

Navarre Green Power Hub

Preliminary Shadow Flicker Assessment

Neoen Pty. Ltd.

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1 Introduction

Neoen Pty. Ltd. (Neoen) engaged Aurecon to assist with development activities at the proposed Navarre Green Power Hub in Victoria, Australia. This report summarises the results of the high-level assessments and commentary on the shadow flicker.

1.1 Input and assumptions

Aurecon has used the wind turbine layout configuration and receptor locations provided by Neoen. The wind turbine maximum dimensions were provided by the Client, with rotor diameter of 190 m and hub height of 175 m. The turbine is assumed to have a maximum blade chord of 5.0 m, which is a conservative maximum for turbines of this rotor diameter and hub height. If a turbine with a wider blade is selected for the final design, then the shadow flicker assessment will need to be updated.

1.2 Limits

The assessments have been performed generally in accordance with:

- **Victorian 2019 guidelines** “Development of Wind Energy Facilities in Victoria – Policy and Planning Guidelines”, March 2019, Department of Environment, Land, Water & Planning, Victorian Government
- **Draft national guidelines** “National Wind Farm Development Guidelines”, DRAFT July 2010, Environment Protection and Heritage Council (EPHC), Commonwealth of Australia.

Aurecon recommends that the appropriate limits, generally in accordance with the draft national guidelines, to ensure that shadow flicker effects are no more than minor are:

- Limit of 30 hours per year and 30 minutes per day **theoretical** (modelled) duration
- Limit of 10 hours per year and 30 minutes per day **realistic** duration
- Limit of 10 hours per year and 30 minutes per day **actual** duration, using a pre-programmed timer to shut down turbine(s).

These limits are applicable to any existing residence other than residences owned by landowners that are involved in the wind farm (i.e., hosts), in the immediate vicinity of the residence (garden fenced area or the notional boundary as defined in NZS 6808 Acoustics – Wind farm noise). If the limit based on theoretical duration is exceeded, then the realistic duration should be considered. If the realistic duration is exceeded at a residence, then the effect must be mitigated by applying a shadow flicker timer that ensures that the limit on actual duration is met.

2 Project overview

2.1 Project location

The Navarre Green Power Hub (the Project) comprises approximately 18,404 hectares (ha) of predominantly private land immediately north of Navarre in north-western Victoria (Project Area). The Project Area consists of 4 main sub-areas:

- Wind Farm Project Area – Eastern Layout: Approximately 5,266 ha located to the east of Ararat Street-Arnaud Road and west of Kara Kara National Park.
- Wind Farm Project Area – Western Layout: Approximately 4,873 ha located to the west of Ararat Street-Arnaud Road and east of Morrl Morrl Nature Conservation Reserve.
- Transmission Line Project Area – Eastern and Western Layout Link: Approximately 1,272 ha investigation corridor located between the Eastern Layout and Western Layout.

- Transmission Line Project Area – Bulgana Terminal Station Connection: Approximately 6,993 ha investigation corridor located between the Eastern Layout and Bulgana Terminal Station.

2.2 Project description

The Project will have a nominal capacity of around 600 MW and will incorporate a total of 102 wind turbines, split across two areas:

- The Wind Farm Project Area – Eastern Layout, which will consist of 50 wind turbines across approximately 5,266 ha of land.
- Wind Farm Project Area – Western Layout, which will consist of 52 wind turbines across approximately 4,873 hectares (ha) of land.

The Project will include a 220 kV transmission line between the Western and Eastern Layout and a 220 kV transmission line between the Western Layout and the Bulgana Terminal Station.

In addition to the turbines and transmission lines, the Project will also include the permanent and temporary infrastructure listed below (Table 1 and Table 2).

Table 1 Permanent and temporary infrastructure associated with the Project – Eastern Layout

| The Wind Farm Project Area – Eastern Layout | |
|---|--|
| Permanent | Temporary |
| <ul style="list-style-type: none"> ■ A substation (up to 10ha) ■ Hardstand and laydown areas surrounding each turbine ■ Access tracks and site access points. It is expected the site access points will be at one location on Barkly-Navarre Road, one location on Ararat-St Arnaud Road and one location on Winjallock Road. ■ Operations and maintenance building and laydown ■ A Battery Energy Storage System with a capacity of 600MW / 1200MWh ■ Road upgrades to the local roads ■ Meteorological monitoring masts ■ Internal power collection stations ■ Internal underground cabling ■ A quarry to source raw material required for construction and maintenance during operations. | <ul style="list-style-type: none"> ■ A construction office and compounds. This will include site offices, car parking, storage and amenities. ■ A concrete batching plant. |

Table 2 Permanent and temporary infrastructure associated with the Project – Western Layout

| The Wind Farm Project Area – Western Layout | |
|---|--|
| Permanent | Temporary |
| <ul style="list-style-type: none"> ■ A substation (up to 10ha) ■ Hardstand and laydown areas surrounding each turbine. ■ Access tracks and site access points. It is expected the site access points will be at one location on Callawadda-Navarre Road and three locations on Bolangum Inn Road. ■ Operations and maintenance building and laydown. ■ Road upgrades to the local roads. ■ Meteorological monitoring masts. ■ Internal power collection stations. ■ Internal underground cabling. ■ A quarry to source raw material required for construction and maintenance during operations. | <ul style="list-style-type: none"> ■ A construction office and compounds. This will include site offices, car parking, storage and amenities. ■ A concrete batching plant. |

3 Assessment and results

Aurecon has undertaken an assessment of theoretical shadow flicker using WindPRO version 3.6 software. The model simulates the path of the sun during the year and can calculate the relative positions of the sun, wind turbine generators, residences, and terrain to predict the possible shadow flicker durations in the vicinity of the proposed wind farm from a purely geometrical standpoint. This calculation gives the theoretical number of hours of shadow flicker experienced at a residence. The actual shadow flicker will be less as there are several factors that the analysis does not consider, including the presence of cloud cover, vegetation screening or intervening structures, the orientation of the wind turbine generator and periods when the wind turbines are not operating.

Figure 1 and Figure 2 present the shadow flicker durations for the theoretical, worst-case scenario based on conservative assumptions, along with the affected residencies.

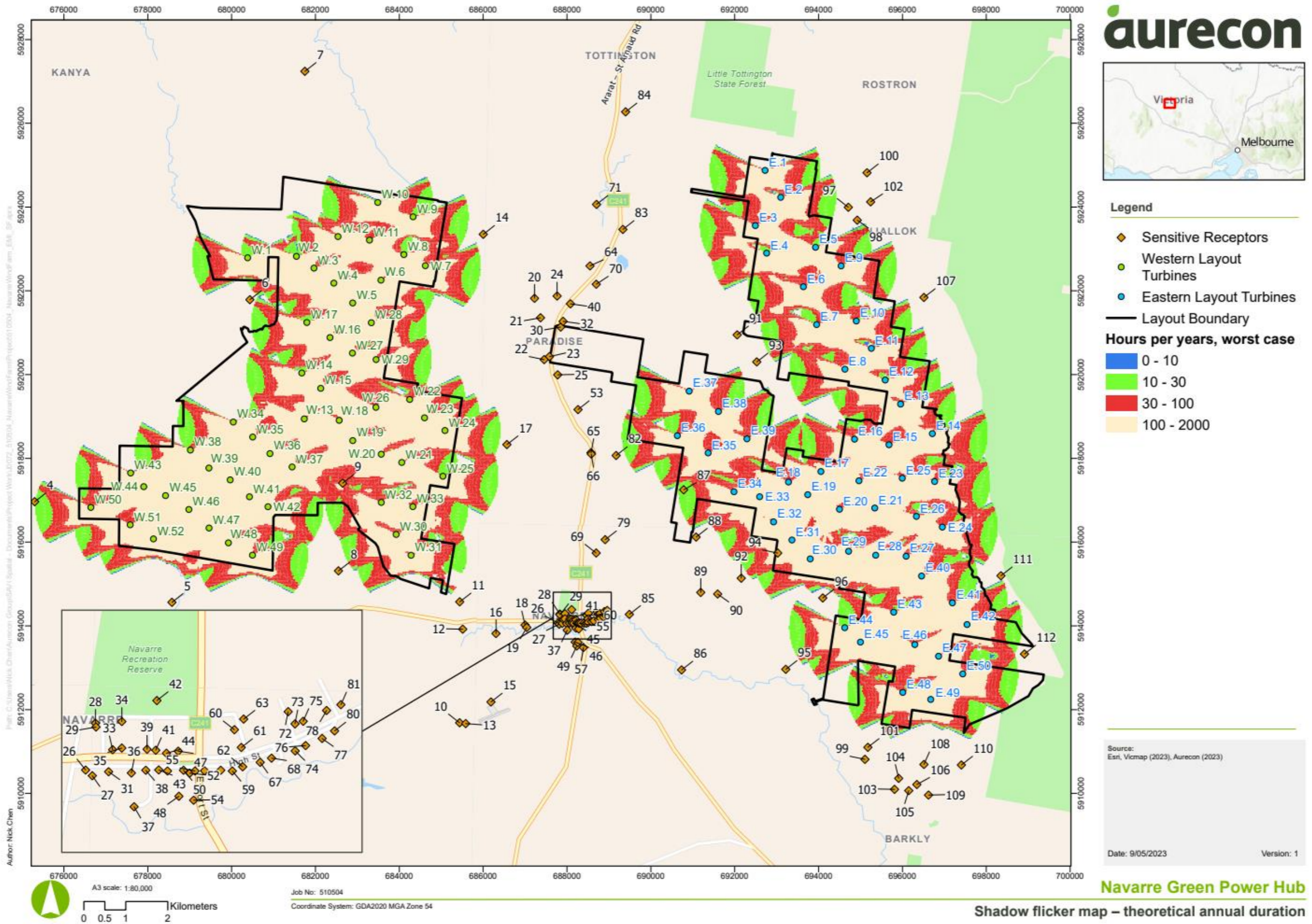


Figure 1 Shadow flicker map – theoretical annual duration

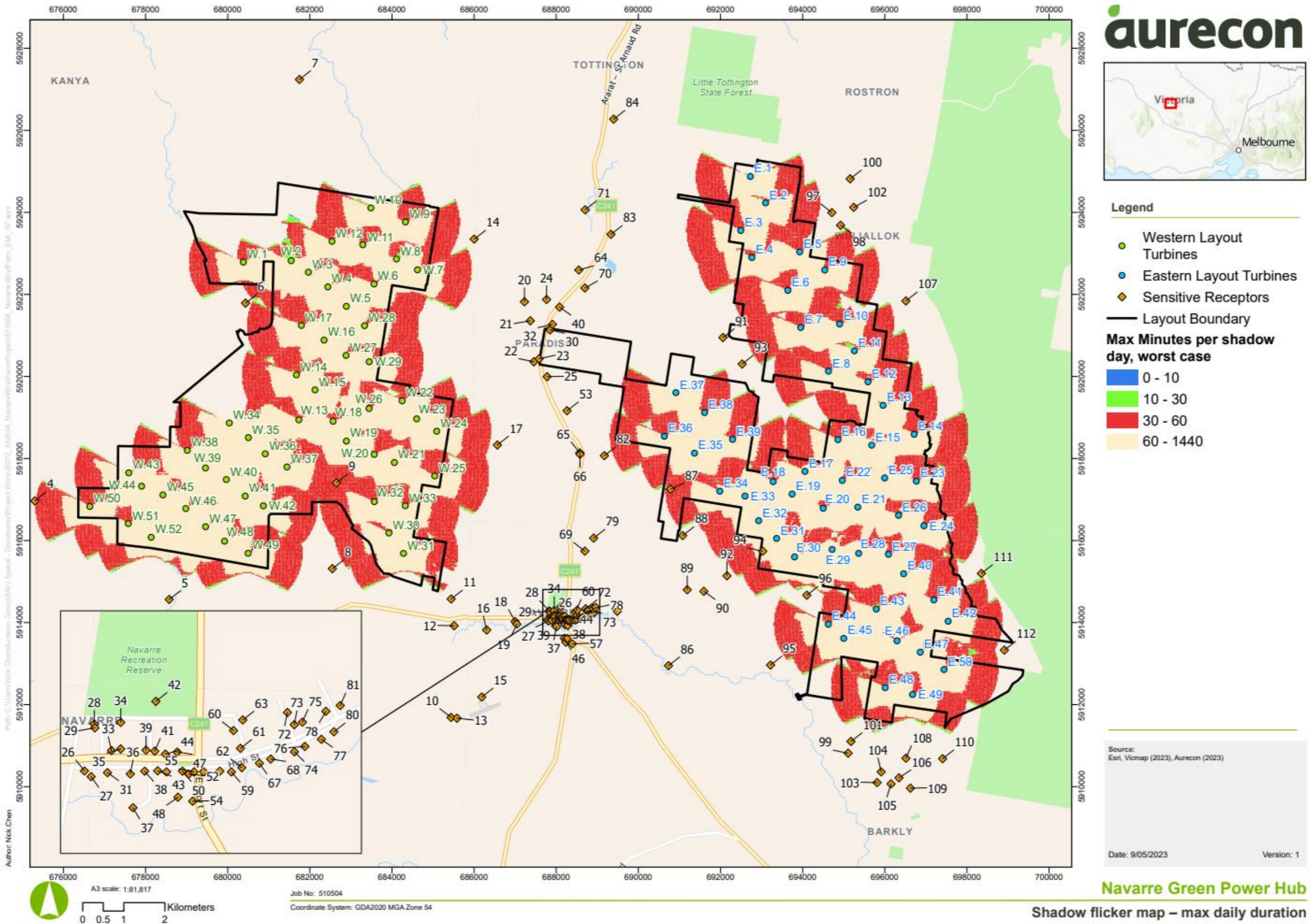


Figure 2 Shadow flicker map – max daily duration

All non-host (i.e., neighbour) residences have zero theoretical duration due to being beyond the distance threshold of 1,325 m (265 x blade chord). Therefore, the limit for theoretical (30 hours per year) is met and realistic duration does not need to be assessed.

Although not subject to the same requirements as non-host residences, three host residences are affected by shadow flicker as shown in Table 3. The “nearest turbine” is the nearest of the turbines that cause any shadow flicker at the residence.

Table 3 Host residences affected by shadow flicker

| Residence ID | East (UTM WGS84 Zone 54) | North (UTM WGS84 Zone 54) | Affecting turbines | Distance to nearest turbine [km] | Theoretical shadow per year [hours] | Max shadow per day [minutes] |
|--------------|--------------------------|---------------------------|---------------------|----------------------------------|-------------------------------------|------------------------------|
| 9 | 682648 | 5917407 | W.20, W.32 and W.37 | 1.03 | 91 | 40 |
| 87 | 690783 | 5917250 | E.34 | 1.20 | 22 | 36 |
| 94 | 693027 | 5915739 | E.30 and E.31 | 0.46 | 228 | 84 |

Aurecon notes that the realistic shadow flicker duration at the affected host residences will be significantly lower than the theoretical results shown above, due to reasons such as cloud cover, turbine orientation, and shut-down time. However, noting the limits for both daily and annual theoretical shadow flicker time are exceeded for the three host residences, it is recommended that some mitigation will be required to prevent discomfort.

The movement of turbines within the turbine flexibility zone has not been considered but is not expected to change the result significantly, however the assessment will need to be redone to confirm this. If the limits for theoretical or realistic duration are exceeded for a non-host landowner for the final turbine model and layout, then mitigation will be required.

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