Attachment 5: s92 Request and Responses Post-Notification

SOUTH WAIRARAPA DISTRICT COUNCIL
Kia Reretahi Tātau

27 June 2023

Far North Solar Farm Limited
c/o Williamson Water and Land Advisory
Unit 10 1 Putaki Drive
Kumeu
Auckland 0841

Attention: Laila Alkamil
Email: Laila.Alkamil@wwla.kiwi

Dear Laila

APPLICATION FOR RESOURCE CONSENT – SOLAR FARM IN RURAL ZONE, MOROA ROAD, GREYTOWN
PLANNING APPLICATION NO 220103

Further information request – following the close of submissions

You will be aware that submissions on your application closed on 6 June 2023. I understand we have both received copies of all the submissions, where 46 submissions have been received to date. Please call me on 021 424 175 or email me if you think this is not the case.

Submitters raised a number of issues about the proposal which are of particular interest to us. Following my review of the submissions I am requesting the following further information from you. This is to help me better understand your proposed activity, its effect on the environment, and the ways any adverse effects on the environment might be mitigated.

Requested information

1. **Effects on electricity transmission lines (Transpower assets)**
   Submitters have raised concerns regarding the access to transmission lines, the heights of shelter belts, the safe separation of mechanical plan during the construction phase and other construction effects. It is noted that a submitter (Transpower) has recommended conditions be imposed on this application. The limitations set out in those conditions on shelterbelts may be incompatible with the landscape mitigation strategy. The outcome of any consultation with Transpower, including any agreed and offered conditions should be provided. Please provide information on how these effects on transmission lines can be managed.

   Note: The AEE does not include an assessment of the proposal against the National Policy Statement on Electricity Transmission (principally the objective and Policy 10), please provide this.

2. **Glint and glare on State Highway 2 users**
   Submitters have identified that the proposed grade of planting for the shelterbelts intended to screen views of the solar farm from State Highway 2 will allow drivers to view the solar panels in the short term, and until the *Cryptomeria japonica* shelterbelt, attains a suitable height. This will have an effect on users of the SH2 network through glint/glare during this time. Please provide information on how these effects can be managed.

3. **Effect on aircraft operations**
   Submitters have identified that the panels pose a risk to aircraft use on nearby sites as a climb out obstruction and through glint and glare creating sun strike for aircraft pilots. Whilst the report entitled '*Glint and Glare Considerations for FNSF Solar Farms*' prepared by Renewable Energy Group addresses aircraft briefly in the summary noting that "The panels have been re-orientated to minimise the effect." This appears to be a generic comment and it is unclear whether this has been factored into the design and layout of the solar farm. Please provide information on how the effects on aircraft use including potential obstructions and glint and glare can be managed.

4. **End of life**
   Submitters have raised concerns regarding the end of life disposal of the panels. The AEE notes:

   > *The panels themselves are warranted for 30 years with an expected lifespan in excess of the consent duration. At the end of the consented period, the solar farm is decommissioned and all materials are removed for recycling.*

   Please provide more information regarding the process of decommissioning and what protocols can be adopted to ensure that actual and potential effects of discharges of contaminated material can be suitably managed.

   Note: at section 1.4 the AEE notes that an 'unlimited duration' is sought as the application is for a land use consent under section 9 of the Resource Management Act 1991. This is not consistent with section 3.7 that implies a 'consented period' and that this is less than 30 years. Please clarify whether a specified duration is sought.

5. **Soil and water contamination from panel run-off and breakdown**
   Submitters have raised concern that over time the panels will breakdown and discharge contaminated material to land and water. Submissions also identify risk associated with panel damage releasing contaminated material. Please provide information on how, if any, adverse effects can be managed.

6. **Noise effects during construction and operational phase**
   A number of submitters have raised concerns regarding the noise effects that may be generated during the construction phase and within the operational phase of the solar farm. It is noted that the AEE asserts that: "The proposed construction works will comply with the New Zealand Standard NZS 6803:1999…" and 'Operational noise effects are minimal and will not be noticeable from the boundary of the site…Average maximum sound pressure at 1m distance was measured at 62dBA.' Noting the permitted standard which excludes mobile sources associated with primary production at the notional boundary is:

Daytime	7.00am – 7.00pm	55dBA L10
Nighttime	7.00pm – 7.00am	45dBA L10
	9.00pm – 7.00am	75dBA L10

Please provide an acoustic assessment, prepared by a suitably qualified person to confirm that both during the construction and operational phase of the activity adverse noise effects will be managed to within acceptable limits, with reference to the permitted standards. Submissions have noted that there are already other noise generating activities that may contribute to noise effects, and the proposal may generate a cumulative effect or exacerbated noise effects on amenity by the introduction of the panels themselves.

7. **Heating effects**
   Submitters have raised concerns that panels will generate localised changes to temperature as a 'heat island'. Please provide information on how, if any, adverse heating effects can be managed.

8. **Highly Productive Land**
   Submitters have raised concerns that the solar farm will diminish the productive capacity of the land by establishing a use on the land that is not 'land-based primary production[1]' and 'primary production[2]' activities. It is noted that essential parts of the solar farm proposal being the substation and switchyard and also part of the 'Extended Plot Area' are located on land identified as LUC 2 on the soil maps. An assessment in respect of the National Policy Statement for Highly Productive Land 2022 has been included in the AEE that states that there are 'functional and operational requirements for it to be located on the subject site'. Please provide further details on this functional and operational need assessment.

Providing the information

Three upcoming points in the consent process are important in relation to this information request. I understand that you have made a request for the application to be processed on a direct referral pathway, this request has not been determined at this time. The below is framed on a standard processing pathway and would need to change if direct referral is confirmed.

Planner's report to the hearing commissioners (section 42A report)

First, I will need to make a full assessment of your proposal in my report to the hearing commissioners.[3] The purpose of the report is to help them make a decision on your application. Without complete information about your proposal, I may not be able to support it. The question of whether requested information has been made available is also a matter that the commissioners are required to have regard to when they make their decision, and they can refuse consent in cases where there is inadequate information.[4]

My report must be completed and made available to you, to all submitters who wish to be heard, and the commissioners on or 15 working days before the scheduled date for the hearing. If you intend to provide the requested information, I will need to receive it in sufficient time to act on it in my report.

Deadline for the provision of information before the hearing

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[1] 'land-based primary production' refer National Policy Statement for Highly Productive Land 2022 – where this term is defined and 'means production, from agricultural, pastoral, horticultural, or forestry activities, that is reliant on the soil resource of the land.'

[2] 'primary production' refer Wairarapa Combined District Plan 2011 – where this term is defined to mean 'the use of land and accessory buildings (e.g. greenhouses) for the raising, growing and breeding of animals or vegetative matter and crops, including horticulture, plantation forestry, agriculture, viticulture, floriculture, racing stables, and outdoor (extensive) pig farming, as well as winemaking, flower packing, and other primary processing activities, but excludes top soil stripping, intensive farming activities, and mineral extraction and processing.'

[3] Section 42A of the RMA

[4] Section 104(6) and (7) of the RMA

Second, the Resource Management Act 1991 (the RMA) requires that any information requested of applicants be made available to us no later than 10 days before the hearing.[5]

Deadline for circulation of evidence before the hearing

Third, you will be required to make all your evidence available to us, so we can make it available to submitters and the hearings panel / commissioners, 10 days before the hearing.[6]

Requesting more time

We will not be suspending your application or waiving or extending our processing timeframes while you prepare and supply this information.

However, if you decide that you will require more time, you can suspend the processing at any time within the 130 working days.[7] As a consequence of suspending processing, the dates for the hearing and prior exchange of evidence will most likely be delayed. If you consider it will be helpful to suspend the process, please make a request to me in writing.

Next steps

Once you have provided the further information, I will review what you have provided to make sure it adequately addresses all of the points of my request.

As you will be aware, the hearing for your application has not been scheduled at this time.

Timeframes that will need to be met by both you and Council leading up to the hearing are:

- At least 15 working days before the hearing we will send you a copy of the planning officer's recommendation report, as well as any other expert evidence.
- At least 10 working days before the hearing you must provide us with all the briefs of evidence, including legal submissions, that you intend to present to support your application at the hearing.
- At least five working days before the hearing submitters must provide to us briefs of any expert evidence they are calling.

If you have any queries, please contact me on 021 424 175 and quote the application number above.

Yours sincerely,

Nick Pollard
Consultant Planner

[5] Section 92(3A) of the RMA
[6] Section 103B of the RMA
[7] Section 91A of the RMA

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South Wairarapa District Council

Attention: Nick Pollard
Nick.Pollard@boffamiskell.co.nz

11 August 2023 WWLA0589

Dear Nick

Resource Consent Application 415 Moroa Road, Greytown (Planning Application No. 220103) – Response to Further Information Request Following the Close of Submissions

This letter provides a response to your letter dated 27 June 2023 which requested further information following the close of submissions on this application. The requests are presented in *blue* italics, followed by our responses.

1. ***Effects on Electricity Transmission Lines (Transpower assets) Assessment of Effects on the Environment***

   Submitters have raised concerns regarding the access to transmission lines, the heights of shelterbelts, the safe separation of mechanical plan during the construction phase and other construction effects. It is noted that a submitter (Transpower) has recommended conditions be imposed on this application. The limitations set out in those conditions on shelterbelts may be incompatible with the landscape mitigation strategy. The outcome of any consultation with Transpower, including any agreed and offered conditions should be provided. Please provide information on how these effects on transmission lines can be managed.

   Note: The AEE does not include an assessment of the proposal against the National Policy Statement on Electricity Transmission (principally the objective and Policy 10), please provide this.

The Applicant has consulted with Transpower following the receipt of their submission. As a result of these discussions, the Applicant accepts the recommended conditions put forward by Transpower as set out in **Attachment 1**.

The conditions put forward by Transpower will ensure the appropriate setbacks and work practices set out under the NZECP:34 Regulations are adhered to for the duration of the project.

The proposed conditions require vegetation within 12 m of the centreline of the transmission lines and support structures to not exceed 2 m in height and to ensure, for any vegetation outside of these setbacks, that they cannot fall within 4 m of the transmission lines. All vegetation planted will comply with the Electricity (Hazards from Trees) Regulations 2003. This will not impact on the proposed screen planting, as this vegetation is focused around the site boundary and not within 12 m of transmission lines or support structures.

There are no plants to plant screening trees within the site, and at along the site boundary all proposed screening will be maintained to comply with the Electricity (Hazards from Trees) Regulations 2003.

2. ***Glint and Glare on State Highway 2 Users***

   Submitters have identified that the proposed grade of planting for the shelterbelts intended to screen views of the solar farm from State Highway 2 will allow drivers to view

the solar panels in the short term, and until the Cryptomeria japonica shelterbelt, attains a suitable height. This will have an effect on users of the SH2 network through glint/glare during this time. Please provide information on how these effects can be managed.

Refer to the Glint and Glare Assessment provided in **Attachment 2**. The assessment notes that up to 3 minutes of green glare between 5-6am from late January to early February and up to 3 minutes of green glare between 4:30 am and 5:30 am from late October to mid-November on State Highway 2 users can be expected. Overall, the impact of this is assessed as being very low (negligible) and no mitigation is required.

3. *Effect on Aircraft Operations*

Submitters have identified that the panels pose a risk to aircraft use on nearby sites as a climb out obstruction and through glint and glare creating sun strike for aircraft pilots. Whilst the report entitled 'Glint and Glare Considerations for FNSF Solar Farms' prepared by Renewable Energy Group addresses aircraft briefly in the summary noting that "The panels have been re-orientated to minimise the effect." This appears to be a generic comment and it is unclear whether this has been factored into the design and layout of the solar farm. Please provide information on how the effects on aircraft use including potential obstructions and glint and glare can be managed.

Please see the Glint and Glare Assessment in **Attachment 2**.

With regards to the airfield immediately east of the site, this does not appear to be a registered aerodrome according to the Civil Aviation Authority New Zealand's list of Aerodrome Coordinates. On that basis, this has been excluded from the Glint and Glare Assessment.

4. *End of Life*

Submitters have raised concerns regarding the end of the life disposal of the panels. The AEE notes:

The panels themselves are warranted for 30 years with an expected lifespan in excess of the consent duration. At the end of the consented period, the solar farm is decommissioned and all materials are removed for recycling.

Please provide more information regarding the process of decommissioning and what protocols can be adopted to ensure that actual and potential effects of discharges of contaminated material can be suitably managed.

Note: at section 1.4 the AEE notes that an 'unlimited duration' is sought as the application is for a land use consent under section 9 of the Resource Management Act 1991. This is not consistent with section 3.7 that implies a 'consented period' and that this is less than 30 years. Please clarify whether a specified duration is sought.

With regards to decommissioning, all site reinstatement is assured in the lease agreement with the property owner which includes a decommissioning bond. At the end of the solar farm operation, the Applicant will removal all energy facility, structures and equipment including subsurface wires and footings. Any access tracks within the site will be removed and re-planted with vegetation and grassland species, as appropriate. The solar panels and all other equipment removed from the project site, unless being reused or repurposed for another project, shall be recycled in accordance with all applicable policies and procedures in effect at the time of decommissioning.

In addition to this, the Applicant would accept a condition of consent that would require a Decommissioning Plan to be prepared and implemented.

With regards to the consent duration, it is noted an unlimited consent was sought in the application. However, the Applicant would like to amend this to a consent duration of 35 years which will be in line with the decommissioning plan for the solar farm.

5. Soil and Water Contamination from Panel Run-Off and Breakdown

Submitters have raised concern that over time the panels will breakdown and discharge contaminated material to land and water. Submissions also identify risk associated with panel damage releasing contaminated material. Please provide information on how, if any, adverse effects can be managed.

The panels are warranted for a duration of 35 years, with an expected lifespan in excess of the duration of the consent. The panels are designed to weather the elements for this period of time and there is no expected leachate of contaminants over the consent duration.

During the operation of the solar farm, the panels will be regularly checked and repaired (as required). At the end of the consented period, the panels will be decommissioned and all material and associated materials (i.e. cabling) will be removed off-site for recycling.

6. Noise Effects During Construction and Operational Phase

A number of submitters have raised concerns regarding the noise effects that may be generated during the construction phase and within the operational phase of the solar farm. It is noted that the AEE asserts that: "The proposed construction works will comply with the New Zealand Standard NZS 6803:1999…" and 'Operational noise effects are minimal and will not be noticeable from the boundary of the site…Average maximum sound pressure at 1m distance was measured at 62dBA'. Noting the permitted standard which excludes mobile sources associated with primary production at the notional boundary is:

Daytime	7.00am – 7.00pm	55dBA L10
Nighttime	7.00pm – 7.00am	45dBA L10
	9.00pm – 7.00am	75dBA L10

Please provide an acoustic assessment, prepared by a suitably qualified person to confirm that both during the construction and operational phase of the activity adverse noise effects will be managed to within acceptable limits, with reference to the permitted standards. Submissions have noted that there are already other noise generating activities that may contribute to noise effects, and the proposal may generate a cumulative effect or exacerbated noise effects on amenity by the introduction of the panels themselves.

Please see the Acoustic Assessment in **Attachment 3**.

With regards to construction noise, the assessment notes that the majority of dwellings are well beyond 100 m from the piling and therefore compliance with the Wairarapa Combined District Plan construction noise rules will be complied with at most dwellings. However, there are some dwellings that will be closer to the piles than this. These are identified as:

- 489 Moroa Road;
- 56 Settlement Road; and
- 312 Bidwills Road.

Mitigation measures are proposed to ensure compliance with the NZS 6803:1999 noise limits at all dwelling facades. This includes limiting the use of unattenuated Vermeer or drop hammer piling occurring in close proximity to dwellings. In the event that a Vermeer-type or drop hammer piling rig was used, that a suitable dolly or shroud (or similarly effective method) is used to mitigate noise from the piling.

To address this, a Noise Management Plan (NMP) is proposed to be prepared as part of the resource consent conditions. The key matter that the NMP will address are maps that will illustrate the "pilling zones" where noise levels may be above the NZS 6803:1999 noise limit without attenuation. For the wording of the proposed conditions, please refer to Section 9 of the Acoustic Assessment.

The operational noise limits have been found to comply with the permitted daytime limits as set out in the Wairarapa Combined District Plan.

7. Heating Effects

Submitters have also raised concerns that panels will generate localised changes to temperature as a 'heat island'. Please provide information on how, if any, adverse heating effects can be managed.

Most of the world's largest solar farms, and therefore a large proportion of solar farm studies, are located in savannah or desert environments (Aman et al., 2015; Barron-Gafford et al., 2016; Fthenakis and Yu, 2013; Montag et al., 2016; Nordberg et al., 2021; Taylor et al., 2019; Turney and Fthenakis, 2011). In these systems, PV panels are typically placed directly on bare ground. One such solar farm observed that temperatures were 3 to 4°C higher 2.5 metres above the ground compared to a natural desert control site. This was likely due to the combined effects of a lack of vegetation at the site, little room for convective cooling beneath the panels, and the low albedo of solar panels, as well as potential effects from the desert environment (Barron-Gafford et al., 2016). It is difficult to apply these findings to the proposed Greytown site as these panels will be 2-2.5 metres above pasture and the site has a very different climate from the Barron-Gafford study.

Agrivoltaic systems - wherein solar energy collection is undertaken on the same land as agricultural activities - affect temperature and soil moisture in very different ways than PV systems where panels are placed directly on bare ground. In a study of 18 soybean farms, areas shaded by panels were up to 10°C cooler than sun-exposed areas due to the combined effects of the lower albedo of crops, evapotranspiration from crops, and convective cooling under the raised panels (Williams et al., 2023). Similar results, showing lower ground temperatures and higher relative humidity and soil moisture, were also found by Dutch (Vervloesem et al., 2022) and American (Adeh et al., 2018) studies. Of particular relevance to the proposed Greytown site, sheep grazing in agrivoltaic systems in Oregon showed a 90% increase in late-season pasture productivity and 328% increased water efficiency compared to pastures without solar panels (Adeh et al., 2018).

Based on the combined results from several studies in more extreme environments than the proposed Greytown solar farm site, no evidence was found to indicate that a Heat Island Effect would be produced by raised solar panels installed over grazed pasture in the Wairarapa.

8. Highly Productive Land

Submitters have raised concerns that the solar farm will dimmish the productive capacity of the land by establishing a use on the land that is not 'land-based primary production' and 'primary production' activities. It is noted that essential parts of the solar farm proposal being the substation and switchyard and also part of the 'Extended Plot Area' are located on land identified as LUC2 on the soil maps. An assessment in respect of the National Policy Statement for Highly Productive Land 2022 has been included in the AEE that states that there are 'functional and operational requirements for it to be located on the subject site'. Please provide further details on this functional and operational need assessment.

The functional and operational need to locate the proposed solar farm in this specific location relates to the proximity of the grid connection point that is provided by the Transpower's substation on the corner of Moroa Road and Bidwills Cutting Road. This enables the solar farm to

connect to the National Grid with minimal cabling / connection works required, which avoids electricity losses.

Furthermore, the site is of a suitable topography (i.e. relatively flat), not in prominent view of sensitive visual receptors and receives well-above average sunlight hours / irradiance, making it suitable for solar panels to be erected.

In addition to this, the Soil Assessment (**Attachment 4**) confirms the proposal will not adversely impact the productive potential of the site's soil and will actually be potentially more beneficial to soil structure and long-term potential productivity than many farming operations.

Conclusion

We trust that there is now sufficient information available for you to continue processing the application. Please do not hesitate to contact Laila Alkamil on 027 266 8405 if you require further clarification of any aspects of this letter.

Yours sincerely,

Laila Alkamil
Planner | 027 266 8405
Laila.Alkamil@wwla.kiwi | www.wwla.kiwi

References

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Attachment 1: Transpower Conditions

General

1. The consent holder shall provide Transpower NZ Ltd 10 working days notice in writing prior to commencing the proposed works. Note: notification can be sent to transmission.corridor@transpower.co.nz

Building and Structures

2. No buildings or structures (except non-conductive fencing) shall be located within 12m of the centreline of the MST-UHT A National Grid transmission lines.

3. No buildings or structures shall be located within 12m of any outer visible edge of the foundation of National Grid support structures MST-UHT-A0192 to 0199; except for non-conductive fencing, which can be located 6m from any outer visible edge of the support structure foundation.

NZECP Compliance

4. All land use activities, including the construction of new buildings/structures, earthworks, fences, any operation of mobile plant and/or persons working near exposed line parts shall comply with the New Zealand Electrical Code of Practice for Electrical Safe Distances (NZECP 34:2001) or any subsequent revision of the code.

Access

5. All buildings, structures and vegetation must be located to ensure vehicle access is maintained to the MST-UHT A National Grid transmission lines, and support structures MST-UHT-A0192 to 0199, for maintenance at all reasonable times, and emergency works at all times.

   Advice note: Transpower NZ Ltd has a right to access its existing assets under s23 of the Electricity Act 1992. Any development on must not preclude or obstruct this right of access. It is an offence under s163D of the Electricity Act 1992 to intentionally obstruct any person in the performance of any duty or in doing any work that the person has the lawful authority to do under s23 of the Electricity Act 1992.

Mobile Plant

6. All machinery and mobile plant operated in association with the works shall maintain a minimum clearance distance of 4 metres from the live overhead conductors (wires) of the MST-UHT A National Grid transmission lines at all times to avoid the potential of machinery striking the lines.

7. To ensure safe separation distances to the conductors (wires) of the National Grid transmission lines are maintained, all machinery, mobile plant and vehicles operating within 12m of the

transmission lines, and traversing beneath the lines, shall be limited to a maximum reach height of 2.1 metres. This includes any loads being lifted or transported underneath the line.

Vegetation

8. Any proposed new trees or vegetation within 12 metres either side of the centreline of the MST-UHT A National Grid transmission line must not exceed 2 metres in height at full maturity and must comply with the Electricity (Hazards from Trees) Regulations 2003, or any subsequent revision of the regulations.

9. Any proposed new trees or vegetation outside of 12 metres either side of the centreline of the MST-UHT A National Grid transmission lines must be setback sufficiently to ensure the tree cannot fall within 4 metres of the National Grid transmission lines and must comply with the Electricity (Hazards from Trees) Regulations 2003, or any subsequent revision of the regulations.

Construction Management Plan

10. Prior to the commencement of the solar farm works, the consent holder shall prepare and submit to the Council for approval a Construction Management Plan (CMP) to ensure the protection of the MST – UHT A National Grid transmission lines and support structures. The CMP must be given to Transpower NZ Ltd for its certification at least 20 working days prior to being submitted to the Council.

    Note: The CMP should be sent to Transpower via PATAI Form 5: https://transpower.patai.co.nz/new-enquiry

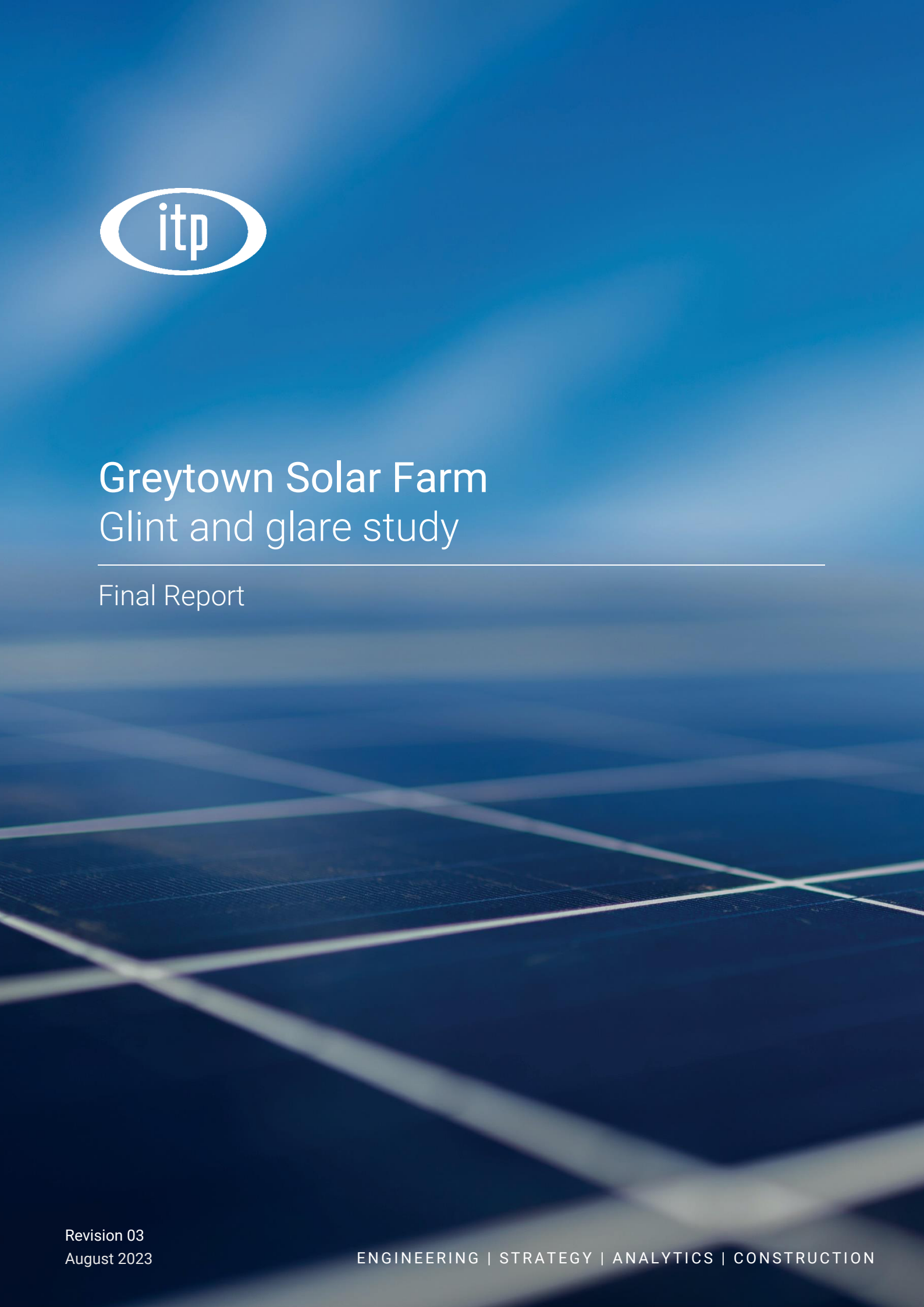
11. The CMP must include the following (but is not limited to):

a) The name, experience and qualifications of the person/s nominated by the consent holder to supervise the implementation of, and adherence to, the CMP.
b) Construction drawings, plans, procedures, methods and measures to demonstrate that all construction activities undertaken on the site will meet the safe distances within the New Zealand Electrical Code of Practice for Electrical Safe Distances 2001 (NZECP 34: 2001) or any subsequent revision of the code; including (but not limited to) those relating to:
    i. Excavation and Construction near Towers (Section 2);
    ii. Building to conductor clearances (Section 3);
    iii. Ground to conductor clearances (Section 4);
    iv. Mobile Plant to conductor clearances (Section 5); and
    v. People to conductor clearances (Section 9).
c) Details of any areas that are "out of bounds" during construction and/or areas within which additional management measures are required, such as fencing off, entry and exit hurdles, maximum height limits, or where a safety observer may be required (a safety observer will be at the consent holder's cost.
d) Demonstrate how the existing transmission lines and support structures will remain accessible during and after construction activities;

e) Demonstrate how the effects of dust (including any other material potentially resulting from construction activities able to cause material damage beyond normal wear and tear) on the transmission lines will be managed;
f) Demonstrate how changes to the drainage patterns, runoff characteristics and stormwater will avoid adverse effects on the foundations of any support structure;
g) Demonstrate how construction activities that could result in ground vibrations and/or ground instability will be managed to avoid causing damage to the transmission lines, including support structures.
h) Details of proposed contractor training for those working near the transmission lines.

12. All activities are to be undertaken in accordance with the approved CMP.

Attachment 2: Glint and Glare Assessment



Greytown Solar Farm
Glint and glare study

Final Report

Revision 03
August 2023

ENGINEERING | STRATEGY | ANALYTICS | CONSTRUCTION

DOCUMENT CONTROL

Report Title		Greytown Solar Farm – Glint and glare study			
Client Contract No.			**ITP Project Number**	23070	
File Path		https://itprenewables.sharepoint.com/sites/Projects/External/23070 - Greytown SF Glare Study/Project/4 Work/4 Reports/23070 - Greytown SF Glare Study REV01.docx			
Client		Far North Solar Farm	**Client Contact**	John Andrews	
Rev	**Date**	**Status**	**Author/s**	**Reviewed By**	**Approved**
1	6/07/2023	Draft	N Logan	I Chawla	N Logan
2	18/07/2023	Final	N Logan	I Chawla	N Logan
3	8/08/2023	Revision	D Thompson	N Logan	N Logan

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ABOUT ITP RENEWABLES

ITP Renewables (ITP) is a global leader in renewable energy engineering, strategy, construction, and energy sector analytics. Our technical and policy expertise spans the breadth of renewable energy, energy storage, energy efficiency and smart integration technologies. Our range of services cover the entire spectrum of the energy sector value chain, from technology assessment and market forecasting right through to project operations, maintenance, and quality assurance.

We were established in 2003 and operate out of offices in Canberra (Head Office), Sydney, North Coast NSW, and Adelaide. We are part of the international ITPEnergised Group, one of the world's largest, most experienced, and respected specialist engineering consultancies focussing on renewable energy, energy efficiency, and carbon markets. The Group has undertaken over 2,000 contracts in energy projects encompassing over 150 countries since it was formed in 1981.

Our regular clients include governments, energy utilities, financial institutions, international development donor agencies, project developers and investors, the R&D community, and private firms.

ABOUT THIS REPORT

This report assesses the glint and glare impact of the proposed Greytown Solar Farm near Greytown, New Zealand. It was commissioned by Far North Solar Farm Limited.

ABBREVIATIONS

AC	Alternating current
CAA	Civil Aviation Authority
DC	Direct current
FAA	Federal Aviation Administration (United States)
FNSF	Far North Solar Farm Limited
ha	Hectare
ITP	ITP Renewables
MW	Megawatt, unit of power (1 million Watts)
MWp	Megawatt-peak, unit of power at standard test conditions; used to indicate PV system capacity
OP	Observation point
PV	Photovoltaic
SGHAT	Solar Glare Hazard Analysis Tool

TABLES

FIGURES

TABLE OF CONTENTS

1 INTRODUCTION

1.1 Overview

Far North Solar Farm Limited (FNSF) has requested a glint and glare assessment for a proposed solar photovoltaic (PV) installation near Greytown, New Zealand. This assessment will be submitted as part of the consent process for the project. It includes:

- Identification of potential receptors of glint and glare from the proposed solar farm
- Assessment of the glint and glare hazard using the Solar Glare Hazard Analysis Tool (SGHAT) GlareGauge analysis

1.2 Glint and glare

The United States Federal Aviation Administration (FAA) defines glint and glare as follows:[1]

- **Glint** is a momentary flash of bright light
- **Glare** is a continuous source of excessive brightness relative to ambient lighting.

Glint and glare can occur when light reflected off a surface (reflector) is viewed by a person (receptor). Glint typically occurs when either the receptor or the reflector is moving, while glare typically occurs when the reflector and receptor are completely, or nearly, stationary. For a transparent material (e.g., glass, water) the quantity of light reflected depends on the surface itself (i.e., material and texture), and the angle at which the light intercepts it (angle of incidence). A higher angle of incidence will result in a higher proportion of light being reflected, as shown in Figure 1.

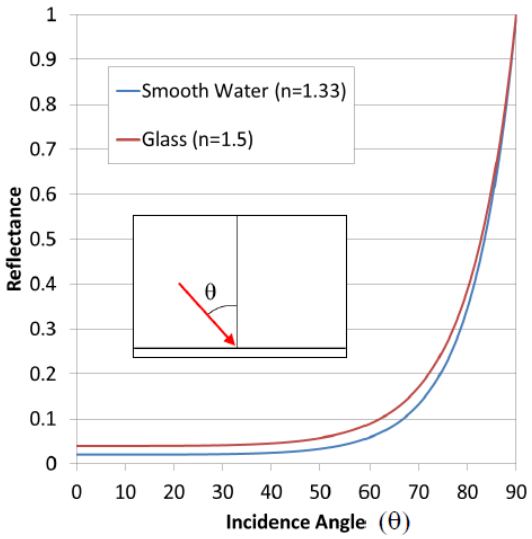

Figure 1: Angles of incidence and increased levels of reflected light

[1] Federal Aviation Administration [FAA], 2018

Potential visual impacts from glint and glare include distraction and temporary afterimage; at its worst, it can cause retinal burn. The ocular hazard caused by glint or glare is a function of:

1. The intensity of the glare upon the eye (retinal irradiance)
2. The subtended angle of the glare source (i.e., the extent to which the glare occupies the receptor's field of vision; dependent on size and distance of the reflector).

The severity of the ocular hazard can be divided into three levels, as shown in Figure 2:

- **Green glare**, which has low potential to cause temporary afterimage
- **Yellow glare**, which has potential to cause temporary afterimage
- **Red glare**, which can cause retinal burn and is not expected for PV.

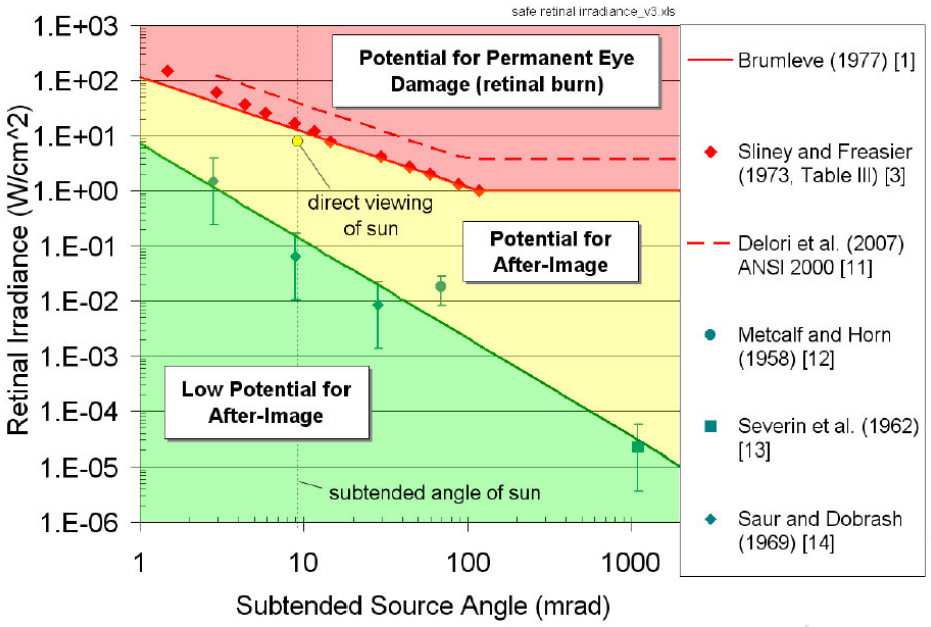

Figure 2: Classification of glare based on severity of ocular effects

1.3 Glare from solar PV

Solar photovoltaic (PV) cells are designed to absorb as much light as possible to maximise efficiency (generally around 98% of the light received). To limit reflection, solar cells are constructed from dark, light-absorbing material and are treated with an anti-reflective coating. PV modules generate less glare than many other surfaces, as shown in Figure 3.

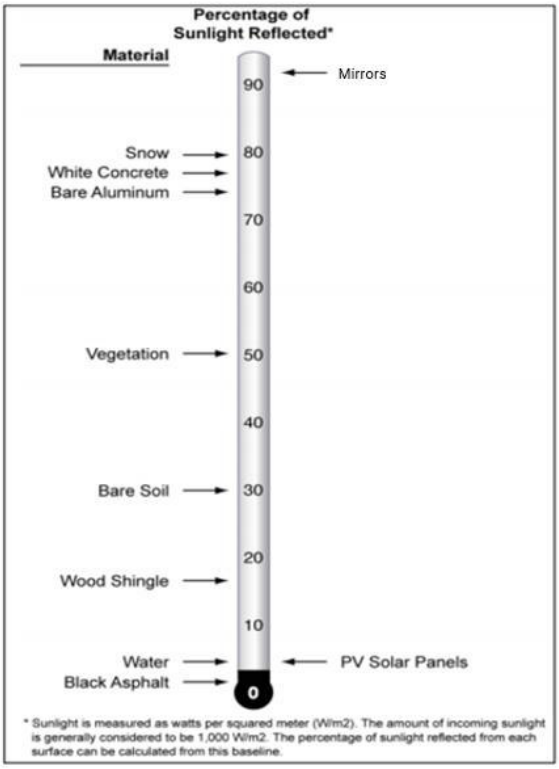

Figure 3: Typical percentage of sunlight reflected from different surfaces (Source: Adapted from Journal of Airport Management, 2014)

The small percentage of light reflected from PV modules varies depending on the angle of incidence. Figure 4 shows an example of this with a solar module. A larger angle of incidence will result in a higher percentage of reflected light.

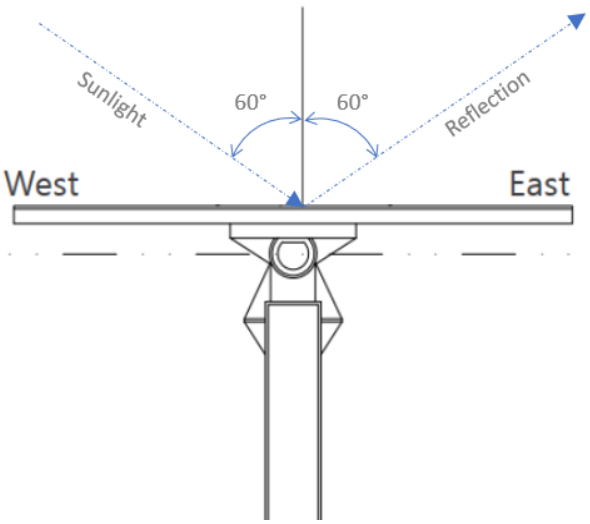

Figure 4: Typical sunlight reflection off the surface of a solar module

The two most common PV mounting structures are fixed tilt and single axis tracking. Fixed tilt arrays are stationary, while single axis tracking arrays rotate the receiving surface of the modules from east to west throughout the day as the sun moves across the sky.

In a fixed tilt PV array, since the sun is moving but the modules are stationary, the angle of incidence varies as the sun moves across the sky. It is smallest around noon when the sun is overhead and largest in the early morning and late afternoon when the sun is near the horizon. There is therefore a higher potential for glare at these times.

The angle of incidence for a single axis tracking system varies less as the reflective surface of the modules rotates on a horizontal axis to follow the sun. Single axis tracking arrays therefore generate less glare than fixed tilt arrays. The tracking varies throughout the year to match seasonal changes in the sun's path (see Figure 5).

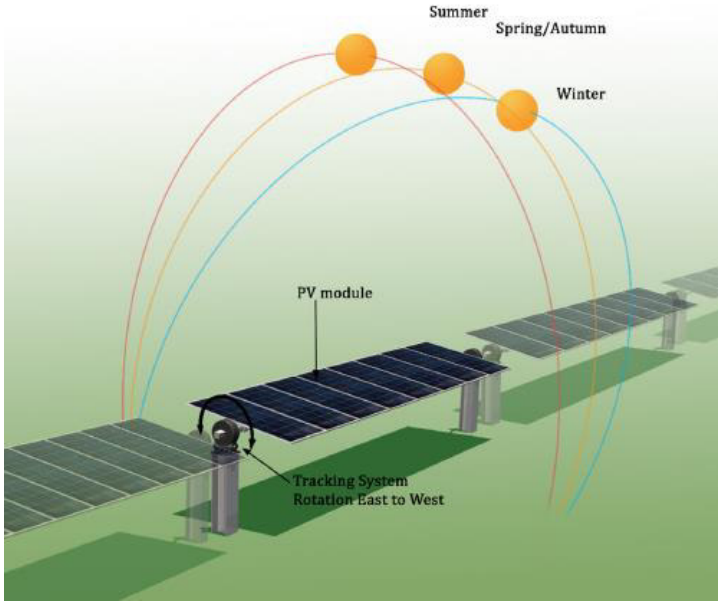

Figure 5: Sun position relative to PV modules on a horizontal single-axis tracking system

2 PROJECT DESCRIPTION

2.1 Site overview

FNSF is proposing a solar farm at the location described in Table 1 and shown in Figure 6. The site is located approximately 4 km south-west of Greytown. An indicative layout is displayed in Figure 7, Figure 8, and Figure 9.

Table 1: Site Information

Parameter	Description
Parcels	Lot 10 DP 3106; Lots 5, 6, & 7 DP 8803; Lot 1 DP 76478; Part Section 122 Moroa DIST; Section 27 Moroa SETT; Lot 1 DP 52574
Address	Moroa Rd
Council	South Wairarapa District Council
Project area	220 ha

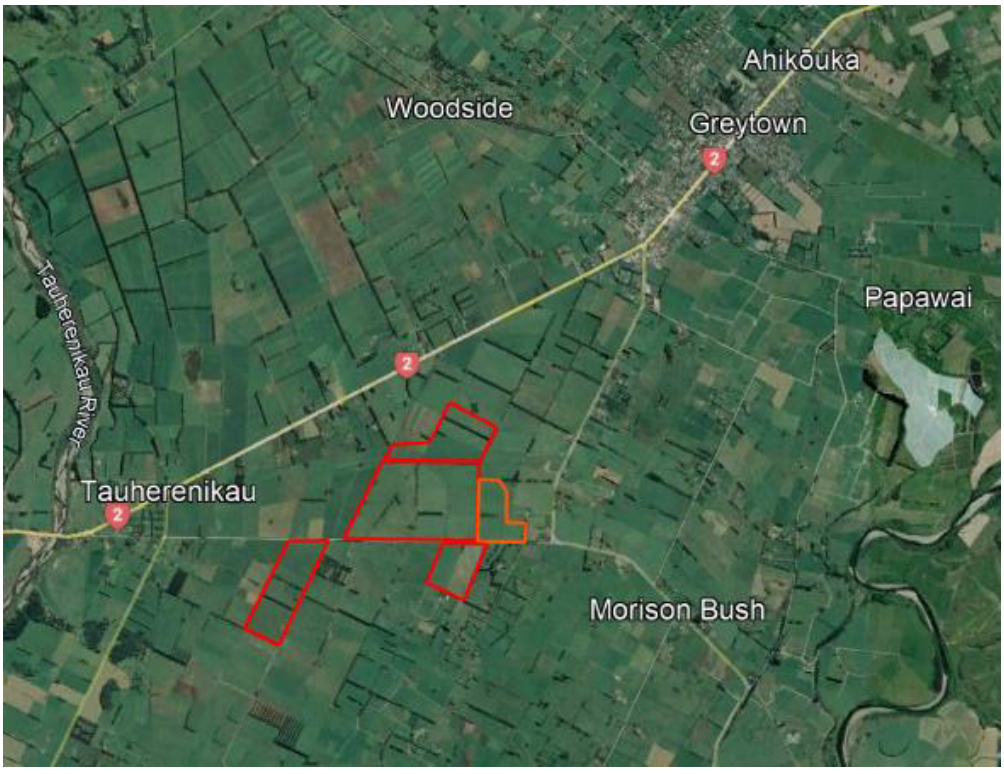

Figure 6: Greytown Solar Farm indicative location and PV layout

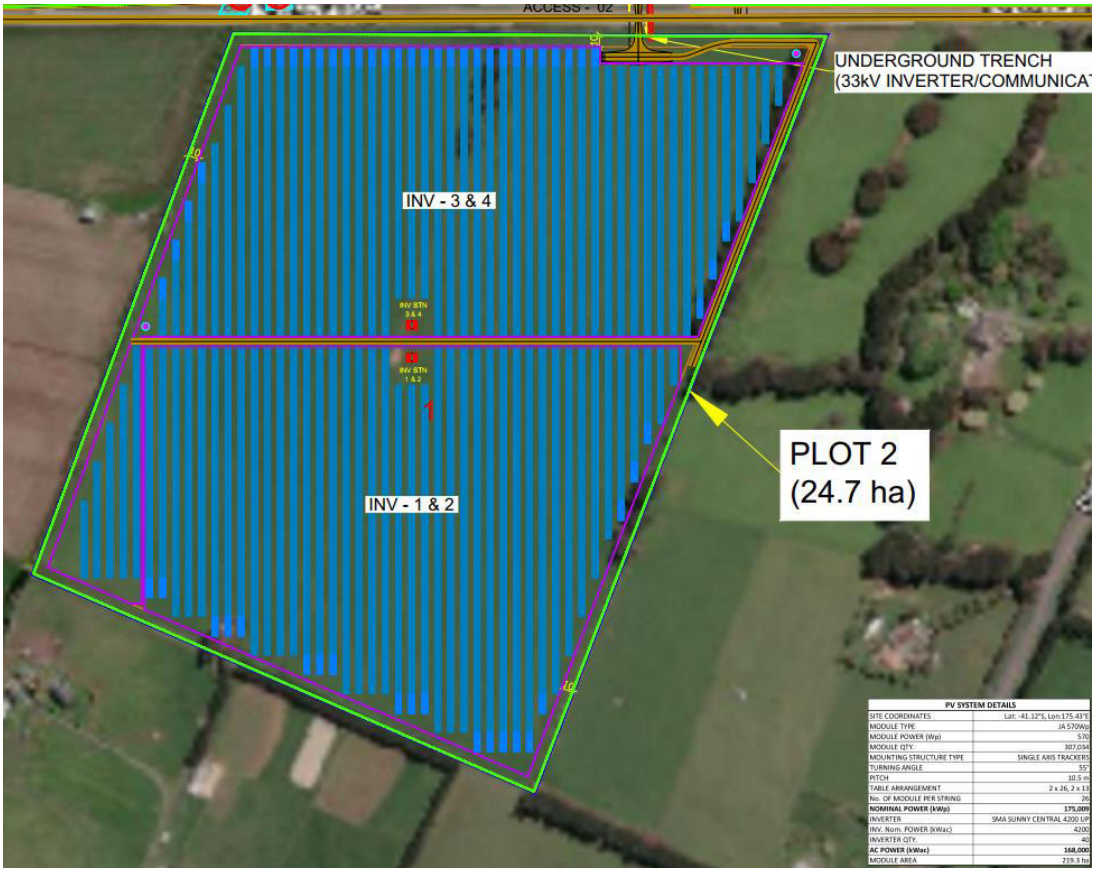

Figure 7: Array layout view 1

Figure 8: Array layout detail view 2

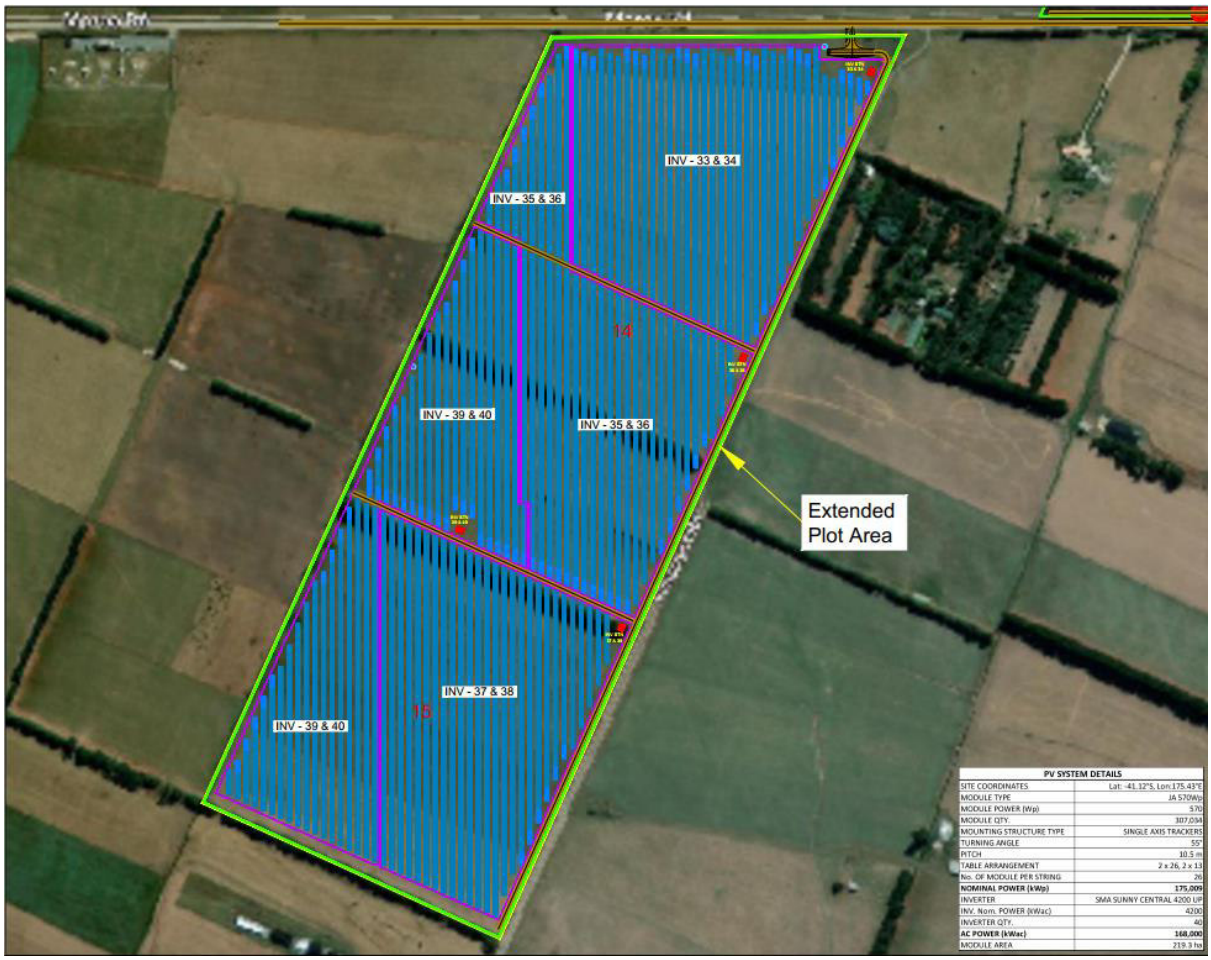

Figure 9: Array layout detail view 3

2.2 Solar farm details

Table 2 summarises the details of the proposed solar farm.

Table 2: Solar farm information

Parameter	Description
Solar farm name	Greytown Solar Farm
Capacity	175 MWp
Mounting system	Single-axis tracking

FNSF is proposing to construct a solar farm with a DC capacity of 175 MWp on an approximately 220 ha site. There will be approximately 300,000 solar modules installed in 6,000 single-axis tracking tables (each table approximately 30 m long) running north-east to south-west. There is approximately 10.5 m spacing between each row and the maximum height of each table is approximately 4 m. The mounting system is constructed on piles that are driven into the ground. The solar farm will include 20 medium voltage (MV) power

stations. Each power station incorporates high/medium voltage switchgear, transformers, and inverters. The solar farm will be surrounded by a vegetation screen with a maximum height of 4 m.

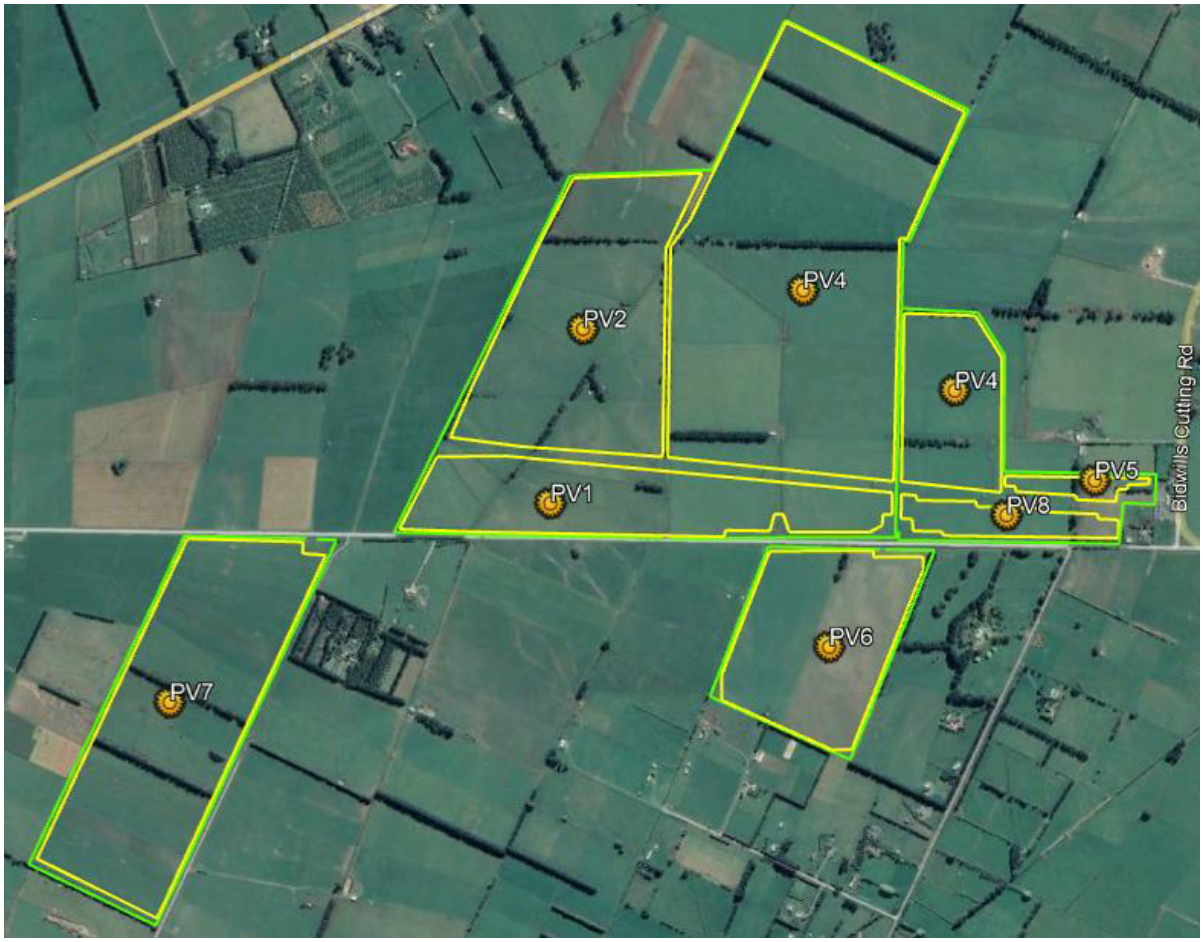

Figure 10: Solar farm model layoutshowing arrays (yellow) surround by proposed screening (green)

3 ANALYSIS

3.1 Overview

The Solar Glare Hazard Analysis Tool (SGHAT) was developed by Sandia National Laboratories to evaluate glare resulting from solar farms at different viewpoints, based on the location, orientation, and specifications of the PV modules. This tool was required by the United States FAA for glare hazard analysis near airports until 2021 and is also recognised by the Australian Government Civil Aviation Safety Authority (CASA).

The GlareGauge software uses SGHAT to provide an indication of the type of glare expected at each potential receptor. It runs with a simulation timestep of one minute. Glint lasting for less than one minute is unlikely to occur from the sun on PV modules due to their slow movement.

Table 3 details the parameters used in the SGHAT model. GlareGauge default settings were adopted for the analysis time interval, direct normal irradiance, observer eye characteristics and slope error. The height of the observation points for road and rail users was assumed to be 1.5 m for a car driver. The height for a person standing was assumed to be 1.65 m.

The solar farm comprises three separate arrays. Each array was modelled separately, and the largest was further divided into five parts to improve the accuracy of the results. The vegetation screening was modelled as an opaque obstruction with a height of 4 m. The division of the array, and the proposed screening is shown in Figure 10.

Table 3: SGHAT specification inputs

Parameters	Input
Time zone	UTC+12:00
Module surface material	Smooth glass with ARC (anti-reflective coating)
Module tracking	Single-axis tracking with backtracking
Backtracking algorithm	Shade
Maximum tilt angle	±55˚
Module axis orientation	0°
Resting angle	0°
Height of modules above ground	2.25 m (height from the ground to the table centre)
Obstruction height	4 m

3.2 Potential receptors

This assessment considers potential visual receptors (e.g., residences and road users) within 2 km of the site. There is no formal guidance on the maximum distance for glint and glare assessments; however, the significance of a reflection decreases with distance for two main reasons:

1. The solar farm appears smaller (smaller subtended angle), and glare has less impact
2. Visual obstructions (e.g., terrain, vegetation) may block the view of the solar farm

Glint and glare impacts beyond 2 km are highly unlikely. This choice of distance is conservative and is based on existing studies and assessment experience.

Seventy-seven observation points and fourteen road routes were identified as potential visual receptors, as shown in Figure 11. Other observation points were excluded from the study due to intervening vegetation and other barriers which block line-of-site to the arrays.

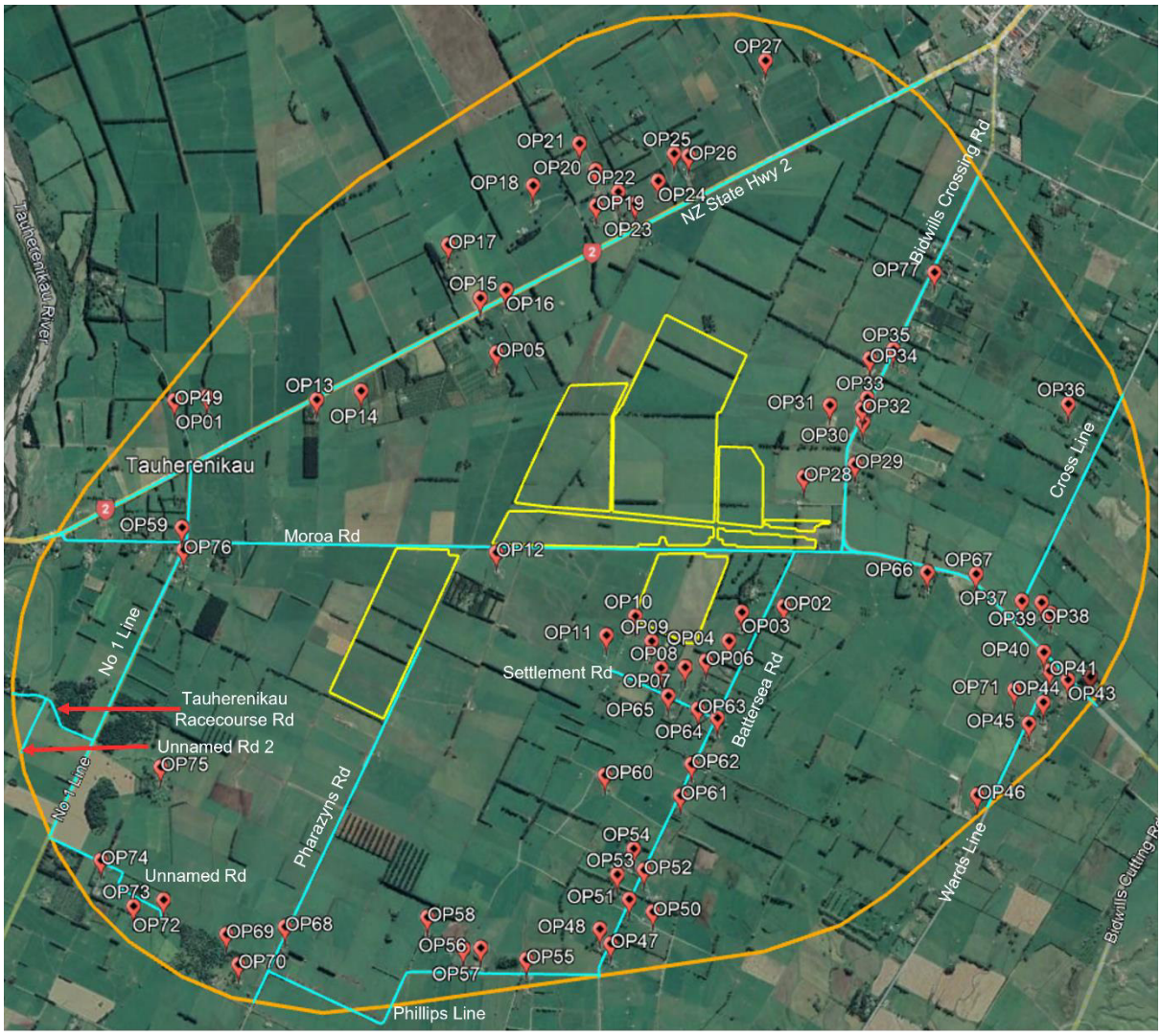

Figure 11: Potential visual receptors within 2 km of the site

The client requested that ITP consider including a potential private airstrip immediately east of the array as shown in Figure 12. The location of the airstrip was difficult to identify, and it does not appear to be a registered aerodrome according to the Civil Aviation Authority New Zealand's list of Aerodrome Coordinates.[2] Hence, ITP has excluded it from this study. The nearest listed aerodrome is Papawai Airfield, approximately 5.5 km northeast of the site.

Figure 12: Runway satellite imagery (Source: Google Maps, 2023)

3.3 Assumptions

The visual impact of solar farms depends on the scale and type of infrastructure, the prominence and topography of the site relative to the surrounding environment, and any proposed screening measures to reduce visibility of the site. ITP modelled a line of tall trees adjacent to NZ State Hwy 2 and the horizon line. Other minor screening was not assessed in detail. The GlareGauge analysis results are therefore considered conservative as the model assumes there is no screening.

[2] Civil Aviation Authority of New Zealand, 2023, Aeronautical Services: NZANR – Aerodrome Coordinates, https://www.aip.net.nz/assets/AIP/Air-Navigation-Register/5-Aerodromes/NZANR-Aerodrome_Coordinates.pdf

The line of tall trees adjacent to NZ State Hwy 2 was modelled using an obstruction object with a height of 5 m as shown in Figure 13.

Figure 13: Obstruction used to model roadside vegetation on NZ State Hwy 2

The horizon line was sourced from the National Institute of Water Atmospheric Research (NIWA) Solarview tool. The horizon line is shown in Figure 14. The line of hills to the north-west of the site introduces a horizon of between 1° and 3° in the afternoon. The horizon limit was modelled by running two ForgeSolar models, one with a minimum sun angle of 0° and the other with a minimum sun angle of 2.5°. For receptors where all glare occurred between May and August, the results from the 2.5° horizon model were substituted for the results from the 0° horizon model as the sun will be below the horizon at these times.

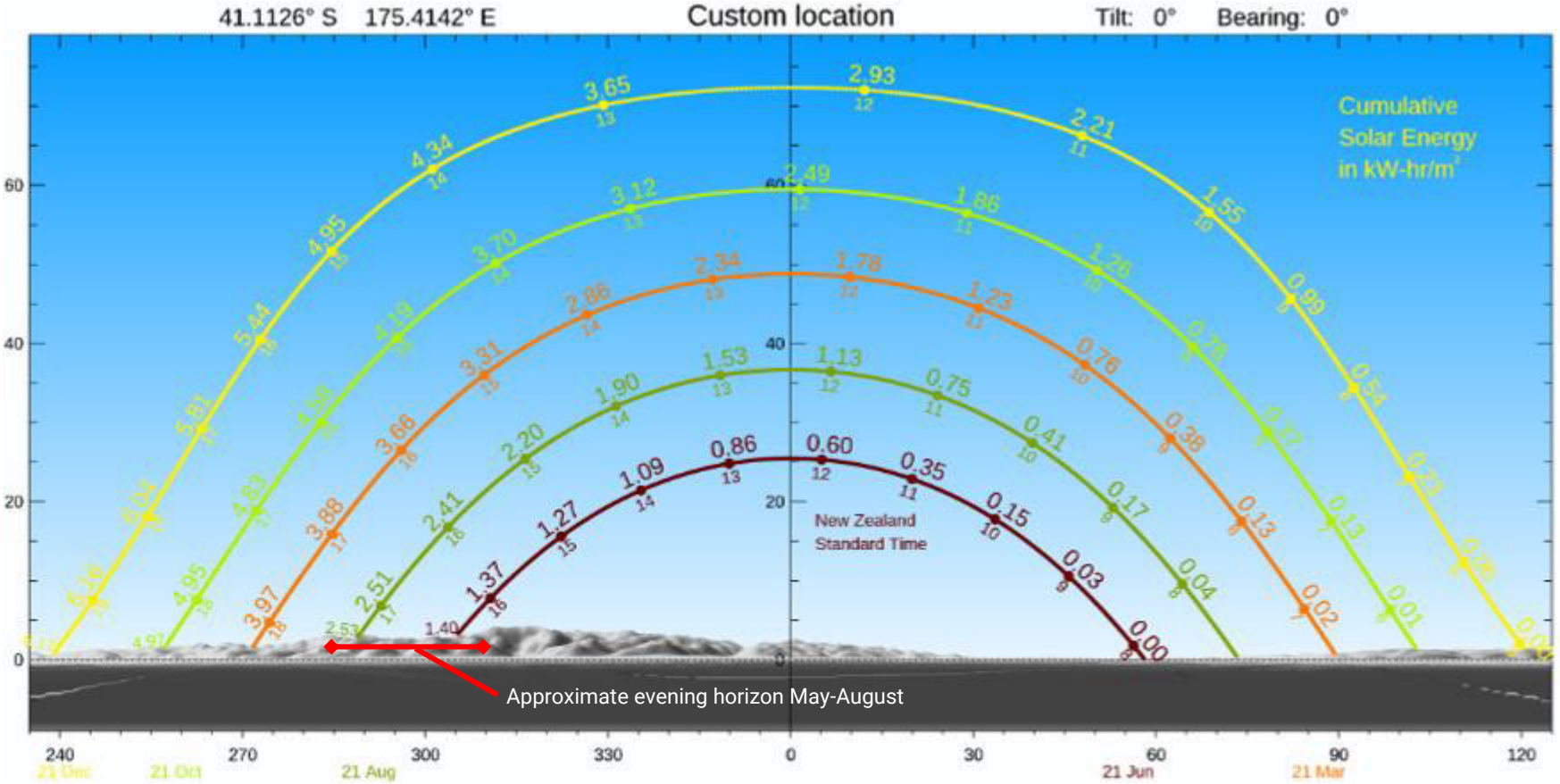

Figure 14: Horizon line at Greytown at different times of year (source: NIWA Solarview)

Atmospheric conditions such as cloud cover will also influence light reflection and the resulting impact on visual receptors. GlareGauge does not model varying atmospheric conditions. The GlareGauge analysis assumes clear sky conditions, with a peak direct normal irradiance (DNI) of 1,000 W/m^2 which varies throughout the day. This is a conservative assumption.

3.4 Results

The results of the GlareGauge analysis are summarised in Table 4. These results count only unique minutes of glare received from any source; they do not detail which of the eight PV areas the glare came from. For observation points where some glare occurred, the impact is described qualitatively. In general, most glare occurred in the early mornings or late evenings when backtracking is active.

The analysis identified 1,373 minutes (23 hours) of cumulative green glare spread across three observation points and three road routes. All other receptors (74 observation points and eleven road routes) received no glare at any time. No observation points or routes received more than 6 minutes of glare in any single day.

The 2.5° horizon model was used for seven observation points and one road route where all glare from the 0° horizon model occurred between May and August. In these cases, the sun will be below the horizon when glare would be expected otherwise. The effected receptors are:

- OPs 40, 41, 42, 43, 44, and 45
- OP 71
- Moroa Rd.

These receptors are highlighted in Table 4. The full results for both horizon models are included in Appendix A.

Table 4: Glare potential at each receptor

Receptor	Location	Horizon model	Green (min/yr)	Yellow (min/yr)	Daily glare potential	Impact	Further mitigation required
OP 1	-41.111, 175.390	0°	125	0	Up to 3 minutes of green glare between 4:30 am and 5:30 am from late November to late January.	Very low	No
OP 2	-41.123, 175.433	0°	0	0	None	None	No
OP 3	-41.124, 175.430	0°	0	0	None	None	No
OP 4	-41.125, 175.429	0°	0	0	None	None	No
OP 5	-41.109, 175.412	0°	0	0	None	None	No
OP 6	-41.126, 175.427	0°	0	0	None	None	No
OP 7	-41.127, 175.426	0°	0	0	None	None	No
OP 8	-41.127, 175.424	0°	0	0	None	None	No
OP 9	-41.125, 175.423	0°	0	0	None	None	No
OP 10	-41.124, 175.422	0°	0	0	None	None	No
OP 11	-41.125, 175.420	0°	0	0	None	None	No
OP 12	-41.120, 175.412	0°	0	0	None	None	No
OP 13	-41.112, 175.398	0°	0	0	None	None	No
OP 14	-41.111, 175.402	0°	0	0	None	None	No
OP 15	-41.106, 175.411	0°	0	0	None	None	No
OP 16	-41.105, 175.413	0°	0	0	None	None	No

Receptor	Location	Horizon model	Green (min/yr)	Yellow (min/yr)	Daily glare potential	Impact	Further mitigation required
OP 17	-41.103, 175.408	0°	0	0	None	None	No
OP 18	-41.100, 175.415	0°	0	0	None	None	No
OP 19	-41.101, 175.419	0°	0	0	None	None	No
OP 20	-41.099, 175.419	0°	0	0	None	None	No
OP 21	-41.097, 175.418	0°	0	0	None	None	No
OP 22	-41.100, 175.421	0°	0	0	None	None	No
OP 23	-41.101, 175.422	0°	0	0	None	None	No
OP 24	-41.099, 175.424	0°	0	0	None	None	No
OP 25	-41.098, 175.425	0°	0	0	None	None	No
OP 26	-41.098, 175.426	0°	0	0	None	None	No
OP 27	-41.093, 175.432	0°	0	0	None	None	No
OP 28	-41.116, 175.435	0°	0	0	None	None	No
OP 29	-41.115, 175.439	0°	0	0	None	None	No
OP 30	-41.113, 175.439	0°	0	0	None	None	No
OP 31	-41.112, 175.437	0°	0	0	None	None	No
OP 32	-41.112, 175.439	0°	0	0	None	None	No
OP 33	-41.112, 175.440	0°	0	0	None	None	No

Receptor	Location	Horizon model	Green (min/yr)	Yellow (min/yr)	Daily glare potential	Impact	Further mitigation required
OP 34	-41.109, 175.440	0°	0	0	None	None	No
OP 35	-41.109, 175.442	0°	0	0	None	None	No
OP 36	-41.112, 175.455	0°	0	0	None	None	No
OP 37	-41.123, 175.451	0°	0	0	None	None	No
OP 38	-41.123, 175.453	0°	0	0	None	None	No
OP 39	-41.124, 175.453	0°	0	0	None	None	No
OP 40	-41.126, 175.453	**2.5°**	226	0	Up to 6 minutes of green glare between 4 pm and 5:30 pm from early May to early August.	Very low	No
OP 41	-41.127, 175.453	**2.5°**	0	0	None	None	No
OP 42	-41.127, 175.457	**2.5°**	0	0	None	None	No
OP 43	-41.128, 175.455	**2.5°**	0	0	None	None	No
OP 44	-41.129, 175.453	**2.5°**	0	0	None	None	No
OP 45	-41.130, 175.452	**2.5°**	0	0	None	None	No
OP 46	-41.134, 175.448	0°	0	0	None	None	No
OP 47	-41.142, 175.420	0°	0	0	None	None	No
OP 48	-41.142, 175.420	0°	0	0	None	None	No
OP 49	-41.112, 175.388	0°	227	0	Up to 4 minutes of green glare between 4:30 am and 6 am from mid-November to early February.	Very low	No

Receptor	Location	Horizon model	Green (min/yr)	Yellow (min/yr)	Daily glare potential	Impact	Further mitigation required
OP 50	-41.141, 175.424	0°	0	0	None	None	No
OP 51	-41.140, 175.422	0°	0	0	None	None	No
OP 52	-41.138, 175.423	0°	0	0	None	None	No
OP 53	-41.139, 175.421	0°	0	0	None	None	No
OP 54	-41.137, 175.422	0°	0	0	None	None	No
OP 55	-41.143, 175.414	0°	0	0	None	None	No
OP 56	-41.143, 175.411	0°	0	0	None	None	No
OP 57	-41.143, 175.409	0°	0	0	None	None	No
OP 58	-41.141, 175.406	0°	0	0	None	None	No
OP 59	-41.119, 175.388	0°	0	0	None	None	No
OP 60	-41.133, 175.420	0°	0	0	None	None	No
OP 61	-41.134, 175.426	0°	0	0	None	None	No
OP 62	-41.132, 175.426	0°	0	0	None	None	No
OP 63	-41.129, 175.427	0°	0	0	None	None	No
OP 64	-41.130, 175.428	0°	0	0	None	None	No
OP 65	-41.128, 175.425	0°	0	0	None	None	No
OP 66	-41.121, 175.444	0°	0	0	None	None	No

Receptor	Location	Horizon model	Green (min/yr)	Yellow (min/yr)	Daily glare potential	Impact	Further mitigation required
OP 67	-41.122, 175.448	0°	0	0	None	None	No
OP 68	-41.142, 175.396	0°	0	0	None	None	No
OP 69	-41.142, 175.391	0°	0	0	None	None	No
OP 70	-41.144, 175.392	0°	0	0	None	None	No
OP 71	-41.128, 175.451	**2.5°**	0	0	None	None	No
OP 72	-41.140, 175.387	0°	0	0	None	None	No
OP 73	-41.140, 175.384	0°	0	0	None	None	No
OP 74	-41.138, 175.382	0°	0	0	None	None	No
OP 75	-41.132, 175.386	0°	0	0	None	None	No
OP 76	-41.120, 175.388	0°	0	0	None	None	No
OP 77	-41.104, 175.445	0°	0	0	None	None	No
Route 1	Bidwills Cutting Rd	0°	616	0	Up to 1 minutes of green glare between 4 pm and 5:30 pm from late April to mid-August.	Very low	No
Route 2 (car)	NZ State Hwy 2	0°	44	0	Up to 3 minutes of green glare between 5 am and 6 am from late January to early February. Up to 3 minutes of green glare between 4:30 am and 5:30 am from late October to mid-November.	Very low	No

Receptor	Location	Horizon model	Green (min/yr)	Yellow (min/yr)	Daily glare potential	Impact	Further mitigation required
Route 2 (truck)		0°	84	0	Up to 3 minutes of green glare between 5 am and 6:30 am from late January to mid-March. Up to 3 minutes of green glare between 4:30 am and 6 am from late September to mid-November.	Very low	No
Route 3	No 1 Line	0°	0	0	None	None	No
Route 4	Moroa Rd	**2.5°**	0	0	None	None	No
Route 5	Moroa & Bidwills Cutting tee-intersection	0°	0	0	None	None	No
Route 6	Battersea Rd	0°	0	0	None	None	No
Route 7	Phillips Line	0°	0	0	None	None	No
Route 8	Settlement Rd	0°	0	0	None	None	No
Route 9	Unnamed Rd 1 (off No 1 Line)	0°	0	0	None	None	No
Route 10	Pharazyns Rd	0°	0	0	None	None	No
Route 11	Tauherenikau-Racecourse Rd	0°	0	0	None	None	No
Route 12	Unnamed Rd 2 (off Taherenikau)	0°	0	0	None	None	No

Receptor	Location	Horizon model	Green (min/yr)	Yellow (min/yr)	Daily glare potential	Impact	Further mitigation required
Route 13	Cross Line	0°	51	0	Up to 2 minutes of green glare between 7 pm and 7:30 pm in February. Up to 2 minutes of green glare between 6:30 pm and 7 pm from mid-October to early November.	Very low	No
Route 14	Wards Line	0°	0	0	None	None	No
Total			**1,373**	**0**			

4 SUMMARY

The results of the GlareGauge analysis indicated that three observation points and three road routes received green glare, which has low potential to cause afterimage. In general, most of the glare occurred during early mornings and late evenings when backtracking is active. No observation points or routes received more than 6 minutes of glare in any single day.

The 2.5° horizon model was used for seven observation points and one road route where all glare from the 0° horizon model occurred between May and August. In these cases, the sun will be below the horizon when glare would be expected otherwise.

The proposed vegetation screen provides effective mitigation of the glare expected from the solar farm. The residual glare is very low impact and does not require further mitigation. These results are conservative as existing roadside vegetation, and other intervening vegetation and structures were not modelled explicitly and will further reduce the glare impact.

5 REFERENCES

Federal Aviation Administration (FAA), 2018. Solar Guide: Technical Guidance for Evaluating Selected Solar Technologies on Airports. Retrieved from the FAA website: https://www.faa.gov/airports/environmental/

Thompson, R., Ave, I., Anne, D., Jan, M., David, S. and Robert, C., 2013. Interim policy, FAA review of solar energy system projects on federally obligated airports.

Barrett, S., Devita, P., Ho, C. and Miller, B., 2014. Energy technologies' compatibility with airports and airspace: Guidance for aviation and energy planners. Journal of Airport Management, 8(4), pp.318-326.

APPENDIX A. FORGESOLAR ANALYSIS REPORTS

The following are provided as an attachment.

1. **23070 – ForgeSolar Analysis Report A 0 deg horizon.pdf:** including results for OP 1 to 40 and all road routes with the minimum sun angle set to 0°.
2. **23070 – ForgeSolar Analysis Report B 0 deg horizon.pdf:** including results for OP 41 to OP 77 with the minimum sun angle set to 0°.
3. **23070 – ForgeSolar Analysis Report A 2.5 deg horizon.pdf:** including results for OP 1 to 40 and all road routes with the minimum sun angle set to 2.5°.
4. **23070 – ForgeSolar Analysis Report B 2.5 deg horizon.pdf:** including results for OP 41 to OP 77 with the minimum sun angle set to 2.5°.

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Attachment 3: Acoustic Assessment

MARSHALL DAY Acoustics

GREYTOWN SOLAR FARM
FOR FAR NORTH SOLAR FARMS
ASSESSMENT OF NOISE EFFECTS

Rp 001 20220654 |7 August 2023

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Report No.: **Rp 001 20230481**

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SUMMARY

Marshall Day Acoustics has been engaged by Far North Solar Farms to undertake a noise assessment for the operation and construction of a proposed solar farm.

The proposed generation only 145 MW solar farm would be located at Bidwills Cutting Road, Greytown on the southern side of the township. The proposed solar farm is in three "blocks": one large block north of Moroa Road and two smaller blocks south of Moroa Road. The combined area of the blocks is approximately 240 hectares.

The proposed solar farm is in a rural area. The surrounding land is used for rural farming and rural lifestyle purposes. Greytown and the surrounding hinterland is flat – there is no significant ground undulation that would result in any appreciable acoustic screening.

The generation facility would include 39 inverters (mostly in pairs). These would be distributed over the farm. The solar panel arrays would include 6,034 motors.

This assessment has drawn the following conclusions:

- The proposed solar farm would readily comply with the Wairarapa Combined District Plan daytime noise rule of 55 dB L_{A10}. Even in the worst-case "100%" scenario, noise levels would be significantly (at least 16 decibels) below the daytime noise rule.
- Evening operation of the proposed solar farm would readily comply with the Wairarapa Combined District Plan nighttime noise rule of 45 dB L_{A10}. Even in the worst-case "100%" scenario, noise levels would be significantly (at least 6 decibels) below the noise rule.
- The proposed solar farm would also comply with the noise rules in the Draft Wairarapa Combined District Plan.
- For dwellings near State Highway 2 and Bidwills Cutting Road, solar farm generated noise levels are expected to be quieter than the existing ambient (L_{A10}) and background (L_{A90}) noise (during the typical hours of solar generation). Solar farm noise levels at dwellings near SH2 would be in the order of 24 to 34 dB L_{A10}, whereas State Highway traffic would generate background and ambient noise levels that are typically higher than this during daylight hours.
- Solar farm noise levels at dwellings on Moroa Road, Settlement Road and Battersea Road would be in the order of 27 to 39 dB L_{A10} at times of solar generation. As the Moroa, Settlement and Battersea Road area is further removed from State Highway 2, it is subject to generally lower noise levels (noting that background noise levels in this area vary depending on local activity). Noise from the solar farm generation is expected to be above the existing background (L_{A90}) noise level at times, but generally similar to or quieter than the existing ambient (L_{A10}) noise level. In this area on settled weather days, the solar farm would be audible at times as a low-level constant noise source.
- The NZS 6803:1999 construction noise guidelines will be complied with at all times. This is likely to require noise mitigation to Vermeer-type or any other drop hammer piling works, such as shrouds, dollies or use of alternative methods at piling locations that are within 100 metres of dwellings. A noise management plan is recommended.

Overall the location of the solar farm is well chosen from a noise perspective. The fairly large distances between the sources of noise and the nearest receivers would result in noise from the solar farm being fairly low overall and well below the District Plan noise limits.

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1.0 INTRODUCTION

Marshall Day Acoustics has been engaged by Far North Solar Farms to undertake a noise assessment for the operation and construction of a proposed solar farm.

This report addresses noise from the proposed operation and from construction. This report is intended to form part of an application for resource consent.

A glossary of terminology is included in Appendix A.

2.0 APPLICATION SITE

The proposed generation only 145 MW solar farm is located at Bidwills Cutting Road, Greytown. The site is comprised of three "blocks": one large block north of Moroa Road and two smaller blocks south of Moroa Road. The combined area of the blocks is approximately 240 hectares and is located on the southern side of Greytown.

The proposed solar farm is in a rural area. The surrounding land is used for rural farming and rural lifestyle purposes. Greytown and the surrounding hinterland is flat – there is no significant ground undulation that would result in any appreciable acoustic screening.

The proposed solar farm is fairly well removed from the nearest rural dwelling receivers. The nearest inverter pair is around 350 metres from the nearest dwelling, though most inverters are around 500 metres or more distant.

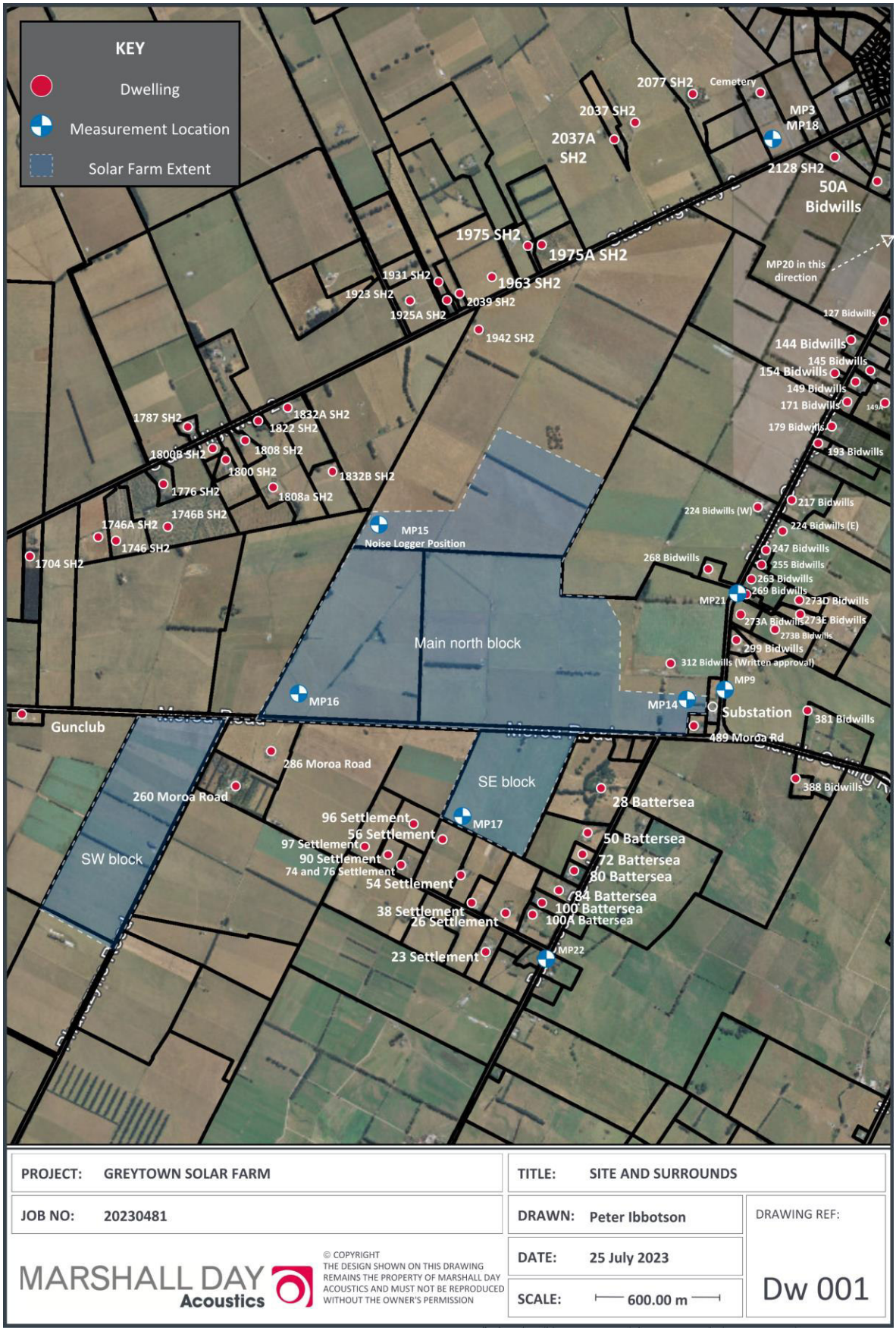
Surrounding receivers are listed in Table 1 and depicted in Figure 1.

Table 1: Surrounding Receivers

Receiver Location	Details	Typical Use[1]	Approx distance of closest dwelling notional boundary (m)[1]	
			To solar farm boundary	To nearest inverter
Settlement and Battersea Road dwellings	The area to the south and south-east of the south-east solar farm "block" includes several dwellings on 1-to-12-hectare sections	Rural lifestyle	100m	370m
Moroa Road dwellings (west)	There are few dwellings on Moroa Road. There are two larger allotments adjacent to the southwest solar farm "block". One of these allotments is understood to have worker accommodation on the site in several detached buildings across the site	Rural	Adjacent	350m
Moroa Road dwelling (east)	A dwelling is located to the south-east of the solar farm site, adjacent to the existing substation	Rural lifestyle	Adjacent	480m
Bidwills Cutting Road dwellings	There are many dwellings along Bidwills Cutting Road, though these are typically well removed from the proposed solar farm site.	Rural and Rural Lifestyle	250m [(2)]	600m [(2)]
State Highway 2	There are many dwellings along SH2, though these are typically well removed from the proposed solar farm site. The closest dwelling is some 300m from the solar farm boundary	Rural and Rural lifestyle	50m	550m

Note 1: Existing land use and distances have predominantly been determined from aerial photography and are indicative. The noise model uses specific distances between source and receiver.
Note 2: Excluding 312 Bidwills Road which is the farm owner from whom the land will be leased

Figure 1: Site and Surrounds



3.0 PROPOSAL

We understand that most of the approx. 240-hectare (total) site would be used for the solar farm arrays. The proposed farm location in relation to the surrounding area is given in Figure 1. A site layout plan is given in Appendix B.

The proposed farm would be divided into three blocks, the majority of which would be located to the north of Moroa Road. In this assessment, these blocks are referred to as follows:

- **Main north block:** the largest block (c. 170 Ha), to the north of Moroa Road and west of Bidwills Cutting Rd
- **South-east block:** the block (c. 25 Ha) nearest Battersea and Settlement Roads, south of Moroa Rd.
- **South-west block:** the block (c. 45 Ha) to the south-west of Moroa Road, towards SH2

3.1 Facility Description

Solar panels would be installed in rows spaced apart to allow access by agricultural machinery and grazing animals. Access to the site would be off Moroa Road.

An existing substation is located to the east of the main north solar farm block. A switchyard is proposed to be located adjacent to the substation which will switch the generated power as required to the substation.

The total generation power rating of the farm would be around 135 MW[1].

The key operational noise sources would be from the following plant:

- **39 central inverters**. An inverter turns Direct Current (DC) created by the photovoltaic cells to alternating current (AC) current used in the electricity grid[2]. These central inverters would be distributed throughout the farm and would be used in the generation of power from the solar arrays. The inverters would generally be arranged in pairs of two as shown in Appendix B.
- **Around 6,034 tracker motors** would be associated with the solar panel arrays. Each solar panel array table would be attached to a tracker motor[3].
- **A switchyard adjacent to the existing substation.** We understand that two 33/100kV transformers will be located in this switchyard.

Power generation at the solar farm would occur during daylight/sunshine hours. In summer, operating daylight hours could begin earlier and extend later than the prescribed[4] daytime period of 7am to 7pm. In particular, generation is still likely to be appreciable after 7pm during the longer days of summer. We have allowed for full load on the inverters when solar load is high.

[1] This is the alternating current generation power. The power of each inverter is nominally 4,200 kVA.

[2] No specific inverter supplier has been selected at this stage of the project. There are two major manufacturers of inverters that are used on most solar projects, although other manufacturers may be considered.

[3] Trackers consist of many solar panels on a frame that tilts vertically to align the panels to the sun throughout the day. The trackers are rotated around a central horizontal axis by a small DC motor (approximately 300 watts running at 24V DC). The motor is the main noise source associated with each tracker. The tracker motors are understood to operate intermittently during daylight hours and only for a short period as they are only required to make small incremental adjustments to the trackers. DC motors are quiet, even under continuous load and operation, and the collective sound power level of even a large number of tracker motors is not normally significant when considered over the normally large solar farm sites.

[4] Refer to Section 5 for discussion of the District Plan noise rules and statutory timeframes.

3.2 Written Approvals

The owner of 312 Bidwills Cutting Road is the lessor of the land that the solar farm would be constructed on. Written approval is understood to have been obtained from this party. The noise effects on this property can be disregarded[5].

3.3 Acoustic Mitigation

Some inverter manufacturers have shrouds / lined bends that can be provided to the inverter intake and discharge ventilation openings. These result in around 3 to 5 decibels of attenuation per source.

As shown later in this report, acoustic mitigation such as enclosure or attenuation of the inverters is not considered necessary on this project to meet the relevant noise limits or to provide a reasonable level of acoustic amenity based on the inverters expected to be used. The final determination of inverter selection can inform if any further noise mitigation package is required. We would not expect it to be required for most inverter units we have reviewed.

4.0 EXISTING NOISE ENVIRONMENT

Site visits were carried out to measure noise in the area over a period of two days of attended measurements and to deploy a noise logger over a longer period. Noise measurements were conducted at various locations on the site and in the adjacent area as follows:

- The attended noise measurements were carried out at intervals over the period 18:00 hrs 16 July to 17:40 hrs on 17 July 2023.
- A site visit to install a noise logger was carried out on the morning of 22 July 2023. The logger data used in this analysis comprises the period 11:45 hrs, 22 July to 06:00 hrs, 31 July 2023.

The purpose of the measurements was to establish ambient noise levels representative of the site and surrounding sites. The area was observed to have a background and ambient noise character that was typically dominated by human-made noises over the daytime, such as traffic on the state highway and local roads. Natural noises such as bird calls were audible at times. There was little insect noise audible generally during the period of winter monitoring, although insect noise may be more present over the warmer months.

Attended and unattended noise measurements results are summarised in the following sections.

[5] Council must not, when considering the application, have regard to any effect on a person who has given their written approval to the application (Section 104 (3) of the Resource Management Act 1991).

4.1 Logger Data

The logger measurement position was located at the north-west corner of the site (MP15, refer Figure 1). This location was approximately 760 metres south-east of State Highway 2.

The logger results obtained provides an indication of the variation in traffic noise over the day, evening and night periods at the logger location. Dwellings adjacent to the State Highway will receive higher levels of traffic noise, and dwellings further from the State Highway (e.g., Moroa, Battersea, Settlement Roads) will receive lower levels of traffic noise. However, all will receive a similar *diurnal variation* in noise from distant state highway traffic[6].

As the solar farm may operate outside the prescribed daytime period, logged data has been analysed for the prescribed daytime, evening and night-time periods[7].

Refer to Appendix C for the noise level variation over the logging period. Meteorological conditions referenced on this graph were those measured at a NIWA weather station in Masterton and confirmed with the landowner's observations.

The following table summarises noise levels at the logger position.

Table 2: Measured Ambient Noise Levels (logged)

Date	Overall Measured Level (dB)[1]						
	Daytime hours[2]		Evening hours		Night hours		Likely meteorological conditions
	L_{A10}	L_{A90}	L_{A10}	L_{A90}	L_{A10}	L_{A90}	
22-Jul	49	44	43	35	37	28	Potentially day winds > 5m/s
23-Jul	46	39	38	28	38	28	Lighter winds, generally < 5m/s
24-Jul	49	45	38	38	42	34	Potentially day/night winds > 5m/s, rain
25-Jul	44	38	43	35	49	40	Light daytime winds, night winds >5m/s
26-Jul	53	43	45	35	42	30	Potentially day winds > 5m/s, rain, light wind night
27-Jul	49	40	45	34	52	45	Potentially day/night winds > 5m/s, some rain
28-Jul	46	39	45	35	39	26	Light winds, no rain
29-Jul	43	38	46	40	39	28	Light winds, no rain
30-Jul	44	37	44	34	39	28	Light winds, no rain

Notes to Table 2:
(1) An explanation of technical terms is provided in Appendix A
(2) Daytime is given as 07:00 to 19:00 hours in this table

The logger data shows that average daytime noise levels are relatively high: between 43 - 53 dB L_{A10} even at 760 metres from State Highway 2. Average background noise levels during this time vary from 37 - 45 dB L_{A90} at this distance. Background noise levels are a little lower in lower wind conditions.

[6] As an approximate guide, dwellings located closer to the State Highway (those around 300 to 400m from the highway) would receive L_{Aeq} and L_{A10} noise levels around 3 decibels higher than those measured at the logger position. Dwellings on Settlement, Battersea and the southern part of Bidwills Crossing Roads will receive noise levels of around 5 decibels lower than measured at the logger position. This is approximate only, and will depend on the meteorological conditions, ground conditions and actual distance between receiver and the State Highway.

[7] Prescribed daytime hours are: 7am to 7pm. Prescribed night-time hours are: 7pm to 7am.

The logger data shows that noise levels in this area reduce through the evening. This appears to typically occur from around 19:00hrs during weekdays (sunset in July is around 17:00 hrs, so this reduction in noise level currently occurs well after dark). During weekends, the data suggests that ambient noise levels begin to reduce a little later, typically from around 20:30hrs. The reduction in noise level at these times is likely due to reducing traffic on the State Highway.

The average evening ambient noise levels varied from 38 to 46 dB L_{A10} with background noise levels between 28 to 40 dB L_{A90}. Note that the evening period currently occurs in the hours of darkness – it is probable that in the warmer months when days are longer that evening noise levels will be higher (due to birds, insects and potentially different traffic patterns).

The logger data shows that morning ambient noise levels are typically elevated by 05:30 to 06:00 hours on weekdays and around 07:00 hours on weekends.

4.2 Attended Measurements

Attended measurements were carried out on and off site to establish the existing level of environmental noise in the area and to identify the main sources of noise that occur at all surrounding dwellings. Table 3 summarises the attended measurement results.

Table 3: Measured Ambient Noise Levels (attended)

Measurement Position	Measurement		Measured Level (dB) [1]				Noise Source [2]
	Date Start (hh:mm)	Duration min:sec	L_{Aeq}	L_{A10}	L_{A90}	L_{AFmax}	
MP3: At cemetery on SH2 (evening), around 65 m from SH2, representative SH2 dwellings	16/07/2023 18:08	15:14	55	59	43	70	Cars are frequent and there are few lulls between vehicles of any significance. During lulls, levels fall away to 45 dB L_{AF} but any lulls are brief and there is always some distant traffic.
MP14: At southern end of proposed Solar Farm (day), near 489 Moroa Rd	17/07/2023 10:39	10:05	48	50	42	63	Traffic on Bidwells Cutting and Moroa Road. Transformer hum at 100Hz. Regular bird calls. Possible distant SH2 noise
MP15: At north-west end of proposed solar farm (day), somewhat representative of SH2 dwellings that are closest to farm (noting measured levels are somewhat lower than dwellings will receive)	17/07/2023 11:18	10:06	37	39	34	50	Distant SH2 traffic, birds (magpies), Possible distant constant noise from industry, but likely distant traffic. Noted absence of insects. Environment noted to consist of predominantly manmade noise
MP16: At south-west corner of proposed solar farm main block (north Moroa Road), representative of Moroa Road dwellings (day)	17/07/2023 11:43	08:01	35	38	31	56	Distant SH2 traffic and magpies. Similar but quieter than MP15

Measurement Position	Measurement		Measured Level (dB) [1]				Noise Source [2]
	Date Start (hh:mm)	Duration min:sec	L_{Aeq}	L_{A10}	L_{A90}	L_{AFmax}	
MP17: At south-west end of south-east "block". Representative of dwellings on Settlement Road and Battersea Road (day)	17/07/2023 12:05	10:01	34	36	30	49	Distant traffic on Bidwills Cutting Road. Distant dog barks and cattle lows. Birds. Two vehicle movements on Battersea Road. Background broadly set by distant traffic.
MP18: At cemetery on SH2 (day), representative of SH2 dwellings	17/07/2023 16:13	15:01	56	59	46	69	Traffic on SH2 is regular, birds also audible
MP20: Kemptons Line, near intersection of Bidwills Cutting Road. Representative of dwelling façades on Bidwills Cutting Road	17/07/2023 16:44	10:18	53	56	43	74	Traffic and birds, traffic is regular but some regular gaps in traffic.
MP21: Bidwills Cutting Road near 273 Bidwills Cutting subdivision	17/07/2023 17:02	10:01	72	75	44	88	Frequent traffic on Bidwills Cutting Road (note that measurement location is closer to road carriageway than dwelling façades, therefore raised L_{Aeq} and L_{A10})
MP22: Settlement Road and Battersea Road Intersection	17/07/2023 17:24	10:04	46	49	34	62	Distant traffic, birds, cattle, distant, people noise calling, cars at nearby house. distant loud dog bark, distant train horn. SH2 sets background noise level

Note to Table 3:
(1) An explanation of technical terms is provided in Appendix A.
(2) Dominant sources are underlined.

The results show that ambient noise levels depend on the proximity to the State Highway.

Noise levels near State Highway 2 are elevated during the daytime and evening and are up to 59 dB L_{A10} at around 65 metres from the road. As there are few gaps between vehicles on SH2 during the daytime and evening, background noise levels are also elevated at between 43 to 46 dB L_{A90}.

Noise levels at dwellings to the north, west and south of the proposed solar farm (e.g., dwellings on Moroa, Settlement and Battersea Roads) vary with the time of the day and the distance of these dwellings from the busier Bidwills Cutting Road. Measurements conducted around the site during daytime hours in settled conditions show that noise levels for dwellings well removed from Bidwills Cutting Road are around 35 to 40 dB L_{A10} and 30 to 35 dB L_{A90} – although noise levels can be up to 50 dB L_{A10} at times when birds are active and there is activity at nearby dwellings.

Dwellings on Bidwills Cutting Road (at around 60 metres from the road) may receive ambient noise levels of up to 56 dB L_{A10} with background noise levels of 40 to 45 dB L_{A90} due to regular traffic on this road during the daytime.

5.0 NOISE PERFORMANCE STANDARDS AND LEGISLATION

The site is subject to the Operative Wairarapa Combined District Plan noise rules. We understand that a draft Wairarapa Combined District Plan has also been prepared.

5.1 Operative District Plan

5.1.1 Zoning

The application site is situated on land zoned *Rural Primary* Production in the Operative Wairarapa Combined District Plan. Surrounding sites are also zoned *Rural Primary.*

5.1.2 Operative Noise Rules

Section 4.5 of the Wairarapa Combined District Plan sets out the noise rules for the Rural Zone. Rule 4.5.2(f) sets out the noise limits for the zone as follows:

(f) **Noise Limits**

(i) *The sound level from activities within any site, excluding mobile sources associated with primary production (e.g. tractors, harvesters), shall not exceed the following limits within any measurement time interval in the stated time-frames, when assessed at any point within the notional boundary of any dwelling on any site within the Rural Zone but excluding any dwelling on the property where the sound levels are generated, and at any point within the boundary of any site within the Residential Zone:*

Daytime	*7:00am to 7:00pm*	*55 dB L_{A10}*
Night-time	*7:00pm to 7:00pm*	*45 dB L_{A10}*
	9:00pm to 7:00pm	*75 dB L_{AFmax}*

(ii) All sound levels shall be measured in accordance with NZS 6801:1999 "Acoustics – Measurement of Environmental Sound", and assessed in accordance with NZS 6802:1991 "Assessment of Environmental Sound".

The above noise rules are fairly typical of Rural zones throughout New Zealand. However it is noted that the statutory daytime in this District is between 7am to 7pm and the statutory night-time therefore begins somewhat earlier than is typical for many rural zones around New Zealand. As there will be times during summer when there is still strong sunshine after 7pm, this means that the solar farm will need to comply with 45 dB L_{A10} when operating at peak generation.

5.1.3 Construction Noise Rules

The Operative District Plan contains the following noise rule (Rule 21.1.13(c))

(c) ***Construction Noise***

(i) Construction noise shall be measured and assessed in accordance with NZS6803:1999 "Acoustics – Construction Noise" and shall not exceed the noise limits set out in Table 2 of that Standard for the timeframes stated.

(ii) Provided that the provisions of the standard related to the duration of construction events and the more or less stringent noise limits applicable in such circumstances shall apply.

5.2 Draft District Plan

5.2.1 Zoning

In the Draft District Plan, the site is zoned *General Rural Zone*. All adjacent sites would also be zoned *General Rural Zone*. There would be some more distant sites closer to Greytown that would be zoned *General Industrial Zone* and *Mixed Use Zone.*

5.3 Draft Noise Rules

The draft District Plan sets out noise rules in NOISE-R1. This rule requires that activities comply with noise rules NOISE-S1, S2, S3 and S4. Of these, only parts of S1 and S2 are relevant to the proposed solar farm operation. These are given as follows:

NOISE-S1 Maximum Noise Levels in Zones

Rural Zones and Future Urban Zone

3. Noise emitted from any activity within a Rural Zone or Future Urban Zone shall not exceed the following noise limits at any point within the notional boundary of any noise sensitive activity on any other site within a Rural Zone or Future Urban Zone, or at any point within the boundary of any other site within a Residential Zone or Māori Purpose Zone:

a. Daytime (7.00am to 7.00pm): 55 dB $L_{Aeq(15min);}$

b. Evening: (7.00pm to 10.00pm): 50 dB $L_{Aeq(15min);}$

c. Night time: (10.00pm to 7.00am): 45 dB $L_{Aeq(15min);}$ and

d. Night time: (10.00pm to 7.00am): 70 dB $L_{Amax.}$

All Zones
All sound levels shall be measured in accordance with NZS 6801:1999 Acoustics Measurement of Environmental Sound and assessed in accordance with NZS 6802:1991 Assessment of Environmental Sound.

NOISE-S2 Maximum noise levels for specified activities

Construction

1. Construction noise shall be measured, assessed, managed, and controlled in accordance with the requirements of New Zealand Standard NZS 6803:1999 Acoustics Construction Noise.

5.4 Discussion of Operative and Draft Rules

We do not expect that the draft rules will yet have statutory effect. Regardless it is noted that the Draft District Plan noise rules are likely to be somewhat less restrictive than the Operative District Plan rules, given that the Draft District Plan introduces an evening shoulder period noise limit that is less restrictive than the Operative District Plan noise rule. Compliance with the Operative District Plan noise rules would also result in compliance with the Draft District Plan noise rules[8].

Both versions of the Plan require construction noise to be measured and assessed using NZS6803:1999. This is a standard approach in most Districts.

Both the operative and draft District Plans require sound levels to be measured in accordance with NZS 6801 and assessed in accordance with NZS 6802. However, the versions of the standards referenced in both plans are the older 1999/1991 versions, rather than the current 2008 versions. We expect that this is an error in the Draft Plan, as the referenced standards do not accord with the National Planning Standards.

[8] Note that solar farm noise emissions will be typically at a constant level and thus the L_{Aeq} and L_{A10} noise levels are likely to be quite similar.

We consider the best approach is for the assessment to be carried out using the most recent versions of these standards: while there are some differences between the current and superseded versions, the outcome of using the most updated version will not be materially different to superseded versions. We have retained the use of the L_{A10} parameter as it is the assessment metric used in the Operative District Plan.

5.5 Resource Management Act

Under the provisions of the Resource Management Act (RMA) there is a duty to adopt the best practicable option to ensure that noise (including vibration[9]) from any development does not exceed a reasonable level. Specifically, Sections 16 and 17 reference noise effects as follows.

Section 16 states that "every occupier of land (including any premises and any coastal marine area), and every person carrying out an activity in, on, or under a water body or the coastal marine area, shall adopt the best practicable option to ensure that the emission of noise from that land or water does not exceed a reasonable level".

Section 17(1) states that "every person has a duty to avoid, remedy, or mitigate any adverse effect on the environment arising from an activity carried on by or on behalf of the person, whether or not the activity is in accordance with –

(a) Any of sections 10, 10A, 10B and 20A; or

(b) A national environmental standard, a rule, a resource consent, or a designation".

6.0 OPERATIONAL NOISE LEVELS

6.1 Noise Sources and Modelling Methodology

The main noise sources from the proposed solar farm would be the central generation inverters. Tracker motors also generate noise, but to a lesser degree than unattenuated inverters. Some noise is generated by transformers, although modern transformers typically have a low sound power level.

We have prepared a noise model using SoundPLAN® environmental noise modelling which considers factors such as the terrain, screening by buildings, and ground effect. Calculations have been carried out using ISO 9613-2:1996 "*Acoustics - Attenuation of sound during propagation outdoors - Part 2: General method of calculation*". Noise levels have been calculated under meteorological conditions that are favourable to sound propagation[10] and represent the typical 'worst case' propagation situation[11].

The following sound power data has been used in the preparation of this noise model. Data has relied on advice given by the manufacturers or from previous measurements we have carried out. We recommend suppliers confirm that the final equipment selected can operate accordingly.

Solar farm inverters may have tonal characteristics at various frequencies. The assessment of environmental noise effects for resource consent allows for inverters to have some tones and the relevant penalties have been applied[12].

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[9] RMA 1991 Part 1 Section 2 Interpretation: Noise includes vibration

[10] These are set out in ISO9613-2 and represent downwind or temperature inversion conditions.

[11] Under most daytime metrological conditions, noise levels will be lower than calculated. This is because when the solar farm is operating at full generation, it will be during periods of high solar gain (typically during the middle part of the day). In general, high solar gain conditions correspond with conditions that are not favourable to sound propagation, as sound will refract upward when air temperatures reduce with increasing altitude (temperature lapse). In temperature lapse conditions, noise levels are expected to be around five decibels lower than calculated for the temperature inversion condition.

[12] Tonality would typically be expected to occur at higher frequencies. Higher frequencies are attenuated with distance due to air and ground absorption, as well as topographical screening. Given the distances involved, tonality may not be audibly present at the

We understand that inverter noise levels will reduce at low loads. A reduction in sound power level of four decibels has been allowed for at 10% inverter power output[13]. Available data shows that tonal character is eliminated at low loads.

Table 4: Sound Power Levels

Noise Source	Sound Power Level dBA re 10^{-12} Watts	Number of Units	Directivity	Operation time
Generation Inverters				
DC / AC inverter 4.2 MVA	93 dB L_{WA} (AC end) 88 dB L_{WA} (DC end)	39	Included	Operation during sunshine hours (therefore within the statutory night period on Sunday)
Tracker modules	74 dB L_{WA} (emission when moving) = 100 dB L_{WA} (total L_w for all trackers across total farm[14])	6,034	None	68 seconds per 15 minutes – sunshine hours
Transformer	79 dB L_{WA}	2 (in switchyard)	None	Sunshine hours
TOTAL SOURCES		**41 + Trackers**		

6.2 Noise Level Calculations

Noise levels have been calculated at the notional boundaries of the receivers surrounding the farm.

Inverter units will likely have appreciable directivity. We have allowed for each inverter pair to have the AC end facing in different directions, and broadly as shown on the plans. Other orientations may result in a slight reduction in noise level, although this will depend on the orientation of the air intake on the final units selected.

The calculations have been carried out based on the following assumptions:

- Inverter source heights at around 4 metres above ground. Inverters distributed across the site as shown in the site drawings. Inverter plant has been allowed to operate at 100% load at times.
- Transformers with 3m source height
- Tracker motors below the table rotational axis at 3m above ground level.

Calculations have applied a broad special audible character[15] correction in accordance with NZS 6802:2008. As the solar farm could potentially operate for more than 80% of the prescribed daytime period (particularly during summer), no duration correction has been applied. Furthermore, as the solar farm can generate during part of the statutory night period (after 7pm), no duration correction is possible at that time.

receiver as any tones may be below the background level. Nonetheless we have conservatively allowed for tonality to be potentially present at low levels.

[13] Our analysis has allowed for inverter ventilation fans to operate at 100% even during times of low power generation. This is likely a conservative assumption where fans are variable speed.

[14] Recent data from manufacturers suggests a sound power level of 74 dB L_{WA} for solar farm 24V DC-type motors at all ranges of torque loads.

[15] Spectral data from some inverter manufacturers shows the potential for tones therefore, a five-decibel special audible character penalty has been applied to the overall noise level from this solar farm. It is possible that tonality will not occur and rating noise levels could be lower – data shows this will occur at lower inverter loads.

6.3 Calculated Noise Levels from Proposed Solar Farm

The following table summarises the results of our calculations. Calculations include a+5 dBA special audible characteristics correction for tonality. No duration correction applied.

Table 5: Calculated Noise levels

Receiver Location	Noise Limits [daytime / night] (dB L_{A10})	Calculated Rating Noise Level (dB L_R)	
		100% LOAD	10% LOAD
Battersea Road, Morison Bush 100	55 / 45	31	27
Battersea Road, Morison Bush 100A	55 / 45	30	26
Battersea Road, Morison Bush 101	55 / 45	28	24
Battersea Road, Morison Bush 28	55 / 45	36	32
Battersea Road, Morison Bush 35	55 / 45	31	27
Battersea Road, Morison Bush 50	55 / 45	34	30
Battersea Road, Morison Bush 72	55 / 45	34	30
Battersea Road, Morison Bush 80	55 / 45	32	28
Battersea Road, Morison Bush 84	55 / 45	32	28
Bidwills Cutting Road, Morison Bush 179	55 / 45	21	17
Bidwills Cutting Road, Morison Bush 193	55 / 45	22	18
Bidwills Cutting Road, Morison Bush 217	55 / 45	25	21
Bidwills Cutting Road, Morison Bush 224 [east]	55 / 45	27	23
Bidwills Cutting Road, Morison Bush 224[west]	55 / 45	29	25
Bidwills Cutting Road, Morison Bush 247	55 / 45	28	24
Bidwills Cutting Road, Morison Bush 255	55 / 45	29	25
Bidwills Cutting Road, Morison Bush 263	55 / 45	30	26
Bidwills Cutting Road, Morison Bush 268	55 / 45	31	27
Bidwills Cutting Road, Morison Bush 269	55 / 45	29	25
Bidwills Cutting Road, Morison Bush 273A	55 / 45	30	26
Bidwills Cutting Road, Morison Bush 273B	55 / 45	27	23
Bidwills Cutting Road, Morison Bush 273D	55 / 45	27	23
Bidwills Cutting Road, Morison Bush 273E	55 / 45	28	24
Bidwills Cutting Road, Morison Bush 299	55 / 45	32	28
Bidwills Cutting Road, Morison Bush 381	55 / 45	26	22
Bidwills Cutting Road, Morison Bush 388	55 / 45	26	22
Moroa Road, Morison Bush 489	55 / 45	36	32
Moroa Road, Tauherenikau 169	55 / 45	28	24
Moroa Road, Tauherenikau 260	55 / 45	38	34
Moroa Road, Tauherenikau 260_1	55 / 45	39	35
Moroa Road, Tauherenikau 260_2	55 / 45	32	28
Moroa Road, Tauherenikau 260_3	55 / 45	31	27
Moroa Road, Tauherenikau 286	55 / 45	33	29
Settlement Road, Morison Bush 23	55 / 45	29	25
Settlement Road, Morison Bush 26	55 / 45	31	27
Settlement Road, Morison Bush 38	55 / 45	29	25
Settlement Road, Morison Bush 45	55 / 45	29	25

Receiver Location	Noise Limits [daytime / night] ($dB L_{A10}$)	Calculated Rating Noise Level ($dB L_R$)	
		100% LOAD	10% LOAD
Settlement Road, Morison Bush 51	55 / 45	27	23
Settlement Road, Morison Bush 51	55 / 45	27	23
Settlement Road, Morison Bush 53	55 / 45	29	25
Settlement Road, Morison Bush 54	55 / 45	34	30
Settlement Road, Morison Bush 56	55 / 45	38	34
Settlement Road, Morison Bush 73	55 / 45	30	26
Settlement Road, Morison Bush 74	55 / 45	30	26
Settlement Road, Morison Bush 74A	55 / 45	32	28
Settlement Road, Morison Bush 76	55 / 45	32	28
Settlement Road, Morison Bush 90	55 / 45	32	28
Settlement Road, Morison Bush 96	55 / 45	34	30
Settlement Road, Morison Bush 97	55 / 45	33	29
State Highway 2, Tauherenikau 1688	55 / 45	26	22
State Highway 2, Tauherenikau 1690	55 / 45	25	21
State Highway 2, Tauherenikau 1704	55 / 45	26	22
State Highway 2, Tauherenikau 1724	55 / 45	24	20
State Highway 2, Tauherenikau 1746	55 / 45	26	22
State Highway 2, Tauherenikau 1746A	55 / 45	26	22
State Highway 2, Tauherenikau 1746B	55 / 45	27	23
State Highway 2, Tauherenikau 1776	55 / 45	27	23
State Highway 2, Tauherenikau 1776A	55 / 45	26	22
State Highway 2, Tauherenikau 1787	55 / 45	24	20
State Highway 2, Tauherenikau 1800	55 / 45	29	25
State Highway 2, Tauherenikau 1800A	55 / 45	26	22
State Highway 2, Tauherenikau 1800B	55 / 45	27	23
State Highway 2, Tauherenikau 1808	55 / 45	29	25
State Highway 2, Tauherenikau 1808a	55 / 45	32	28
State Highway 2, Tauherenikau 1832A	55 / 45	29	25
State Highway 2, Tauherenikau 1832B	55 / 45	33	29
State Highway 2, Tauherenikau 1923	55 / 45	27	23
State Highway 2, Tauherenikau 1925A	55 / 45	28	24
State Highway 2, Tauherenikau 1931	55 / 45	25	21
State Highway 2, Tauherenikau 1937	55 / 45	27	23
State Highway 2, Tauherenikau 1942	55 / 45	28	24
State Highway 2, Tauherenikau 1963	55 / 45	25	21
State Highway 2, Tauherenikau 1975A	55 / 45	23	19
Bidwills Cutting Road 312 (Written Approval)	55 / 45	40	36
Gunclub: 170 Moroa Road, Tauherenikau	55 / 45	32	28

6.4 Results Summary

Our calculations show that for the compliance receivers that have not given written approval:

- The proposed solar farm would readily comply with the Wairarapa Combined District Plan daytime noise rule of 55 dB L_{A10}. Even in the worst-case "100%" scenario, noise levels would be significantly (at least 16 decibels) below the daytime noise rule.
- Evening operation of the proposed solar farm would readily comply with the Wairarapa Combined District Plan night-time noise rule of 45 dB L_{A10}. Even in the worst-case "100%" scenario, noise levels would be significantly (at least 6 decibels) below the night-time noise rule,
- The proposed solar farm would also comply with the noise rules in the Draft Wairarapa Combined District Plan.
- For dwellings near State Highway 2 and Bidwills Cutting Road, solar farm generated noise levels are expected to be quieter than the existing ambient (L_{A10}) and background (L_{A90}) noise (during the typical hours of solar generation). Solar farm noise levels at dwellings near SH2 would be in the order of 24 to 34 dB L_{A10}, whereas State Highway traffic would generate background and ambient noise levels that are typically higher than this during daylight hours.
- Solar farm noise levels at dwellings on Moroa Road, Settlement Road and Battersea Road would be in the order of 27 to 39 dB L_{A10} at times of solar generation. As the Moroa, Settlement and Battersea Road area is further removed from State Highway 2, it is subject to generally lower noise levels (noting that background noise levels in this area vary depending on local activity). Noise from the solar farm generation is expected to be above the existing background (L_{A90}) noise level at times, but generally similar to or quieter than the existing ambient (L_{A10}) noise level. In this area on settled weather days, the solar farm would be audible at times as a low-level constant noise source.

6.5 Operational Traffic

Operational traffic has been assessed for the project. We understand the farm would only require around two staff on site which we expect could generate perhaps 4 to 12 vehicle movements per day. During the initial period of commissioning, we understand that there may be more staff on site and a higher number of traffic movements may result. Operation of the solar farm would only require very occasional heavy vehicle movements, which are not expected to occur during the evening and night periods.

The locations of the vehicle entry points are generally well removed from most dwellings and we therefore expect noise from on-site movements to be very low, typically below the existing background noise level at most dwellings at most times.

Based on our observations, the above number of vehicles would not significantly increase traffic on SH2 or Bidwills Cutting Road. We would not expect traffic noise levels from these roads to appreciably increase. Traffic on Moroa Road may increase markedly over the commissioning period as it currently has few movements per day on it. However the number of overall movements would still remain low. We understand all roads surrounding the proposed solar farm are public roads, and the District Plan rules do not apply to any traffic using these roads.

Overall, we consider that operational traffic noise is likely to be largely insignificant in comparison to existing (non-site) noise traffic noise levels in the area.

7.0 SUMMARY OF OPERATIONAL NOISE EFFECTS

- The location of the solar farm is well chosen from a noise perspective. The significant distances between the sources of noise and the nearest receivers would result in noise from the solar farm being fairly low overall.
- For most dwellings to the north, west and east of the site, noise generated by the solar farm will typically be below the existing ambient and background noise levels. For some dwellings south of the site, solar farm noise may be above the existing background (L_{A90}) noise level at times, but generally similar to or quieter than the existing ambient (L_{A10}) noise level. In this area, the solar farm would be audible on days with settled weather as a low-level constant noise source.
- Compliance with the District Plan noise limits would readily occur for the proposed operation.

8.0 CONSTRUCTION NOISE LEVELS

8.1 On-site construction

Construction of the solar farm is likely to involve the following:

- Delivery of panels, inverters and other infrastructure, requiring trucks and small cranes. Around three trucks per day are expected.
- Earthworks would occur using trucks, loaders and excavators
- A 'Vermeer PD10 Pile Driver' to impact drive the support piles into the ground.

Solar farm construction typically takes place over a period of less than 20-weeks and between the hours 7:30 to 18:00, Monday to Saturday. Therefore, the 'typical duration' construction noise limits: 75 dB L_{Aeq} and 90 dB L_{AFmax} would apply. The proposed Greytown Solar Farm is relatively large, and the total duration of piling could be longer than 20 weeks, however the activity will not be stationary during this time and piling in any one location will occur for much shorter than 20 weeks. Based on section c7.2.1 of NZS 6803:1999, the appropriate NZS 6803 noise limit is 75 dB L_{Aeq}.

All significant equipment likely to be used on the project is listed in Table 6. The sound levels given are based on measurements we have made of similar plant or from BS 5228-1:2009 *Code of practice for noise and vibration control on construction and open sites* Part 1: Noise.

Table 6: Activity Specific Noise Levels at 1m from a building façade (without screening)

Item/Activity	Operating Sound Power Level (dB L_{WA})	Noise Level (dB L_{Aeq})				75dBA Limit Setback (m)
		100m	250m	500m	750m	
Large Trucks (operating within the site)	108	60	50	43	38	25m
Excavators and other earthmoving plant	103	55	45	38	33	14m
Vermeer PD10 Pile Driver (unattenuated impact piling noise level)	123	75	65	58	53	100m
Impact piling (with casing and dolly)	114	66	58	49	44	44m
Concrete truck & pump	103	55	45	38	33	14m
Truck idling	91	43	33	26	21	4m

The majority of dwellings would be well beyond 100 metres from the piling and thus compliance with the District Plan construction noise rules will be complied with at most dwellings. However there are some dwellings that will be closer to the closest piles than this. We have identified these dwellings as:

- Potential worker accommodation on 260 Moroa Road

- 489 Moroa Road
- 56 Settlement Road
- 312 Bidwills Road (written approval from lessor)

The applicant has advised that they will take all required mitigation measures to ensure compliance with the NZS 6803:1999 noise limits at all dwelling façades. In some piling locations close to dwellings, that may mean that unattenuated Vermeer or drop hammer piling may not be able to occur. The applicant would ensure that if a Vermeer-type or drop hammer piling rig was used, that a suitable dolly or shroud (or similarly effective method) is used to mitigate noise from the piling. If the piling contractor advises that that method is impractical for the Vermeer-type rig, the applicant my need to use an alternative method (potentially screw, auger or bored piling) for piles within around 100m of dwellings.

We recommend that a noise management plan is prepared by the piling contractor to show the "zones" where Vermeer-type or drop hammer piling cannot occur. These zones are expected to be relatively small, nonetheless piling in these areas will need to be restricted to attenuated or quieter methods.

The key matter that the noise management plan should show are maps that illustrate the "piling zones" where noise levels may be above the NZS 6803:1999 noise limit without attenuation. Other matters should be addressed in the construction noise management plan as generally required in NZS 6803 and as part of typical best-practice.

There would be no perceptible vibration from the above construction activity.

8.2 Construction vehicles on public roads

Truck and construction passenger vehicle movements will occur on Moroa Road during construction. These are public roads and the construction noise and vibration limits do not technically apply to activities on these roads, although we note that vehicles using these roads would likely generate noise levels that comply with NZS 6803 guidelines regardless.

9.0 RECOMMENDED NOISE CONDITIONS

It is recommended that the following noise conditions are imposed on any consent granted.

1. The noise level from operation of the solar farm shall meet the following noise limits at the notional boundary of dwellings existing at the time of consent on any other site (excluding those where written approval has been obtained):

Daytime	7:00am to 7:00pm	55 dB L_{A10}
Night-time	7:00pm to 7:00pm	45 dB L_{A10}
	9:00pm to 7:00pm	75 dB L_{AFmax}

   Noise levels shall be measured and assessed in accordance with NZS 6801:2008 *Acoustics – Measurement of Environmental Sound* and *NZS 6802:2008 Acoustics – Environmental Noise.*

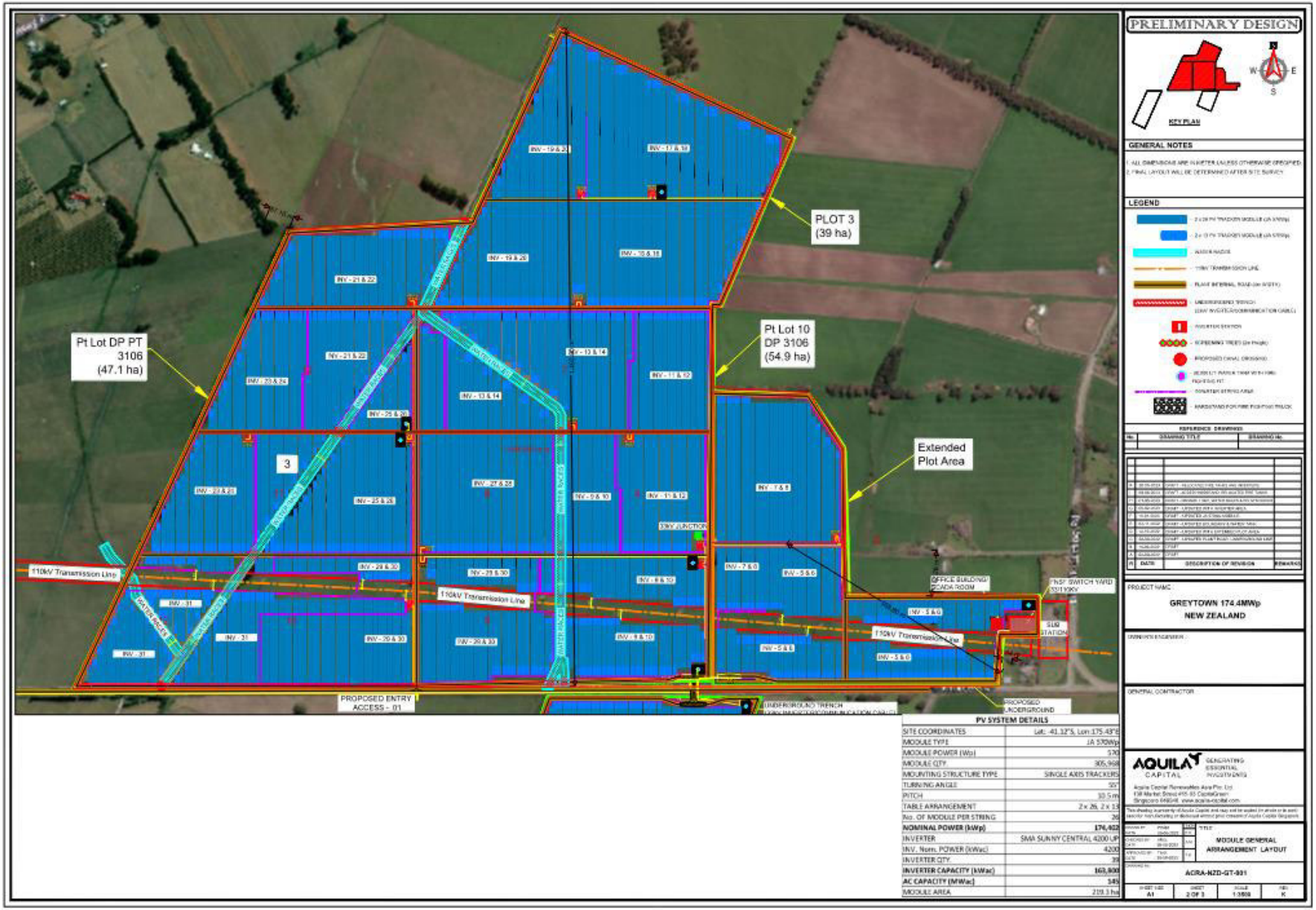
2. Noise from construction activities shall not exceed the typical duration limits recommended in, and shall be measured and assessed in accordance with, New Zealand Standard NZS 6803: 1999 *"Acoustics – Construction Noise".*

3. A Construction Noise Management Plan (CNMP) shall be prepared and submitted to Council. The CNMP shall identify any areas of piling on maps that are likely to breach the consented construction noise limits without further attenuation. The CNMP shall identify suitable methods of noise attenuation that should be used by the contractor to comply with the noise limits when piling within these zones and/or any procedures that should be carried out to identify these methods of noise attenuation prior to work beginning in these areas.

APPENDIX A GLOSSARY OF TERMINOLOGY

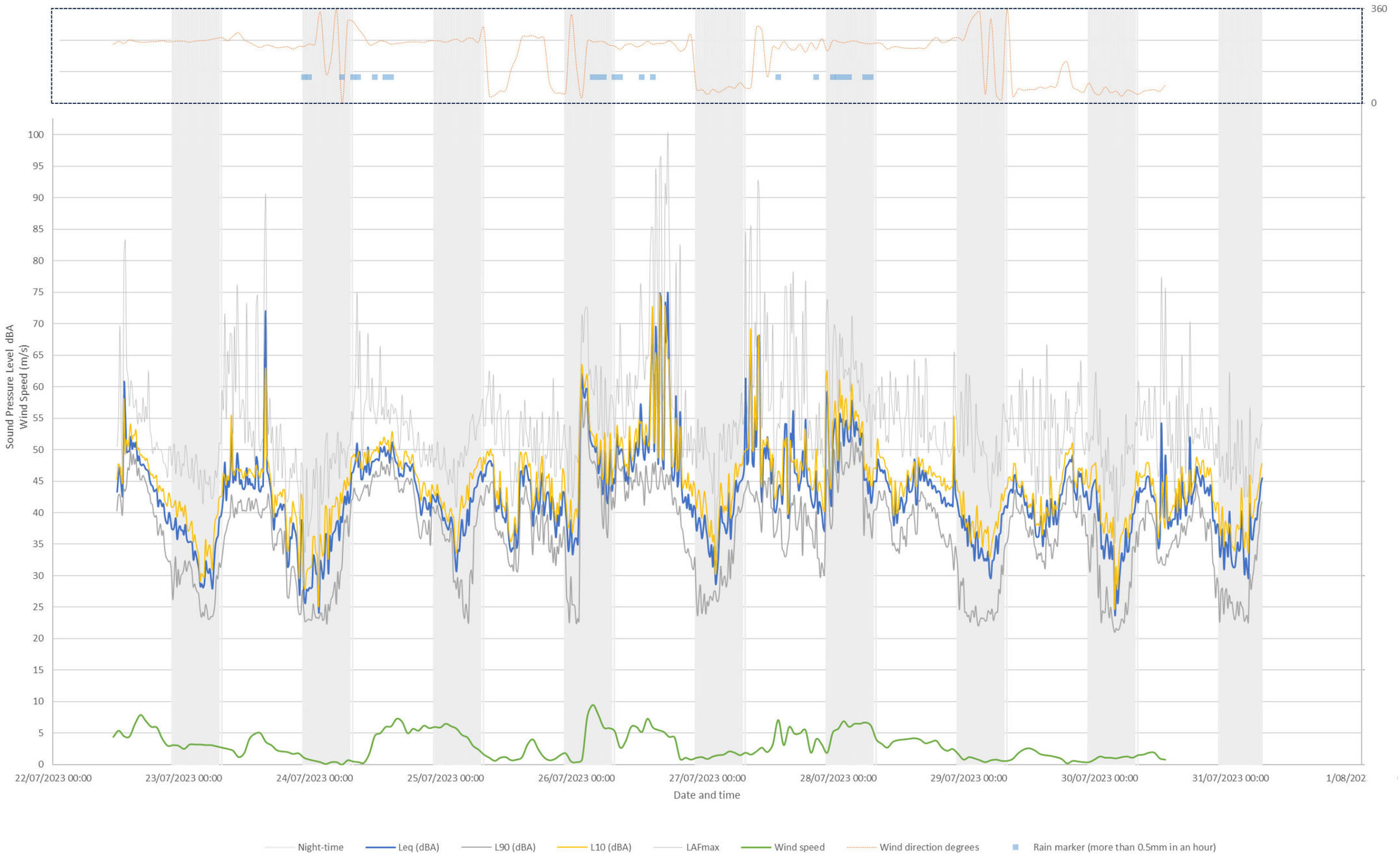
Ambient Noise	Ambient Noise is the all-encompassing noise associated with any given environment and is usually a composite of sounds from many sources near and far.
dBA	A measurement of sound level which has its frequency characteristics modified by a filter (A-weighted) so as to more closely approximate the frequency bias of the human ear.
L_{eq}	The time averaged sound level (on a logarithmic/energy basis) over the measurement period (normally A-weighted).
L_{90}	The sound level which is equalled or exceed for 90% of the measurement period. L_{90} is an indicator of the mean minimum noise level and is used in New Zealand as the descriptor for background noise (normally A-weighted).
L_{10}	The sound level which is equalled or exceeded for 10% of the measurement period. L_{10} is an indicator of the mean maximum noise level and is used in New Zealand as the descriptor for intrusive noise (normally A-weighted).
L_{AFmax}	The maximum sound level recorded during the measurement period (normally A-weighted).
NZS 6801:2008	New Zealand Standard NZS 6801:2008 *Acoustics – Measurement of environmental sound*
NZS 6802:2008	New Zealand Standard NZS 6802:2008 *Acoustics - Environmental Noise*
NZS 6803:1999	New Zealand Standard NZS 6803:1999 "*Acoustics – Construction Noise*"
Prescribed time frame	'Daytime', night-time', 'evening', or any other relevant period specified in any rule or national environmental standard or in accordance with 8.3.2 in NZS 6802:2008.
Rating level	A derived level used for comparison with a noise limit. Considers any and all corrections described in NZS 6801 and NZS 6802, e.g. duration, special audible character, residual sound etc. This definition is from NZS 6802:2008.
Special audible characteristics	Distinctive characteristics of a sound that make it more likely to cause annoyance or disturbance. A penalty of up to 5 decibels can be applied when assessing sounds with SAC Examples are tonality – a hum or a whine) and impulsiveness – bangs or thumps.

APPENDIX B SITE LAYOUT PLAN



APPENDIX C LOGGED NOISE RESULTS (OVERLEAF)

Figure 2: Diurnal Ambient and Background Noise Levels Measured at Logger Position



Attachment 4: Soil Assessment

Greytown Solar Farm – Expert Statement on the Effects on Soil

Prepared By: Ian Hanmore

Prepared For: Far North Solar Farm Limited

20th July 2023

Hanmore Land Management

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WAITARA SOLAR FARM - EXPERT STATEMENT ON HIGHLY PRODUCTIVE LAND

Introduction

Qualifications and experience

1. My name is Ian Hanmore. I am the Director of Hanmore Land Management Limited, a company specialising in land management and environmental consultancy. Prior to this I contracted my service through AgFirst Northland. I provide services to a range of private clients, planners, Regional and District Councils, and Māori Trusts throughout New Zealand, with a particular focus on the Waikato, Auckland, and Northland regions.

2. I hold a Master of Applied Science majoring in Natural Resource Management from Massey University, I am an approved competent mapper for the National Environmental Standards for Plantation Forestry Erosion Susceptible Classification with MPI, I have an Advanced Nutrient Management Certificate from Massey University and am a member of the New Zealand Association of Resource Managers, the New Zealand Institute of Primary Management and the New Zealand Society of Soil Science.

3. I have been a consultant in the above capacity for 17 years and have worked extensively throughout the North Island. As part of my work I carry out soil and land use capability (LUC) mapping. This work involves detailed soil and LUC surveys to map soils suitable for horticultural and specific horticultural crops, to identify prime, elite, high class and highly versatile soils and highly productive land. This work is used in regard to subdivisions and land use consents, assisting farmers matching their production policy to their land resource, identifying land use development opportunities and enterprise diversification.

THE IMPACTS OF A PROPOSED SOLAR FARM ON HIGHLY PRODUCTIVE LAND

Background

A proposed solar farm is to be located at 415 Moroa Road, Greytown, Wairarapa and covers approximately 219ha (see figure 1 below). The land on which the proposed solar farm is to be located is classified as Land Use Capability (LUC) unit 4s 1 by the New Zealand Land Resource Inventory (NZLRI) and is therefore outside of the Highly Productive land (HPL) category. The soils at the site are mapped by the NZLRI and S-Map as very stony causing severe limitations to arable use and being suitable for grazing, root and green fodder cropping and forestry.

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Figure 1. Approximate proposed solar farm area.

Proposed Solar Array Structures

The following information has been supplied to Hanmore Land Management Ltd by Far North Solar Farm Limited (FNSF) regarding the proposed solar array structures and supporting hard stand areas for inverters and a substation.

This project will use a single axis tracking system, arranged in a 2-modules-in-portrait configuration. The arrangement will include 28/14 modules in series, corresponding to 2x28 and 2x14 table arrangements. The solar panels will be mounted on H piles driven into the ground as illustrated in Figure 2 below. Piles will be 50mm wide with a maximum cross section height of 150mm and be driven 1.2m into the ground, with approximately 80,290 piles across the whole site. Hard surface areas will be needed for 39 x 20' shipping containers (6.06mx2.43m), for inverters and the size of two shipping containers for an office building. (details are subject to slight changes after geophysical testing conducted by the EPC team).

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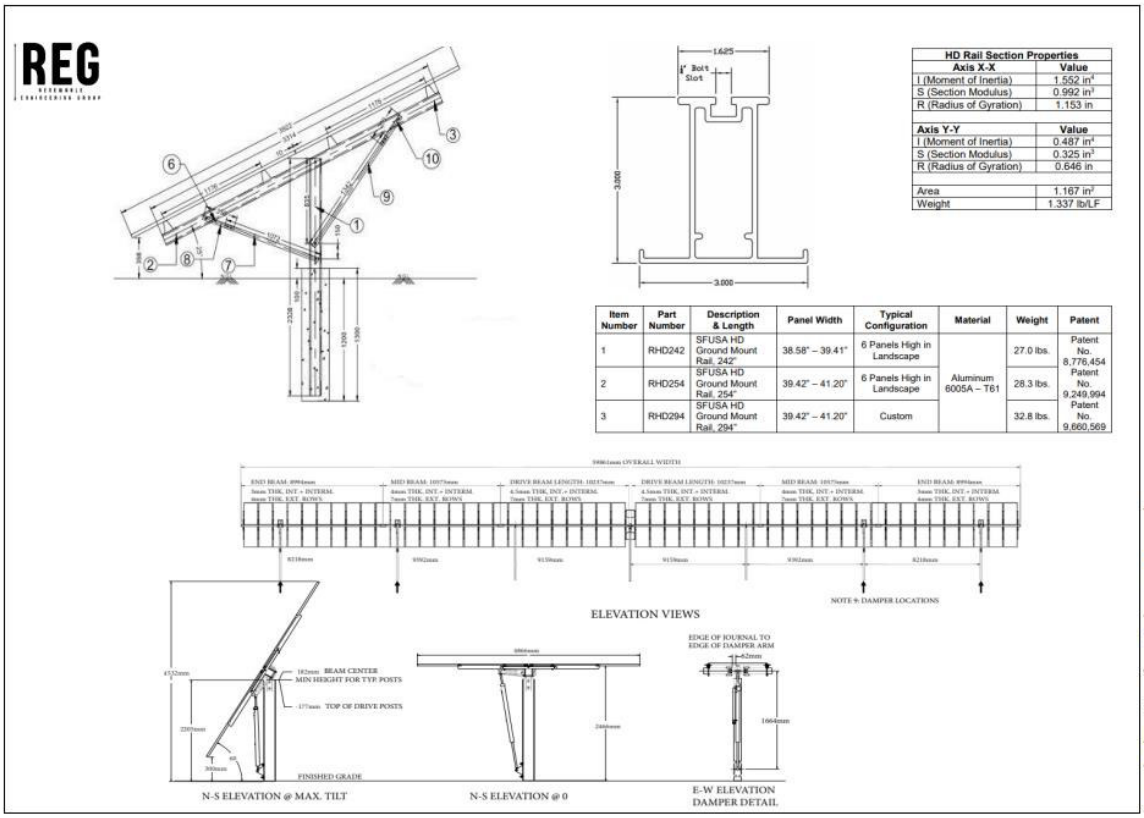

Figure 2. Proposed solar panel structures.

While the solar farm is in operation the area will be grazed by sheep to control pasture growth and when the project is decommissioned structures will be unscrewed and removed, piles uplifted and wiring/cabling taken out.

Soil Surface Area Impacted

Based on the information supplied by FNSF the total surface area of ground impacted by the installation of the solar structures has been calculated below.

Area for 20' shipping containers: 41 x 6.06mx2.43m = **603.7578m^2**

Total surface area impacted: **603.7578m^2**

Total area of the project approximately 219ha = 2,190,000m^2

Percentage of whole site impacted by structures: **0.03%**

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Assessment of Effects on HPL

As can be seen from the calculations above the total surface area impacted by the proposed solar structures is approximately 604m^2. In the context of the whole site this area will have a less than a minor impact on the site and would not be dissimilar to any agriculture or horticulture operation. Using H piles rather than solid piles to support the solar panels will minimize soil impacts and have a negligible impact on soil structure across the site.

The overall project will be potentially more beneficial to soil structure and long-term potential productivity than many farming operations. Eliminating the possibility of future heavy stock such as cattle and cropping operations will minimize the risk of soil compaction and organic matter loss due to pugging damage, cultivation and machinery movement. If good stock and pasture management are followed on the proposed site soil structure, water hold capacity, aeration and nutrient status will be improved through minimizing compaction and increased organic matter incorporation in the soil profile. When the project is decommissioned, as outlined by FNSF, minimal soil disturbance will occur which will preserve the productivity potential of the HPL.

Over the life of the proposed project energy generation will be the main production focus with primary production on the site continuing in a supporting capacity through sheep grazing for meat production. The project itself as outlined above will not reduce or negatively impact the productivity potential of the soil. When the project is decommissioned, the land will be available for primary based production with potentially improved soil structure and productivity potential.