STEPHENSON &TURNER

ASSESSMENT OF ENVIRONMENTAL EFFECTS FOR PROPOSED LIGHTING

MT MUNRO WIND FARM PROJECT
NORTH WAIRARAPA

Prepared for:
Meridian Energy

50471

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Glen Wright, Principal

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1. INTRODUCTION

Stephenson & Turner was engaged by Meridian Energy to provide an assessment of the lighting effects for the lighting associated with their application for the proposed 20 turbine Mt Munro Wind Farm in North Wairarapa.

Stephenson & Turner is an Architectural and Engineering Consultancy, Principal Glen Wright carried out this assessment. I hold a New Zealand Certificate of Engineering (Electrical), am a Registered Engineering Associate, an Associate Member of the Illuminating Engineering Society of Australia and New Zealand and a Member of Engineering New Zealand.

I have over 30 years' experience in lighting design, application, and review of lighting effects; this includes aviation warning lights, digital billboards, illuminated signs, feature and facade floodlighting, security lighting and sports lighting in urban and rural environments. I was South Wairarapa District Councils lighting technical adviser for the recent Wairarapa Combined District Plan, Dark Sky Plan Change 12 associated with the establishment of the Dark Sky Management Area. I am a past recipient of six national lighting awards.

2. EXISTING ENVIRONMENT

I made a visit to the site and its immediate surrounds on Wednesday 9th August 2023, this included both daytime and nighttime observations of the existing environment.

The following existing stationary light sources are present in the surrounding environment:

- Rural residential dwelling lights, both interior and exterior.
- Eketahuna township streetlights, building lights both interior and exterior.

The following existing flashing or moving light sources are present in the surrounding environment:

- Headlights on vehicles moving through the area particularly SH2 which has a reasonable traffic count and includes B train trucks with truck and trailer amber and red marker lights.
- Headlights and amber flashing beacon warning lights on tractors and trucks working on and around farms after dark.
- Aviation warning lights on nacelles of selected wind turbines on Taraua Ranges (refer Photo 1 below), all eight lights visible from the top of Mt Munro were red and flashed in unison.

Photo 1 – Nighttime view from top of Mt Munro Wind Farm site looking towards Tararua Ranges, wind turbines with red warning lights circled.

With reference to the Environmental Zones defined in *AS/NZS 4282:2019 – Control of obtrusive effects of outdoor lighting* the environment surrounding the Mt Munro Wind Farm would be best described as an environmental lighting zone 'A2 – Low district brightness' as it is a sparsely inhabited rural and semi-rural area. The exception would be the Eketahuna township which would be best described as an environmental lighting zone 'A3 - Medium district lightness' as it has suburban areas.

3. RELEVANT STATUTORY PROVISIONS

3.1 National Policy Statement for Renewable Electricity Generation 2011

The NPS REG covers the construction, operation, maintenance and upgrading of new and existing structures associated with renewable electricity generation. Under the NPS REG decision-makers shall recognise and provide for the national significance of renewable electricity generation activities and have particular regard to the need to locate the renewable electricity generation activity where the renewable energy resource is available and the technical practicalities associated with developing, operating or maintaining the renewable electricity generation activity.

3.2 Tararua District Plan

Under the Tararua District Plan, the site is zoned Rural.

The applicable objectives and policies are outlined within Meridian Energy's AEE lodged on 4 May 2023 at section 3.10 (including objective 2.8.4.1 which seeks to recognise the potential of the District's Rural Management Area for renewable electricity generation and wind farms in particular).

Standard 5.4.7.2(b) states "In all Management Areas, any exterior lights shall be installed, designed, shaded and arranged in order that the level of lighting measured on the boundaries of the site are no greater than 8.0 lux (lumens per square metre).

3.3 Wairarapa Combined District Plan

Under the Wairarapa Combined District Plan, the site is zoned Primary Production.

Objective GAV1 seeks to maintain and enhance general amenity values, with its subsequent policies considering noise, vibration, lighting and odour. In particular Policy GAV1(e) addresses artificial lighting and to avoid light spill and glare onto adjoining sites and roads, and to protect the clarity and brightness of the night sky.

Under Rule 21.1.11 Outdoor Artificial Light, the emission of outdoor light (including glare) is a permitted activity provided that the artificial light level does not exceed eight lumens per square metre (8 lux) when measured at 1.5m above ground level at the site boundary.

There is additional Rule 21.1.11 rules that only apply within the Dark Sky Management Area, these do not apply as the site is not within the Dark Sky Management Area.

3.4 Civil Aviation Authority (CAA)

With reference to *CAA Level 4 Group Management Policies and Procedures, Lighting and Marking of Wind Farm Turbines, Version B dated 2 March 2020*, the following requirements apply to the proposed wind farm turbines.

5. Condition and Limitations

(b) 1. Selected individual turbines at wind farms with turbines over 60 m high will be required to have lighting.

2. Turbines 150m and 315m will require a secondary backup light and an array of 3 intermediate low intensity lights at a distance of half the nacelle height.

4. The highest turbines, those at the extremities of the site, and other turbines around the perimeter of the site will be lit to enable pilots to identify the extent of the windfarm. The spacing between lit turbines will not exceed 900m along the perimeter, and the flashing should be coordinated between the lights in the wind farm so that they flash simultaneously.

5. Lighting will be medium intensity red as defined in Rule Part 77, Appendix B10, i.e. an effective intensity of not less than 1600 candela of red light, and will flash between 20 and 60 times per minute.

With reference to CAA Rule Part 77, the following are the requirements for the obstacle lights.

B.9 Low-intensity obstacle light characteristics

(a) A low-intensity obstacle light on a fixed obstacle shall be a fixed red light having an intensity that is-

(1) conspicuous in the surroundings in which it is placed: and

(2) not less than 10 cd of red light.

B.10 Medium-intensity obstacle light characteristics

(a) A medium-intensity obstacle light on a fixed obstacle shall be a fixed red light having an intensity that is-

(1) be red except when used in conjunction with a high-intensity obstacle light, in which case it shall be white; and

(2) flash simultaneously at a rate of between 40 and 60 per minute; and

(3) have an effective intensity of not less than 1600 cd of red light.

Based on these CAA requirements, selected turbines will have 3 intermediate low intensity red non flashing lights at a distance of half the nacelle height and 1 medium intensity flashing red light on top of their nacelle with secondary backup light should this light fail to operate.

4. LIGHTING CONCEPT DESIGNS

4.1 Fixed Lighting

Where a fixed lighting solution is proposed it will typically consist of building wall mounted security lights and tall pole mounted lights for yards.

For the purposes of this lighting assessment, lighting concept designs for fixed lighting were prepared by Stephenson & Turner, and computer models created. These designs are indicative of the expected proposed lighting performance and obtrusive effects. These obtrusive light calculations do not include any mitigation that may be provided by topography, vegetation or barriers and they use the initial light output with a maintenance factor of 1.0 to demonstrate the worst-case effect.

The results of these calculations are included in Appendix B – S&T AEE Lighting Calculations.

To minimise lighting effects this lighting has been designed to be as near as practicable to the minimum lighting levels required for the activities, safety and security. For areas where lighting is required for operations, maintenance, loading or unloading an average horizontal illuminance target of 30 lux is required and for areas where lighting is required for safe movement and security an average horizontal illuminance target of 3 lux is required.

Lights will have a light source colour temperature of 3000K, except the Concrete Batching Plant lights will be 4000K to provide better lighting for monitoring concrete mix colour.

Portacom building security lighting will be provided by wall mounted lights of 1400 lumen output, 105° side throw and 69° forward throw optics, no light is projected above their horizontal. Lights will be nominally mounted at 3m above ground level. Refer image of proposed wall light below.

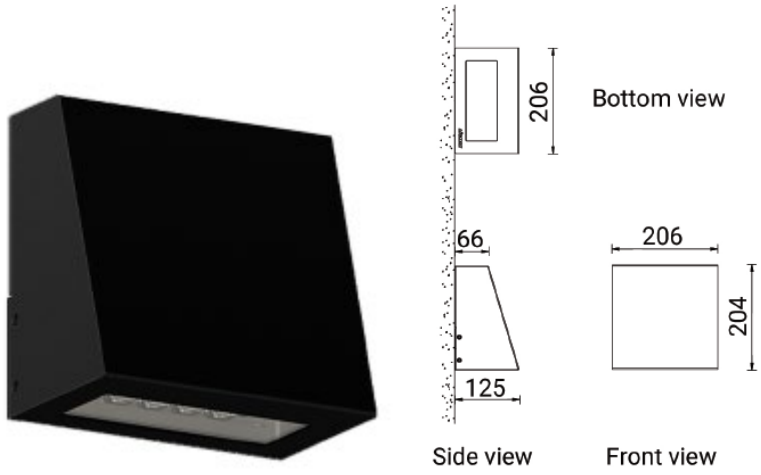

Image 1 – Typical wall light used in lighting design

The taller Operations and Maintenance building security lighting and concrete batching plant lights will be provided by similar wall mounted lights, but of higher 2050 lumen output. Lights nominally mounted at 6m above ground level.

Yard lighting will be provided by 0° tilt luminaires mounted on poles located around the yard perimeter and directing light into the site. The pole heights have been selected to control the obtrusive effects, a lower pole height would require the luminaires to be tilted above the 0° tilt with increased obtrusive effects.

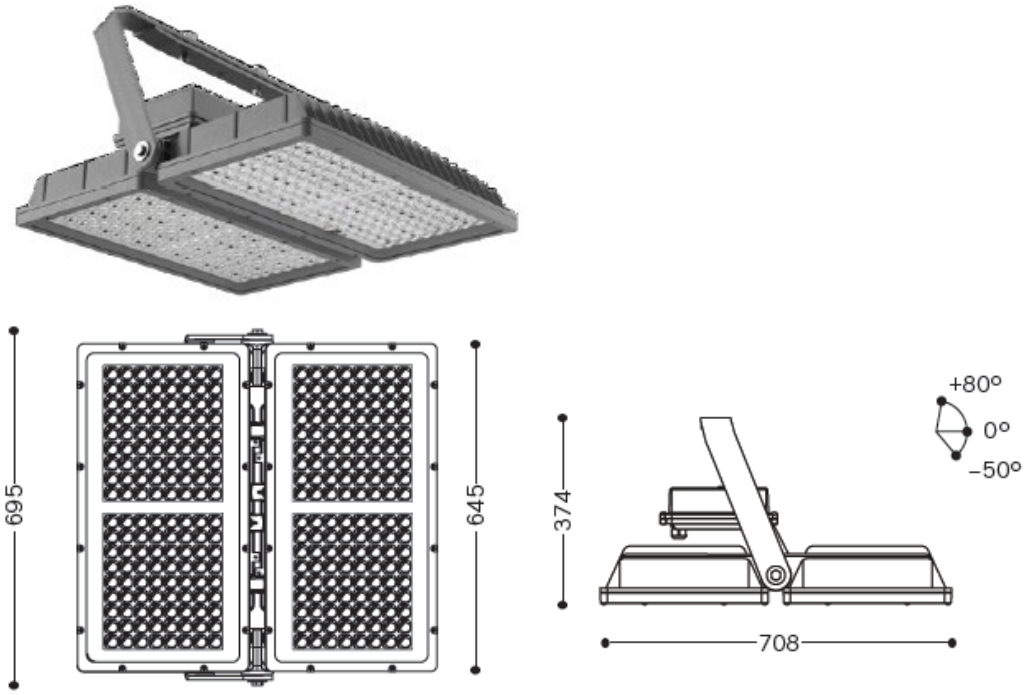

Image 2 – Typical tall pole mounted light used in lighting design

4.2 Temporary Lighting

Where temporary lighting is proposed it will typically consist of machinery mounted floodlights and portable telescopic pole mounted floodlights with extendable booms up to 9m in height. The selection and set up of the temporary lighting would be controlled through a Construction Lighting Management Plan that would provide guidance requiring all lights to be directed / focused to the work area and not in the direction of light sensitive receivers such as dwellings and public roads.

Image 3 – Typical portable lighting tower

5. PROPOSED LIGHTING - CONSTRUCTION

5.1 Internal Road Lighting

The roads built to construct and service the wind farm will have low traffic levels, with no regular traffic at night, and will not be lit.

5.2 Vehicle Movements – Headlight Sweep

As noted in the overall AEE the addition of construction vehicles on SH2 is low compared to current traffic volumes, therefore headlight sweep for construction vehicles on SH2 has not been assessed as it is an existing effect with no significant increase in frequency.

Construction traffic activity on the access road and site at night is expected to include:

- Monday to Saturday 7am to 7pm (excluding concrete pouring activities which run continuously for up to 15 hours, and turbine component delivery).
- Turbine components being over-dimensional are typically restricted to only operate overnight on state highways, so will use Old Coach Rd outside the above hours.

- Concrete mixer and pump trucks will operate over night, between the batching plant and foundation location. These vehicles may return to where they are based via Old Coach Road at the completion of pouring activities. There is no requirement for the delivery of aggregate from quarries at night.

5.3 Security Building Lighting

The security building will be a 6m x 3m portacom located at the eastern end of the Site Entrance area and adjacent to the main laydown area.

The security building lighting will consist of wall mounted perimeter lights controlled by occupancy sensors, these lights are only on at night when occupancy has been detected.

5.4 Main Laydown Area Lighting

During construction the main storage laydown area is proposed to be located on the western side of Old Coach Road, opposite the wind farm site entrance. This laydown area will be used to store turbine components transported in by road prior to being taken to the turbine site.

The size of the laydown area required will depend on the project construction schedule, the number of turbine components and other parts and equipment being stored, the requirements for any pre-erection activities such as preliminary work on the nacelles and the temporary building location and layout.

The temporary buildings in this area will be portacoms, and include:

- Kitchen and chiller portacom structures.
- 12m x 3m portacoms adjacent to the dwelling being used as temporary offices, toilet blocks and general staff areas.
- Security building.

The portacom structures are single storey buildings and will be removed upon the completion of the construction phase.

Post construction, some or all of this storage laydown area will be retained for spare parts storage (such as blades) and may be used for the operations and maintenance building.

Concept lighting design

All buildings will have wall mounted perimeter lights controlled by occupancy sensors.

The laydown areas will have 12m high poles adjacent to the north boundary and 20m high poles adjacent the south boundary, each pole will have a pole top floodlight providing a target of 30 lux average for the safe unloading and loading of materials at night.

There will also be truck and machinery with headlights and flashing amber warning lights.

Operation of lighting

Building exterior lights will only be on at night when occupancy has been detected.

Yard lighting will only be on when required for nighttime deliveries or pick up of components.

5.5 Concrete Batching Plant Lighting

A temporary concrete batching plant will be established within the site. The final location is yet to be determined but will be within the Turbine Envelope Zone or Turbine Exclusion Zone. For this assessment the concrete batching plant has been located on the main ridge of the site, within the turbine envelope zone near turbine 7, elevation 450m, we believe this will provide a good representation of any obtrusive lighting effects.

The concrete batching plant will occupy an area of approximately 100m by 60m, surrounded by a fence. The temporary structures to be located in this area would include the following (indicative dimensions included in brackets):

- Control room and storage building (6m long x 3m high x 3m wide);
- Portacoms for office and amenities (6m long x 3m high x 3m wide);
- Mobile batching plant unit which includes, but is not limited to, hoppers, aggregate storage bins, compressor, cement silos and conveyors (18m long x 4m wide x 7m high);
- Additional cement storage silo (6m long x 3m wide x 3m high);
- Diesel storage facility;
- Water tank;
- Aggregate stockpile area (50m x 20m);
- Generator.

Concept lighting design

The building lighting will consist of wall mounted perimeter lights controlled by occupancy sensors. These lights are only on at night when occupancy has been detected.

The yard areas will have 20m high poles with pole top floodlights providing a target of 30 lux average for the safe operations of the batching plant at night. The batching plant unit will also have some plant mounted lights as required for safe operation of the plant at night, with four wall mounted lights like the proposed building security lights, but of higher output and higher 6m mounting height.

There will also be truck and machinery with headlights and flashing amber warning lights.

Operation of lighting

The batching plant will be used during the night only when continuous concrete pours for turbine and metrological mast foundations, such pours are expected to be of up to 15 hours durations. Approximately 30 days of night operation of the plant and its lights is expected. The concrete batching plant and its lights will be removed within six months of the wind farm being fully operational.

5.6 Turbine Laydown Area Lighting

Each turbine will require a flat area for the foundation, crane pad, and blade laydown area onto which the turbine can be erected. This hardstand area will measure approximately 136m long by 60m wide (including the access road) and require cuts of up to 25.5m along a central ridge which is generally screened from external view.

Proposed lighting

For nighttime foundation concrete pours temporary lighting will be provided for task lighting and safety. This will be provided by concrete truck mounted spotlights and portable telescopic working lights.

For nighttime erection of turbines temporary lighting will be provided for task lighting and safety. This will be provided by crane mounted spotlights and portable telescopic working lights.

There will also be truck and machinery with headlights and flashing amber warning lights.

Operation of lighting

As continuous concrete pours of up to 15 hours are required for the turbine and metrological mast foundation, localised temporary construction lighting will be provided, estimated to occur over 30 nights spread across the pour sites and over 2.5 – 3 years.

As light wind conditions are required for the erection of turbines some nighttime lifts may be required, localised temporary construction lighting will be provided, estimated to occur over 30 nights spread across the turbine locations and over 9 months. When lifts are occurring the portable telescopic working lights will project light upwards to illuminate the object being lifted.

6. PROPOSED LIGHTING - OPERATIONAL

6.1 SH2 Intersection Lighting

Meridian's traffic engineering consultants have reviewed Waka Kotahi's street light guidance, and advise that no intersection lighting is required.

6.2 Internal Road Lighting

The roads built to service the wind farm will have low traffic levels, with no regular traffic at night, and will not be lit.

6.3 Vehicle Movements – Headlight Sweep

When the wind farm is operational the only nighttime vehicle movements will be those associated with nighttime maintenance when required.

As noted in the overall AEE the additional maintenance vehicles on SH2 is low compared to current traffic volumes, therefore headlight sweep for maintenance vehicles on SH2 has not been assessed as it is an existing effect with no significant increase in frequency.

6.4 Operations and Maintenance Building Lighting

A permanent operation and maintenance building will be located either within the main laydown area or terminal substation area.

This building will house a workshop, control room for managing the wind farm, and will be approximately 50m by 20m, and 6.5m high.

Concept lighting design

Operations and maintenance buildings has been included in the concept lighting designs for both sites.

Exterior lighting will be wall mounted lights at 6m, with the lights controlled by occupancy sensors.

Operation of lighting

Building exterior lights will only be on at night when occupancy has been detected.

6.5 Site Substation Lighting

A Site Substation will be located at the southern end of the Turbine Envelope Zone. The Site Substation will have a total footprint of approximately 70m x 90m and will consist of a switchyard and potentially up to two small control buildings, one approximately 20 m x 10m and the other approximately 10 m x 6 m and both up to 7m in height. The external perimeter of the compound will be fenced.

The Site Substation will take power from the underground cables from the wind turbines and connect to the Internal Transmission Line. The main transformer (33 kV to 110 kV) will be housed here (or at the Terminal Substation), as well as various switches and electrical protection devices.

Concept lighting design

All buildings will have wall mounted perimeter lights controlled by occupancy sensors.

Switchyard will have 20m high poles, each pole will have a pole top floodlight providing a target of 30 lux average for site operations and maintenance.

There will also be truck and machinery with headlights and flashing amber warning lights.

Operation of lighting

Building exterior lights will only be on at night when occupancy has been detected.

Switchyard lighting will only be on when required for nighttime operations and maintenance.

6.6 Terminal Substation Lighting

A Terminal Substation site will be located on Kaiparoro Road off SH2. The Terminal Substation will have a total footprint of approximately 100m x 125m and will consist of a switchyard and up to two control buildings one approximately 20m x 10m, the other 10m x 6m and both up to 7m in height. A permanent Operations and Maintenance building approximately 30m x 25m may be included within the substation compound, together with storage facilities and carparking. The substation will be accessed from Kaiparoro Road.

Concept lighting design

All buildings will have wall mounted perimeter lights controlled by occupancy sensors.

Switchyard will have 20m high poles, each pole will have a pole top floodlight providing a target of 30 lux average for site operations and maintenance.

There will also be truck and machinery with headlights and flashing amber warning lights.

Operation of lighting

Building exterior lights will only be on at night when occupancy has been detected.

Switchyard lighting will only be on when required for nighttime operations and maintenance.

6.7 Aviation Warning Lights

To meet CAA requirements 9 of the 20 turbines will be fitted with aviation warning lights. The lights will operate continuously. Lights that flash will all flash simultaneously across the wind farm.

Based on the CAA criteria (extremities, highest, no spacing larger than 900m along perimeter), Figure 1 below shows the turbines that will have aviation warning lights. Note that these are indicative locations, and that a 20-turbine layout would likely have this distribution of lit turbines to comply with the CAA guidelines.

Aviation warning lights will not be required on the wind monitoring tower as at 92m height it is shorter than nearby turbine 10 which will have aviation warning lights.

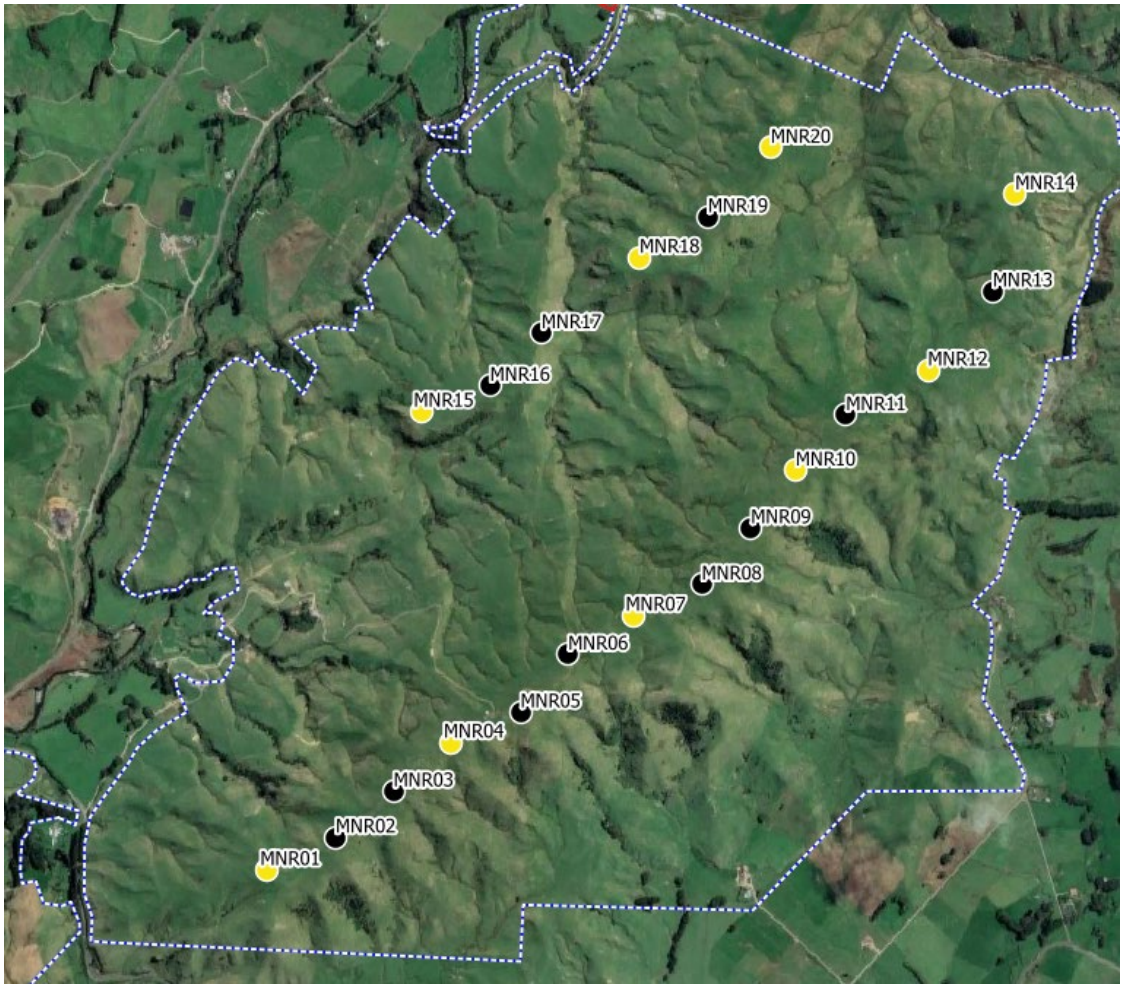

Figure 1 – Turbine Locations (Yellow dots denote turbine with lights)

The following table 1 lists the turbines that will have aviation lights, their platform elevation above sea level and the light elevation above sea level (lights are 72 metres above the turbine platform). Turbines are listed in order of elevation, from the lowest light at 213m through to the highest at 497m.

Turbine			Elevation		
Label	**x**	**y**	**Base**	**Intermediate Light**	**Nacelle Light**
MNR01#	1826726	5489947	450.9	497.9	544.9
MNR02	1826947	5490052	463.7	510.7	557.7
MNR03	1827134	5490201	463.8	510.8	557.8
MNR04#	1827320	5490359	468.3	515.3	562.3
MNR05	1827545	5490457	462.5	509.5	556.5
MNR06	1827699	5490644	458.7	505.7	552.7
MNR07#	1827909	5490770	471.6	518.6	565.6
MNR08	1828132	5490871	478.8	525.8	572.8
MNR09	1828291	5491053	495	542	589
MNR10#	1828436	5491240	496.4	543.4	590.4
MNR11	1828599	5491419	479.1	526.1	573.1
MNR12#	1828864	5491564	457.8	504.8	551.8
MNR13	1829074	5491819	387.3	434.3	481.3
MNR14#	1829146	5492134	395	442	489
MNR15#	1827223	5491430	372.7	419.7	466.7
MNR16	1827446	5491514	386.7	433.7	480.7
MNR17	1827613	5491685	386.3	433.3	480.3
MNR18#	1827931	5491929	418.9	465.9	512.9
MNR19	1828152	5492060	442.4	489.4	536.4
MNR20#	1828355	5492284	417.9	464.9	511.9

Table 1 – Turbine Schedule (# denote turbine with lights)

Low Intensity Aviation Warning Lights

If the tip height of the selected turbine model has a tip height of greater than 150 m, an array of 3 low intensity lights (equally spaced around the circumference of the turbine tower) will be installed at half the nacelle height, these lights will be red and will not be flashing.

Meridian are proposing to install Orga L92 Low-Intensity LED Obstruction Light (photo 4) which are specifically designed for wind turbine application., they utilise the latest LED optical technology providing a highly accurate and uniform beam or an equivalent light.

These lights will emit 32 candela day-time and night-time steady red light, with minimum 120 horizontal beam.

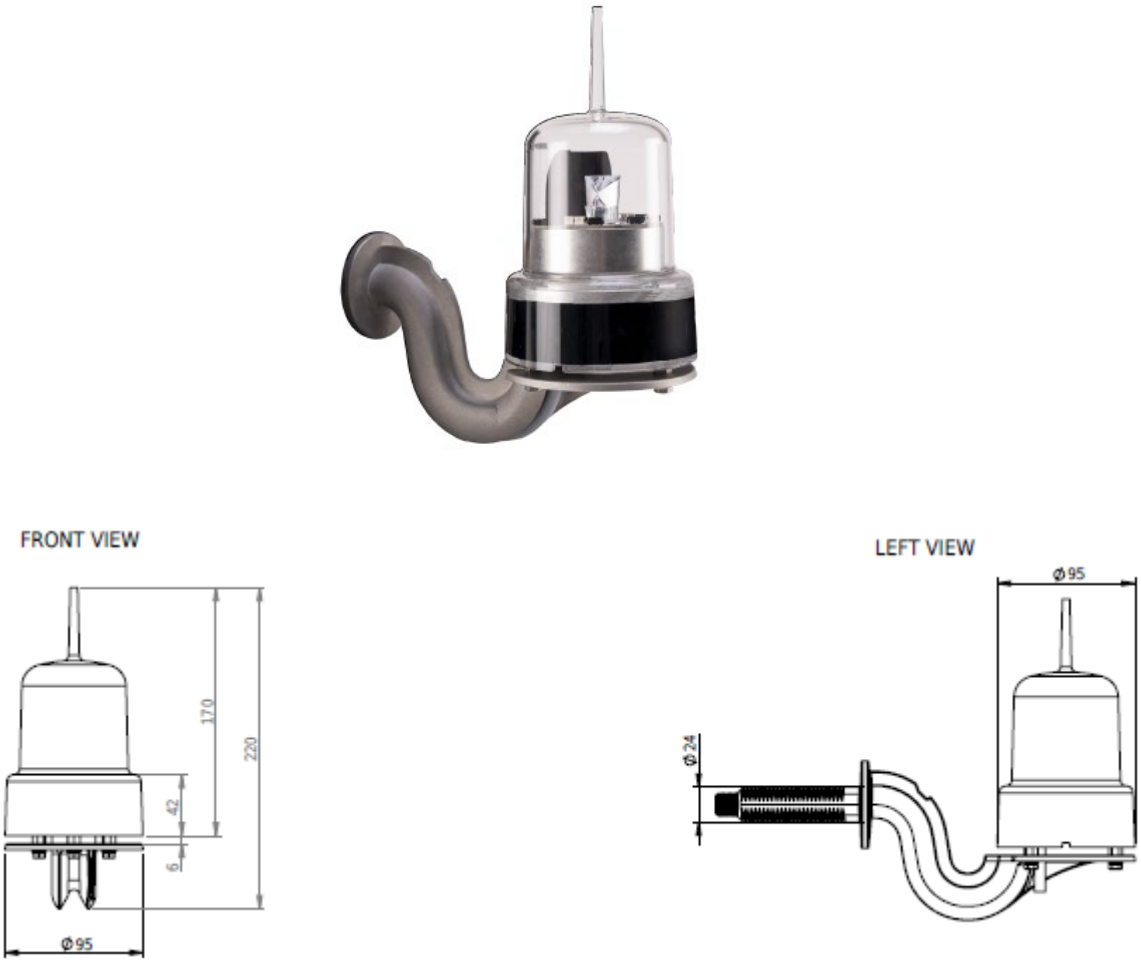

Image 4 – Proposed Orga L92 low intensity aviation warning light

Medium Intensity Aviation Warning Lights

Medium intensity aviation warning lights will be provided on selected turbines on top of the turbine nacelle, this light will be red and will flash simultaneously at a rate of between 40 and 60 per minute, it will have a secondary backup medium intensity obstacle light on top of turbine nacelle.

Meridian are proposing to install Orga L550 Medium-Intensity LED Obstruction Lights (image 4) or an equivalent lights which are specifically designed for wind turbine application, they utilise the latest LED optical technology, maximising both intensity and colour output. Their precision engineered reflective prism optics provide a highly accurate light beam which ensures light output is tightly focused beam spreads, limiting upward and downward lighting to the minimums required by CAA and thus providing reduced light pollution.

They will provide 20,000 candela day-time red flashing and 2,000 candela night time red flashing light, built-in photocell to automatically adjust intensity as ambient lighting levels drop (reducing intensity to 2,000 candela at night), integrated automatic GPS flash synchronisation and monitoring.

Image 5 – Proposed Orga L550 medium intensity aviation warning light

Refer to Appendix A - Proposed Orga L550 aviation warning light intensity distribution diagram.

Light intensities for horizontal and angles below the horizontal are summarised in table 2.

Installation	**West Winds Proposed Orga L550**
0°(horizon)	2000 cd
-1.5°	800 cd
-3.0°	200 cd
-5.0°	60 cd

Table 2 – Light Intensities at horizon level and below

7. POTENTIAL OBTRUSIVE LIGHTING EFFECTS

7.1 Applicable Standards

In assessing the lighting effects of the Mt Munro Wind Farm, I have assessed the proposed lighting in relation to the following standards:

1. Tararua District Plan permitted activity lighting standards.
2. Wairarapa Combined District Plan permitted activity lighting standards.
3. Recommendations in the Australian / New Zealand standard AS/NZS 4282:2019 Control of the obtrusive effects of outdoor lighting.

7.2 AS/NZS 4282:2019

My assessment of the obtrusive effects of the Mt Munro Wind Farm proposed lighting is with reference to the limits recommended in AS/NZS 4282:2019.

7.3 Obtrusive Effects

There are several possible obtrusive effects of the proposed lighting that require consideration and comment. These include:

- Spill light.
- Glare.
- Skyglow.
- Effects on road users
- Headlight sweep

To support the assessment of effects on surrounding dwellings, dwellings considered to be representative of the effects were those dwellings within approximately 2 km. This approach is consistent with the Boffa Miskell Landscape effects assessment and for consistency we have used the same dwelling numbering and included the Boffa Miskell Landscape effects assessment Figure 6 in our Appendix C which shows the dwelling locations and numbering.

7.4 Spill Light

Spill light is light emitted by an installation that falls outside of the design area. Spill light may or may not be obtrusive depending on what it affects. Spill light can be considered to be the amount of light hitting the windows of a dwelling as illustrated in figure 2 below.

Figure 2 – Illustration of Spill Light.

Both the Taraua District Plan and Wairarapa Combined District Plan have a limit of 8 lux for spill lights at 1.5m height at the site boundary.

With reference to AS/NZS 4282:2019 limits for spill light at windows on dwellings, Table 3.2 (see below) for an A2 environmental zone the curfew limit is 1 lux.

TABLE 3.2

MAXIMUM VALUES OF LIGHT TECHNICAL PARAMETERS

Zones	Vertical illuminance levels (E_v) lx		Threshold increment (TI)		Sky glow
	Non-curfew	Curfew	%	Default adaptation level (L_{ad})	Upward light ratio
A0	See Note 1	0	N/A	N/A	0
A1	2	0.1	N/A	N/A	0
A2	5	1	20%	0.2	0.01
A3	10	2	20%	1	0.02
A4	25	5	20%	5	0.03

Computer models of the proposed lighting were created using AGI 32 Lighting Calculation Software. To assess the magnitude of spill light effects, within these computer models, vertical spill light calculation planes were placed along the line of selected property boundaries and the exterior of selected dwellings. The results of these calculations are included in Appendix B – S&T AEE Lighting Calculations.

7.5 Glare

Glare is light that hinders or bothers the human eye. It is the sensation produced by luminance within the visual field that is sufficiently greater than the luminance to which the eyes are adapted, which causes annoyance, discomfort, or loss in visual performance and visibility (Refer to Figure 3).

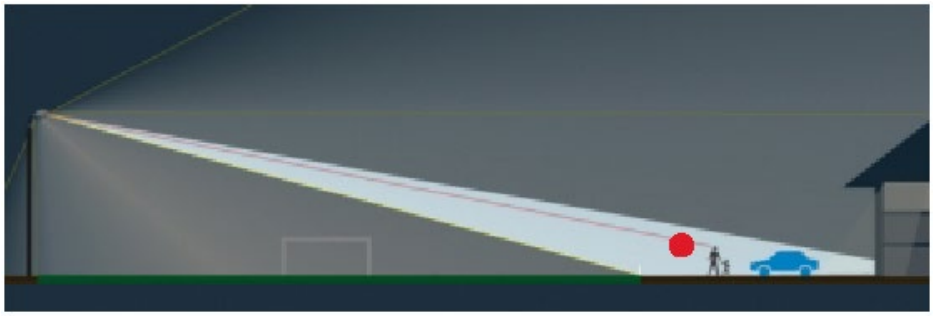

Figure 3 – Illustration of Glare.

For this assessment glare relates to an observer direct view of the luminaire.

Both the Taraua District Plan and Wairarapa Combined District Plan do not have any standards for glare.

With reference to AS/NZS 4282:2019 limits for glare at windows on dwellings, Table 3.3 (see below) for an A2 environmental zone the curfew limit is 1000 candela.

TABLE 3.3

MAXIMUM LUMINOUS INTENSITIES PER LUMINAIRE

Zone	Luminous intensity (*I*), cd		
	Non-curfew L1	Non-curfew L2	Curfew
A0	See Note	See Note	0
A1	2 500	5 000	500
A2	7 500	12 500	1 000
A3	12 500	25 000	2 500
A4	25 000	50 000	2 500
TV	100 000	150 000	0

NOTE: For A0, *I* shall be as close to zero as practicable without impacting safety considerations.

Within the computer models, to assess the magnitude of glare effects, vertical glare calculation planes were placed along the exterior of selected dwellings. The results of these calculations are included in Appendix B – S&T AEE Lighting Calculations.

7.6 Skyglow

Sky glow is the lighting of the night sky caused by light directed into the sky either directly (from light sources that projected light above the horizontal) or indirectly (reflected from a surface) this light reflects off airborne particles and it is dependent on atmospheric conditions. On an atmospherically clear night there would be nil sky glow.

Skyglow is the upward leakage of light that artificially brightens the night sky, as illustrated in figure 4.

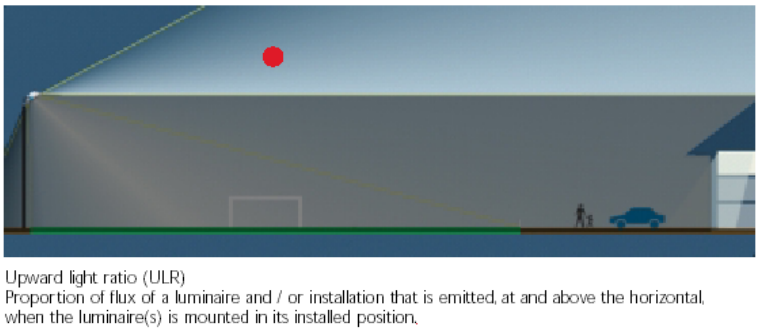

Figure 4 – Illustration of Skyglow

Both the Taraua District Plan and Wairarapa Combined District Plan do not have any standards for skyglow.

With reference to AS/NZS 4282:2019 limits for skyglow, Table 3.2 for an A2 environmental zone the limit is 0.01 upward light ratio (ULR).

The International Dark Sky Association states that “the issue is not light against darkness, it is good lights versus bad lights. You can have dark skies and still have lights”. By applying correct design principals and luminaires the sky glow can be minimised.

7.7 Effects on Road Users

Effects on road users (e.g. motorists, cyclists, pedestrians) normally involve a reduction in the ability to see caused by disability glare from bright light sources. The apparent contrast of objects against their backgrounds will be lowered, rendering them less visible or even invisible, especially if the environment is intrinsically dark. The magnitude of the effect will depend on the level of light to which the user is adapted. The relevant indicator is the threshold increment (TI), which is used to specify the limitation of glare in road lighting.

With reference to AS/NZS 4282:2019 limits for TI, Table 3.2 for an A2 environmental zone the limit is 20%.

Within the computer models, special calculation points were placed along roads that are near the proposed lighting, with separate points for different directions of travel. The results of these calculations are included in Appendix B – S&T AEE Lighting Calculations.

7.8 Headlight Sweep

The light beam generated from a headlight is the same for a truck and car. The headlight beam is made up of two components, the first being the oval more intense beam used for driving and the second being the wider low intensity beam on the edges. Only the oval beam is a source of glare, but this beam is directed down on to the road, this is where the intensity of light is the highest. The intensity of the beam dissipates quickly from this point.

Headlight sweep is a common occurrence particularly for properties located adjacent to intersections and bends. When the headlight sweep occurs across a dwelling bedroom window it can disrupt a person's sleep.

8. ASSESSMENT OF EFFECTS

8.1 Headlight Sweep

I have reviewed traffic movements in both directions from the SH2 intersection with Old Coach Road, along Old Coach Road to the site access and along the site turbine access roads. There are only two dwellings where there is potential for headlight sweep across their bedroom windows:

- 47 Old Coach Road (ID 24) is located near a bend in Old Coach Road, but the dwelling is enclosed within mature vegetation which I expect will block headlight sweep from windows.

- 168 Old Coach Road (ID 21) is located alongside one of the site access roads, but is at sufficient distance from any bends and intersections. The distance between the headlights and the location will reduce the intensity of the headlight sweep. Additionally, there is some vegetation that is expected to also reduce the intensity of any headlight sweep on the bedroom windows.

Therefore, it is my opinion that headlight sweep from wind farm construction and operations vehicles effects are less than minor.

8.2 Security Building and Main Laydown Area Lighting

With reference to the lighting concept design for the main laydown area (which includes the security building adjacent to the entry off Old Coach Road and the operations and maintenance building) obtrusive lighting calculations were included for the site's north boundary, Old Coach Road and dwellings 21, 22, 34 & 35A.

Spill light calculations show there will be 7 lux maximum on the north boundary and 0 lux spill light to surrounding dwellings. The 7 lux boundary maximum is less than the District Plan's limit of 8 lux and is therefore permitted.

Glare calculations show there is potential for a maximum luminous intensity of 478 candelas in the direction of dwelling 21. This is less than the AS/NZS 4282:2019 limit of 1000 candela.

With Old Coach Road running adjacent the main laydown area, threshold increment (TI) calculations were included for road users travelling in both directions, a maximum of 2% TI was calculated for Old Coach Road users travelling south, this is less than the AS/NZS 4282:2019 limit of 20%.

Therefore, it is my opinion that security building, main laydown area and operations and maintenance building lighting effects are less than minor.

8.3 Concrete Batching Plant Lighting

With reference to the lighting concept design for the concrete batching plant, obtrusive lighting spill and glare calculations were included for dwellings 1, 2, 6, 15, 17, 18, 19 & 21.

Spill light calculations show there will be 0 lux spill light to surrounding dwellings.

Glare calculations show there is potential for a maximum luminous intensity of 934 candelas in the direction of dwelling 6, this is less than the AS/NZS 4282:2019 limit of 1000 candela.

As this site is at significant distance from public roads, no public road users are affected by this lighting.

Therefore, it is my opinion that concrete batching plant lighting effects are less than minor.

8.4 Turbine Laydown Lighting

No lighting concept design calculations were prepared for any of the turbine laydown areas as nighttime lighting would only be in place at a turbine or metrological mast site on the night required and would be primarily provided by portable telescopic working lights which can be setup and directed to minimise effects on any surrounding dwellings.

As these sites are all at significant distance from public roads, no public road users are affected by this lighting.

Lighting is only expected be in operation for up to three nights per turbine site, with the considerable distance of these sites from surrounding dwellings and with the ability for the flexibility in location and direction of the portable telescopic working lights it is my opinion that any lighting effects are less than minor.

8.5 Site Substation Lighting

With reference to the lighting concept design for the site substation, obtrusive lighting spill and glare calculations were included for dwellings 6, 7, 8, 9, 10, 11, 14 & 15.

Spill light calculations show there will be 0 lux spill light to surrounding dwellings.

Glare calculations show there is potential for a maximum luminous intensity of 909 candelas in the direction of dwelling 10, this is less than the AS/NZS 4282:2019 limit of 1000 candela.

As the site substation is at significant distance from public roads, no public road users are affected by this lighting.

Therefore, it is my opinion that the site substation lighting effects are less than minor.

8.6 Terminal Substation Lighting

With reference to the lighting concept design for the terminal substation, which includes an operations and maintenance building, obtrusive lighting calculations were included for the site's south boundary, SH2 and Kaiparoro Road and dwellings 26 & 27.

Spill light calculations show there will be 4.2 lux maximum on the south boundary and 0 lux spill light to surrounding dwellings. The 4.2 lux boundary maximum is less than the District Plans limit of 8 lux and is therefore permitted.

Glare calculations show there is potential for a maximum luminous intensity of 458 candelas in the direction of dwelling 26, this is less than the AS/NZS 4282:2019 limit of 1000 candela.

With both SH2 and Kaiparoro Road running adjacent to the terminal substation, threshold increment (TI) calculations were included for road users travelling in both directions on these roads, a maximum of 1% TI was calculated for both SH2 road users travelling north and Kaiparoro Road users travelling west, these are less than the AS/NZS 4282:2019 limit of 20%.

Therefore, it is my opinion that terminal substation and operations and maintenance building lighting effects are less than minor.

8.7 Aviation Warning Lights

The low intensity aviation warning lights installed at half nacelle height have a very low intensity of only 32 candela, well below the AS/NZS 4282:2019 glare limit of 1000 candela.

The medium intensity aviation warning lights installed on top of the nacelle have a horizontal intensity of 2000 candela, but its lens drops the intensity to 800 candela @1.5° below the horizontal, therefore for dwellings below the elevation of a turbine base the intensity will be less than 800 candela which is less than the AS/NZS 4282:2019 glare limit of 1000 candela.

No health effects can be attributed to the flashing of the medium intensity aviation warning lights as the flashing rate is low.

Therefore, it is my opinion that aviation warning lights effects are less than minor.

8.8 Skyglow

The fixed lighting proposed will use luminaires that direct light downwards and not emit any light above their horizontal, therefore as the sky glow will be due to indirect light reflected off the ground surfaces, rather than direct rays, the upward light ratio is 0. This is less than the AS/NZS 4282:2019 limit of 0.01. As the reflectance off ground surfaces is typically low (10 to 30%), the lighting effect to a 'dark sky' environment will be low. Lighting levels have been kept to the minimum levels required for the activities and safety, there will be no overlighting which would increase the amount of light reflected skyward. Light sources will have 3000K colour temperature except for the concrete batching plant which has 4000K. 3000K light sources typically emit up to 25% less blue wavelength light, with blue wavelength producing more light scatter which contributes to skyglow. The use of occupancy sensor controlled lighting on buildings also reduces the skyglow.

When viewed on a misty or wet night, the location may present a minor 'glow in the sky effect'. On an atmospherically clear night there will be no noticeable glow.

The temporary lighting proposed for the turbine lift will project light above the horizontal which may contribute to skyglow, but this will not occur on more than 30 nights over the construction period.

The low intensity aviation warning lights will project light at and above their horizontal, but their low intensity of 32 candela means their contribution to skyglow would be less than minor.

The medium intensity aviation warning lights will project light at and above their horizontal and at up to 2000 candela they will contribution to skyglow, but this will be no more than minor.

With the site being outside and away from the Combined Wairarapa District Plans Dark Sky Management Area, the level of skyglow effects will be no more than minor.

9. CONCLUSIONS

Except for the aviation warning lights the proposal does not include any lighting that is on throughout every night, building mounted security lights are only on at night when there is occupancy. Yard lighting is only on when required and its expected usage is very low. This lighting will not project any light above the horizontal and no spill light to dwellings, obtrusive effects will be less than minor.

Temporary portable construction lighting usage is low, only required for continuous concrete pours and some turbine lifts. Only the turbine lift lighting will project light above the horizontal

and this is not expected to occur for more than 30 nights over the construction period.

Nighttime vehicle movements associated with the Wind Farm will not result in headlight sweep effects to dwellings on Old Coach Road.

Flashing aviation warning lights already exist within the wider environment, with views of the Turitea Wind Farm aviation warning lights available.

The proposed aviation warning lights provide positive aviation safety effects, there are no medical effects from their flashing as the flashing rate is too low and their obtrusive effects are no more than minor.

All of the proposed lighting will meet the Tararua and Wairarapa Combined District Plans permitted spill light standard of 8 lux at the site boundary.

10. APPENDICES

A. Proposed Orca L550 medium intensity aviation warning light – Intensity distribution diagram
B. S&T Concept Lighting Designs – AEE Lighting Calculations.
C. Boffa Miskell Limited Landscape Assessment - Figure 6 - Dwellings

Appendix A – Proposed Orca L550 medium intensity aviation warning light – Intensity distribution diagram