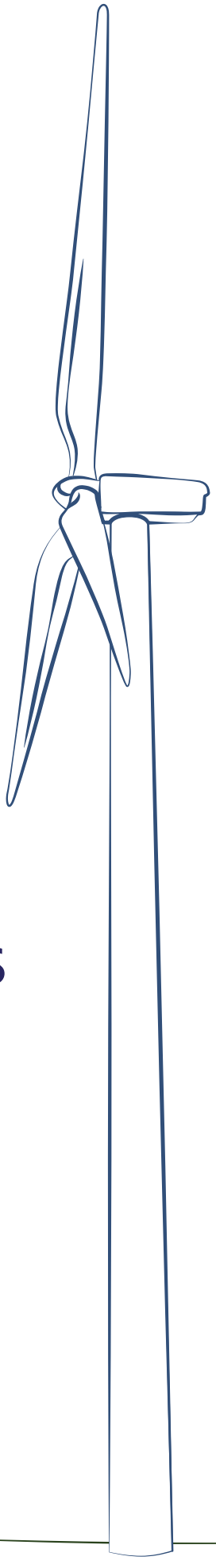


Attachment K

Traffic & Transport Issues

INFIGEN ENERGY

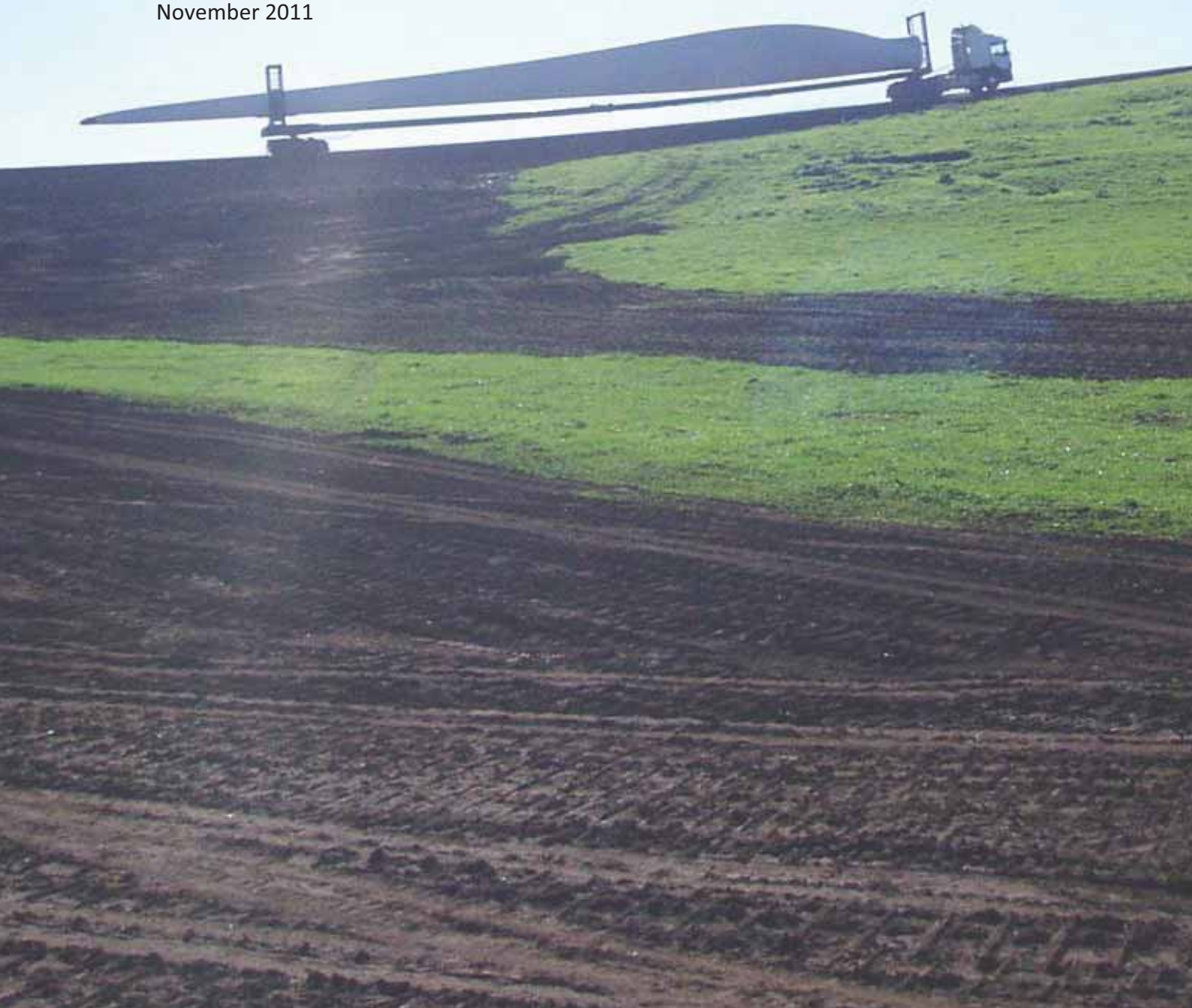
This page intentionally blank.

Bodangora Wind Farm

Traffic and Transport Issues

Revision 1.0: ISSUED FOR SUBMISSION

November 2011



1. Introduction

This chapter of the Environmental Assessment describes the traffic and transport issues associated with the construction and operation of the Bodangora Wind Farm including:

a) the nature and volume of traffic that will be generating from both construction and operation of the project,
b) the proposed access routes to the site,
c) assessment the potential impact on the road network, and
d) proposed mitigation measures to be utilised.

Bodangora Wind Farm is to be constructed on the hills around Mount Bodangora located 15 kilometres north-east of Wellington and around 40 kilometres south-east of Dubbo within the Central West Slopes and Plains of NSW. The project will include 34 Wind Turbine Generators (WTGs), access tracks to WTGs, crane hardstands, site electrical reticulation (underground and overhead), construction compound, an operation and maintenance centre and a substation for connection to the grid.

1.1 Methodology

This assessment of the nature and volume of project traffic is based on the proponent's prior wind farm construction experience and industry standards with reference to:

- NSW Roads and Traffic Authority (RTA), Heavy Vehicle Mass Limits, July 2010
- RTA, Vehicle standards information, Revision 4, November 2007
- RTA, Operating Conditions: Specific permits for oversize and overmass vehicles, version 2 August 2008

The proposed access route to the site was reviewed during site visits to Bodangora and a desktop study of publically available information on road conditions and RTA guidelines including:

- RTA, Travel Restrictions Vehicle Routes; Maps 10, 11, 16, 18, Newcastle, Kurri Kurri and Dubbo, July 2011
- RTA, Route Assessment Guidelines, May 2002
- RTA, RTA Special Permits Unit – Peak Hour, Clearway & Transit Lane Travel, September 2009

1.2 Legislative Requirements

The following section describes the legal and planning requirements that are applicable to transportation to and from the wind farm site and to road improvements to the surrounding network (should they be required).

In NSW, the **Road Transport (Vehicle Registration) Regulation 2007** limits the overall dimensions relating to width, height and length, and some internal dimensions of vehicles.

These dimension limits are set to ensure that vehicles using the road network have adequate manoeuvrability and are compatible with the road systems and other road users. However, vehicles that are constructed or used for specific applications may be allowed to operate under the **Road Transport (Mass, Loading and Access) Regulation 2005** (referred to as the 'MLAs'), or permit notices.

Permits may be required under **Section 138 of the Roads Act 1993** for underground cabling that may be required under public roads surrounding the project site, intersection widening and construction of access points to the site. All underground cabling and road improvement works in road reserves will be designed and constructed in accordance with applicable Council and RTA requirements and Australian Standards.

1.3 Planning Context

The Preliminary Environmental Assessment was submitted to the Department of Planning on 14th October 2010. On 12th November 2010 the Department issued the Director General's Requirements (DGR). The DGR's addressed in this report are:

> *The EA must assess the construction and operational traffic impacts of the project including:*
>
> *Details of the nature of traffic generated, transport routes, traffic volumes and potential impacts on local and regional roads (including impacts on the structural integrity of the road network), bridges and intersections, including any proposed road upgrades and repairs and taking account of relevant Council road policies;*
>
> *Details of measures to mitigate and/or manage the potential impacts, including measures to control soil erosion and dust generation by traffic volumes;*
>
> *Details of site access roads including how these would connect to the existing road network and any operational maintenance or handover requirements.*

Furthermore, the **Wellington Local Environmental Plan 1995** outlines the following objective with regard to transportation in the area:

> *TRANSPORT—to maintain the arterial road system and railway and airport to provide an efficient traffic network for the movement of goods and people.*

1.4 Approval and Permit Requirements

Restricted Access Vehicles (RAVs) are those vehicles, including combinations, which exceed either a general access dimension or mass limit:

a) Oversize (longer than 19 metres, wider than 2.5 metres or higher than 4.3 m or
b) Overmass (gross mass in excess of 42.5 tonnes)
Ref: Road Transport (General) Act 2005

RAVs may only operate under a permit or notice issued by the RTA Special Permits Unit.

Vehicles between 4.3m and 4.6m high do not need a specific permit, however a copy of the 4.6 metre High Vehicle Route Notice 2008 must be carried. In addition the vehicle must only travel on designated 4.6m high restricted access vehicle routes.

The vehicles delivering of the following components are anticipated to be considered RAV and require special permitting; nacelles, hubs, blades, tower sections, transformer, cranes and other plant and transmission poles.

Operators of oversize vehicles must carry the relevant General Class 1 Oversize Notice in the vehicle at all times when operating oversize in New South Wales.

Where height exceeds 5 metres, Electrical Clearance letters must be supplied with the permit application.

1.5 Consultation

Consultation requirements outlined in the DGRs relevant to this report are:

- Wellington Shire Council
- NSW Roads and Traffic Authority

Initial consultation was undertaken on the 25th of July 2011 with Wellington Shire Council regarding the potential transportation issues. The Council and RTA were also provided a preliminary draft of this report for comment. Comments received from Council were incorporated where possible. Comments are yet to be received from the RTA. However, the proponent will continue to liaise with the Shire Council and the RTA with regards to determining the optimum transportation route(s) and developing the mitigation measures. Implementation of the final routes will be in accordance with any conditions agreed with the Council (and other Councils where relevant) and the RTA.

The Construction Environmental Management Plan (CEMP) and the Operational Environmental Management Plan (OEMP) will contain the detailed Traffic Management Plans which will be developed in consultation with the above stakeholders. The RTA will also be the authority issuing permits under the Roads Act.

2. Wind Farm Traffic Generation

In terms of traffic analysis the project has been considered in two distinct phases, Construction and Operation, as the traffic impacts from these two phases have different regimes. Construction will have the larger impact on the road network due to both short term volume of traffic and the sizes of loads. Construction and commissioning is expected to take around eighteen months with deliveries of majority of the major components typically arriving between months six and twelve. Operation will continue from the completion of construction for 25 years.

2.1 Construction Traffic

2.1.1 Loads

Dimensions and loads for the major components are given in the table below.

Table 1: Load Dimensions and Masses

Component	Component Height (m)	Component Width (m)	Component Length (m)	Load (t)	On Road Weight (t)
Hubs/Nose Cone	3.1	3.9	4.5	20	35
Blades	3.0	3.0	55	15	30
Tower Sections	4.3	4.3	26	65	85
Nacelles	4.0	4.0	9.5	120	160
Main Transformer	4.5	4.5	8	120	160
Transmission line poles *(Depending on number of poles per vehicle)*	-	-	20	-	-

It should be noted that dimensions and weights of loads and vehicles cannot be finalised until final turbine supplier and the specialist haulage contractors are selected.

2.1.2 Typical Delivery Vehicles

The following vehicle combinations are considered to include the worst cases for the overmass and oversize. The oversize vehicle (blade delivery) typically has rear wheel steering. Delivery vehicle dimensions will be confirmed in the CEMP along with an assessment of the vertical and horizontal alignment suitability of the access route for the proposed vehicle configurations.

Figure 1: Example vehicle for transformer delivery (Overmass)

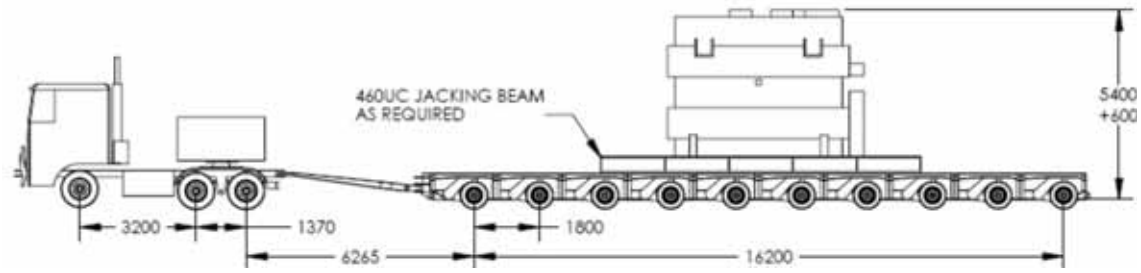
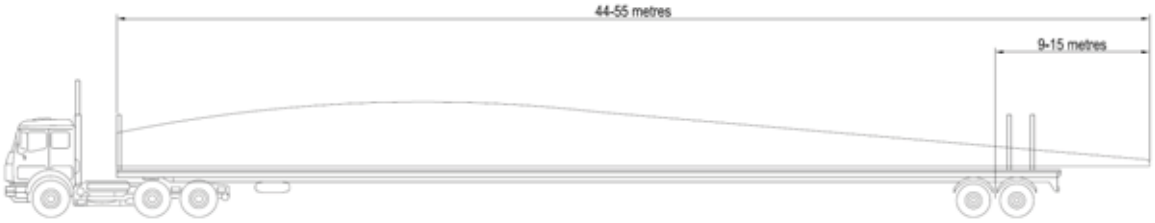


Figure 2: Example vehicle for blade delivery (Oversize)



2.1.3 Traffic Volumes

The following table outlines the expected transport volumes for the construction of the wind farm based on the following assumptions:

- Offsite concrete batching
- Foundations will be gravity type (larger volume of concrete)
- Rock will need to be imported to site for capping of tracks

These assumptions constitute the estimated worst probable case for trip generation.

Table 2: Estimated construction traffic volumes

Phase	Purpose	Vehicle type / Trailer type	No. of one way vehicle movements
Site Set-Up and De-mobilisation	Portacabin delivery and removal	Low loader	8
	Skip delivery and removal	Low loader	4
	Generator delivery and removal	Semi-trailer	2
	Water tank delivery and removal	Truck	2
Roads and hardstands	Delivery of imported capping for roads, laydowns and crane hardstands	Truck and dog	3668
	Delivery of sediment fences, surveying, culverts, riprap and other materials	Truck	12
	Plant delivery and removal: excavators, compactors, bulldozers	Low loader	16
Foundations	Concrete delivery	Concrete agitator	3288
	Reinforcing steel and formwork delivery	Semi-trailer	50
	Foundation bolts or steel insert delivery	Semi-trailer	14
	Plant delivery and removal: 30t to 50t crane and excavator	Low loader	16
Wind Turbine Generators	Tool container delivery and removal	Low loader	4
	Tower section deliveries	RAV	272
	Blades deliveries	RAV	204
	Nacelle deliveries	RAV	68
	Hub deliveries	RAV	68
	Delivery of other WTG materials, i.e. ducting, entry stairs, platforms	Semi-trailer	8
	Main crane (1,000t) mobilisation and demobilsation	Low loader	60
	Trailing crane (200t) mobilisation and demobilisation	Low loader	4
Cable Installation	Cable delivery	Semi-trailer	30
	Backfill material delivery	Dump Truck	290

	Plant delivery and removal: Telescopic handler and excavator	Low loader	8
Overhead Line	Conductor delivery	Semi-trailer	16
	Pole deliveries	RAV	6
	Pole dressing delivery	Semi-trailer	2
	Plant delivery and removal: Telescopic handler and excavator	Low loader	8
Sub Station	Concrete deliveries	Concrete agitator	20
	Switchroom delivery	Low loader	4
	O&M and workshop deliveries	Low loader	8
	Transformer delivery	RAV	2
	Electrical equipment deliveries	Semi-trailer	16
Other	Employee vehicle movements	Light vehicle	11900
	Met masts	Truck	8
	Waste Collection	Truck	104
	Consumables (Oil, Petrol etc.)	Truck	28
	Miscellaneous deliveries	Light vehicle/vans	136
		Total	**20,354**

It should also be noted that although the delivery of the oversize load of turbine blades to site will be by RAV, some custom trailers used for blade delivery can be retracted for their return trip.

2.1.4 Timing

The above volumes will be spread over the 14 months construction period and over the different potential access routes. The morning peak (6am to 7am) would include approximately 30 light vehicles, 3 RAVs and 5 heavy vehicles one way in the hour. It is noted that oversize vehicles and loads are not allowed to drive in some urban areas during designated Peak Hour times. This applies to the metropolitan zone of Newcastle as such additional permitting conditions may dictate hours for delivery to site. Further, RAV transport through Dubbo will be avoided during school drop off and pick up hours.

2.2 Operation Traffic

Once the wind farm is operational there will be a low level of traffic accessing the site. This traffic will generally comprise of to and from work trips by 6 to 10 site staff in light vehicles but may also include periodic visits by other maintenance staff and mobile plant and equipment as required. Overall, the traffic impact during the operational phase will be minor. Local transportation routes will be as per those approved in the OEMP and expected to be the same as those identified in the CEMP and used during construction.

Any RAVs required for major maintenance activities will be subject to the same approval and permitting processes as the construction traffic noted above.

3. Proposed Routes

The site is located about 10 kilometres west of Maryvale train station, which is on the Main Western Railway line. Both road and rail options have been considered, however a review of the option to transport the turbine components from by rail has shown that it is not feasible due to the vertical and horizontal clearances available on the rail system. Even if rail transport were possible it would involve an additional stage of handling to transfer the various items from rail to road transport vehicles at Maryvale for delivery to site, which is not desirable. As such, only road routes have been investigated further.

The following proposed route represents the shortest path from the likely delivery port to the site. Immediately surrounding the site there are a number of alternative access points and internal and external tracks that could be utilised.

The final access routes will be selected in consultation with Wellington Shire Council and the RTA to minimise disruption to local traffic and on-site environmental impacts.

3.1 Points of Origin

3.1.1 WTG Components

The components of the wind turbines; nacelle, blades and hubs will be imported from overseas. The review of the options for transport of components to site by road has considered delivery from the Port of Newcastle primarily with the next viable option likely to be Port Kembla.

3.1.2 Tower Sections

Tower sections for wind turbines may be manufactured in Australia at a number of different locations in Queensland, Victoria or South Australia. Alternatively, if these are imported from overseas they will be arriving at the same port with the WTG components.

3.1.3 Electrical Equipment

Depending on selection of the suitable suppliers, electrical equipment may be sourced from various locations around Australia however it is expected that the main transformer will arrive at the Port of Newcastle and commence road transport from there following the same route identified for the WTG Components.

3.1.4 Concrete and Aggregate

The local quarries located in Dubbo, Mudgee, Molong and Maryvale are potential sources for imported stone and concrete. Examples of supply sources include:

Boral: Dubbo (concrete) Maryvale (concrete and aggregate) and Mudgee (concrete)

Hanson: Dubbo (concrete) and Molong (aggregate)

Holcim: Mudgee (concrete) and Dubbo (aggregate)

3.1.5 Employees and van deliveries

Dubbo and Wellington are the main commercial centres surrounding the project area, as such employee, services and small delivery trips are most likely to originate from these centres.

3.2 RAV access to site

The National and State Highways that could be used for delivery of wind farm components to the project site are important transport routes for freight vehicles, buses and cars, and generally have a speed limit of 100 or 110 kilometres per hour. It is anticipated that pilot vehicles will be required for parts of the transport activities including police escort.

The preferred route for imported components (turbine components and some electrical components) arriving via Port of Newcastle transport is as follows:

Bourke St / Cowper St / Hannell St (Ccl Rds), Industrial Drv (MR316), Pacific Hwy (NH1), New England Hwy (NH15)/ Golden Highway (SH27)/ Wheelers Lane / Mitchell Highway (SH7) / Goolma Road (MR233) (Mudgee Road) / Gillinghall Road.

The route is approximately 450km.

3.2.1 Route Description

Bourke St to Hannell St: The Throsby Bridge is a 5km/hr bridge and no traffic is allowed on it while the load crosses. Right turn on the two lane roundabout. The road is dual lane to the next roundabout.

Industrial Drive to Pacific Hwy*:* there are two traffic lights to avoid with high loads however this route has been used for the construction of previous wind farms and is proven. The right turn onto the Pacific Hwy is has sufficient turning radius available.
There are two bridges to cross at low speed and the road is divided and level for this section.

New England Highway to Golden Highway: There is one overpass over the highway which has a sufficient clearance of 6.2m and the road is level. This section is two lane dual carriageway through to Rutherford and two lane single carriageway through to the Golden Highway turnoff. The roundabouts with Church Street, High Street and Racecourse Road in Maitland and Shipley Drive are two lane and relatively flat and should be able to be negotiated at a low speed.

There is a pedestrian overpass in Maitland that was involved in an accident in early 2009.

Golden Highway to Mitchell Highway: The left turn onto the Golden Highway before Singleton has a dedicated left turn lane. There is a truck stop adjacent to the Golden Highway at this location which could be used to ensure timing of travel is in accordance with permitting. The Golden Highway is largely single carriageway two lane with turning lanes and acceleration and deceleration lanes typically at intersections.

The left turn onto Putty Road/Golden Highway prior to Mount Thorley doesn't have a left turning lane though an acceleration lane is present on Putty Road/Golden Highway. The right turn from Putty Road/Golden Highway onto Golden Highway has a dedicated right turn lane onto the highway on ramp. A further left turn is required onto Denman Road/Golden Highway followed by a right turn at Palace Street.

The Golden Highway continues through two double lane roundabouts in Dubbo, Wheelers Lane and Myall Street as these are relatively straight through and negotiation at

low speed should be possible. However, the roundabout entering Erskine Street requires a slight right turn onto the second exit and the roundabout at Darling Street similarly presents challenging geometry. As such the preferred route is to take a left turn into Wheelers Lane and continue to the Mitchell Highway. This would avoid travelling through the business centre of Dubbo and the geometry is more favourable. There are two double lane roundabouts, with Myall and Birch Streets on Wheelers Lane though these are both relatively straight and should be possible at a low speed.

It is recommended that travel through Dubbo avoid school hours due to proximity of a number of schools including St Mary's Public School on Wheelers Lane.

Mitchell Highway to Goolma Road: The Mitchell Highway is a single carriageway two lane road for the majority of the route. The left turn into Goolma Road has sufficient pavement width and the corner is free from obstructions.

Goolma Road to Gillinghall Road: Goolma Road is an 80km/h single carriageway two lane road and is a B-Double route. The concrete crossing over Mitchell Creek may need further investigation to ascertain any weight restriction which may apply. The left turn into Gillinghall will likely require widening. Currently the intersection is largely free from roadside obstructions and avoidance of property fences should be possible based on the swept path analysis undertaken (refer to Figure 3). Gillinghall Road is currently unpaved. It is recommended that capping stone be added to ensure safety of road users prior to large deliveries.

3.2.2 Tower Delivery Route Description

The above route focuses on deliveries from the Port of Newcastle. Tower sections transported from South Australia to the wind farm site could be via the Sturt, National, Newell and Mitchell Highways to Wellington. Tower sections delivered from Queensland may be transported via the Warrego Highway, Leichhardt Highway and Newell Highway to Dubbo then following the same approach outlined above for the WTG components. These routes have been identified on Figure 1.

3.3 Unrestricted Vehicles access to site

As stated above, and shown on Figure 1, the majority of cars and delivery vans trips will originate in the surrounding centres of Dubbo, Wellington and Mudgee utilising Goolma Road in both directions to Gillinghall Road site access points.

4. Road Network Impacts

4.1 Capacity – Traffic Volume

The New England, Golden and Mitchell Highways are major arteries and are under the jurisdiction of the RTA. The following table is extracted from the 2005 Western Region Traffic Volume publication.

Table 3: Traffic Data

Station	Road	Location	2002 AADT	2005 AADT
93.828	MITCHELL HWY,SH7	AT DUBBO CITY BDY	4448	4165
93.351	GOLDEN HIGHWAY - DUNEDOO RD,SH27	DUBBO-0.3KM W OF MERRILEA RD	4671	3496

Source: NSW Roads and Traffic Authority, AADT for 2005 93.828 was converted from VAX.

The maximum traffic per day to the wind farm is estimated to be in the order of 120 vehicles per day (during foundation concrete pours) in each direction with an average of around 25 per day in each direction outside of the peak period. However, given the points of origin for the different vehicle movements is spread between Newcastle, Mudgee, Wellington and Dubbo, the impact to the volumes on the surrounding highways will be minimal.

The construction stage of the Bodangora Wind Farm project will increase the volume of traffic on local roads. Movements of construction staff to and from the site on a daily basis will also temporarily increase the traffic volumes on local roads.

4.2 Capacity – Strength and Geometry

The delivery of the heaviest equipment will require special trailer combinations, as shown above, to reduce the axle loading.

After detailed design and selection of suppliers and contractors, and as part of the development of the TMP, the requirement for upgrading of the horizontal geometry or pavement for safe access will be investigated by the haulage company. Swept path analysis and if required dry run may be carried.

The following table identifies the areas that will require further investigation:

Location	Issue
Denman Road /Golden Highway, Denman	The turning angle is acute however the geometry appears sufficient given the oversize vehicles may need to enter into the opposite lane to negotiate the turn.
Palace Street / Golden Highway, Denman	Traffic control and may require temporary removal and vehicles may need to mount median strip.
Goolma Road / Gillinghall Road intersection	Swept path analysis was undertaken to prove the geometry of the intersection would allow for delivery of blades to site. The swept path is shown in Figure 3 and proves that the geometry is adequate for turbine blade delivery (worst oversize case). However, it is recommended that the spray seal at the intersection be extended to allow for the increased turning movements.

	 
Crossing of Mitchell Creek on Goolma Road	Investigation into strength rating of bridge required.
Gillinghall Road	Gillinghall road is unsealed and will require regular maintenance by the Contractor during the construction phase. Capping stone may also be required.

4.3 Watercourse Crossings

Marked onsite watercourses will typically be negotiated by the construction of new culverts with inlet and outlet protection. Existing forwards may need to be upgraded for construction due to vertical geometry suitability for delivery vehicles. All works to watercourses will be subject to sedimentation and erosion control measures to be outlined in the CEMP.

4.4 Cabling Crossings

Underground cables will typically run parallel to site access tracks on the wind farm site area. Where underground cables are required to cross the council road of Gillinghall Road, they will be buried and protected in accordance with Council standards as Australian Standard AS3000. Construction works will be carried out in the road reserve under permit (Section 138) with the appropriate traffic controls in place. Likewise, the overhead line crossing of Mudgee/Goolma Road will be designed and constructed in accordance with applicable RTA and Council standards.

5. On-site roads

5.1 Access Points

The locations of the access points identified in Figure 2 have been determined based on:

- adequacy of sight lines along the public road to ensure that operational safety is not compromised while entering or exiting the wind farm site during both the construction and operation phases;
- suitability of existing entries to maximise the use of existing tracks within the wind farm site;
- proximity to turbine locations to reduce required track lengths;
- site topography and other environmental assessment works.

5.2 Layout Considerations

A number of onsite tracks have been identified, micrositing and rationalisation of the roads will be undertaken during the detailed design phase once site geotechnical investigations have been undertaken and environmentally sensitive areas demarcated. As such the layout presented in Figure 2 identifies a number of different options not all of which will be required to be constructed.

On site layout issues considered during the preliminary site layout design include:

- location of new access track works;
- avoidance of environmentally sensitive areas and trees;
- the standard of track work required, including upgrade of existing tracks;
- drainage, erosion and sediment control measures to be incorporated;
- restoration of any temporary tracks on completion of the works.

The proposed locations of the access tracks have been determined in consultation with the respective landowners, and are based on the recommendations of the ecological and heritage consultants while considering the access parameters (grade and alignment restrictions) for the large RAVs. Additional recommendations with regard to minimising any potential impacts on flora and fauna and indigenous heritage with the proposed routes will be addressed by the CEMP.

5.3 Operation Phase

The onsite tracks will require ongoing maintenance grades throughout the life of the wind farm. These tracks will remain private roads and be maintained by the Service and Maintenance contractor.

6. Mitigation measures

As part of the CEMP the construction contractors will develop the Traffic Management Plan (TMP) in consultation with RTA, local councils and other stakeholders, the following mitigation measures shall be further developed.

6.1 Traffic Control

Traffic control measures to be included where appropriate will include:

- provision of traffic control personnel, pilots and police escort with specific control arrangements where large vehicles are required to execute difficult or potentially unsafe manoeuvres on public roads;
- restrictions on the timing of some large equipment and materials deliveries to site to mitigate specific local impacts. In particular the following measures may need to be adopted:
  - restriction of traffic movements to avoid RAVs passing schools during the school zone periods and to avoid RAV movements conflicting with school bus operations;

  - local deliveries to the site during daylight hours only to mitigate safety problems on local roads and to reduce disturbance for residences near to the access roads;
- establishment of an inspection and maintenance program for the local road access network to ensure condition of roads are maintained in safe state;
- road access/occupation permits used if upgrade works are require to the public road network.

6.2 Notifications

The implementation of a community information and awareness program will assist in managing the traffic impacts. Prior to construction commencing and during the construction period, a program of consultation shall be initiated to ensure the local residents are fully aware of the construction activities, with particular regard being given to construction traffic accessing the site. This program may include elements of the following as appropriate to the phase of works:

- press releases in the local newspapers;
- specific newsletters and individual letter drops to neighbouring residents along the access route to the site;
- provision of a website providing details of the status of works and contact details for any complaints or enquiries.

General signposting of the access roads with appropriate heavy vehicle and construction warning signs shall also be undertaken in consultation with Wellington Shire Council. Specific warning signs may be located adjacent to the entrances to the site to warn existing road users of entering and exiting traffic and this will be supported by the use of escort vehicles for RAVs where necessary, as previously described. The use of day warning notices where signs are activated on a specific day to warn local road users of construction activities will also be considered.

6.3 Onsite Mitigation Measures

Onsite mitigation measures targeted at safety and reducing the impact of onsite transport will include:

- onsite speed restrictions;
- construction of access track routes in proximity to any environmentally sensitive areas to be guided by relevant specialists;
- regular water spray to suppress dust;
- maintenance program for on-site access tracks to ensure safe access;
- implementation of a proactive erosion and sediment control plan for on-site roads, hardstands and laydown areas;
- at the conclusion of the construction phase, any tracks not required for subsequent operation and maintenance of the wind farm will be restored and revegetated.

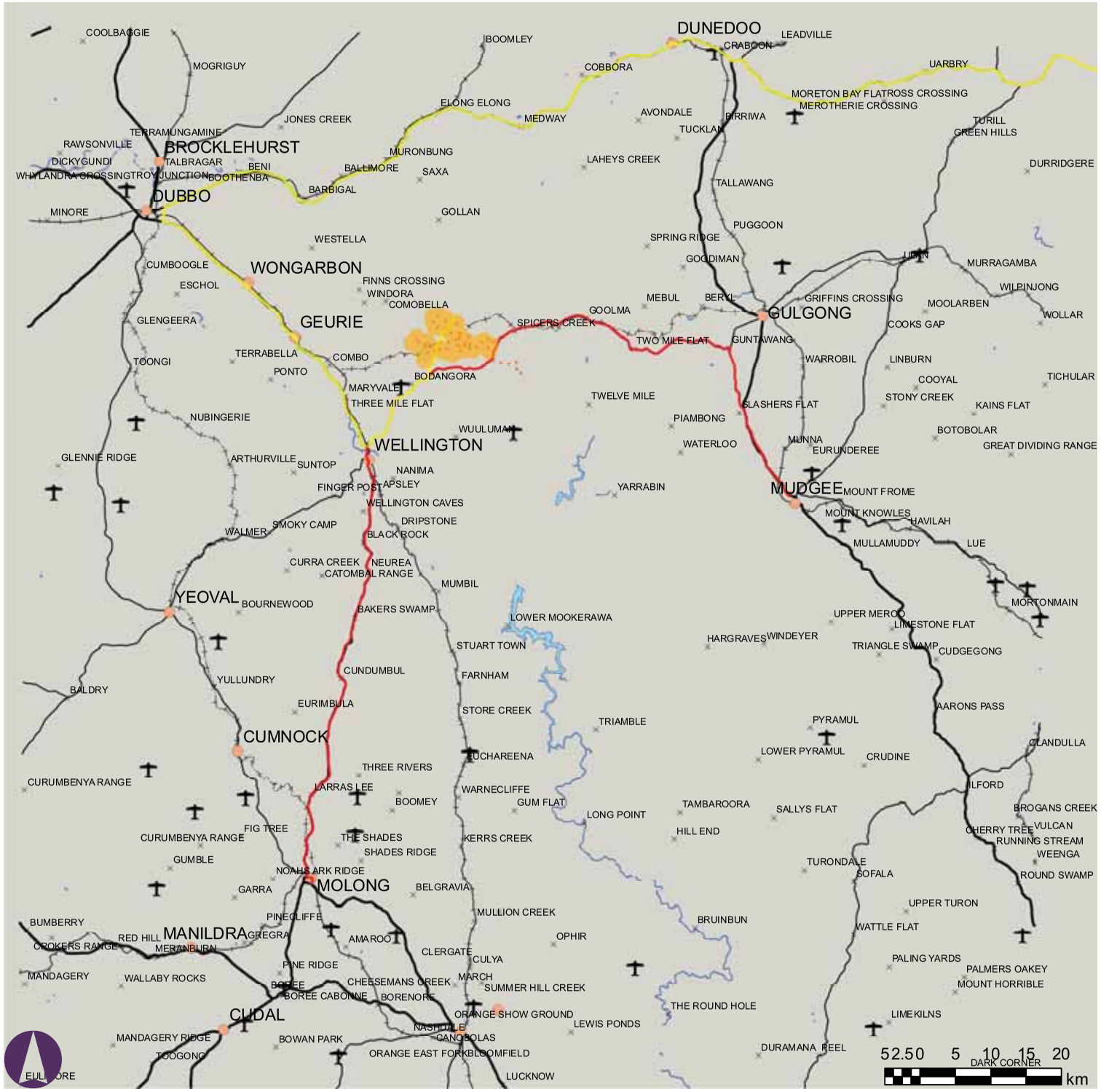
7. Summary and Conclusions

The main issues for traffic management are associated with the construction stage of the Bodangora Wind Farm project, due to the additional volumes of traffic on local roads and the need to use RAVs to transport the wind farm components and associated materials to the project site. The volume increase impact on local roads will be reduced by the fact that construction traffic for the wind farm construction will originate from different locations and as such traffic generation will be spread.

The operational wind farm will require low levels of vehicle access to the site from local roads and accordingly will only have minor impact on local traffic.

Based on this assessment, it is concluded that the traffic and transport impacts associated with the construction of the wind farm can be appropriately controlled to minimise adverse impacts on the local community. In addition, such impacts will be limited to the relatively short periods during the construction phase.

A Traffic Management Plan will be prepared as part of the CEMP to confirm the most efficient access routes to and around the site. This plan will be developed in consultation with surrounding Councils and the RTA. The location of local access roads will be dependent upon the final turbine layout and wind farm detailed design. The assessment will provide for management and mitigation techniques to reduce the impact of traffic movement to and from the site. Further an Operation Traffic Management Plan will be developed for the ongoing operation and maintenance of the wind farm.

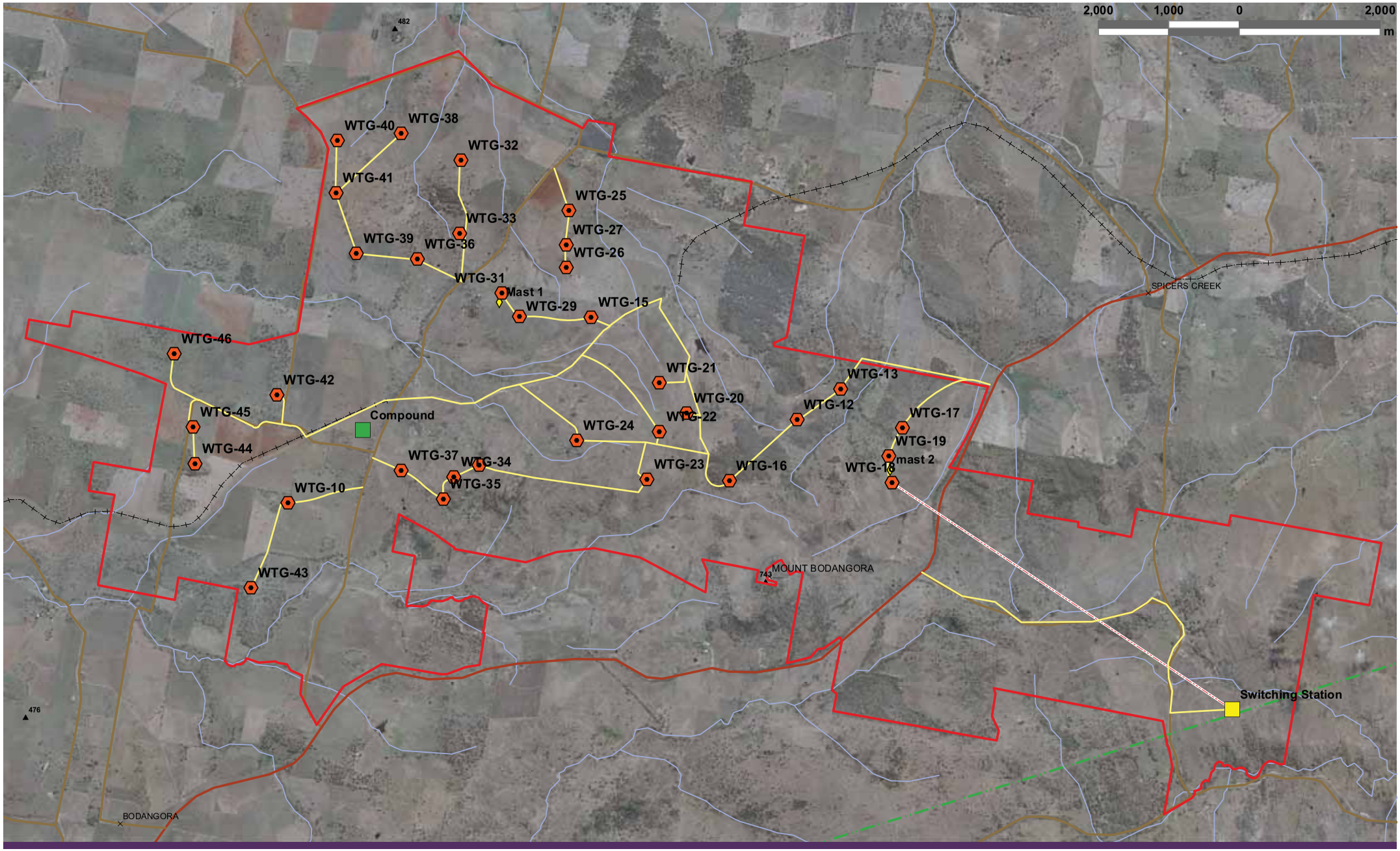


SOURCE: Background information from Geoscience Australia and ESRI

Figure 1: Location and Proposed Access Route Plan

Bodangora Wind Farm

This page intentionally blank.



Proposed Turbine Locations
Proposed Construction Compound
Proposed Switching Station
Existing masts
Proposed Internal Access Tracks
Proposed Overhead Line
Project Boundary
Operational railway
Abandoned Railway
Existing Principal Road
Existing Secondary Road
Existing Minor Road

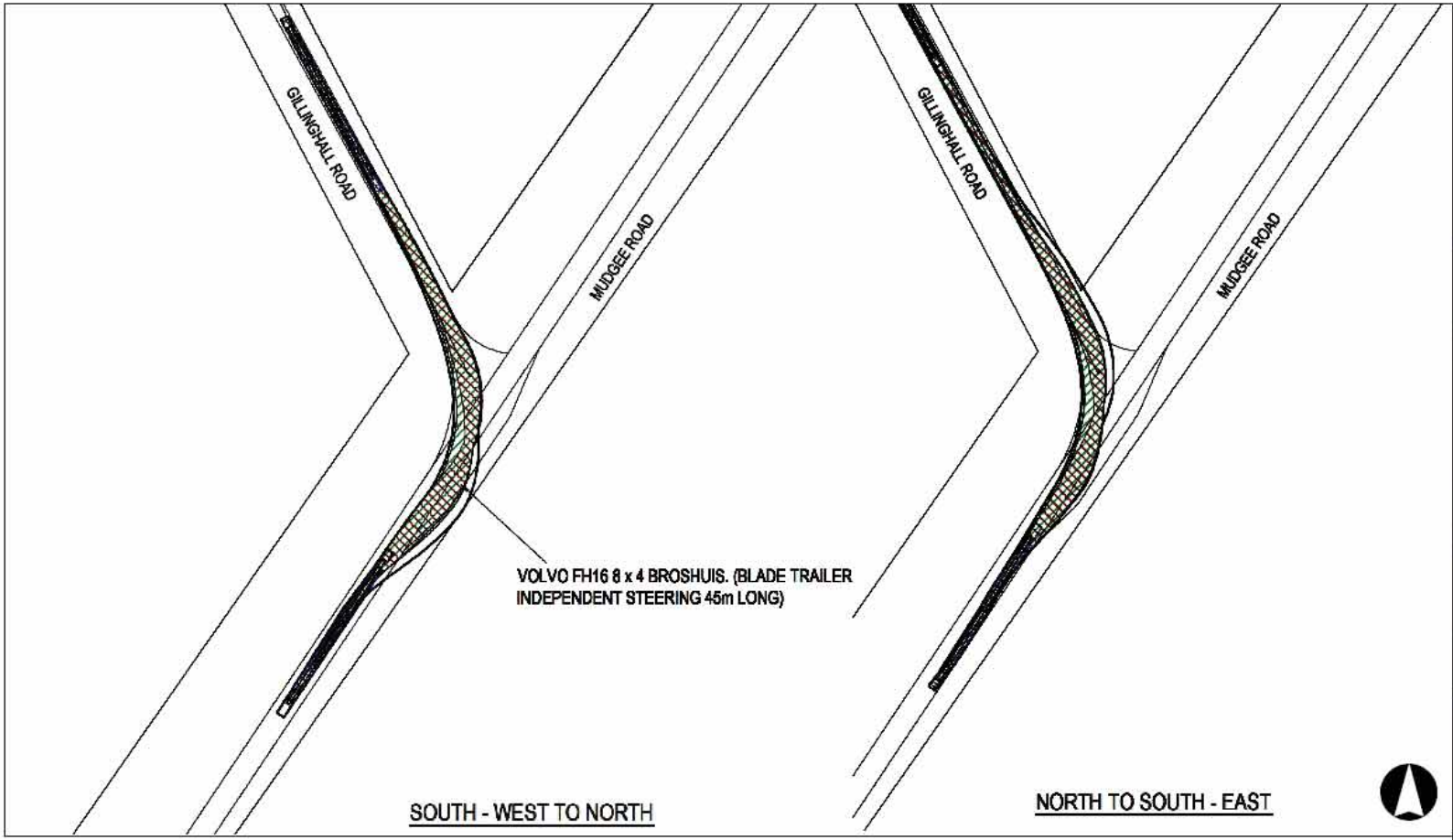
SOURCE: Background information from Geoscience Australia

Figure 2: Proposed Site layout

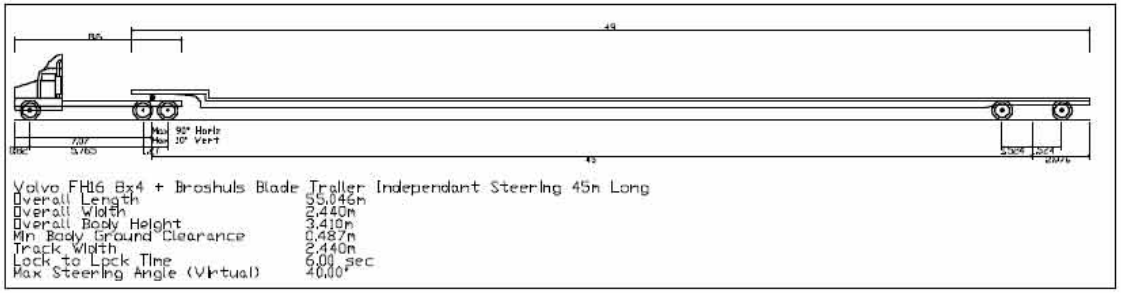
Bodangora Wind Farm

infigen

This page intentionally blank.



Design Vehicle Used (Blade Delivery)



Volvo FH16 8x4 + Broshuis Blade Trailer Independant Steering 45m Long

Overall Length	55.046m
Overall Width	2.440m
Overall Body Height	3.410m
Min Body Ground Clearance	0.487m
Track Width	2.440m
Lock to Lock Time	6.00 sec
Max Steering Angle (Virtual)	40.00°

NOTES:

1. DESIGN VEHICLE = VOLVO FH16 8 x4 BROSHUIS.
2. DESIGN VEHICLE SPEED = 5km/h.
3. TURNING PATH IS APPROXIMATE AND ROAD OUTLINE HAS BEEN CREATED USING AN AERIAL PHOTO.
4. EXISTING TOPOGRAPHY HAS NOT BEEN CONSIDERED.

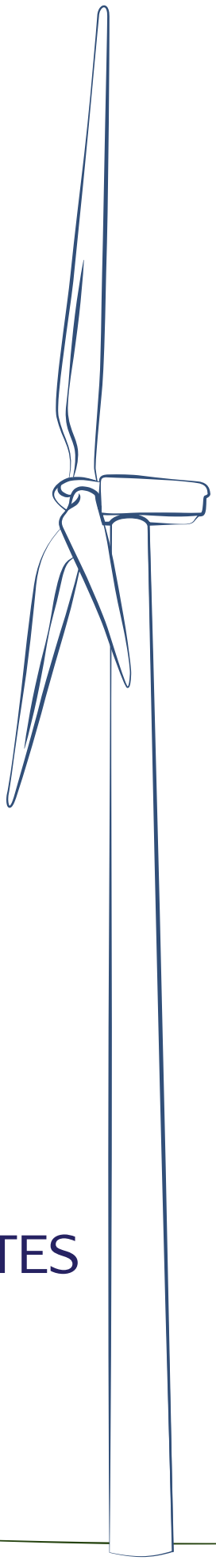
SOURCE: Background information from Geoscience Australia and ESRI
Swept Path Analysis Provided by Aurecon Australia Pty Ltd

Figure 3: Swept Path - Intersection of Mudgee Road and Gillinghall Road

Bodangora Wind Farm

infigen

This page intentionally blank.



Attachment L

Telecommunications Assessment

LAWRENCE DERRICK & ASSOCIATES

This page intentionally blank.

Lawrence Derrick & Associates

BODANGORA WIND FARM - INVESTIGATION OF POSSIBLE IMPACTS ON BROADCASTING AND RADIOCOMMUNICATION SERVICES

[Final]

30th August 2011

L. J. Derrick B. E. (Elec.) ACMA Accreditation No 008
Lawrence Derrick & Associates
Engineering Consultants & RF Frequency Assigners

CONTENTS

1. BACKGROUND

Infigen Energy Development Pty Ltd is proposing the development of the Bodangora Wind Farm in the NSW Wellington Council area. The site is located approximately 15 km north-east of Wellington and about 40 km south-east of Dubbo at the closest point. The project is proposed to contain 25 to 40 turbines. Infigen Energy has sought advice on the Broadcasting and Radiocommunication constraints that occur in the Project Area and surrounds. The proposed wind turbines will consist of tapered cylindrical metal towers of up to 100 metre in height on which are the nacelle and turbine rotor of up to 120 metres diameter. The nacelle will house the generator, gearbox, motors for turning the turbine into the wind and for adjusting blade pitch. As part of the environmental study of the proposal, the potential for disruption to radiocommunications and broadcasting in the wind farm area is being assessed. Clearance distances between any near point to point radio link paths and the turbines are also required to avoid any degradation to the performance of the links. Buffer zones from radio sites within or close to the boundaries of the wind farm are also to be specified where necessary.

2. INTRODUCTION

It is considered necessary to include an assessment of potential impacts of the wind turbines on TV and sound broadcasting reception in the general area of the wind farm from the transmitting stations utilised by residents and to determine if any of the turbines are close to radio link paths traversing the wind farm site. This report covers the outcomes of a desktop study to identify any potential issues and makes recommendations on radio link path and radio site clearances.

3. LEGISLATION AND GUIDELINES

3.1 Commonwealth legislation Under the Australian Radiocommunications Act 1992, “interference” is defined as:

• **In relation to radiocommunications**: Interference to, or with, radiocommunications that is attributable, whether wholly or partly and whether directly or indirectly, to an emission of electromagnetic energy by a device; or

• **In relation to the uses or functions of devices:** Interference to, or with, those uses or functions that is attributable, whether wholly or partly and whether directly or indirectly, to an emission of electromagnetic energy by a device.

In using these definitions, the Radiocommunications Act deals with the radiocommunications interference caused by electromagnetic fields and provides protection for users where such interference is caused. It does not, however, deal with radiocommunications interference caused by physical obstructions.

This report provides best practice guidance about the issues associated with the physical obstruction impacts of wind turbine structures, and details methods for assessing the potential of such impacts. It also advises which stakeholders should be consulted and what sort of information they may require. Mitigation strategies and post-construction monitoring methodologies are also presented. Some guidance has been taken from Appendix F of the Environment Protection

and Heritage Council's (EPHC) draft National Wind Farm Development Guidelines (Ref. 9).

Radiated EMI can potentially be generated from wind turbine generators and the associated distribution power lines on the site. These issues are also discussed in this report.

3.2 NSW Planning Guidelines It is understood that the NSW Department of Planning and other agencies are developing the *NSW Planning and Assessment Guidelines for Wind Farms*. The guidelines will update the *Environmental Impact Assessment Guidelines for Wind farms* released by the Department of Planning in 2004. An assessment of potential telecommunications impacts is also included in the Bodangora Wind Farm Directors General's Requirements in response to the Infigen Preliminary Environmental Assessment of October 2010..

4. DESKTOP STUDY

A desk top study has been carried out on the likely impact of wind turbines and their supporting towers on broadcasting and radiocommunications in the area surrounding the wind farm. This study is based on relevant International Telecommunications Union (ITU) documents and on other professional reports on overseas and Australian experience of wind farm impacts on broadcasting services in the vicinity of any wind turbine structures. For Radiocommunication services sites up to at least 50 Km from the site need to be considered because of the length of point to point paths of up to 100 Km.

Using data from the Australian Communications & Media Authority's (ACMA) RADCOM Database, checks have been made on radiocommunication services within at least a 50 km radius of the wind farm to determine if any of the turbine towers could obstruct line-of-site paths or have any likely detrimental affect on these services. Clearance criteria for ray lines have been indicated for any point to point radio paths crossing or near the wind farm site.

5. BROADCASTING SERVICES IN THE AREA

From ACMA TV and Sound Broadcasting Station listings, and from a map survey of the area surrounding the Bodangora wind farm site, the following is a general summary of the broadcast transmitter site locations and radio frequency channels which provide cover of the area.

5.1 Analogue and Digital Television

It is expected that residents in the area surrounding the wind farm location currently generally view analogue or digital TV from the Central Tablelands or Central Western Slopes National and Commercial main stations located at Mt Canobolas and Mt Cenn Cruiach respectively. These stations are approx. 105 km and 118 km from the wind farm site centre. These conclusions are based on the ABC's web site TV service area predictions for the towns surrounding the wind farm. The station utilised by individual residents for TV reception will depend on the least obstructed path to the transmitters and in some locations reception of channels from more than one station will be possible. A summary of possible channels available from the stations listed is shown in Attachment 2

5.2 Analogue Television Cessation

Digital television signals are currently being radiated in parallel with analogue television signals from the same locations listed in 5.1 under the current programme of transition to digital television in Australia which commenced in 2001. The Government has announced that digital only transmission in Southern NSW will be achieved by 30th June 2012. It is therefore considered that any remedial action necessary for mitigation of any interference to TV reception would need to focus on digital transmission of signals.

5.3 TV Retransmission Stations

Within the study area of approx. 50 km radius there are 4 TV retransmission stations listed that may receive their input signal “off air” from the Central Tablelands and Central Western Slopes main stations at Mt Canobolas and Mt Cenuiach. The potential interference issue is that the path to some of these stations may pass through the wind farm potentially causing interference to the signal which is retransmitted. This is discussed below.

5.4 FM Sound Broadcasting

Central Tablelands FM Services radiated from Mt Canobolas and Mt Cenn Cruiach are predicted to service the general area. It is unlikely that these services will be affected by the proposed wind farm project. FM Stations covering this area have therefore not been listed.

5.5 MF Sound Broadcasting

Some Sydney and the Cumnock and Tamworth Medium Frequency stations will be receivable in the general area. As indicated below, wind farm effects on MF radio are highly unlikely and therefore the stations serving the area have not been listed.

5.6 Satellite Pay Television

Some homesteads in the area may have satellite pay TV or “Free to Air” service antenna installations. Unless a particular subscribers antenna reception direction and elevation is closely aligned with a turbine, which is highly unlikely, no impacts on TV reception are expected.

6. RADIOCOMMUNICATIONS SERVICES

The wind turbine current grid coordinates are listed in Attachment 1. Maps generated from data in the ACMA database are shown in Attachments 3 & 4 Attachment 3 shows all radio sites and point to point links within at least 50 Km of the wind farm and with operational frequencies in the range 40 – 999 MHz (VHF & UHF). Attachment 4 is a similar map for links in frequency range above 1 GHz (microwave). It should be noted that due to the close spacing of adjacent link sites the site number displayed on the PDF maps may not be the appropriate one for a given point to point link due to overlaying of site labels. The wind farm site is shown as a rectangle and wind turbine and near house locations are also shown.

6.1 Point to Point

A large number of point to point links are registered for operation within 50 km of the wind farm site. The only links which cross the wind farm site have one repeater located on one of three separate towers on Mt Bodangora listed on the ACMA database. As shown in the map Attachment 3 here are in excess of 20 UHF/VHF link paths which traverse the boundaries of the wind farm. In fact there are 47 actual radio links registered with multiple links existing on some of the paths.

Attachment 4 indicates that there are 6 microwave links (> 1GHz) with cross the wind farm site, also with repeaters on Mt Bodangora. Clearance requirements are to be met to ensure turbines are not located close to the ray lines of these links to avoid any impact on their performance. The ray lines passing near the wind turbines are shown in zoomed maps in Attachments 5, 6, 7 & 8.

A Photograph of the Mt Bodangora site is shown in Attachment 17

6.2 Cellular Mobile Base Stations

The nearest Optus and Telstra cellular mobile base stations are registered at site 10774, 204201 and 10771 which are 19, 13 and 16 km respectively from the nearest turbines on the wind farm site. At these distances it is considered that the operation of the turbines will have no significant impact on the cellular mobile coverage; however, it is recommended that Optus and Telstra be advised of the wind farm proposal.

6.3 Two-Way Mobile

A number of private and Public Utility mobile bases exist in the area surrounding the wind farm site. These bases potentially provide cover to mobiles in a 360 degree arc from their bases. No significant impact from the wind farm on base coverage beyond normal mobile operational performance is predicted in view of the geographic separation between the base antennas and the turbine structures. Of course, a mobile transceiver unit communicating with a base station when the mobile is located within metres of the wind turbine structures (or indeed near any large building, silo, tower etc) may experience some very local performance change, however moving a short distance would restore performance to normal.

6.4 CB Radio

CB radios are not individually licensed, the equipment being subject to class licensing only. Therefore no records of location or operators of CB radios exist, and the channels are shared without any right of protection from interference. No impact from the wind farm is predicted except perhaps for very local effects to portable or mobile units in the immediate vicinity of the turbines which could be avoided by a small location change of the unit.

6.5 Aviation Services

There are no radar sites listed within the 50 km of the wind farm study area. Air Services, have a registration for a ground – air VHF services at Mudgee. Due to adequate separation distance to turbines no impact to these services is predicted.

6.6 Point to Multipoint (PMP) Systems

There are a number of PMP systems registered in the 50 km radius from the wind farm study area boundaries. The PMP base stations are registered in the ACMA data base however the customer/remote ends are generally not registered for PMP systems, so that it is not possible to check if any turbines are in the paths from the base station to the customer ends. These systems operate in the microwave frequency bands.

6.7 Radio Sites in Close Proximity to Wind Turbines

The only sites existing on or close to the boundaries of the wind farm are the 3 facilities on Mt Bodangora (Sites 250307, 10768 and 10769). Consideration is required on the near field distance separation required for the various radio repeaters on the 3 towers. There are no TV/Radio broadcasting or emergency services paging facilities on the sites which would require consideration of buffer zones

6.8 Met Bureau Radar and Other Services

No registrations for the Met Bureau were found in the area

7. EMI EFFECTS OF WIND TURBINES

The following is an extract from Ref. 1:

"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.

Television Interference from wind turbines is characterised by video distortion that generally occurs in the form of a jittering of the picture that is synchronised with the blade passage frequency.

Effects on FM broadcast reception have been observed only in laboratory simulations."

Point to point links in microwave and lower frequency bands will be affected only if the turbine tower or turbine clearance to the line of site path to the other end of the link is within the second Fresnel zone which 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. 8) proposes 3 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 to Fresnel Zone clearance for certain links with low antenna gain. This has been taken into account for this study.

8. DISCUSSION OF OVERSEAS EXPERIENCE

Observations and studies have been carried out for a number of years in both the USA and the UK on the effects of wind turbines on TV and other radiocommunication services. In 1976 the US Energy Research and Development Administration (ERDA) funded the RadLab at the University of Michigan for investigations into these effects and this continued for 7 years. Ref. 1 summarises the results of theoretical and field measurements.

The BBC's Research Department in the UK has also investigated this subject in some depth, and in 1983 a report was issued (Ref. 2). Another Report (Ref. 3) was issued in 1992 after the Research Department had carried out observations from test transmissions at existing wind farms in Denmark in 1991.

In 1992 the ITU issued a Recommendation (Ref. 4) on the assessment of impairment caused to television reception by a wind turbine.

In a recent exchange of emails, Mr Chris Gandy of the BBC Research Department summarised the conclusions they had come to on this subject as follows - "…..in the UK the only significant broadcast reception difficulties that have successfully been attributed to wind turbines so far have been associated with UHF analogue television, not FM radio and certainly not MF or LF radio. There may be some potential for effects on digital terrestrial television, but possibly only in cases where turbine blades are between the transmitter and the receiver - cases of reflection from the blades are much more common and in the majority of cases should do little damage to our DTT signals because of the guard interval present in each DVB signal. Of course, there will be the odd case where reception was right on the edge of the 'digital cliff' before the turbines were built. Also we have no record of interference with our Digital Radio transmissions in Band III."

Ref. 5 summarises the results of model measurements of the level of interference signals scattered by turbine blades and the supporting tower and confirms some of the backscatter estimates calculated in Ref. 4.

Metal blades were used for some earlier turbines unlike the modern ones where composite material - fibre glass, carbon fibre, plastics are used. In some cases metal exists in the composite material blades for strength reinforcing or for

lightning protection. Some references indicate that the composite blades will have a reduced interference potential, however the BBC view is that at UHF TV frequencies the difference will be small.

It is also indicated in some of the reports that due to variable wind speeds and direction, the resulting changes to turbine blade pitch and turbine facing direction will modify any interference levels at a given location in the service area ie interference effects would be time variant.

In relation to domestic TV reception in close proximity to wind turbines Ref. 7 issued by the BBC/Ofcom in the UK states that “In practice rarely does the tower or nacelle have any effect on reception; the impact on reception is solely on account of the rotating turbine blades. As the blades are moving objects, in terms of both their rotational speed and orientation, their effect is variable and hard to predict. When the combined effects of a number of turbines that comprise a wind farm are considered, the result is considerably more difficult to predict

From a study of the above references and others, the following general conclusions are drawn:

(a) No turbine interference effects are expected to MF radio reception.

(b) There is a very low probability of perceptible interference to FM radio reception

(c) Some interference may be experienced to analogue TV services and particularly where the path to the TV transmitter for a given receiver location is through the wind turbine blades or where there is a partly obstructed path to the transmitter and there is a clear path to a turbine. These effects may be restricted up to a distance of about 3 km from a single wind turbine in forward scatter directions (receiver on opposite side of the wind farm to the TV station). Backscatter may occur up to 0.5 km or so however as TV receiving antennas have a reasonable signal rejection to the rear it is unlikely that TV reception at dwellings in the back scatter zone will experience any impairment.

(d) Digital TV services are unlikely to suffer degraded picture quality, eg, ghosting, where signals have a margin above threshold levels, however a reduction in service area could occur due to time varying reflected signals.

9. BODANGORA WIND FARM SITUATION

From overseas experience, calculations using the University of Michigan method and the topography of the area:

9.1 No interference from the wind farm is expected to the MF and FM sound broadcasting services in the area.

9.2 Theoretical estimates outlined in Attachment 16, of reflections of the typical analogue VHF and UHF TV transmissions from typical transmitting sites by the turbine blades indicate that some possibility of analogue TV picture degradation exists at times for dwellings located such that wind turbines exist within a +/- 20 degree sector (Ref. 6) from the TV antenna nominal direction of

reception, and up to about 3 km from the turbines. Estimates of typical scattering from the blades are based on available data for three blades each have a one sided projected surface area of 67 sq. metres (44 metres long), that the turbine towers will be tapered steel columns about 100 metres high and on using the method outlined in Ref.1. The turbines proposed may have longer blades and so will have a nominal increase in reflected signal level. These measurements overseas indicate that the calculations using the alternative ITU method (Ref.4) over estimate the scattering /reflection so this method has not been used. It is also difficult to estimate the additive effects of a number of turbines distributed over some distance and on the effect of the undulating terrain on the ratio of the reflected signal to the main wanted TV signal. Some neighbouring residences are predicted to have some probability of perceptible TV picture degradation for a percentage of time depending on the direction and speed of the wind.

9.3 Due to the undulating terrain around the wind farm and the possible individual choice of a few TV transmitting stations it is difficult to predict where interference may occur. In general, dwellings to the south of the wind farm and close to turbines are at increased risk of having some interference to analogue TV signals.

9.4 As indicated above, digital television is not subject to ghosting degradation in high signal strength areas, however some reduction of service area could result from reflected unwanted signals at the limits of the service area. There may be some isolated areas which are shadowed by local hills resulting in reduced signal levels; however, such effects are unlikely, but are also difficult to categorically exclude as a possibility.

9.5 There are at least 4 low power TV rebroadcast station locations listed in the ACMA database in the study area.. These stations generally retransmit the TV signals transmitted from Mt Canobolas or Mt Cenn Curiach for local area fill-in coverage. These off air reception situations are not shown on the ACMA database as licensed links, and therefore do not appear on the link mapping. Rebroadcast stations for Dubbo, Mudgee, Wellington and Kandos are in the 50 km study radius and if their input signals passed near to, or through, the wind farm, some interference to input signals and therefore to the TV service areas of each station could potentially occur. However a check of the three paths from Mt Canobolas or Mt Cenn Cruiach to the retransmission sites indicates that they do not cross or come close to the wind farm boundaries. Any disturbance to the input to these TV rebroadcast stations as a result of the wind farm is therefore very unlikely. In some cases individual services are few via a satellite link with little probability of obstruction from wind turbines.

9.6 For satellite pay TV services in the area of the wind farm no interference to these services is likely to occur unless the required pointing of their dish antennas to the serving satellite is also in line with a turbine.

9.7 The ACMA RADCOM database has been studied for services within at least 50 km of the wind farm to determine if any point to point services will have their paths obstructed by the wind turbine blades or the supporting towers. Maps derived from the ACMA database showing radio sites and links in the general area surrounding the site are shown in Attachments 3 & 4. Six microwave radio link paths and in excess of 20 VHF/UHF radio link paths involving some 47 actual

radio links have been identified as crossing the wind farm site. As all of these links have one end point on Mt Bodangora which is located within the wind farm and they all require consideration of turbine clearances. These are shown in zoomed map views in Attachments 5, 6, 7 & 8. Attachment 14 provides sample calculations of the clearance required to achieve 2nd Fresnel clearance near the turbines for the microwave systems and 0.6 X 1ST Fresnel zone clearance in the VHF/UHF cases. In Attachment 15 these Fresnel zone distances have been calculated for a distance from the towers of 10 km to cover the worst case on the wind farm site and provides some margin for error of radio tower grid references in the ACMA database. Except for one all VHF/UHF link paths currently have sufficient horizontal clearance. WTG 10 is shown to have insufficient horizontal clearance to one link path however the vertical path profile indicates that there is sufficient vertical clearance. To determine if any of the radio path ray lines potentially have sufficient vertical clearance over the top of the turbines representative vertical path profiles were generated from digital elevation model data and are shown in Attachments 9 to 13. These show the terrain profile including earth curvature along the radio ray lines. Representative wind turbine structures are superimposed on these terrain profiles representing the turbine tower height plus blade length (150 metres) and have been positioned in the general locations of turbines on the paths. A check of the latest radio link maps in relation to the turbine layout and the vertical path profiles of links paths shown in Attachments 9 to 13 indicate that some links may have adequate turbine blade tip clearance. Horizontal spacings of the distances calculated and shown in the tables of Attachment 15 are however required to be maintained in any micro-siting. Unfortunately not all antenna heights above ground have been listed in the ACMA database so some heights are assumed.

9.8 The closest Airservices radio facilitiy at Mudgee is sufficiently separated from turbines and are of the type not to be interfered with by turbines as they are for ground – air communication

9.9 Microwave Band PMP Systems registrations existing in the study area include Telstra (3.4GHz), Optus, Murray Regional Telecommunications (3.8GHz), Vertical Telecoms (3.8GHz), QEStel (3.8 GHz) Pty Ltd and Allegro Networks (3.8GHz). Most are located at significant distances from the wind farm at Dubbo and Mudgee. The closest operated by Murray Regional Telecommunications is at site 10757 at Wellington. The operators of this system may be in a position to assess if there are any impacts to their individual customers' services.
It is recommended that this organisation be corresponded with to obtain their views of any potential turbine interference potential to their customers.

9.10 The buffer zones required around the Mt Bodangora radio towers are controlled by the greatest near field zone which is determined by calculations related to antenna gain and operating frequency for each radio link. The worst case is for the Australian Capital Television links with 3 metre diameter parabolic antennas and an operating frequency band of 8 GHz. With a near field out to 720 metres from the antenna. There are no other broadcasting or emergency services paging transmitters on the Mt Bodangora towers which would warrant consideration of greater buffer zone distances A buffer zone for the location of any wind turbine recommended is a circle of radius 800 metres around the tower locations.

10. AVOIDANCE OF INTERFERENCE DURING CONSTRUCTION

10.1 There is a potential to cause interference to some microwave links during construction of the wind farm from the use of large construction cranes. These could be erected in locations where the crane tower or boom could traverse across the line of site paths of radio links

10.2 It is understood however that the cranes will normally work within the rotor diameter so that no special procedures will be necessary as the location of turbine towers allows for the operational rotor diameter in the clearances specified. If any movement of cranes is contemplated without dismantling avoidance of the operating radio link paths and Fresnel clearances will be needed.

11. FORTUITOUS RECEPTION OF BROADCAST SIGNALS

On some previous projects Responsible Authorities have imposed conditions such as:

"if the qualitative survey establishes any detrimental increase in interference to reception or transmission measures must be taken to mitigate the interference to return the affected reception or transmission to pre-construction quality" (Waubra Vic Planning Permit No PL-SP/05/0150),
This raises two issues primarily for analogue TV reception, the first being the criteria for interference assessment and the second being the protection of reception of some services outside their designed coverage area - termed fortuitous reception. For analogue television reception which is the most vulnerable service for turbine interference it is proposed to use the ITU grade 4, of a 5 grade impairment scale as the limit of acceptance, which is described as "perceptible but not annoying". On the second point, the ACMA's attitude to protection of reception outside designed service areas is understood to be that the reception is fortuitous and will not be protected. They will therefore plan for reuse of frequencies for new stations which in future may impair reception in areas where it is currently acceptable or useable, often for at least part of the time.

This is, of course, difficult for individuals to accept who, due to their particular location, cannot receive an acceptable service from their planned station. Others may use distant stations to avail themselves of diverse programs. It is not reasonable to attempt to protect these services which are likely to be of low signal level and may vary in quality of reception depending on time of day, weather patterns and season. It is therefore not recommended to mitigate any reception which may be impacted by turbine effects where the receivers are clearly outside the ACMA planned coverage area for the particular service being received.

12. MITIGATION TECHNIQUES

As indicated above, analogue TV will be switched off for Southern NSW by 30th June 2012. This will occur before the completion of the wind farm. Therefore, any mitigation of interference will involve digital television reception and issues like those discussed in Section 11 would not be applicable.

For individuals who experience any degraded FM (unlikely) or TV broadcasting service due to identified interference from the wind farm, possible techniques to reduce the interference to acceptable limits include:

1. Replacement of receiving antenna system with a higher gain more directive model,

2. Reposition antenna in height or horizontally on the dwelling,

3. Install an antenna elsewhere on the property and cable to dwelling,

4. Change the orientation of antennas to receive an alternative station if available, e.g. Central Western Slopes instead of Central Tablelands.

5. Provision of an alternative satellite service eg, the proposed Viewer Access Satellite Television (VAST) (Ref. 10) or Austar Pay TV Service.

6. In certain circumstances, consideration could be given to the installation of a TV or FM Repeater station to provide service to groups of residents in a shadow zone. However this is only likely to be justified for higher density population areas

Potential point to point system and mobile base coverage conflict is not predicted if turbines can be located with recommended clearance zones from radio sites or point to point ray lines. There are 3 identified microwave links passing close to turbines with none closer than the 2nd Fresnel.

Any minor affects to MF broadcasting would occur within 10's of metres of the turbines only and with a buffer zone of at least 500m to any dwelling, no corrective action will be required.

13. CONCLUSIONS

Interference to MF and FM sound broadcasting is not expected.

Potential conflicts between point to point radio systems and the wind turbines identified above will require clearance to be maintained between link ray lines and turbines as proposed in the Attachment 15. The current wind turbine locations with grid references shown in Attachment 1 have acceptable clearances from currently registered point to point radio links and buffer zones from radio sites on the wind farm site are considered to be adequate.

Mobile radio and other radiocommunication services in the area are not expected to be significantly impacted by the wind farm or its operation.

Analogue TV reception at dwellings within about 5 km of the wind farm turbines and with antennas having turbines located with +/- 20 degrees angle of their reception direction will have some probability of noticeable effects at times. Any degradation of reception experienced may be time variant depending on wind direction and speed. However, as analogue TV transmission is scheduled to end prior to construction of the wind farm, this will not be an issue.

Digital TV is not susceptible to visible ghosting degradation where the signal level is above a minimum threshold.The area surrounding the wind farm is expected to be a medium signal area. However there may be a few individual houses located in shadow areas where other mitigating techniques may need to be applied.

Should any confirmed analogue interference problems occur during the wind farm construction period where TV receiving antenna system improvements are unsuccessful, the use of a set top box with reception of the available digital channels may be the best solution. Existing Digital TV services are expect to provide unimpaired picture to any houses near the turbines which may have experienced picture quality problems as a result of ghosting on analogue TV services as long as the signal levels have a margin above a threshold level. However as indicated above the NSW Central Tablelands TV stations covering the areas near the wind farm will be operating as digital only by June 2012 which presumably will be before the wind farm is operational. Provision of digital TV solutions to any degraded analogue reception would be simply advancing an inevitable transition to digital reception.

Alternatively a satellite service could be considered if digital TV reception is unsatisfactory in individual cases. In particular, the proposed Viewer Access Satellite Television (VAST) Service announced by the Government recently would be available to provide a full complement of digital channels including a regional news channel.

Overseas experience indicates that EMI produced by the wind farm generators and controls is not a problem with reputable world class wind turbine manufacturers and therefore no electrical noise measurements from the electrical generators are warranted.

It is recommended that operators of point to point radio systems that cross the wind farm site, PMP operators identified in section 9.9 above, the Commercial Television Station operators in the area, Broadcast Australia for the ABC and SBS and Air Services be advised of the wind farm project to enable these organizations to confirm that there are no potential interference issues seen to be relevant to their operations.

REFERENCES

1. David E Spera, Wind Turbine Technology, Chapter 9 ASME Press 1994

2. J.L. Eaton, R.I. Black, G.H. Taylor, Interference to Television Reception from Large Wind Turbines, BBC Research Department Report 1983/2

3 D.T. Wright, Effects of Wind Turbines on UHF Television Reception, Field Tests in Denmark Nov 1991, BBC Research Department Report 1992/7

4. ITU, ITU-R Recommendation BT805 Assessment of Impairment Caused to Television Reception by a Wind Turbine 1992

5. C. Salema, C. Fernandes, L. Fauro, TV Interference From Wind Turbines Conferencia de Telecomunicacoes April 2001 Portugal

6. ITU, ITU-R, Recommendation BT 419-3 Directivity and Polarisation Discrimination of Antennas in the Reception of Television Broadcasting 1992

7. BBC, Ofcom, UK, The Impact of Large Buildings and Structures (Including Wind Farms) on Terrestrial Television Reception

8. D. F. Bacon, A Proposed Method for Establishing an Exclusion Zone around a Terrestrial Fixed Link outside of which a Wind Turbine will cause Negligible Degradation of the Radio Link, Ofcom UK Report Ver 1.1, 28 Oct 2002

9. Environment Protection and Heritage Council (EPHC) National Wind Farm Development Guidelines (Draft) - July 2010.

10. Media Release, Senator the Hon Stephen Conroy, "Digital Switchover Legislation Passed" 25th June 2010

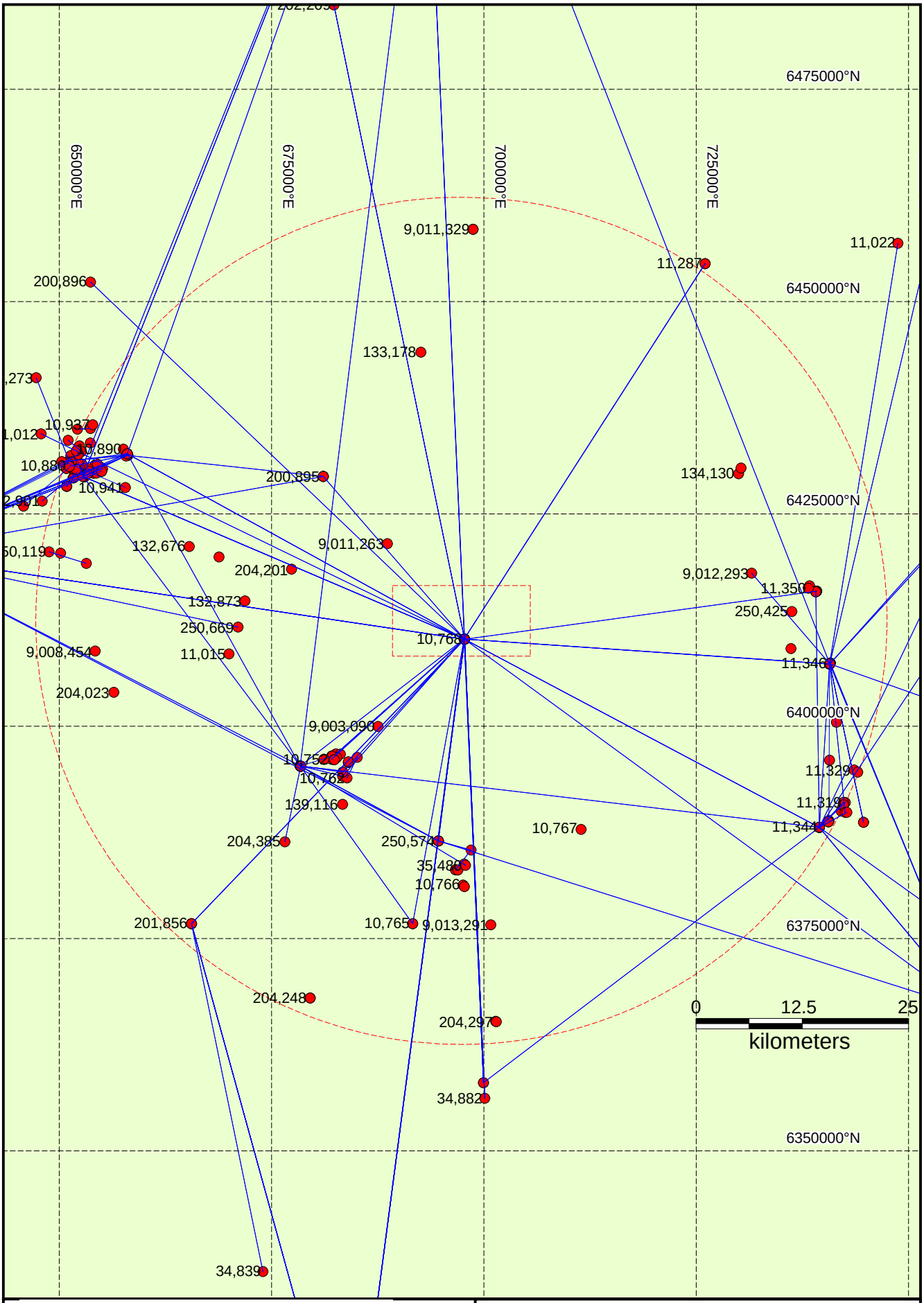
ATTACHMENT 1 –BODAGORA NSW WIND FARM TURBINE COORDINATES

Bodangora Wind Turbine Locations MGA Zone 55			
Turbine No	X	Y	
WTG-10	690990	6411498	WTG-10
WTG-12	698211	6412679	WTG-12
WTG-13	698831	6413115	WTG-13
WTG-15	695291	6414133	WTG-15
WTG-16	697255	6411811	WTG-16
WTG-17	699713	6412565	WTG-17
WTG-18	699560	6411787	WTG-18
WTG-19	699518	6412163	WTG-19
WTG-20	696649	6412773	WTG-20
WTG-21	696262	6413204	WTG-21
WTG-22	696260	6412508	WTG-22
WTG-23	696086	6411834	WTG-23
WTG-24	695086	6412384	WTG-24
WTG-25	694977	6415650	WTG-25
WTG-26	694944	6414839	WTG-26
WTG-27	694935	6415159	WTG-27
WTG-28	694526	6411184	WTG-28
WTG-29	694275	6414144	WTG-29
WTG-30	694083	6411772	WTG-30
WTG-31	694025	6414477	WTG-31
WTG-32	693448	6416362	WTG-32
WTG-33	693423	6415324	WTG-33
WTG-34	693346	6411867	WTG-34
WTG-35	693193	6411552	WTG-35
WTG-36	692829	6414961	WTG-36
WTG-37	692599	6411960	WTG-37
WTG-38	692599	6416740	WTG-38
WTG-39	691963	6415040	WTG-39
WTG-40	691692	6416642	WTG-40
WTG-41	691672	6415899	WTG-41
WTG-42	690833	6413029	WTG-42
WTG-43	690466	6410294	WTG-43
WTG-44	689673	6412056	WTG-44
WTG-45	689646	6412574	WTG-45
WTG-46	689376	6413614	WTG-46
WTG-47	688635	6412811	WTG-47

ATTACHMENT 2 - TELEVISION STATIONS & CHANNELS - BODANGORA WIND FARM AREA

Transmitter Location/service	Operator	Analog Channels	Digital Channels	Comment
Central Tablelands	SBS	30H	42H	UHF
	ABC	1V	36H	VHF/UHF
	CBN	8V	37H	VHF/UHF
	CTC	33H	43H	UHF
	WIN	39H	40H	UHF
Central Western Slopes	SBS	29H	44H	UHF
	ABC	11V	12V	VHF
	CBN	6V		VHF
	CTC	35H	46H	UHF
	WIN	32H	45H	UHF

ATTACHMENT 3 - Radio Link Map 40- 999 MHz Frequencies



SPECTRUM ENGINEERING AUSTRALIA Pty Limited A.C.N. 008 642 028

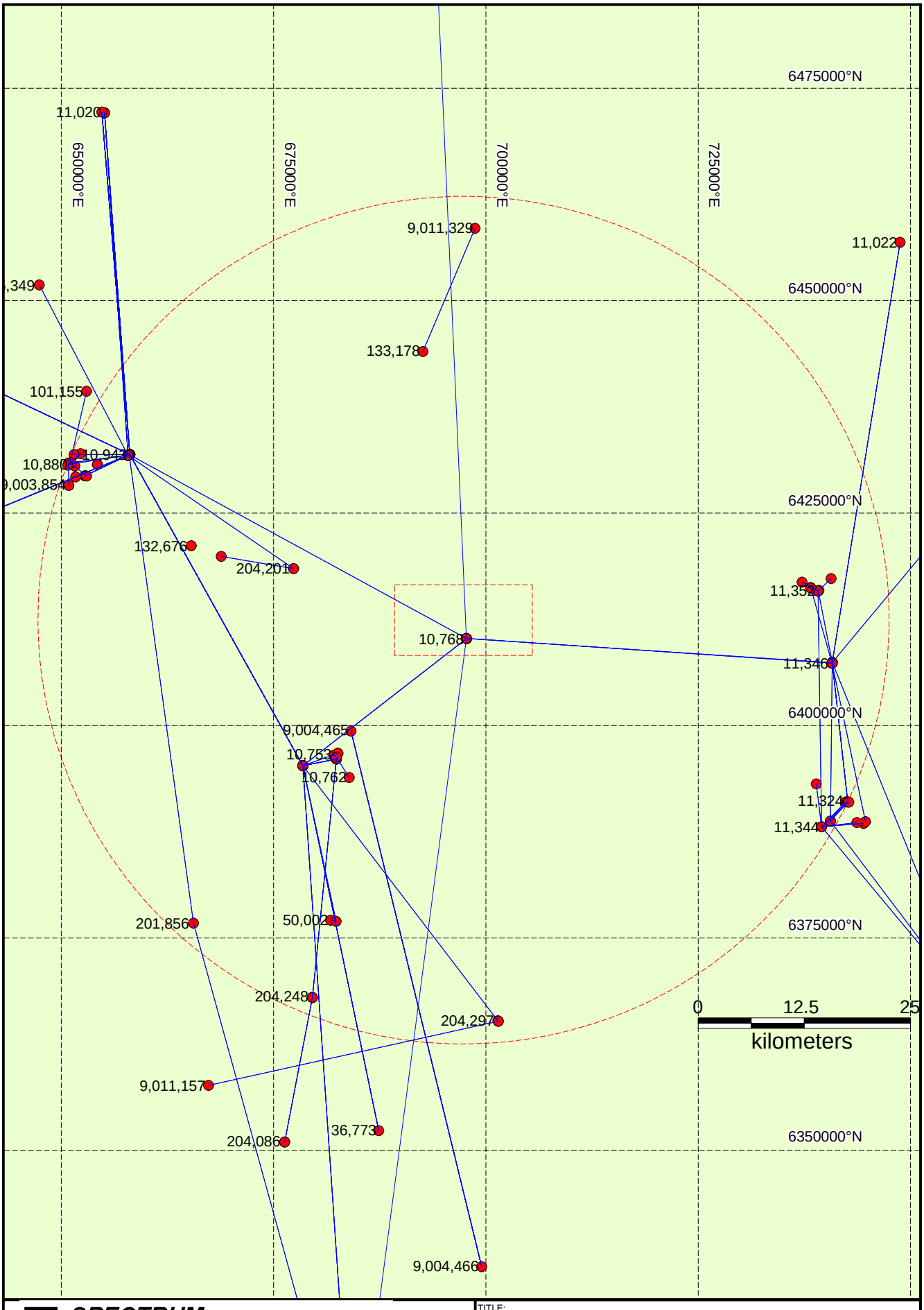
Radiocommunications Planning and Design

Postal: P.O. Box 3213, BELCONNEN ACT 2617
Telephone: 02 6253 2555
Facsimile: 02 6253 2800

TITLE: **40-999 MHz Assignments As Extracted from RRL Database**

FILENAME:	Bodangora 40-999 MHz	DATE:	22/7/2011
PROJECT:	Bodangora	SCALE:	N/A
DRWG NO:	1 of 2	BY:	SEA

ATTACHMENT 4 - Radio Link Map above 1000 MHz Frequencies



SPECTRUM ENGINEERING AUSTRALIA *Pty Limited A.C.N. 008 642 028*

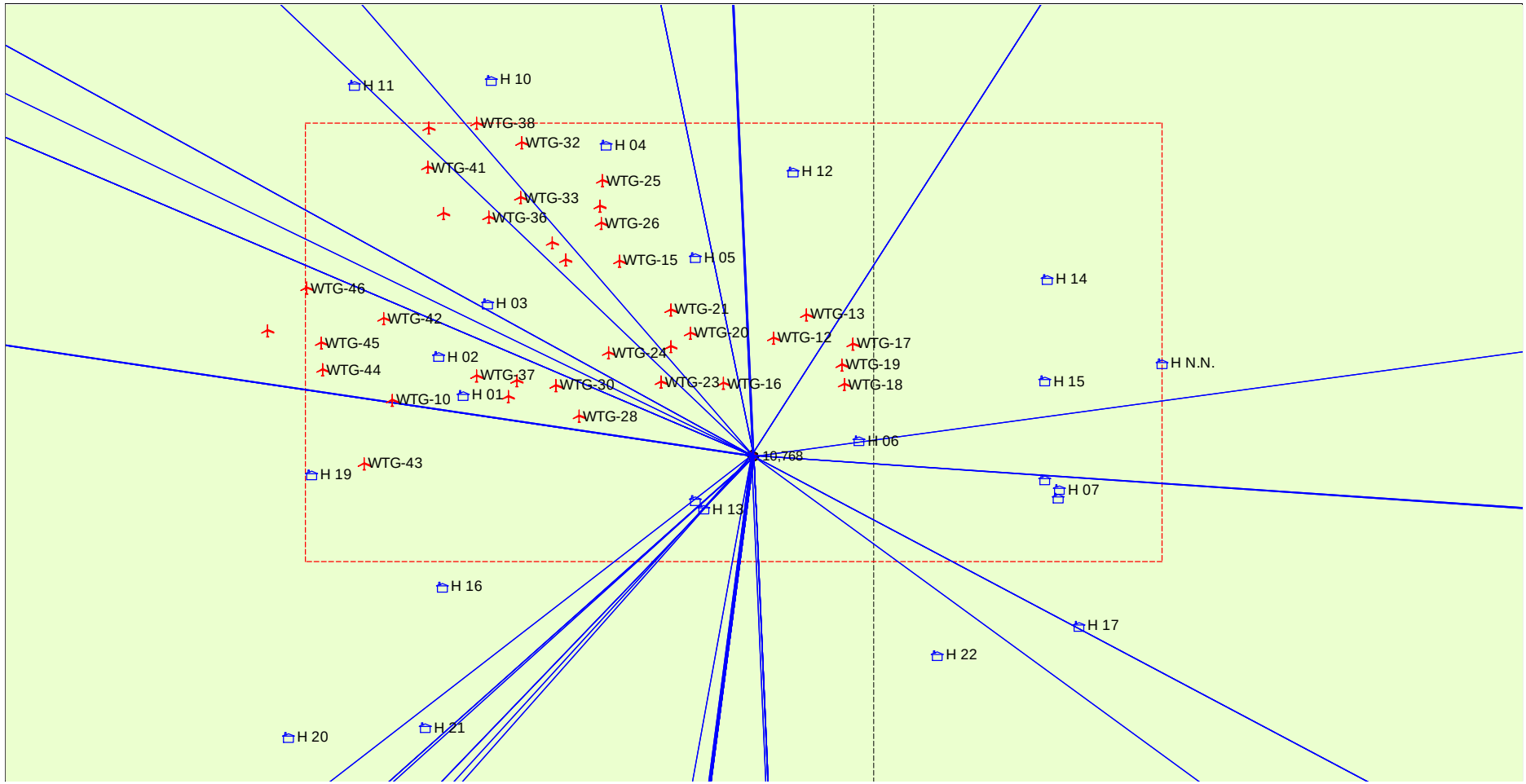
Radiocommunications Planning and Design

Postal: P.O. Box 3213, BELCONNEN ACT 2617
Telephone: 02 6253 2555
Facsimile: 02 6253 2800

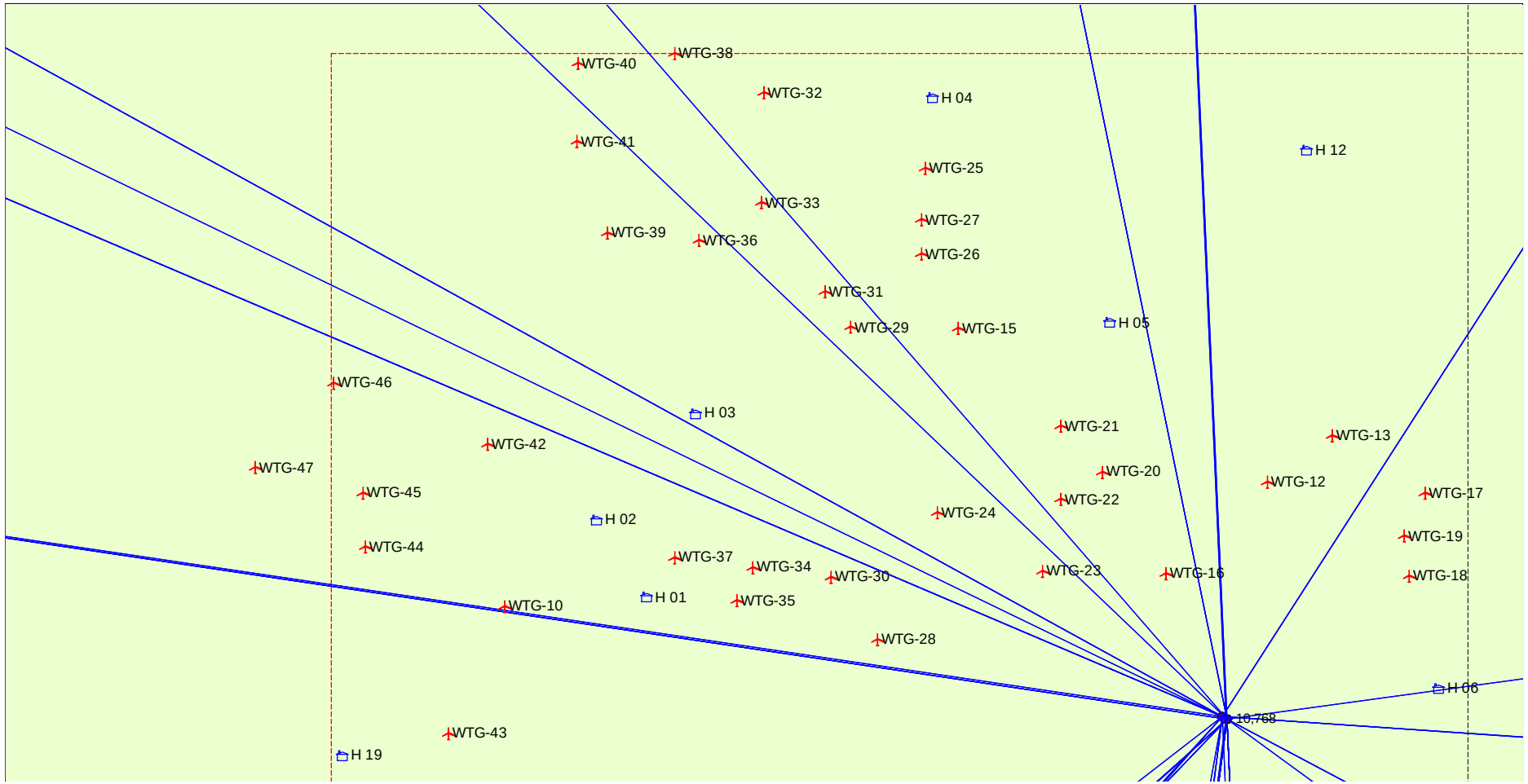
TITLE: **Above 1GHz Assignments As Extracted from RRL Database**

FILENAME:	Bodangora Above 1GHz	DATE:	22/7/2011
PROJECT:	Bodangora	SCALE:	N/A
DRWG NO:	2 of 2	BY:	SEA

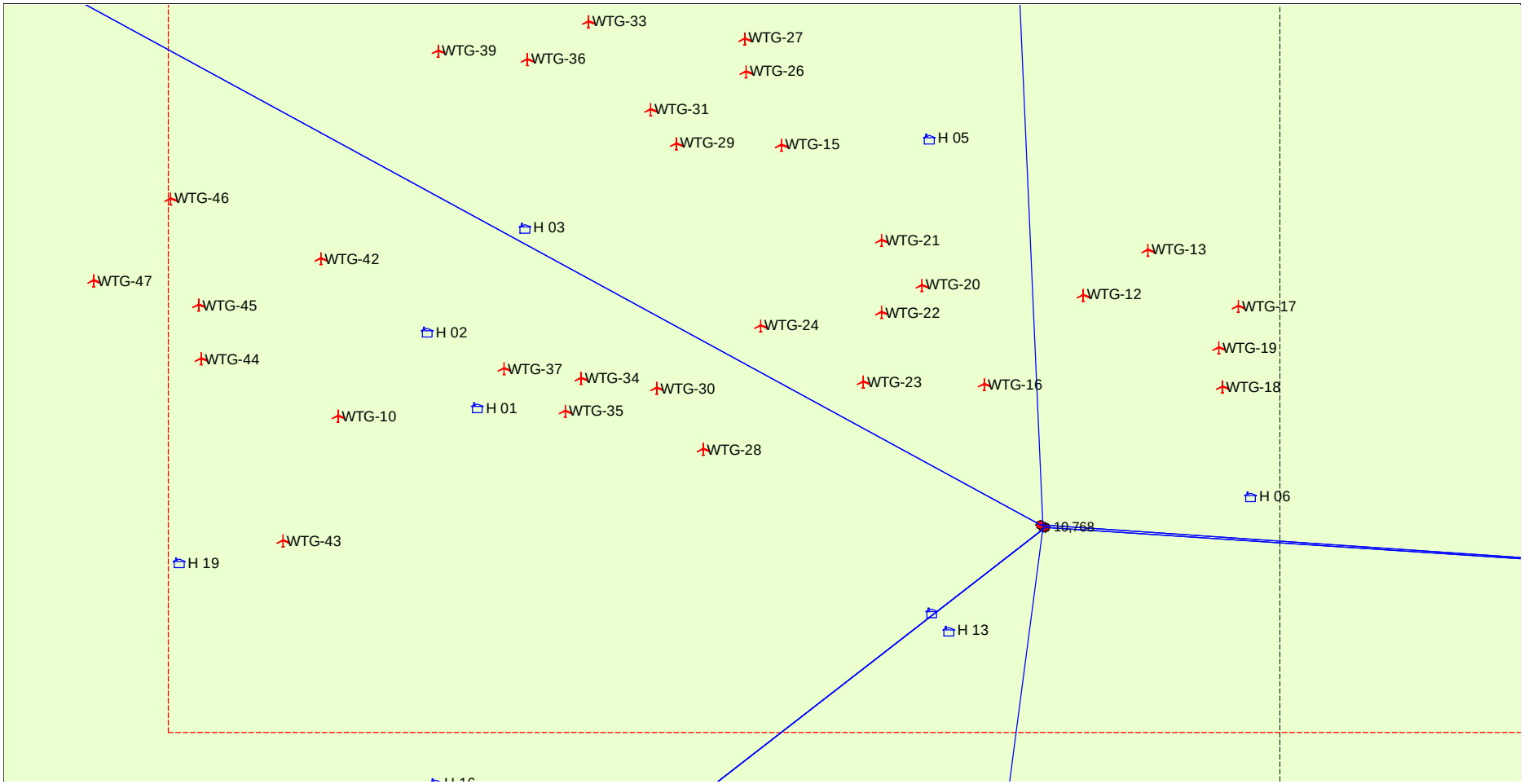
ATTACHMENT 5 – Map of VHF/UHF Radio Link Paths Near Wind Turbines



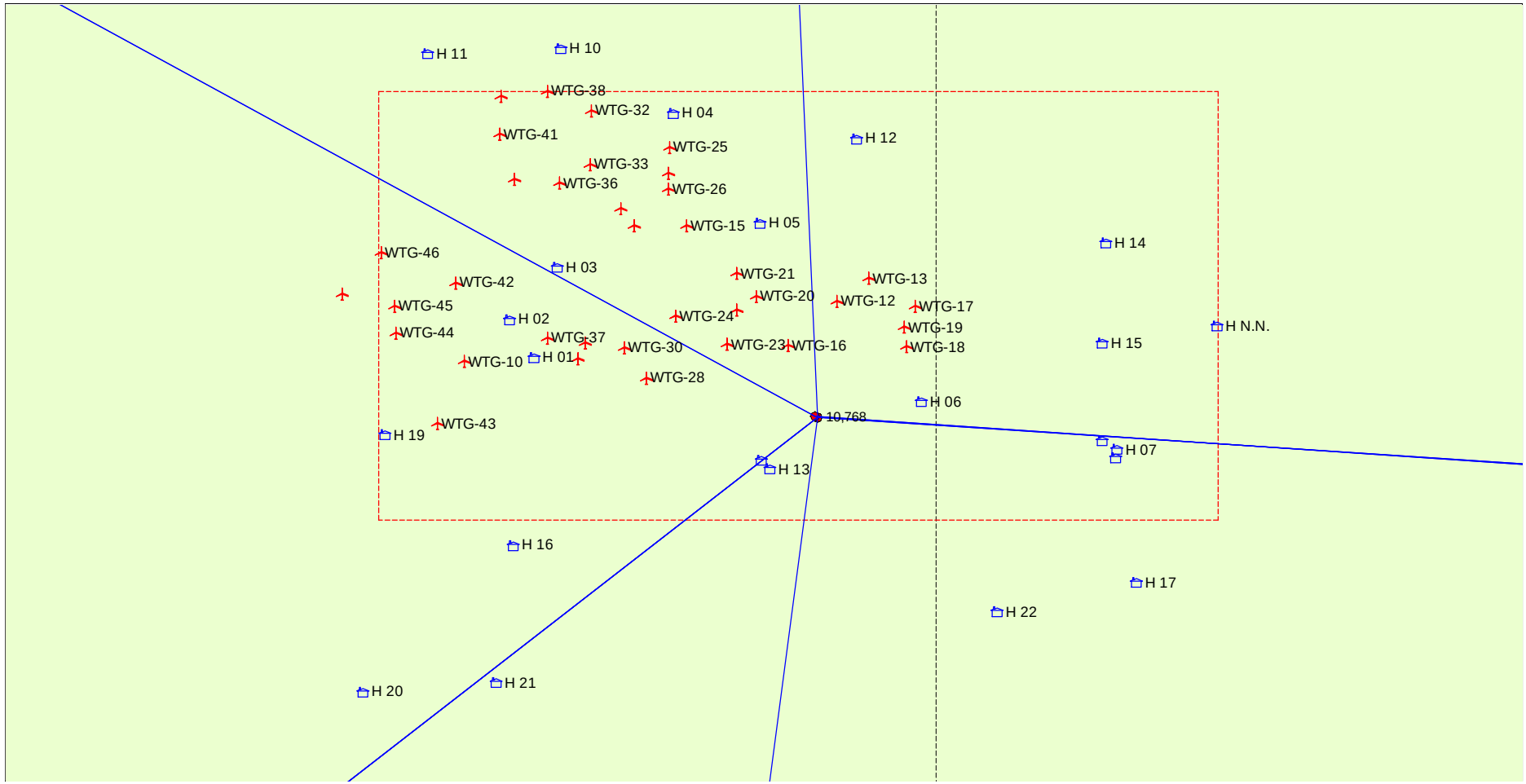
ATTACHMENT 6 – Map of VHF/UHF Radio Link Paths Near Wind Turbines – Detail



ATTACHMENT 7 – Map of Microwave Radio Link Paths Crossing Wind Farm - Detail

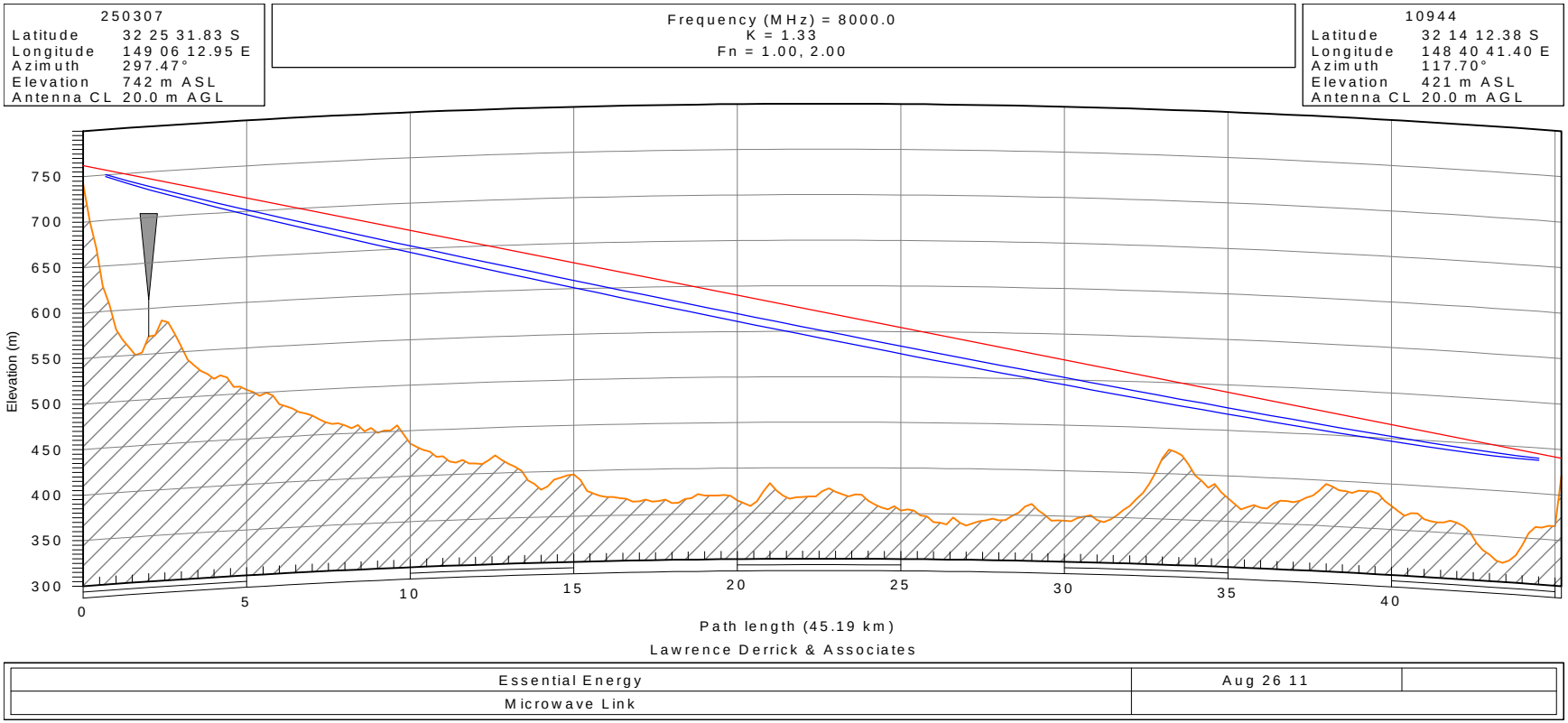


ATTACHMENT 8 – Map of Microwave Radio Link Paths Near Wind Turbines



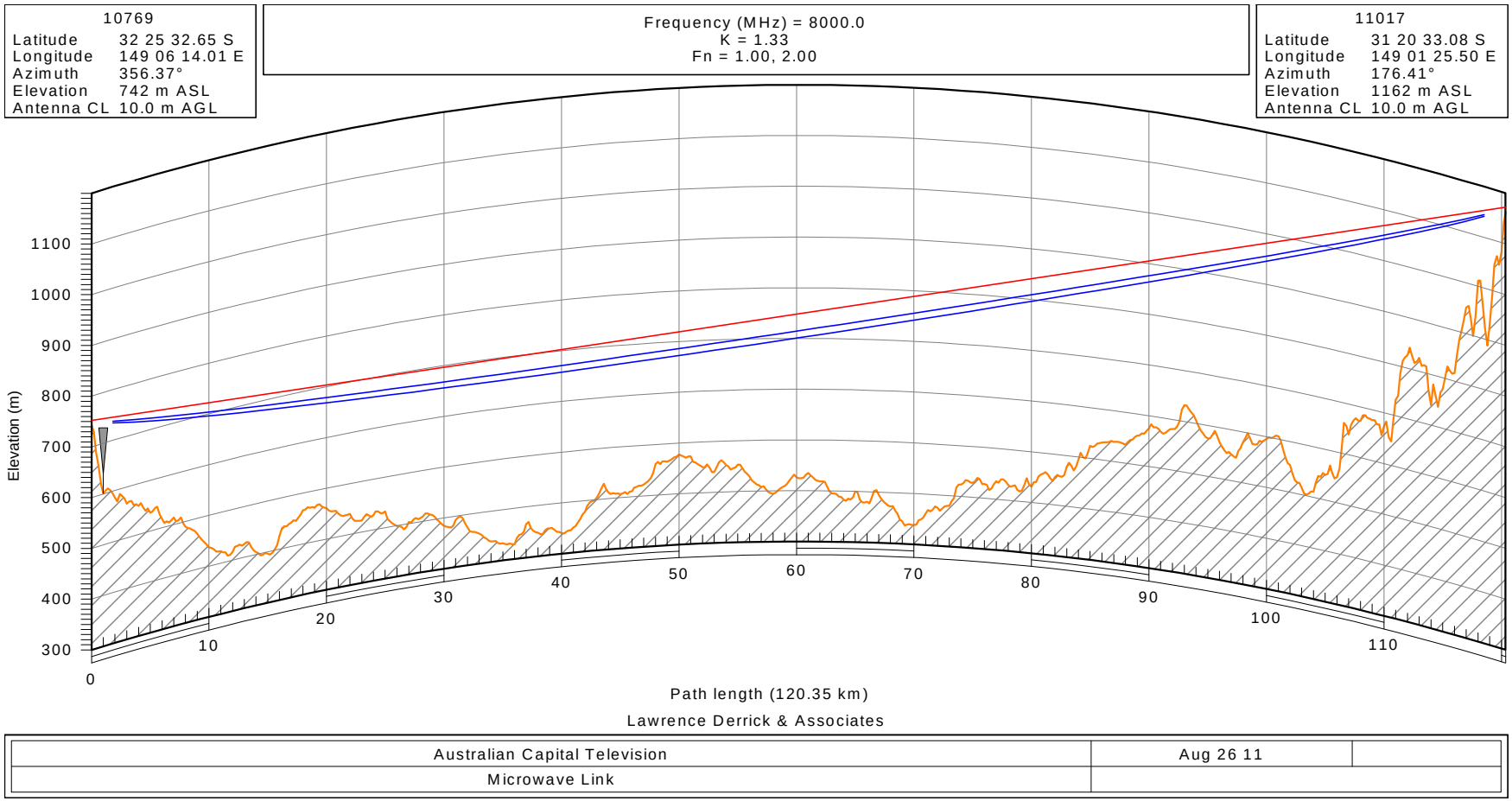
ATTACHMENT 9 – PATH PROFILE ESSENTIAL ENERGY MICROWAVE LINK

Red line – radio path ,Blue lines – 1st and 2nd Fresnel zones



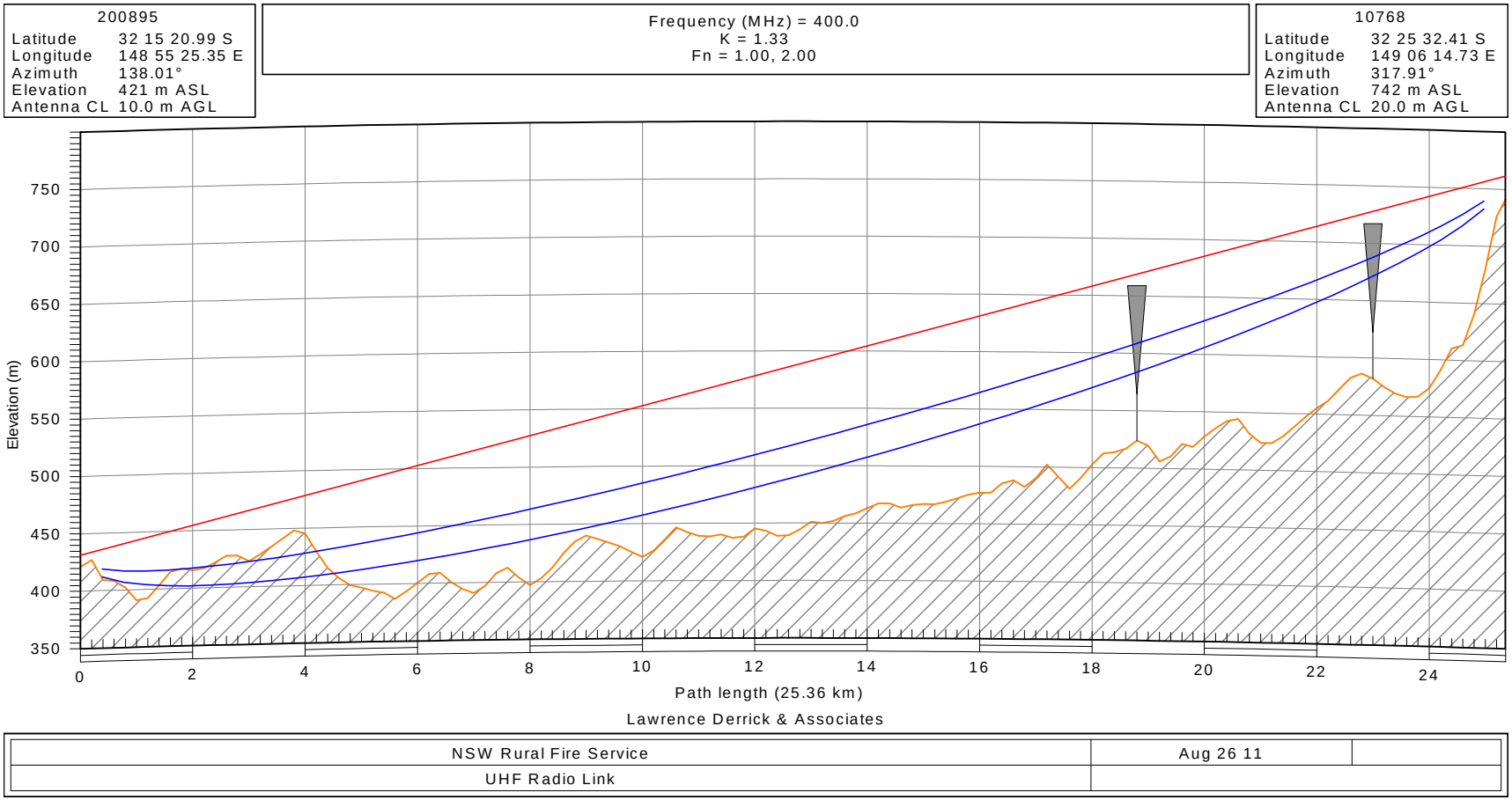
ATTACHMENT 10 PATH - PROFILE AUSTRALIAN CAPITAL TELEVISION MICROWAVE LINK

Red line – radio path ,Blue lines – 1st and 2nd Fresnel zones



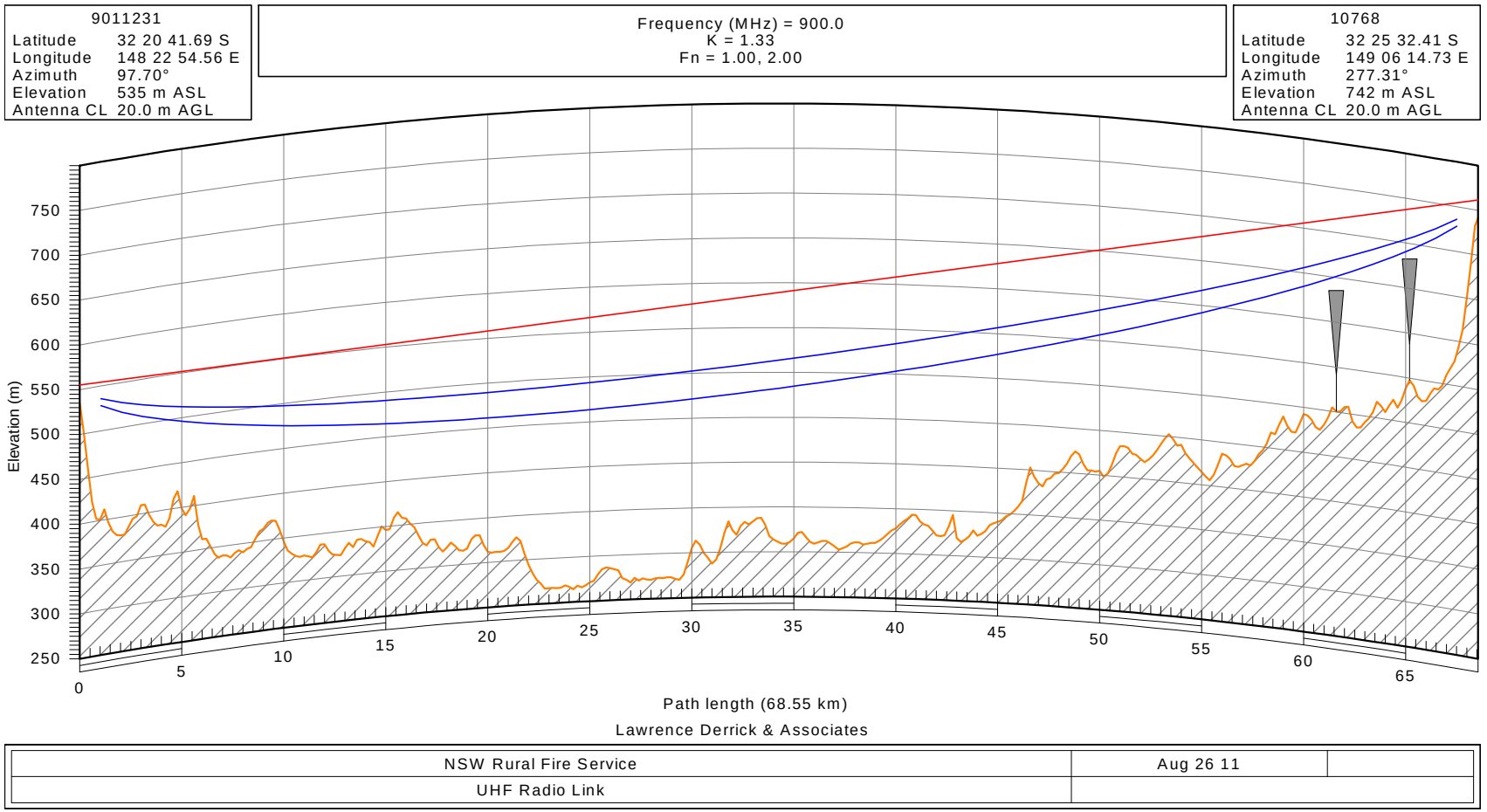
ATTACHMENT 11 – PATH PROFILE NSW RURAL FIRE SERVICE UHF LINK 1

Red line – radio path ,Blue lines – 1st and 2nd Fresnel zones



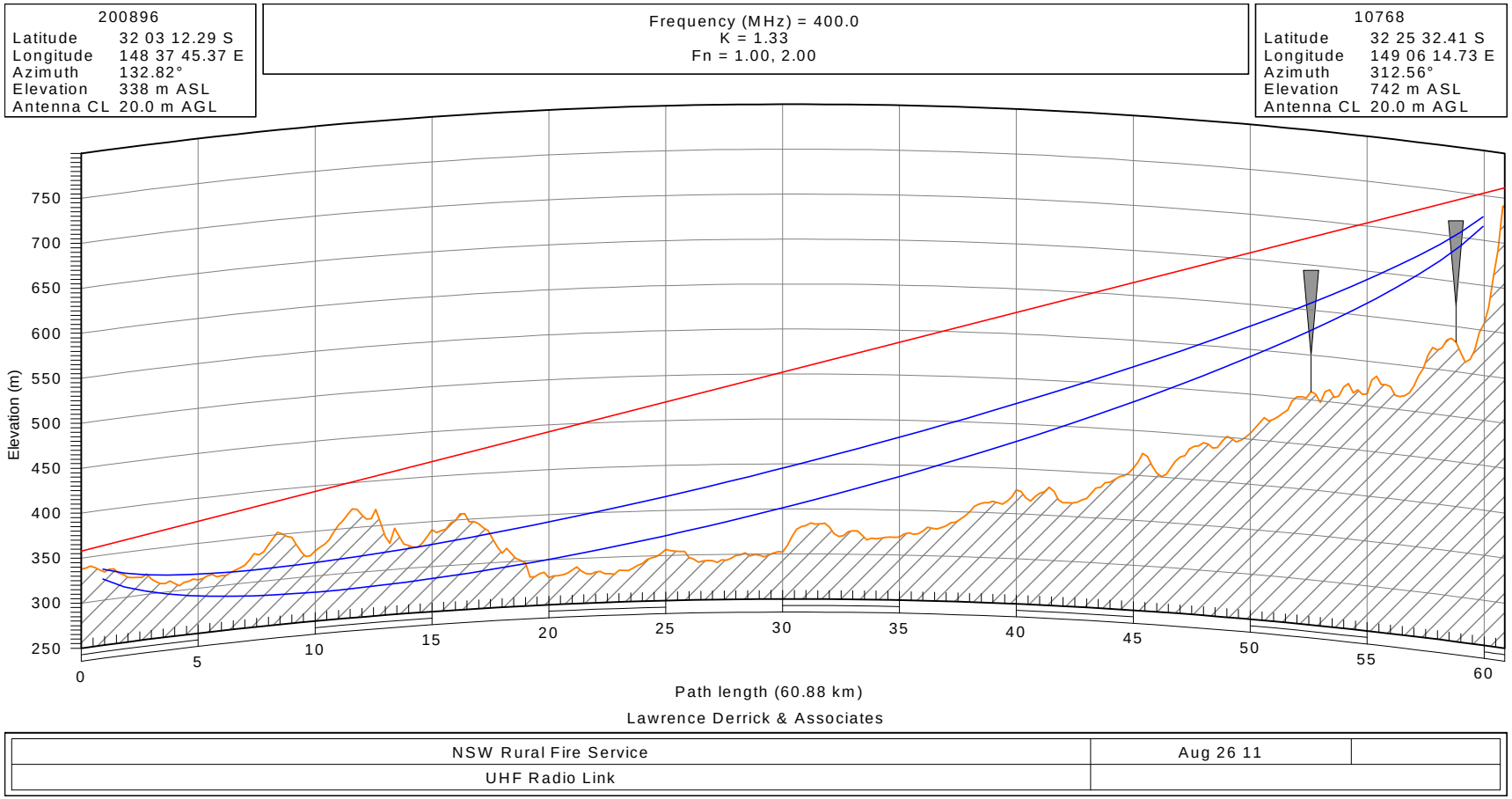
ATTACHMENT 12 – PATH PROFILE NSW RURAL FIRE SERVICE UHF LINK 2

Red line – radio path ,Blue lines – 1st and 2nd Fresnel zones



ATTACHMENT 13 – PATH PROFILE NSW RURAL FIRE SERVICE UHF LINK 3

Red line – radio path ,Blue lines – 1st and 2nd Fresnel zones



ATTACHMENT 14 – RADIO LINK DATA AND CLEARANCES

In the event of a microwave point to point system passing near a turbine the recommended clearance from link ray line to turbine blade tip is the Second Fresnel zone radius calculated using the following formula:

$$\text{Ymin} = \sqrt{2\lambda D1(1 - D1/D2)} \qquad \text{(Ref. 1)}$$

Example Only

1. Site 1 ID 204434 to Site 2 ID 9001068

   Operator: Optus
   Frequency Band 15000 MHz
   Calculated Path Length : 17.85 km
   Clearance to WTG at 3.7 km from near site.
   2nd Fresnel Clearance D1

   D1 = SQRT(2 x λ x d1 x (1 – d1/d2))
   =SQRT(2x (300/15000) x 3700(1- 3.7/17.85))
   = 10.83 metres

The required clearance from the ray line to a tower centreline is 50 + 10.83 = 60.83 metres (at 3.7 metres from the microwave tower)

For a VHF/UHF point to point system the recommended clearance from the link ray line to turbine blade tip can be relaxed to 0.6 X Ist Fresnel Zone clearance as there is less disturbance at the lower frequencies due to blade movements or obstructions generally.

Example only

2. Site 1 ID 10712 to Site 2 ID 10652

$$\text{Ymin} = 0.6\sqrt{\lambda D1(1 - D1/D2)}$$

   Operator: NSW Fire
   Frequency Band 450 MHz
   Calculated Path Length: 38.3 km
   Clearance at mid path
   0.6 x 1st Fresnel Clearance D1

   D1 = 0.6*SQRT (λ x d1 x (1 – d1/d2))
   = 0.6*SQRT ((300/450) x 19150(1-19.15/38.3))
   = 47.94 metres

The required clearance from the ray line to a tower centreline is 50 + 47.94 = 97.94 metres at mid path (19.15 km from either end of link path.)

ATTACHMENT 15 - SUMMARY OF CLEARANCE REQUIREMENTS

VHF & UHF LINKS - REQUIRED CLEARANCES AT 10 km 0.6 X1st FRESNEL ZONE CRITERIA

								Site 1 Grid Ref		Site 2 Grid Ref	
Site 1 ACMA ID	**Site 2 ACMA ID**	**Operator**	**Freq MHz**	**Path m**	**dist m**	**Clearance* m**		**AMG 66 Zone 55**		**AMG 66 Zone 55**	
10769	11017	Australian Capital Television Pty Ltd	852	120350	10000	34.09		697706	6410241	692411	6530484
10769	10713	Australian Capital Television Pty Ltd	852	102230	10000	33.81		697706	6410241	684412	6308876
10768	10712	TransGrid	42.6	120000	10000	152.32		697725	6410248	684363	6308652
10768	34882	NSW Rural Fire Service	413	54250	10000	46.15		697725	6410248	700100	6356200
10768	34882	NSW Rural Fire Service	413	54250	10000	46.15		697725	6410248	700100	6356200
10768	10757	NSW Rural Fire Service	413	20310	10000	36.43		697725	6410248	682575	6396725
10768	10752	NSW Rural Fire Service	413	21120	10000	37.08		697725	6410248	682050	6396100
10768	10792	NSW Rural Fire Service	413	68550	10000	47.26		697725	6410248	629880	6420321
10768	10757	NSW Rural Fire	413	20310	10000	36.41		697725	6410248	682575	6396725

		Service									
10768	9011012	NSW Rural Fire Service	413	55400	10000	46.29		697725	6410248	647875	6434420
10768	201856	NSW Rural Fire Service	413	46450	10000	45.30		697725	6410248	665574	6376749
10768	200895	NSW Rural Fire Service	413	25300	10000	39.77		697725	6410248	681100	6429400
10768	200896	NSW Rural Fire Service	413	60840	10000	46.75		697725	6410248	653700	6452300
10768	34882	NSW Rural Fire Service	413	54250	10000	46.18		697725	6410248	700100	6356200
10768	35200	NSW Rural Fire Service	413	74000	10000	47.51		697725	6410248	757443	6366615
10768	10712	NSW Rural Fire Service	414	102400	10000	48.51		697725	6410248	684363	6308652
10768	10712	NSW Rural Fire Service	414	102400	10000	48.51		697725	6410248	684363	6308652
10768	201856	NSW Rural Fire Service	460	46450	10000	42.92		697725	6410248	665574	6376749
10768	202209	Department of Environment and Heritage	460	76230	10000	45.16		697725	6410248	682361	6484922
10768	202209	Department of	460	76230	10000	45.16		697725	6410248	682361	6484922

		Environment and Heritage									
10768	202933	Wellington Council	460	52430	10000	43.55		697725	6410248	699955	6358011
10768	11344	NSW Police Force	928	47260	10000	30.29		697725	6410248	739505	6388090
10768	152348	NSW Police Force	928	41770	10000	29.75		697725	6410248	739200	6415900
10768	202933	NSW Police Force	928	52410	10000	30.68		697725	6410248	699955	6358011
10768	250690	NSW Police Force	928	45300	10000	30.11		697725	6410248	658028	6432080
10768	10792	NSW Police Force	928	68500	10000	31.51		697725	6410248	629880	6420321
10768	250690	NSW Rural Fire Service	928	45300	10000	30.10		697725	6410248	658028	6432080
10768	9011231	NSW Rural Fire Service	928	68550	10000	31.53		697725	6410248	629922	6420310
10768	250690	NSW Police Force	928	45300	10000	30.11		697725	6410248	658028	6432080
10768	11344	NSW Police Force	928	47220	10000	30.27		697725	6410248	739505	6388090
10768	11017	Department of Environme	931	120340	10000	32.61		697725	6410248	692411	6530484

		nt and Heritage									
10768	41408	Department of Environment and Heritage	931	102290	10000	32.35		697725	6410248	684410	6308825
250307	11287	Essential Energy	413	52700	10000	45.99		697679	6410267	726040	6454467
250307	10761	Essential Energy	414	21570	10000	37.41		697679	6410267	683400	6394125
250307	10945	Essential Energy	414	48600	10000	45.52		697679	6410267	652800	6429400
250307	10945	Essential Energy	460	48600	10000	43.18		697679	6410267	652800	6429400
250307	10945	Essential Energy	460	48600	10000	43.17		697679	6410267	652800	6429400
250307	151198	Essential Energy	460	43060	10000	42.44		697679	6410267	740740	6407338
250307	35475	Essential Energy	460	21210	10000	35.21		697679	6410267	683400	6394600
250307	10765	Essential Energy	460	34150	10000	40.72		697679	6410267	691625	6376750
250307	202933	Essential Energy	460	52410	10000	43.55		697679	6410267	699955	6358011
250307	10773	Essential Energy	460	24410	10000	37.20		697679	6410267	678380	6395320
250307	10792	Essential Energy	928	68450	10000	31.52		697679	6410267	629880	6420321
250307	250574	State Water Corporation	928	24010	10000	26.05		697679	6410267	694650	6386500
250307	10712	State Water Corporation	928	102700	10000	32.40		697679	6410267	684363	6308652
250307	11287	Essential Energy	928	52600	10000	30.68		697679	6410267	726040	6454467

250307	150063	State Water Corporation	928	43110	10000	29.88		697679	6410267	740700	6407300

MICROWAVE LINK CLEARANCES CALCULATED FOR LOCATIONS NEAR TURBINES

Site 1	**Site 2**	**Operator**	**Freq**	**D1**	**D2**	**2nd Fresnel**	**Site 1 Grid Ref**		**Site 2 Grid Ref**		
ACMA ID	**ACMA ID**		**Mhz**	**Metres**	**Metres**	**Metres***	**AMG66 Z55**		**AMG66**		
250307	151198	Essential Energy	8000	10000	43150	24.00391	697679	6410267	740740	6407338	
10768	134618	Soul Pattinson	8000	10000	43150	24.00391	697725	6410248	740785	6407407	
10769	10713	ACTV	8000	10000	120350	26.22369	697706	6410241	684412	6308876	
10768	36772	Soul Pattinson	8000	10000	24410	21.0416	697725	6410248	678450	6395270	
250307	10944	Essential Energy	8000	10000	45190	24.1668	697679	6410267	658000	6431900	
10769	11017	ACTV	8000	10000	102230	26.01223	697706	6410241	692411	6530484	

*Corridor Width is total zone width around radio path where no intrusion of blade tip can occur = 2 x clearances above

ATTACHMENT 16 – PREDICTED INTERFERENCE LEVELS TO TELEVISION RECEPTION

The estimates below of reflection of TV signals from generator blades use the formulas in Ref.1 and the details of a Suzlon S88 generator has been used. This is a three bladed 44 metre radius rotor on a tower of 80 metres in height. Information from Suzlon Energy Australia suggests that the blades have the following details:

Planform Area of each Blade approx 67 m² (calculated)
Coning Angle 4.3 degrees
Twist of Blade 9.9 degrees
Lightning Protection bus inside Blade 60mm² stainless steel

Signal Scattering Efficiency η_S

η_S = 0.8x0.41 x exp(- 2.3Δβ) for non-metallic blades

$\Delta\beta$ = total blade twist = 9.9/180 x π

η_S = 0.8 x 0.41 x 0.67206

= 0.2204

lightning protection 60mm² cable could increase efficiency by 20% so

η_S = 0.264

For VHF TV at on say Channels 7 & 9 (190 Mhz)

Effective Number of Blades for receiver in the back scattering zone

$$B_e = 1 + \sin c\left\{\frac{2\pi R}{\lambda}\sin(2\theta)\cos(k)\right\} \le B_e \max$$

$k = \phi_{RT}/2$ for backward scatter zone

$k = 2\phi_{RT}$ for forward scatter zone

$$B_e = 1 + \sin c\left\{\frac{2\pi 44}{300/190}\sin 2x4.3\right\}$$

= 1.8672

where $B_e \max = 1 + \frac{\lambda R}{A_P}$ (Note 1.)

= 1 + 300/190x44/67 = 2.0369

therefore B_e = 1.8672 is applicable

$$Z_I = \eta_S \frac{B_e A_P}{\lambda D}\cos(k)$$

= 0.264x1.8672x67x190/(300x1000) for D = 1km for the maximum directions

= 0.020917

= -33.6db

= 0.264x1.8672 x67x190/(300x250) for D = 250m for the maximum directions
= .083668
= -21.5db

The required wanted to unwanted signal ratio for a just perceptibly degraded TV picture as a function of the time difference between the wanted and unwanted signals is shown in Fig. 2 of Ref. 4 and varies between 28db (<1μs delay) and 34db(>5μs delay). If it was assumed that the wanted signal strength at the residents' TV antennas was the same as at the generator centre, from the above signal scatter ratio estimates perceptible TV picture degradation would occur up to near 500 metres from generators in the forward scatter area. No TV receiving antenna discrimination is possible in the forward scatter case. As, in fact, the signals at the lower height TV antennas in the close in areas will be lower than at the 80m generator height by, for example 6 db, perceptible interference up to 1.0 Km is predicted.

Similar estimates have been made for other UHF channels. The signal scatter ratios for representative UHF channels are summarised below:
Channel 65 (765 MHz) at 1Km $Z_I = -26.8db$
Channel 34 (570 MHz) at 1Km $Z_I = -29.5db$

The calculations also show that at 250m
Channel 65, $Z_I = -14.8db$.
Channel 34, $Z_I = -17.5db$.

These figures indicate that there is a potential for interference for the UHF channels up to and beyond 1.5 Km from the generators in the forward scatter region.

Scatter from multiple generators would be additive to some degree at each receiver.

Note1. The formula for $B_{e,\max}$ was established for a 3 bladed generator in a recent exchange of emails with Prof. Sengupta, of the University of Michigan, USA, one of the Authors of Ref.1.

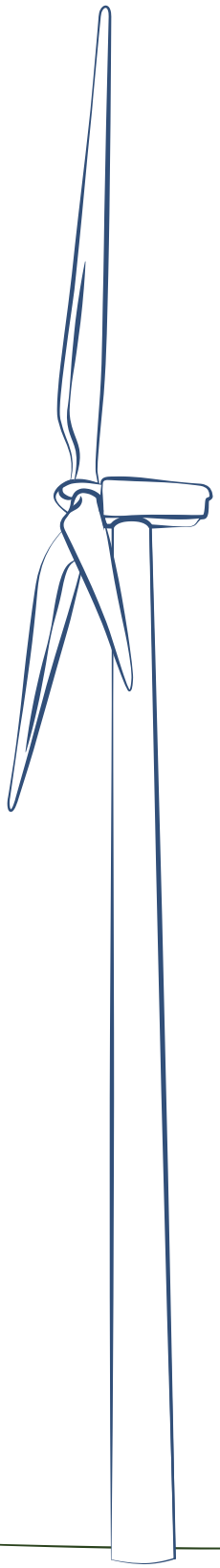
ATTACHMENT 17 - MT BODANGORA RADIO TOWERS PHOTOGRAPH

ATTACHMENT 18- GLOSSARY OF TECHNICAL TERMS

VHF	Very High Frequency
UHF	Ultra High frequency
EMI	Electromagnetic Interference
VHF Channels	TV Channels 0 to 12 (45 - 230 Mhz)
UHF Channels	TV Channels 28 - 46 (526 - 820 Mhz)
Band 111	VHF TV Channels 5A - 12
First Fresnel Clearance	Clearance to obstructions from the ray line on a radio Path which does not produce any additional loss above free space loss
FM	Frequency Modulation
MF	Medium Frequency
LF	Low Frequency (not used for sound broadcasting in Australia)
GSM	European Digital Cellular Mobile System
CDMA	Code Division Multiple Access Cellular Mobile System
ITU	International Telecommunications Union
ACMA	Australian Communications & Media Authority
CB Radio	Citizens Band Radio
VOR	VHF Omnidirectional Range (short range air Navigation aid)

This page intentionally blank.

MASTERPLAN
TOWN + COUNTRY PLANNERS



SOUTH AUSTRALIA
33 Carrington Street
Adelaide, 5000
P (08) 8221 6000

masterplan.com.au

NORTHERN TERRITORY
Unit 33, 16 Charlton Court
Woolner, 0820
P (08) 8942 2600

ISO 9001:2008 Certified

ABN 30 007 755 277