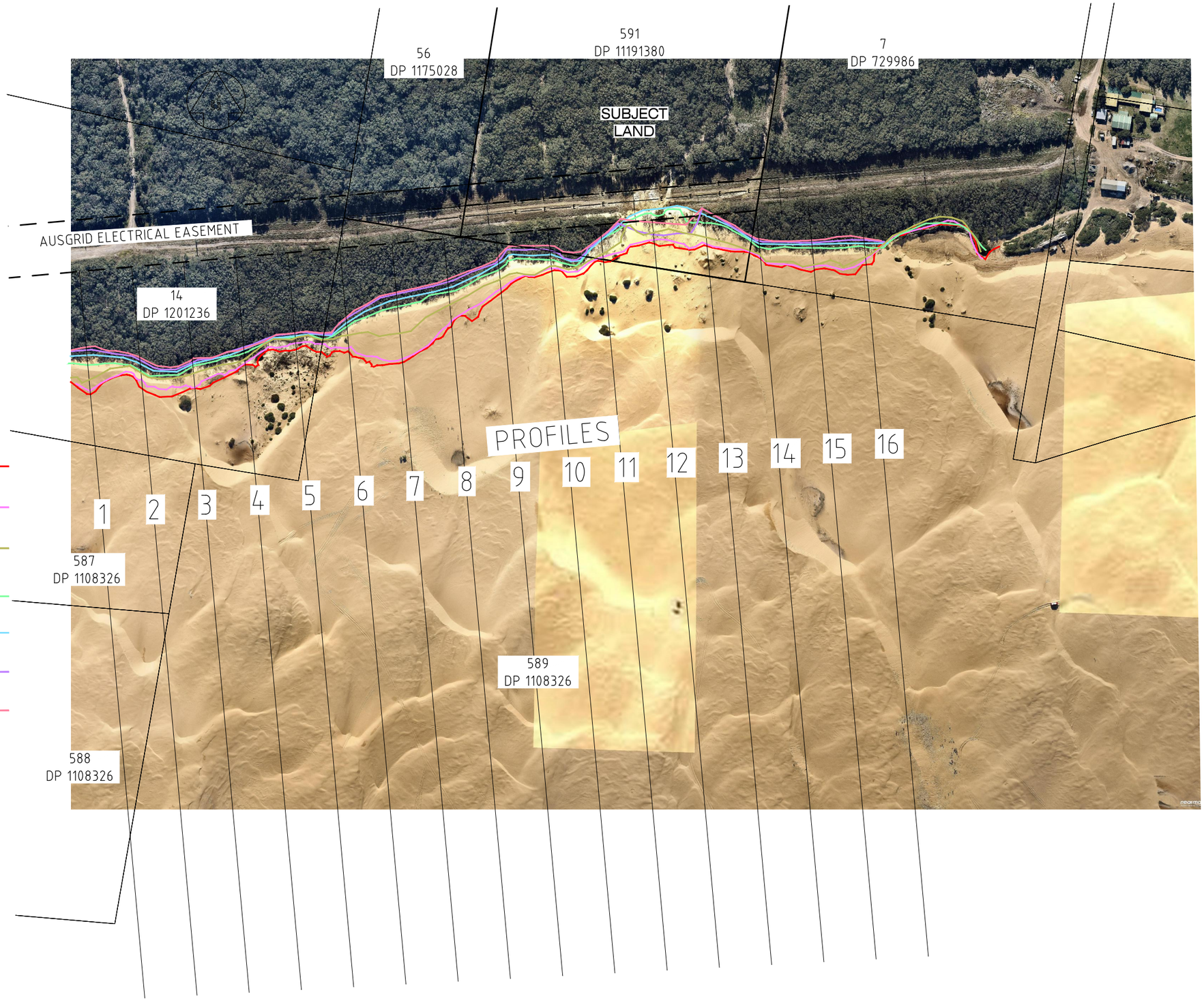

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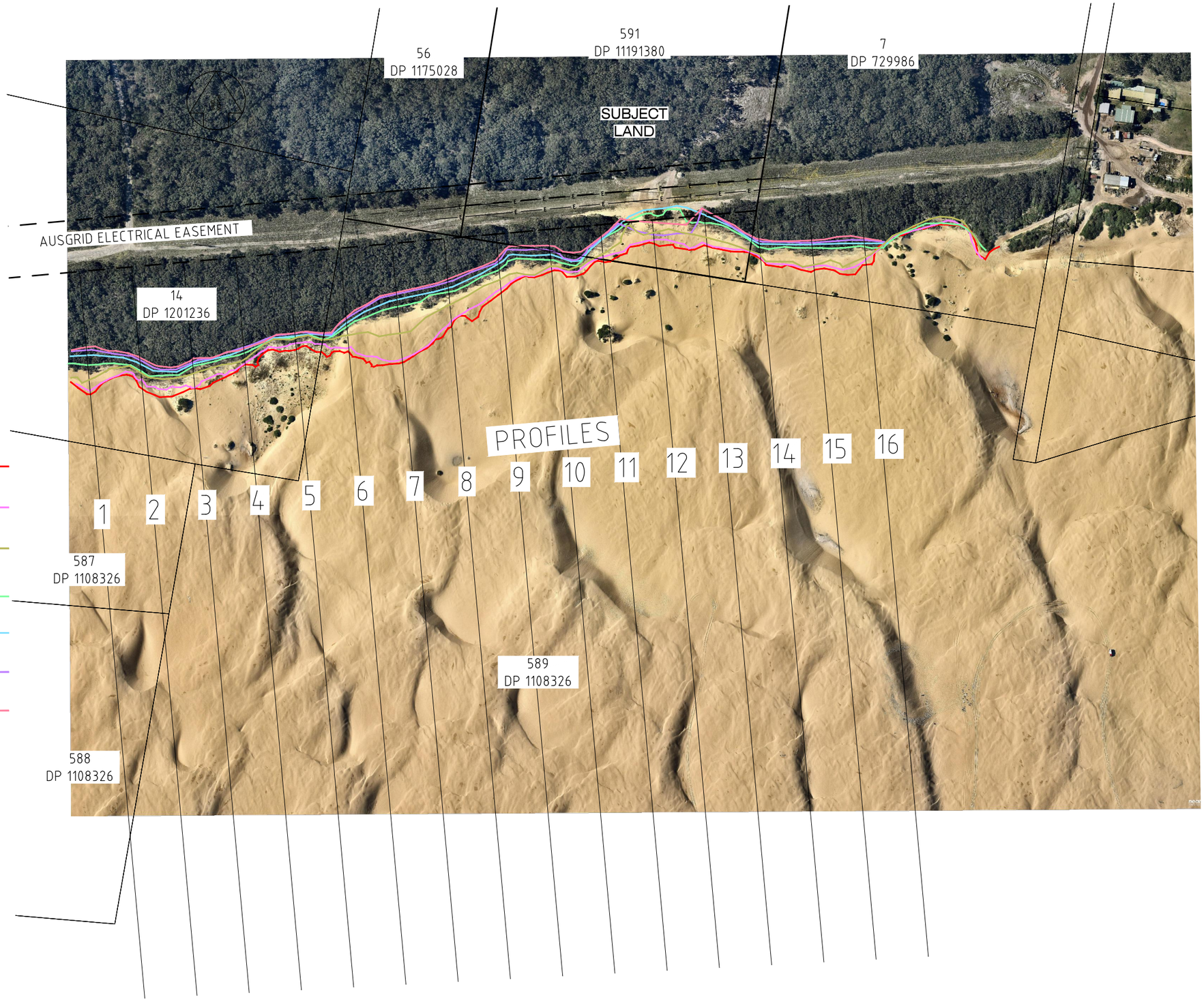

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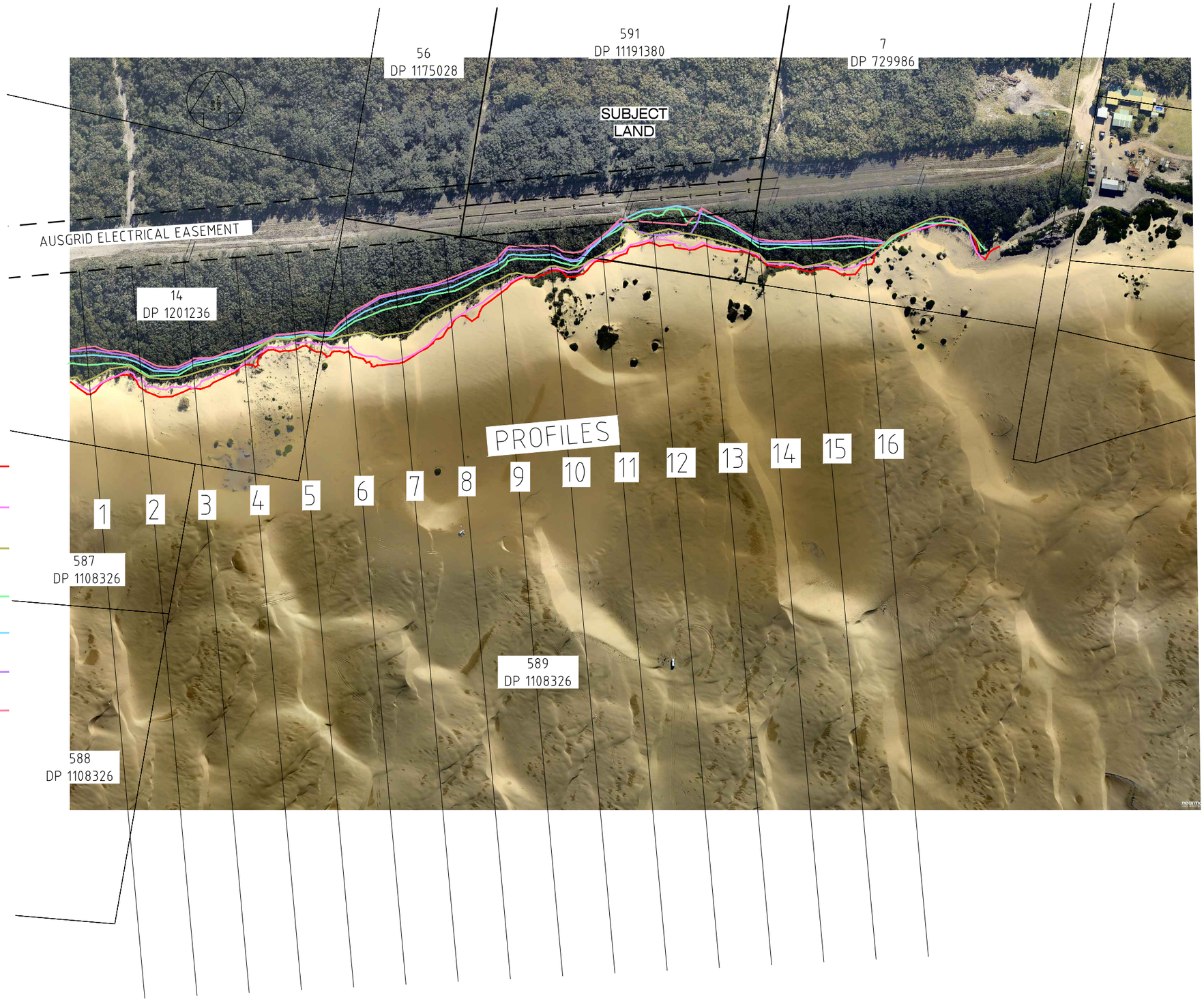

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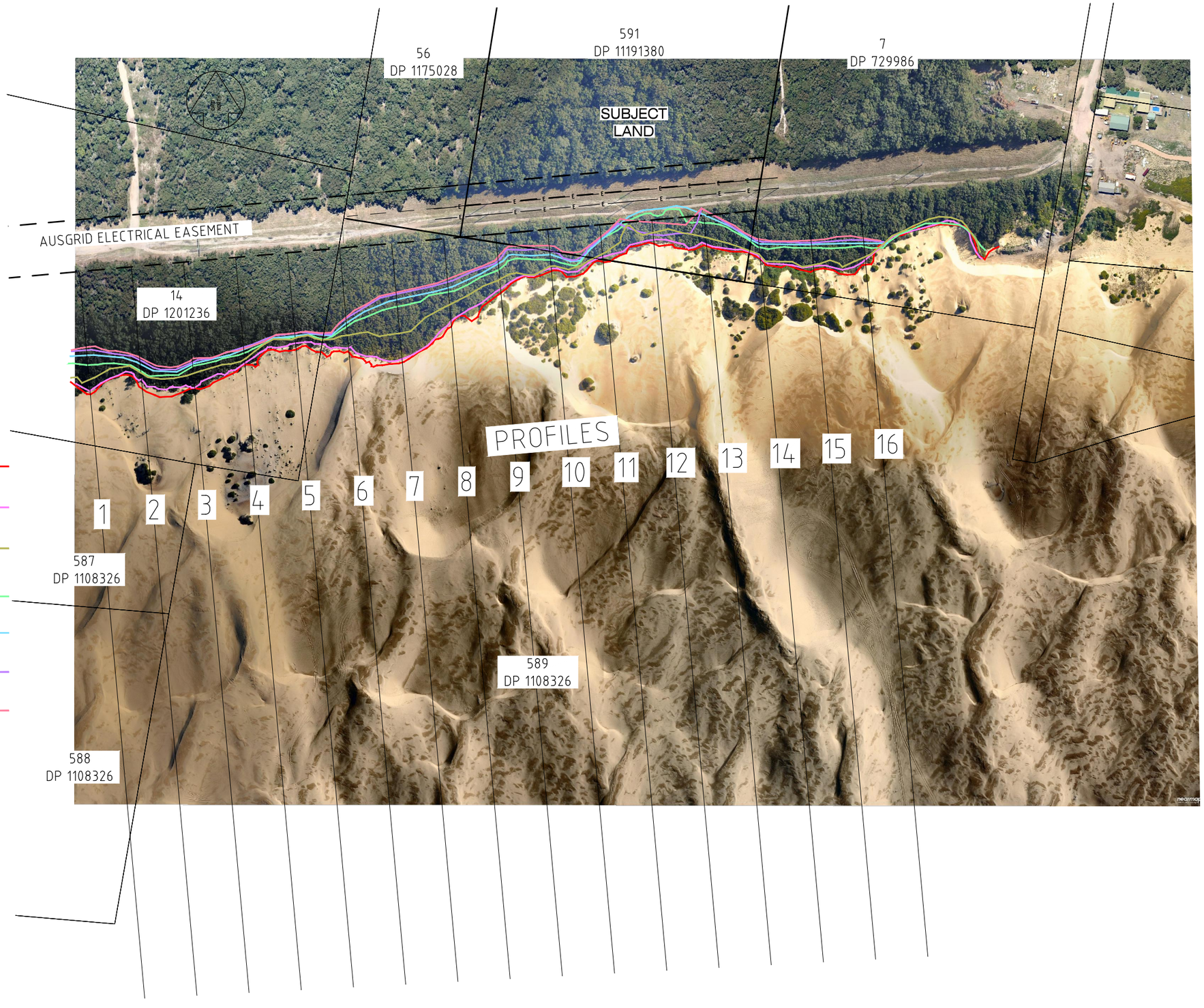

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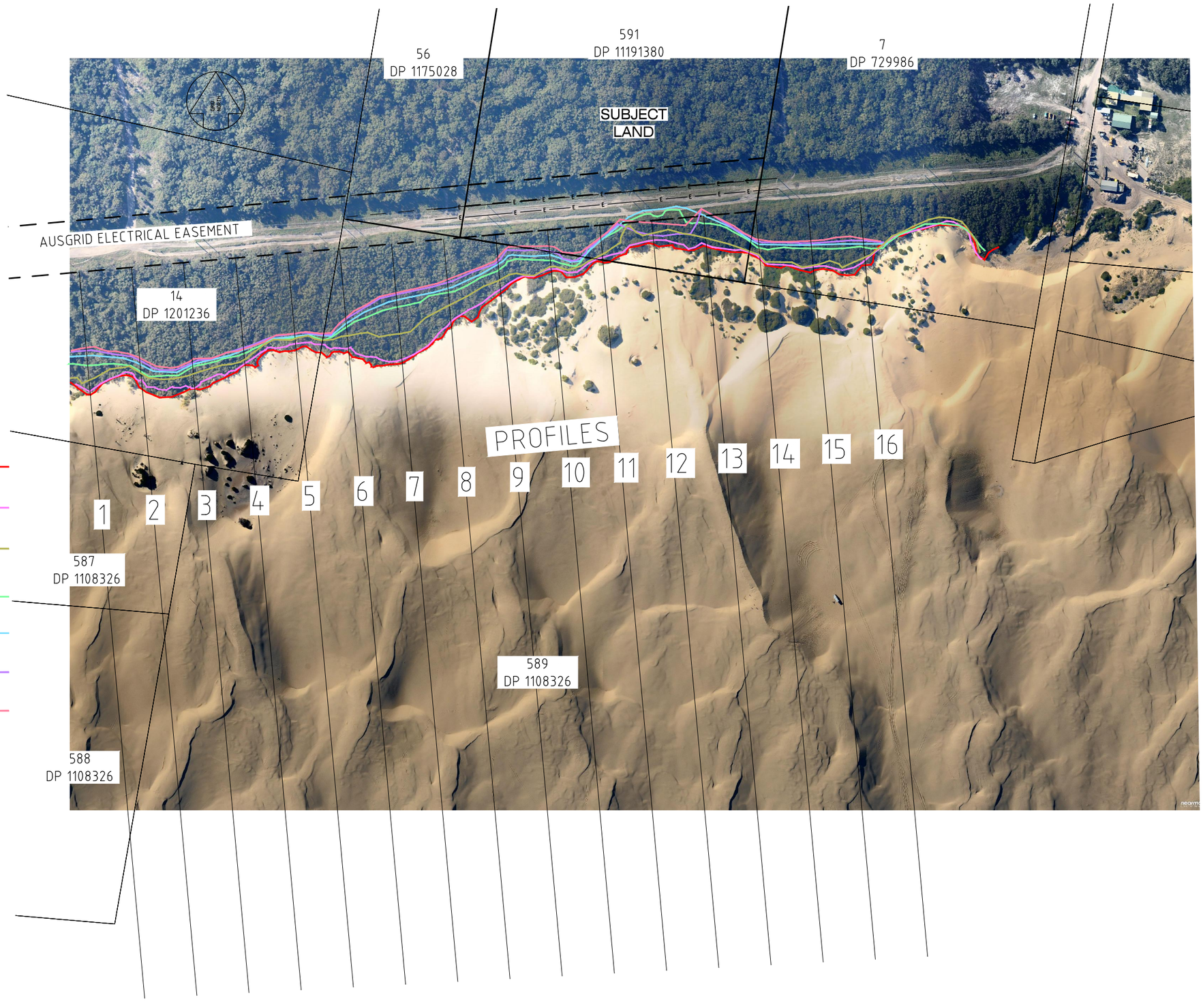

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APPENDIX B: REHABILITATION PLAN

REHABILITATION PLAN

for a
Proposed Sand Extraction Facility
at

Lot 591 DP 1191380
Nelson Bay Road
ANNA BAY
NSW

Prepared by: WILDTHING Environmental Consultants
38c Stapleton Street
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ABN: 41 033 509 215

For: **Hay Enterprises**
C/. Tattersall Lander Pty. Ltd.
PO Box 580
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Job No: 12462 ***January 2020***

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Email: admin@wildthing.com.au www.wildthing.com.au
A division of Tattersall Lander Pty Ltd
ABN: 41 003 509 215

Project Name	Rehabilitation Plan for a Proposed sand extraction facility within Lot 591 DP 1191380 Nelson Bay Road, Anna Bay NSW	
Project Number	12462	
Prepared By	Dr Kylie Bridges BEnvSc Hons PhD Ecologist	
Reviewed By	Daryl Harman BEnvSc Senior Ecologist	
Status	January 2020	

Disclaimer

This report has been prepared in accordance with the proposal provided by the Client and outlined within this report. All findings, conclusions or recommendations contained within this report are based upon the data and results collected under the times and conditions specified in the report and are only applicable for the proposal considered within this report. This report has been prepared for use exclusively by the Client. No responsibility for its use by any other party is accepted by WILDTHING Environmental Consultants.

CONTENTS

1.0 INTRODUCTION

Wildthing Environmental Consultants has prepared this Rehabilitation Plan for the proposed sand extraction facility at Lot 591 DP 1191380 Nelson Bay Road, Anna Bay NSW (Figure 1.1). The Rehabilitation Plan is required to demonstrate compliance with Section 7.2 of the *Biodiversity Conservation Act 2016* and Clause 13 of the *State Environmental Planning Policy (Coastal Management)* 2018. The Rehabilitation Plan provides a description of native vegetation on site; a breakdown of the sand extraction facility location into management zones; a schedule of works detailing the sequence and duration or works necessary for revegetation and maintenance works for each management zone.

1.1 OBJECTIVE OF THE REHABILITATION PLAN

The objectives of the Rehabilitation Plan include:

- To rehabilitate vegetation south of the Ausgrid easement during Stage 2 of the proposed development
- To rehabilitate vegetation south of the Ausgrid easement upon completion of the sand extraction facility licence.
- To ensure the ongoing ecological viability of the retained areas of vegetation by protecting the ecological biodiversity and habitat values of the land;
- To create stabilisation of the sand dunes to allow plantings to establish.

The Rehabilitation Plan will include:

- The condition of the existing vegetation;
- Description of proposed environment;
- Protection of native vegetation;
- Weed management techniques;
- Planting methods;
- Monitoring and reporting;
- Costs.

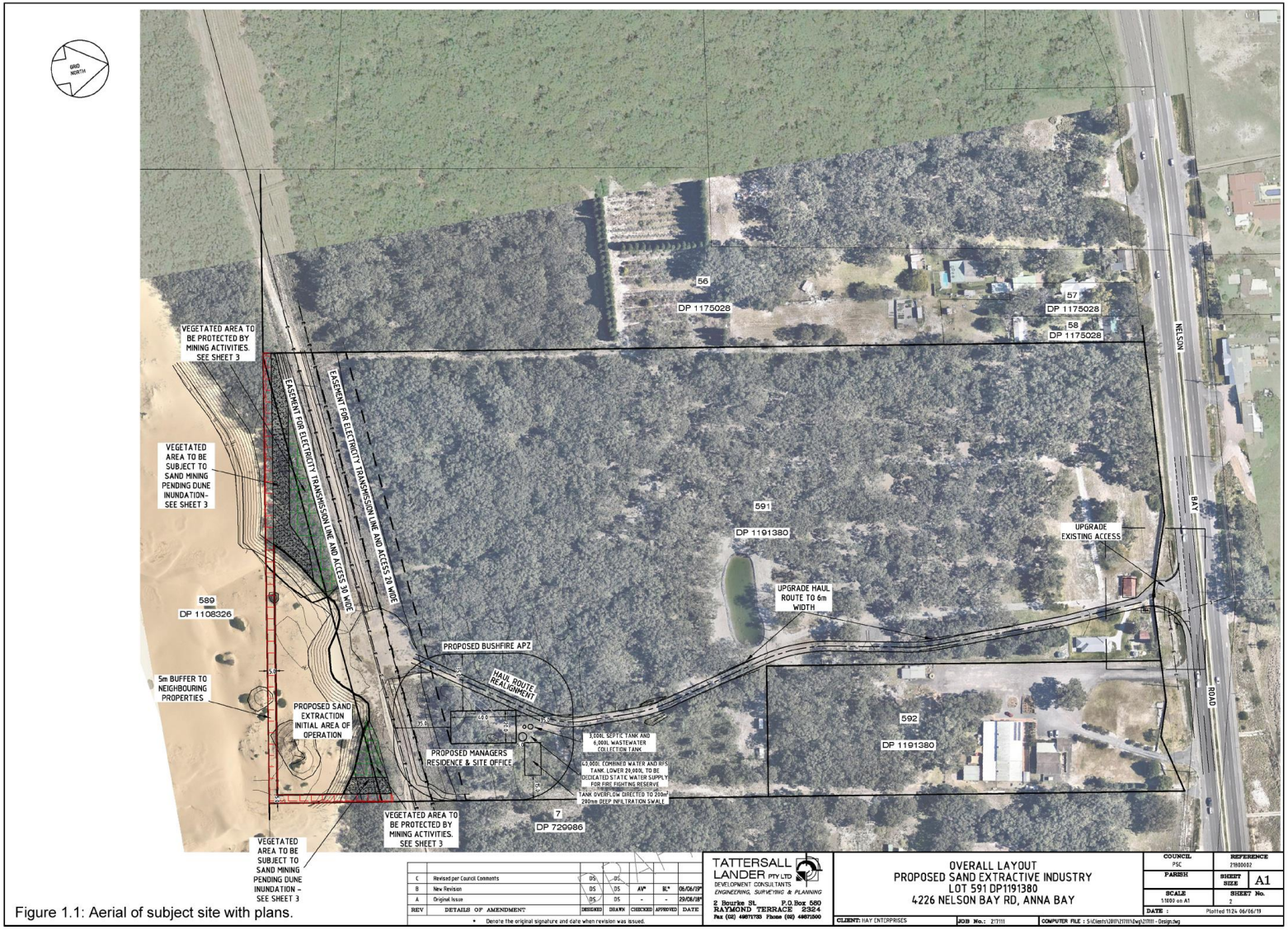


Figure 1.1: Aerial of subject site with plans.

1.2 DOCUMENTATION USED IN REHABILITATION PLAN

The Rehabilitation Plan has considered the information contained within the following documentation:

- Wildthing Environmental Consultants. *Biodiversity Development Assessment Report for a proposed sand extraction quarry at Lot 591 DP 1191380 Nelson Bay Road, Anna Bay NSW.* Updated January 2020.
- Port Stephens Council (2014). *Port Stephens Council Development Control Plan,* November 2014;
- Port Stephens Council (2014). *Port Stephens Council Vegetation Technical Specification*. May 2014.
- NSW Department of Land and Water Conservation (2001). Coastal Dune Management: A Manual of Coastal Dune Management and Rehabilitation Techniques, Coastal Unit, DLWC, Newcastle

2.0 SITE DESCRIPTION

2.1 SITE LOCATION

The 13.66 ha study area (Lot 591 DP 1191380) is located at Anna Bay, NSW, approximately 32km north-east of Newcastle and 9km south-west of Nelson Bay. The study area is situated on the southern side of Nelson Bay Road, bounded by the Stockton sand dunes to the south and predominantly bushland to the east and west.

2.2 DESCRIPTION OF DEVELOPMENT

The proposed sand extraction facility will require the installation of several minor project components during its construction stage, which are:

- A minor realignment of a pre-existing access track running north through the study area to allow for the movement of reticulated vehicles accessing the sand dunes of Stockton Bight from Nelson Bay Road
- The construction of a site office/manager's residence with a development footprint of approx. 800m2
- The establishment of a bushfire asset protection zone with a radius of approximately 35m from the edge of the site office/manager's residence

Operational effects of the sand extraction process will be restricted to the bulk handling of sand material, utilising front end loaders and reticulated vehicles for the transport of the material to the required markets. Initially the extraction of sand will be restricted to the area of Stockton Sand Dunes that has encroached into the study area (approximately 1 ha). It is anticipated, based upon previous observations made by the proponent, that the sand dune incursion within the study area will advance over time allowing for more sand material extent to be extracted. The sand extraction will continue to be largely dependent on wind deposition. Once the existing sand resource is retrieved, the facility will only operate occasionally. The operation will provide up to 50,000 cubic metres of extracted material per annum. When in operation, the development is proposed to operate between the hours of 7:00 am and 6:00 pm Monday to Friday and between 8:00 am to 1:00 pm on Saturdays. No work is proposed on Sundays or on Public Holidays.

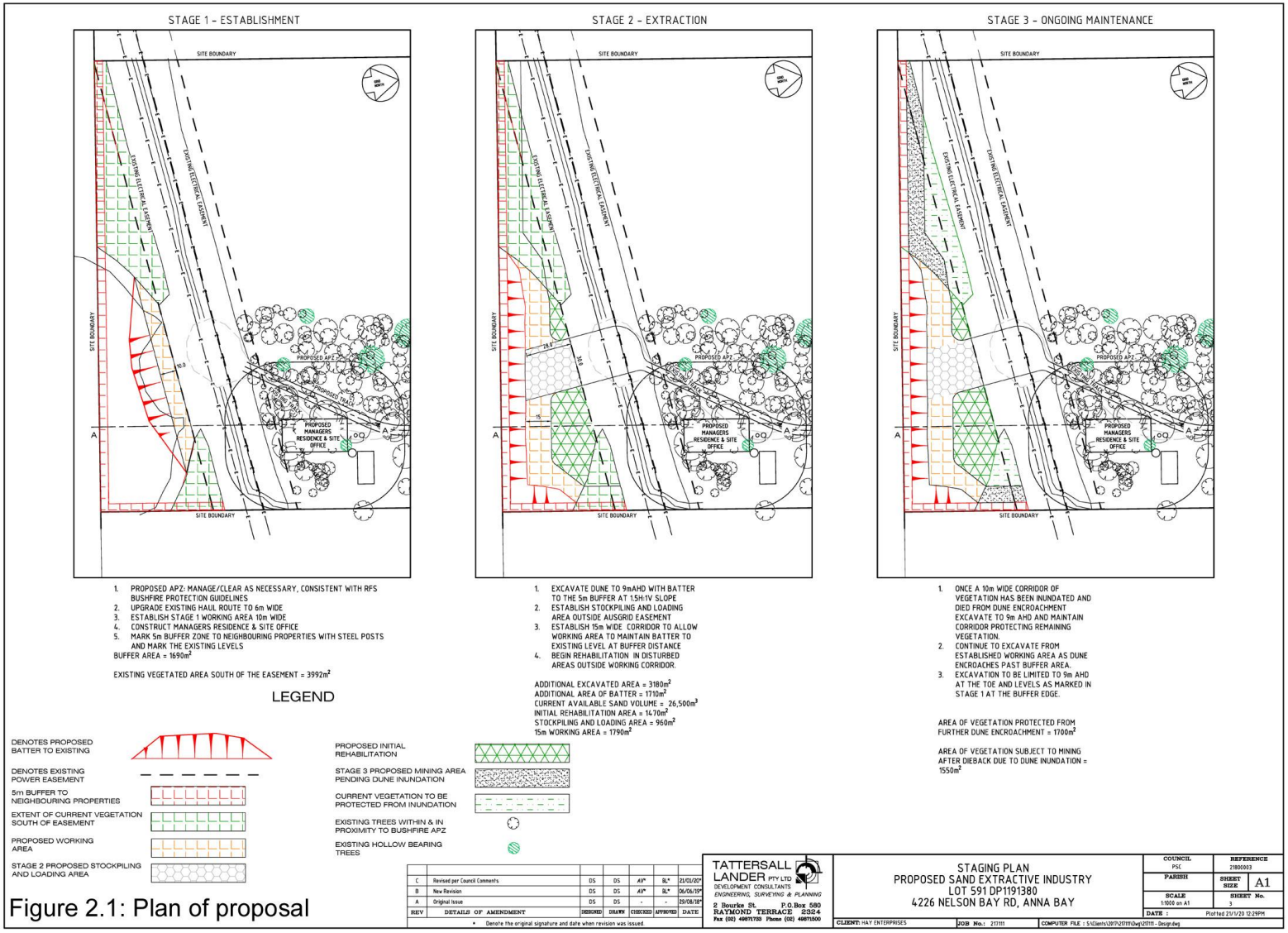


Figure 2.1: Plan of proposal

The above project components and operational effects of the proposed sand extraction facility are hereafter collectively referred to as the proposed development.

2.3 TOPOGRAPHY & HYDROLOGY

The study area is located on the Port Stephens soil landscape, composed of Holocene sand sheets and beach ridges (Murphy, 1995). The soil consists of loamy sand throughout the majority of the study area. The topography is flat to undulating throughout the study area, with a sharp incline into sand dunes in the south of the study area. The southern portion of the study area borders Stockton Bight sand dunes and is characterised by transgressive sand dunes of marine and Aeolian Holocene sands. There are no karst, caves, cliffs or other areas of geological significance within the study area or within the surrounding assessment area.

The study area is located within the Hunter Central Rivers Catchment. According to the NSW Government SEED mapping, no rivers, streams and estuaries are present within the study area (NSW Gov 2018). A Coastal Wetland (Coastal Management SEPP) was present approximately 0.65km to the north west of the study area, this wetland was not a listed as a wetland of International Importance developed under the Ramsar Convention (NSW Gov 2018) nor a DIWA listed wetland (DoEE 2108).

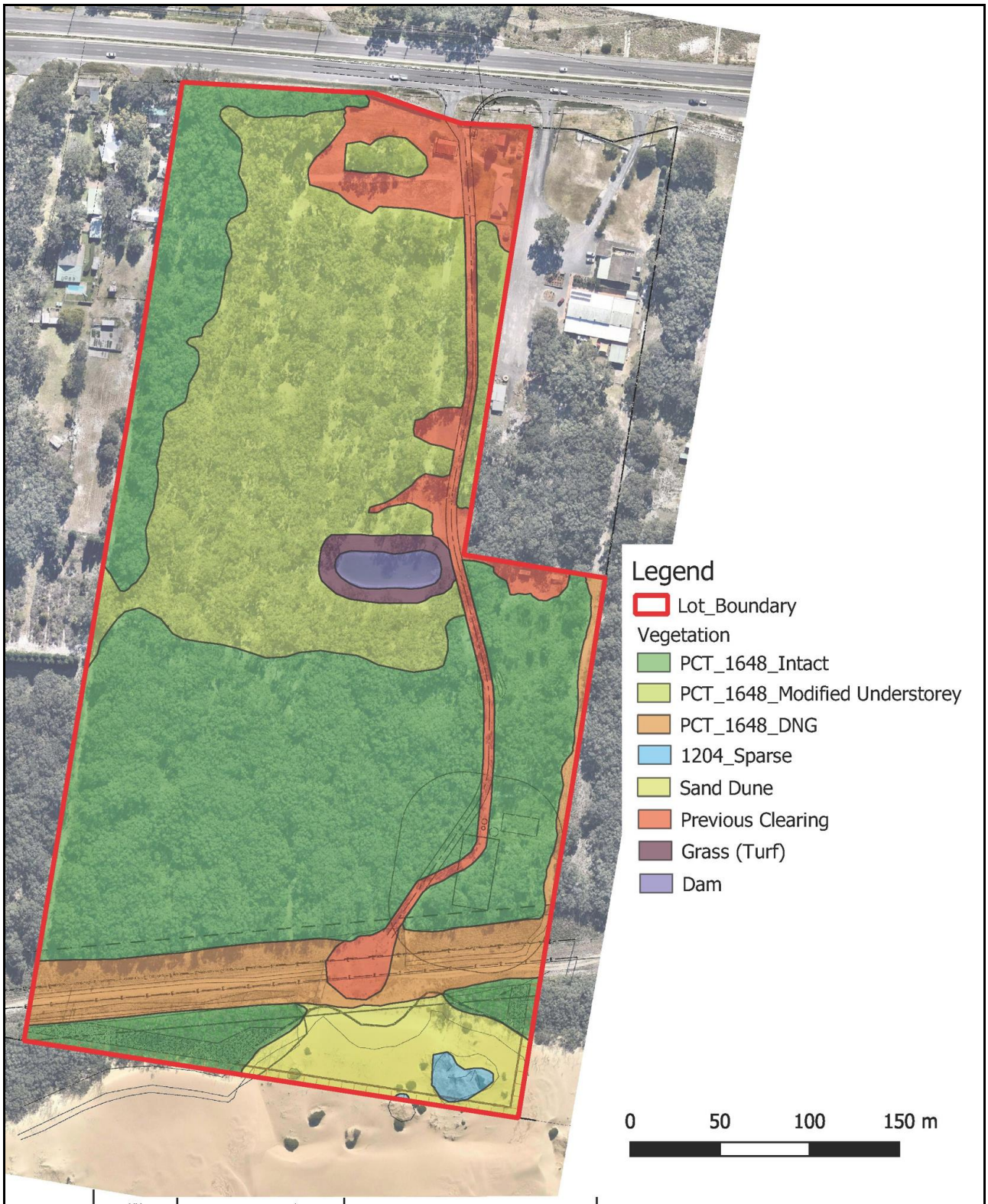
2.4 VEGETATION

Two Plant Community Types (PCT) were determined to be present within the study area, being:

- PCT 1648 - Smooth-barked Apple - Blackbutt heathy open forest of the Tomaree Peninsula (11.17 ha);
- PCT 1204 - Spinifex beach strand grassland, Sydney Basin Bioregion and South East Corner Bioregion (0.06 ha).

A description of the two vegetation communities is shown below in Table 2.1. A vegetation map of the subject site is shown in Figure 2.2.

*Note on Vegetation Community Distribution Map. A map of vegetation of any area seeks to describe the distribution of the plant species in that area by defining a number of vegetation units (assemblages or communities), which are relatively internally homogenous. Whilst such mapping is a convenient tool, it greatly oversimplifies the real situation. Plants rarely occur in defined communities with distinct boundaries. Accordingly vegetation units used for the accompanying map should be viewed as indicative of their extent rather than being precise edges of communities.



Author	XX
A4 Scale	1:10000

Disclaimer: While all reasonable care has been taken to ensure the information contained on this map is up to date and accurate, no guarentee is given that the information protrayed is free from error or omission. In addition the spatial accuracy of the map is wholly dependant on source data. Please verify the accuracy of all information prior to use. Development footprint areas should be used for indicative areas only.

Figure 2.2

Vegetation Zones

Nelson Bay Road
Anna Bay, NSW

January 2020

WILDTHING Environmental Consultants
(a Division of Tattersall Lander Pty Ltd)
ABN 41 003 509 215

Table 2.1: Descriptions of vegetation communities located within the site.

Smooth-barked Apple Blackbutt heathy open Forest of the Tomaree Peninsula	
Vegetation Formation	Dry Sclerophyll Forests (Shrubby sub-formation)
Vegetation Class	Coastal Dune Dry Sclerophyll Forests
Vegetation Community Type (PCT) No.	PCT -1648
PCT Name	Smooth-barked Apple Blackbutt heathy open Forest of the Tomaree Peninsula
Extent	11.404ha
Species present	***Angophora costata**, Corymbia gummifera, **Eucalyptus pilularis** / **Banksia serrata**, Acacia terminalis, **Bossiaea rhombifolia**, **Dillwynia retorta**, Eriostemon australasius, **Acacia suaveolens** , **Ricinocarpus pinifolius**, **Acacia ulicifolia** , **Persoonia levis / Themeda australis** , Leucopogon ericoides, Tetratheca ericifolia , Hypolaena fastigiata , **Pteridium esculentum**, Epacris pulchella* *The associated species above which occurred within the study area and informed assignment of this PCT have been made bold
TEC Status	This PCT can form part of the TEC River-Flat Eucalypt Forest on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions, which is listed as Endangered under Schedule 2 of the BC Act. No occurrence of this PCT within the study area was situated within a floodplain, thus this PCT was not found to be consistent with this TEC.
Examples of PCT 1649 on site.	
Spinifex beach strand grassland, Sydney Basin Bioregion and South East Corner Bioregion (PCT 1204)	
Vegetation Formation	Grasslands
Vegetation Class	Maritime Grasslands
Vegetation Community Type (PCT) No.	1204
PCT Name	Spinifex beach strand grassland, Sydney Basin Bioregion and South East Corner Bioregion
Extent	0.11 ha
Species present	***Spinifex sericeus**; Austrofestuca littoralis; Carpobrotus glaucescens; Calystegia soldanella; Actites megalocarpa; Isolepis nodosa* *The associated species above which occurred within the study area and informed assignment of this PCT have been made bold.

TEC Status	This PCT is not likely to form part of a TEC
Example of PCT 1646 within the site.	

2.4.1 THREATENED ECOLOGICAL COMMUNITIES AND THREATENED FLORA

No Threatened Ecological Communities were located within the site. A number of specimens of *Diuris praecox* (Rough Doubletail) were located within the Ausgrid easement within the site.

2.5 PRIORITY WEEDS AND WEEDS OF STATE AND NATIONAL SIGNIFICANCE

The impact of weeds on site is considered to be a threat to rehabilitation works and the long-term survival of the area of native vegetation within the vegetation to the south of the Ausgrid easement. Three priority weed species listed under the Biosecurity Act 2015 were identified on site and are listed below in Table 2.2. The site lies within the Hunter Regional Weed Committee (HRWC).

Table 2.2: Priority Weed species found within the subject site.

Weed Species	Biosecurity Duty	Additional Significance
Senecio madagascariensis (Fireweed)	• General Biosecurity Duty • Prohibition on dealings	N
Nephrolepis cordifolia (Fishbone Fern)	• General Biosecurity Duty • Prohibition on dealings	
Arundo donax (Giant Reed)	• General Biosecurity Duty • Prohibition on dealings • **Regional Recommended Measure** Land managers should mitigate the risk of new weeds being introduced to their land. The plant should not be bought, sold, grown, carried or released into the environment.	

Weed Species	Biosecurity Duty	Additional Significance
Eragrostis curvula (African lovegrass)	• General Biosecurity Duty • Prohibition on dealings	
Schinus sp (Peppercorn)	• General Biosecurity Duty • Prohibition on dealings	
Conyza species (Fleabane)	• General Biosecurity Duty • Prohibition on dealings	
Chrysanthemoides monilifera subsp. Rotundata (Bitou bush)	• General Biosecurity Duty • Prohibition on dealings • **Biosecurity Zone** Within the Biosecurity Zone (all of NSW) this weed must be eradicated where practicable, or as much of the weed destroyed as practicable, and any remaining weed suppressed. The local control authority must be notified of any new infestations of this weed within the Biosecurity Zone	T N
Ricinus communis (Castor oil plant)	• General Biosecurity Duty • Prohibition on dealings	
Lantana camara (Lantana)	• General Biosecurity Duty • Prohibition on dealings	T N
Lilium formosanum (Taiwan lily)	• General Biosecurity Duty • Prohibition on dealings	

T – Listed as a Threatening Process under the NSW BC Act 2016.
N –Weed of National Significance.

***Priorities under the Biosecurity Act 2015**

General Biosecurity Duty - any person dealing with plant matter must take measures to prevent, minimise or eliminate the biosecurity risk (as far as is reasonably practicable).

Prohibition on dealings - Must not be imported into the State or sold

Regional Recommended Measure - Land managers mitigate the risk of the plant being introduced to their land. Land managers reduce impacts from the plant on priority assets. Land managers prevent spread from their land where feasible. The plant or parts of the plant are not traded, carried, grown or released into the environment

Biosecurity Zone – The Bitou Bush Biosecurity Zone is established for all land within the State except land within 10 kilometres of the mean high water mark of the Pacific Ocean between Cape Byron in the north and Point Perpendicular in the south. *Within the Biosecurity Zone this weed must be eradicated where practicable, or as much of the weed destroyed as practicable, and any remaining weed suppressed. The local control authority must be notified of any new infestations of this weed within the Biosecurity Zone*

Information on the control of these species as contained within the NSW DPI *Noxious and environmental weed control handbook* (2014) is included in Appendix A. Other weed species recorded in the vegetation to the south of the Ausgrid easement include:

Cyperus eragrostis	*Umbrella Sedge*
Andropogon virginicus	*Whisky Grass*
Anthoxanthum odoratum	*Sweet Vernal Grass*
Axonopus fissifolius	*Narrow-leaved Carpet Grass*
Briza maxima	*Quaking Grass*

Chloris gayana	*Rhodes Grass*
Melinis repens	*Red Natal Grass*
Paspalum dilatatum	*Paspalum*
Setaria gracilis	*Slender Pigeon Grass*
Setaria parviflora	
Foeniculum vulgare	*Fennel*
Hydrocotyle bonariensis	*Kurnell Curse*
Bidens pilosa	*Cobblers Pegs*
Cirsium vulgare	*Spear Thistle*
Conyza bonariensis	*Flax-leaved Fleabane*
Conyza parva	*Whorled Fleabane*
Coreopsis lanceolata	*Coreopsis*
Acanthospermum australe	*Star Burr*
Sonchus oleraceus	*Common Sow Thistle*
Cakile edentula	*American Sea Rocket*
Ricinus communis	*Castor Oil Plant*
Medicago polymorpha	*Burr Medic*
Trifolium repens	*White Clover*
Solanum mauritianum	*Wild Tobacco*
Solanum nigrum	*Blackberry Nightshade*
Verbena bonariensis	*Purple Top*
Richardia humistrata	
Anagallis arvensis var. arvensis	*Scarlet Pimpernel*
Plantago lanceolata	*Plantain*
Verbena bonariensis	*Purple Topped Verbena*

These species should be controlled during primary weed control to assist the establishment of planted species in vegetation to the south of the Ausgrid easement.

3.0 DESCRIPTION OF PROPOSED ENVIRONMENT

Initial rehabilitation will occur during Stage 2 of the proposed development and will be undertaken by revegetation in disturbed areas outside of the working corridor (Figure 2.1). This will consist of an area of 1470 m^2 that will be revegetated with Smooth-barked Apple - Blackbutt heathy open forest. During Stage 2 the current vegetation present to the south of the easement will be retained and weed control will be carried out. The southern extent of the vegetation is currently subject to dune encroachment. Once dieback to a 10m corridor has occurred from inundation, Stage 3 of the proposed development will commence and this corridor will be removed and sand extracted (Figure 2.1). This will enable 1700m^2 of Smooth-barked Apple - Blackbutt heathy open forest to be retained and protected from further dune encroachment to the immediate south of the Ausgrid easement within the site. Due to the nature of this area of vegetation, natural regeneration of the understorey would be feasible after weed control is undertaken. Post-operation rehabilitation will be undertaken in Management Zones 2, 4 and 5 by planting 3350m^2 of Spinifex beach strand grassland on the 5m buffer and batter of sand dune and 3950m^2 of Smooth-barked Apple - Blackbutt heathy open forest within the proposed working area and stockpiling/loading area.

3.1 VEGETATION REHABILITATION AND ENHANCEMENT

Two main approaches to vegetation rehabilitation to be used are:

- Assisted natural regeneration;
- Revegetation.

3.2 ASSISTED NATURAL REGENERATION

Assisted Natural Regeneration will involve the following stages to control weeds and facilitate native regeneration:

- **Weed control –** targeting the removal of invasive species. Species to target include *Chrysanthemoides monilifera* subsp. *rotundata* (Bitou Bush). This will involve the use of mechanical and/or chemical approaches as discussed in Section 4.3.

3.3 REVEGETATION

Revegetation of Smooth-barked Apple - Blackbutt heathy open forest will be undertaken in Management Zone 1 & 2. Revegetation of Spinifex beach strand grassland will be undertaken in Management Zone 3. Suitable species and techniques have been suggested in Section 4.5.

4.0 REHABILITATION PLAN IMPLEMENTATION

The implementation of the Rehabilitation Plan will include:

- Management Zones
- Site Protection
- Weed Control
- Dune Stabilising Fences
- Revegetation Plantings
- Maintenance
- Monitoring and Reporting

4.1 MANAGEMENT ZONES

To ensure the success of the Rehabilitation Plan, the site has been broken down into five management zones (Figure 4.1). These zones include:

- Management Zone 1: Vegetation to be retained south of Easement (1700m^2)
- Management Zone 2: Mining Area pending Dune Inundation (1550m^2)
- Management Zone 3: Initial Rehabilitation Area: Smooth-barked Apple - Blackbutt heathy open forest (approximately 1470m^2);
- Management Zone 4: Post Operations Area: Smooth-barked Apple - Blackbutt heathy open forest (2400m^2);
- Management Zone 5: Post Operations Area: Spinifex beach strand grassland (approximately 3350m^2);

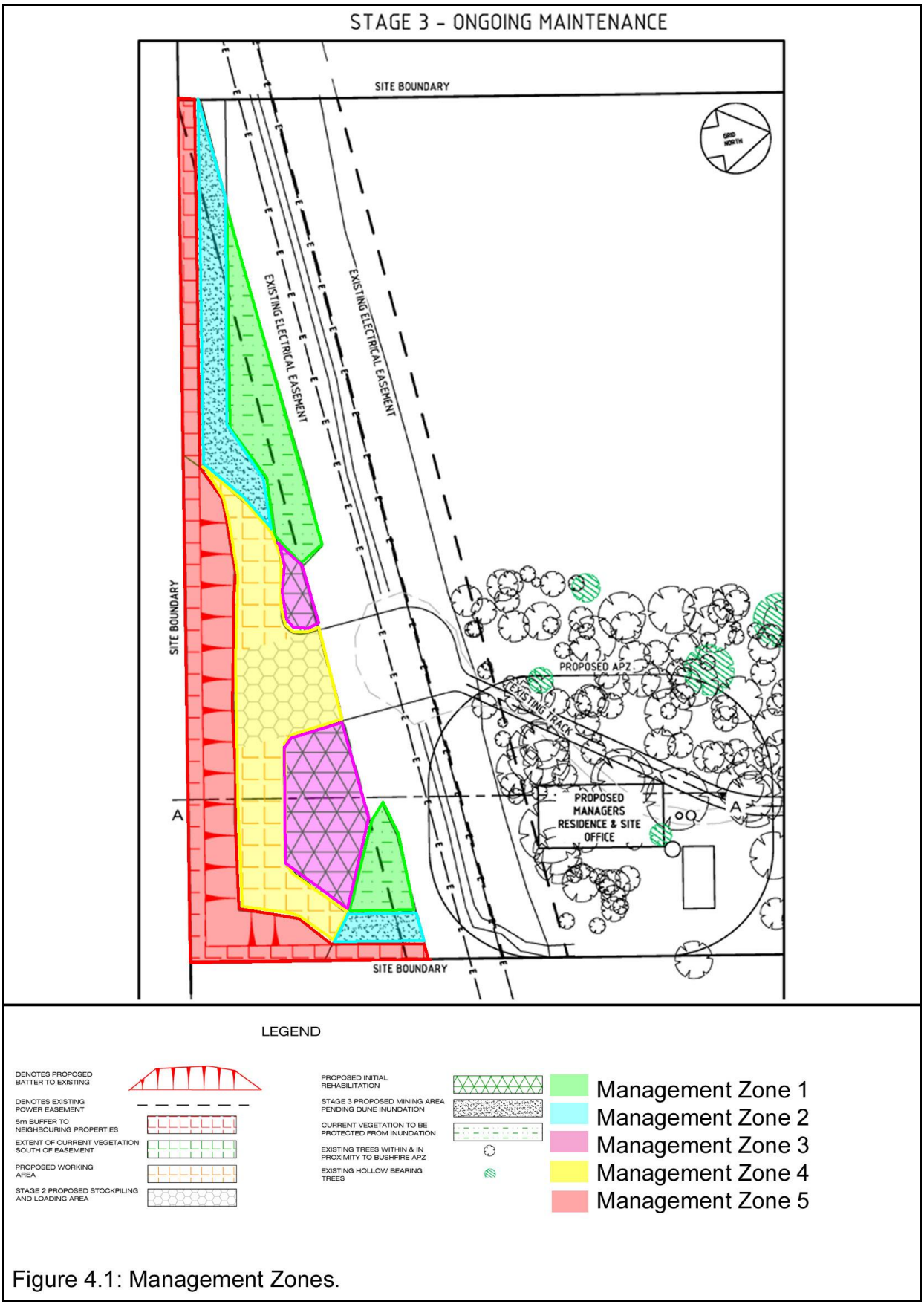


Figure 4.1: Management Zones.

The following sections provide a description of the management activities to be undertaken in each of these zones:

4.1.1 ZONE 1 – VEGETATION TO BE RETAINED SOUTH OF EASEMENT

The 1700m^2 area is located to the immediate south of the Ausgrid easement. Management actions within this area will largely be in the form of weed control and assisted regeneration.

Required actions:

- Assisted revegetation;
- Control of weeds;
- Exclusion of livestock;
- Relocation of dead wood from Management Zone 2.

4.1.2 ZONE 2 – MINING AREA PENDING DUNE INUNDATION

A 10m wide corridor of vegetation, which is located to the immediate north of the sand dunes, will die back from dune encroachment and subsequently be removed once dead to initiate Stage 3 of the proposal. The removal will allow the protection of Management Zone 1 from dune encroachment for the remaining lifespan of the sand extraction facility.

Required actions:

- Control of weeds (to prevent incursion into Management Zones 1 and 3)
- Mark out 10m corridor to monitor dune encroachment and allow natural dieback
- Once dieback has occurred, initiate Stage 3 of the development proposal;
- Install clearing boundary using flagging tape;
- Immediately prior to clearing an ecologist is required to inspect dead vegetation to identify any hollow-bearing trees;
- If hollow-bearing trees are located within this zone, an ecologist is required to supervise removal;
- Dead trees are to be felled away from Management Zone 1;
- Relocate dead wood into Management Zone 1;
- Post-operations, implement revegetation of Smooth-barked Apple - Blackbutt heathy open forest.
- Monitor and maintain revegetation works

4.1.3 ZONE 3 – INITIAL REHABILITATION AREA: SMOOTH-BARKED APPLE - BLACKBUTT HEATHY OPEN FOREST

The 1470m^2 area is located to the immediate south of the Ausgrid easement.

Required actions:

- Revegetation of Smooth-barked Apple - Blackbutt heathy open forest during Stage 2 of the development proposal;
- Control of weeds;

- Exclusion of livestock;
- Monitor and maintain revegetation works.

4.1.4 ZONE 4 – POST OPERATIONS AREA: SMOOTH-BARKED APPLE - BLACKBUTT HEATHY OPEN FOREST

The 2400m^2 area is composed of the Stage 2 working area, proposed stockpiling and loading area.
Required actions:

- Revegetation of Smooth-barked Apple - Blackbutt heathy open forest;
- Control of weeds;
- Exclusion of livestock;
- Monitor and maintain revegetation works.

4.1.5 ZONE 5 – POST OPERATIONS AREA: SPINIFEX BEACH STRAND GRASSLAND

The 3350m^2 area is composed of the batter and 5m buffer to neighbouring properties.
Required actions:

- Revegetation of Spinifex beach strand grassland;
- Implement dune stabilisation techniques including dune stabilising fencing to act as a sand trap and protect plantings;
- Control of weeds;
- Exclusion of livestock;
- Monitor and maintain revegetation works.

4.2 SITE PROTECTION

Prior to the commencement of clearing in Management Zone 2, a defined clearance zone is to be clearly marked along the clearance boundary between Management Zone 2 and 3 using flagging tape, ensuring no machinery can enter the retained vegetation corridor. Also, prior to any earthworks occurring, silt fencing is to be erected along the boundary of the clearance zone and retained vegetation corridor (between Management Zone 2 and 3) so that no excess sediment will enter this habitat.

4.3 WEED CONTROL

Noxious weeds and a number of additional weed species are to be treated within the vegetation corridor in a targeted weed control program prior to revegetation work. Control of weeds within the vegetation corridor will aid in the natural regeneration of the corridor and give established native vegetation and plantings the best chance of survival.

Weed control is proposed for the entire vegetated corridor to the immediate north of the sand dunes and will involve the following stages:

- **Primary weed control -** target removal of noxious weeds and other most invasive species.

- **Follow-up weed control** - following on from primary weed control to treat regenerating weed species. To be carried out during general maintenance visits.

Weed control will involve the use of mechanical and/or chemical approaches. Chemical approaches should only be undertaken in August, which is when *Diuris praecox* (Rough Doubletail) is in flower. The suggested control of individual weed species is contained in Appendix A of the Rehabilitation Plan.

4.4 DUNE STABILISING FENCES

Dune stabilising fences will be constructed within Management Zone 5 during vegetation establishment at the completion of the sand extraction facility licence. The fences are to be constructed along the southern boundary of the site, midway down along the length of the batter and at the toe of the batter to slow dune transgression. The fencing should be constructed with preferably natural fibres/products with a 40% porosity (NSW Department of Land and Water Conservation, 2001).

4.5 REHABILITATION PLANTINGS

4.5.1 SPECIES COMPOSITION

The recommended species composition for Management Zones 2, 3, 4 and 5 are shown below in Tables 4.1 & 4.2.

Table 4.1: Management Zone 2, 3 & 4: Recommended species list for the revegetation planting works and the source of plant material

Plant Species	Source of plant material
Canopy Species	
Eucalyptus pilularis (Blackbutt)	Tubestock
Angophora costata (Smooth-barked Apple)	Tubestock
Mid-Storey Species	
Banksia serrata (Old Man Banksia)	Tubestock
Pittosporum undulatum (Sweet Pittosporum)	Tubestock
Glochidion ferdinandi (Cheese Tree)	Tubestock
Shrub Species	
Bossiaea rhombifolia	hiko or enviro cells
Dillwynia retorta (Heathy Parrot Pea)	hiko or enviro cells
Acacia suaveolens (Sweet-scented Wattle)	hiko or enviro cells
Ricinocarpus pinifolius (Wedding Bush)	hiko or enviro cells
Acacia ulicifolia (Prickly Moses)	hiko or enviro cells
Persoonia levis (Cheese Tree)	hiko or enviro cells
Ground Species	
Themeda australis (Kangaroo Grass)	hiko or enviro cells
Pteridium esculentum (Bracken)	hiko or enviro cells

MANAGEMENT ZONE 5 – Revegetation of Spinifex beach strand grassland

Table 4.2: Management Zone 5: Recommended species list for the revegetation planting works and the source of plant material

Plant Species	Source of plant material
Spinifex sericeus (Coastal Spinifex)	hiko or enviro cells

4.5.2 SOURCE NATIVE TUBESTOCK

The required plants should be sourced from a suitably experienced plant production nursery. Specimens will be required to be of local providence, and will likely involve seed collection and propagation. Plants will be planted as tubestock and hiko or enviro cells.

4.5.3 PLANTING METHODS

It is recommended that manual planting be carried out within Management Zones 2, 3, 4 & 5. Planting will involve preparing the ground by such means of auger holes. All tubestock will be required to be suitably guarded to prevent herbivory. Plantings are to be well watered on installation. Follow-up watering is also to be undertaken. Spinifex is best established between October and March inclusive.

4.5.4 ESTIMATED COSTINGS AND PLANTING DENSITIES

The cost per plant is estimated at:

- Tubestock - $3.50
- Hiko or enviro cell - $2.50

MANAGEMENT ZONE 3 - Stage 2 plantings of Smooth-barked Apple - Blackbutt heathy open forest

It is recommended that species be planted at the following densities:

- Canopy species - 1 plant per 4m x 4m;
- Mid-storey species - 1 plant per 3m x 3m;
- Shrub species - 1 plant per 2m x 2m;
- Ground cover species - 2 plant per 1m x 1m.

See Table 4.3 for the number of plants required and the estimated costing for Management Zone 3. *Please note that inflation has not been taken into consideration for these costings.

Table 4.3: Management Zone 3: Numbers of each species required for the revegetation works and costings.

Plant Species	Number required	Estimated Total Cost*
Canopy Species		
Eucalyptus pilularis (Blackbutt)	184	$644.00
Angophora costata (Smooth-barked Apple)	184	$644.00
Mid-storey Species		
Banksia serrata (Old Man Banksia)	164	$574.00
Pittosporum undulatum (Sweet Pittosporum)	163	$570.50
Glochidion ferdinandi (Cheese Tree)	163	$570.50
Shrub Species		
Bossiaea rhombifolia	123	$307.50
Dillwynia retorta (Heathy Parrot Pea)	122	$305.00
Acacia suaveolens (Sweet-scented Wattle)	122	$305.00
Ricinocarpus pinifolius (Wedding Bush)	122	$305.00
Acacia ulicifolia (Prickly Moses)	122	$305.00
Persoonia levis (Cheese Tree)	122	$305.00
Ground Cover Species		
Themeda australis (Kangaroo Grass)	1470	$3675.00
Pteridium esculentum (Bracken)	1470	$3675.00

MANAGEMENT ZONE 2 & 4 - Post-operation plantings of Smooth-barked Apple - Blackbutt heathy open forest

It is recommended that species be planted at the following densities:

- Canopy species - 1 plant per 4m x 4m;
- Mid-storey species - 1 plant per 3m x 3m;
- Shrub species - 1 plant per 2m x 2m;
- Ground cover species - 2 plant per 1m x 1m.

See Table 4.4 for the number of plants required and the estimated costing for Management Zones 2 and 4.

*Please note that inflation has not been taken into consideration for these costings.

Table 4.4: Management Zone 2 & 4: Numbers of each species required for the revegetation works and costings.

Plant Species	Number required	Estimated Total Cost*
Canopy Species		
Eucalyptus pilularis (Blackbutt)	494	$1729.00
Angophora costata (Smooth-barked Apple)	494	$1729.00
Mid-storey Species		
Banksia serrata (Old Man Banksia)	439	$1536.50
Pittosporum undulatum (Sweet Pittosporum)	438	$1533.00
Glochidion ferdinandi (Cheese Tree)	438	$1533.00
Shrub Species		
Bossiaea rhombifolia	330	$825.00
Dillwynia retorta (Heathy Parrot Pea)	329	$822.50
Acacia suaveolens (Sweet-scented Wattle)	329	$822.50
Ricinocarpus pinifolius (Wedding Bush)	329	$822.50
Acacia ulicifolia (Prickly Moses)	329	$822.50
Persoonia levis (Cheese Tree)	329	$822.50
Ground Cover Species		
Themeda australis (Kangaroo Grass)	3950	$9875.00
Pteridium esculentum (Bracken)	3950	$9875.00

MANAGEMENT ZONE 5 – Post-Operation plantings of Spinifex beach strand grassland

It is recommended that species be planted at the following densities:

- Ground cover species - 2 plants per 1m x 1m

Table 4.5 for the number of plants required and the estimated costing for Management Zone 5.

*Please note that inflation has not been taken into consideration for these costings.

Table 4.5: Management Zone 5: Numbers of each species required for the revegetation works and costings.

Plant Species	Number required	Estimated Total Cost*
Canopy Species		
Spinifex sericeus (Coastal Spinifex)	6700	$16750.00

4.6 PERFORMANCE TARGETS

Quantifiable performance targets for native species cover (canopy, mid-storey and groundcover) and exotic cover for the primary, secondary and maintenance phases of the Rehabilitation Plan have been given in Table 4.7.

Table 4.7: Quantifiable performance targets for native species cover and exotic cover for the primary, secondary and maintenance phases of the Rehabilitation Plan.

Management Zone	Primary phase			Secondary Phase			Maintenance Phase		
1, 2	Proportion of exotic canopy species no greater than 5%	Proportion of exotic mid-story species no greater than 60%	Proportion of exotic groundcover species no greater than 80%	Proportion of exotic canopy species no greater than 2%	Proportion of exotic mid-story species no greater than 30%	Proportion of exotic groundcover species no greater than 40%	Proportion of exotic canopy species no greater than 0%	Proportion of exotic mid-story species no greater than 5%	Proportion of exotic groundcover species no greater than 5%
1, 2	A demonstrated increase in native cover and diversity and a demonstrated decrease in exotic cover and diversity by the end of year 5								
2, 3, 4, 5	A minimum of 85% survival rate of all plantings								

4.7 MAINTENANCE PROGRAM

4.7.1 GENERAL MAINTENANCE

The completion of the works will be considered as the date of the practical completion of the revegetation plantings for each Management Zone and will signal the commencement of six-monthly maintenance program for a period of two years then annually for a further three years. General maintenance will involve monitoring survival rates, installing replacement plants, guards and continued follow-up weeding. The 5 year maintenance program will commence for Management Zones 1 and 3 upon completion of weeding and plantings, and for Management Zones 2, 4 & 5 once plantings are installed post-operation of the sand extraction facility.

4.7.2 WATERING

All plantings are to be well watered on installation. They will then receive a further two applications of water during the first two months to assist in establishment. Depending on the soil/sand moisture at the time a further watering may be required.

4.7.3 MAINTENANCE WEEDING

Follow-up weed control will be carried out. Noxious weeds and other problem weeds present at the time should be targeted.

4.7.4 INSTALLING REPLACEMENT PLANTS

Plant losses discovered during maintenance visits are to be replaced at the cost of the applicant as per the Port Stephens DCP (2014).

4.7.5 INAPPROPRIATE PRACTICES

It is recommended that the following practices are observed to ensure the continued viability of the Rehabilitation Plan:

- No lawn clippings or other vegetation is to be discarded within any Management Zone;
- No livestock is to be allowed to access within any Management Zone;
- No rubbish is to be retained/stored within any Management Zone once plantings are installed;

5.0 MONITORING AND REPORTING

Monitoring for a period of 5 years after plantings are installed will be conducted to accurately evaluate the success of the rehabilitation works. The 5 year monitoring program will commence for Management Zones 1 and 3 upon completion of weeding and plantings, and for Management Zones 2, 4 & 5 once plantings are installed post-operation of the sand extraction facility. A report is to be submitted to Port Stephens Council by a suitably qualified ecologist or bush regenerator annually for 5 years.

Monitoring should address the following issues:

- Average plant growth
- Plant losses

- Plant replacement
- Weed regrowth and control measures

Nine fixed photo points have been set up to monitor the progress of restoration works within all Management Zones. Photo point details such as GPS location and aspect can be found in Table 5.1 and their locations are shown in Figure 5.1. Star pickets should be placed at each photo point for future reference.

At the end of the 5-year period a final report certifying completion of the Rehabilitation Plan is to be submitted to Port Stephens Council detailing whether the specific objectives of the plan have been met.

Table 5.1: Location and direction of each photo monitoring point.

Photo Number	Management Zone	Photo Point Number	Photo Point GPS Location		Direction
			Easting	Northing	
1	1	1	411957	6373445	Facing north-west
2	1	2	412077	6373455	Facing north-west
3	2	4	411824	6373442	Facing east
4	2	2	412077	6373455	Facing north-east
5	3	1	411957	6373445	Facing north-east
6	3	2	412077	6373455	Facing west
7	4	1	411957	6373445	Facing south-east
8	4	2	412077	6373455	Facing south-west
9	5	3	412099	6373463	Facing south
10	5	4	411824	6373442	Facing south-east

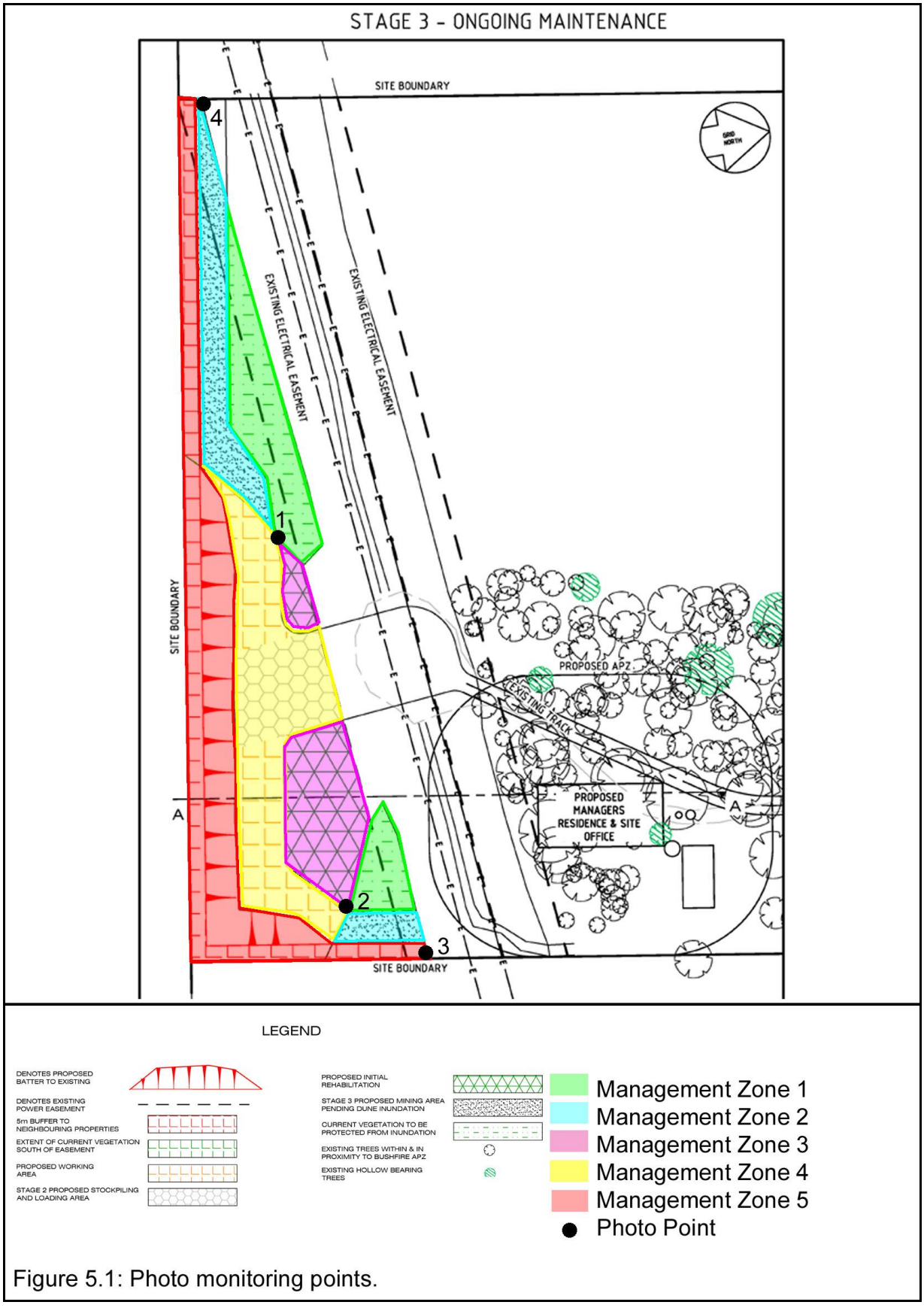


Figure 5.1: Photo monitoring points.

6.0 IMPLEMENTATION PLAN

The Rehabilitation Plan program is detailed in Table 6.1 and will guide the site's management. Weeding, plantings and the long-term up-keep of the vegetation corridor will be undertaken by suitably qualified personnel. Personnel undertaking bush regeneration works must have a Certificate Bushland Regeneration or a Certificate III Natural Area Restoration (or equivalent). Landowners may undertake weed control and rehabilitation work under the guidance/supervision of an appropriately qualified bush regenerator. However, the supervisors must have the relevant Certificate IV or Diploma level qualification in bush regeneration. Restoration works are to be carried out in accordance with these requirements. Technical advice pertaining to the ongoing management of the vegetation, such as information on the plants selected for revegetation and how they are likely to perform can be obtained from a number of agencies and organisations. These providers would include:

- HIP – Hunter Indigenous Plants – Beresfield (02) 4966 0457 hunterindigeplants@aapt.net.au
- Riverdene Nursery – East Gresford (02) 4938 9280 www.riverdenenursery.com.au/
- Muswellbrook Forest Nursery – Muswellbrook (02) 65432622 www.muswellbrookforestnursery.com.au
- Hunter Local Land Services – Paterson (02) 301030 www.hunter.lls.gov.au

7.0 ESTIMATED PROGRAM OF WORKS

An estimated program of works is shown in Table 7.1.

Table 6.1: Rehabilitation Plan Program

IMPLEMENTATION PLAN – REHABILITATION PLAN			
Strategy	**Action**	**Responsibility**	**Performance Measure**
Plant procurement	Seed Collection/Propagation	Plant production nursery/owner	Tubestock and hiko or enviro cells ready to plant.
Site Protection	Installation of silt fencing.	Fencing contractor/owner	Fence in place.
	Installation of clearance zone tape between Management Zones 1 and 2 are clearly marked with tape.	Contractor/owner	Clearance zone clearly marked.
Weed Control	Noxious weed infestations / occurrences. Other weed/infestations/occurrences.	Weeding Contractor/owner	Site largely cleared of weeds.
Planting	Planting of Tubestock and hiko or enviro cells Water all plantings	Revegetation Contractor/owner	Planting in ground.
Maintenance	Follow-up weed control Replacement of planting losses. Watering if required.	Contractor/owner	Site largely cleared of weeds. Plant losses replaced.
Monitoring	Monitor for - Plant losses - Growth of Plantings - Weed regrowth - Plant replacement	Contractor/owner	Report sent to Port Stephens Council

Table 7.1: Estimate program of works to be implemented when applicable for each Management Zone.

Task	Month 1	Month 2	Month 3	Month 4	Month 5	Month 6	Month 7	Year 1	Year 1.5	Year 2	Year 2.5	Year 3	Year 4	Year 5
Plant procurement														
Primary Weed Control														
Installation of silt fencing														
Planting														
Maintenance visit and secondary weed control														
Reporting														
Final report														

8.0 BIBLIOGRAPHY

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Port Stephens Council (2014d). *Port Stephens Council Vegetation Technical Specification*. May 2014.

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APPENDIX A
WEED CONTROL MEASURES FOR SPECIFIC SPECIES

SPECIES	LEGAL REQUIREMENTS	CONTROL MEASURES		
		Comment/occurrence within vegetation to the south of the easement	Physical	Chemical
Lantana camara Lantana	General Biosecurity Duty Prohibition on dealings	Clumped and isolated individuals.	Grub out small isolated occurrences. Place removed branches off ground to prevent root formation. Pull out small seedlings.	Spot Spray larger occurrences with a registered herbicide.
Senecio madagascariensis Fireweed	General Biosecurity Duty Prohibition on dealings	Clumped and isolated individuals.	Hand removal.	Spot Spray with a registered herbicide.
Chrysanthemoides monilifera subsp. monilifera Bitou Bush	General Biosecurity Duty	Clumped and isolated individuals.	Mature bitou bush plants can be slashed, whilst seedlings can be hand-pulled to remove the entire root system. Plants are liable to resprout after slashing alone, but applying herbicide to stems immediately after cutting should prevent regrowth.	Herbicides registered for bitou bush can be applied in winter at low rates that effectively kill the weed, yet have minimal impacts on coastal vegetation. Herbicides can be applied by a cut-and-paste method.
Acanthospermum australe Star Burr	General Biosecurity Duty Prohibition on dealings	Clumped	Hand remove isolated plants. Frequent mowing and pulling before the buds open are good ways to keep the plants from going to seed.	Spot Spray with a registered herbicide.
Bidens pilosa Cobblers Pegs	General Biosecurity Duty	Scattered occurrences.	Carefully bag seed heads. Plants and small infestations should be hand pulled when the ground is soft.	Spot Spray with a registered herbicide.
Cirsium vulgare Spear Thistle	General Biosecurity Duty	Scattered individuals	Carefully bag seed heads, dig out with mattock.	Spot Spray with a registered herbicide.
Conyza bonariensis Fleabane *Conyza parva*	General Biosecurity Duty	Scattered individuals.	Carefully bag seed heads. Dig up plant with taproot, with minimal soil disturbance.	Spot Spray with a registered herbicide.

SPECIES	LEGAL REQUIREMENTS	CONTROL MEASURES		
		Comment/occurrence within vegetation to the south of the easement	Physical	Chemical
Whorled Fleabane				
Sonchus oleraceus Common Sowthistle	General Biosecurity Duty	Scattered individuals.	Dig up plant with taproot, with minimal soil disturbance.	Spot Spray with a registered herbicide.
Trifolium repens White Clover	General Biosecurity Duty	Clumped and isolated individuals.	Dig out isolated occurrences. Spray larger areas before flowering.	Spot Spray with a registered herbicide before flowering.
Anagallis arvensis Scarlet Pimpernel	General Biosecurity Duty	Scattered individuals.	Hand remove isolated plants. Frequent mowing and pulling before the buds open are good ways to keep the plants from going to seed.	n/a
Plantago lanceolata Plantain	General Biosecurity Duty	Scattered individuals.	Carefully bag seed heads, dig up plant with taproot, with minimal soil disturbance.	Spot Spray with a registered herbicide.
Solanum mauritianum Wild Tobacco Bush	General Biosecurity Duty	Isolated occurrences	Small plants may be hand-pulled but mature plants will re-sprout if they are cut down.	Easily killed with herbicides applied as foliar, basal bark (painting herbicide onto the bark) or cut stump applications with a registered herbicide.
Verbena bonariensis Purple Topped Verbena	General Biosecurity Duty	Scattered throughout site.	Carefully bag seed heads, dig out with mattock.	Spot Spray with a registered herbicide.
Avena fatua Wild Oats	General Biosecurity Duty	Clumped and isolated individuals.	Carefully bag seed heads. Dig up or pull plant with taproot, with minimal soil disturbance.	Spot Spray with a registered herbicide
Briza maxima Quaking Grass *Briza minor* Quaking *Grass*	General Biosecurity Duty	Clumped and isolated individuals.	Carefully bag seed heads. Dig up or pull plant with taproot, with minimal soil disturbance.	Spot Spray with a registered herbicide
Paspalum dilatatum Paspalum	General Biosecurity Duty	Clumped and isolated individuals.	Carefully bag seed heads. Dig up or pull plant with taproot, with	Spot Spray with a registered herbicide

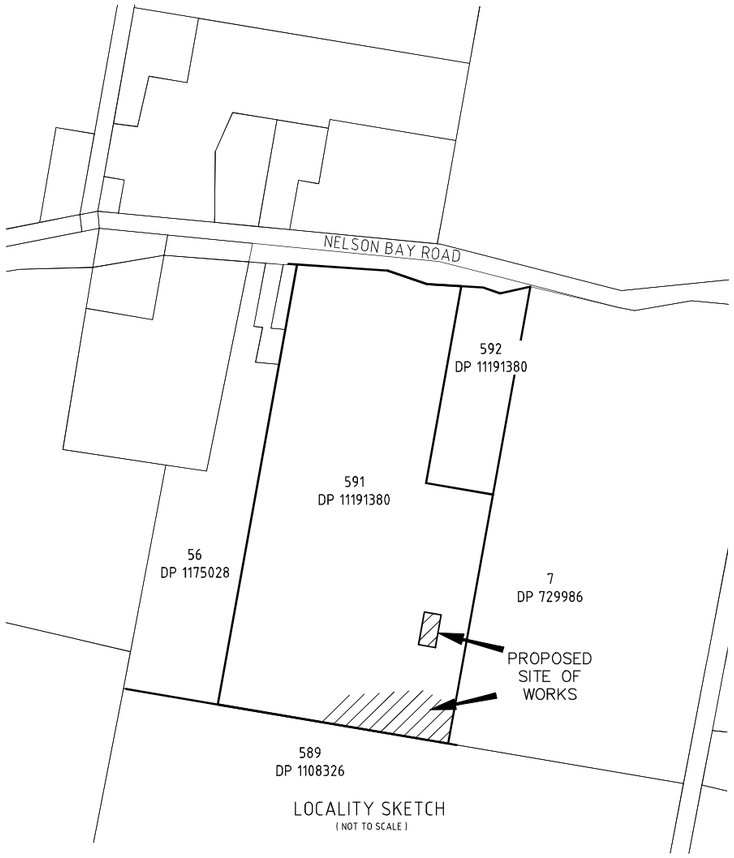
SPECIES	LEGAL REQUIREMENTS	CONTROL MEASURES		
		Comment/occurrence within vegetation to the south of the easement	**Physical**	**Chemical**
			minimal soil disturbance.	
Andropogon virginicus Whisky Grass *Setaria gracilis* Slender Pigeon Grass *Chloris gayana* Rhodes Grass *Melinis repens* Red Natal Grass	General Biosecurity Duty	Clumped and isolated individuals.	Carefully bag seed heads. Dig up or pull plant with taproot, with minimal soil disturbance.	Spot Spray with a registered herbicide
Cenchrus clandestinum Kikuyu *Axonopus fissifolius* Narrow-leaved Carpet Grass *Stenotaphrum secundatum* Buffalo Grass	General Biosecurity Duty	Dense areas present within site.	Remove isolated plants by hand.	Spot Spray with a registered herbicide
Solanum nigrum Blackberry Nightshade	General Biosecurity Duty	Scattered individuals.	Dig up plant with taproot, with minimal soil disturbance.	Spot Spray with a registered herbicide
Lilium formosum Formosa lily	General Biosecurity Duty	Scattered individuals.	Remove isolated plants by hand.	Spot Spray with a registered herbicide
Medicargo polymorpha Burr Medic	General Biosecurity Duty	Scattered individuals.	Remove isolated plants by hand.	Spot Spray with a registered herbicide
Passiflora edulis Passionfruit	General Biosecurity Duty	Scattered individuals.	Remove isolated plants by hand.	Spot Spray with a registered herbicide
Richardia humistrata	General Biosecurity Duty	Scattered individuals.	Dig up plant with taproot, with minimal soil disturbance.	Spot Spray with a registered herbicide.

APPENDIX C: DESIGN PLANS

PROPOSED SAND EXTRACTIVE INDUSTRY

INCLUDING MANAGERS RESIDENCE & SITE OFFICE

LOT 591 DP 1191380
4226 NELSON BAY ROAD, ANNA BAY



LOCALITY SKETCH
(NOT TO SCALE)

Schedule of Drawings			
Sheet	File Number	Description	Revision
1	21800001	TITLE PAGE, LOCALITY SKETCH & TABLE OF CONTENTS	C
2	21800002	OVERALL LAYOUT	C
3	21800003	STAGING PLAN	C
4	21800004	SITE SECTION	C
5	21800075	MACHINERY SHED & MANAGERS RESIDENCE PLAN & ELEVATIONS	C
6	21800005	ADJOINING MINING OPERATIONS	C
7	21800006	REHABILITATION PLAN	C
8	21801001	STORMWATER MANAGEMENT PLAN	C

Designed By TATTERSALL LANDER PTY LTD
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PO Box 580 RAYMOND TERRACE Phone (02) 4987 1500

FILE : 21800001
JOB No. : 217111
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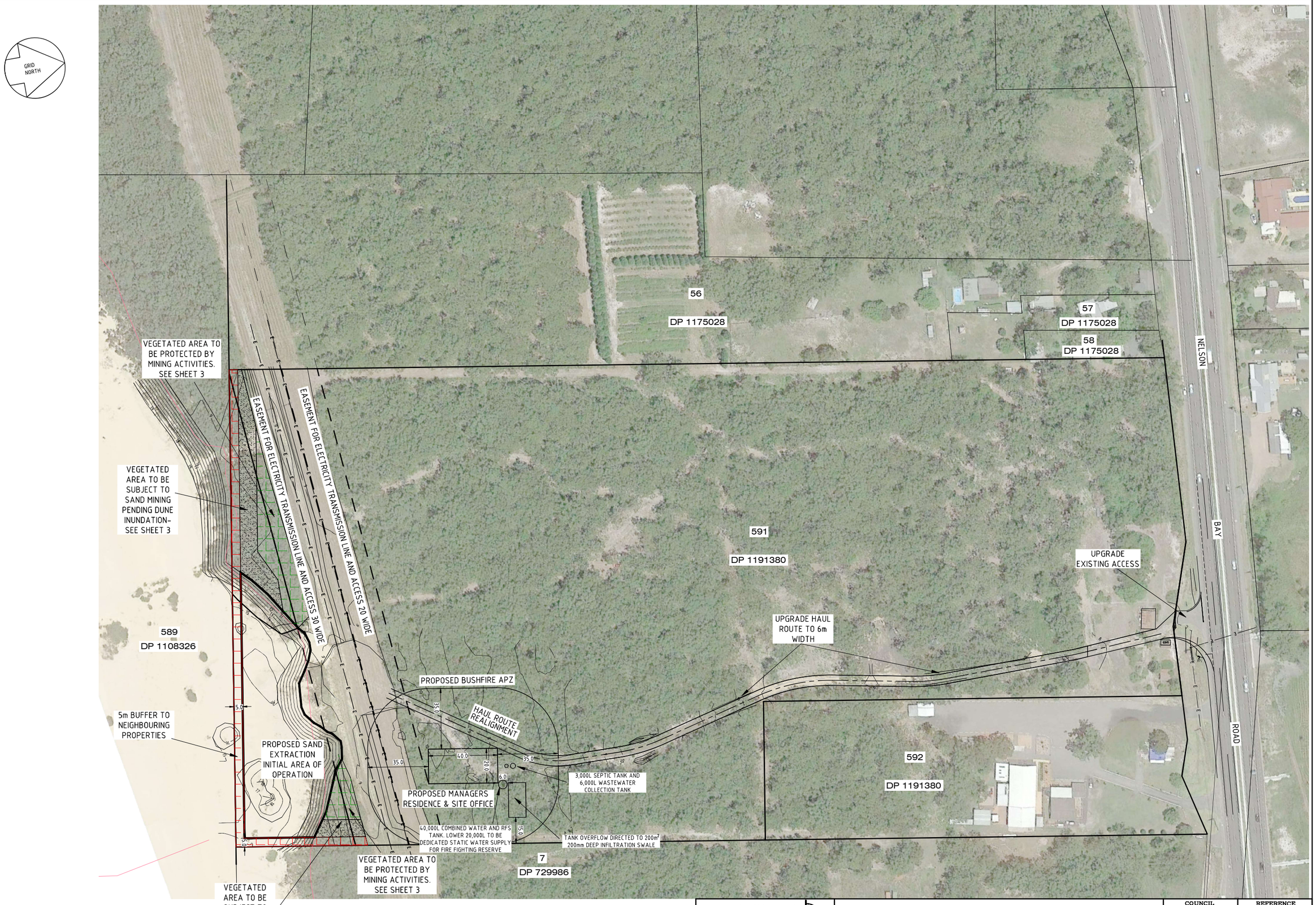

REV	DETAILS OF AMENDMENT	DESIGNED	DRAWN	CHECKED	APPROVED	DATE
C	Revised per Council Comments	DS	DS	AV*	BL*	21/01/20*
B	New Revision	DS	DS	AV*	BL*	06/06/19*
A	Original Issue	DS	DS	-	-	29/08/18*

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OVERALL LAYOUT
PROPOSED SAND EXTRACTIVE INDUSTRY
LOT 591 DP1191380
4226 NELSON BAY RD, ANNA BAY

COUNCIL: PSC	REFERENCE: 21800002
PARISH	SHEET SIZE: A1
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CLIENT: HAY ENTERPRISES	JOB No.: 217111
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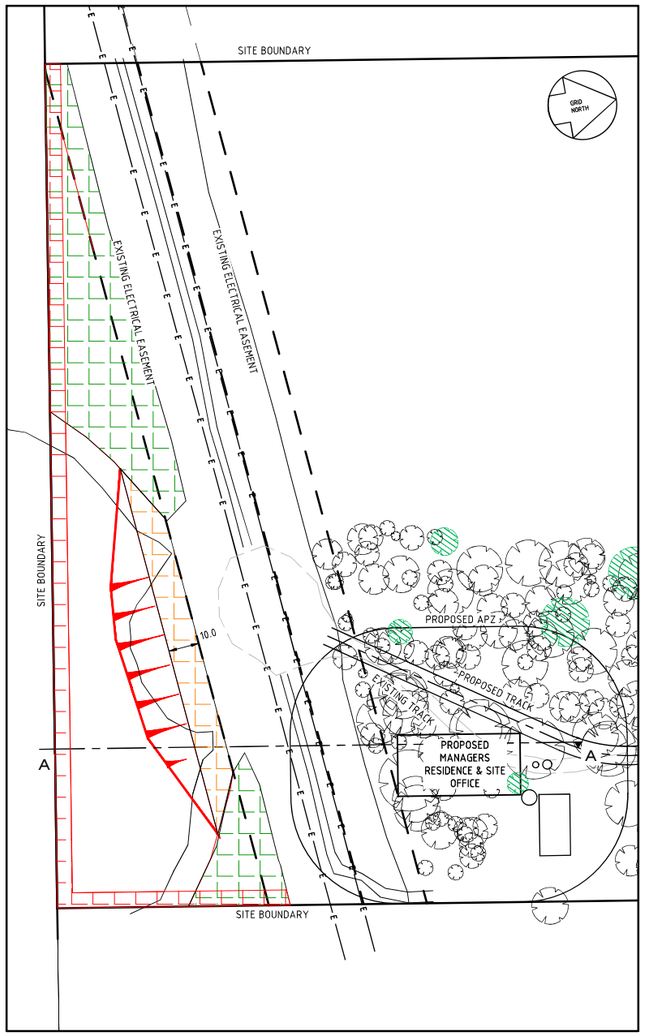
STAGE 1 - ESTABLISHMENT

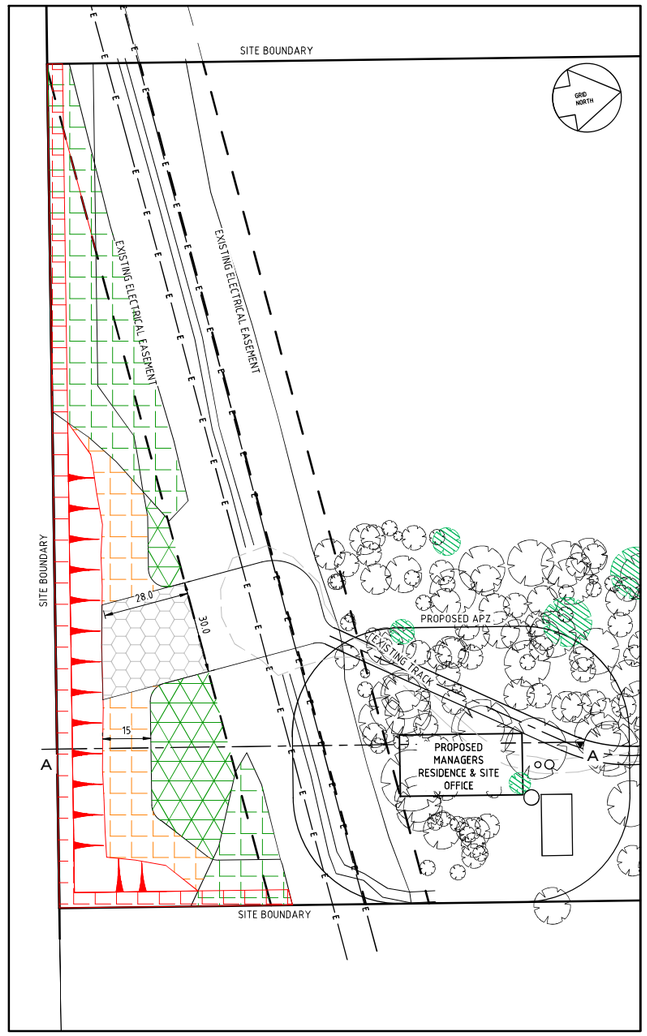


1. PROPOSED APZ: MANAGE/CLEAR AS NECESSARY, CONSISTENT WITH RFS BUSHFIRE PROTECTION GUIDELINES
2. UPGRADE EXISTING HAUL ROUTE TO 6m WIDE
3. ESTABLISH STAGE 1 WORKING AREA 10m WIDE
4. CONSTRUCT MANAGERS RESIDENCE & SITE OFFICE
5. MARK 5m BUFFER ZONE TO NEIGHBOURING PROPERTIES WITH STEEL POSTS AND MARK THE EXISTING LEVELS

BUFFER AREA = 1690m^2

EXISTING VEGETATED AREA SOUTH OF THE EASEMENT = 3992m^2

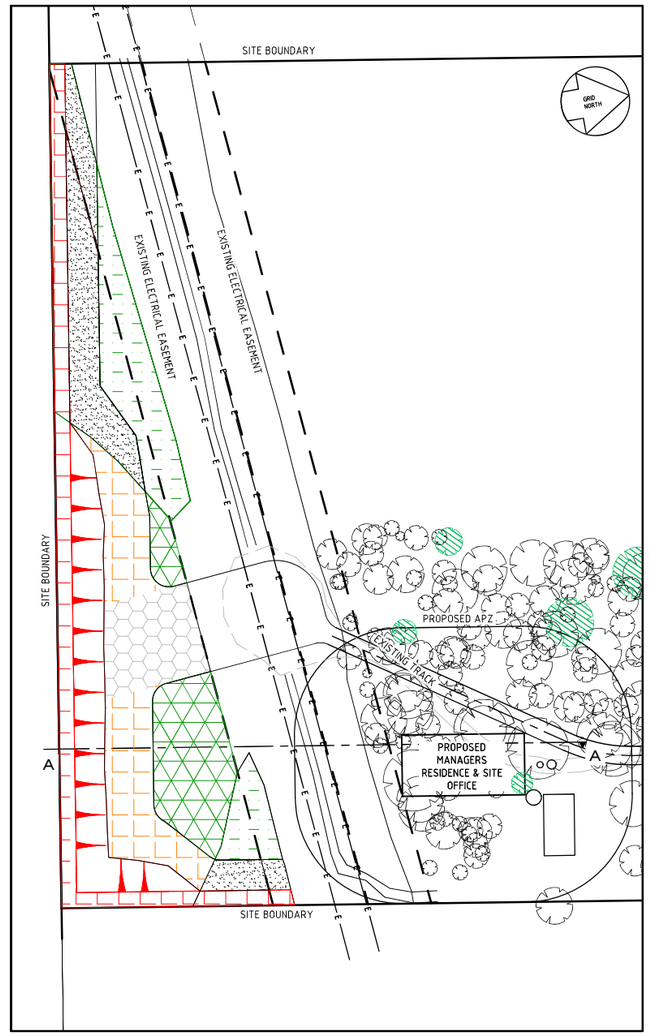
STAGE 2 - EXTRACTION



1. EXCAVATE DUNE TO 9mAHD WITH BATTER TO THE 5m BUFFER AT 1.5H:1V SLOPE
2. ESTABLISH STOCKPILING AND LOADING AREA OUTSIDE AUSGRID EASEMENT
3. ESTABLISH 15m WIDE CORRIDOR TO ALLOW WORKING AREA TO MAINTAIN BATTER TO EXISTING LEVEL AT BUFFER DISTANCE
4. BEGIN REHABILITATION IN DISTURBED AREAS OUTSIDE WORKING CORRIDOR.

ADDITIONAL EXCAVATED AREA = 3180m^2
ADDITIONAL AREA OF BATTER = 1710m^2
CURRENT AVAILABLE SAND VOLUME = 26,500m^3
INITIAL REHABILITATION AREA = 1470m^2
STOCKPILING AND LOADING AREA = 960m^2
15m WORKING AREA = 1790m^2

STAGE 3 - ONGOING MAINTENANCE



1. ONCE A 10m WIDE CORRIDOR OF VEGETATION HAS BEEN INUNDATED AND DIED FROM DUNE ENCROACHMENT EXCAVATE TO 9m AHD AND MAINTAIN CORRIDOR PROTECTING REMAINING VEGETATION.
2. CONTINUE TO EXCAVATE FROM ESTABLISHED WORKING AREA AS DUNE ENCROACHES PAST BUFFER AREA.
3. EXCAVATION TO BE LIMITED TO 9m AHD AT THE TOE AND LEVELS AS MARKED IN STAGE 1 AT THE BUFFER EDGE.

AREA OF VEGETATION PROTECTED FROM FURTHER DUNE ENCROACHMENT = 1700m^2

AREA OF VEGETATION SUBJECT TO MINING AFTER DIEBACK DUE TO DUNE INUNDATION = 1550m^2

LEGEND

DENOTES PROPOSED BATTER TO EXISTING

DENOTES EXISTING POWER EASEMENT

5m BUFFER TO NEIGHBOURING PROPERTIES

EXTENT OF CURRENT VEGETATION SOUTH OF EASEMENT

PROPOSED WORKING AREA

STAGE 2 PROPOSED STOCKPILING AND LOADING AREA

PROPOSED INITIAL REHABILITATION

STAGE 3 PROPOSED MINING AREA PENDING DUNE INUNDATION

CURRENT VEGETATION TO BE PROTECTED FROM INUNDATION

EXISTING TREES WITHIN & IN PROXIMITY TO BUSHFIRE APZ

EXISTING HOLLOW BEARING TREES

REV	DETAILS OF AMENDMENT	DESIGNED	DRAWN	CHECKED	APPROVED	DATE
C	Revised per Council Comments	DS	DS	AV*	BL*	21/01/20*
B	New Revision	DS	DS	AV*	BL*	06/06/19*
A	Original Issue	DS	DS	-	-	29/08/18*

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STAGING PLAN
PROPOSED SAND EXTRACTIVE INDUSTRY
LOT 591 DP1191380
4226 NELSON BAY RD, ANNA BAY

COUNCIL: PSC	REFERENCE: 21800003
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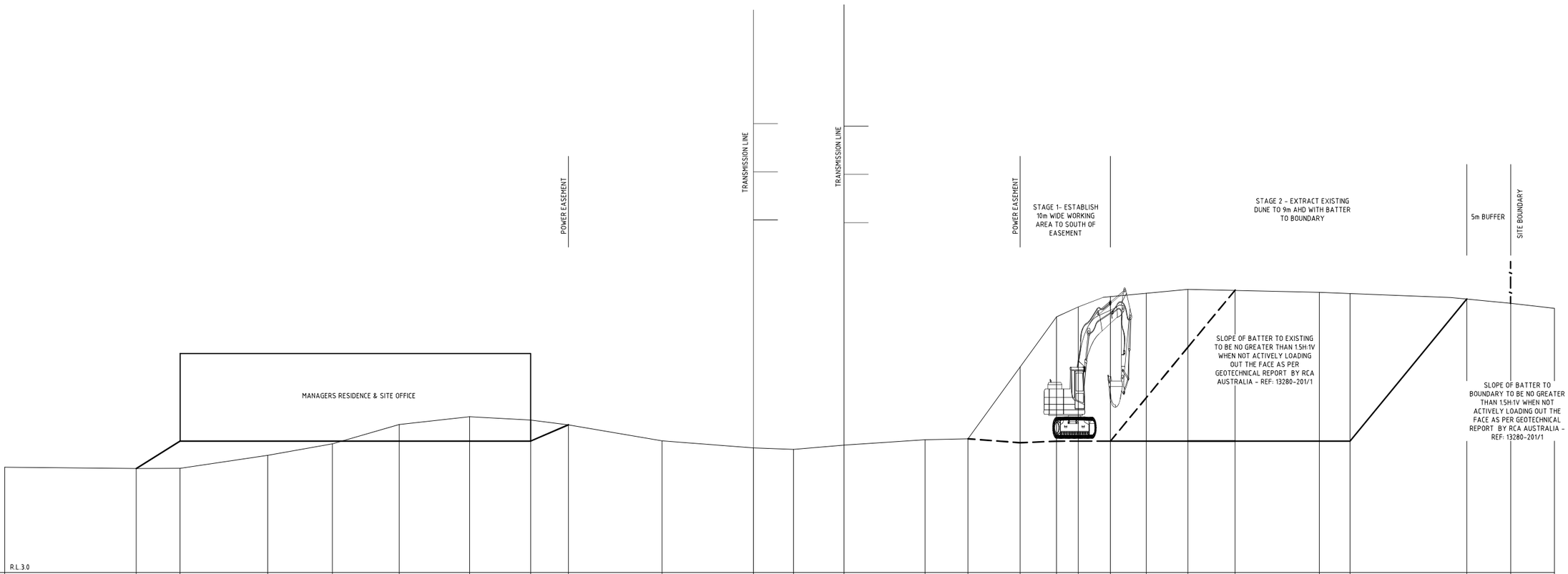

STAGE 3 LEVEL	7.749	7.749	9	9	9	9	9	9	9	9.743	9.007	8.686	8.624	8.817	9.056	9.104	9	9	9	9	9	9	9	9	9	9	15.486	15.289	15.061
STAGE 2 LEVEL	7.749	7.749	9	9	9	9	9	9	9	9.743	9.007	8.686	8.624	8.817	9.056	9.104	9	9	9	9	9	9	9	9	9	9	15.486	15.289	15.061
STAGE 1 LEVEL	7.749	7.749	9	9	9	9	9	9	9	9.743	9.007	8.686	8.624	8.817	9.056	9.104	9	9	9	9	15.754	15.892	15.898	15.795	15.734	15.486	15.289	15.061			
EXISTING LEVEL	8.291	7.749	7.757	8.348	8.871	9.758	10.111	9.957	9.743	9.007	8.686	8.624	8.817	9.063	9.104		14.672	15.127		15.754	15.926	15.898	15.795	15.734	15.486	15.289	15.061			
CHAINAGE	0.000	15	20	30	37.388	45	53.034	60	64.309	75	85.423	90	95.764	105	109.909	115.848	120	122.490	126.162	130.232	135	140.384	150	153.499	166.815	171.815	176.817			

SECTION A

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B	Batter Slope Values Added	DS	DS	AV*	BL*	06/06/19*
A	Original Issue	DS	DS	-	-	09/04/18*

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SITE SECTIONS
PROPOSED SAND EXTRACTIVE INDUSTRY
LOT 591 DP1191380
4226 NELSON BAY RD, ANNA BAY

COUNCIL: PSC	REFERENCE: 21800004
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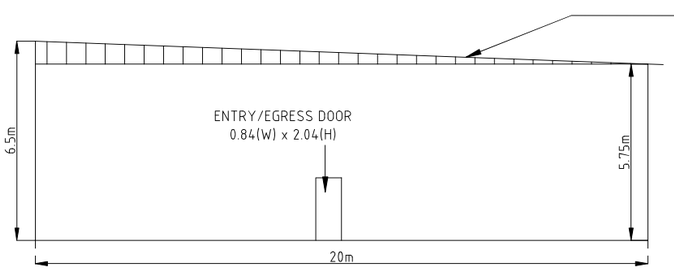
ELEVATION 3 - SOUTH
Typical
Scale 1:200



ELEVATION 4 - NORTH
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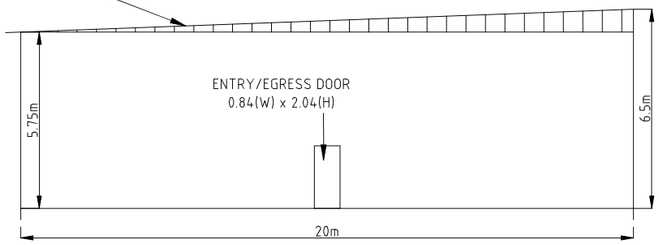

ELEVATION 2 - EAST
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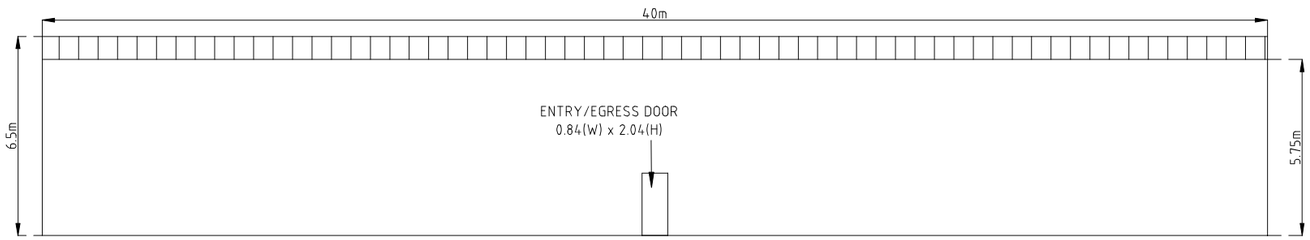

ELEVATION 1 - WEST
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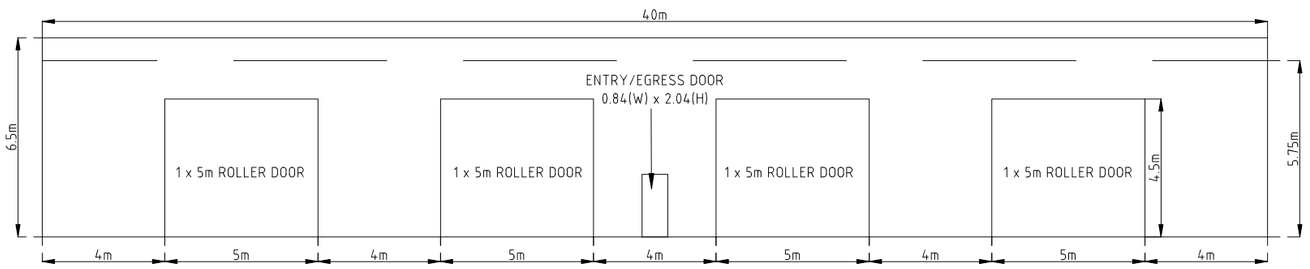
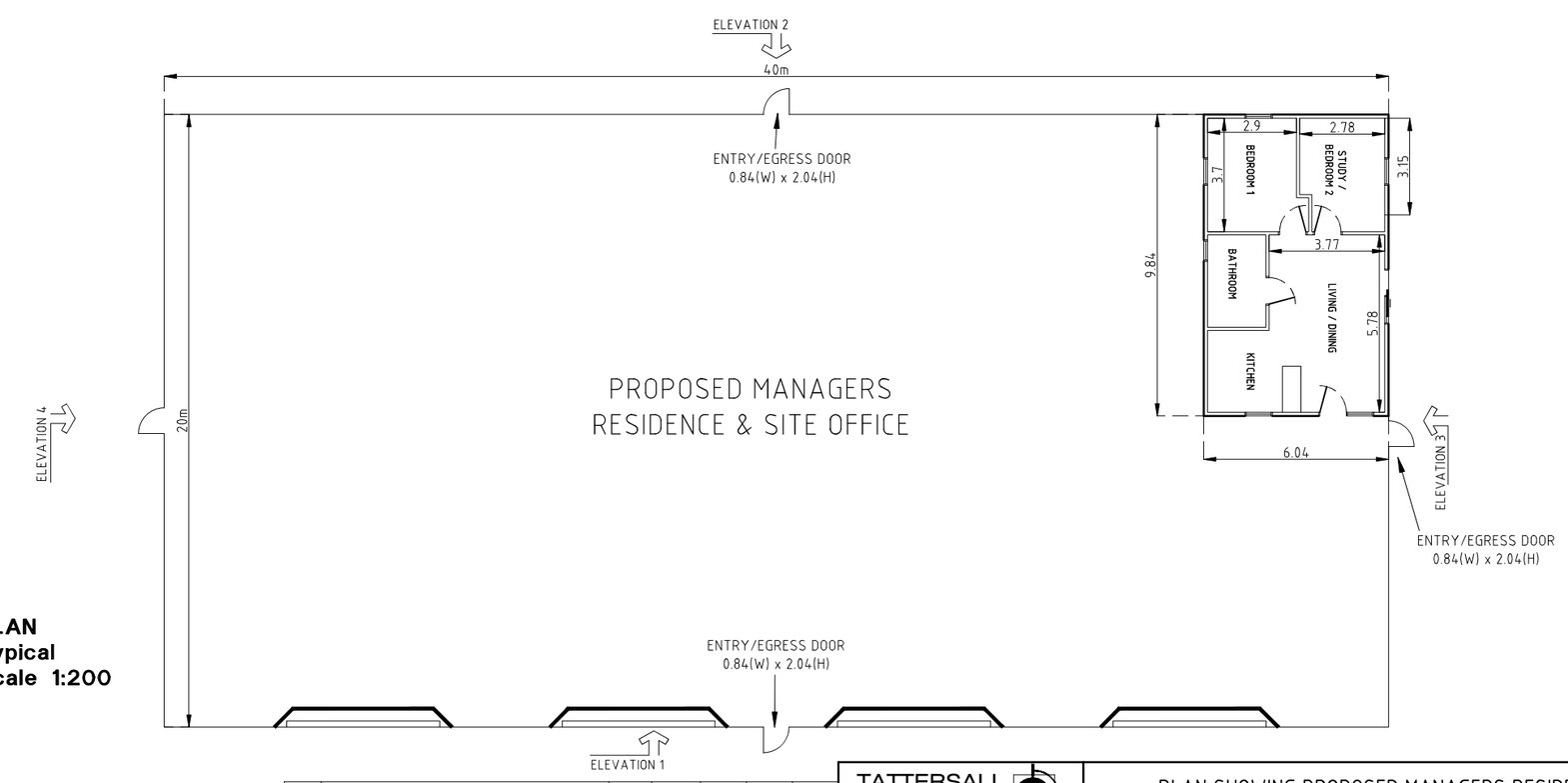
Scale 1:200



PLAN
Typical
Scale 1:200



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B	New Revision	DS	DS	AV*	BL*	06/06/19*
A	Original Issue	DS	DS	-	-	29/08/18*

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2 Bourke St. P.O.Box 580
RAYMOND TERRACE 2324
Fax (02) 49871733 Phone (02) 49871500

PLAN SHOWING PROPOSED MANAGERS RESIDENCE AND SITE OFFICE PLAN & ELEVATIONS
LOT 591 DP1191380
4226 NELSON BAY RD, ANNA BAY

COUNCIL: PSC	REFERENCE: 21800075
PARISH	SHEET SIZE: A1
SCALE: 1:1000 AT A1	SHEET No.: 5
DATE : Plotted 21/1/20 12:30PM	

CLIENT: HAY ENTERPRISES | JOB No.: 217111 | COMPUTER FILE : S:\Clients\2017\217111\Dwg\217111 - Design.dwg

GRID NORTH

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C	Revised per Council Comments	DS	DS	AV*	BL*	21/01/20*
B	New Revision	DS	DS	AV*	BL*	06/06/19*
A	Original Issue	DS	DS	-	-	29/08/18*

* Denote the original signature and date when revision was issued.

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Fax (02) 49871733 Phone (02) 49871600

ADJOINING SAND EXTRACTION OPERATIONS

COUNCIL: PSC	REFERENCE: 21800005
PARISH:	SHEET SIZE: A1
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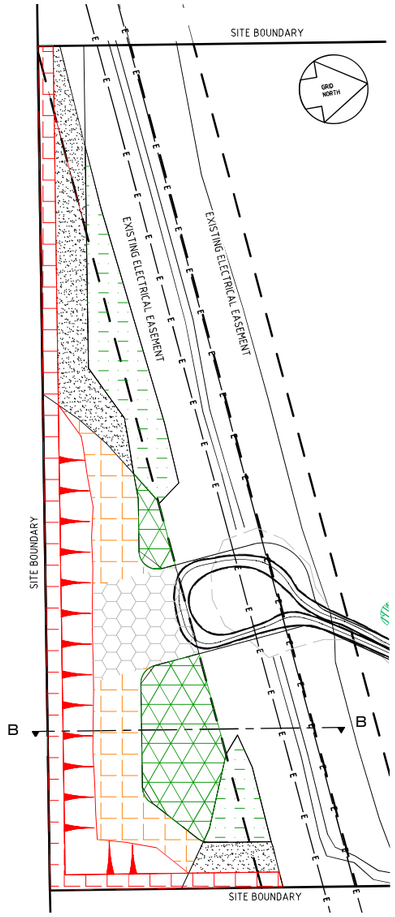
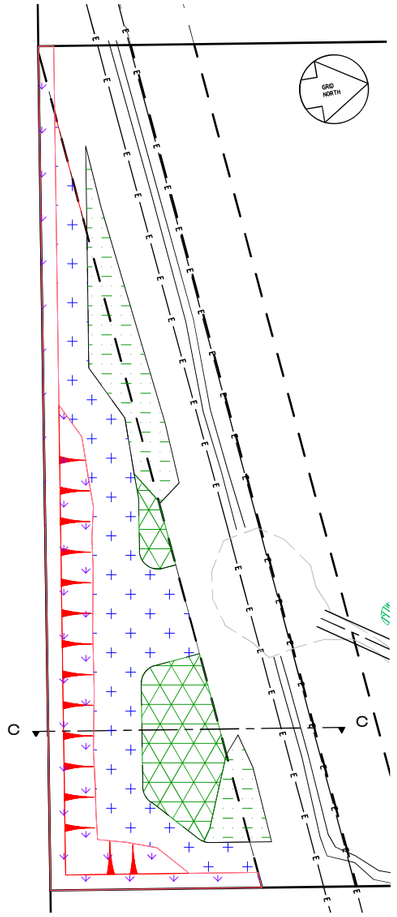
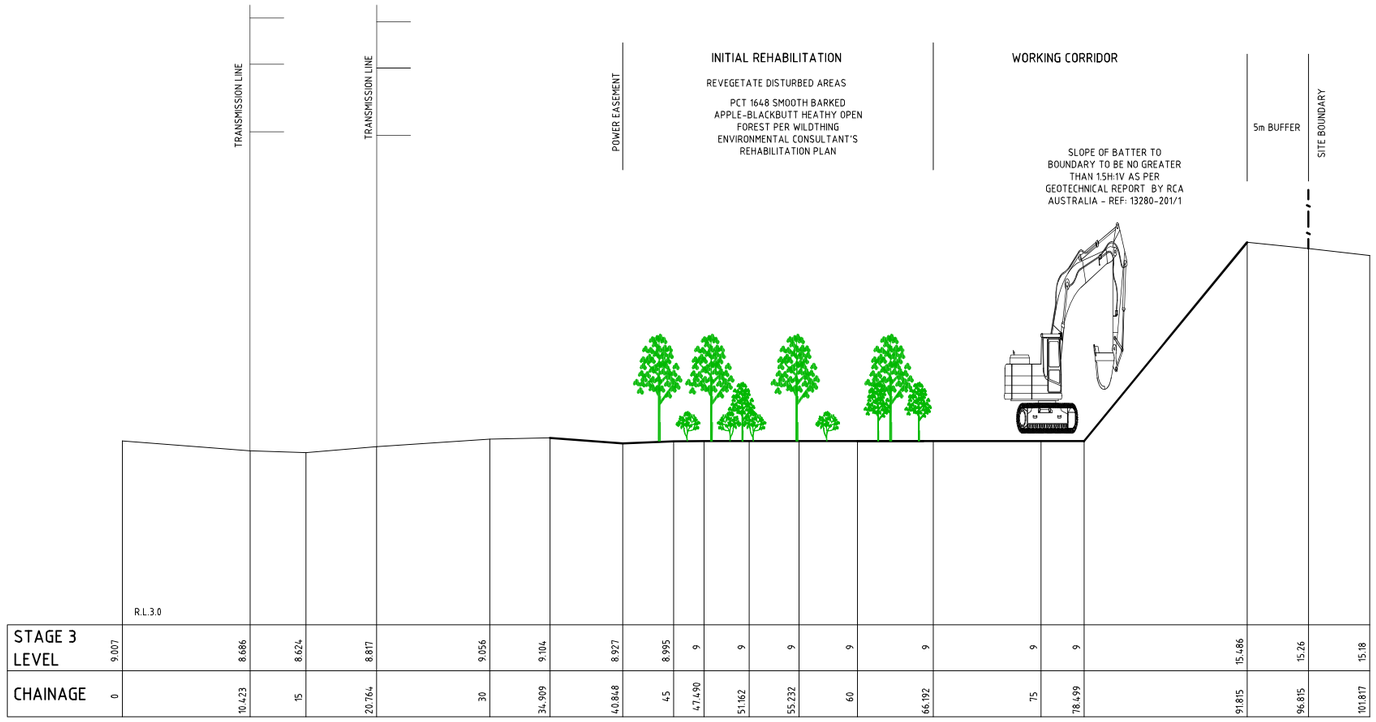


INITIAL REHABILITATION - DURING MINE STAGE 2

REHABILITATION AREA = 1470m²



FINAL REHABILITATION - PRIOR TO CLOSURE OF THE MINE
FLAT REHABILITATION AREA = 3950m²
BATTER REHABILITATION AREA = 3350m²



SECTION B INITIAL REHABILITATION DURING MINE STAGE 2

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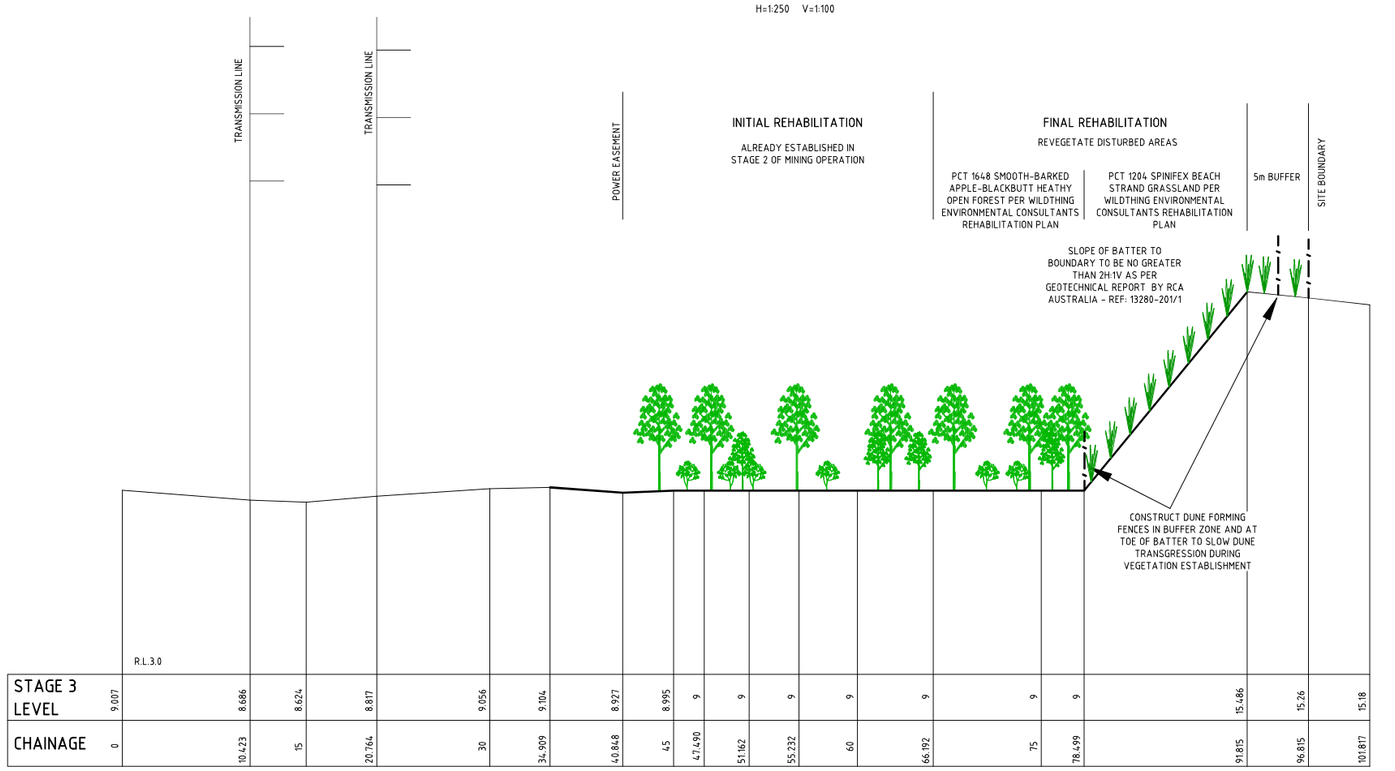

SECTION C - FINAL REHABILITATION PRIOR TO MINE CLOSURE

H=1:250 V=1:100

DENOTES PROPOSED BATTER TO EXISTING

DENOTES EXISTING POWER EASEMENT

5m BUFFER TO NEIGHBOURING PROPERTIES

EXTENT OF CURRENT VEGETATION SOUTH OF EASEMENT

STAGE 2 PROPOSED WORKING AREA

STAGE 2 PROPOSED STOCKPILING AND LOADING AREA

INITIAL REHABILITATION AREA SMOOTH BARKED APPLE

STAGE 3 PROPOSED MINING AREA PENDING DUNE INUNDATION

CURRENT VEGETATION TO BE PROTECTED FROM INUNDATION

FINAL REHABILITATION AREA PCT1204 SPINIFEX BEACH STRAND GRASSLAND

FINAL REHABILITATION AREA PCT1648 SMOOTH BARKED APPLE-BLACKBUTT HEATHY OPEN FOREST

REV	DETAILS OF AMENDMENT	DESIGNED	DRAWN	CHECKED	APPROVED	DATE
C	Revised per Council Comments	DS	DS	AV*	BL*	21/01/20*
B	Batter Slope Value Added	DS	DS	AV*	BL*	06/06/19*
A	Original Issue	DS	DS	-	-	09/04/18*

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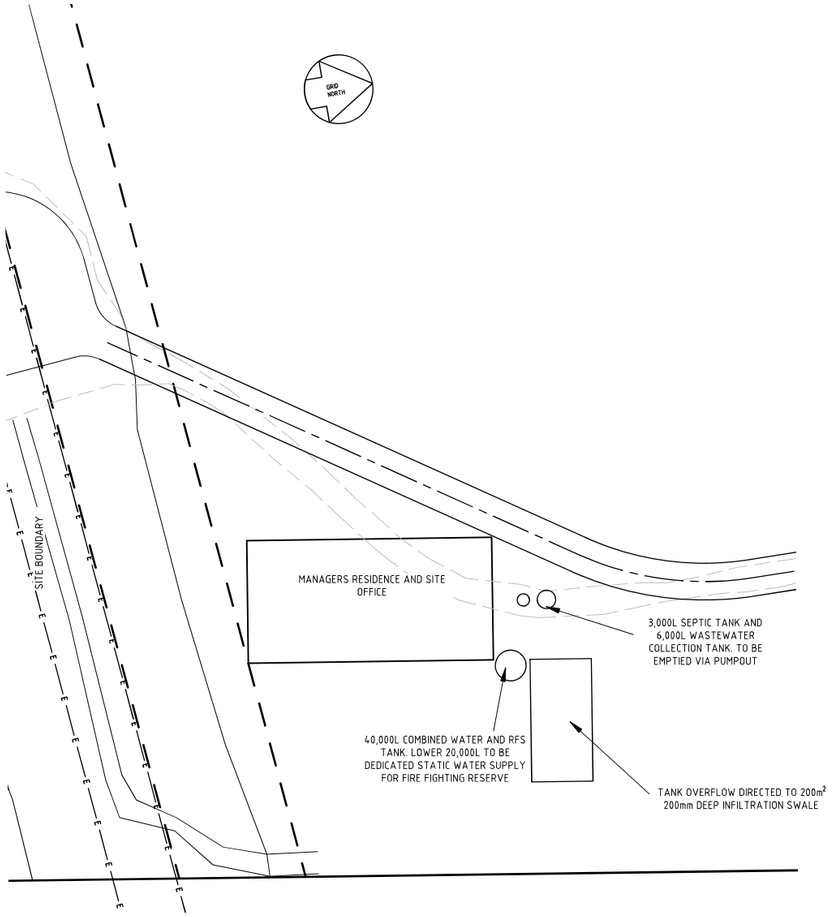
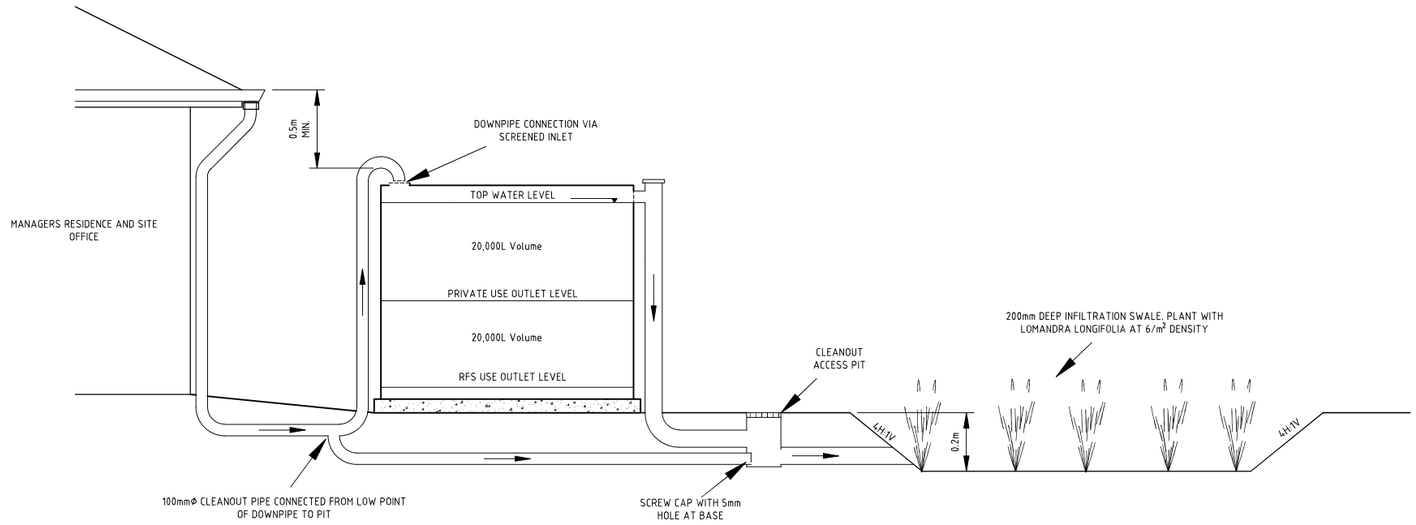
REHABILITATION PLAN
PROPOSED SAND EXTRACTIVE INDUSTRY
LOT 591 DP1191380
4226 NELSON BAY RD, ANNA BAY

COUNCIL: PSC	REFERENCE: 21800006
PARISH	SHEET SIZE: A1
SCALE: 1:1000 on A1	SHEET No.: 7
DATE : Plotted 21/1/20 12:30PM	

CLIENT: HAY ENTERPRISES | JOB No.: 217111 | COMPUTER FILE : S:\Clients\2017\217111\Dwg\217111 - Design.dwg





RAINWATER TANK AND INFILTRATION BASIN DETAIL

NOT TO SCALE

Roof Area	800	m^2
Infiltration Area	200	m^2
Infiltration Rate	0.0004	m/s
Infiltration FOS	5	
Design Infiltration Rate	0.00008	m/s
$Q_{infiltration}$	0.016	m^3/s

× INFILTRATION RATE FROM GEOTECHNICAL INVESTIGATION BY RCA AUSTRALIA ref 13280-201/2

AEP	%	100	100	100	100	100	100	100	100
Duration	min	1	5	10	20	30	45	60	90
Intensity	mm/hr	485	334	267	194	155	121	101	76.9
Intensity	m/s	1.3E-04	9.3E-05	7.4E-05	5.4E-05	4.3E-05	3.4E-05	2.8E-05	2.1E-05
Q_{inflow}	m^3/s	0.108	0.074	0.059	0.043	0.034	0.027	0.022	0.017
Vol Runoff	m^3	6.47	22.27	35.60	51.73	62.00	72.60	80.80	92.28
Q_{Net} (Q_{inflow}-$Q_{infiltration}$)	m^3/s	0.092	0.058	0.043	0.027	0.018	0.011	0.006	0.001
Net Volume	m^3	5.51	17.47	26.00	32.53	33.20	29.40	23.20	5.88
Depth Req	mm	28	87	130	163	166	147	116	29

NOTES:
1. 2016 IFD DATA FROM BOM NEAREST GRID CELL 32.7635(S) 152.0625 (E)
2. RATIONAL METHOD CALCULATIONS IN ACCORDANCE WITH ARR 2019 FIGURE 9.6.1 FOR THE SCALE OF THE DEVELOPMENT. RUNOFF COEFFICIENT C =1

REV	DETAILS OF AMENDMENT	DESIGNED	DRAWN	CHECKED	APPROVED	DATE
C	Original Issue	DS	DS	AV*	BL*	21/01/20*
B	-	-	-	-	-	-
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STORMWATER MANAGEMENT PLAN

COUNCIL: PSC	REFERENCE: 21801001
PARISH	SHEET SIZE: A1
SCALE: 1:500 on A1	SHEET No.: 8
DATE : Plotted 21/1/20 12:32PM	

CLIENT: HAY ENTERPRISES | JOB No.: 217111 | COMPUTER FILE : S:\Clients\2017\217111\Dwg\217111 - Design.dwg

APPENDIX D: GEOTECHNICAL REPORT

GEOTECHNICAL & GROUNDWATER INVESTIGATION

Proposed Sand Mine at 4226 Nelson Bay Road, Anna Bay

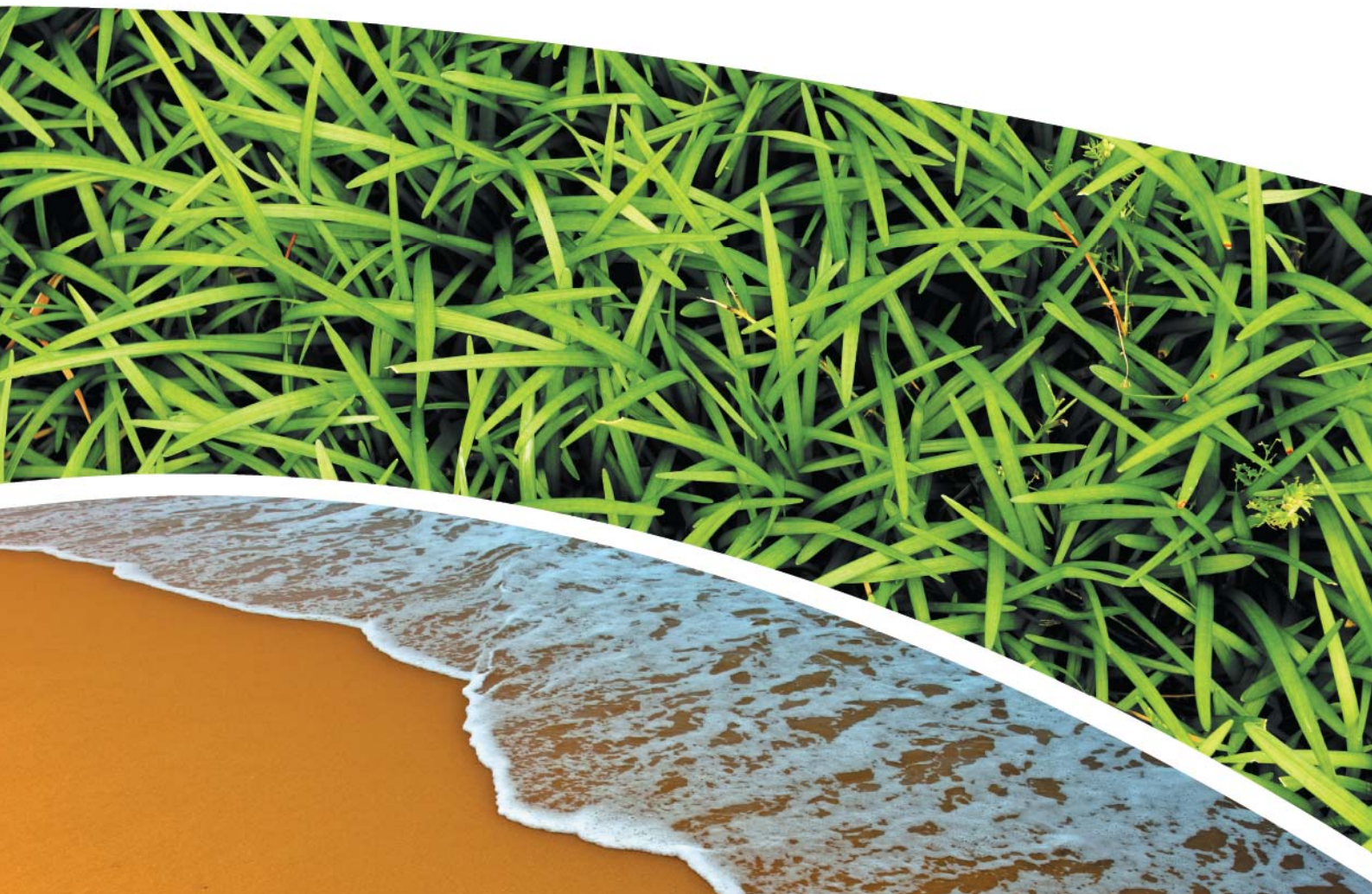
Prepared for Tattersall Lander

Prepared by RCA Australia

RCA ref 13280-201/2

August 2018

RCA AUSTRALIA
GEOTECHNICAL • ENVIRONMENTAL



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DOCUMENT STATUS

Rev No	Comment	Author	Reviewer	Approved for Issue (Project Manager)		
				Name	Signature	Date
/0	Draft	Jason Haines	Robert Carr	Robert Carr		13.03.18
/1	Draft	Jason Haines	Robert Carr	Robert Carr		16.03.18
/2	Final	Jason Haines	Robert Carr	Robert Carr		22.08.18

DOCUMENT DISTRIBUTION

Rev No	Copies	Format	Issued to	Date
/1	1	Electronic (email)	Tattersall Lander – Julie Wells – julie@tatland.com.au	16.03.18
/1	1	Electronic report	RCA – job archive	16.03.18
/2	1	Electronic (email)	Tattersall Lander – Julie Wells – julie@tatland.com.au	22.08.18
/2	1	Electronic report	RCA – job archive	22.08.18

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Engineering Geology
Environmental Engineering
Hydrogeology
Construction Materials Testing
Environmental Monitoring
Sound & Vibration
Occupational Hygiene

RCA ref 13280-201/2

22 August 2018

Tattersall Lander
PO Box 580
RAYMOND TERRACE NSW 2324

Attention: Julie Wells

GEOTECHNICAL & GROUNDWATER INVESTIGATION
PROPOSED SAND MINE AT 4226 NELSON BAY ROAD, ANNA BAY

1 SUMMARY

A proposed sand mine and ancillary development are proposed at 4226 Nelson Bay Road, Anna Bay.

The base of the proposed sand mine is at the approximate level of the existing ground surface at an existing electricity easement which runs approximately east to west across the property.

The sand dune system is advancing to the north towards the electricity easement at the south-eastern corner of the property. It is understood that sand mining is proposed to control the advancement of the dunes.

Ground levels vary from approximately RL9mAHD in the vicinity of the electricity easement up to approximately RL17mAHD in the vicinity of the proposed sand mine.

A subsurface investigation has been carried out to assess the soil and groundwater conditions across the site. The investigation comprised drilling of bores up to 12 m deep, construction of groundwater monitoring wells (fitting of one well with an automatic data logger), infiltration testing and laboratory testing of the soils for particle size distribution and presence of acid sulfate soils.

Soils beneath the site comprise a quatzose aeolian sand profile. Ground water was encountered at a depth corresponded to a level of approximately 2m AHD.

The groundwater present beneath the site forms part of the Stockton Groundwater Resource and falls under the Water Sharing Plan for the North Coast Coastal Sands Groundwater Sources.

Based on long term monitoring in nearby monitoring wells and published information, it is considered that the level of the groundwater surface may rise up to 2.8m below the base of the proposed sand mine operational during extreme wet climatic periods.

Surface water infiltration testing yielded infiltration rates which varied from 4 to $5x10^{-4}$m/sec.

The sand mining operations are not expected to encounter actual acid sulfate (AAS) nor potential acid sulfate soils (PASS).

In regard to geotechnical stability of batter associated with the sand mine, it is suggested that when the mine is not actively loading out that batters be limited to a maximum of 1.5H:1V and for long term stability against mass failure that the slopes be battered at a maximum 2H:1V.

2 INTRODUCTION

This report presents the findings of a geotechnical and groundwater investigation undertaken for a proposed sand mine at Lot 591 DP1191380, 4226 Nelson Bay Road, Anna Bay. The investigation was undertaken at the request of Julie Wells from Tattersall Lander on behalf of Hay Enterprises.

Ancillary development for the proposed sand mine at the site includes:

- A machinery shed/storage area and caretaker residence with amenities; and
- An upgraded 6m wide haul route from Nelson Bay Road realigned around the proposed machinery shed and caretaker residence.

This investigation has been undertaken to provide information to address a number of the Secretary's Environmental Assessment Requirements (SEARs) as requested by Tattersall Lander for the preparation of an Environmental Impact Statement (EIS) for the proposed sand mine. The SEARs to be addressed by RCA and the scope of work are shown in **Table 1**.

Table 1 *SEARs to be addressed by RCA and scope of work*

Secretary's Requirement	**RCA scope of work**
A detailed consideration of maintenance of and adequate buffer between all excavations and the highest predicted groundwater table	Details of the predicted highest groundwater level at the development site. RCA to drill piezometer borehole and install data logger to monitor groundwater depth below ground surface and predict maximum likely groundwater level.
An assessment of potential impacts on the quality and quantity of existing surface and groundwater resources, including a detailed assessment of proposed water discharge quantities and quality against receiving water quality and flow objectives	RCA to provide results of infiltration testing on soils.
Potential impacts on acid sulfate soils including proposed management strategies	RCA to drill and sample to confirm that acid sulfate soils conditions are not present in dune sands above RL9mAHD and liaise with Tattersall Lander to prepare an Acid Sulfate Management Plan if required.
Potential impacts on landforms (topography), paying particular attention to the long-term geotechnical stability of any new landforms	RCA to provide advice on suitable landform batter slopes for: - Long-term remediated batter slopes; - Working quarry staging batter slopes; for input into Tattersall Lander design.

This report includes the following:

- Site description.
- Description of fieldwork undertaken which includes drilling of boreholes, penetration testing, installation of instrumented groundwater piezometers and surface water infiltration testing.
- Description of the laboratory testing undertaken which comprise particle size distribution (PSD) and acid sulfate soil (ASS) testing.
- Details of the subsurface conditions encountered by way of logs of boreholes and results of surface water infiltration tests.
- The results of laboratory testing.
- The monitoring of the groundwater level with time.
- Assessment of maximum likely groundwater levels and fluctuations.

- Assessment of the presence of acid sulfate soils.
- Assessment of batter stability of the sand mine batters with respect to short-term and long-term applications.

For the purpose of the investigation the following was provided:

- Development plans drawn by Tattersall Lander comprising a locality sketch and drawings of the overall layout, staging plan, site section, adjoining mining operations and rehabilitation plan.
- A map and coordinates of the location of protected diuris praecox orchids provided by WILDTHING Environmental Consultants (a division of Tattersall Lander).

3 SITE DESCRIPTION

3.1 SITE DESCRIPTION

The proposed sand mine is to be situated in the sand dunes on the southern portion of 4226 Nelson Bay Road, Anna Bay south of an electricity transmission easement which runs approximately east to west across the property. The approximate location of the sand dune system is shown on the site location plan which is attached as **Drawing 1**, in **Appendix A** which also shows the approximate investigation test locations carried out for this report and the indicative location of proposed site developments (Machinery Shed, Caretakers Residence and Access).

The ground surface level in the vicinity of the proposed mine is variable. Away from the sand dunes the existing ground surface slopes across the site are gently undulating with slopes typically of the order of 0 to 5 degrees.

In the area of the electricity easement the ground surface has been modified and is roughly level at approximately RL 9mAHD. South of the electricity easement the ground surface levels rise abruptly at about 30 to 33 degrees up into the sand dunes to approximately RL17mAHD in the vicinity of the proposed sand mine. Slopes on top of the sand dune system are variable with slopes typically in the order of 0 to 10 degrees with localised sand dune faces having slopes up to 30 degrees.

Drainage across the site comprised infiltration drainage in the permeable sand.

Vegetation on the site at the time of the field investigation comprised mostly mature trees with visible treetops protruding through the inundating sand dune system. Some bitou bush was located atop the sand dune system. Grass and small plants including the protected diuris praecox orchid was found in the electricity transmission easement where the trees had been cleared.

Site photographs are shown on **Figure 1**.

Photograph 1 *Looking east atop the sand dune in the proposed sand mine initial area of operation.*

Photograph 2 *Looking west along the southern boundary where the vegetated area is being inundated with sand.*

Photograph 3 *Looking west along the electricity transmission easement from the eastern site boundary.*

Photograph 4 *Looking east across the sand dune slope.*

Photograph 5 *Looking south across the location of the proposed machinery shed and caretaker residence.*

Photograph 6 *Looking north across the location of the proposed machinery shed and caretaker residence and haul road.*

Figure 1 *Site Photographs taken on 30 January 2018.*

3.2 BACKGROUND

3.2.1 PROPOSED SAND MINE

As may be seen from Photographs 7 & 8 in **Figure 2** the sand dune system is advancing to the north towards the electricity easement at the south-eastern corner of the property. It is understood that sand mining is proposed to control the advancement of the dunes.

Photograph 7 *Aerial photograph taken from Nearmap 8 May 2010.*

Photograph 8 *Aerial photograph taken from Nearmap 5 July 2017.*

Figure 2 *Aerial photographs showing the dynamic nature of the sand dune system- showing the northward advancement of the sand dunes during the time between the photographs.*

It is understood that the body of dune sand currently proposed to be mined has a volume of approximately 37,000m^3. It is also understood that the proposed sand extraction area may extend to the west and northeast of the current proposed extraction area in the future as the dune system advances.

3.3 SOIL LANDSCAPE, GEOLOGICAL AND HYDROGEOLOGICAL SETTING

3.3.1 GEOLOGICAL SETTING

Reference to the New South Wales Zone 56 Seamless Geology, version 1 [Digital Dataset] (Ref [1]) shows the site to overlay Quaternary age dune sand deposits.

3.3.2 SOIL LANDSCAPE AND ACID SULFATE RISK MAPS

The Port Stephens 1:100,000 Soil Landscape Series Sheet 9332 indicates that the majority of the site is situated in the Hawks Nest soil landscape (an Aeolian soil landscape) with the proposed sand mine to the south situated in the Stockton Beach soil landscape.

The Hawks Nest soil landscape is noted to generally comprise stable, gently undulating, Holocene sand sheets and beach ridges.

The Stockton Beach soil landscape is noted to generally comprise beaches, foredunes and often extensive and unstable dunes and blowouts on Holocene marine and Aeolian sand. Very well-drained Calcareous Sands are expected in the sand dunes.

The Morna Point Acid Sulfate Soil Risk Map published by the Department of Land and Water Conservation indicates that there is a low probability of the occurrence of acid sulfate soil materials at depths greater than 3m below the ground surface in the areas

from which sand extraction is proposed. It is noted however that lowlands to the west of the site associated with Tilligerry Creek estuary/ flood plain have a well-known acid sulfate setting.

3.3.3 HYDROGEOLOGICAL SETTING

The site overlies part of the North Stockton sand beds and forms part of the Stockton Groundwater Resource and falls under the Water Sharing Plan for the North Coast Coastal Sands Groundwater Sources.

The sand aquifer extends from the mouth of the Hunter River in the south to Anna Bay in the north and is bounded by the Newcastle Bight/Tasman Sea in the east and the Tilligerry Creek estuary and flood plains in the west. **Figure 3** presents a schematic cross-section of the geological/hydrogeological conceptual model of the site and its environs.

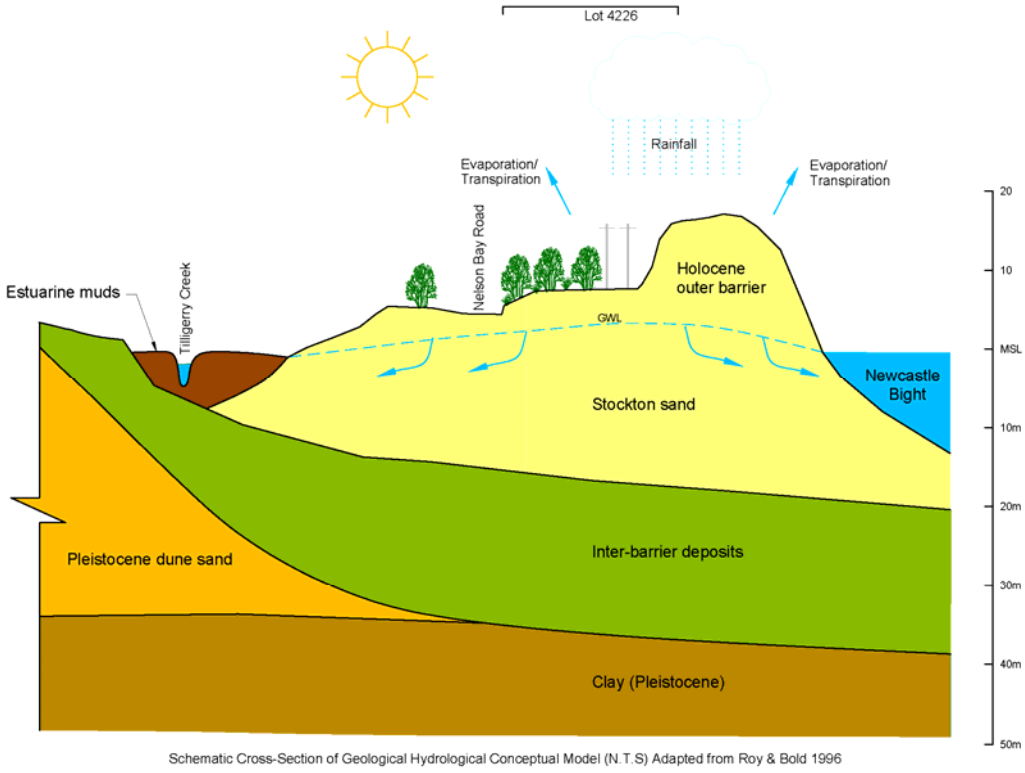


Figure 3 *Schematic Cross-section of Geological/Hydrogeological Conceptual Model (adapted with modification from Ref [2])*

The groundwater beneath the coastal dune system forms a groundwater divide between the ocean and Tilligerry Creek. Groundwater recharge is primarily from rainfall infiltrating the dune system and discharges by evapotranspiration and from groundwater discharge down gradient to the ocean and tidal estuary/ floodplain drains.

There are a number of licenced water works (wells) within about 0.5km of the site on the Department of Industries, Office of Water (OoW) data site. These include the following:

- GW047490 adjacent to Jessie Road south of the intersection with Nelson Bay Road. The OoW work sheet record this to be a local government owned bore with a standing groundwater depth of 6.1m.
- GW079407/GW079408 approximately 0.5km along the electricity easement west of the boundary of Lot 4226. No details are contained on the OoW work sheets apart from the installation being owned by Hunter Water ref Sk9593b.
- GW079138/GW079370 approximately 0.35km along the electricity easement east of the boundary of Lot 4226. No details are contained on the OoW work sheets apart from the installation being owned by Hunter Water ref BL215A.

The nearest bore on the DIP OoW database which contains monitoring results is GW080359 also referenced as GW800083_2 and Anna Bay Public School bore 3 located approximately 3km east of the site. A plot of water depth variations contained in the data base is shown on **Figure 4**.

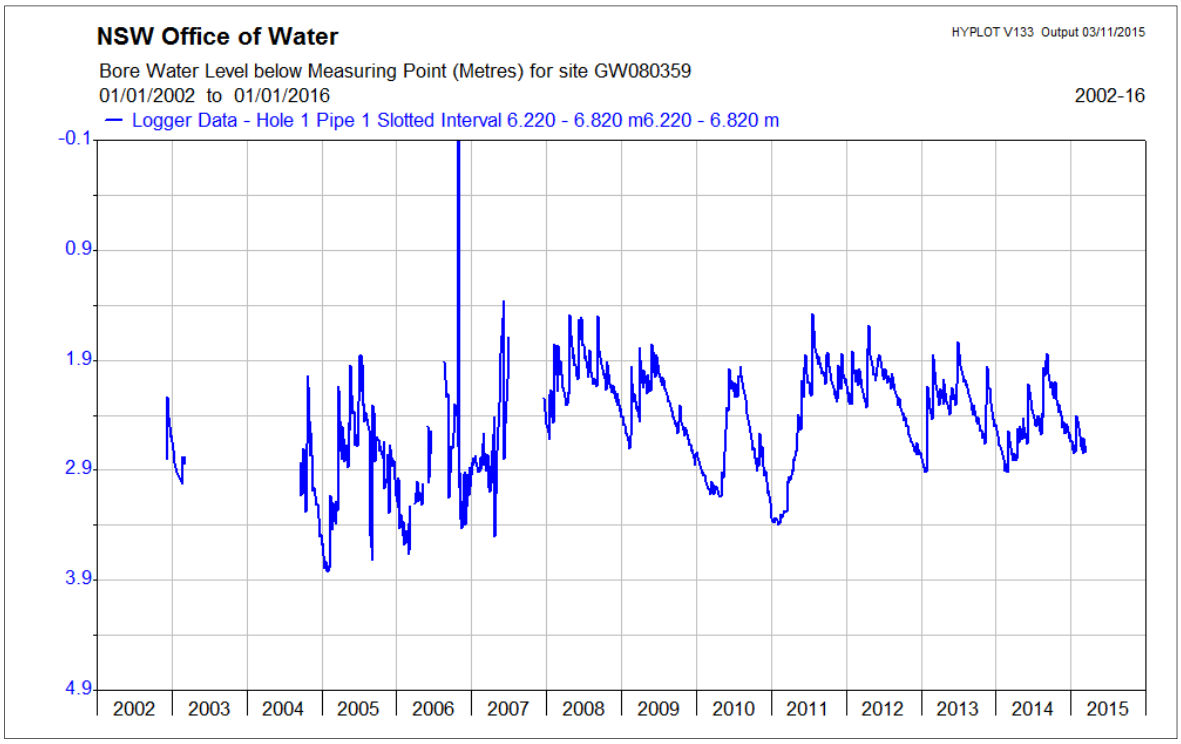


Figure 4 *Plot of water depth in GW080359 (copied from OoW database) from 2002 to 2015*

The spread sheet that accompanies the plot in the OoW data set indicates that the water level was deepest at 3.816m in earlier 2005 and spiked to 0.535m/0.498m on the 28/29 October 2006. The resulting maximum water level fluctuation is 3.318m from the lowest record over the period for which there is data. It is noted however that the rainfall records of stations (see **Figure 5** as an example) in the vicinity of the site do not record the occurrence of a significant rainfall event. Accordingly the cause of the spike is not known.

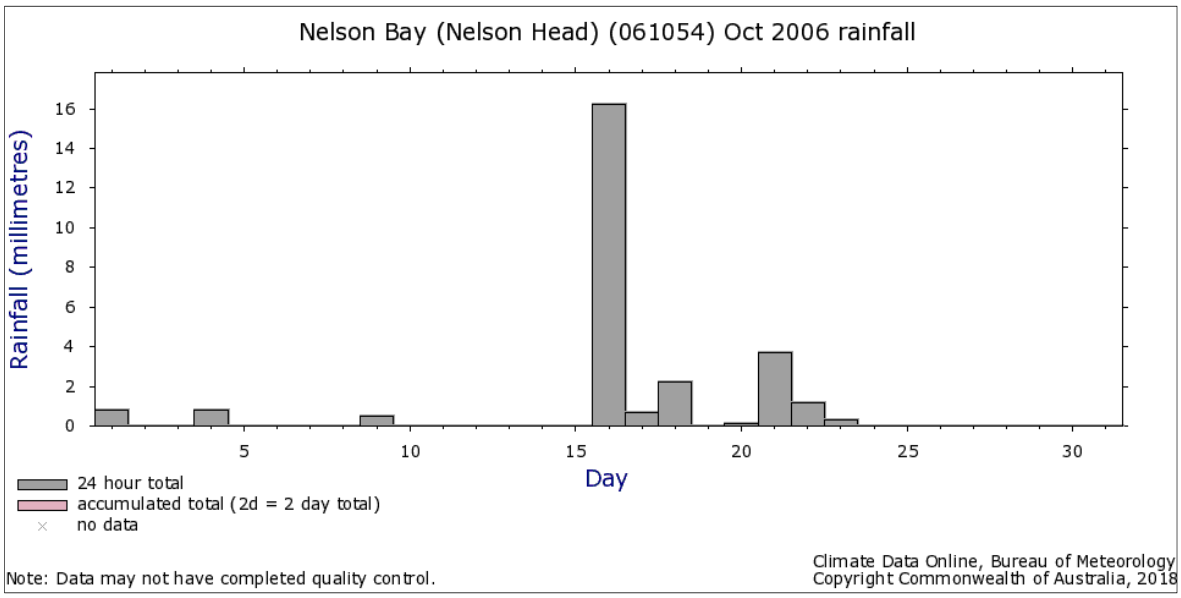


Figure 5 *Daily Rainfall Nelson Bay October 2006 from BOM site*

With reference to **Figure 4** it may be seen that in the absence of the spike in late 2006 the groundwater surface appears to have varied up to 2.5m in depth over the years of monitoring for which data is available.

Hunter Water (HW) have supplied monitoring information on the North Stockton network of monitoring bores including Sk9593b and BL215A which as noted above lie to the west and east of the site, respectively.

The monitoring results are presented on **Figure 6**.

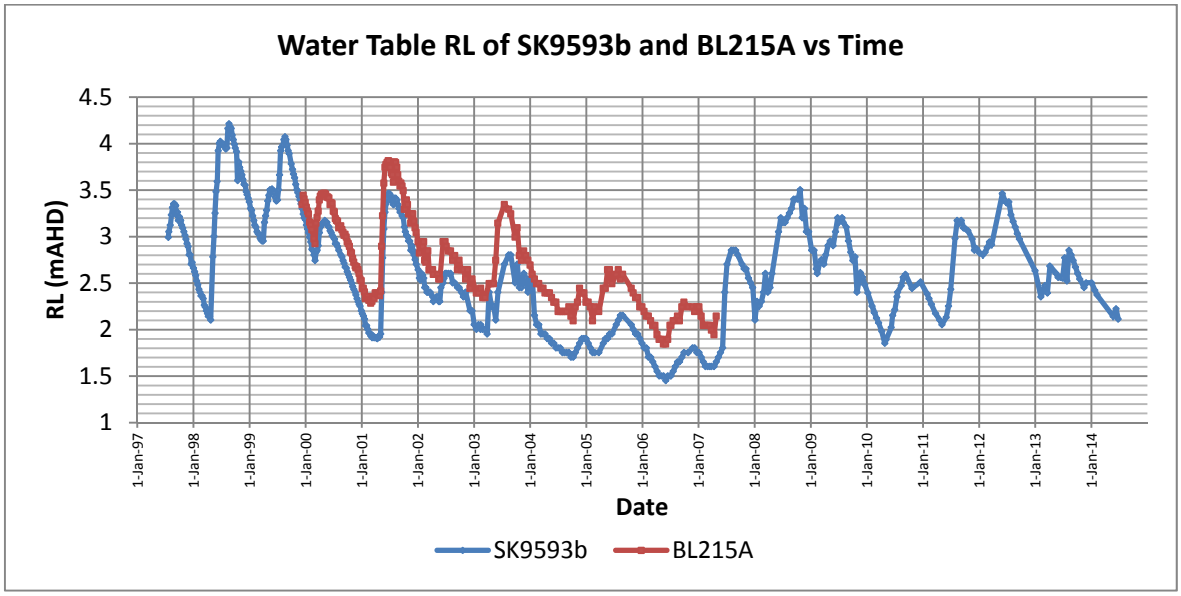


Figure 6 *Plot of groundwater level monitoring data at SK9593b and BL215A (Hunter Water data)*

It is noted that HW no longer monitors these sites and that the above is a complete data set apart from the removal of erroneous readings.

It may be seen from the **Figure 6** that the maximum variation in water level is approximately 2.8m.

4 FIELD AND LABORATORY INVESTIGATION

4.1 INVESTIGATION FIELDWORK

Field investigation was carried out on 23, 30 January 2018 and 2, 5, 12 February 2018 and involved the following:

- A visual appraisal and mapping of site conditions and features.
- Drilling, sampling and logging of five (5) hand auger bores (HA1 to HA5) to depths ranging from 0.95m to 6.0m.
- Dynamic penetrometer testing at 5 locations adjacent to the hand auger boreholes.
- Drilling, sampling and logging of two (2) boreholes (BH6 & BH7) to 12.0m. The boreholes were completed by a track mounted drilling rig using hollow flight augers.
- Installation of two (2) 50mm diameter standpipe piezometers (PZ1in BH7 & PZ2 in BH6) to depths ranging from 11.60 to 11.70m. The piezometers were installed by a licenced water well driller from Total Drilling.
- Installation of an automatic down-hole data logger (HOBO) in one piezometer (BH7/PZ1). The data logger was set to read at 0.5hr intervals.
- Conducting four (4) in situ infiltration tests (INF1 To INF4) using double ring infiltrometer methodology.

The approximate test locations together with site features are shown on the site layout drawing provided by Tattersall Lander which is attached as **Drawing 1**, in **Appendix A**. The location and level of the test sites have not been located by survey.

Engineering logs of the subsurface conditions encountered in the hand auger bores and boreholes are presented in **Appendix B** along with piezometer diagrams and explanation sheets.

Double ring infiltrometer test reports are presented in **Appendix C**.

Photographs of selected investigation locations are shown below on Photographs 9 to 16 in **Figure 7**.

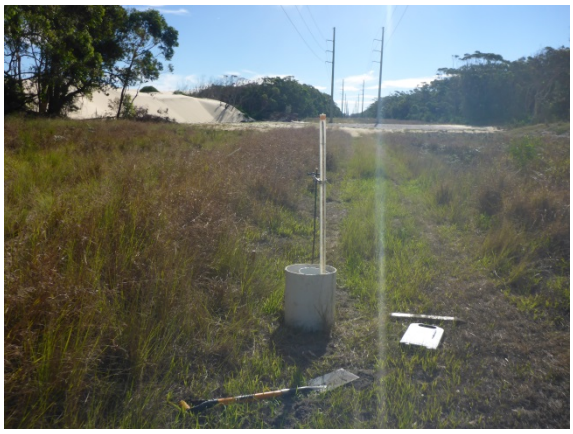
Photograph 9 *Hand auger borehole location atop the sand dune system at HA4.*

Photograph 10 *Drilling of hand auger HA3 atop the sand dune system.*

Photograph 11 *Borehole drilling at the location of BH6/PZ2.*

Photograph 12 *Installed Piezometer PZ1 at the location of BH7.*

Photograph 13 *Double ring infiltrometer apparatus set up at location INF1.*



Photograph 14 *Double ring infiltrometer apparatus set up at location INF2.*

Photograph 15 *Double ring infiltrometer apparatus set up at location INF3.*

Photograph 16 *Double ring infiltrometer apparatus set up at location INF4.*

Figure 7 *Photographs of selected fieldwork test locations*

4.2 MONITORING WELL LOCATIONS

As noted above groundwater monitoring wells PZ1 and PZ2 were installed at the locations of BH7 and BH6 respectively. PZ1 is fitted with an automatic down-hole data logger taking readings of air and water pressure at half hour intervals and is finished above ground level within a lockable, galvanised steel monument. The groundwater monitoring well PZ2 was installed where heavy machinery is likely to traffic during the operation of the sand mine and is finished 0.3m below ground level with a concrete encased gaiter cover. PZ2 was installed as a precautionary measure; in case of damage to or the vandalisation of PZ1 prior to the completion of the requirement for groundwater monitoring. The location of PZ2 is 25.0m from the closest edge of the electricity transmission pole on an imaginary line extending through the centre of both electricity transmission poles, as shown in **Photograph 17**.

Photograph 17 *Sketch of the location of BH6/PZ2 relative to the location of electricity transmission poles.*

4.3 LABORATORY TESTING

Laboratory testing comprised the following:

- Four (4) particle size distribution (PSD) tests on samples of sand from the proposed sand mine area of operation.
- Nine (9) acid sulfate screening tests conducted on samples of sand from the area of operation and above and below the water table to assess the presence of acid sulfate soils. Three (3) samples were sent for chromium reducible sulphur (CRS) testing to determine the presence or otherwise of sulphides.

Details of the laboratory testing are shown on the laboratory test reports attached in **Appendix D** and the results of the laboratory testing are summarised in Section 4.2.

5 SUBSURFACE CONDITIONS

5.1 SUBSURFACE CONDITIONS ENCOUNTERED DURING INVESTIGATION

5.1.1 SOIL PROFILE

The subsurface conditions encountered in the bores drilled and hand augered across the site of the proposed sand mine are detailed on the attached bore and hand auger report log sheets. The depths noted on the borehole logs have been recorded relative to the existing ground surface at the borehole locations at the time of the field investigation. An indicative generalised section through the section of the site of interest is shown on **Drawing 2** in **Appendix A**.

The subsurface conditions encountered in the hand augers atop the sand dune (HA3 and HA4) comprised aeolian, quartzose, fine to medium grained, pale yellow-white sand.

A plot of the dynamic penetration testing from the top of the dune sand at HA3 & HA4 is shown on **Figure 8** together with the interpreted relative density.

Dynamic penetrometer testing indicates that the density of the sand is generally medium dense in HA3 and varies from very loose to loose/medium dense with depth in HA4.

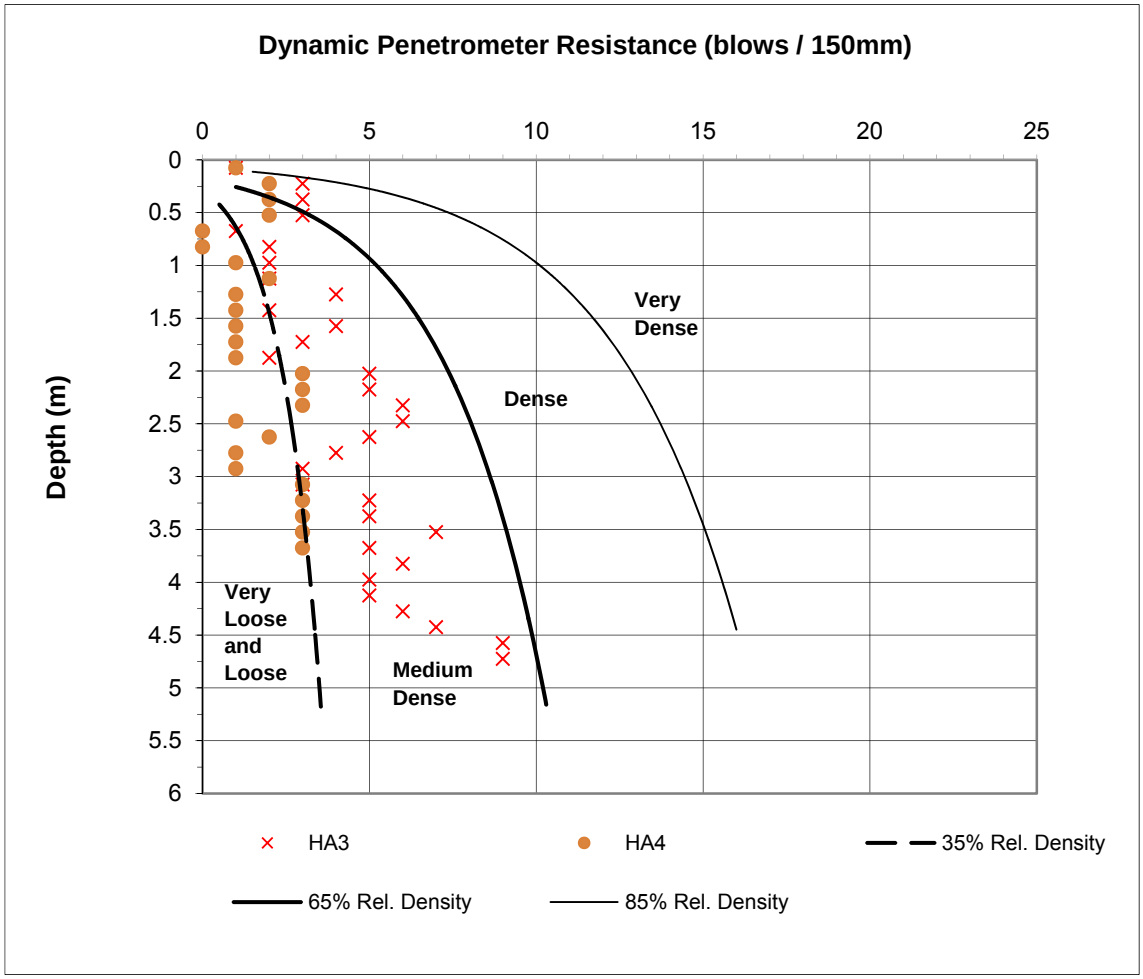


Figure 8 *Plot of dynamic penetrometer resistance test carried out from the top of the sand dunes at the location of hand augers HA3 & HA4 (density curves from Ref [5])*

The subsurface conditions encountered in the boreholes and hand augers drilled to the north of the dunes site can generally be summarised as follows:

- Topsoil (encountered in HA1, HA2, HA5, and BH7) comprising silty sand, fine to medium grained, grey, to a depth of 0.3m in the hand augers and 0.8m in BH7; overlying
- Aeolian sand, quartzose, fine to medium grained, encountered in all test holes to depths in excess of 12m in BH6 and BH7.

Dynamic penetrometer test results carried out at the location of HA 1, 2 & 5 are plotted on **Figure 9.**

With reference to **Figure 9** the density of the near surface sands is variable but generally medium dense (ie relative density index between 35% to 65%) or better below a depth of 0.7m.

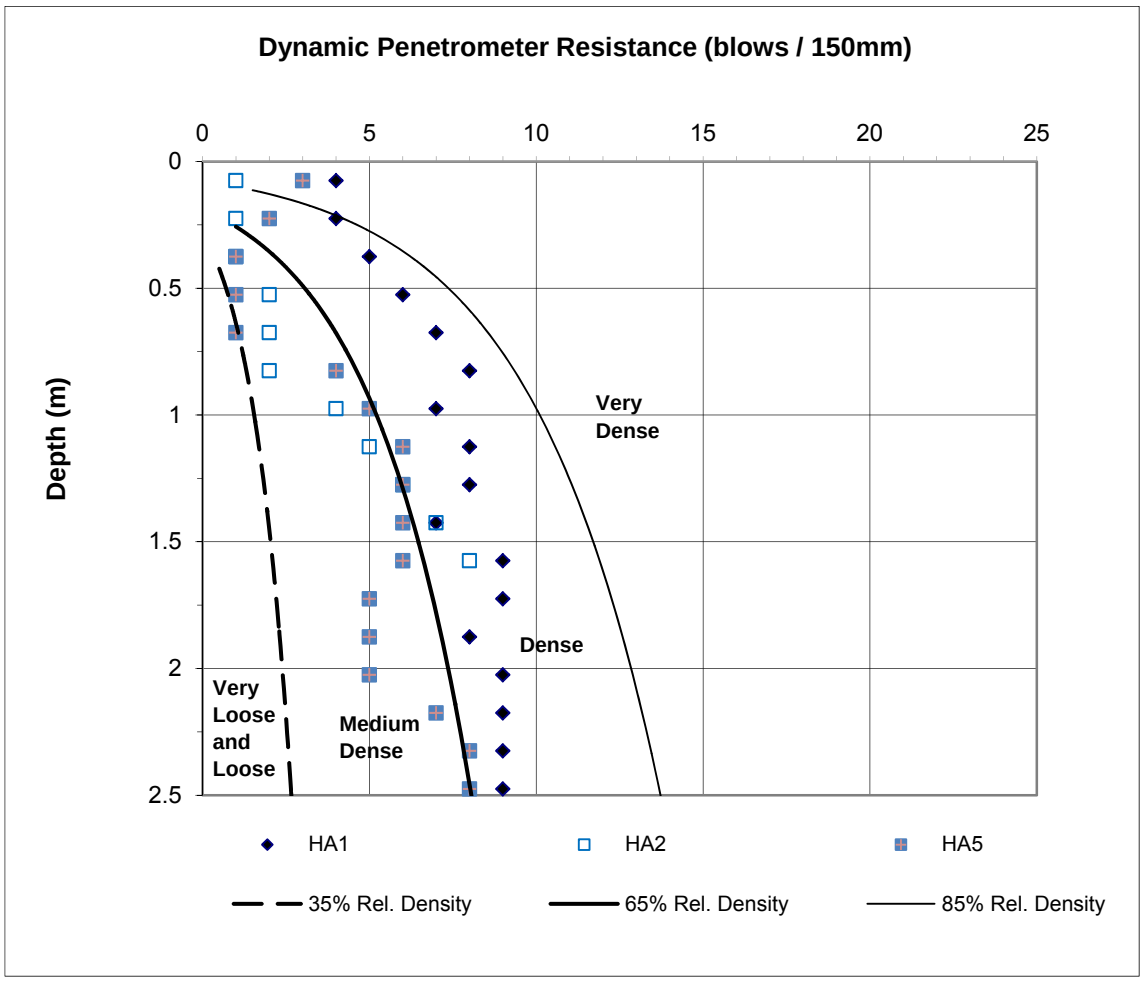


Figure 9 *Plot of dynamic penetrometer resistance at the location of hand augers HA1, HA2 & HA5 (density curves from Ref [5])*

The results of the Standard penetration testing (SPT) in BH6 & 7 are plotted on **Figure 10.** The results indicate that the sands are loose to medium dense in the upper zone and medium dense with depth.

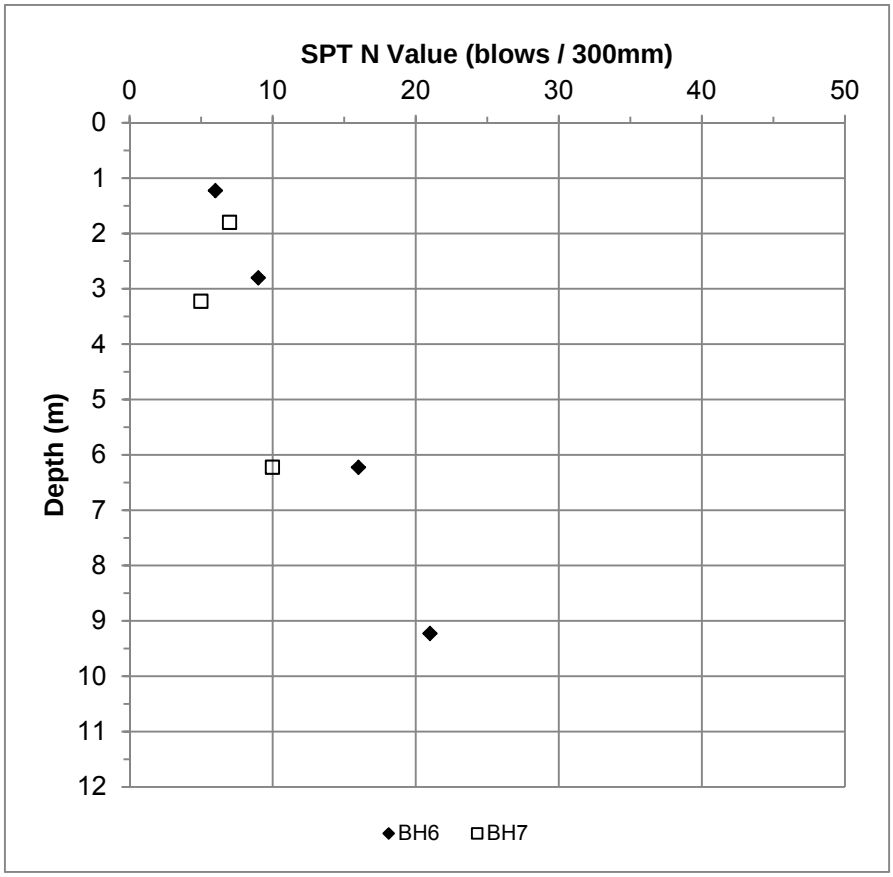


Figure 10 *Summary of SPT testing in BH6 and BH7*

5.1.2 GROUNDWATER LEVELS

The test locations have not been surveyed and all groundwater measurements are relative to the existing ground surface level. On 5 February 2018 groundwater was measured in PZ1 (in BH7) and PZ2 (in BH6) at depths of 7.45m and 6.30m below ground level respectively. With reference to **Drawing 2** in **Appendix A** the depths corresponded to a groundwater level of approximately 2m AHD.

The automatic down-hole data logger installed in BH7/PZ1 commenced taking readings on the 5 February 2018 and the data was downloaded on 28 February 2018 after some rainfall. The water level in PZ1 is recorded in **Figure 11** along with rainfall data from the Nelson Bay (Nelson Head) weather station approximately 12km away.

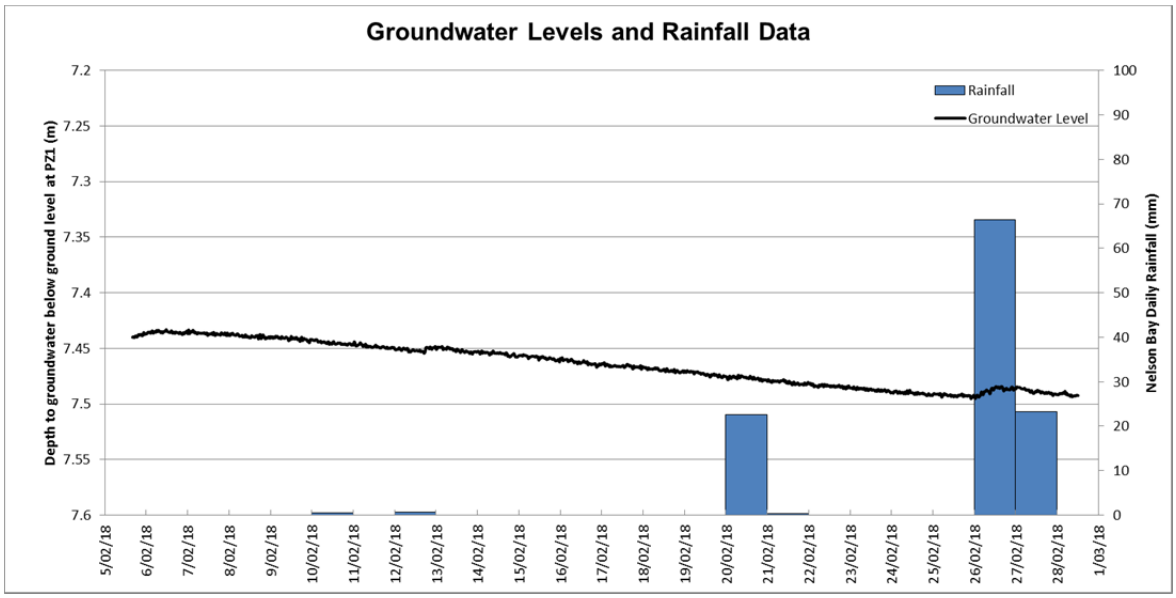


Figure 11 *Continuous groundwater measurements throughout February 2018.*

The depth to groundwater has steadily decreased by a total of approximately 50mm across the 23 days recorded. After significant rainfall on 26 February the groundwater level rose by 10mm however returned the next day to the downward trend.

5.1.3 INFILTRATION TEST RESULTS

Double ring infiltrometer testing was undertaken at four (4) locations (INF1 to INF4) across the site. Infiltrometer rings were driven 100mm into the surface of the soil layer. The sites of the test were soaked with water for an approximate 30 minute period of time to establish saturated soil conditions before the testing was conducted.

Two tests were undertaken at each testing location using a 1.5L Marriotte tube. The double ring infiltrometer test reports are presented in **Appendix C** and are summarised in **Table 2**.

Table 2 *Summary of In Situ Infiltration Rate Testing*

Borehole	Depth of test (m)	Soil Type	Test Method	Average Infiltration Rate (m/s)
INF1	0.1	SAND, fine to medium grained	Double Ring Infiltrometer – Constant Head	5.0×10^{-4}
INF2	0.1	SAND, fine to medium grained	Double Ring Infiltrometer – Constant Head	4.0×10^{-4}
INF3	0.1	SAND, fine to medium grained	Double Ring Infiltrometer – Constant Head	4.2×10^{-4}
INF4	0.1	SAND, fine to medium grained	Double Ring Infiltrometer – Constant Head	4.1×10^{-4}

The measured infiltration rates as shown in **Table 2** indicate that the sand clean at the site has an approximate surface infiltration rate of 4.0×10^{-4} to 5.0×10^{-4}m/s.

The Hazen formula for permeability along with particle size distribution results suggests the dune sand has permeability of between 2×10^{-4} and 6×10^{-4}m/s.

5.2 LABORATORY TEST RESULTS

5.2.1 PARTICLE SIZE DISTRIBUTION TESTING RESULTS

Laboratory testing results are attached in **Appendix C** and are plotted and summarised in **Figure 12** and **Table 3** respectively.

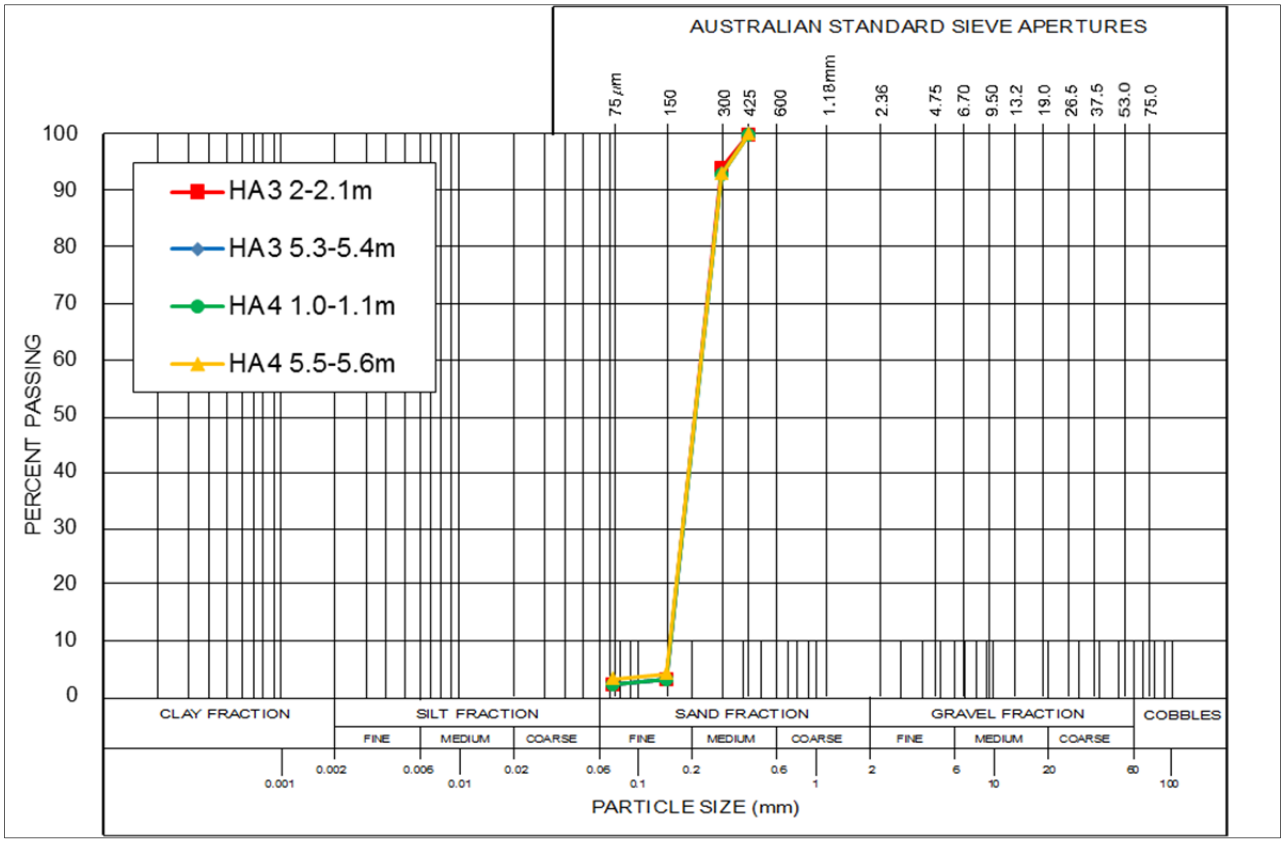


Figure 12 *Particle Size Distribution Test Results*

Table 3 *Summary of Particle Size Distribution Testing Results*

Borehole	Depth (m)	Soil Type	Particle Size Distribution		
			% Silt and Clay	% Sand	% Gravel
HA3	2.0-2.1	Aeolian SAND	2	98	0
HA3	5.3-5.4	Aeolian SAND	2	98	0
HA4	1.0-1.1	Aeolian SAND	2	98	0

HA4	5.5-5.6	Aeolian SAND	3	97	0

The particle size distribution results indicate that the fine to medium grained dune sand is uniform in grain size with approximately ninety percent of the sand having a grain size between 0.15 and 0.30mm.

5.2.2 ACID SULFATE TEST RESULTS

The results of the acid sulfate screening testing on the samples of sand taken from the bores are shown on **Table 4**.

Table 4 *Summary of ASS screening test results*

	UNITS (m)	HA3 4.0-4.1	HA3 5.0-5.1	HA3 5.9-6.0	HA4 4.0-4.1	HA4 5.0-5.1	HA4 5.9-6.0	BH6 4.0-4.1	BH6 6-6.45	BH6 9-9.45
pH_F	pH unit	7.63	7.54	7.79	8.17	6.82	8.08	7.09	6.89	6.97
pH_{FOX}	pH unit	6.12	6.16	6.30	6.22	5.72	6.12	5.60	5.89	5.88
$pH_F - pH_{FOX}$	pH unit	1.51	1.38	1.49	1.95	1.1	1.96	1.49	1	1.09
Reaction Rate	-	1	1	1	1	1	1	1	1	1

pH_F - pH

pH_{FOX} – pH after oxidation

Reaction Rate Rate: 0 = No Reaction, 1 = Slight, 2 = Moderate, 3 = High, 4 = Very Vigorous

The screening test results indicate that the pH of the soils tested was greater than 4 and as such soils are not actual acid sulfate soils.

The screening testing indicate a drop on oxidation of greater then 1pH unit on oxidation but the resulting pH after oxidation is greater than 5 pH units and the reaction rate is slight indicating limited acid generation potential that the soils are unlikely to be potential acid sulfate soils. To confirm the limited acid potential of the sands four (4) chromium reducible sulphur analysis were carried out. The results are presented in **Appendix D**.

In summary, the % chromium reducible sulphur varied from 0.005% to 0.008% well below the trigger criteria of 0.03%S for a potential acid sulfate soil (PASS).

6 ADVICE ON REQUESTED SEARS

6.1 GROUNDWATER LEVELS

Groundwater monitoring has been ongoing for a limited period of time following a relatively dry period.

Available information on the maximum groundwater fluctuations likely in the sand beds included the following:

- Anna Bay Public School Bore 3 (discussed in section 2.3.3) indicates maximum groundwater surface level fluctuations over the years of monitoring presented (2002 to 2015) of 2.5m.

- The HW groundwater monitoring data for BL215A and SK9593b (monitoring wells closest to the site) indicates a maximum groundwater surface level fluctuation over the years monitored of approximately 2.8m.
- Ref [3], Figure 11 graphs groundwater levels between 1976 and 1987 for 2 long term monitoring wells in the Tomago sand beds which indicate maximum fluctuations of 2.5 to 3m for the period monitored.
- Ref [3] reports the monitoring of 7 wells at Salt Ash between July 2008 and October 2011 which fluctuated with climatic conditions typically from 1.0 to 1.7mAHD. The report considers the Hunter Water groundwater monitoring wells and modelling to include consideration of the effect of the heavy rainfall periods during 1990 and 2007 and reports a transient groundwater model run over the period from January 1997 to August 2011. The data and model indicate that the highest groundwater levels in the north Stockton aquifer were recorder in May to August 1999. Accordingly, the report finds that the August 1999 groundwater levels represent the maximum groundwater level. Modelling and the groundwater monitoring observation wells indicate a maximum fluctuation in groundwater level of 3.2m.

Based on the above groundwater surface level fluctuations (and the current relatively dry weather conditions) it is considered that the level of the groundwater surface may rise up to 3.5m above the current water depth as indicated in BH6/PZ2. Accordingly, it is expected that the highest probable water level would be 2.8m below the ground level at BH6/PZ2 in the proximity of the proposed sand mine operational area.

6.2 SURFACE WATER INFILTRATION TESTING

The results of the surface water infiltration testing are presented in Section 4.1.3. The test results yielded infiltration rates which varied from 4 to 5 $x10^{-4}$m/sec.

The results are considered to be typical or representative values of infiltration rates for the clean, fine to medium grained sands at the site.

6.3 ACID SULFATE TESTING

Based on the results of the ASS testing, the sand mining operations are not expected to encounter actual acid sulfate (AAS) nor potential acid sulfate soils (PASS).

6.4 BATTER STABILITY AND SITE EARTHWORKS

6.4.1 ANGLE OF REPOSE OF THE DUNE SAND

The angle of repose of a sand batter is a measure of the shear strength friction angle of the sand in its loose state. With reference to **Figure 8** it may be seen that at least parts of the dune sand are composed of loose sand. Accordingly, it is considered that the angle of repose of the batter provides a good estimate of the shear strength friction angle of the sand.

The angle of repose was measured using a hand held inclinometer on an excavated sand dune to the south of the electricity power easement at site on 30 January 2018. The sand dune slope face was assessed to be at its critical angle of repose as disturbance of the batter surface caused surface flow and raveling on the batter. The measured angle of repose was approximately 30-33 degrees.

Based on the above and previous experience with similar materials the following Parameters have been adopted for stability assessment:

- Friction Angle (ϕ) – 33^o
- Cohesion – 0
- Density (γ) – 19kN/m^3

6.4.2 BATTER STABILITY ANALYSIS FOR SHORT-TERM APPLICATIONS

It is understood that it is proposed to extract sand from the face of the dune system with an approximate height of 8m by excavator.

It is expected that the batter face in moist sand will be steeper than 1.5H:1V (35^o) for short periods of time due to the capillary suction of the moisture between the sand particles imparting an additional shear strength by way of apparent cohesion.

In this state the batter is susceptible to a sudden collapse onto anything that is at the toe of the batter.

It is therefore suggested that when the sand mine is not actively loading out that the face should be battered down to an angle of no greater than 1.5H: 1V.

6.4.1 BATTER STABILITY ANALYSIS FOR LONG-TERM APPLICATIONS

It is understood that a stable batter slope is required for long term remediation of the sand mine batters on site at the boundary. In practical terms it is difficult to rehabilitate batter slopes in excess of 2H:1V.

A 2H:1V sand batter would have a factor of safety of 1.3 against sand raveling down the batter surface face. Due to the trivial nature of the movement a factor of safety of 1.3 is considered acceptable for this type of movement.

The factor of safety against mass rotational slumping of a 2H:1V batter slope extending behind the batter crest has been analyzed using commercially available stability program SlopeW and the parameters discussed in Section 5.4.1. The result is shown on **Figure 13**.

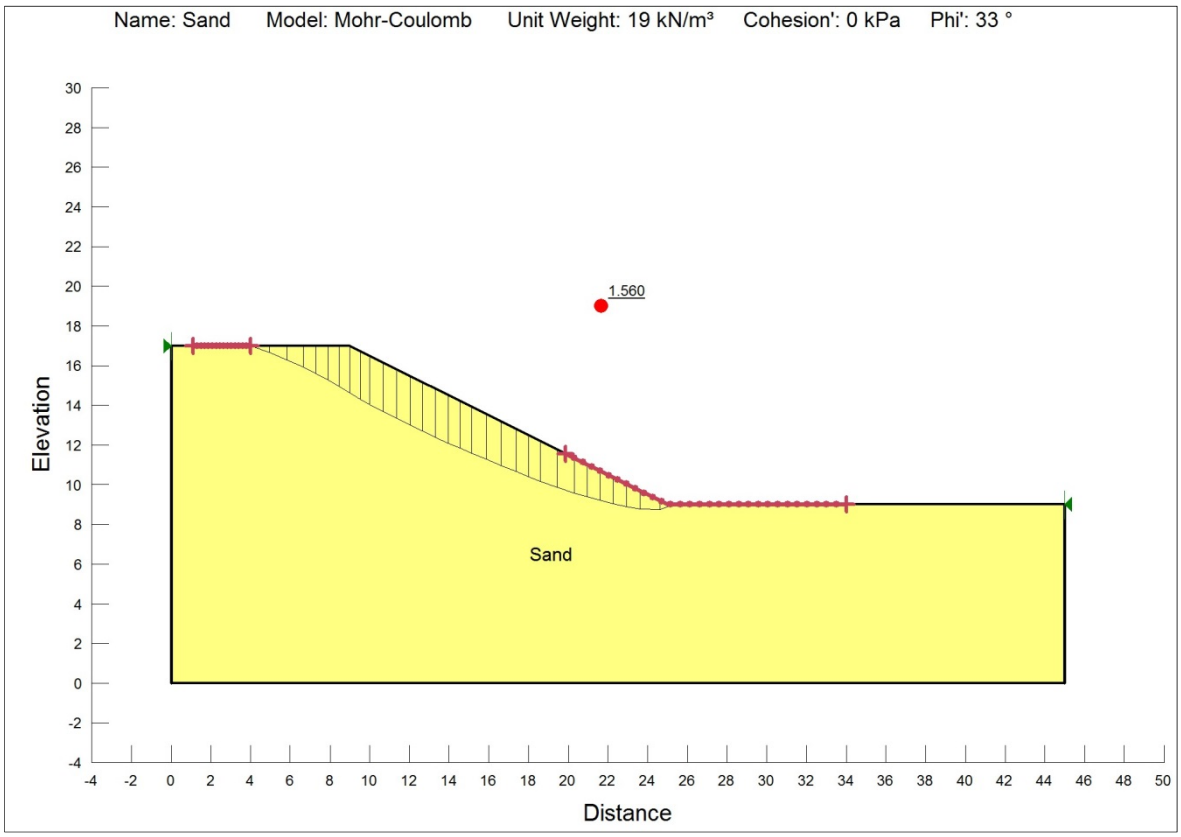


Figure 13 *Plot of Factor of safety against mass rotational slumping of 2H:1V batter slope*

The factor of safety against mass rotational slumping of a 2H:1V batter slope is in excess of 1.5 and this is considered acceptable for the proposed situation.

Based on the above it is suggested that from a geotechnical perspective a maximum batter slope of 2H:1V be adopted for the final landform batter.

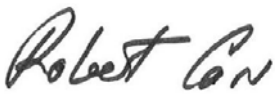
7 LIMITATIONS

This report has been prepared for Tattersall Lander Pty Ltd in accordance with the agreement with RCA Australia (RCA). The services performed by RCA have been conducted in a manner consistent with that generally exercised by members of its profession and consulting practice.

This report has been prepared for the sole use of Tattersall Lander Pty Ltd for the specific purpose and the specific development described in the report. The report may not contain sufficient information for purposes or developments other than that described in the report or for parties other than Tattersall Lander Pty Ltd. This report shall only be presented in full and may not be used to support objectives other than those stated in the report without permission.

The information in this report is considered accurate at the date of issue with regard to the current conditions of the site. The conclusions drawn in the report are based on interpolation between boreholes or test pits. Conditions can vary between test locations that cannot be explicitly defined or inferred by investigation.

Yours faithfully
RCA AUSTRALIA



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[4] Report titled *Determination of Maximum Predicted Groundwater Level and Maximum Extraction Level at Lot 218 and 220, Salt Ash,* prepared for Mackas Sand Pty Ltd by Umwelt Environmental Consultants November 2011.

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