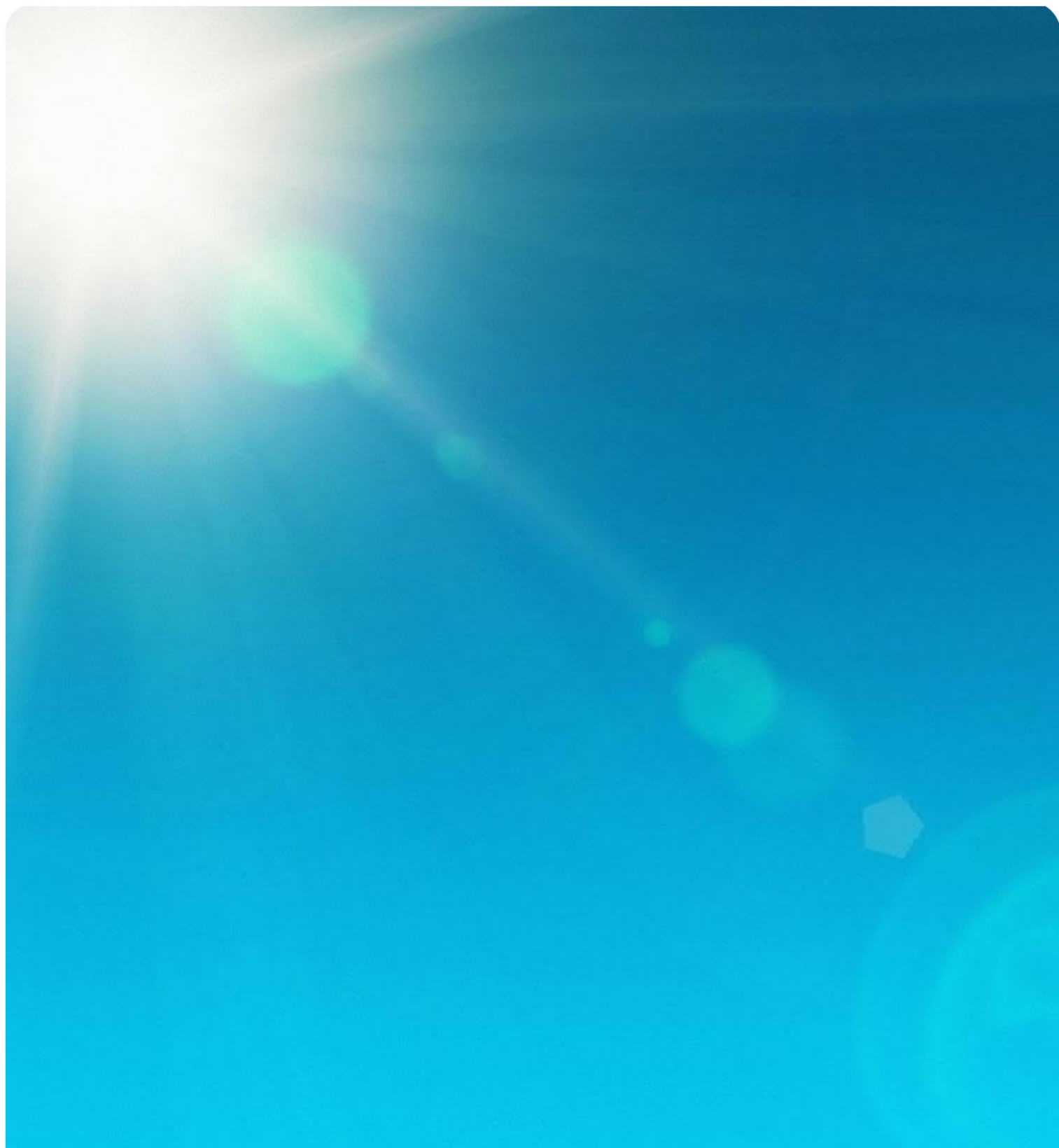


March 2022

Appendix L – Noise Technical Memo

Australia-Asia PowerLink Environmental Impact Statement



Project Memo

H366646

3/23/2022

Sun Cable
Australia-Asia PowerLink

Appendix L: Noise Screening-Level Technical Assessment

H366646-00000-247-030-0001, Rev. 0

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Appendix A AAPowerLink Estimated Fleet Productions Table

1. Noise

This technical appendix estimates noise emission sound levels associated with the construction and operation of the Australia-Asia Powerlink (AAPowerLink) project. Noise emissions from the project have the potential to impact amenity and human health environmental factors required to be assessed by the Northern Territory Environmental Protection Authority (NT EPA); comparison of noise emissions to wildlife or marine mammal behaviour noise exposure thresholds are not specifically considered here.

The objective for the community and economy environmental factor is to: *“Enhance communities and the economy for the welfare, amenity and benefit of current and future generations of Territorians”* and the objective for human health is to *“Protect the health of the Northern Territory population”*. Project activities causing noise and vibration and impacts of noise on amenity, fauna, and marine mammals are required to be assessed in the AAPowerLink Environmental Impact Statement (EIS) as stated in the Terms of Reference (TOR; 2021).

1.1 Information Sources

The key information source used to prepare this chapter is the AAPowerLink Estimated Fleet Productions Table (Appendix A). A screening level noise assessment was conducted to identify the potential construction and operational noise impact on noise sensitive receptors adjacent to AAPowerLink project sites. This assessment was based on noise produced by anticipated construction and operational equipment, including during commissioning.

A construction noise source inventory was prepared based on the construction layout and schedule developed by Sun Cable and as described in Chapter 2 Proposal Description. Sound power levels for individual construction equipment were estimated from data published in the *British Standards Code of Practice for Noise and Vibration for Construction and Open Sites* (BSI 2008). All pieces of equipment were conservatively assumed to be operating at 100% usage factors.

An operational noise source inventory was prepared based on the layout of operational equipment at the solar precinct, over-head transmission line (OHTL), Darwin converter site, and cable transition facilities, as described in Chapter 2 Proposal Description. Sound power levels were estimated based on a repository of sound powers from similar equipment and scaled accordingly to designed capacities (CIGRÉ 2002; Hatch 2016). All pieces of equipment at all locations were assumed to be operating continuously, which is a highly conservative assumption.

Noise screening distances were calculated using the Cadna/A software package utilizing the ISO 9613-2 algorithm for outdoor sound propagation (ISO 1996). Cadna/A is a well-established industry standard noise propagation modelling application that accounts for ground surface absorption, air absorption, terrain profiles, and structure obstructions.

1.2 Relevant policies and guidelines

1.2.1 Waste Management and Pollution Control Act 1998

This Act provides the main legal framework and basis for managing unacceptable, offensive noise in the NT. The Act contains obligations on all persons to prevent noise pollution and includes tools that may be used to promote compliance.

1.2.2 Northern Territory Noise Management Guideline

The approach herein follows the framework for assessing environmental noise impacts as set out in the NT EPA Noise Management Framework Guideline (2018). NT provides standards for assessing, managing, and regulating community noise issues with the resolution of complaints under the provisions of the *Waste Management and Pollution Control Act* (Northern Territory 2022).

This guideline also:

- Provides clarity for businesses and the communities on how noise is regulated in the Northern Territory (NT);
- Provides guidance on ways to minimise noise emissions, and provides advice on how NT noise regulatory requirements can be met;
- Encourages activities to be undertaken by setting benchmark noise levels;
- Establishes a clear and consistent framework for assessing environmental noise impacts;
- Provides information on regulatory responses consistent with the level of harm generated and;
- Provides guidance to NT regulatory agencies in addressing noise matters.

1.2.3 Approved Methods for the Modelling and Assessment for Construction and Operational Noise

The approved methods for modelling construction and operational noise as outlined in the NT Noise Management Guideline (NTEPA 2018) prescribes two levels of evaluation:

- Qualitative Noise Assessment
- Quantitative Noise Assessment

The AAPowerLink noise assessment was conducted as a quantitative noise assessment. Qualitative assessments are typically completed for short-term infrastructure maintenance works. A simplified quantitative assessment has been completed for this project based on availability of preliminary information and using conservative assumptions. Where the outcome suggests that noise levels are likely to exceed relevant noise thresholds, more detailed quantitative modeling may be necessary, supported by more detailed design and construction information to confirm and specify noise mitigation strategies. This quantitative noise assessment provides distance decay screening distances around construction and operational sites. Areas where sensitive receptors occur within the screening distance (i.e. elevated noise levels above threshold) may also require a more detailed re-assessment.

1.3 Noise Thresholds

1.3.1 Construction Noise Criteria

The noise management guideline (NTEPA 2018) sets out air-borne construction and noise criteria for sensitive land uses. For the construction phase, residential criteria are applied during anticipated hours of work. The majority of construction activity will be limited to the daytime standard hours listed in Table 1-1 and to the noise levels listed in Table 1-2.

The construction of the Solar Precinct, Darwin Converter Site and Cable Transition Facilities is anticipated to undertake 24-hour shifts at times and accordingly, more stringent noise criteria that encompasses nighttime limits has been applied. The recommended assigned construction noise levels for airborne noise at 'non-residential' sensitive land uses surrounding construction sites are listed in Table 1-3.

Table 1-1: Recommended Standard Hours of Work

Work Type	Recommended Standard Hours of Work	Notes
Normal Construction	Monday to Saturday 7am to 7pm and between 9am and 6pm Sundays or public holidays	Construction activities occurring before or after the recommended standard hours of work will incur a regulatory response in accordance with the NT Noise Management Framework Guideline

Table 1-2: Recommended assigned construction noise levels for airborne noise at residential sensitive land uses

Location	Hours of Work	Recommended assigned noise level at residences L_{Aeq} (15min)
Solar Precinct	24-hour	35 dBA ¹
Overhead Transmission Line	Standard Hours	45 dBA ²
Darwin Converter Site	24-hour	35 dBA ¹
Cable Transition Facilities	24-hour	35 dBA ¹

Table 1-3: Recommended assigned construction noise levels for airborne noise at non-residential land uses

Land Use	Recommended assigned noise level at sensitive land uses L_{Aeq} (15min)
Classrooms at schools and other educational institutions	45 dBA (internal)
Hospital Wards and operating theatres	45 dBA (internal)
Places of worship	45 dBA (internal)
Active Recreation Areas	65 dBA (external)
Passive Recreation Areas	60 dBA (external)
Industrial Premises	75 dBA (external)

¹ The recommended assigned noise level is taken as the Rating Background Level (RBL) + 5dB for activity occurring outside the standard hours of work. As the existing RBL is unknown, the minimum assumed nighttime RBL for rural areas of 30 dBA is used.

² The recommended assigned noise level is taken as the Rating Background Level (RBL) + 10dB for activity occurring within standard hours of work. As the existing RBL is unknown, the minimum assumed daytime RBL for a rural area of 35dB is used.

Land Use	Recommended assigned noise level at sensitive land uses L_{Aeq} (15min)
Offices, retail outlets	70 dBA (external)

1.3.2 Operational noise criteria

Criteria during operations is based on residential amenity limits listed in Table 1-4. Since the operations of all sites are considered continuous 24-hours, 7-days per week, the more stringent night level is considered. All other non-residential receptors are assessed against the project amenity noise limits summarized in Table 1-5.

Table 1-4: Recommended assigned operational noise levels for airborne noise at residential sensitive land uses

Receptor	Day (7 am to 6 pm)	Evening (6 pm to 10 pm)	Night (10 pm to 7 am)
Residential Amenity, L_{eq}	50 dBA	45 dBA	40 dBA

Table 1-5: Recommended assigned operational noise levels for airborne noise for all sensitive land uses

Receptor	Noise Amenity Area	Time of Day	L_{Aeq} dBA
Classrooms at schools and other educational institutions	All	Noisiest 1-hour when in use	35 dBA (internal)
Hospital Wards and operating theatres	All	Noisiest 1 hour	35 dBA (internal)
Places of worship	All	When in use	40 dBA (internal)
Active Recreation Areas	All	When in Use	55 dBA (external)
Passive Recreation Areas	All	When in Use	50 dBA (external)
Industrial Premises	All	When in Use	70 dBA (external)
Commercial Premises	All	When in Use	65 dBA (external)

1.4 Screening methodology

The noise associated with construction and operational activities and their zone of influence were assessed using a screening approach. The method of assessment was based on the following:

1.4.1 Construction Noise

All construction phases across the entire footprint were identified. These phases include the following:

- Site ground preparation, site formation, bulk earthworks, pole installations, road sealing, unsealed road works, landscaping, bituminous sprayed hardstand works, concrete structure, ballast works, station building, trenching, cable installation and backfilling.

Development of noise source inventory of all construction equipment required for each phase of construction.

- A cumulative sound power level for each construction phase was calculated. The construction phase for each site with the highest sound power was used to develop the screening distance for the site.
- The following construction zone sizes were evaluated:
 - ◆ 500 m by 500 m Solar Precinct construction activity zone
 - ◆ 100 m by 100 m OHTL construction activity zone as workfronts advance
 - ◆ 55 ha Darwin Converter Site activity area encompasses the entire converter site)
 - ◆ 100 m by 100 m area Cable Transition Facilities' construction activity zone

The sound emissions for each site were modelled using Cadna/A as a cumulative equipment area noise source 2 m relative to the ground. A ground absorption of 1 for porous soil was used as the surrounding area is not developed and to account for not including elevation contours. Screening distances were then calculated at a noise sensitive receptor height of 1.5 m for the daytime and 4.5 m for the night-time scenario. The screening distance is the distance from the construction site where the noise limits summarized in Section 1.3.1 are met.

1.4.2 **Operational Noise**

All operational sources of noise for the project footprint were identified. The sources include the following:

- Solar Precinct Operational Noise
 - ◆ Inverter noise, assumed 2 m relative to the ground
 - ◆ Substation DC Hall, assumed 2 m relative to the ground
 - ◆ Substation Converter Hall, assumed 2 m relative to the ground
 - ◆ Substation Transformers with Cooling, assumed 2 m relative to the ground
 - ◆ Substation Valve Cooling, assumed 2 m relative to ground
- Overhead Transmission Line Operational Noise, assumed 55 m relative to the ground
- Darwin Converter Site Operational Noise
 - ◆ DC Hall, assumed 2 m relative to the ground
 - ◆ Converter Hall, assumed 2 m relative to the ground
 - ◆ Transformers with Cooling, assumed 2 m relative to the ground
 - ◆ Valve Cooling, assumed 2 m relative to ground

The sound power for each operational noise source was developed. Sound power spectra for the Solar Precinct and Darwin Converter Site were predicted based on the overall sound power of typical pieces of equipment (CIGRÉ 2002). Sound Power for the OHTL was predicted based on an empirical method of audible noise for DC transmission lines (CIGRÉ 2009) which was used for a similar HVDC transmission line project in Chile (Engie 2021). The sound emissions for each site were modelled using Cadna/A as area and point noise sources for the Solar Precinct and Darwin converter sites. The OHTL was modelled as a line noise source.

The operational noise screening distances were calculated using the more stringent night-time height of 4.5 m due to the 24-hour operation of all sites. A ground absorption of 1 for porous soil was used as the surrounding area is not developed and to account for not including elevation contours. The operational screening distance is the distance from each site and transmission line corridor where the noise limits summarized in Section 1.3.2 are met.

1.4.3 Sensitive Receptors

Much of the AAPowerLink project is located in remote areas with little to no noise sensitive land use within 1km of the project. Where noise sensitive land use is near to the project, the majority of this land consists of residential noise sensitive receptors. Receptors are shown in the zone of influence figures below in Section 1.4.

1.4.3.1 Solar Precinct

The nearest sensitive noise receptor to the Solar Precinct is the Jangirulu Family Outstation, 17 km to the north-east, which is occasionally used for hunting purposes and is not a permanent residence.

1.4.3.2 Overhead Transmission Line

OHTL runs adjacent and through several populated centers, including Katherine, Pine Creek, Adelaide River and outskirts of Darwin. Section 1.4 identifies locations along the OHTL corridor where construction and operational activities will result in increased noise levels. Three key sections of the OHTL may require deviation from the railway easement to address constraints at Katherine, Pine Creek and Adelaide River. (Chapter 2 Proposal Description). Residential areas will be avoided by these deviations.

1.4.3.3 Darwin Converter Site and Cable Transition Facilities

The nearest noise sensitive receptor to the Darwin Converter Site and Cable Transition Facilities at Murrumujuk is the Tree Point Aboriginal Community located 6 km away. Gunn Point Beach, a recreational land use is located adjacent to the converter site and a future aquaculture project is also being planned directly adjacent the west boundary. Locations that could experience the effects of construction and operational noise are further detailed in Section 1.5.

1.5 Screening Model Results

1.5.1 Construction Noise

1.5.1.1 Solar Precinct Construction Noise

At the solar precinct, the following construction activity areas will result in noise:

- Main Road construction
- Secondary Road construction
- Intermodal facility construction
- Railway construction
- Solar array construction

The bulk earthworks of the above listed activities is expected to produce the highest noise during the construction of the Solar Precinct. Table 1-6 lists the cumulative sound power spectrum of the bulk earthworks construction phase. Table 1-7 presents the calculated screening distance from the Solar Precinct construction site along with the nearest sensitive land uses. Daytime and nighttime screening distances are calculated however, the more stringent nighttime screening distance applies for work occurring outside the standard hours of construction operation. Figure 1-1 and Figure 1-2 illustrates the screening distance surrounding the Solar Precinct in the daytime and nighttime, which identifies that no noise sensitive receptors are within this screening distance.

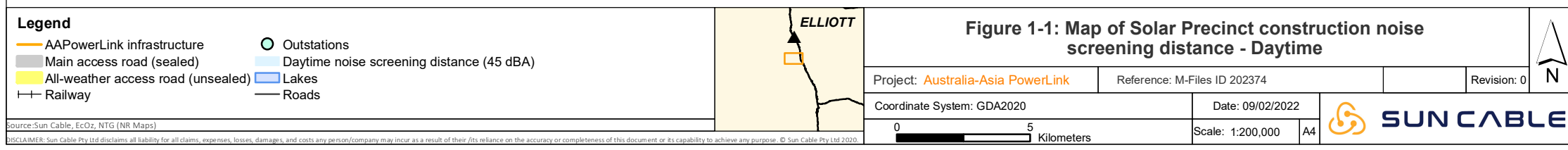
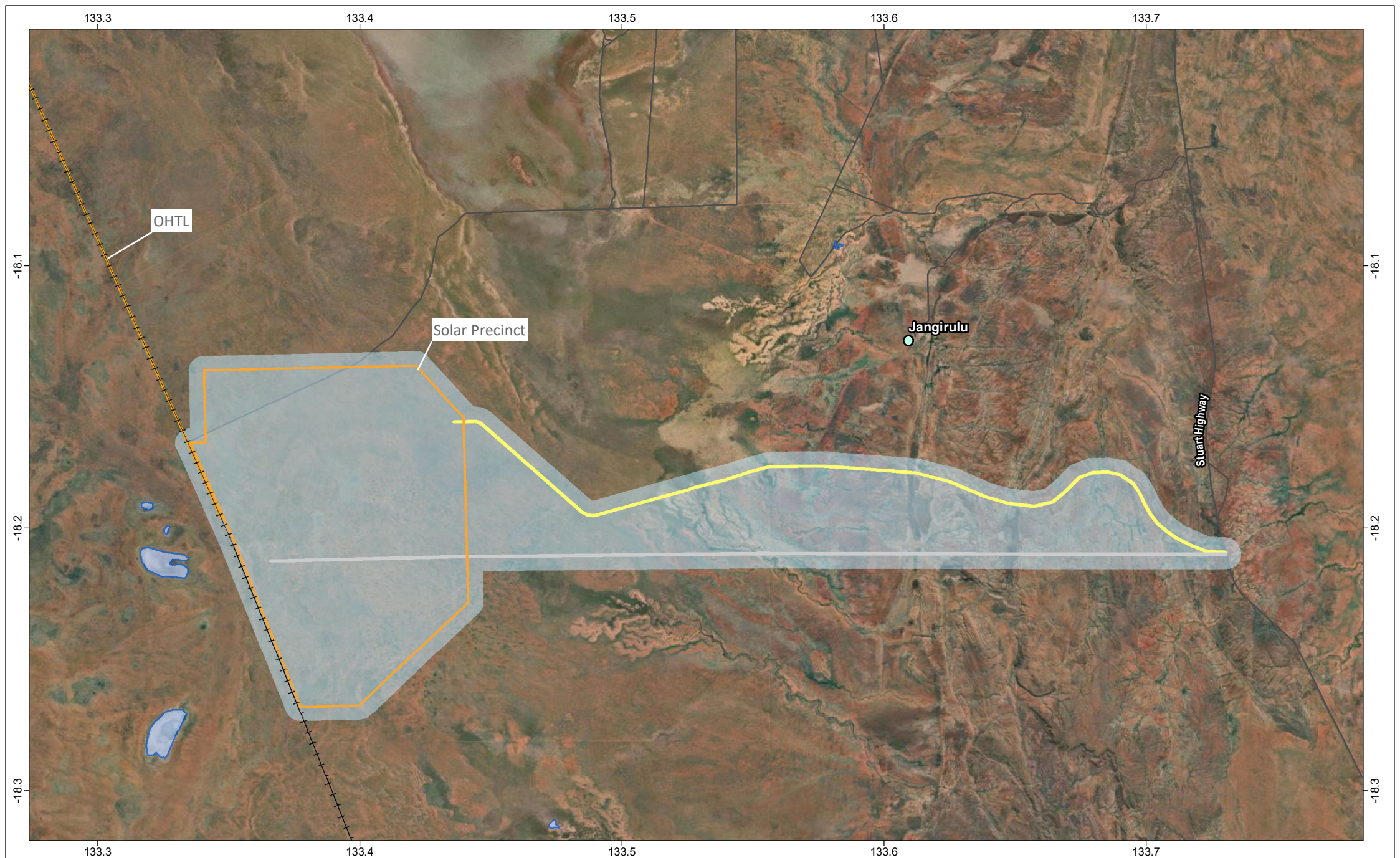
Table 1-6: Estimated Worst-case Sound Power Spectra for Construction Activities at the Solar Precinct

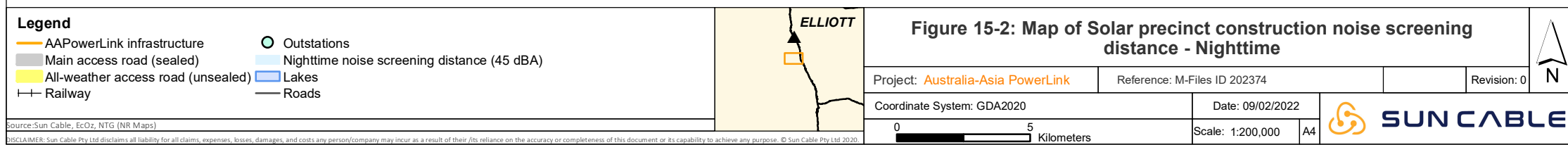
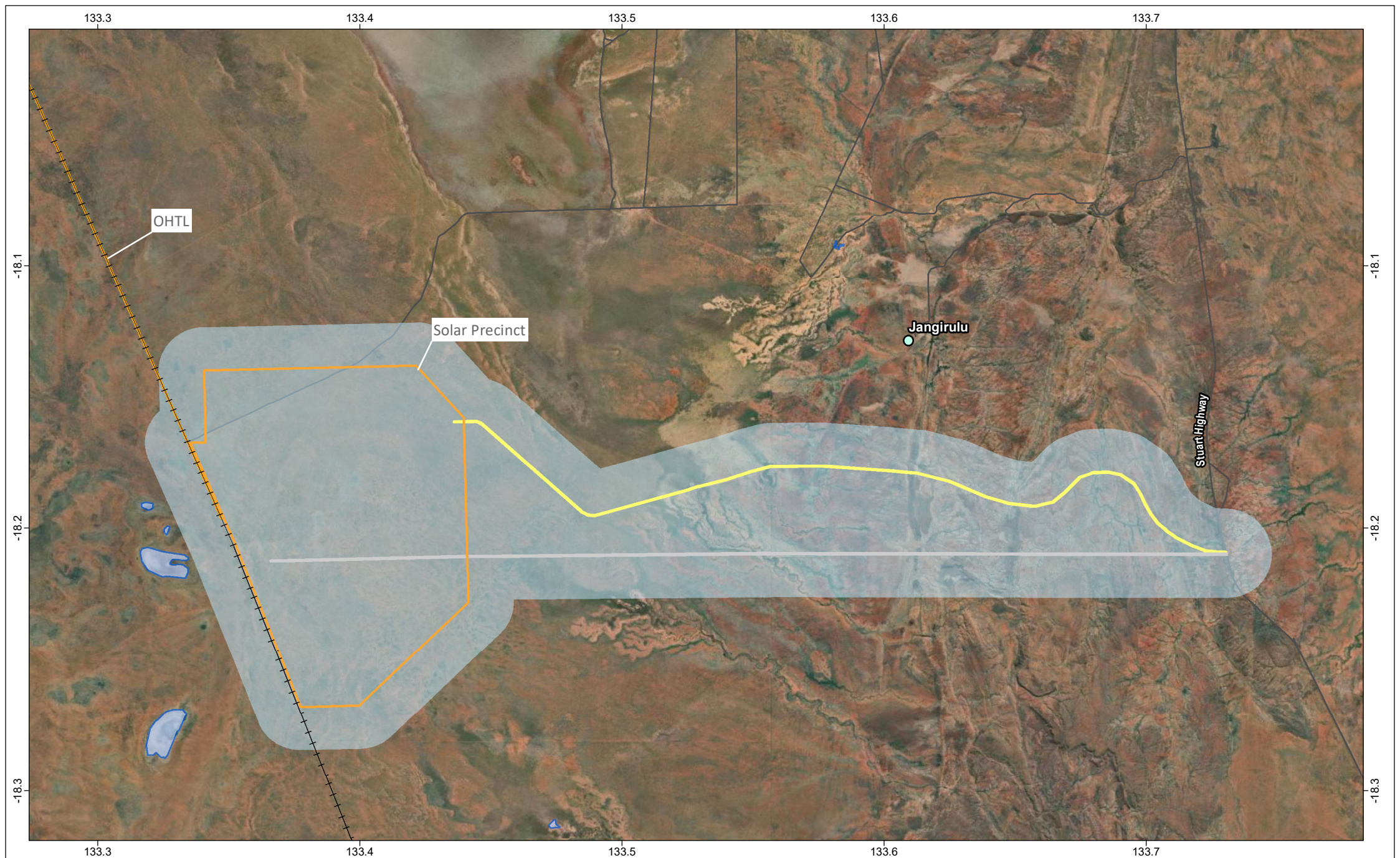
Construction Activity	Sound Power per Octave dB, Linear								
	63 Hz	125 Hz	250 Hz	500 Hz	1k Hz	2k Hz	4k Hz	8k Hz	Overall dBA
Bulk Earthworks	151	139	126	120	116	111	106	103	128

Table 1-7: Predicted Screening Distance from Construction Activity at the Solar Precinct to meet relevant Noise Criteria

Component Location	Receptor	Land Use	Criteria Day/Night (dBA)	Distance from Project Footprint (m)	Screening Distance Day/Night (m)	Predicted Impact (Yes/No)
Solar Precinct	Renner Springs Roadhouse	R	45/35	36,000	600/1,815	No
Solar Precinct	Powell Creek outstation	R	45/35	25,000	600/1,815	No
Solar Precinct	Jangirulu Family Outstation	R	45/35	17,000	600/1,815	No
Solar Precinct	Lake Woods Site of Conservation Significance	PREC	60	10,000	35/48	No

R-Residential, IND-Industrial, INST-Institutional, AREC-Active Recreational, PREC-Passive Recreational





1.5.1.2 Overhead Transmission Line Construction Noise

Site preparation and installation of transmission poles is anticipated to be the loudest construction activity of the OHTL. Table 1-8 lists the cumulative sound power spectrum of the transmission pole installation phase. Table 1-9 presents the noise screening distance from the OHTL construction. Noise controls shall be introduced to construction sites as required to ensure the construction noise screening distance does not encompass any surrounding noise sensitive receptors. Figure 1-3 and Figure 1-4 illustrate the screening distances surrounding the OHTL and identify noise sensitive receptors that are within this screening distance.

Table 1-8: Estimated Worst-case Sound Power Spectra for OHTL Construction Activity

Construction Activity	Sound Power per Octave dB, Linear								
	63 Hz	125 Hz	250 Hz	500 Hz	1k Hz	2k Hz	4k Hz	8k Hz	Overall dBA
Pole Installations	145	137	122	121	113	109	104	101	125

Table 1-9: Calculated Noise Screening Distance from OHTL Construction Activity

Component Location	Receptor	Land Use	Criteria (dBA)	Distance from Project Footprint (m)	Screening Distance (m)	Predicted Impact (Yes/No)
KP153	Murranji Family Outstation	R	45	3,500	620	No
KP265	Farmhouse	R	45	1,600	620	No
KP358	Farmhouse	R	45	1,500	620	No
KP465	Industrial buildings	IND	75	1000	5	No
KP466	Rural housing (multiple buildings)	R	45	600	620	Yes
KP467	Rural housing (multiple buildings)	R	45	1000	620	No
KP473	Rural housing (multiple buildings)	R	45	600	620	Yes
KP474	Rural housing (multiple buildings)	R	45	400	620	Yes
KP550	Bonrook homestead	R	45	2,600	620	No
KP552	Kybrook Farm Aboriginal Community	R	45	3,400	620	No
KP554	Farmhouse	R	45	400	620	Yes
KP556	Pine Creek Aboriginal Community	R	45	600	620	Yes
KP557	Pine Creek golf course and track	AREC	65	200	55	No
KP557	House	R	45	800	620	No
KP596	The Banyans homestead	R	45	1,300	620	No
KP608.5	House	R	45	100	620	Yes
KP665	House	R	45	1,200	620	No
KP666	Burnside Farm homestead	R	45	2,600	620	No

Component Location	Receptor	Land Use	Criteria (dBA)	Distance from Project Footprint (m)	Screening Distance (m)	Predicted Impact (Yes/No)
KP667	Racecourse - Adelaide River	AREC	65	200	55	No
KP667	Amangal Indigenous Village	R	45	800	620	No
KP667	Adelaide River township	R	45	110	620	Yes
KP671.5	House	R	45	600	620	Yes
KP672	Litchfield National Park boundary	PREC	60	400	116	No
KP673	House	R	45	450	620	Yes
KP675	House	R	45	200	620	Yes
KP679	Small rural blocks	R	45	100	620	Yes
KP680	Gulngarring Family Outstation	R	45	2,450	620	No
KP680	Small rural blocks	R	45	100	620	Yes
KP681	Small rural blocks	R	45	100	620	Yes
KP690	Albany Park	PREC	60	1,210	116	No
KP691	Small rural blocks	R	45	1,100	620	No
KP692	Small rural blocks	R	45	1,100	620	No
KP715	Acacia Larrakia family Outstation	R	45	4,500	620	No
KP723 to KP788	Darwin rural areas; Noonamah, Wak Wak, Lambells Lagoon, Herbert and Koolpinyah	R	45	200-300	620	Yes

R-Residential, IND-Industrial, INST-Institutional, AREC-Active Recreational, PREC-Passive Recreational

 Anticipated noise impact



- Legend**
- AAPowerLink infrastructure
 - ++ Railway
 - Roads
 - ▲ OHTL Kilometre Points
 - Daytime noise screening distance (45 dBA)
 - Potential receptors within the noise zone of impact

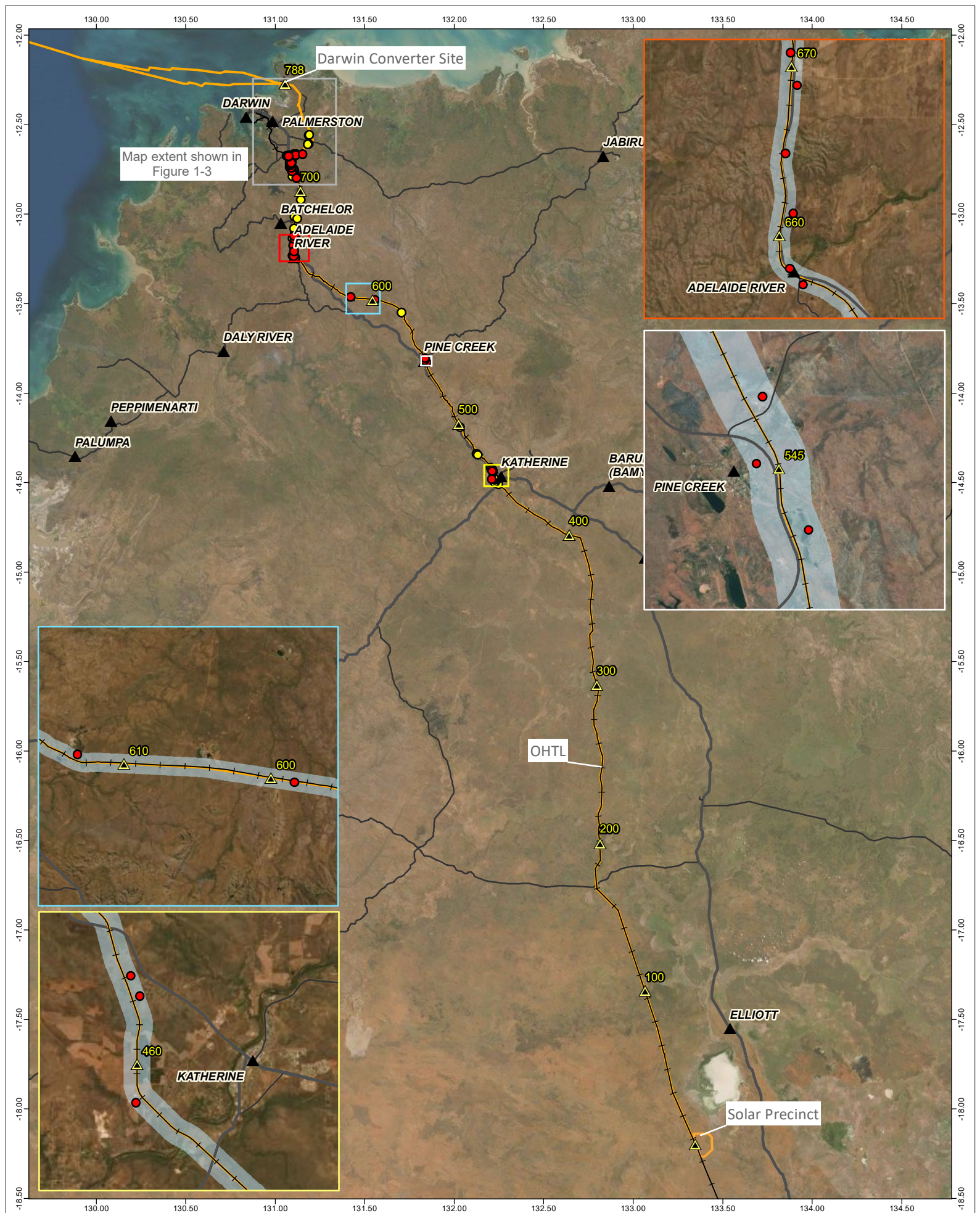


Figure 1-3: Map of zone of influence from construction noise along northern section of OHTL and NTG Utilities Corridor - Daytime

Project: Australia-Asia PowerLink		
0 5 Kilometers		
Scale: 1:250,000		Reference: M-Files ID 202374
Coordinate System: GDA2020		Date: 09/03/2022 Revision: 0
A4		SUN CABLE

source: Sun Cable, Eco2, NTG (NR Maps)

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- Legend**
- AAPowerLink infrastructure
 - Railway
 - Principal road
 - Secondary road
 - ▲ OHTL Kilometre Points
 - Daytime noise screening distance (45 dBA)
 - Potential receptors within the noise zone of impact

Source: Sun Cable, EcOz, NTG (NR Maps)



Figure 1-4: Map of zone of influence from construction noise along the OHTL Southern section - Daytime

Project: Australia-Asia PowerLink		Reference: M-Files ID 202374	
Scale: 1:2,900,000		Date: 08/03/2022	Revision: 0
Coordinate System: GDA2020		A4	
		SUN CABLE	

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1.5.1.3 Darwin Converter Site Construction Noise

Site preparation, formation, and landscaping are anticipated to be the loudest construction phase of the Darwin Converter site. Table 1-10 lists the cumulative sound power spectrum of site preparation, formation, and landscaping phase. Table 1-11 presents converter site noise screening distance and noise sensitive receptors nearest to converter site construction. Daytime and nighttime screening distances are calculated; however, the more stringent nighttime screening distance applies for work occurring outside the standard hours of construction operation. Figure 1-5 and Figure 1-6 illustrate the screening distances surrounding the Darwin Converter Site during the day and nighttime.

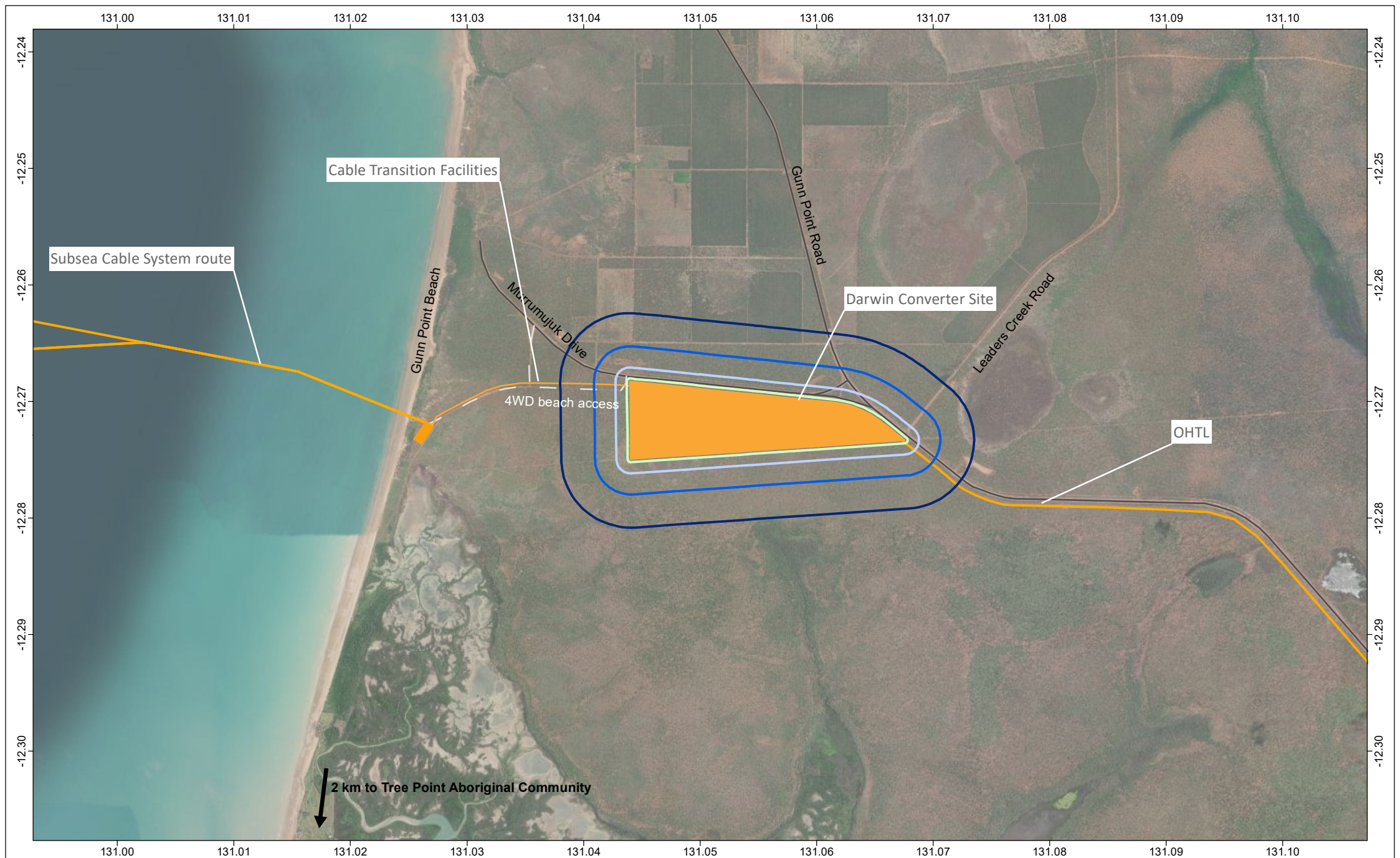
Table 1-10: Estimated Worst-case Sound Power Spectra for Darwin Converter Site Construction Activity

Construction Activity	Sound Power per Octave dB, Linear								
	63 Hz	125 Hz	250 Hz	500 Hz	1k Hz	2k Hz	4k Hz	8k Hz	Overall dBA
Site Preparation, Site formation, Landscaping	152	140	128	120	119	113	109	105	129

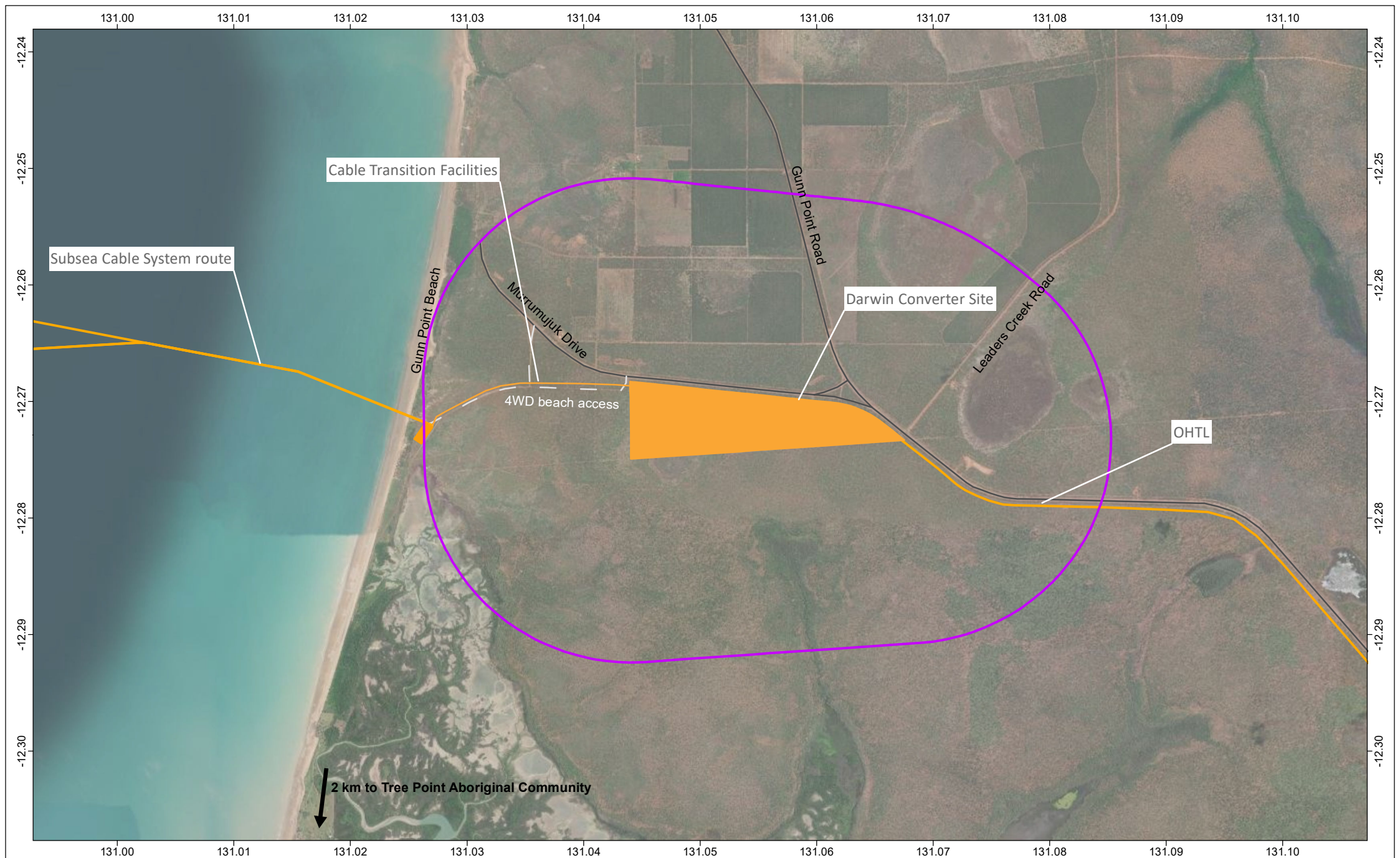
Table 1-11: Predicted Screening Distance from Construction Activity at the Darwin Converter Site to meet relevant Noise Criteria

Component Location	Receptor	Land Use	Criteria Day/Night (dBA)	Distance from Project Footprint (m)	Screening Distance (m)	Predicted Impact (Yes/No)
Darwin Converter Site	Tree Point Aboriginal Community	R	45/35	5,000	650/1,930	No
Darwin Converter Site	Sea Dragon aquaculture facility (proposed)	IND	75	Adjoins West of Site	0	No

R-Residential, IND-Industrial, INST-Institutional, AREC-Active Recreational, PREC-Passive Recreational



Legend AAPowerLink infrastructure 4WD beach access Road		Daytime noise screening distances 45 dBA 50 dBA 55 dBA 60 dBA			Figure 1-5: Map of zone of influence from construction noise at Darwin Converter Site - Daytime				
Project: Australia-Asia PowerLink		Reference: M-Files ID 202374			Revision: 0				
Coordinate System: GDA2020		Date: 08/03/2022			Scale: 1:45,000				
Source: Sun Cable, EcOz, NTG (NR Maps), Air Environment 2021 DISCLAIMER: Sun Cable Pty Ltd disclaims all liability for all claims, expenses, losses, damages, and costs any person/company may incur as a result of their /its reliance on the accuracy or completeness of this document or its capability to achieve any purpose. © Sun Cable Pty Ltd 2020.									



Legend

- AAPowerLink infrastructure
- 4WD beach access
- Road
- Nighttime noise screening distance (35 dBA)



Figure 1-6: Map of zone of influence from construction noise at Darwin Converter Site - Nighttime

Project: Australia-Asia PowerLink		Reference: M-Files ID 202374		Revision: 0
Coordinate System: GDA2020		Date: 21/03/2022		SUN CABLE
		Scale: 1:45,000 A4		

Source: Sun Cable, EcOz, NTG (NR Maps), Air Environment 2021
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1.5.1.4 Cable Transition Facilities Construction Noise

Cable installation and backfilling is anticipated to produce the greatest noise at the Cable Transition Facilities site. Table 1-12 lists the cumulative sound power spectrum of the cable installation and backfilling phase. Table 1-13 presents the sensitive receptors nearest to the Cable Transition Facility construction areas and the required screening distance. Gunn Point Beach access and recreational area in the vicinity to the north of the site will be affected by construction noise during standard and non-standard operating hours as illustrated in Figure 1-7 and Figure 1-8.

Table 1-12: Estimated Worst-case Sound Power Spectra for Cable Transition Facilities Construction Activity

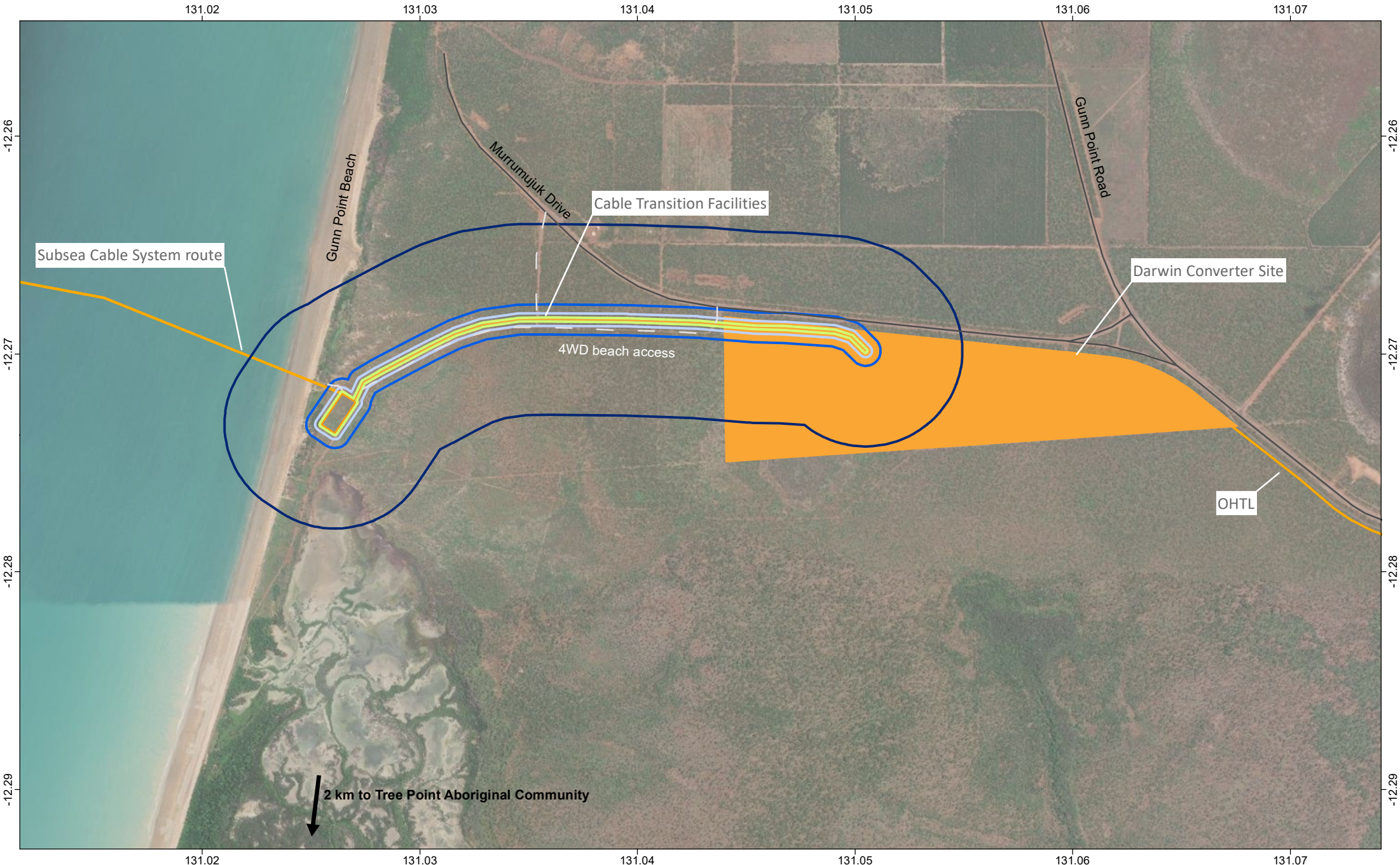
Construction Activity	Sound Power per Octave dB, Linear								
	63 Hz	125 Hz	250 Hz	500 Hz	1k Hz	2k Hz	4k Hz	8k Hz	Overall dBA
Cable Installation and Backfilling	149	135	122	117	110	106	100	95	125

Table 1-13: Predicted Screening Distance from Construction Activity at the Cable Transition Facilities Site to meet relevant Noise Criteria

Component Location	Receptor	Land Use	Criteria Day/Night (dBA)	Distance from Project Footprint (m)	Screening Distance Day/Night (m)	Predicted Impact (Yes/No)
Cable Transition Facilities	Gunn Point Beach access and recreational Area	PREC	60	Adjacent North of Site	76/92	Yes

R-Residential, IND-Industrial, INST-Institutional, AREC-Active Recreational, PREC-Passive Recreational

 Anticipated noise impact will occur



Legend

AAPowerLink infrastructure

4WD beach access

Road

Daytime noise screening distances

45 dBA

60 dBA

65 dBA

70 dBA

Source: Sun Cable, EcOz, NTG (NR Maps), Air Environment 2021

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Figure 1-7: Zone of influence from daytime construction noise at Cable Transition Facilities

Project: **Australia-Asia PowerLink**

Reference: M-Files ID 202374

Revision: 0

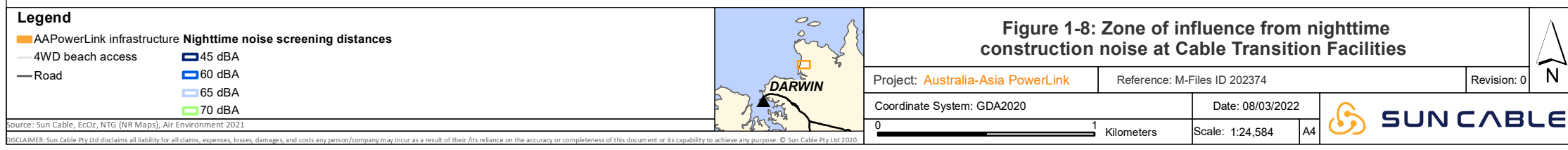
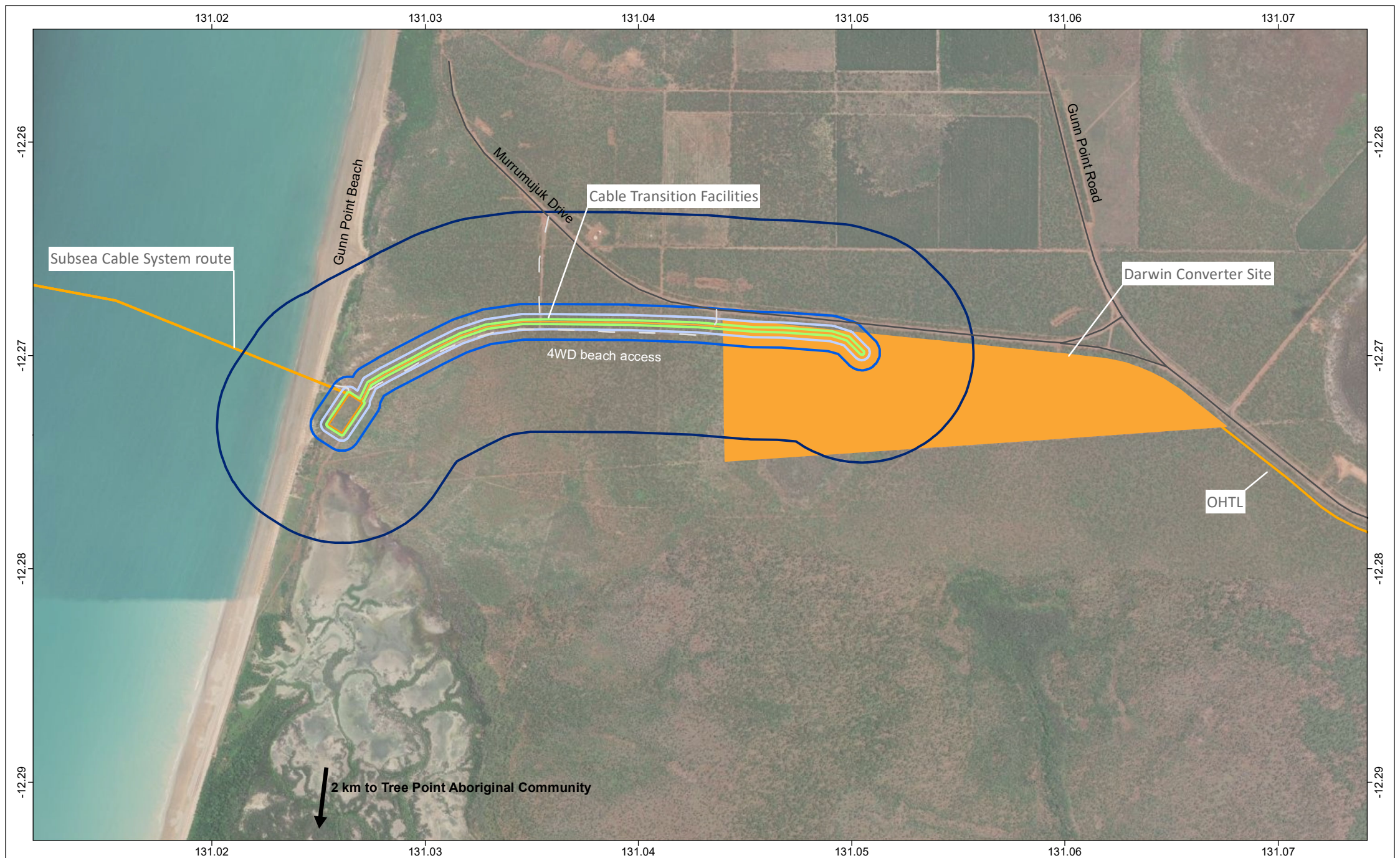
Coordinate System: GDA2020

Date: 08/03/2022

0 1 Kilometers

Scale: 1:24,584

A4



1.5.2 Operational Noise

1.5.2.1 Solar Precinct Operational Noise

Inverters, transformers, converter hall, DC hall and valve coolers are anticipated to be the major operational noise sources at the solar precinct. The sound power spectrums for majority of these sources were estimated based on typical sound power levels (CIGRÉ 2002). Inverter noise was estimated based on measurements taken at a 100MW solar facility (Hatch 2016). The sound power of approximately 12,500 1.6 MW inverters was evenly spread across the site to make up the 20 GW power rating of the site. The sound power of the substation transformers, converters, reactors and coolers were modelled as a point source positioned conservatively at the edge of the site nearest to connection with the OHTL. Sound power levels were scaled up to represent the noise of a 20 GW solar facility. The sound power spectra for the equipment are listed in Table 1-14. Table 1-15 presents the screening distance and nearest sensitive land uses to the Solar precinct. The screening distance is dominated by noise from the Solar Precinct substation (not the solar cell operation) and the screening distance shall be taken from the substation. All sensitive receptors in the vicinity of the Solar Precinct will not be affected by operational noise.

Table 1-14: Calculated Sound Power Spectra for Solar Precinct Operational Activity

Operational Activity	Sound Power per Octave dB, Linear								
	63 Hz	125 Hz	250 Hz	500 Hz	1k Hz	2k Hz	4k Hz	8k Hz	Overall dBA
Inverters (20 GW)	133	131	132	132	127	130	139	128	141
Transformer (20 GW)	119	121	116	116	110	105	100	93	124
DC Hall (20 GW)	98	100	95	95	89	84	79	72	104
Converter Hall (20 GW)	104	108	102	100	89	86	79	70	111
Valve Cooling (20 GW)	117	112	109	109	105	102	93	83	119

Table 1-15: Calculated Screening Distance from Operational Activity at the Solar Precinct to meet the relevant Noise Criteria

Component Location	Receptor	Land Use	Criteria* (dBA)	Distance from Project Footprint (m)	Screening Distance (m)	Predicted Impact (Yes/No)
Solar Precinct	Renner Springs Roadhouse	R	40	36,000	3,390	No
Solar Precinct	Powell Creek outstation	R	40	25,000	3,390	No
Solar Precinct	Jangirulu Family Outstation	R	40	17,000	3,390	No
Solar Precinct	Lake Woods Site of Conservation Significance	PREC	50	10,000	1,583	No

*The nighttime criteria for residential land uses is used as it provides a more stringent screening distance

1.5.2.2 Overhead Transmission Line Operational Noise

The OHTL will have operating voltages between 525 kV to 600 kV. The noise for transmission lines was estimated based on calculations conducted for a similar HVDC line in Chile (Engie 2021). Calculations used the Chartier method produced by CIGRÉ, which is an empirical method that provides the average level of audible noise for DC transmission lines (CIGRÉ 2009). The calculated sound pressure levels were back calculated to achieve a sound power. The calculated sound pressure was 49 dBA directly under the transmission line at approximately 55 m (Engie 2021). The calculated sound power was adjusted per 100 m of transmission line and modelled as a line source considering the post spacing of 23 m within this 100 m length (approximately 4 poles). The sound power was modelled as a single band at 125 Hz at an elevation of 55 m. The sound power used for the OHTL is listed in Table 1-16. Table 1-17 presents the screening distance and nearest sensitive land uses to the OHTL. Four sensitive receptors in the vicinity of the OHTL have the potential to be affected by operational noise.

Table 1-16: Estimated Sound Power for OHTL Operational Activity

Operational Activity	Sound Power, dBA Single band, 125 Hz
OHTL	75

Table 1-17: Predicted Screening Distance from Operational Activity at the OHTL to meet relevant Noise Criteria

Component Location	Receptor	Land Use	Criteria (dBA)*	Distance from Project Footprint (m)	Screening Distance (m)	Predicted Impact (Yes/No)
KP153	Murranji Family Outstation	R	40	3,500	101	No
KP265	Farmhouse	R	40	1,600	101	No
KP358	Farmhouse	R	40	1,500	101	No
KP465	Industrial buildings	IND	70	1000	0	No
KP466	Rural housing (multiple buildings)	R	40	600	101	No
KP467	Rural housing (multiple buildings)	R	40	1000	101	No
KP473	Rural housing (multiple buildings)	R	40	600	101	No
KP474	Rural housing (multiple buildings)	R	40	400	101	No
KP550	Bonrook homestead	R	40	2,600	101	No
KP552	Kybrook Farm Aboriginal Community	R	40	3,400	101	No
KP554	Farmhouse	R	40	400	101	No
KP556	Pine Creek Aboriginal Community	R	40	600	101	No

Component Location	Receptor	Land Use	Criteria (dBA)*	Distance from Project Footprint (m)	Screening Distance (m)	Predicted Impact (Yes/No)
KP557	Pine Creek golf course and track	AREC	55	200	0	No
KP557	House	R	40	800	101	No
KP596	The Banyans homestead	R	40	1,300	101	No
KP608.5	House	R	40	100	101	Yes
KP665	House	R	40	1,200	101	No
KP666	Burnside Farm homestead	R	40	2,600	101	No
KP667	Racecourse - Adelaide River	AREC	55	200	0	No
KP667	Amangal Indigenous Village	R	40	800	101	No
KP667	Adelaide River township	R	40	110	101	No
KP671.5	House	R	40	600	101	No
KP672	Litchfield National Park boundary	PREC	50	400	0	No
KP673	House	R	40	450	101	No
KP675	House	R	40	200	101	No
KP679	Small rural blocks	R	40	100	101	Yes
KP680	Gulngarring Family Outstation	R	40	2,450	101	No
KP680	Small rural blocks	R	40	100	101	Yes
KP681	Small rural blocks	R	40	100	101	Yes
KP690	Albany Park	PREC	50	1,210	0	No
KP691	Small rural blocks	R	40	1,100	101	No
KP692	Small rural blocks	R	40	1,100	101	No
KP715	Acacia Larrakia family Outstation	R	40	4,500	101	No
KP723 to KP788	Darwin rural areas; Noonamah, Wak Wak, Lambells Lagoon, Herbert and Koolpinyah	R	40	200-300	101	No

*The nighttime criteria for residential land uses are used as it provides a more stringent screening distance

 Anticipated noise impact

1.5.2.3 Darwin Converter Site Operational Noise

The Darwin Converter Site operation is a 2 GW facility and noise sources consist of transformers, DC Hall, Converter Hall and Valve Cooling. The noise spectra are listed in Table 1-18. The Darwin Converter Site was modelled as an area source spanning the entire site. Table 1-19 presents the calculated screening distance from the Darwin Converter site along with the nearest sensitive land uses. All sensitive receptors in the vicinity of the Darwin Converter Site will not be affected by operational noise.

Table 1-18: Estimated Sound Power for Darwin Converter Site Operational Activity

Operational Activity	Sound Power per Octave dB, Linear								
	63 Hz	125 Hz	250 Hz	500 Hz	1k Hz	2k Hz	4k Hz	8k Hz	Overall dBA
Transformer (2 GW)	109	111	106	106	100	95	90	83	114
DC Hall (2 GW)	88	90	85	85	79	74	69	62	94
Converter Hall (2 GW)	94	98	92	90	79	76	69	60	101
Valve Cooling (2 GW)	107	102	99	99	95	92	83	73	109

Table 1-19: Predicted Screening Distance from Operational Activity at the Darwin Converter Site to meet relevant Noise Criteria

Component Location	Receptor	Land Use	Criteria* (dBA)	Distance from Project Footprint (m)	Screening Distance (m)	Predicted Impact (Yes/No)
Darwin Converter Site	Tree Point Aboriginal Community	R	40	5,000	350	No
Darwin Converter Site	Sea Dragon aquaculture facility (proposed)	IND	70	Adjoins West of Site	0	No

*The nighttime criteria for residential land uses is used as it provides a more stringent screening distance

 Anticipated noise impact will occur

1.5.2.4 Cable Transition Facilities Operational Noise

No operational noise is anticipated for the Cable Transition Facilities as the cabling will be buried underground.

1.6 Avoidance, Mitigation, and Monitoring

It is recommended to follow general construction best practices to minimize increased sound level including:

- Whenever possible, schedule work that creates the most noise during the NT EPA prescribed acceptable construction times of Monday to Saturday 7am to 7pm, and between 9am and 6pm Sundays or public holidays (NTEPA 2018). Justification to work outside the NT EPA construction will be required such as during construction of the Cable Transition Facility, Darwin Converter Site and Solar Precinct.
- Locate site access roads, laydown areas and stationary equipment (e.g., generators) as far away as possible from sensitive receptors;
- Whenever possible, plan haul routes to avoid residential areas;
- Maintain access routes to avoid the formation of potholes. Design access roads and laydown areas to minimize reversing of trucks/equipment;
- Use broadband back-up alarms to extent possible;
- Do not use engine brakes unless necessary;
- Maintain equipment as per manufacturer's instructions;
- Keep engines covers closed;
- Where practical, machines shall be operated at low speeds and power and turned off instead of left idling for prolonged periods when not in use;
- Dampen tailgates to avoid banging;
- Avoid dropping loads into dump trucks from heights;
- Limit the use of diesel generators by drawing power from other sources.
- Install temporary noise enclosures in areas of prolonged high noise activities (more details below regarding temporary noise barriers). This could be achieved with the "Echo Barrier" or equivalent, shown in Figure 1-9; and
- Notify the local community within the project area of the construction activities, especially if overnight construction is required. Notifications should include the location, extent, and duration of construction activities.



Figure 1-9: Temporary Noise Enclosure Example

To further reduce the risk of increased sound levels, the NT EPA recommends developing a noise management plan (NMP). Where an activity that will generate noise has the potential not to comply with the WMPC or recommended noise levels, a Noise Management Plan should be submitted to the NT EPA which is to include:

- For work that is likely to occur outside the acceptable construction times (Monday to Saturday 7am to 7pm and between 9am and 6pm Sundays or public holidays), justification for work on the development site shall be given;
- Details of the activities and their duration on the development site likely to cause noise that exceeds the construction noise level limits defined in the NT noise guidelines for development sites (NT EPA);
- Details demonstrating how noise emissions will be managed to minimize impacts on noise sensitive receptors and comply with 'AS 2436 Guide to Noise and Vibration Control on Construction, Maintenance and Demolition Sites'.
- Documentation of the consultation and feedback program with all affected, or potentially affected noise sensitive receptors. This program shall demonstrate that all occupants were provided with prior notice on dates, times and expected noise emissions for a potentially noisy and disruptive activity.
- A noise monitoring program that details monitoring frequency, monitoring locations, actions that will be undertaken should monitored emission levels exceed anticipated noise levels;

- A documented complaint response process which will record contact details of all complaints, the time and date of all received complaints, the description of the complaint and the activities occurring which led to the complaint; and
- The name of the person that will be responsible for implementing noise management measures and plan if developed, and the name and phone number of the person to whom a complaint may be made about noise emissions associated with NMP.

1.7 Summary

The AAPowerLink is predicted to result in minor increased noise levels for receptors outside of the screening distance, and moderately increased levels for sensitive receptors identified within the screening distances listed in Table 1-20. Noise levels can be further mitigated by implementing adequate noise controls on key construction or operational noise sources, such that the screening distance is sufficiently reduced to no longer encompass noise sensitive receptors.

Table 1-20: Construction and operational screening distances

Location	Land Use	Construction Screening Distance ³ (m)	Operational Screening Distance (m)
Solar Precinct	R	1,815	3,390
	PREC	48	1,583
OHTL	R	620	101
	IND	5	0
	PREC	116	0
	AREC	55	0
Darwin Converter Site	R	1,930	350
	IND	0	0
Cable Transition Facilities	PREC	92	-

R-Residential, IND-Industrial, INST-Institutional, AREC-Active Recreational, PREC-Passive Recreational

³ Summarized construction screening distances are for the more stringent nighttime construction works occurring outside standard hours.

1.8 References

Bolt, Beranek, & Newman, Inc. (1979) Initial study on the effects of transformer and transmission line noise on people.

British Standards Institution BS 5228-1:2009 (2008) Code of practice for noise and vibration control on construction and open sites – Part 1: Noise.

CIGRÉ -Technical Brochure No 202, “HVDC Stations Audible Noise”. Working group 14.26, April 2002.

CIGRÉ 388, “Impacts of HVDC Lines on the Economics of HVDC Projects,” August 2009.

Engie Chile – HVDC Kimal Lo Aguirre, “Pole Conductor Calculation Memory,” July 2021.

Hatch (2016), ‘Confidential Project,’ City of Kingston

International Standard Organization ISO 9613-2 (1996) Acoustics – Attenuation of sound during propagation outdoors – Part 2: General method of calculation.

Northern Territory of Australia Environment Protection Authority NTEPA (2018) - Northern Territory noise management framework guideline.

Northern Territory of Australia (2022) Waste Management and Pollution Control Act 1998

Appendix A

AAPowerLink Estimated Fleet Productions Table

Client
Project

Sun Cable
AAPowerLink - Solar Precinct
Estimated Fleet Productions Table
Rev B



SUN CABLE



Requirement	Equipment (proposed)	Work Scope	input	calc	sourced		sourced	input	Total Equipment Operating Hours (hours)	calc		calc	input	calc
			comment	Quantity (of work)		Equipment operating productivity		Equipment diesel consumption		Duration (to complete work) operating hours only not actual duration on site.		Diesel usage	Number of Zones	Diesel usage per Zone
					unit		Unit	(litres/hr)	(each)	(hours)	(4 week months)	(litres)	(each)	(litres/zone)
Airfield														
Clear & Grub		Whole airfield area												
Grader	Cat 140	clear, grub & strip topsoil along formation	630000	63	ha	0.2	ha/hr	22	2	315.0	157.5	0.6	6930.0	
Water cart	18kL	dust suppression	630000	63	ha	0.4	ha/hr	13	1	157.5	157.5	0.6	2047.5	
Dozer	D10	tree removal (large)	20000 - allowance	20	ha	0.6	ha/hr	40	1	33.3	33.3	0.1	1333.3	
light Vehicle	Hilux ute	travel						7	4	404.7	101.2	0.4	2832.7	
Bulk Earthworks		Embankment / Formation												
Water cart	Cat ADT 35kL	moisture control		189000	m3	200.0	m3/hr	30	2	945.0	472.5	1.7	28350.0	
Grader	Cat 140	spread material (cut to fill)		189000	m3	100.0	m3/hr	22	2	1890.0	945.0	3.4	41580.0	
Scraper	Cat 623	haul & tip (import to fill)		189000	m3	200.0	m3/hr	50	2	945.0	472.5	1.7	47250.0	
Truck	15T tipper	gravel spread material		65000	m3	50.0	m3/hr	15	3	1300.0	433.3	1.5	19500.0	
Excavator/Loader	Cat 326	detail allow 10% of total		18900	m3	50.0	m3/hr	25	2	378.0	189.0	0.7	9450.0	
Compactor	Cat 825	Compact embankment material	300mm / 1 pass	189000	m3	190.0	m3/hr	25	1	994.7	994.7	3.6	24868.4	
Sealed Road/paved areas		Airstrip / Carpark												
Grader	Cat 140	place and trim pavement layers	150mm x3 layers	57316	m3	100.0	m3/hr	22	2	573.2	286.6	1.0	12609.5	
Roller	10 ton	compact pavements / final surface preparation	3 passes	171948	m3	100.0	m3/hr	10	3	1719.5	573.2	2.0	17194.8	
Truck	15T tipper	gravel spread material	3 passes	171948	m2	250.0	sq/hr	15	5	687.8	137.6	0.5	10316.9	
Bitumen sprayer		spray bitumous seal	2 coats	119274	m2	250.0	sq/hr	15	5	477.1	95.4	0.3	7156.4	
Roller	Multityre (2	Final Compaction	1 pass	119274	m2	250.0	sq/hr	10	5	477.1	95.4	0.3	4771.0	
Concrete Structures		Buildings												
Concrete placement	Agitated truck	concrete mixer/ placement		405	m3	30.0	m3/hr	18	3	13.5	4.5	0.0	243.0	
Concrete pumping	Pump truck	concrete mixer/ placement		405	m3	30.0	m3/hr	13	3	13.5	4.5	0.0	175.5	
Buildings		terminal building		1620	m2									
Fencing		Fence, posts, gates												
Fence installation		install fencing (posts and wire) bobcat and truck		5950	m	30.0	m/hr	5	1	198.3	198.3	0.7	991.7	
Landscaping		Topsoil respreading	109570		metre sq									
Grader	Cat 140	spread material (cut to fill) 200mm	511556	51.1556	ha	0.3	ha/hr	22	6	170.5	28.4	0.1	3751.4	
light Vehicle	Hilux ute	12 months 7 days/week 10hrs/day used 50% of time		6720	hrs	1.0	50%	7	4	6720.0	1680.0	6.0	47040.0	
Rail - (formation only)														
Clear & Grub														
Grader	Cat 140	clear, grub & strip topsoil along formation	221540	22.154	ha	0.2	ha/hr	22	2	110.8	55.4	0.2	2436.9	
Water cart	18kL	dust suppression	221540	22.154	ha	0.6	ha/hr	13	1	36.9	36.9	0.1	480.0	
Dozer	D10	tree removal (large) - allowance	(as required)	7	ha	0.6	ha/hr	40	1	11.7	11.7	0.0	466.7	
Bulk Earthworks		Embankment / Formation												
Water cart	Cat ADT 35kL	moisture control		42420	m3	50.0	m3/hr	30	3	848.4	282.8	1.0	25452.0	
Grader	Cat 140	spread material (cut to fill)		42420	m3	100.0	m3/hr	22	2	424.2	212.1	0.8	9332.4	
Scraper	Cat 623	haul & tip (import to fill)		42420	m3	100.0	m3/hr	50	1	424.2	424.2	1.5	21210.0	
Excavator/Loader	Cat 326	detail		18900	m3	50.0	m3/hr	25	3	378.0	126.0	0.5	9450.0	
Truck	Cat ADT 740	haul & tip (import to fill)		42420	m3	50.0	m3/hr	37	3	848.4	282.8	1.0	31390.8	
Compactor	Cat 825	compact fill	600mm / 2 pass	132924	m3	190.0	m3/hr	25	3	699.6	233.2	0.8	17490.0	
Ballast		Supply / install	10712		m									
Truck	Cat ADT 740	haul & tip (import materials)		16000	m3	50.0	m3/hr	37	3	320.0	106.7	0.4	11840.0	
Excavator/Loader	Cat 326	detail	handle on and placement	32000	m3	50.0	m3/hr	25	3	640.0	213.3	0.8	16000.0	
Crane		lift and load sleepers and track		0.0		0.0								
Truck (flatbed)		haul materials		0.0		0.0								
Concrete Structures		buildings / culverts												
Concrete placement	Agitated truck	concrete mixer/ placement		113	m3	30.0	m3/hr	18	1	3.8	3.8	0.0	67.8	
Concrete pumping	Pump truck	concrete mixer/ placement		113	m3	30.0	m3/hr	13	1	3.8	3.8	0.0	49.0	
Buildings		Station building		250	m2									
Crane		2 hours per each of 50 units		100	hrs	1.0	50%	22	1	100.0	100.0	0.4	2200.0	
Truck (flatbed)		2 hours per each of 50 units		100	hrs	1.0	50%	22	1	100.0	100.0	0.4	2200.0	
Fencing		Fence, posts, gates												

Fence installation		install fencing (posts and wire)		230	m	30.0	m/hr	5	1	7.7	7.7	0.0	38.3		
Landscaping		Topsoil respreading	109570		metre sq										
Grader	Cat 140	spread material (cut to fill) 200mm	109570	10.957	ha	0.3	ha/hr	22	1	36.5	36.5	0.1	803.5		
light Vehicle	Hilux ute	12 months 7 days/week 10hrs/day used 50% of time		6720	hrs	1.0	50%	7	4	6720.0	1680.0	6.0	47040.0		
Broadacre Solar Array (assumed whole site)															
Clear & Grub															
Slasher (behind tractor/truck)	4WD	grass slashing	103333034	10333.3034	ha	0.8	ha/hr	12	4	12916.6	3229.2	11.5	154999.6		
Water cart	18kL	dust suppression - 20% of area	103333034	10333.3034	ha	0.6	ha/hr	13	4	17222.2	4305.5	15.4	223888.2		
Dozer	D10	tree removal (large) - allowance	(as required)	3000	ha	0.6	ha/hr	40	1	5000.0	5000.0	17.9	200000.0		
Bulk Earthworks		Diversion bunds													
Water cart	Cat ADT 35kL	moisture control		957294	m3	200.0	m3/hr	30	2	4786.5	2393.2	8.5	143594.1		
Grader	Cat 140	spread material (cut to fill)		957294	m3	100.0	m3/hr	22	4	9572.9	2393.2	8.5	210604.7		
Truck	Cat ADT 740	haul & tip (import to fill) allow 10%		100000	m3	50.0	m3/hr	37	2	2000.0	1000.0	3.6	74000.0		
Scraper	Cat 623	haul & tip (import to fill)		957294	m3	200.0	m3/hr	50	4	4786.5	1196.6	4.3	239323.5		
Excavator/Loader	Cat 326	detail allowance		100000	m3	50.0	m3/hr	25	2	2000.0	1000.0	3.6	50000.0		
Compactor	Cat 825	compact fill	1m / 4 pass	1914588	m3	190.0	m3/hr	25	4	10076.8	2519.2	9.0	251919.5		
Truck	15T tipper	gravel placement material		23918	m3	50.0	Sq/hr	15	2	478.4	239.2	0.9	7175.4		
Fencing		Fence, posts, gates													
Fence installation		install fencing (posts and wire)		43460	m	30.0	m/hr	5	1	1448.7	1448.7	5.2	7243.3		
Landscaping		Topsoil respreading	357380		metre sq										
Grader	Cat 140	spread material (cut to fill) 200mm	71476	7.1476	ha	0.3	ha/hr	22	1	23.8	23.8	0.1	524.2		
Pole Installations															
Excavator	50 ton / 30 ton	excavate and load material		950	m3	15.0	m3/hr	30	1	63.3	0.0	0.0	0.0		
Boring machine		720 33kv poles - 3m deep		2160	m	1.0	m/hr	30	1	2160.0	2160.0	7.7	64800.0		
Piling rig		400 220kv piles - 4 piles per pole y 12m deep		19200	m	12.0	m/hr	30	1	1600.0	1600.0	5.7	48000.0		
Concrete placement	Agitated truck	concrete mixer/ placement (pole footings)		2550	m3	30.0	m3/hr	18	2	85.0	42.5	0.2	1530.0		
Concrete pumping	Pump truck	concrete mixer/ placement (pole footings)		2550	m3	30.0	m3/hr	13	1	85.0	85.0	0.3	1105.0		
Trenching															
Trencher	vermeer T1055	excavate and stockpile		410000	m	90.0	m/hr	50	1	4555.6	4555.6	16.3	227777.8		
Excavator	50 ton / 30 ton	excavate and load material		410000	m3	30.0	m/hr	30	4	13666.7	3416.7	12.2	410000.0		
Grader	Cat 140	strip topsoil along formation		600	ha	0.3	ha/hr	22	1	2000.0	2000.0	7.1	44000.0		
Truck	Cat ADT 740	haul & tip		82000	m3	50.0	m3/hr	37	2	1640.0	820.0	2.9	60680.0		
Compactor	Cat 825	compact fill - by excavator		0	m3	50.0	m3/hr	25	1	0.0	0.0	0.0	0.0		
light Vehicle	Hilux ute	45 months 7 days/week 10hrs/day used 50% of time		63000	hrs	1.0	50%	7	10	63000.0	6300.0	22.5	441000.0		
Main Access Road															
Clear & Grub															
Grader	Cat 140	clear, grub & strip topsoil along formation	935400	93.54	ha	0.2	ha/hr	22	2	467.7	233.9	0.8	10289.4		
Water cart	18kL	dust suppression	935400	93.54	ha	0.4	ha/hr	13	3	233.9	78.0	0.3	3040.1		
Dozer	D10	tree removal (large) - allowance	(as required)	33	ha	0.6	ha/hr	40	1	55.0	55.0	0.2	2200.0		
Road - Bulk earthworks		Embankment / Formation													
Water cart	Cat ADT 35kL	moisture control		181880	m3	200.0	m3/hr	30	2	909.4	454.7	1.6	27282.0		
Grader	Cat 140	spread material (cut to fill)		181880	m3	100.0	m3/hr	22	2	1818.8	909.4	3.2	40013.6		
Scraper	Cat 623	haul & tip (import to fill)		181880	m3	200.0	m3/hr	50	4	909.4	227.4	0.8	45470.0		
Excavator/Loader	Cat 326	detail allowance		18900	m3	50.0	m3/hr	25	2	378.0	189.0	0.7	9450.0		
Truck	Cat ADT 740	haul & tip (import to fill)		18900	m3	50.0	m3/hr	30	2	378.0	189.0	0.7	11340.0		
Compactor	Cat 825	compact fill	600mm / 2 pass	561240	m3	190.0	m3/hr	37	8	2953.9	369.2	1.3	109294.1		
Sealed Road		Bitumous Sprayed Road													
Grader	Cat 140	place and trim pavement layers	150mm x3 layers	187060	m3	100.0	m3/hr	22	4	1870.6	467.7	1.7	41153.2		
Roller	10 ton	compact pavements / final surface preparation	3 passes	561180	m3	100.0	m3/hr	10	8	5611.8	701.5	2.5	56118.0		
Truck	15T tipper	gravel spread material	2x passes	374120	m2	250.0	sq/hr	15	2	1496.5	748.2	2.7	22447.2		
Bitumen sprayer		spray bitumous seal	(2x coats)	379620	m2	250.0	sq/hr	15	3	1518.5	506.2	1.8	22777.2		
Roller	Multityre (2	Final Compaction	1 pass	0	m2	250.0	sq/hr	10	1	0.0	0.0	0.0	0.0		
Landscaping		Topsoil respreading	733600		metre sq										
Grader	Cat 140	spread material (cut to fill) 200mm	146720	14.672	ha	0.3	ha/hr	22	1	48.9	48.9	0.2	1075.9		
Concrete Structures		Culverts													
Concrete placement	Agitated truck	concrete mixer/ placement		0	m3	30.0	m3/hr	18	1	0.0	0.0	0.0	0.0		
Concrete pumping	Pump truck	concrete mixer/ placement		0	m3	30.0	m3/hr	13	1	0.0	0.0	0.0	0.0		
Crane		lift and load culvert (prefab)		400	ea	4.0	item/hr	5	1	100.0	100.0	0.4	500.0		
Truck (flatbed)		haul materials		28000	km	100.0	km/hr	15	1	280.0	280.0	1.0	4200.0		
light Vehicle	Hilux ute	8 months 7 days/week 10hrs/day used 50% of time		8960	hrs	1.0	50%	7	8	8960.0	1120.0	4.0	62720.0		
All Weather Road															
Clear & Grub															
Grader	Cat 140	clear, grub & strip topsoil along formation	422040	42.204	ha	0.2	ha/hr	22	5	211.0	42.2	0.2	4642.4		
Water cart	18kL	dust suppression	422040	42.204	ha	0.4	ha/hr	13	10	105.5	10.6	0.0	1371.6		
Dozer	D10	tree removal (large) - allowance	(as required)	1	ha	0.6	ha/hr	40	1	1.7	1.7	0.0	66.7		

Road - Bulk earthworks		Embankment / Formation													
Water cart	Cat ADT 35kL	moisture control		70340	m3	200.0	m3/hr	30	2	351.7	175.9	0.6	10551.0		
Grader	Cat 140	spread material (cut to fill)		0	m3	100.0	m3/hr	22	1	0.0	0.0	0.0	0.0		
Scraper	Cat 623	haul & tip (import to fill)		0	m3	200.0	m3/hr	50	4	0.0	0.0	0.0	0.0		
Excavator / Loader	Cat 326	detail		18900	m3	50.0	m3/hr	25	2	378.0	189.0	0.7	9450.0		
Truck	Cat ADT 740	haul & tip (import to fill)		70340	m3	50.0	m3/hr	30	4	1406.8	351.7	1.3	42204.0		
Compactor	Cat 825	compact fill	1m / 4 pass	422040	m3	190.0	m3/hr	37	4	2221.3	555.3	2.0	82186.7		
Unsealed Road		Gravel Road													
Grader	Cat 140	place and trim pavement layers	150mm x2 layers	105510	m3	100.0	m3/hr	22	1	1055.1	1055.1	3.8	23212.2		
Roller	10 ton	compact pavements / final surface preparation	2 passes	211020	m3	100.0	m3/hr	10	3	2110.2	703.4	2.5	21102.0		
Truck	15T tipper	gravel spread material	2x passes	211020	m2	250.0	sq/hr	15	1	844.1	844.1	3.0	12661.2		
Roller	Multytre (2	Final Compaction	1 pass	105510	m3	250.0	sq/hr	10	2	422.0	211.0	0.8	4220.4		
Landscaping		Topsoil respreading	351700		metre sq										
Grader	Cat 140	spread material (cut to fill) 200mm	70340	7.034	ha	0.3	ha/hr	22	1	23.4	23.4	0.1	515.8		
Concrete Structures		Culverts													
Concrete placement	Agitated truck	concrete mixer/ placement		0	m3	30.0	m3/hr	18	1	0.0	0.0	0.0	0.0		
Concrete pumping	Pump truck	concrete mixer/ placement		0	m3	30.0	m3/hr	13	1	0.0	0.0	0.0	0.0		
Crane	Frana	lift and load culvert (prefab)		100	ea	4.0	item/hr	5	1	25.0	25.0	0.1	125.0		
Truck (flatbed)	10t	haul materials		7000	km	100.0	km/hr	15	1	70.0	70.0	0.3	1050.0		
light Vehicle	Hilux ute	5 months 7 days/week 10hrs/day used 50% of time		2800	hrs	1.0	50%	7	4	2800.0	700.0	2.5	19600.0		
Internal Roads															
Clear & Grub															
Grader	Cat 140	clear, grub & strip topsoil along formation	7603300	761.2	ha	0.3	ha/hr	22	5	2537.3	507.5	1.8	55821.3		
Water cart	18kL	dust suppression	7603300	761.2	ha	0.6	ha/hr	13	5	1268.7	253.7	0.9	16492.7		
Dozer	D10	tree removal (large)	(as required)	150	ha	0.6	ha/hr	40	1	250.0	250.0	0.9	10000.0		
		Formation													
Grader	Cat 140	spread material (cut to fill) 200mm	6809000	680.9	ha	0.3	ha/hr	22	1	2269.7	2269.7	8.1	49932.7		
Water cart	Cat ADT 35kL	road wetting	6809000	680.9	ha	0.3	ha/hr	13	1	2269.7	2269.7	8.1	29505.7		
Roller	10 ton	compact pavements / final surface preparation	300mm / 1 pass	6809000	m2	300.0	m2/hr	10	6	22696.7	3782.8	13.5	226966.7		
Truck	15T tipper	gravel spread material	100mm	651100	m3	50.0	sq/hr	15	4	13022.0	3255.5	11.6	195330.0		
Landscaping		Topsoil respreading	5141000		metre sq										
Grader	Cat 140	spread material (cut to fill) 200mm	1028200	102.82	ha	0.3	ha/hr	22	1	342.7	342.7	1.2	7540.1		
light Vehicle	Hilux ute	15 months 7 days/week 10hrs/day used 50% of time		8400	hrs	1.0	50%	7	4	8400.0	2100.0	7.5	58800.0		
VSC & central battery storage															
Clear & Grub															
Grader	Cat 140	clear, grub & strip topsoil along formation	245000	24.5	ha	0.3	ha/hr	22	5	81.7	16.3	0.1	1796.7		
Water cart	18kL	dust suppression	245000	24.5	ha	0.6	ha/hr	13	10	40.8	4.1	0.0	530.8		
Dozer	D10	tree removal (large)	(as required)	1	ha	0.6	ha/hr	40	1	1.7	1.7	0.0	66.7		
		Formation													
Grader	Cat 140	spread gravel material 200mm	245000	24.5	ha	0.1	ha/hr	22	1	245.0	245.0	0.9	5390.0		
Water cart	Cat ADT 35kL	road wetting	245000	24.5	ha	0.2	ha/hr	13	1	122.5	122.5	0.4	1592.5		
Roller	10 ton	compact pavements / final surface preparation	300mm / 1 pass	103500	m2	300.0	m2/hr	10	1	345.0	345.0	1.2	3450.0		
Truck	15T tipper	gravel spread material	100mm	103500	m2	250.0	sq/hr	15	1	414.0	414.0	1.5	6210.0		
Landscaping		Topsoil respreading	19950		metre sq										
Grader	Cat 140	spread material (cut to fill) 200mm	3990	0.399	ha	0.3	ha/hr	22	1	1.3	1.3	0.0	29.3		
Fencing		Fence, posts, gates													
Fence installation		install fencing (posts and wire) - bobcat + truck		2840	m	30.0	m/hr	5	1	94.7	94.7	0.3	473.3		
light Vehicle	Hilux ute	5 months 7 days/week 10hrs/day used 50% of time		1400	hrs	1.0	50%	7	2	1400.0	700.0	2.5	9800.0		
Working Accommodation/Operational Facilities															
Clear & Grub															
Grader	Cat 140	clear, grub & strip topsoil along formation	65824	6.5824	ha	0.3	ha/hr	22	5	21.9	4.4	0.0	482.7		
Water cart	18kL	dust suppression	65824	6.5824	ha	0.6	ha/hr	13	10	11.0	1.1	0.0	142.6		
Dozer	D10	tree removal (large) - allowance	(as required)	1	ha	0.6	ha/hr	40	1	1.7	1.7	0.0	66.7		
		Formation													
Water cart	Cat ADT 35kL	road wetting	64854	6.4854	ha	0.6	ha/hr	13	1	10.8	10.8	0.0	140.5		
Roller	10 ton	compact pavements / final surface preparation	300mm / 1 pass	64854	m2	300.0	m2/hr	10	1	216.2	216.2	0.8	2161.8		
Sealed Road		Hardstand / Bitumous Sprayed													
Grader	Cat 140	place and trim pavement layers	150mm x1 layers	7497	m3	100.0	m3/hr	22	1	75.0	75.0	0.3	1649.3		
Roller	10 ton	compact pavements / final surface preparation	3 passes	22491	m3	100.0	m3/hr	10	1	224.9	224.9	0.8	2249.1		
Truck	15T tipper	gravel spread material	2x passes	14994	m2	250.0	sq/hr	15	1	60.0	60.0	0.2	899.6		
Bitumen sprayer		spray bitumous seal	(2x coats)	34601	m2	250.0	sq/hr	15	1	138.4	138.4	0.5	2076.1		
Roller	Multytre (2	Final Compaction	1 pass	0	m3	250.0	sq/hr	10	2		0.0	0.0	0.0		
Landscaping		Topsoil respreading	8550		metre sq										
Grader	Cat 140	spread material (cut to fill) 200mm	1710	0.171	ha	0.3	ha/hr	22	1	0.6	0.6	0.0	12.5		
Concrete Structures		Culverts													

Concrete placement	Agitated truck	concrete mixer/ placement		1781	m3	30.0	m3/hr	18	1	59.4	59.4	0.2	1068.6		
Concrete pumping	Pump truck	concrete mixer/ placement		1781	m3	30.0	m3/hr	13	1	59.4	59.4	0.2	771.8		
Fencing															
Fence installation	bobcat+truck	install fencing (posts and wire) - bobcat + truck		1215	m	30.0	m/hr	5	1	40.5	40.5	0.1	202.5		
light Vehicle	Hilux ute	3 months 7 days/week 10hrs/day used 50% of time		840	hrs	1.0	50%	7	2	840.0	420.0	1.5	5880.0		
Intermodal Facility															
Clear & Grub															
Grader	Cat 140	clear, grub & strip topsoil along formation	516266	51.6266	ha	0.3	ha/hr	22	1	172.1	172.1	0.6	3786.0		
Water cart	18kL	dust suppression	516266	51.6266	ha	0.6	ha/hr	13	1	86.0	86.0	0.3	1118.6		
Dozer	D10	tree removal (large) - allowance	(as required)	1	ha	0.6	ha/hr	40	1	1.7	1.7	0.0	66.7		
Bulk Earthworks		Embankment / Formation													
Water cart	Cat ADT 35kL	moisture control		72630	m3	200.0	m3/hr	30	1	363.2	363.2	1.3	10894.5		
Grader	Cat 140	spread material (cut to fill)		0	m3	100.0	m3/hr	22	1	0.0	0.0	0.0	0.0		
Excavator/Loader	Cat 326	detail allowance		18900	m3	50.0	m3/hr	25	2	378.0	189.0	0.7	9450.0		
Truck	Cat ADT 740	haul & tip (import to fill)		72630	m3	50.0	m3/hr	37	1	1452.6	1452.6	5.2	53746.2		
Compactor	Cat 825	Compact embankment material	300mm / 1 pass	154879.8	m3	190.0	m3/hr	25	1	815.2	815.2	2.9	20378.9		
		Hardstand / Bitumous Sprayed													
Grader	Cat 140	place and trim pavement layers	150mm x3 layers	232230	m3	100.0	m3/hr	22	1	2322.3	2322.3	8.3	51090.6		
Roller	10 ton	compact pavements / final surface preparation	3 passes	696690	m3	100.0	m3/hr	10	3	6966.9	2322.3	8.3	69669.0		
Excavator/Loader	Cat 326	detail		18900	m3	50.0	m3/hr	25	2	378.0	189.0	0.7	9450.0		
Truck	15T tipper	gravel spread material	2x passes	464460	m2	250.0	sq/hr	15	1	1857.8	1857.8	6.6	27867.6		
Bitumen sprayer		spray bitumous seal	(2x coats)	42500	m2	250.0	sq/hr	15	1	170.0	170.0	0.6	2550.0		
Roller	Multityre (2	Final Compaction	1 pass	0	m3	250.0	sq/hr	10	2	0.0	0.0	0.0	0.0		
Landscaping		Topsoil resspreading		22500	metre sq										
Grader	Cat 140	spread material (cut to fill) 200mm		4500	ha	0.3	ha/hr	22	1	1.5	1.5	0.0	33.0		
light Vehicle	Hilux ute	10 months 7 days/week 10hrs/day used 50% of time		2800	hrs	1.0	50%	7	2	2800.0	1400.0	5.0	19600.0		
PCS and Battery Storage Zone (x720)															
Clear & Grub															
Grader	Cat 140	clear, grub & strip topsoil along formation	2401200	240.12	ha	0.3	ha/hr	22	5	800.4	160.1	0.6	17608.8		
Water cart	18kL	dust suppression	2401200	240.12	ha	0.6	ha/hr	13	5	400.2	80.0	0.3	5202.6		
Dozer	D10	tree removal (large) - allowance	(as required)	1	ha	0.6	ha/hr	40	1	1.7	1.7	0.0	66.7		
		Formation													
Water cart	Cat ADT 35kL	road wetting	2401200	240.12	ha	0.6	ha/hr	13	1	400.2	400.2	1.4	5202.6		
Excavator/Loader	Cat 326	detail allowance		18900	m3	50.0	m3/hr	25	2	378.0	189.0	0.7	9450.0		
Roller	10 ton	compact pavements / final surface preparation	300mm / 1 pass	2401200	m2	300.0	m2/hr	10	2	8004.0	4002.0	14.3	80040.0		
Unsealed Road		Gravel Pad													
Grader	Cat 140	place and trim pavement layers	150mm x2 layers	405612	m3	100.0	m3/hr	22	1	4056.1	4056.1	14.5	89234.6		
Roller	10 ton	compact pavements / final surface preparation	2 passes	811224	m3	100.0	m3/hr	10	2	8112.2	4056.1	14.5	81122.4		
Excavator/Loader	Cat 326	detail		80900	m3	50.0	m3/hr	25	2	1618.0	809.0	2.9	40450.0		
Truck	15T tipper	gravel spread material	2 passes	811224	m2	50.0	sq/hr	15	5	16224.5	3244.9	11.6	243367.2		
Roller	Multityre (2	Final Compaction	1 pass	811224	m3	250.0	sq/hr	10	2	3244.9	1622.4	5.8	32449.0		
Concrete Structures															
Concrete placement	Agitated truck	concrete mixer/ placement		19440	m3	30.0	m3/hr	18	1	648.0	648.0	2.3	11664.0		
Concrete pumping	Pump truck	concrete mixer/ placement		19440	m3	30.0	m3/hr	13	1	648.0	648.0	2.3	8424.0		
Landscaping		Topsoil resspreading		829440	metre sq										
Backhoe		spread material (cut to fill) 200mm		165888	ha	0.02	ha/hr	15	1	829.4	829.4	3.0	12441.6		
light Vehicle	Hilux ute	15 months 7 days/week 10hrs/day used 50% of time		8400	hrs	1.0	50%	7	4	8400.0	2100.0	7.5	58800.0		
Substation (x36)															
Clear & Grub															
Grader	Cat 140	clear, grub & strip topsoil along formation	48600	4.86	ha	0.3	ha/hr	22	1	16.2	16.2	0.1	356.4		
Water cart	18kL	dust suppression	48600	4.86	ha	0.6	ha/hr	13	1	8.1	8.1	0.0	105.3		
Dozer	D10	tree removal (large)	(as required)	1	ha	0.6	ha/hr	40	1	1.7	1.7	0.0	66.7		
		Formation													
Excavator/Loader	Cat 326	detail allowance		18900	m3	50.0	m3/hr	25	2	378.0	189.0	0.7	9450.0		
Truck	15T tipper	gravel spread material	2 passes	37800	m3	50.0	m3/hr	15	5	756.0	151.2	0.5	11340.0		
Water cart	Cat ADT 35kL	road wetting	48600	4.86	ha	0.6	ha/hr	13	1	8.1	8.1	0.0	105.3		
Roller	10 ton	compact pavements / final surface preparation	300mm / 6 pass	113400	m2	300.0	m2/hr	10	1	378.0	378.0	1.4	3780.0		
		Roads and hardstand													
Grader	Cat 140	place and trim pavement layers	150mm x2 layers	15552	m3	100.0	m3/hr	22	1	155.5	155.5	0.6	3421.4		
Roller	10 ton	compact pavements / final surface preparation	4 passes	62208	m3	100.0	m3/hr	10	2	622.1	311.0	1.1	6220.8		
Excavator/Loader	Cat 326	detail		80900	m3	50.0	m3/hr	25	2	1618.0	809.0	2.9	40450.0		
Truck	15T tipper	gravel spread material	2 passes	31104	m2	50.0	sq/hr	15	5	622.1	124.4	0.4	9331.2		
Roller	Multityre (2	Final Compaction	2 passes	31104	m2	250.0	sq/hr	10	2	124.4	62.2	0.2	1244.2		
Landscaping		Topsoil resspreading		24480	metre sq										
Backhoe		spread material (cut to fill) 200mm		4896	ha	0.01	ha/hr	10	1	49.0	49.0	0.2	489.6		

Fencing		Fence, posts, gates													
Fence installation		install fencing (posts and wire) - bobcat + truck		5760	m	30.0	m/hr	15	1	192.0	192.0	0.7	2880.0		
light Vehicle	Hilux ute	2 months 7 days/week 10hrs/day used 50% of time		560	hrs	1.0	50%	7	2	560.0	280.0	1.0	3920.0		
Quarry															
Clear & Grub															
Grader	Cat 140	clear, grub & strip topsoil along formation	150000	15	ha	0.3	ha/hr	22	1	50.0	50.0	0.2	1100.0		
Water cart	18kL	dust suppression	150000	15	ha	0.6	ha/hr	13	1	25.0	25.0	0.1	325.0		
Dozer	D10	tree removal (large)	(as required)	3	ha	0.6	ha/hr	40	1	5.0	5.0	0.0	200.0		
		Production													
Excavator/Loader	Cat 326	loading trucks - Raw Rock		1547000	m3	100.0	m3/hr	25	1	15470.0	15470.0	55.3	386750.0		
Excavator/Loader	Cat 326	loading trucks - crushed rock		1547000	m3	100.0	m3/hr	25	1	15470.0	15470.0	55.3	386750.0		
Truck	15T tipper			1547000	m3	50.0	m3/hr	15	2	30940.0	15470.0	55.3	464100.0		
Crusher	mobile unit			1547000	m3	100.0	m3/hr	60	1	15470.0	15470.0	55.3	928200.0		
Screening plant	mobile unit			1547000	m3	100.0	m3/hr	18	2	15470.0	7735.0	27.6	278460.0		
Water cart	Cat ADT 35kL	road wetting		1547000	m3	100.0	m3/hr	13	1	15470.0	15470.0	55.3	201110.0		
light Vehicle	Hilux ute	45 months 7 days/week 10hrs/day used 50% of time		12600	hrs	1.0	50%	7	2	12600.0	6300.0	22.5	88200.0		
Construction												Total	8,551,947.14 litres		

Roads - Maintenance - Estimated at 1 maintenance pass every 2 years - this will ramp up over 5 years in a linea progression										Hrs/month	Hrs/month	Months/month			
Grader	Cat 140	light grading & drain cleaning - two passes		468750	m2/month	800.0	m2/hr	22	2	585.9	293.0	1.0	12890.6		
Roller	10 ton	Smooth drum / Multityre		468750	m2/month	800.0	m2/hr	10	2	585.9	293.0	1.0	5859.4		
Truck	15T tipper	gravel spread material	2 passes	14000	m3	50.0	m3/hr	15	1	280.0	280.0	1.0	4200.0		
Water cart	18kL	Road Maintenance watering/moisture control		468750	m2/month	800.0	m2/hr	15	2	585.9	293.0	1.0	8789.1		
Water cart	18kL	Maintenance watering - general dust control - water of a nominal 50km of road on any one day - 3 passes @ 40km/r with 5m coverage		21000000	m2/month	80000.0	m2/hr	15	1	262.5	262.5	0.9	3937.5		
Backhoe	4WD	cleaning culverts grader support		100000	m2	200.0	m2/hr	18	2	500.0	250.0	0.9	9000.0		
light Vehicle	Hilux ute	travel						7	5	1400.2	280.0	1.0	9801.1		
Operations - Road Maintenance												Total /month	54477.7 litres/month		