APPENDIX I ELECTROMAGNETIC INTERFERENCE (EMI) ASSESSMENT

LAWRENCE DERRICK AND ASSOCIATES

Environmental Resources Management (ERM)

Hills of Gold Wind Farm EMI Study

Final rev3 27th October 2020

Lawrence Derrick & Associates ABN 61020039450

ABOUT THIS DOCUMENT

TITLE:	Study for ERM
PROJECT NAME:	Hills of Gold Wind Farm EMI Study
PROJECT NO:	202009
AUTHORISED:	Laurie Derrick

Document History

Rev	Date	Description	Author	Reviewed
A	14/09/2020	Initial draft	LJD	
B	25/09/2020	Second draft	LJD	
0	07/10/2020	Final	LJD	
1	08/10/2020	WT Coords Added	LJD	
2	26/10/2020	NBN Comments Added	LJD	
3	27/10/2020	NBN Maps, Latest dwelling map, added. Proj. Desc updated	LJD	

TABLE OF CONTENTS

1 EXECUTIVE SUMMARY

Wind Energy Partners (WEP) is seeking approval for the development of the Hills of Gold Farm (the Project) located 50 km South of Tamworth, NSW. WEP has engaged ERM to prepare an Environmental Impact Statement (EIS) to accompany the Development Application for the Project. ERM has subcontracted Lawrence Derrick and Associates to conduct a communications assessment in relation to the Project for inclusion in the EIS.

The wind farm will consist of 70 wind turbine generators (WTGs). These generators will have a ground to maximum blade tip height of 230 m and rotor diameters of up to 170 m.

The approval process for the proposed wind farm requires an electromagnetic and communication impact assessment which has prompted this study.

This report documents the findings of the study which examined the radiocommunications systems and radio links in the vicinity of the wind farm, and for determination of the potential impact if any that the wind turbines may have on the operation of these radiocommunication systems. Any impacts on television and radio broadcasting have also been examined. A new 330 kV power line associated with the wind farm project has also been examined for potential interference.

This study found that there is one point to point radio link which passes through the wind farm boundaries. It is a Telstra VHF Link for proving a telephone service to a dwelling in the Project Area. Examination of the current wind turbine layout in relation to the link paths indicated that based on the design references applied to this study the radio link may not have sufficient horizontal clearance for a normal operation without interference. Although it has adequate Fresnel zone clearance it may be affected by reflection scattering from the nearest turbines. It is understood that this radio link proving a telephone service to a dwelling on the wind farm site may not be used if the Project proceeds.

The Tamworth AM and FM stations are predicted to serve the area around the wind farm with transmitters about 110 km and 86 km respectively from the nearest turbine. It is considered that the turbines will not have any impact on the general coverage of these stations. Reception at dwellings in the vicinity of the wind farm are unlikely to be affected due to the robust nature of the technology used and from experience reported in the literature.

An Air Services receiver on 1090 MHz at Mt Sandon about 8 km from the wind turbines may be associated with a radar system and if it has not been checked by any aviation safety consultant it should be referred for formal clearance by the operators.

Existing TV reception is expected to be variable between dwellings in view of the terrain height variations. TV stations available in the area include The Tamworth stations and from the upper Namoi stations on Mt Nardi. TV reception interference at dwellings in the area may be experienced in individual cases. Any remedial action in the event of interference is outlined in this report.

2 INTRODUCTION

This report was commissioned by ERM and will provide information and conclusions for submissions with the documentation required for approval of the Hills of Gold wind project.

The Project consists of the following key components:

- up to 70 WTGs, each with:
    - -a generating capacity of approximately 6 MW;
    - three blades mounted to a rotor hub on a tubular steel tower with a combined height of blade and tower limited to a maximum tip height of 230 m AGL;
    - a gearbox and generator assembly housed in the nacelle; and
    - adjacent hardstands for use as crane pads and assembly and laydown areas;
- decommissioning of three current monitoring masts and installation of up to five additional monitoring masts for power testing. The new monitoring masts will be located close to a WTG location with a maximum height of approximately 150 m AGL, equivalent to the installed height of the WTGs. The exact number and location will be defined at the detailed design stage;
- a centrally located330 kV electrical substation, including transformers, insulators, switchyard and other ancillary equipment;
- an operations and maintenance facility;
- a battery energy storage system (BESS) of 100/400 MWh (4 hours of 100 MW of power;
- aboveground and underground 33 kV electrical reticulation and fibre optic cabling connecting the WTGs to the onsite substation (following site access tracks where possible) (connection lines);
- a 330 kV single circuit twin conductor overhead transmission line (transmission line) to connect the onsite substation to the existing 330kV TransGrid Liddell to Tamworth overhead transmission line network, located approximately 18.8 km west of the substation;
- a switching station to connect the Project to the 330 kV TransGrid Liddell to Tamworth line and enable the Project to connect to the grid. The switching station will also be located approximately 18.8 km west of of the substation, or approximately 13.5 km from the WTG Project Area;
- an internal private access road network (combined total length of approximately 48 km) connecting the WTGs and other Project infrastructure to the public road network; and
- upgrades to local roads and crossings, as required for the delivery, installation and maintenance of WTG components and associated materials and structures.

The Department of Planning, Industry and Environment (DPIE) Secretary's Environmental Assessment Requirements (SEARs) issued for the Project provides the scope for the EMI report:

> **Telecommunications** – identify possible effects on telecommunications systems, assess impacts and mitigation measures including undertaking a detailed assessment to examine the potential impacts as well as analysis and agreement on the implementation of suitable options to avoid potential disruptions to radio communication services; which may include the installation and maintenance of alternative sites;

Further, the former NSW Department Planning and Environment's (DPE) *Wind Energy Guideline* (Dec. 2016) under Hazard and Risks states:

> **Telecommunications:** the consent authority will give consideration to the risk of electromagnetic interference with telecommunication services in the area, and the adequacy of the measures proposed to ensure the level of service is maintained.

The radio link and site data was sourced from the ACMA RRL database and used for the radio link studies to establish buffer zone corridors and to determine separation distances between the radio sites and the turbines.

The analysis was based on the advice that the wind farm would use 170 m diameter wind turbines rotors with tip heights above the ground of up to 230 m. The proposed wind turbines will have hub height of up to 151 m.

3 EMI EFFECTS OF WIND TURBINES

3.1 Electromagnetic signal interference

The following is an extract from Ref. 4:

"It is well known that any large structure, whether stationary or moving, in the vicinity of a receiver or transmitter of electromagnetic signals may interfere with those signals and degrade the performance of the transmitter/receiver system. Under certain conditions, the rotor blades of an operating wind turbine may passively reflect a transmitted signal, so that both the transmitted signal and a delayed interference signal (varying periodically at the blade passage frequency) may exist simultaneously in a zone near the turbine. The nature and amount of electromagnetic interference (EMI) in this zone depend on a number of parameters, including location of the wind turbine relative to the transmitter and receiver, type of wind turbine, physical and electrical characteristics of the rotor blades, signal frequency and modulation scheme, receiver antenna characteristics, and the radio wave propagation in the local atmosphere. Other wind turbine components which have been considered to be potential causes of EMI are towers and electrical systems. However, neither of these has been found to be a significant source of interference. Thus, moving blades are the components of most importance in determining EMI levels".

Ref. 3 also documents early theoretical work carried out by experts in the USA in 1994 on the effects of moving turbine blades on point to point radio links and on TV and Radio reception.

3.2 Microwave link interference

Point to point links in microwave frequency bands will be affected if the turbine tower or turbine blade clearance to the line-of-site path between both ends of the link is within the 2nd Fresnel zone of that link. Fresnel zones can be defined as clearance distances to obstructions from the ray line on a radio path which does not produce any additional loss above free space loss. This is dependent on the operating frequency of the link, the distance of the tower/turbine from the link antenna and the total link distance.

D. F. Bacon (Ref. 1) proposes three potential degradation mechanisms - near field effects, diffraction and reflection or scattering. The reflection or scattering treatment in the reference suggests greater clearance requirements at positions close to the link terminals than the usually applied 2nd Fresnel Zone clearance.

3.3 VHF/UHF link interference

Point to point links in the VHF/UHF band are more tolerant to turbine blade effects and a lower clearance of 0.6 X 1st Fresnel clearance has been applied. This was adopted after some discussions with David Bacon, the author of Ref 1 some years ago. He confirmed his paper was basically written for microwave links (above 1000 Mhz frequency of operation) as the lower frequencies could bend around obstacles to a greater degree. However the reflection scattering effect was still a potential issue for turbines located close to link sites and within 1 km or so along the path of VHF/UHF links.

4. METHOD OF ANALYSIS

4.1 Introduction

The grid references' shown in Attachment 2 of the wind turbine layout for the Hills of Gold wind farm have been superimposed on radio link maps which were generated from the latest ACMA RRL database. For completeness wind turbine positions were included on the mapping. These maps show all point to point radio link paths and radio sites within a site radius of at least 50 km from the wind farm (Study Area). Attachment 1 shows a general area map with a 50 km radius circle centred on the wind farm. Any link site within the 50 km area is paired with its connecting site even it is outside the 50 limit. The overview maps for two operating frequency ranges of radio links. The close-up map views show the actual wind turbine locations. In addition, spread sheets of all ACMA licence data for the 50 km radius Study Area have been generated for the purpose of identifying the licence types and other technical details to allow analysis of interference potential. Attachment 3 shows the wind turbine layout with the nearby dwellings (shown in green (associated dwellings) and brown (non-associated dwellings).

4.2 Objective of this Study

The objective of this study is to confirm the clearance requirements for the radio services in the vicinity of the wind farm to allow the turbine layout to be confirmed or modified so that there will be no detrimental effects on the performance of the existing radio services.

4.3 Scope

The criteria for clearance of obstructions from point to point microwave link ray lines has been well established in the literature including for the specific case of rotating wind turbines. For microwave links Bacon's paper (Ref. 1) was basically written for microwave links (> 1 GHz in operating frequency) and a clearance distance to the tip of the turbine blade of the 2nd Fresnel zone was specified. The clearance for VHF and UHF links < 1GHz in operating frequency has not been defined in the literature however 0.6 X 1st Fresnel Zone has been adopted after correspondence with David Bacon, the Author of Ref. 1.

As indicated above the source of data for the existing services in the area is the ACMA RRL data base for licensed radiocommunication services both from the latest issued downloadable data and the ACMA public website. The accuracy of the location of radio towers is that contained in the data base, shown in some cases to be within 10 metres and in the others within 100 metres. In a few cases accuracy of latitude and longitude of radio sites have been checked from Google Earth mapping where towers can be identified visually. No confirmation surveys has been undertaken.

4.4 Radiated EMI

It is also assumed that modern wind generators are well shielded and comply with relevant international standards and hence will not be a source of any significant generated electromagnetic interference in the frequency bands used for radio services in the area.

This report therefore focuses on potential interference (reflection, scattering or obstruction) to radio signals associated with services, which might potentially be caused by the close proximity of the wind turbines.

5 WIND TURBINE IMPACTS ON RADIOCOMMUNICATIONS

5.1 Introduction

The paper by D. F. Bacon in 2002, Ref. 1, appears to have become the most used reference by the industry for the calculation of clearance zones between radio paths and wind turbines. As indicated above this paper identifies three principal mechanisms which are relevant to wind turbines in proximity to radio paths. These are discussed below.

5.2 Near-field Effects

A transmitting or receiving antenna has a near-field zone where local inductive fields are significant, and within which it is not simple to predict the effect of other objects. Bacon's paper provides the well-known formulae for calculation of the near-field distance which depends on the gain or physical aperture of antenna and the frequency.

5.2 Diffraction

An object detrimentally modifies an advancing wavefront when it obstructs the wave's path of travel. Here the formula applied relates to the classical Fresnel Zone distance where diffraction will be insignificant if obstructions are kept outside an ellipsoid volume of space around a ray line.

5.3 Reflection

The physical structure of the wind turbine, and in particular the rotating rotor blades, reflects interfering signals into the receiving antenna of a fixed link. A formula is given to derive a distance from the radio path where any reflected/scattered signal will be of an amplitude sufficiently smaller than the direct signal arriving at the receiver. The acceptable Carrier/Interference (C/I) ratio will depend on the modulation and coding schemes of the link. Bacon's Paper provides formulas to calculate the distance from the link path where the C/I will be below a desirable level depending on the link parameters.

The calculation of the scattering level of RF signals from wind turbines is complex and varies with RF frequency, physical dimensions of the rotor blades and their twist, tilt and orientation. Radar Cross-Section (RCS) values are used in the Bacon paper and elsewhere to account for the scattering characteristics of individual wind turbines. A wide spread of values appear in the literature for typical modern wind turbines which makes the estimation of the scattered signal levels uncertain. It is noted that the Bacon Paper uses an RCS value of 30 m² whereas the SA DTEI guidelines (Ref. 4) uses a value of 480 m² which is the total area of the 3 blades based on an assumed width of 4 metres each and lengths of 40 metres. In another British study (Ref. 2) the RCS of turbines were modelled and validated with actual field measurements. The study was focused on the aviation radar signatures of wind farms and measurements were carried out with radar in the 1 to 3 GHz range. Peak RCS values can significantly exceed the physical area of the wind turbine but they will occur over narrow arcs. The nacelle and the general shape of the tower itself can make significant contributions. A 100-metre-tall tower with 45 metre blades was estimated to have a maximum peak RCS of 25,000 m². According to the British study this high peak was probably associated with a particular style of nacelle and tower.

For the purposes of this study a peak of 1,000 m² associated with the blades is considered appropriate. The RCS will of course vary with wind direction, blade pitch and other design factors including rotor tilt and coning angle. Multiple wind turbine interference from a wind farm will also be additive on a power basis due to the uncoordinated sources from physically separated locations.

Ref. 5 provides a methodology for analysing UHF radio links where the paths are obstructed i.e. not line-of-site due to the terrain.

6. EXISTING SITUATION/ENVIRONMENT

6.1 Introduction

The latest ACMA RRL database has been used to prepare maps which show registered radio sites and point to point links in the vicinity of the wind farm. Attachment 4 shows the situation for radio systems with frequencies below 1000 MHz. (VHF and UHF systems). Attachment 5 shows the links and sites for radio systems operating on frequencies above 1000 MHz which are generally considered to be microwave systems.

6.2 Point to Point Systems

A number of point to point links are registered for operation within 50 km of the wind farm site. As shown in the map in Attachment 5 there are no microwave links which pass near to the turbines. Attachment 4 indicates that there is one VHF link path (< 1GHz) which passes through the wind farm site. The paper by Bacon applies to microwave systems (> 1000 MHz frequency of operation) and recommends an exclusion zone from the link paths of the 2nd Fresnel zone width. The paper does not specifically cover VHF/UHF (<1000 MHz) Links and there appears to be no definitive acceptance of a particular exclusion distance by experts who provide analysis reports of wind farm telecommunications impacts. Some previous projects have adopted a clearance criterion of 0.6x1st Fresnel zone after considering expert submissions on this subject. This clearance criterion has been adopted in this study for the VHF/UHF Link.

Radio terminal/repeater sites that might potentially be impacted by turbines due to their proximity to the wind farm have been considered. For all but one link, all others are set back by a considerable distance from the proposed site. Therefore detailed consideration of the near-field and reflection issues mentioned above were not required for this study apart from a VHF Telstra link.

Calculations of horizontal clearance have also been made for the two closest link paths outside the wind farm to ensure there is sufficient clearance to the nearest turbine. The calculated clearance is shown with the actual clearance in Attachment 8 which shows that there is a very significant margin.

The total width of the exclusion zone required for a microwave point to point radio links for a 170 metre diameter rotor (85 m blade length) is 170 + 2 X 2nd Fresnel zone width, centred on the link ray line. For VHF/UHF links the total clearance zone with is 170 + 2 X 0.6 1st Fresnel zone width.

6.3 Microwave Links (> 1 GHz)

A general view of the microwave link ray lines near the wind turbines is shown in Attachment 5. There is no link of this class passing near the wind turbines.

6.4 VHF/UHF Links (< 1 GHz)

The view of the VHF/UHF link ray lines near the wind turbines is shown in Attachment 4. There is one link of this class crossing the wind farm. It is operated by Telstra and is a customer telephone link to a property inside the wind farm. The horizontal clearance calculation results are shown in Attachment 8. A zoomed up view of this link near turbines is shown in Attachment 6 with the overall link path shown in Attachment 7. A vertical path profile has been generated for this link in Attachment 9 which shows that it has normal ground clearance over most of the path apart from at the customer end. As antenna heights were not shown on the ACMA RRL database for this link 20 m nominal heights above ground for both antennas of were assumed.

6.5 Point to Multipoint (PMP) Systems

There are no PMP class of licence for base stations registered in the ACMA RRL data base which appear in the Study Area. However as discussed in Section 6.10, NBN Co has Spectrum Licences issued to them which are understood to be used by NBN for PMP services to connect customers to the broadband network. This is considered further in Section 6.10.

6.6 Air Services and Aviation

Tamworth Airport is located about 50 km from the wind farm and there are a number of aviation communications facilities on the airport site including DME, Ground – Air Communications and Radar. The sites and Services are listed in Table A.

TABLE A Air Services and Aviation Communications

ACMA Site ID/ Dist. to nearest WT km	Frequency MHz	Type	Air Services
9010989/27.5	133	Gnd - air	Air Services
9010989/27.5	1090	Radar Receiver	Air Services
10013103/52	134.55	Gnd- Air	Scone Airport
6510/59	129.15	Gnd- Air	Tamworth Airport
6513/59	131.65	Gnd- Air	Tamworth Airport

The VHF services are considered sufficiently distant to be not be impacted by the wind farm. It is recommended that radar impacts be considered by an aviation safety consultant if not already being carried out.

6.7 TV Broadcasting

From the "My Switch" TV prediction tool, provided online by the Australian Government, reception of terrestrial TV is patchy or in places non-existent due to the terrain around the wind farm. The Upper Namoi Main TV station on Mt Dowe appears to be received in high elevation locations. There are two low/medium power TV Stations operating at site 6402 / 6401 to serve Murrurundi and at site 6531 to serve Tamworth. Some residents near the wind farm may receive these stations where they are close to them. Other residents may have satellite TV services either pay TV services or the VAST free satellite service. Interference to satellite TV services are low due to the high elevation angle of the antennas and their narrow reception beam width. Table B lists the TV transmitter sites in the study area

TABLE B TV Radio Transmitter Sites in the Study Area

ACMA Site ID/ Dist. km to nearest WT	Frequency MHz/Licensee	Power	Coverage Impact	Station
6402/40	578.5/Prime	Low	Negligible	Murrurundi
6402/40	685.5/NBN	Low	Negligible	Murrurundi
6402/40	606.5/Network Invest.	Low	Negligible	Murrurundi
6401/40	592.5/ABC	Low	Negligible	Murrurundi
6401/40	571.5/SBS	Low	Negligible	Murrurundi
6531/39.3	627.5/Prime	Medium	Negligible	Tamworth
6531/39.3	643.5/NBN	Medium	Negligible	Tamworth
6531/39.3	641.5/Network Invest.	Medium	Negligible	Tamworth
6531/39.3	620.5/ABC	Medium	Negligible	Tamworth
6531/39.3	613.5/SBS	Medium	Negligible	Tamworth

Consideration of a Pre construction TV/Radio reception survey being carried out at a sample of dwellings in the area is recommended to establish a base line of TV reception for comparison with any complaints of reception post construction. This assists with determining whether any TV reception interference issues were pre existing. Knowing what transmitter locations or technology used (terrestrial, pay TV, satellite VAST) could also assist with determining appropriate mitigation methods in cases of wind farm interference. The Towns of Nundle and Hanging Rock receive terrestrial TV from the north-west direction which is away from the wind farm and is likely to avoid any interference to TV reception.

6.8 FM Sound Broadcasting

Table C below lists the FM Radio transmitter sites in the Study Area. No impact from the wind turbines is expected to the coverage of the stations due to the significant separation distances.

TABLE C FM Radio transmitter sites in the Study Area

ACMA Site ID/ Dist. km to nearest WT	Frequency MHz	Power	Coverage Impact
6531/42.4	91.7, 93.9 94.7 103.1	Medium	Negligible
6532/43	92.9	Medium	Negligible
6553/39.2	96.3	Low	Negligible
6401/25.1	96.9, 104.1	Low	Negligible
6405/25	100.1	Low	Negligible
153057/31.4	98.5	Low	Negligible

6.9 AM Sound Broadcasting

There are two AM Stations in the area, an ABC 648 KHz Station on site 141452, 110 km from the nearest turbine and a commercial station (2TM) on site 151289 about 8 km South of Tamworth. AM broadcasting reception is not known to be affected by wind turbines.

6.10 NBN Point to Multi Point Services

NBN have many Spectrum Licences on approximately 40 sites in the Study Area which are used for Point to Multipoint (PMP) services to connect customers to the broadband network. The Systems operate in two microwave bands 2.3GHz and 3.4 GHz. The customer ends of these systems are not shown on the ACMA RRL database so it required additional information to check if any wind turbines will exist in or be close to radio paths to customers. NBN were provided with wind farm layout details and were requested to either provide customer locations or to determine if customer NBN services were likely to be impacted by turbines. The Manager, National Wireless Technical Specialist NBN responded "I have reviewed the data provided and based on the proposed wind farm location it would appear to have no line of sight [LOS] impact between any nearby nbn LTE-TDD base station sites and premises within the current nbn Wireless Coverage Areas" (Ref. 7) The NBN provided mapping in Attachment 16 shows the NBN predictions of the coverage areas of their base stations near the wind farm. The areas shown as coloured which are not on or close to the wind farm site. It is concluded by NBN that no interference to customers is likely. NBN have indicated that the coverage areas are predicted and are not necessarily showing where customers currently live in all cases

6.11 Radio Site Buffer Zones

The radio sites and link maps indicate that there is one radio site within the wind farm Project Area with the nearest external site four kilometres from the nearest turbine. The nearest radio sites are listed in Table D below. These are taken from the ACMA RRL and are shown on the link maps. They can be seen on the zoomed up Google Earth KMZ files.

Table D Radio Site Buffer Distances

Site/ Service	Frequency Band MHz	Approx. Distance to Nearest Turbine km	Buffer Zone km	Operator
6386	160	0.23	0.5	Telstra
6420	8000	4.0	1.0	Telstra
9011509	700 - 8000	9.0	1.0	Various
6419	160 - 8000	6.6	0.5 – 1.0	Various
405164	150	6.7	0.5	Met Bureau
52893	160	6.7	0.5	Water NSW

The only potential issue is the closeness of one or two turbines to the Telstra 160 MHz customer link antenna on the wind farm site. This is due to potential interference from reflection scattering. It is difficult to calculate the level of this interference due to uncertainty in the radar cross section (RCS) value of the turbine rotor and the required Carrier to Interference (C/I) ratio requirement of the link. The C/I ratio for a radio receiver is the ratio of received signal to the maximum level of interference from all sources it will tolerate to operate satisfactorily. This is specified by the manufacturer and depends on frequency, Bandwidth and modulation technique. As mentioned elsewhere this customer telephone link is from an associated dwelling that will not be used if the Project proceeds. Consultation with Telstra may be required if this link remains in traffic.

6.12 DGPS Systems

No radio Licences for agricultural or other precision position GPS systems using local base stations within the Study Area were identified in the ACMA RRL data base.

6.13 Cellular Mobile Services

Optus and Telstra have cellular mobile base stations at sites in the Study Area including sites 6554 and 9011509. These closest sites are 10 km and 12.9 km from the nearest turbine. At these distances which exceed a 1 km recommended clearance no impact on cellular radio coverage is expected.

6.14 Private Mobile Systems

There are a number of Private Mobile base station sites in the Study Area but all are set back in excess of 1km from turbines and therefore no impact to coverage is expected.

6.15 High Voltage 330 kV Power Line EMI and Hardware Impacts.

It is expected that the 330kV transmission line being constructed as part of the Project to convey the wind farm power output from the Project substation to the electricity grid at a 330 kV switching station will be built to TransGrid standards and typical of 330 kV transmission lines in NSW.

Two potential issues exist for domestic TV and radio reception. One is the EMI emitted from the lines because of corona and the other is the hardware – poles and lines causing shadowing for TV reception. For point to point links the 50 m poles and the lines could be in the ray line. As dwellings will be located outside the standard 60 m easement, emissions at AM, FM frequencies are expected to be low with no noticeable interference to these services. As the poles and the lines are static the impact on digital TV expect to be low and ghosting is not a problem in comparison with analogue TV services which have ceased in Australia.

Attachment 10 shows the radio links which cross the transmission line route. There are about 12 link paths. A sample of the vertical path profile for links crossing the transmission line are shown

in Attachments 11- 15. The position of the transmission line where links cross are shown as a scaled 50 m high vertical line on the profiles. There is adequate Fresnel clearance for all paths.

7. CONCLUSIONS

This study indicates that there is one point to point radio link which passes through the Hills of Gold wind farm Project Area. This is a VHF customer telephone link operated by Telstra. Attachment 8 provides details of the clearances which are required to be satisfied so that the interference levels are below an acceptable threshold. This analysis is based on a 0.6x1st Fresnel clearance on either side of the link ray line. Examination of the current wind turbine layout in relation to the link path indicates that the link has sufficient horizontal clearance for a normal line-of-site link. However reflection scattering may be an issue from close turbines. Any micro-siting within the usual 100 m allowable for repositioning of turbines will need to be taken into account. It is understood that this service is owned by a Project landowner and will not be used if Project approval is received.

The following Table E summarises the horizontal clearance zone (with respect to tower centreline to ray line of link) required.

Table E VHF Link Clearance

Site A	Site B	Freq MHz	Operator	Nearest Turbines	Clearance Reqd m	Actual Clearance m
6386	65083	160	Telstra	WP30 WP34	142	200

In relation to the microwave Point to Multipoint systems with base stations licenced at the nearer sites within the Study Area the operator NBN has advised that no impacts to the radio systems to their customers are expected and the nearest customer service area ends about 4 km from the wind farm site boundary.

TV in the area is provided by Upper Namoi main station transmitters at Mt Dowe, which is expected to provide a patchy service in the wind farm area. Two low power transmitter stations which serve Tamworth and Murrurundi may provide service to some residents if they are close and in reasonable line of site to the stations. There is some risk that a few residents close to the turbines and with TV signals coming through the moving turbine blades may cause interference to TV reception. Mitigation such as the installation of more directional receiving antennas or provision of the VAST satellite service are available.

Radio reception is not expected to be affected. Due to the more robust technology AM and FM radio services are unlikely to be affected by wind turbines.

The proposed 330 kV transmission line being constructed as part of the Project is seen as a low risk for interfering with AM FM and TV reception at dwellings in the vicinity of the transmission lines. There is also a low risk of the hardware being in the ray lines of point to point systems. Path profiles of a sample of the paths crossing indicate that there is little risk of the link ray lines being impacted by transmission lines or poles/towers due to the vertical clearance where the ray lines cross the transmission line and structures.

8. REFERENCES

[1] Fixed-Link wind-turbine exclusion zone method, Version 1.1, 28 October 2002, D.F. Bacon, OFCOM UK

[2] Wind Farms Impact on Radar Aviation Interests-Final Report, September 2003, FES W/14/00614/00/REP, Contractor QinetiQ Prepared by Gavin J Poupart.

[3] Electromagnetic Interference from Wind Turbines, Sengupta & Senior, Chapter 9, Wind Turbine Technology Ed. David E. Spera ASME Press 1994

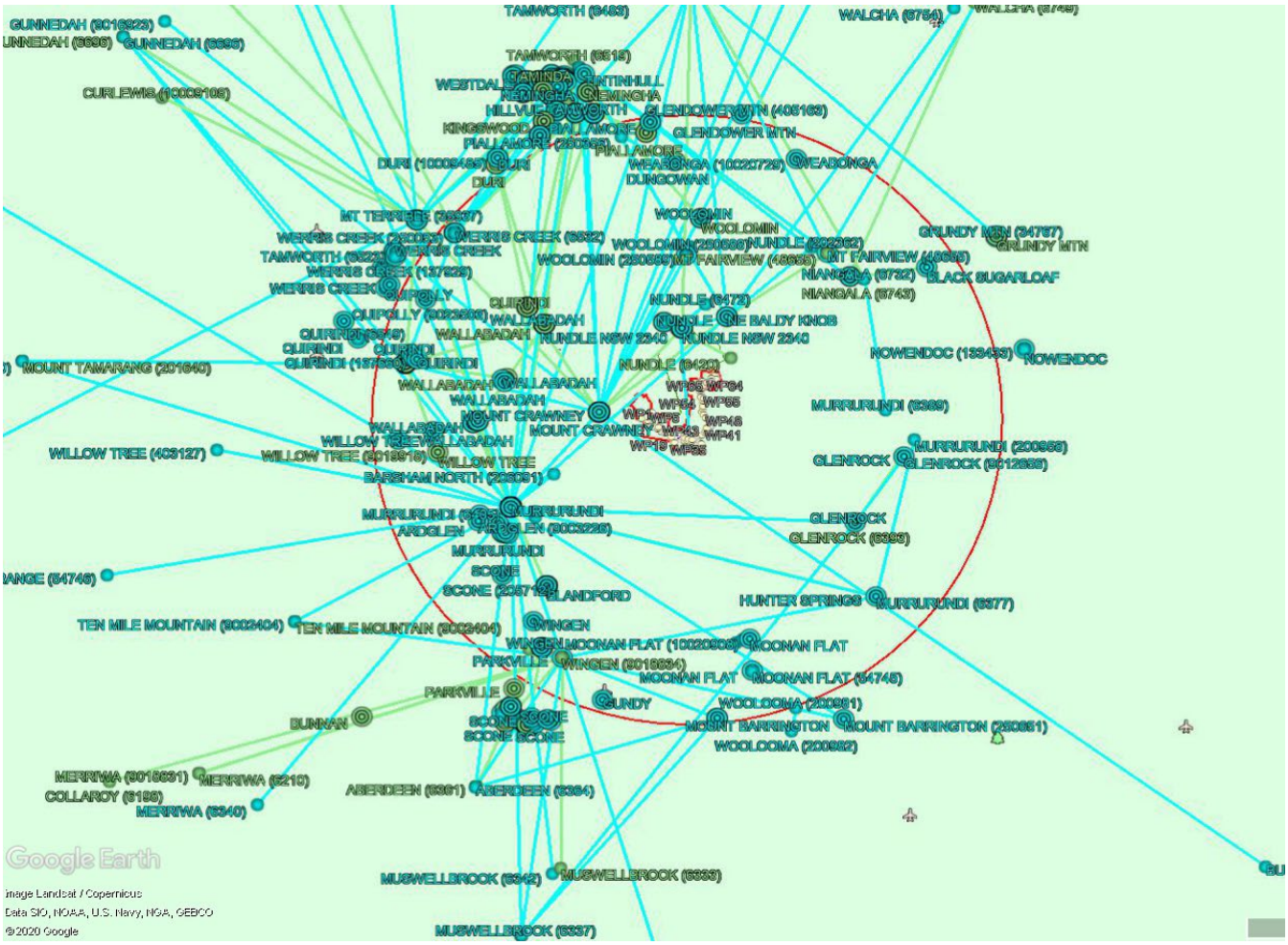
[4] Guidelines for Minimizing the Impact of Wind Farms on the SAGRN, Issue 1, 22 October 2003, Rohan Fernandez, Telstra SA, Document TR049-SA

[5] Calculation of Wind Turbine clearance zones for JRC managed fixed services with particular reference to UHF (460MHz) Telemetry Systems when turbine sizes and locations are accurately known Joint Radio Company Issue 2.4 December 2014

[6] Wind Energy Guideline for state significant wind energy development December 2016 (former) NSW Department of Planning and Environment

[7] NBN Email dated 26th October 2020 to Laurie Derrick from FrankVanRooden@nbnco.com.au Subject: Hills of Gold Wind Farm ,Tamworth NSW: Electromagnetic Interference Consultation

ATTACHMENT 1 RADIO LINKS WITH AT LEAST ONE SITE WITHIN APPROX. 50 km OF WIND FARM



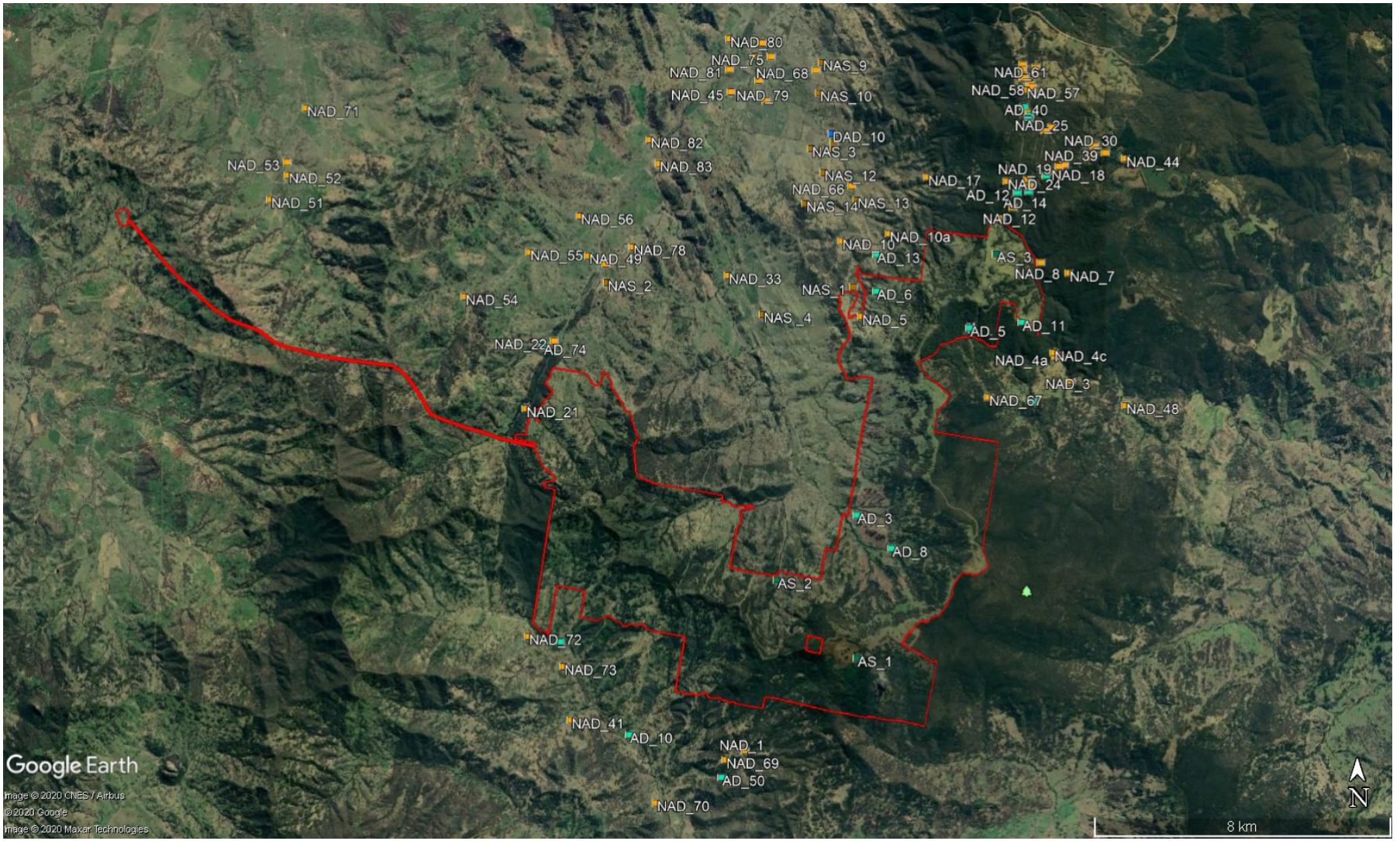
ATTACHMENT 2 WIND TURBINE CO ORDINATES HILLS OF GOLD WIND FARM

Turbine Co-ordinates

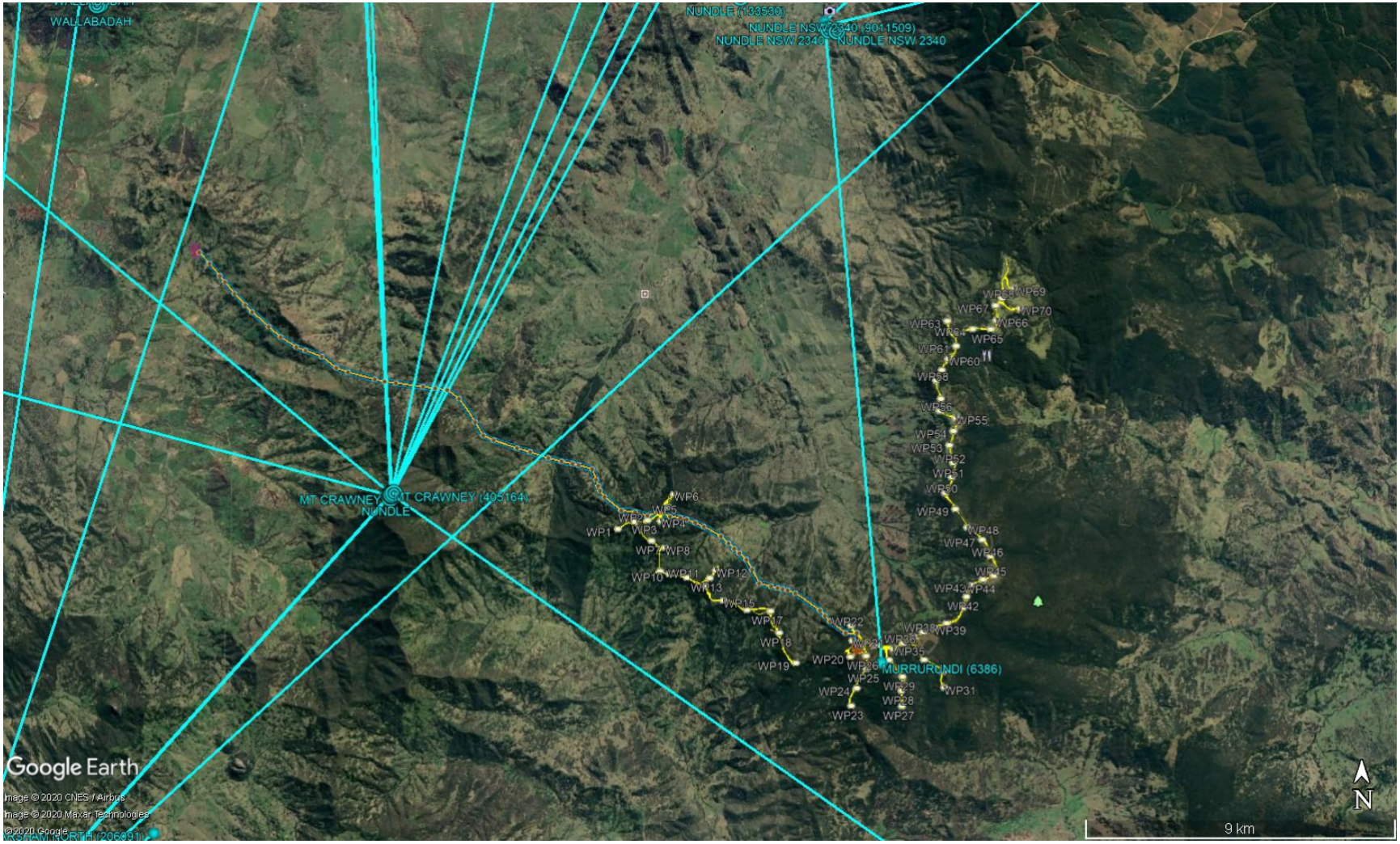
Turbine	x	y	z
WP1	316190.846	6502649.423	1222.331
WP2	316660.033	6502869.954	1259.577
WP3	317061.845	6502922.861	1254.732
WP4	317449.239	6502903.104	1199.659
WP5	317646.578	6503320.59	1142.293
WP6	317817.553	6503696.303	1171.941
WP7	317184.441	6502322.26	1185.671
WP8	317588.545	6502126.598	1167.515
WP9	317453.026	6501426.236	1153.009
WP10	317732.464	6501347.185	1160.409
WP11	318250.898	6501255.867	1127.112
WP12	319102.057	6501480.181	1131.467
WP13	318924.1	6501258.676	1161.777
WP14	318777.791	6501032.549	1161.323
WP15	319341.128	6500599.035	1118.492
WP16	320042.268	6500328.808	1069.753
WP17	320736.01	6500326.421	1169.627
WP18	321007.066	6499684.836	1130.549
WP19	321513.273	6498815.938	1195.134
WP20	323082.517	6499076.731	1410.867
WP21	323138.002	6499550.962	1408.267
WP22	323095.633	6499977.322	1372.691
WP23	323198.929	6497537.828	1211.541
WP24	323308.03	6498134.149	1255.078
WP25	323580.758	6498725.926	1366.018
WP26	323545.962	6499107.037	1391.794
WP27	324703.502	6497555.803	1294.542
WP28	324612.564	6498100.249	1344.47
WP29	324632.3	6498514.803	1333.736
WP30	324229.061	6498998.423	1341.849
WP31	325872.662	6498217.873	1312.107
WP32	325818.826	6498681.887	1319.679
WP33	325257.989	6499019.076	1335.646
WP34	323773.148	6499406.095	1405.229
WP35	324341.665	6499321.566	1358.823
WP36	324635.236	6499495.047	1365.77
WP37	324927.945	6499682.672	1341.408
WP38	325216.988	6499831.368	1336.228
WP39	325542.572	6499948.689	1332.414

WP40	325908.197	6500088.913	1282.261
WP41	326393.749	6500561.993	1317.789
WP42	326467.498	6500880.587	1325.202
WP43	326624.181	6501222.002	1373.124
WP44	326929.625	6501399.61	1380.357
WP45	327248.683	6501519.799	1383.036
WP46	327153.191	6502076.909	1343.305
WP47	326890.069	6502553.69	1351.775
WP48	326439.481	6502905.657	1375.709
WP49	326079.134	6503433.761	1373.295
WP50	325789.146	6503901.545	1329.437
WP51	325975.227	6504359.619	1325.475
WP52	326001.772	6504778.277	1336.069
WP53	325887.628	6505288.792	1311.58
WP54	325995.059	6505707.101	1316.168
WP55	326064	6506091.801	1318.91
WP56	325597.428	6506290.322	1296.246
WP57	325618.03	6506644.815	1291.57
WP58	325468.553	6507176.882	1294.455
WP59	325632.774	6507482.547	1276.788
WP60	325827.066	6507813.573	1241.825
WP61	326056.198	6508201.729	1213.552
WP62	326035.871	6508550.506	1240.455
WP63	325787.51	6508927.482	1194.219
WP64	326518.5	6508699.386	1249.239
WP65	327050.469	6508701.461	1267.584
WP66	327215.065	6508969.014	1259.707
WP67	327184.579	6509402.788	1251.136
WP68	327366.554	6509622.758	1245.471
WP69	327737.176	6509901.339	1187.555
WP70	327921.575	6509330.633	1212.258

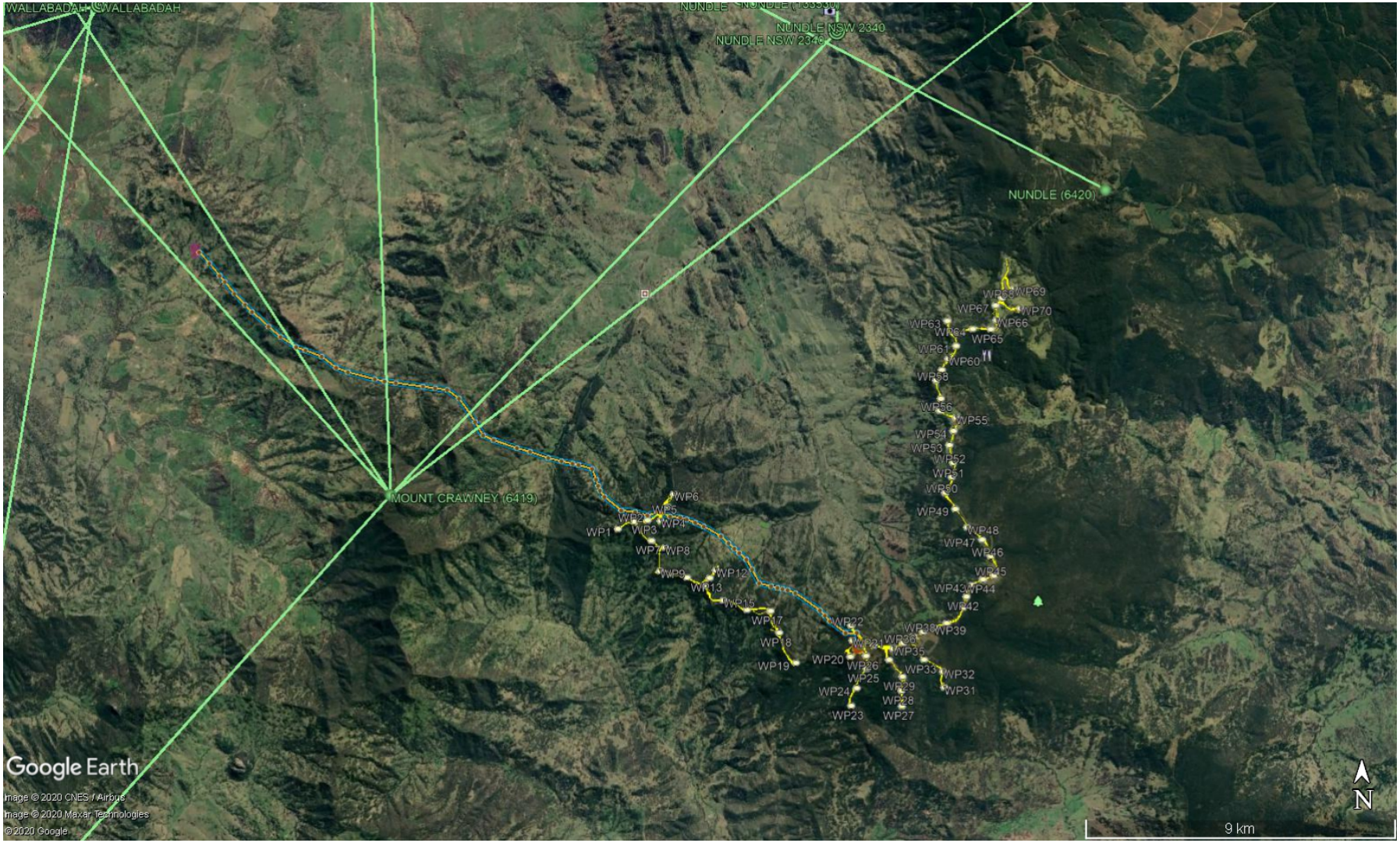
ATTACHMENT 3 – DWELLINGS LOCATIONS WITH PROJECT AREAS



ATTACHMENT 4 MAP OF RADIO LINKS & SITES OPERATING BELOW 1000 MHz, HILLS OF GOLD WIND FARM

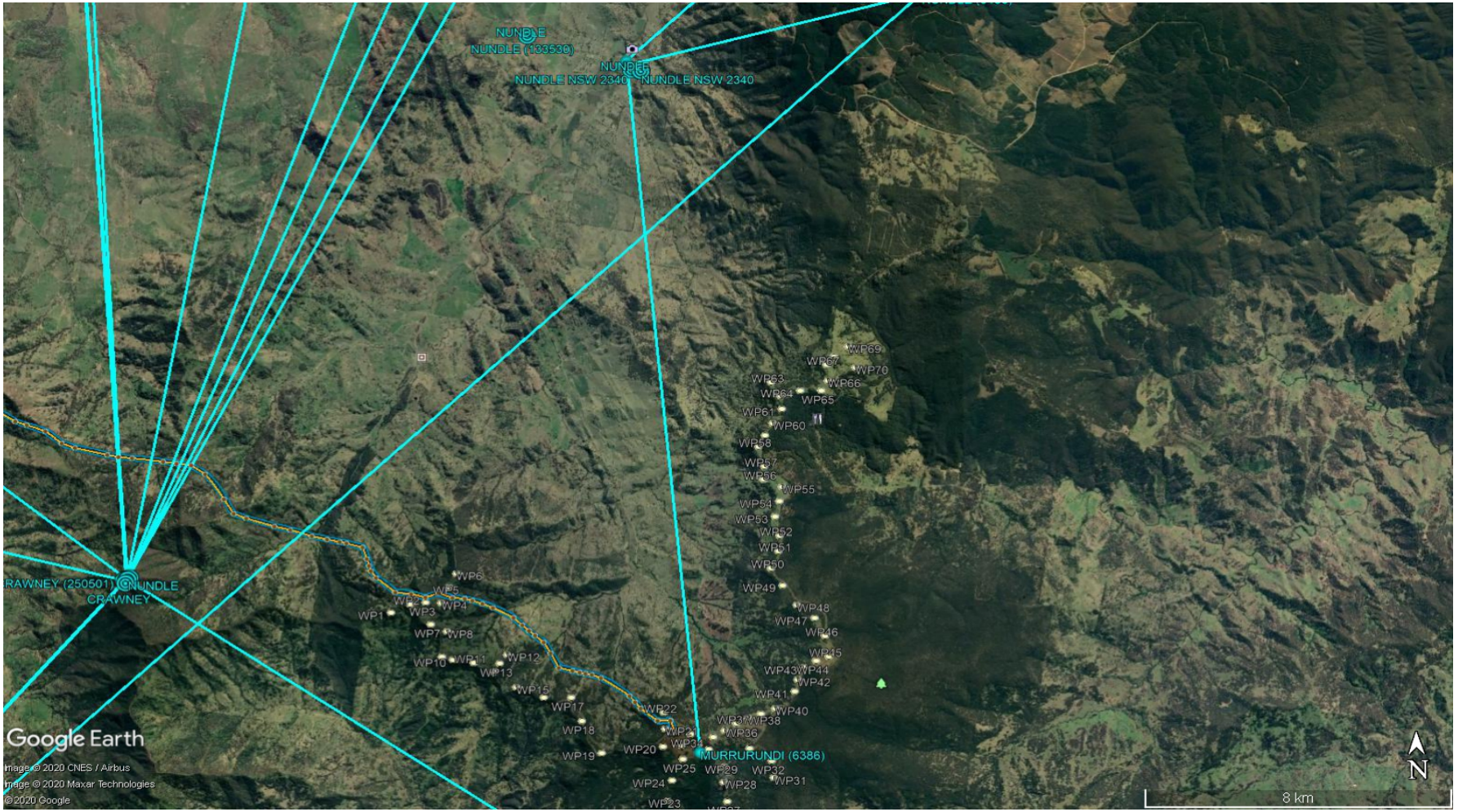


ATTACHMENT 5 MAP OF RADIO LINKS & SITES OPERATING ABOVE 1000 MHz, HILLS OF GOLD WIND FARM



ATTACHMENT 6 VHF TELSTRA RADIO LINK PATHS NEAR WIND TURBINES

ATTACHMENT 7 VHF TELSTRA RADIO LINK PATH OVERALL



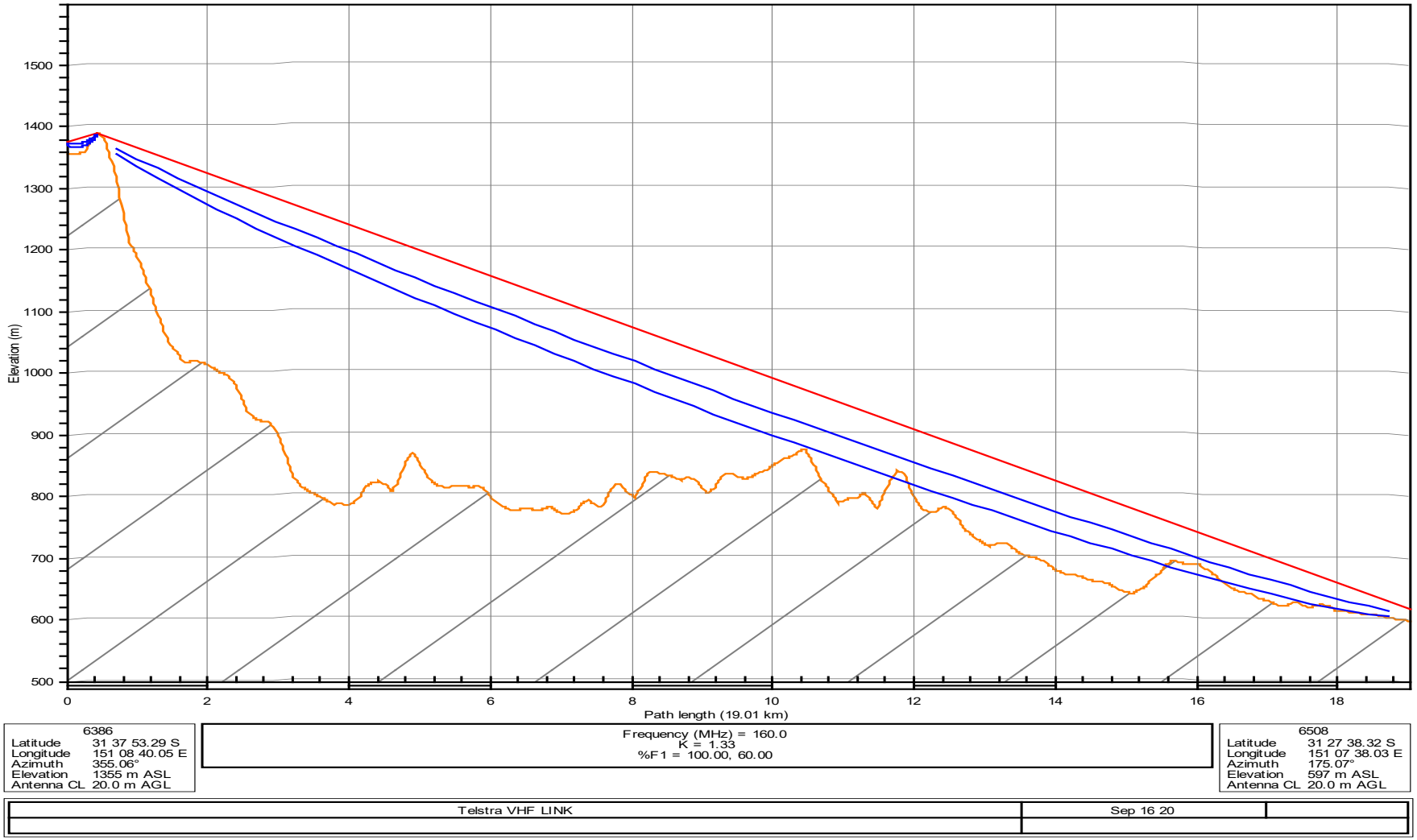
ATTACHMENT 8 LINK CLEARANCES

VHF/UHF RADIO LINKS

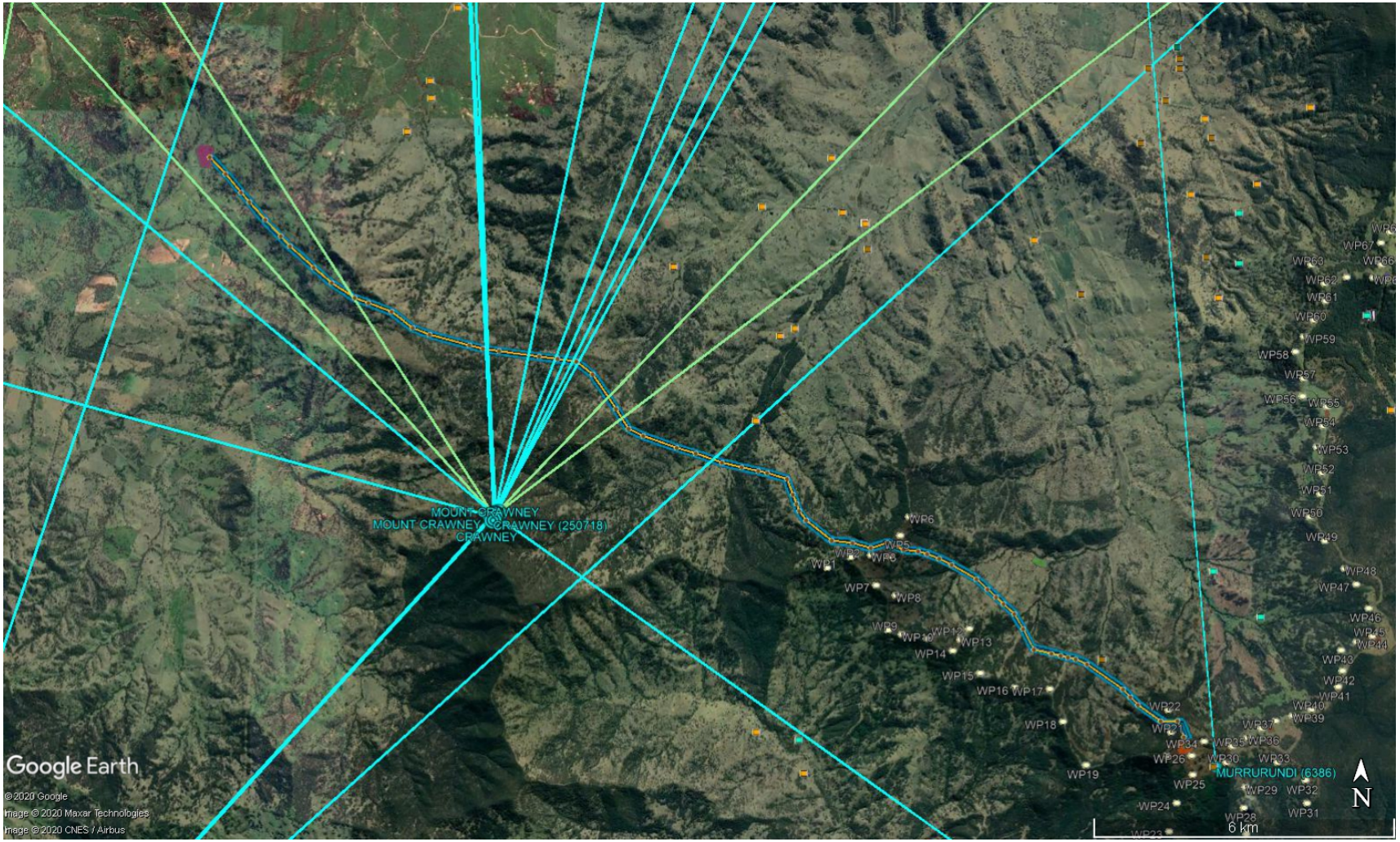
Site 1	Site 2	Operator	Freq MHz	Total Path m	Dist from Link end m	*2nd fresnel m	0.6 x Ist fresnel m	Blade Length m	Nearest Turbines	Required Clearance m	Actual Clearance m
6386	6508	Telstra	160	19010	9505	70.69	56.64	85	WP30	141.64	200
6416	7461	NSW Elec. Networks	45	113300	56650	614.55	260.73	85	WP23	345.73	2700
6404	6486	NSW RFS	450	46200	23100	124.10	52.65	85	WP1	137.65	3240

*For comparison

ATTACHMENT 9 – TELSTRA VHF LINK PATH PROFILE

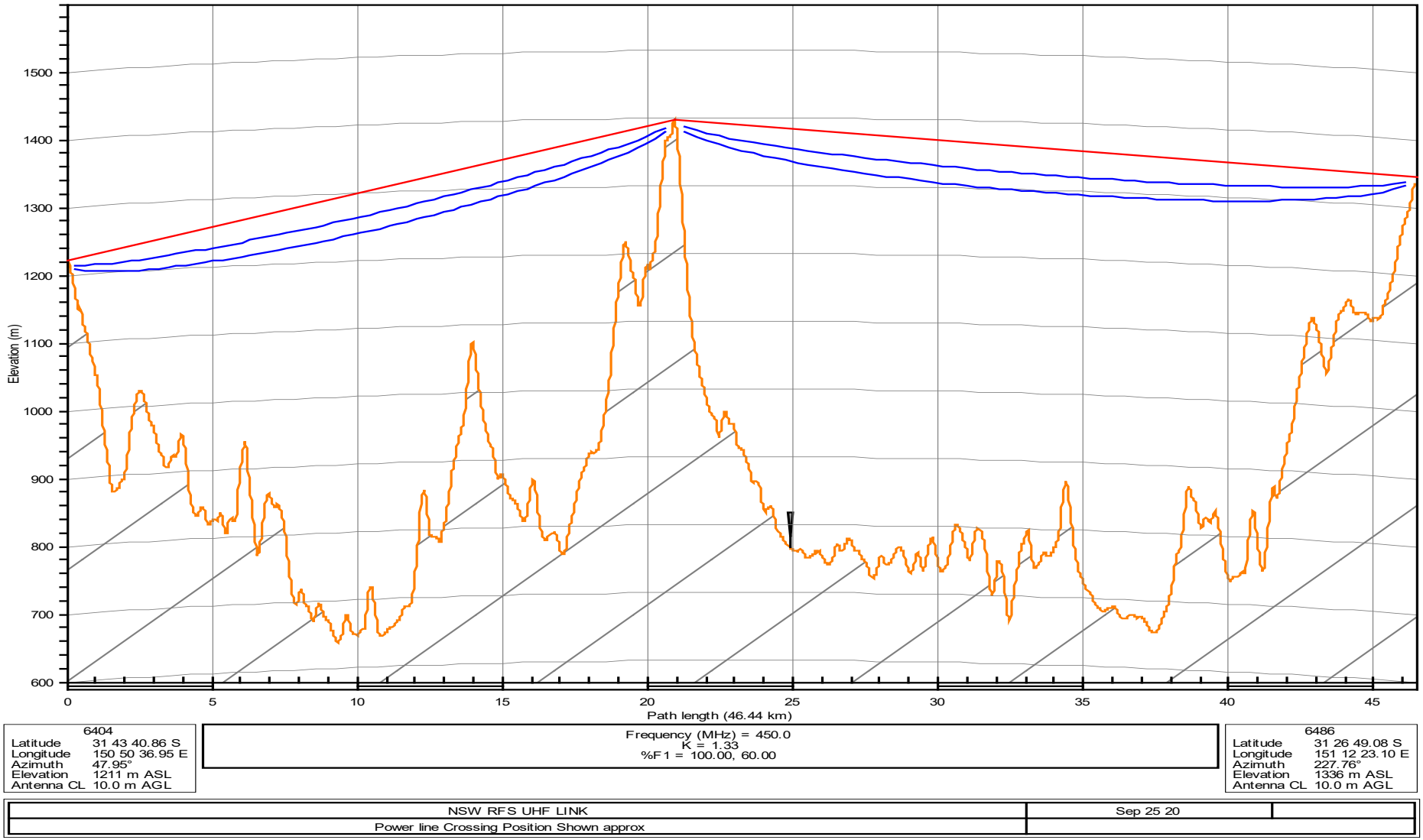


ATTACHMENT 10 – MAP OF RADIO LINKS CROSSING 330 KV TRANSMISSION Line

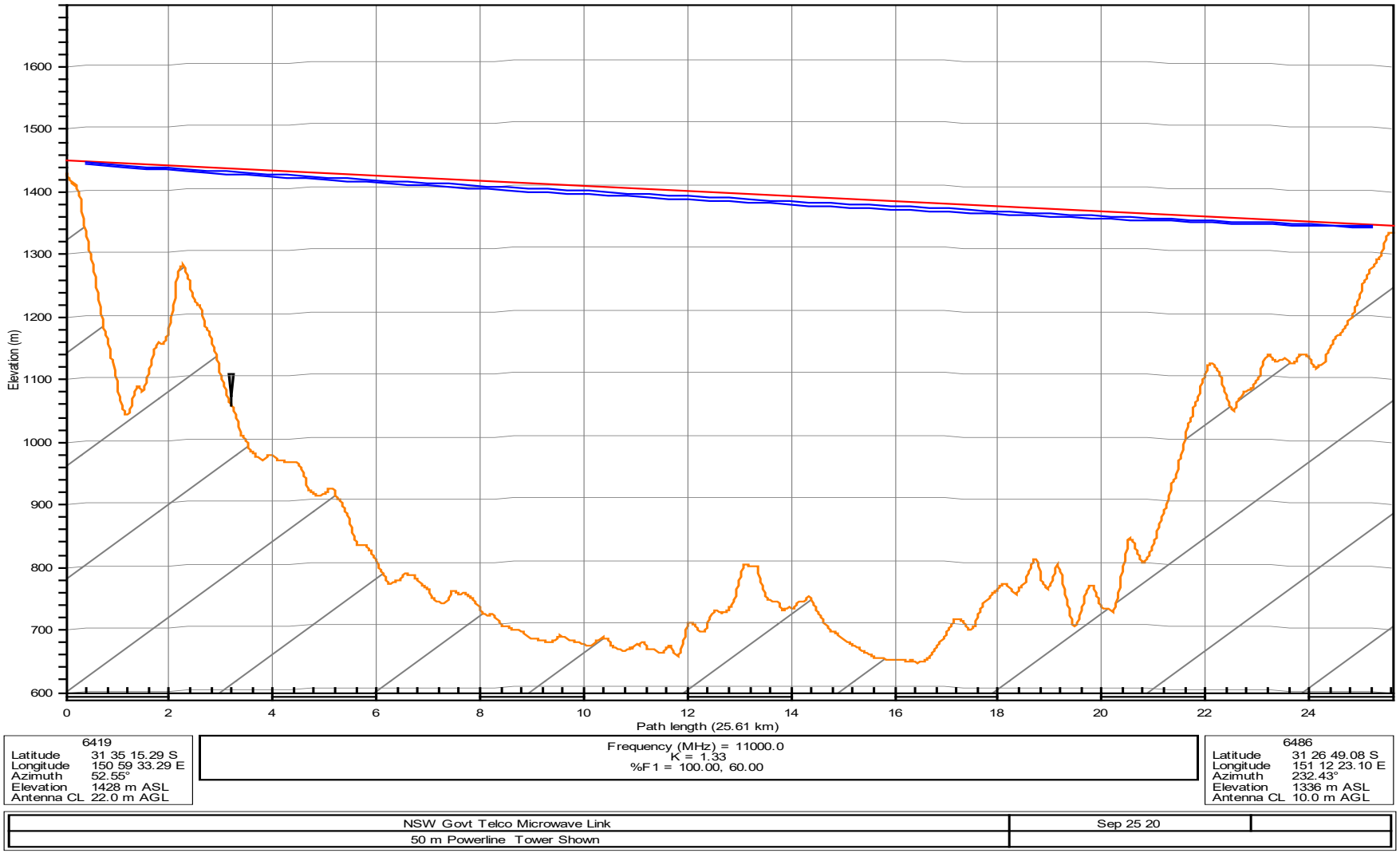


Power line route shown as the blue line with yellow centre

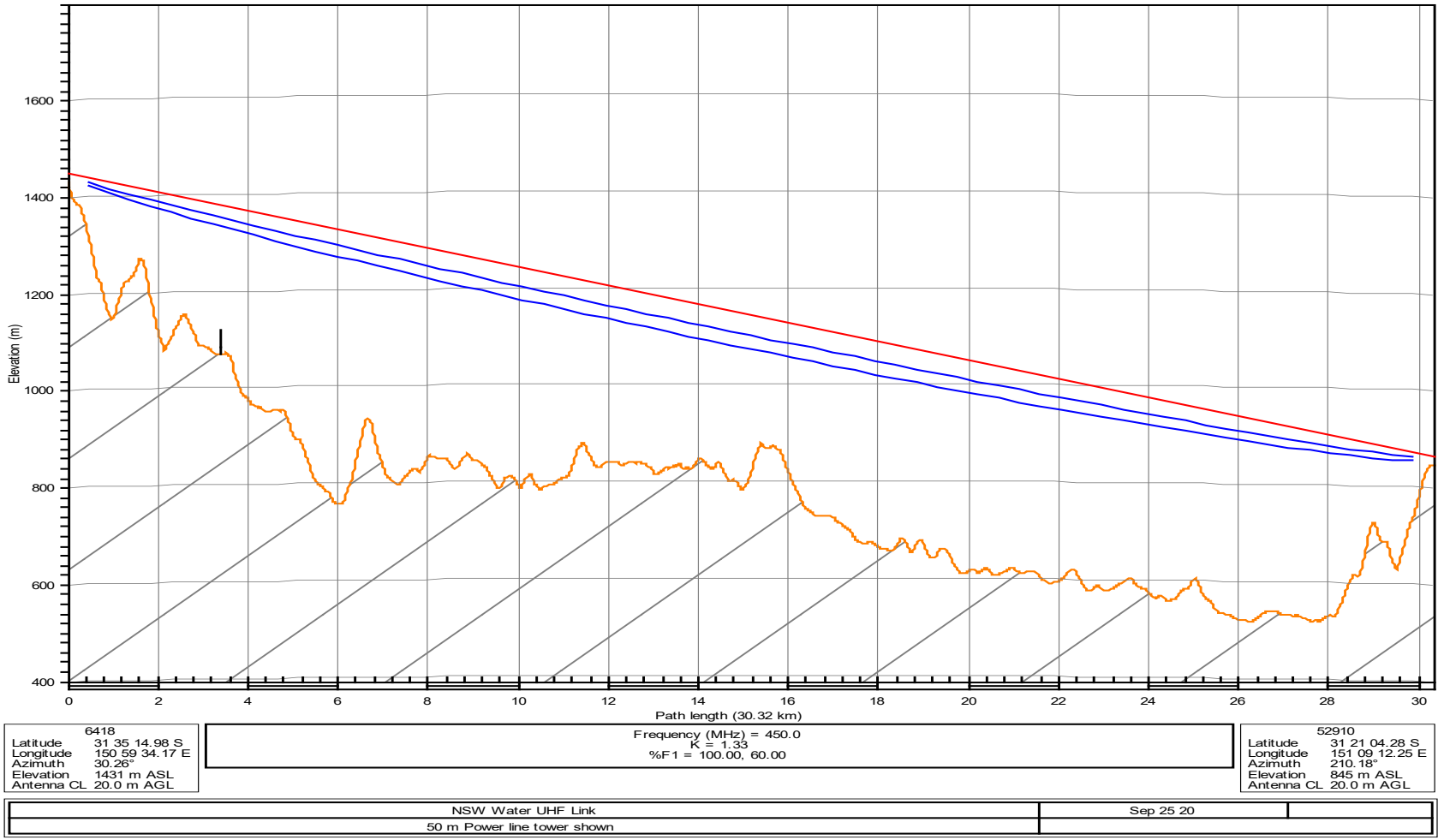
ATTACHMENT 11 – NSW RFS LINK VERTICAL PATH PROFILE SHOWING POWER LINE CLEARANCE



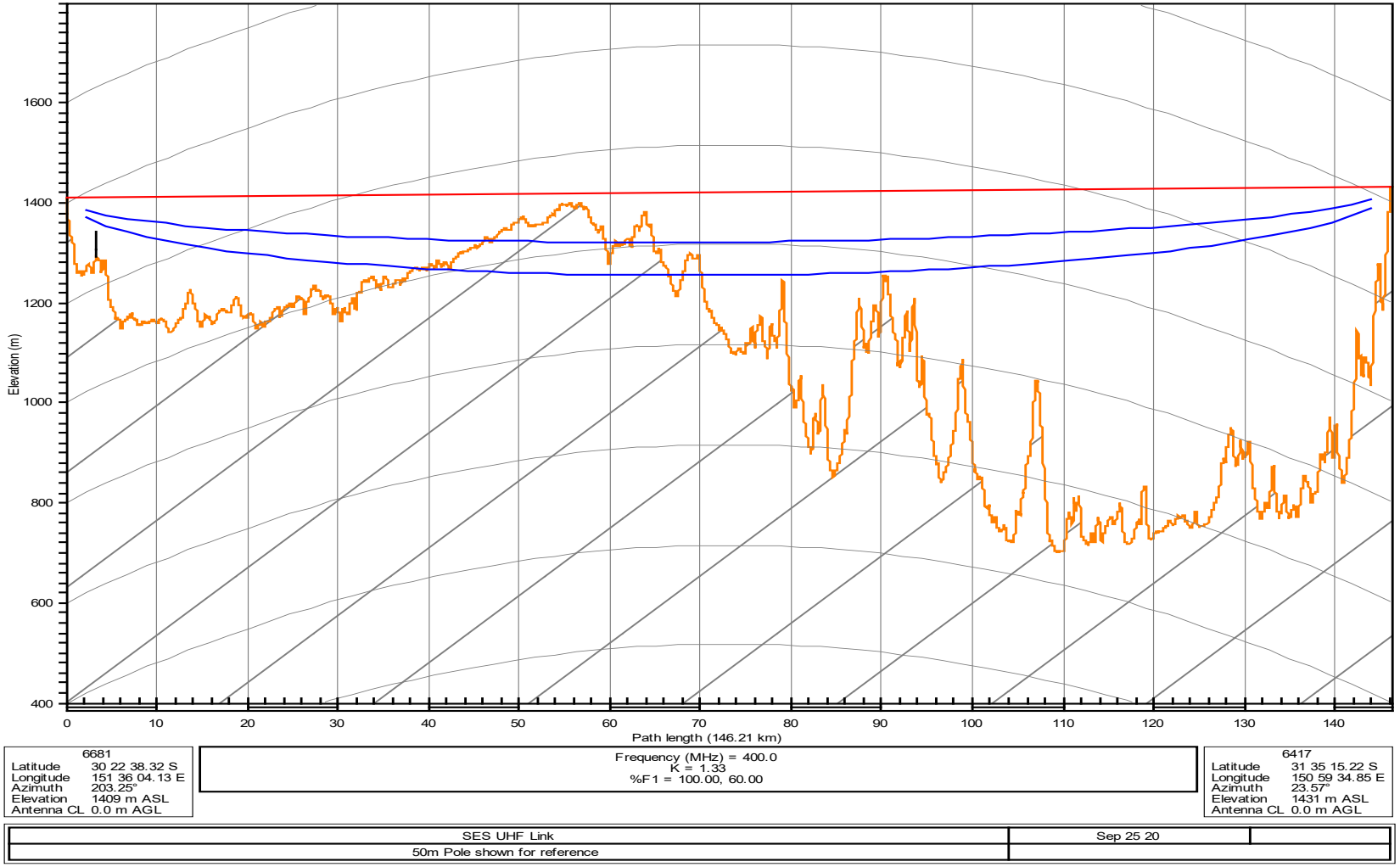
ATTACHMENT 12 – NSW GOVT TELCO LINK VERTICAL PATH PROFILE SHOWING POWER LINE CLEARANCE



ATTACHMENT 13 – NSW WATER LINK VERTICAL PATH PROFILE SHOWING POWER LINE CLEARANCE

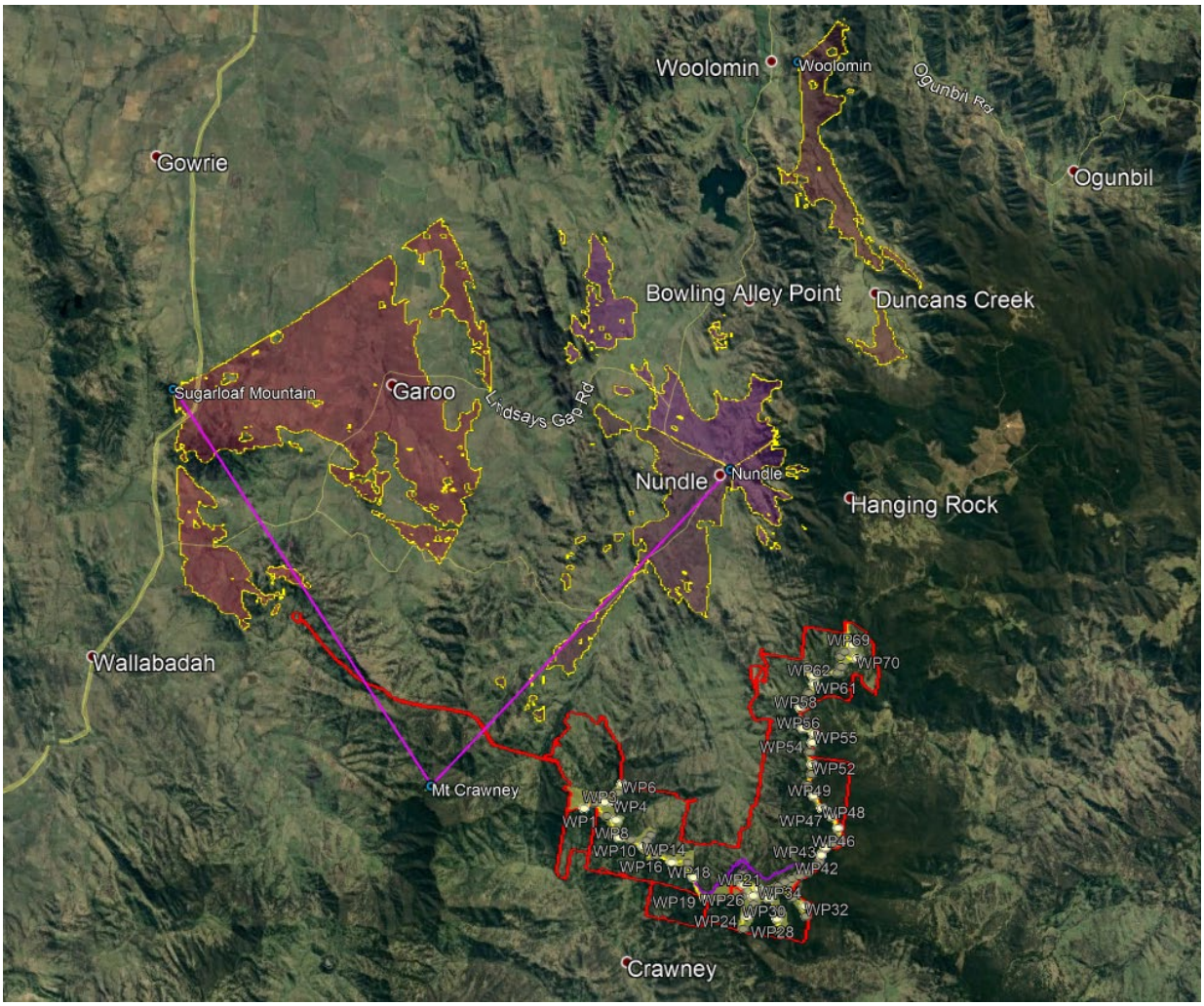


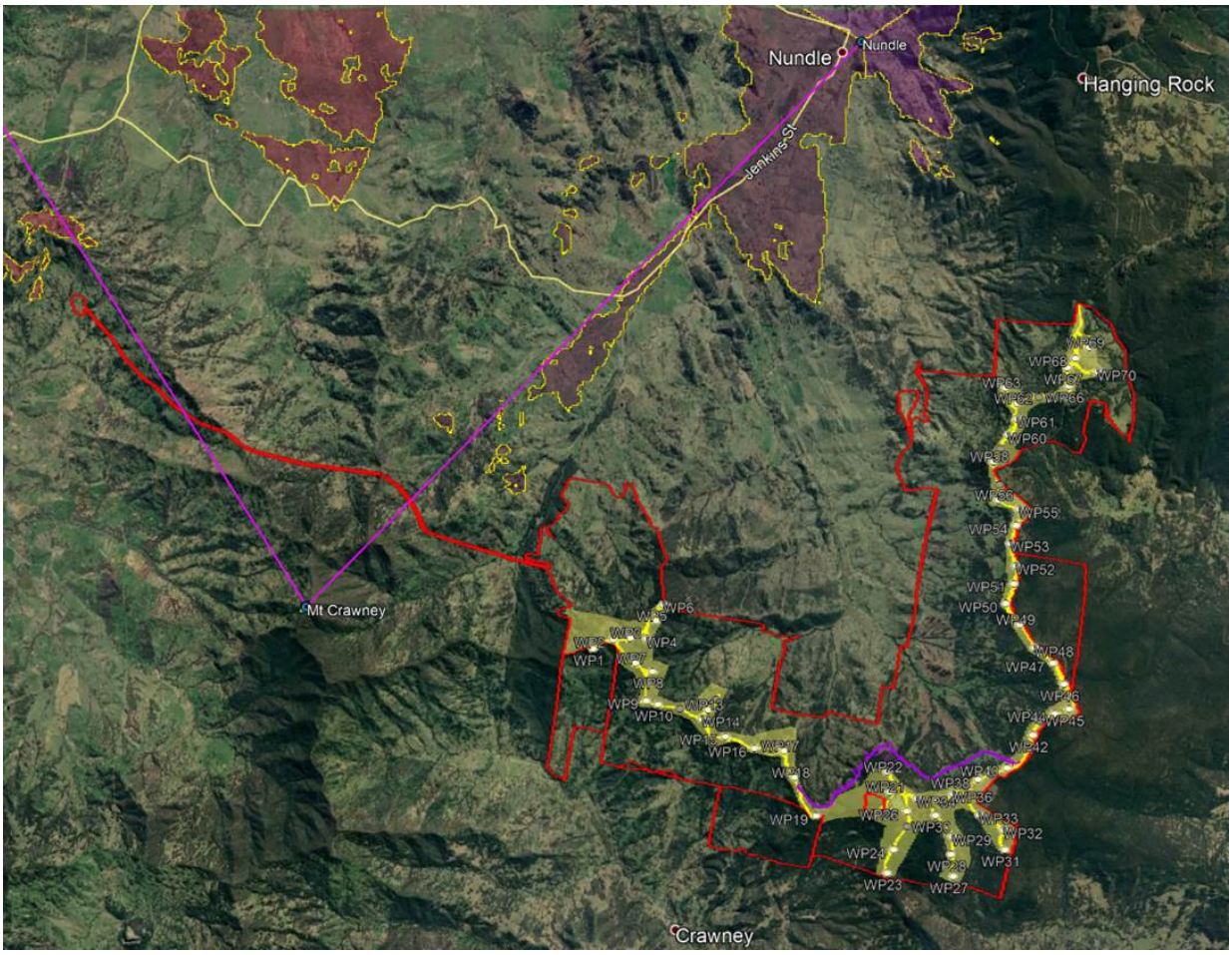
ATTACHMENT 14 – SES LINK VERTICAL PATH PROFILE SHOWING POWER LINE CLEARANCE



ATTACHMENT 15 – NBN Co LINK VERTICAL PATH PROFILE SHOWING POWER LINE CLEARANCE

ATTACHMENT 16 – NBN COVERAGE AREAS OF BASE STATIONS




Nundle
Nundle
Hanging Rock
Jenkins St
Mt Crawney
Crawney
WP1
WP2
WP3
WP4
WP5
WP6
WP7
WP8
WP9
WP10
WP11
WP12
WP13
WP14
WP15
WP16
WP17
WP18
WP19
WP20
WP21
WP22
WP23
WP24
WP25
WP26
WP27
WP28
WP29
WP30
WP31
WP32
WP33
WP34
WP35
WP36
WP37
WP38
WP39
WP40
WP41
WP42
WP43
WP44
WP45
WP46
WP47
WP48
WP49
WP50
WP51
WP52
WP53
WP54
WP55
WP56
WP57
WP58
WP59
WP60
WP61
WP62
WP63
WP64
WP65
WP66
WP67
WP68
WP69
WP70