Boffa Miskell

Balmoral Station Solar Farm

Ecological Impact Assessment
Prepared for Infratec New Zealand Ltd

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Cover photograph: Proposed solar farm site at 'Irishman Paddock', Braemar Rd, looking east. July 2021. © Boffa Miskell 2021.

Executive Summary

Infratec and Lake Tekapō Enterprises are proposing to construct and operate a solar farm that would occupy c.95 ha of a c.111 ha site at Balmoral Station, Tekapo. The solar farm would be built in two stages some years apart, but this assessment largely considers the proposal as a whole. As yet, no such solar farm development has occurred in the Mackenzie Basin, where recent land use changes have caused widespread concern over the loss of important indigenous habitats. Accordingly, the solar farm site selected for this development is an already-modified habitat.

The proposed solar farm site at ‘Irishman Paddocks’ on Braemar Rd is actively farmed, and the original (pre-European) vegetation of the area has been modified for pastoral improvement (including by OSTD and direct drilling), but the solar farm site has not been fully cleared of indigenous vegetation. Hence, indigenous plant species (particularly fescue tussock, copper tussock, and a range of locally common and widespread inter-tussock species) remain prevalent across the ‘main paddock area’ of the solar farm site where solar panel arrays and other infrastructure would be constructed. This main paddock area contains three broad indigenous vegetation types including grasslands with fescue tussock or copper tussock, and herbfields on dry raised areas dominated by exotic mouse-ear hawkweed. These vegetation types are of **Moderate** ecological value despite the overall dominance of exotic pasture species. Of note is that several plant species present in the main paddock are classified as being nationally At Risk and one is nationally Threatened. Three wetland areas are present at the site. A central wetland contains Threatened and At Risk wetland plant species, but two more modified southwest areas are of lower value as they are dominated by exotic wetland plants. All wetland areas along with a c.20 m setback of dryland habitat (14.5 ha in total) would not form part of the solar farm development. Instead, these wetland and setback areas would be protected and expected to recover in terms of habitat quality and indigenous vegetation cover in the absence of cattle particularly, and all grazing including by rabbits / hares would be excluded.

A limited range of fauna currently uses the main paddock area, with a small number of indigenous bird species likely to occupy the solar farm site in low numbers. Very low numbers of southern grass skink are present in the main paddock, but it appears that this is almost entirely in artificial habitats (habitats inadvertently created by old shelterbelt slash piles, and construction of a ditch). If lizards occur more widely in central areas of the main paddock it is likely they are in extremely low numbers. In the central wetland, habitat is potentially available for a somewhat greater range of bird species, and low numbers of southern grass skink and also very low numbers of McCann’s skink are present. Invertebrates in main paddock areas of the solar farm site appear typical of modified short tussock grasslands; the solar farm site lacks intact or distinctive invertebrate habitat.

The main paddock area where development would take place occurs on moraine and alluvial deposit landforms. The vegetation in the main paddock meets the definition of both ‘improved pasture’ and ‘indigenous vegetation’

and is therefore ecologically significant under MDP PC18 rules (it also meets CRPS significance criteria).

The ecological effects of the solar farm to vegetation include direct vegetation clearance amounting to approx. 2.7 ha in total (permanent loss would be around 1.3 ha), a **Very Low** level effect. Clearance of the solar farm site is not required as solar panel arrays are piled directly into the existing substrate. Nevertheless, the panels themselves are highly likely to exert microclimatic effects that may drive changes in vegetation composition towards the growth of exotic grasses and indigenous and exotic herbs, particularly beneath panels. Vegetation in areas between panels (panels would directly cover around half the area) would likely remain largely similar, maintaining habitat for At Risk plant species (which would persist, and would be expected to have improved habitat in time, in proposed setback areas). Effects to vegetation especially beneath panels would be mitigated to a degree by changes to site grazing management (exclusion of cattle). Overall, these indirect effects to indigenous vegetation would amount to a **Low** level of effect. Further, all species and habitats present at the solar farm site are widespread and frequently far more intact across the surrounding area and at the level of the ED. Following construction, weed spread and establishment is possible, and post-construction monitoring and control is recommended.

The solar farm development has the potential to cause the loss of part of a low-quality habitat for some bird species, and construction disturbance to feeding and nesting is possible (avoidance of construction during the nesting season, or pre-construction checks, are recommended). The possibility of bird strike to solar panel arrays has been considered in light of international studies and the local context. We are uncertain whether bird strike effects could occur, but if it does, it may have **Low** level effects. Post construction monitoring and response measures (if this effect were to occur) are recommended.

The effect on lizards (most likely southern grass skink and McCann's skink) due to the construction of the solar farm and the alteration of lizard habitat is likely to be of a Negligible magnitude and **Very Low** level of effect. However, the level of effect in terms of possible lizard mortality during site preparation is considered of potentially **Low** level at the scale of the ED (and higher at the site scale), for example if existing slash piles that currently provide habitat are burnt. However, dismantling and moving piles following appropriate lizard salvage (as proposed) would substantially reduce the level of effect to a **Very Low** level at both scales. Construction mortality due to machinery movements is considered to be of a **Very Low** level of effect and could be minimised by avoiding construction in cold weather. The effect of potentially increased predation rates could be reduced through predator control throughout the wetland areas where lizards are present in higher numbers, and by creation of suitable habitat refugia (to replace that lost by slash pile removal). Effective implementation of these measures would reduce the level of effect to lizard species to **Very Low**.

Effects to invertebrates due to the solar panel arrays have also been considered, but are not of ecological concern in the context of this proposal.

Overall, the level of effect of the construction and operation of the proposed solar farm on ecological values, with implementation of project shaping, site management, and other recommendations, is generally expected to be **Very Low** to **Low** in the solar farm footprint, but would constitute a **Net Gain** in wetland and setback areas. The setting aside of a portion of the solar farm site for habitat enhancement mitigates to a degree the likely changes in vegetation induced by the prolonged presence of solar panel arrays across a relatively large area. Even though the proposal is for a large infrastructure project, our assessment of at-worst **Low** level effects considers the already modified nature of the solar farm site but also the relatively insignificant direct impacts of earthworks and site clearance required to construct the solar panel arrays. Indirect effects to vegetation are the main likely ongoing effect of the proposal; adverse effects to fauna can be avoided or otherwise managed by pre-construction management or post-construction monitoring measures.

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Appendices

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1.0 Introduction

1.1 Background

Infratec New Zealand Limited (Infratec) and Lake Tekapō Enterprises Limited (LTE) have formed a joint venture to establish and operate a solar array (solar farm) for renewable electricity generation at a c.111 ha site called 'Irishman Paddocks' surrounded by pine shelterbelts ('the solar farm site') on Balmoral Station, adjacent to the Braemar Rd, near Tekapō (see Figure 1). The proposed solar array will be developed in two phases:

- Phase 1: 12 MWp to be constructed in 2023.
- Phase 2: 76 MWp to be constructed at a later date.

Phase 1 will cover that part of the solar farm site shown in pink on the site concept layout in Figure 1. This area is approximately 13.5 ha, with a megawatt-peak of 12 MW. In real terms, over the course of a year this will produce enough electricity to power 2800 households, equivalent to around 70% of the Tekapo township.

Phase 2 will cover the balance of the solar farm site as shown on the site concept layout in Figure 1. This area is approximately 86 ha. Phase 2 is subject to the cost, time and planning considerations of network upgrades to both Transpower and Alpine Energy infrastructure. However, this application seeks consent for both Phase 1 and Phase 2.

1.2 Purpose and Scope

Infratec asked Boffa Miskell Limited (Boffa Miskell) to undertake a survey of the ecological values at the proposed solar farm site, and to provide an Ecological Impact Assessment (EcIA) report to accompany the necessary resource consent applications for the proposed solar farm.

This EcIA has been prepared to:

- Describe the existing ecological environment at the solar farm site;
- Assess the ecological significance and ecological value of the existing environment;
- Assess the ecological effects of the construction and operation of the proposed solar farm on ecology values; and
- Make recommendations to avoid, minimise, remedy or mitigate potential adverse effects of the construction and operation of the proposed solar farm on ecology values.

This EcIA report focuses on terrestrial ecology values (including a description of wetlands at the solar farm site that are to be avoided by the solar farm proposal, with setbacks applied). Because the proposal does not include any works in or near waterways, freshwater ecology assessments do not form part of the scope of this EcIA. Previously, Boffa Miskell were engaged by Infratec to undertake a literature review to obtain information about the possible effects of solar farm structures (panel arrays) on indigenous dryland vegetation, as part of a preliminary assessment of an alternative solar farm location ('Site A') that was not ultimately pursued due to the high ecological values found there (see *Site Selection* in the proposal's Assessment of Effects, to which this EcIA is attached). The findings of that exercise, insofar as they are relevant to understanding the effects of this proposal, have been included in this report.

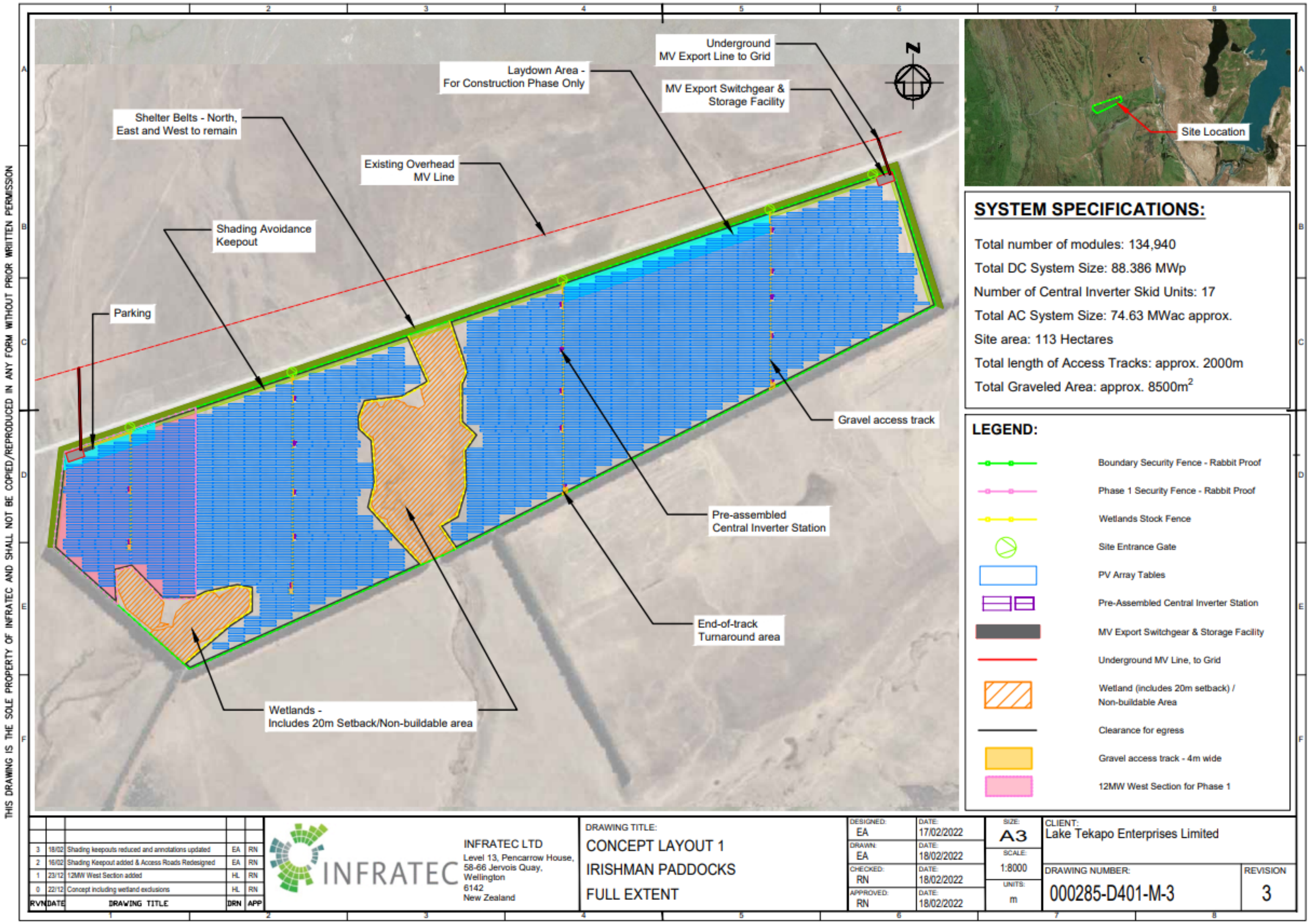

Figure 1. Proposed solar farm concept layout (source: Infratec).

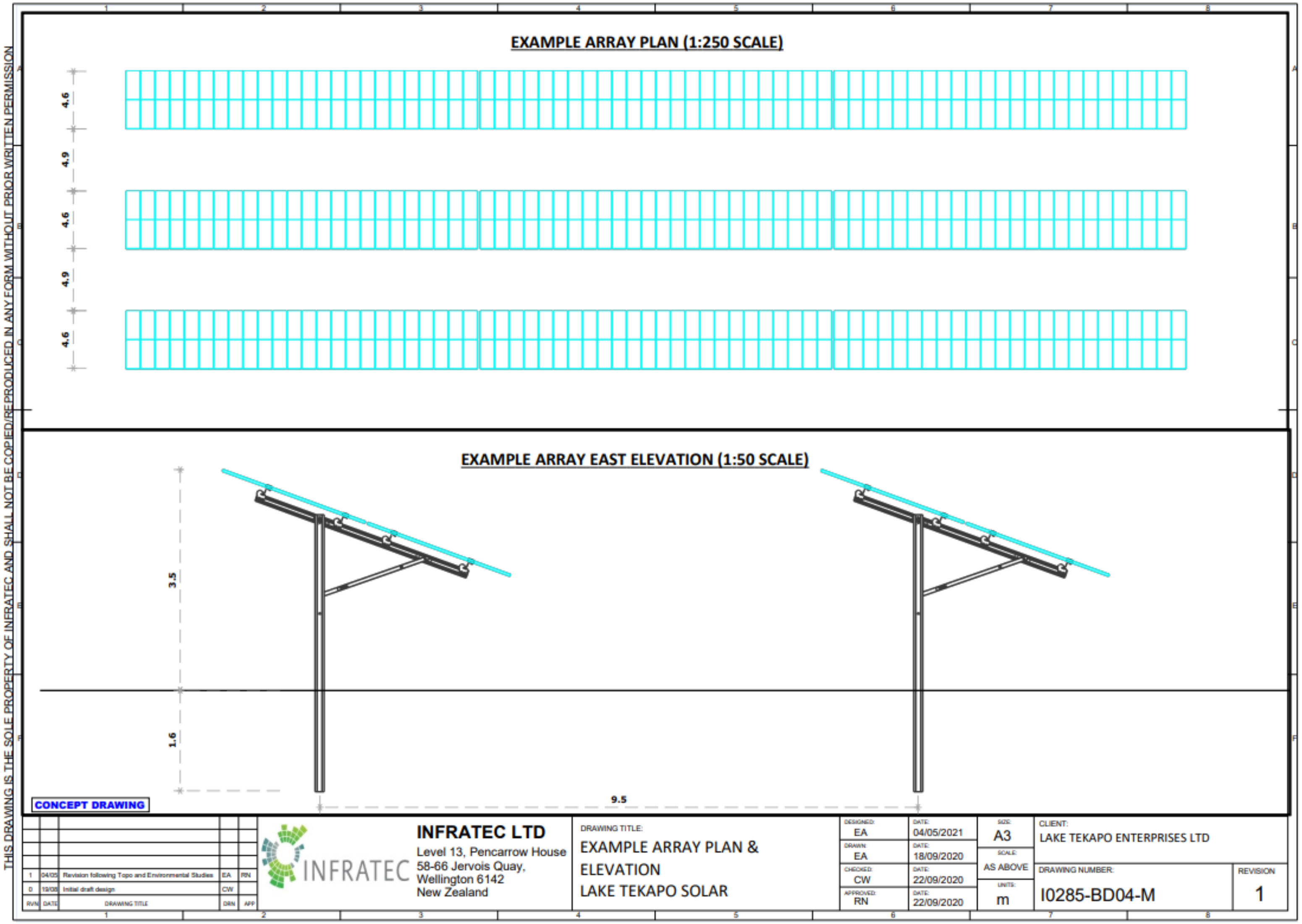

Figure 2. Typical mounted PV modules (source: Infratec).

2.0 Project Description

The following Project Description has been summarised from the Assessment of Effects, to which this report is attached.

2.1 Solar Farm Description

The proposed solar farm will comprise:

- PV array modules – Phase 1 will contain approximately 20,000 bifacial PV modules and Phase 2 will contain approximately 114,940 bifacial PV modules. In total, there will be 134,940 modules. These modules generate electricity on both sides, allowing for direct and reflected light to be captured and harnessed.
- Perimeter security fencing.
- Two new underground lines connecting the solar farm site to the transmission network.
- Seventeen Central Inverter Skid Units.
- Two MV Export Switchgear and storage areas.
- Internal tracks, parking and laydown area.

2.2 PV Modules

Each bifacial PV module will be approximately 2.4 m by 1.3 m and will be mounted on framing that will be typically supported by a single line of C-section galvanised steel piles. The piles will be driven approximately 1.6 m into the ground (depending on geotechnical conditions). A concept elevation depicting typical mounted PV modules is provided in Figure 2.

The modules will be erected in rows to form arrays. Actual ground coverage will be approximately 40% (48 ha) by area. The proposed layout will provide approximately 4.9 m between each array to provide access for maintenance and replacement (if required) and 3 access tracks of approximately 4 m in width that will enable vehicle access as shown on the solar farm site Plan in Figure 1. The modules will be setback approximately 10 m from the shelterbelts and at least 24 m from the edge of the wetlands, which includes a 4 m strip for light vehicles i.e., quad bikes to access the modules.

The PV modules will likely have a 20-year life and then need to be replaced at that time or earlier if there are significant advancements in technology. However, it is intended that the solar array will operate on the solar farm site in perpetuity.

2.3 Operation of the Array

The electricity will be collected from each module, passing through cables. The voltage at this point is typically around 1500V. The power will then routed to MV inverters which convert the direct current generated by the solar modules into alternating current which can be fed into the electricity grid. The inverters will also manage the amount of electricity entering the grid to ensure the system does not get overloaded. A further series of high voltage AC cables will then carry the electricity to the MV export switchgear unit comprised of electrical disconnect switches, fuses or circuit breakers used to control, protect and isolate electrical equipment. The switchgear is used to both de-energize equipment to allow maintenance or replacement work, and to disconnect the solar array from the electrical network if there is a fault.

To connect the part of Phase 2 west of the central wetland to the switchgear unit in the northeast corner of the solar farm site, it is proposed to run an underground cable out of the solar farm site and along Braemar Rd to avoid the central wetland. It is acknowledged that this will require approval from Mackenzie District Council's (MDC's) Roading Department.

2.4 Buildings

2.4.1 Permanent Structures

It is proposed to install inverters in weather resistant housings on a single ISO 20' or 40' container skid (2.5 m wide x 2-3 m in height x 7-8 m in length) sitting on a reinforced concrete slab. It is expected that in Phase 1 there will be approximately two of these, with a further 15 (approximately) being required for Phase 2.

Figure 3: Photograph of HEMK MV skid gen 3 (source: Infratec).

The MV Export switchgear and storage facility is typically a prefabricated building the size of a two 40' containers side-by-side, i.e. approx. 5 m in width x 12 m in length, which sit on a reinforced concrete slab. This will be located near the connection points to the local network, as shown on the solar farm site Plan attached in Figure 1.

Figure 4: Photograph of MV Export switchgear and storage facility (source: Infratec).

A permanent site storage facility comprising a 20 ft or 40 ft container or kit set building may also be installed on-site to provide simple office facilities, storage and welfare facilities.

Overall, permanent site coverage will be approximately 41% (48.5 ha).

2.4.2 Temporary Structures

During the construction of Phase 1, a temporary site office will be established in a converted shipping container or similar, as well as temporary amenities for staff such as self-contained toilets and a break area. These will be located in a temporary laydown area that will be located close to the entrance to the solar farm site as identified in light blue on the solar farm site Plan in Figure 1.

During construction there will 15-20 40 ft shipping containers in the temporary laydown area, for receiving stock of piles, framing, PV modules and cable.

These buildings / containers will be removed after the completion of Phase 1 and solar modules erected within the laydown area.

This process will be repeated for Phase 2. The laydown area for Phase 2 is identified on the solar farm site Plan in Figure 1.

2.4.3 Fencing

Phase 1 will be surrounded by a 2.4 m tall chain-link fence throughout its construction and operation. This will be extended around the entire Site when Phase 2 is constructed. The fence will be located within the solar farm site and screened by the existing shelterbelts.

All the wetland areas will be fenced as shown on the solar farm site Plan in Figure 1 as part of Phase 1 with a stock and rabbit-proof fence, which will be setback at least 20 m from the edge of the wetlands. An initial rabbit and hare knock-down (and follow-up surveillance / control) will be employed following site establishment, to eliminate and exclude rabbits and hares from the wetland and setback areas.

2.5 Three Waters

It is intended to truck potable water to the solar farm site to meet drinking water demands for construction workers and staff as required. An above ground water tank with a capacity of up to 5,000 L will be constructed during Phase 1 and situated adjacent to the solar farm site Office to provide drinking water and service the ablutions. The water tank will be filled with potable water offsite and trucked to the solar farm site as required.

The temporary site office and staffroom will be self-contained having a surface effluent tank (2,700 L capacity) that will be emptied as required, via a truck that will take sewerage offsite to be disposed of appropriately at an authorised facility.

Stormwater runoff from the proposed buildings and structures will be discharged to ground as there is no reticulated stormwater system in this area. The proposed internal tracks will be constructed using shingle only and there will be central drainage swales that will be permeable allowing stormwater drainage from the internal tracks direct to ground. Furthermore, the Applicant proposes to prepare a Stormwater Management Plan.

2.6 Earthworks

The proposal (Phase 1 and 2) will require a total volume of 13,074 m^3 of earthworks over a total area of 27,372 m^2 (2.74 ha or 2.4% of the solar farm site) to:

- Provide a flat platform for structures, parking for 9 cars and the laydown areas;
- Create foundations for the solar array framework;
- Create internal roads;
- Undertake minor levelling works within the array area; and
- Create trenches or reticulation of DC and AC cables between modules, inverters, transformers and to the grid connection. These will be backfilled once work is complete and allowed to revegetate.

Earthworks will be setback at least 20 m from the wetlands on the solar farm site. A swale drain will also be created along each of the access tracks as noted above. Given this, a Sediment and Erosion Control Plan will be prepared to manage the effects of earthworks during the construction phases.

2.7 Vegetation Clearance

It is understood that the area of vegetation that will need to be cleared during Phases 1 and 2 is minimal given that the modules will sit above the ground and because piles are driven into the ground. Vegetation clearance associated with construction activities such as earthworks (not shading) will be approximately 1.3 ha (c.1.3% of the solar farm site).

It is not proposed to undertake vegetation clearance, earthworks or construct modules within 20 m of the wetlands on the solar farm site. However, it is proposed to remove several existing crack willow trees and surveillance for (and elimination of) several key weed species will occur within wetland / setback areas (Russell lupin, scotch broom, gorse, lotus, sweet briar, and all exotic trees e.g., willow, conifer, poplar and birch species).

2.8 Vehicle Crossings, Tracks and Hardstanding

There are two vehicle crossings to the solar farm site that will be retained as shown on the solar farm site Plan in Figure 1. It is proposed to establish a further four vehicle crossings that will provide direct access from Braemar Rd to four internal tracks thus minimising the need for tracks and associated vegetation clearance and earthworks within the solar farm site. The vehicle accesses will be formed to MDC standards.

Four permanent gravel tracks will be constructed in a north / south direction across the solar farm site to provide for the construction of the array and access by staff for on-going maintenance. Aggregate will also be needed to create hardstanding in the laydown areas, and concrete may be required to create foundations for the inverters and fencing.

2.9 33kV Overhead Power Line

The project will require two new connections to the existing 33kV electricity network. Two underground lines, cumulatively 350 m in length, are proposed to connect the solar farm site to the existing Alpine Energy 33 kV network at Braemar Rd. One will be associated with Phase 1 and located at the southern end of the solar farm site and the other with Phase 2 and located at the northern end of the solar farm site.

2.10 Primary Production

The solar farm site will continue to be used for pastoral activities, likely grazing sheep, as sheep can walk under and amongst the modules without damaging them, but all cattle grazing will cease. All grazing would be fully excluded from a 10.5 ha ‘central wetland’ area (which includes a ≥20 m setback of existing dry pasture / short tussockland) and from two other ‘southwest wetlands’ (4.0 ha in total) in the southwest corner of the solar farm site (including dryland setback as above), by means of an internal stock and rabbit-proof fence. This means c.14.5 ha of the c.111[1] ha site that is currently grazed by cattle would no longer be grazed at all. Aerial over sowing and top-dressing will cease in the wetlands and setback areas but may continue in other areas of the solar farm site. The land use changes described above will commence as part of Phase 1.

Once Phase 2 construction commences, the solar farm site may be fertilised, with machinery being able to access between the rows of modules, although a hand or more manual approach may be required to fertiliser under the Modules. However, fertiliser may not be required at all, depending on the rate of growth achieved when the land is sheltered from the worst of the Mackenzie weather.

[1] Depending on whether the existing farm fence or proposed outer security fence is used as the boundary, site size numbers (including, therefore, the size of Phase 1 and Phase 2) may vary slightly between this sections of this assessment, and between this and other reports.

2.11 Project Shaping

2.11.1 Site Layout

The terrestrial vegetation and habitat surveys (see Section 3.3) were carried out based on a draft solar farm footprint. Following completion of the survey, the field data was analysed, and the terrestrial plant communities were mapped during a project shaping process. In this process, advice was provided by Boffa Miskell to Infratec that:

- Provided recommendations to change the draft solar farm layout, and recommendations regarding the locations, extents, and methods for cable laying, to avoid or minimise effects on important terrestrial ecological values (particularly wetlands).
- Identified the location of wetland areas and provided options for construction setbacks from wetlands to avoid adverse effects and in relation to planning rules. Specifically, wetland setback distances were discussed by Infratec, Lake Tekapō Enterprises and Boffa Miskell, and a minimum 20 m construction setback was agreed. This setback distance strikes a balance between the need to:
    - Avoid any possible hydrological effects on wetlands (we do not foresee that the piling works to install solar arrays could have any effect on adjacent wetland water supply and hydrology; but out of an abundance of caution advised the application of at least some setback);
    - Maintaining an economically viable solar farm size: 50 or 100 m setbacks were considered, but would reduce the potential build area of the solar farm site by c.7-28 ha respectively, for no benefit to the specific wetlands; and
    - Providing an ecologically meaningful area of dryland habitat to buffer wetland areas and act as an ecological enhancement / on-site mitigation area for any potential adverse effects of the solar farm to vegetation or habitat.

What this means is that within the solar farm site, fences would be erected at least 20 m (however, the setback is generally c.40 m on the eastern edge of the central wetland) from the wetland boundaries (as determined following the methodology outlined in Section 3.4), and the combined wetland and setback areas (see Figure 1) would be excluded from solar farm development, retired from grazing and allowed to regenerate.

2.11.2 Site Management

Other site management changes have been proposed by the applicant or accepted by recommendation from Boffa Miskell.

- As described in Section 2.10 above, the existing grazing regime at the solar farm site is proposed to be altered as part of the solar farm proposal.
    - Existing cattle grazing[2] would cease, and subsequent grazing would be by sheep only. This would take effect on construction of phase one (proposed by applicant).

[2] Currently, a fence divides the overall ‘Irishman Paddocks’ site roughly in half (into two paddocks known as ‘Cattle Yard’ and ‘Tom’s’), but both halves are used predominantly for cattle or else for sheep grazing at various times of the

- Aerial over sowing and top-dressing would cease in wetlands and setback areas but may continue in other areas of the solar farm site (agreed by applicant and Boffa Miskell).
- As outlined in Section 2.11.1 above, all grazing would be fully excluded from the ‘central wetland’ area (which includes a ≥20 m setback of existing dry pasture / short tussockland) and from two other ‘southwest wetlands’ at the southwest of the solar farm site (including dryland setback as above), by means of an internal stock fence (accepted by applicant on recommendation from Boffa Miskell). Practically, this means c.14.5 ha of the c.111[1] ha site that is currently grazed by cattle would no longer be grazed at all, and across the balance of the solar farm site (c.95 ha[1]) grazing would shift from cattle to sheep.
- Fencing and stock retirement from all wetland and setback areas (i.e., both the central and southwest wetlands) would be implemented on construction of Phase 1, even though the central wetland is not in the Phase 1 area (accepted by applicant on recommendation from Boffa Miskell).

year, including in winter when the solar farm site is used for feeding out. Typically, the solar farm site is grazed for two weeks and then spelled for around two months (A. Simpson, *pers. comm*. 2021).

3.0 Methods

This EcIA report has been based on ecological field survey and desktop investigation methods, as follows:

3.1 Definitions and Naming Conventions

The terms used to refer to the project locations and activities follow the Environment Institute of Australia and New Zealand's (EIANZ) EcIA guidelines (Roper-Lindsay et al. 2018). Key terms are:

- The 'solar farm site' (the zone of influence), which refers to all land, water bodies, and receiving environments that the project could potentially affect. It includes the proposed future solar farm footprint and any environments beyond the solar farm footprint where 'indirect effects' may extend.
- The 'solar farm footprint', which encompasses the maximum extent of all works associated with the solar farm, both permanent and temporary, and therefore defines the limit of direct effects on the solar farm site's ecology.

Where possible, common names for plants and animals have been used in this report. Where a species does not have a common name, or its common name cannot be used to identify the species without ambiguity, scientific names have been used.

3.2 Desktop Review

3.2.1 Terrestrial Ecology Values

Desktop information on terrestrial ecology values (indigenous vegetation, habitats of terrestrial fauna and terrestrial species) likely to occupy habitats within and adjacent to the proposed solar farm footprint were gathered from the following sources:

- Aerial imagery, including high-resolution orthorectified UAV imagery and terrain modelling obtained for the solar farm site in November 2021, and oblique aerial images obtained by UAV on 28 July 2021;
- GIS (Geographic Information System) databases including:
    - Topographical (Topo50) data (Land Information New Zealand);
    - Threatened Environment Classification (Walker et al. 2015);
    - Ecological region and ecological district GIS layers;
    - Environment Canterbury 'Canterbury Wetlands' and 'Canterbury Regional Wetlands' GIS layer (no longer publicly available, downloaded May 2019); and
    - Department of Conservation (DOC) 'Recommended Areas for Protection' GIS layer.

- Ecological databases including DOC Herpetofauna database[3] records; and bird records for the general area on the New Zealand Bird Atlas[4];
- Balmoral Station's Integrated Farm Management Plan (Balmoral Station 2020).

3.2.2 Ecological Effects of Solar Farms

Desktop information on the general ecological effects of solar farms, such as those induced by light reflection and micro-climatic changes were obtained from international peer-reviewed studies and 'grey literature' reports.

- Key references included:
    - Armstrong et al. (2016). Solar park microclimate and vegetation management effects on grassland carbon cycling. *Environmental Research Letters* 11.
    - Bennun et al. (2021). *Mitigating biodiversity impacts associated with solar and wind energy development. Guidelines for project developers*. Gland, Switzerland: IUCN and Cambridge, UK: The Biodiversity Consultancy.

In addition, a range of studies that have investigated the effects of site management on indigenous habitats in the Mackenzie Basin (studies into shading of short-tussock grassland, and grazing regimes) were reviewed.

- Key references included:
    - Norton and Young (2016). Effect of artificial shade and grazing removal on degraded grasslands: Implications of woody restoration for herbaceous vegetation. *Ecological Management & Restoration* 17 (2). doi: 10.1111/emr.12205
    - Walker et al. (2016). Hawkweed invasion does not prevent indigenous non-forest vegetation recovery following grazing removal. *New Zealand Journal of Ecology* 40 (1). doi: 10.20417/nzjecol.40.16

3.3 Site Investigations

Preliminary site observations were made by Dr Jaz Morris (Ecologist, Boffa Miskell) during very brief visits to the solar farm site on 5 May 2021 and again on 28 July 2021 during discussions about the project with MDC. Due to the time of year of these visits, most vegetation had died off, and only basic site notes were recorded. On 28 July 2021, oblique aerial images of the solar farm site were obtained by use of a UAV, which later assisted in determining the extent of seasonally wet areas at the solar farm site.

Alex Gault and Matt Turner (Ecologists, Boffa Miskell[5]) visited the solar farm site on 4 and 5 November 2021 to undertake a lizard survey and set tracking tunnels to determine the presence of lizards. Michael McMillan (Aoraki Environmental Consultancy) attended as an iwi observer.

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[3] Lizard records within 20 km of the nearby 'Site A' were obtained in March 2021 from DOC. As Site A is located c.3 km from the proposed solar farm site assessed in this report, the same records are considered sufficiently relevant.

[4] NZ Bird Atlas grid square: DC30 - New Zealand Bird Atlas (ebird.org) – accessed 3 December 2021.

[5] Ms Gault is no longer employed by Boffa Miskell.

Jaz Morris visited the proposed solar farm site on 18 and 19 November to undertake a detailed survey of terrestrial and wetland vegetation / habitats, including plot measurements as described below. During this survey Cara-Lisa Schloots (Research Assistant, University of Otago Botany Department) assisted in a voluntary capacity, and her help is gratefully acknowledged. Michael McMillan (Aoraki Environmental Consultancy) also attended as an iwi observer, and his assistance and knowledge of the area is also gratefully acknowledged.

Jaz Morris made a brief follow up visit to the 'southwest wetlands' area on 9 December 2021.

Matt Turner visited the solar farm site on 14-18 February 2022 to undertake a second lizard survey using pitfall traps and visual / manual searches to determine what species occupy the solar farm site and the extent of lizard distribution throughout the solar farm site. Dr Mandy Tocher (LizardExpertNZ) supervised the lizard survey on site on 14-16 February 2022.

Field assessments and surveys were carried out as described below.

3.3.1 Terrestrial and Wetland Vegetation / Habitats

A walking survey of the vegetation and habitats was conducted within the proposed solar farm site. During the vegetation surveys:

- The plant communities at the solar farm site were classified using the classification system and naming conventions developed by Atkinson (1985). A handheld Garmin Global Positioning System (GPS) was also used to mark plant community boundaries were necessary.
- Plant species, and their cover (using the 'DAFOR' scale) was recorded in each of the plant communities (a list of the plant species recorded during the solar farm site visit is provided in Appendix 1, Table 1).
- General notes were made on the condition of the plant communities and habitats present.

In addition to the walking survey, fourteen 10 x 10 m temporary vegetation plots were measured within areas of the solar farm site proposed to be developed (i.e., not within wetlands). Within each plot, the cover (Braun-Blanquet cover classes from 1-6) of all plant species, bare soil, litter, dung and rock was recorded in each of the three broad plant communities[6] listed below:

a) Fescue tussock / browntop / mouse-ear hawkweed grassland (east of site, n = 2; west of site, *n* = 7; overall *n* = 9);

b) Mouse-ear hawkweed herbfield (east of site, *n* = 3); and

c) (Copper tussock) / sweet vernal grassland (east of site, *n* = 2).

Plot data is provided in Appendix 1, Table 2, and plot locations and a vegetation map are provided in Appendix 2.

[6] These three vegetation types are overall aggregates. The specific vegetation type within each plot is presented in the plot data in Appendix 2.

3.3.2 Lizards

Lizard surveys were carried out in two separate visits in November 2021[7] and February 2022[8].

During the first lizard survey (November 2021) by Matt Turner and Alex Gault:

- A walk-through survey was carried out over the solar farm site, with visual searches undertaken in possible lizard habitat, such as dense tussocks and near slash piles of felled trees. Binoculars were used to scan ahead before approaching potential habitat. Conditions were ideal for lizard activity, with temperatures between 12 and 17°C and little to no wind. The survey also included hand-searching habitat including overturning logs and lifting any possible cover objects.
- Passive detection methods[9] (baited tracking tunnels) were used across the solar farm site in different habitat types, including within fescue tussock and copper tussock areas, and in the adjacent pine shelter belts. Eight lines of tracking tunnels were set, with each line consisting of ten tunnels placed at 5 m spacings. One tracking tunnel line was placed in each aspect of the shelter belts surrounding the solar farm site (i.e., four tracking tunnel lines were set in the shelter belts). Additional tracking lines were set within different habitat types within the solar farm site, including two each within fescue tussock and copper tussock areas (the latter were adjacent to piles of felled trees). Tracking cards were placed in the tunnels at the time of setting the tunnels and were retrieved on 12 November (after 8 days). While tracking tunnels were deployed, weather conditions were favourable for lizard activity (see Appendix 3); weather remained fine with no precipitation, generally moderately warm conditions, and little wind.

During the second lizard survey (February 2022) by Matt Turner and Dr Mandy Tocher:

- Manual and visual searches were also carried out in specific areas where lizards were likely to occur, including around slash piles, under cover objects and within dense tussocks and rock piles. Visual searches were carried out around slash piles and in the central wetland area. A walk-through search of the main paddock was also undertaken to detect any basking / foraging skinks.
- Pitfall traps[10] (baited) were placed throughout the site where tracking tunnel detections of lizards had occurred (see map, Appendix 4), and in suitable lizard habitat including near slash piles, on the edges of the central wetland area, and within fescue tussock and

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[7] Lizard tracking tunnel surveys and hand / visual searches (November 2021) were undertaken under a Wildlife Act Authority (WAA, permit number 81898-FAU) from DOC held by Katherine Muchna, who provided advice and oversight for survey methods used on this site. WAA 81898-FAU allows for lizard surveys (including disturbance and handling of lizards) to be undertaken by people under Katherine's supervision in the Canterbury region, and confirmation that Matthew Turner was permitted to survey under this WAA was received in writing from the Manahuna / Twizel DOC office on 2 November 2021. Matthew Turner has a separate (pending) application for a WAA to independently undertake similar surveys, but this was not available at the time of survey.

[8] Lizard pitfall trap surveys and hand / visual searches (February 2022) were undertaken under a Wildlife Act Authority (WAA, permit number 96063-FAU) from DOC held by Dr Mandy Tocher (LizardExpertNZ), who was present on site and provided supervision. WAA 96063-FAU allows for lizard surveys (including disturbance and handling of lizards) to be undertaken in the Canterbury region. Katherine Muchna also remotely supervised the survey as required.

[9] Prior to undertaking site survey work, it was considered uncertain (based on site photographs and the existing land use) that lizards would inhabit the solar farm site, and that, if present, any lizards present would likely be at a low population density that might not be detectable using visual and hand search methods.

[10] This was undertaken to resolve which skink species are present at the solar farm site, and to obtain information about likely population density (these matters cannot be determined using tracking tunnels).

copper tussock areas. Twelve trap lines consisted of five pitfall traps placed at 5 m spacings. Three trap lines were set along the banks of the wetlands and an additional trap line was set within the wetland in areas of long grass. A single trap line was set in fescue tussock or patches of copper tussock on both the western and eastern paddock area. Six pitfall trap lines were placed around the edges of slash piles and in surrounding tussocks. Traps were left for four nights and were checked each morning and removed on 18 February 2022. Weather conditions during the survey period were mostly suitable for lizards to be active. Weather was generally fine and warm (see Appendix 3).

Locations of tracking tunnel and pitfall traps deployed at the solar farm site, and results (November and February respectively) are provided in Appendix 4.

3.3.3 Birds

A roaming inventory was compiled of all bird species seen and heard during both the first lizard survey and both botanical surveys, including species observed on the ground and overflying the solar farm site. At each vegetation plot site, the plot data recorder used the ample time available to scan and listen for bird species, but no formal bird count methods were employed.

3.3.4 Terrestrial Invertebrates

A roaming inventory was compiled of readily identifiable invertebrate species seen during the botanical field investigations. However, specific terrestrial invertebrate surveys were not undertaken as part of this assessment. This is because widespread clearance of the indigenous plant communities / habitats at the solar farm site is not proposed as part of solar farm construction; and the lack of highly intact or distinctive plant communities within the solar farm site mean that we consider it is unlikely that terrestrial invertebrates are present that would require specific impact management responses.

3.4 Plant Community and Lizard Habitat Mapping

The plant communities and lizard habitats within the solar farm site were mapped in ArcMap. Detailed UAV aerial imagery and topographic data collected from the solar farm site, and information collected during the solar farm site investigations (GIS waypoints and photographs) was used to map plant communities. GPS records of lizard sightings and capture locations were used to map lizard habitat.

3.5 Conservation Status

The conservation status of nationally Threatened and At Risk indigenous species used in this report are from the most current versions of their respective New Zealand Threat Classification System[11] status reports:

- Plants: de Lange et al. (2018);
- Birds: Robertson et al. (2021); and
- Reptiles: Hitchmough et al. (2021).

[11] https://nztcs.org.nz/

3.6 Assessing Ecological Significance

Section 6(c) of the RMA requires identification of sites of significant vegetation and significant habitats of indigenous fauna. The significance of terrestrial communities and habitats was assessed against the criteria in the Mackenzie District Plan, Plan Change 18 (PC18). PC18 criteria for significance are listed in Section 5.1. In addition, the solar farm site was assessed against the criteria for determining significant indigenous vegetation and significant habitat of indigenous biodiversity listed in Appendix 3 of the Canterbury Regional Policy Statement (CRPS) (Environment Canterbury 2013). Following CRPS Policy 9.3.1(3), areas or habitats are significant under the CRPS criteria if they meet one or more of the criteria in Appendix 3 of the CRPS.

3.7 Evaluation of Ecological Effects

To determine the level of ecological effects associated with the proposal, we have followed the Environmental Institute of Australia and New Zealand's (EIANZ) ecological impact assessment (EcIA) guidelines (Roper-Lindsay et al. 2018). In summary, the EcIA method requires assessments of:

- The values of communities, habitats / ecosystems and species (Table 1-Table 3);
- The magnitude of impact (Table 4); and
- The level of ecological effect based on a decision matrix of ecological effect and magnitude of impact (Table 5).

Table 1. Attributes to be considered when assigning ecological value or importance to a site or area of vegetation / habitat / community for terrestrial ecosystems (from Roper-Lindsay et al. 2018).

MATTERS	ATTRIBUTES TO BE CONSIDERED
Representativeness	Criteria for representative vegetation and aquatic habitats: - Typical structure and composition - Indigenous species dominate - Expected species and tiers are present - Thresholds may need to be lowered where all examples of a type are strongly modified Criteria for representative species and species assemblages: - Species assemblages that are typical of the habitat - Indigenous species that occur in most of the guilds expected for the habitat type
Rarity/distinctiveness	Criteria for rare/distinctive vegetation and habitats: - Naturally uncommon, or induced scarcity - Amount of habitat or vegetation remaining - Distinctive ecological features - National priority for protection Criteria for rare/distinctive species or species assemblages: - Habitat supporting nationally Threatened or At Risk species, or locally uncommon species - Regional or national distribution limits of species or communities - Unusual species or assemblages - Endemism
Diversity and pattern	- Level of natural diversity, abundance and distribution - Biodiversity reflecting underlying diversity

MATTERS	ATTRIBUTES TO BE CONSIDERED
	- Biogeographical considerations – pattern, complexity - Temporal considerations, considerations of lifecycles, daily or seasonal cycles of habitat availability and utilisation
Ecological context	- Site history, and local environmental conditions which have influenced the development of habitats and communities - The essential characteristics that determine an ecosystem's integrity, form, functioning, and resilience (from "intrinsic value" as defined in RMA) - Size, shape and buffering - Condition and sensitivity to change - Contribution of the solar farm site to ecological networks, linkages, pathways and the protection and exchange of genetic material - Species role in ecosystem functioning – high level, key species identification, habitat as proxy

Table 2. Criteria for assigning ecological value to species (Roper-Lindsay et al., 2018).

ECOLOGICAL VALUE	SPECIES CLASSIFICATION
Negligible	Exotic species, including pests, species having recreational value.
Low	Nationally and locally common indigenous species.
Moderate	Species listed as any other category of *At Risk* (Recovering, Relict, Naturally Uncommon) found in the 'zone of influence' (ZOI) either permanently or seasonally; or Locally (ED) uncommon or distinctive species.
High	Species listed as *At Risk – Declining* found in the ZOI either permanently or seasonally.
Very High	*Nationally Threatened* (Nationally Critical, Nationally Endangered, Nationally Vulnerable) species found in the ZOI either permanently or seasonally.

Table 3. Assigning overall value to areas (refer to Table 1 for the matters to be considered for terrestrial communities) (Roper-Lindsay et al., 2018).

VALUE	DESCRIPTION
Negligible	Area rates Very Low for three matters and Moderate, Low or Very Low for remainder.
Low	Area rates Low or Very Low for majority of assessment matters and Moderate for one. Limited ecological value other than as local habitat for tolerant native species.
Moderate	Area rates High for one matter, Moderate and Low for the remainder, or Area rates Moderate for two or more assessment matters Low or Very Low for the remainder Likely to be important at the level of the Ecological District.
High	Area rates High for two of the assessment matters, Moderate and Low for the remainder, or Area rates High for one of the assessment maters, Moderate for the remainder. Likely to be regionally important and recognised as such.
Very High	Area rates High for three or all of the four assessment matters. Likely to be nationally important and recognised as such.

Table 4. Criteria for describing magnitude of effect (Roper-Lindsay et al., 2018).

MAGNITUDE	DESCRIPTION
Very High	Total loss of, or very major alteration, to key elements/ features of the baseline conditions such that the post development character/ composition/ attributes will be fundamentally changed and may be lost from the solar farm site altogether; AND/OR Loss of a very high proportion of the known population or range of the element / feature.
High	Major loss or major alteration to key elements/ features of the existing baseline conditions such that the post-development character, composition and/or attributes will be fundamentally changed; AND/OR Loss of a high proportion of the known population or range of the element / feature.
Moderate	Loss or alteration to one or more key elements/features of the existing baseline conditions, such that post-development character, composition and/or attributes will be partially changed; AND/OR Loss of a moderate proportion of the known population or range of the element / feature.
Low	Minor shift away from baseline conditions. Change arising from the loss/alteration will be discernible, but underlying character, composition and/or attributes of the existing baseline condition will be similar to pre-development circumstances/patterns; AND/OR Having a minor effect on the known population or range of the element / feature.
Negligible	Very slight change from existing baseline condition. Change barely distinguishable, approximating to the “no change” situation; AND/OR Having a negligible effect on the known population or range of the element / feature.

Table 5. Criteria for describing the level of effect (Roper-Lindsay et al., 2018).

		ECOLOGICAL VALUE				
		Very High	High	Moderate	Low	Negligible
MAGNITUDE	Very High	Very High	Very High	High	Moderate	Low
	High	Very High	Very High	Moderate	Low	Very Low
	Moderate	High	High	Moderate	Low	Very Low
	Low	Moderate	Low	Low	Very Low	Very Low
	Negligible	Low	Very Low	Very Low	Very Low	Very Low
	Positive	Net Gain	Net Gain	Net Gain	Net Gain	Net Gain

The EIANZ EcIA guidelines (Roper-Lindsay et al. 2018) note that the level of effect can then be used as a guide to the extent and nature of the ecological management response required (including the need for biodiversity offsetting). For example:

- ‘**Very High**’ represents a level of effect that is unlikely to be acceptable on ecological grounds alone (even with compensation proposals). Activities having very high adverse effects should be avoided.
- ‘**High**’ and ‘**Moderate**’ represents a level of effect that requires careful assessment and analysis of the individual case. Such an effect could be managed through avoidance, design, or extensive offset or compensation actions.
- ‘**Low**’ and ‘**Very Low**’ should not normally be of concern, although normal design, construction and operational care should be exercised to minimise adverse effects. If effects are assessed taking impact management measures developed during project shaping into consideration, then it is essential that prescribed impact management is carried out to ensure low or very low-level effects.
- ‘**Very Low**’ level effects can generally be classed as ‘not more than minor’ effects.

3.8 Consultation and Engagement

The AEE contains a full description of the consultation and iwi engagement undertaken to date.

3.8.1 Mackenzie District Council

The Applicant has actively engaged with MDC and its experts on this proposal to ensure that it is a feasible proposition and the potential and adverse effects are being addressed in an appropriate manner.

Meetings were held with parties representing both MDC and Aoraki Environmental Consultancy Limited (AECL) on 28th July 2021 and 26th January 2022 (the January 2022 meeting did not address ecological matters). Two phone conversations were held with MDC's ecologist regarding ecological field assessment requirements prior to the drafting of this report, but the conclusions of this report have not been discussed with MDC to date.

3.8.2 Iwi Engagement

Te Rūnanga o Arowhenua hold mana whenua over the solar farm site. Initially the Applicant engaged with both Te Rūnanga o Arowhenua and Te Rūnanga o Waihao but was advised that Aoraki Environmental Consultancy Limited (AECL) would essentially represent both rūnanga.

AECL has been part of the journey in progressing the proposal. As described in Section 3.3, Mike McMillian was also on-site when the botanical survey and initial lizard survey were undertaken, but unfortunately, no-one from AECL was able to attend the second lizard survey as a result of availability constraints due to COVID-19 pandemic (red light setting) restrictions.

However, a copy of the draft application and technical reports were provided to AECL on 16 March 2022, so they could digest these prior to a hui on 30 March 2022 and a further hui to discuss volunteered consent conditions on 26 April 2022. Engagement with iwi has been a key part of the process and the hui provided an opportunity to discuss the proposal and for iwi to provide comments and / or recommendations on the application.

3.9 Limitations

To date, no similar large-scale solar farm has been constructed in the country, and other existing / proposed solar farms in New Zealand of which we are aware are (or will be) located in quite different environments (i.e., lowland areas influenced by mild maritime weather patterns, rather than a dry inland basin). This means that there have been no opportunities to monitor or research the effects of any very similar project, particularly in terms of their effects to vegetation. Further, the effects of different site management practices are frequently subtle and difficult to detect in the sorts of dryland vegetation (e.g., Walker et al. 2019) that would have naturally occurred at the proposed solar farm site prior to pastoral modification. This means that the likely effects of solar panels on New Zealand dryland vegetation (including long-term effects) are presently unknown. Therefore, as described in Section 3.2.2, this assessment has considered findings from research conducted in nearby similar habitats for different purposes (e.g., Norton and Young 2016, which generally tested the effects of shade on dryland vegetation, rather than the effects of solar panel arrays), or solar farm studies conducted in dissimilar habitats overseas (e.g., Armstrong et al. 2016).

4.0 Existing Ecological Environment

4.1 Ecological Context

The solar farm site is within the Tekapō Ecological District (ED) in the Mackenzie Ecological Region, in the inter-montane Mackenzie Basin. The original vegetation of the Tekapō ED was strongly influenced by recent glaciation, a harsh inter-montane basin climate and infrequent natural fires. It is unlikely that forest was present, except perhaps for areas of low stature mountain toatoa-bog pine forest on moraines and mountain totara forest on lower range slopes (McGlone 2001). The district was probably dominated by short tussockland, tall tussockland (including copper tussockland), mountain toatoa – bog pine scrub and matagouri – *Coprosma* spp. scrub (Espie et al. 1984). Within the Tekapō ED, areas of wetland were probably relatively extensive along the numerous small rivers and lake margins (Harding 2009).

The existing (present day) vegetation reflects modification following human settlement. Following human settlement, particularly European pastoralism, the extent of scrub / low forest and tall tussock communities has been reduced, and the extent of short tussockland has increased as a result of an increased frequency of fire. Existing short tussock grasslands have been degraded by years of grazing by sheep and rabbits, and the introduction and spread of exotic plants (particularly grasses and mouse-ear hawkweed). Relatively extensive areas of copper tussock are still present in the Tekapō ED, although much of it has been modified. Sparsely vegetated cushionfield, herbfield, and short tussock grassland communities are present on shallow soils on outwash plains, and specialised turfland communities occur in the numerous kettlehole wetlands that occupy moraine hollows (Harding 2009).

In terms of the Threatened Environment Classification[12], the solar farm site is divided roughly in half: the eastern end of the solar farm site is within a land environment (E4.1a), where 10-20% indigenous vegetation remains nationally; and the western end of the solar farm site is within land environments (J2.2a and K2.1a), where 20-30% indigenous vegetation remains nationally (Walker et al. 2015).

Geologically, the solar farm site comprises mid-late Pleistocene age fluvioglacial deposits of generally slightly to moderately weathered gravels, sands, silts and clays, and scarce erratic boulders almost fully embedded in the soils. The east of the solar farm site (east of the central wetland area) is comprised of old, subdued moraines from the Wolds formation (mid-Pleistocene glacier deposits) with a slightly undulating land surface and a small number of hummocky / conical moraines. The west of the solar farm site occurs on a slightly more recent alluvial landform (late-Pleistocene river deposits) and shows some patterned fluve / interfluve surfaces reflecting variable soil depth. A small portion of the southwestern boundary of the solar farm site includes mid-Pleistocene outwash deposits (Balmoral formation), but this portion of the solar farm site features a generally uniform land surface with little evidence of typical outwash fluve / interfluve patterning (based on site observations).

The solar farm site is located at 820-840 m elevation with a semi-continental climate, meaning hot and dry summers and cold frosty winters and snow on the ground at times. The solar farm site is also very windy. A nearby NIWA climate station at Tekapo Airport (data from 2004-2021) is likely to reflect the conditions at the solar farm site. Mean annual rainfall is c.570 mm, with

[12] The Threatened Environment Classification is a combination of three national databases: Land Environments of New Zealand, Land Cover Database (Version 2) and the Protected Areas Network. The Threatened Environment Classification shows how much indigenous vegetation remains within land environments, how much is legally protected, and how the past vegetation loss and legal protection are distributed across New Zealand's landscape.

little variation in monthly mean (c. 30-50 mm). Mean annual temperature is 9.1°C, with a summer mean maximum (day-time, January) temperature of 22.5°C and a winter mean minimum (night-time, July) temperature of -2.5 °C. Negative temperatures have been recorded in all months (but not in all months in all years). Mean annual windspeeds are 3.7 m/s and are highest in spring – early summer (October-January).

As described in Section 2.11, the solar farm site is presently used for low-intensity sheep and beef grazing. There is a small area of beehives in the northwest of the solar farm site. Surrounding land uses are military training (on a very large expanse of outwash and moraine environments north of Braemar Rd towards the Gamack Range; intensively cultivated paddocks (Balmoral Station) immediately south of the solar farm site, and low-intensity grazing on other surrounding areas of Balmoral Station to the east and west. Several moderate to large-sized wetlands occur in the area, with one at the northern toe of the Old Man Range (south of the solar farm site), to the east (Metties Well area and Forks Stream wetlands), and a smaller wetland between Irishman Creek and the western edge of the solar farm site. A very high proportion of the Tekapō ED remains in tussockland similar to what occurs presently at the solar farm site, but much of this habitat (including at the solar farm site) has been modified to varying degrees by pastoral use. In 2009, 62% of the ED had this land cover (Harding 2009), and although this has diminished substantially with some recent highly intensive land use changes, this habitat likely still covers most of the ED.

4.2 Terrestrial Ecosystems and Habitats

4.2.1 Dryland Habitats

Broadly, the vegetation types within the solar farm site represent a small range of plant communities that have been subject to a moderate and at times high degree of ongoing modification, but indigenous species typical of the area remain because the original vegetation has never been fully cleared (e.g., by irrigation or mechanical means). All vegetation types within the solar farm site are listed in Table 6 below. Three vegetation types are present within the proposed solar farm footprint:

a) Fescue tussock / browntop / mouse-ear hawkweed grassland;

b) (Copper tussock) / sweet vernal grassland; and

c) Mouse-ear hawkweed herbfield.

An overall species list for these three vegetation types is provided in Table 1 in Appendix 1; plot data is provided in Table 2 in Appendix 1; the location and extent of all vegetation types within the solar farm site is shown in Appendix 3, and photographs are provided in Figure 5-Figure 13 and Appendix 5.

The principal difference between these vegetation types is the absence of fescue tussock on drier / slightly elevated areas, and the presence of copper tussock in places that likely have deeper soils or somewhat higher moisture levels[13]. Otherwise, these three vegetation types are generally quite uniform in terms of species composition. This likely reflects the treatment of the paddock as a whole in terms of prior modification (over-sowing and top-dressing, direct drilling) and ongoing cattle and sheep grazing. They are hereafter described in aggregate as the '**main**

[13] While copper tussock and other red tussock subspecies are often associated with wetlands, the copper tussock area of the main paddock is clearly dryland habitat and does not support any wetland plant species.

paddock' or **'main paddock[14] area**,' but important differences between the three vegetation types that make up the main paddock are noted below.

Table 6. Vegetation types within the solar farm site and their locations, described using the classification system of Atkinson (1985). A '' denotes exotic species.*

Vegetation type	Locations at site
Fescue tussock / browntop* / mouse-ear hawkweed* grassland	Main paddock: majority (c.95% of solar farm site excluding wetlands)
(Copper tussock) / sweet vernal* grassland	Main paddock: northeast of site near Braemar Rd (c.2% of solar farm site excluding wetlands)
Mouse-ear hawkweed* herbfield	Main paddock: elevated moraine hummocks, terrace riser near central wetland (c.3% of solar farm site excluding wetlands)
(Soft rush* – bog rush) / exotic grass* – jointed rush* grassland	Central wetland area
[Oval sedge* – soft rush*] / (kneed foxtail*) – browntop* grassland / mudfield	Southwest wetland areas

4.2.1.1 Main Paddock Area

Broadly, the main paddock area's vegetation is a grassland with frequent-abundant fescue tussock among exotic grass species (frequent-abundant browntop and sweet vernal), occasional clover species (white clover and alsike clover, which was direct drilled some years ago) and frequent - abundant mouse-ear hawkweed (Figure 5). Broadly, fescue tussock cover is consistently frequent – abundant in the eastern half of the solar farm site and the southern portion of the western half of the solar farm site, but is occasional – frequent in the northern half of the western end, likely reflecting boundaries in landform and underlying soil types.

Only relatively small areas (roughly 3 ha or 3%[15]) of the main paddock area lack fescue tussocks (or have very little fescue tussock cover; this vegetation type is a mouse-ear hawkweed herbfield and is located on moraine hummocks and along a terrace riser east of the central wetland). On hummocks, hawkweed cover is very high, but in terrace riser areas browntop grass is patchy and in places abundant. The area of copper tussock represents only a small fraction of the north-eastern half of the solar farm site (2.2 ha or 2.0% of the overall main paddock area, or 3.8% of the eastern half). A narrow margin (a few metres wide) of the solar farm site boundary adjacent to the shelterbelts also lacks fescue tussocks (perhaps due to influence of the trees, vehicle and stock tracking, and stock camping effects), but this area is mapped as part of the fescue tussock / browntop / mouse-ear hawkweed grassland.

In all areas of the main paddock, a low-moderate diversity of indigenous species typical of modified short-tussock grasslands is present, including NZ harebell, blue tussock, pātōtara, slender mountain daisy, a native daphne (*Pimelea oreophila*), mountain twitch (classified as At Risk – Declining), and juniper haircap moss. While these sorts of species are seldom more than occasional even in intact native systems, they were generally not more than rare (in terms of cover) at the solar farm site, due to the overall dominance of exotic grass, clover and hawkweed species. Other species present throughout the solar farm site, but present in very rare levels (generally much less than 1% cover) include Mueller's sedge, two native orchids (leek orchid

[14] The solar farm site is in fact currently divided in two for grazing purposes by a fence, but for simplicity the 'main paddock' means the entire area within the shelterbelts that is not identified as wetland in Appendix 2 (Figure A1).

[15] This is likely a slight underestimate, as only moderately sized or larger (>0.1 ha) continuous herbfield features could practically be mapped (see Figure A1 in Appendix 2).

and *Pterostylis tanypoda*, the latter is classified as At Risk - Declining), and red woodrush. Exotic species included king devil hawkweed (rare-occasional throughout); ripgut brome, sheeps sorrel, catsear and annuals including grassland forget-me-not and spring speedwell were generally rare in terms of cover but occurred throughout. Chewings fescue grass is frequent in places, especially on edges near shelterbelts and among copper tussocks.

The areas of mouse-ear hawkweed herbfield are clearly a drier and harsher habitat than the grassland areas, in that highly drought and disturbance tolerant species (e.g., haresfoot trefoil and non-vascular mosses and lichens) are relatively more important in terms of cover, and very few individuals of some specialist indigenous dryland species were present only in this area (pin cushion and Celadon mat daisy, both At Risk - Declining).

Copper tussock areas generally support a more vigorous growth of exotic grass and clover species, likely due to higher soil moisture. However, aside from the copper tussock itself, no plant species were distinctive to this vegetation type.

Plot data (Appendix 1, Table 2) shows that vascular vegetation cover in both grassland areas was almost total (c.92% on average) with very little cover of non-vascular species, bare ground or rocks (c.1% or less of each on average). Vegetation stature was low, with only copper tussock exceeding 1 m in height and with no shrubs higher than 30 cm. Cover of litter (feed-out detritus or dried tussock material) was c.3% on average and dung cover was c.3%. Herbfield areas consistently had much less vascular plant cover (76% on average), and relatively much higher non-vascular (6% on average), rock (c.3% on average), and bare ground (c.12% on average) cover. Cover of litter was slightly lower and dung cover was similar to grassland areas. Across the solar farm site, stock grazing was visibly heavy, particularly on highly palatable indigenous species like blue tussock, and the partial smothering of vegetation by cow pats and feed-out hay was noted especially near paddock access points along Braemar Rd.

4.2.1.2 Ecological Value of Main Paddock Area

The main paddock area, despite comprising three vegetation types, is assessed for ecological value in aggregate. If assessed individually, all three vegetation types would score the same.

- Representativeness: This area has been modified by historic direct drilling in the 1980s (Andrew Simpson, *pers. comm*. 2021), it is regularly oversown and top-dressed (OSTD, fertilising occurs roughly every 3-4 years), and ongoing stock grazing by sheep and cattle (including feeding out) occurs. The solar farm site is generally grazed for two weeks and spelled for up to two months. The cover of indigenous fescue tussock and copper tussock is variable across the area, and dense in places, but the inter-tussock species are largely exotic grasses and herbs with only infrequent indigenous species. This vegetation is modified especially in terms of indigenous species richness and abundance, and the absence of highly palatable indigenous species and other typical short tussockland species. For example, as shown in plot data (Appendix 1, Table 2) mat daisies are extremely scarce, native dwarf broom and desert broom species are totally absent and, excepting very low-stature native daphne, shrubs are effectively absent. Exposed moraine hummocks (herbfield areas), while very limited in extent, supported very small numbers of two typical dryland taxa: pin cushion and Celadon mat daisy. Overall, the main paddock is not considered highly representative of intact short-tussock grassland systems, but essentially all short-tussock grasslands in the Mackenzie Basin have been altered to some degree. In this context, the main paddock area scores low – moderate for representativeness.
- Rarity and Distinctiveness: The main paddock area occurs generally on naturally uncommon landforms (glacial deposits; Williams et al. 2007), and in terms of the Threatened Environment Classification half the solar farm site contains a landform on

which less than 20% indigenous vegetation remains nationally, the balance of the solar farm site is relatively better represented and protected nationally. It provides habitat for very low numbers of a Threatened plant species (dryland sow thistle), and several At Risk species are present (while some are present as sparse individuals only, two are present throughout the solar farm site: *Pterostylis tanypoda* and mountain twitch). The area likely provides foraging habitat for mobile Threatened and At Risk indigenous bird species such as tarapirohe / black-fronted tern, pīhoihoi / New Zealand pipit and tōrea / South Island pied oystercatcher from time to time, but is not core habitat for these species. The nationally At Risk -Declining southern grass skink is present at this habitat in very low numbers, mostly in association with slash piles (an artificial habitat) and copper tussocks. All these species are widespread in the wider area and at the level of the ED. The solar farm site is not distinctive. It scores moderate to high for rarity / distinctiveness.

- Diversity and Pattern: Indigenous plants include occasional to frequent fescue tussock and copper tussock, but the diversity of indigenous inter-tussock plant taxa is low-moderate, reflecting historic and current land-use practices. The somewhat mixed cover of grassland and herbfield habitat is not considered to be an ecologically important or notable habitat pattern. It scores low-moderate for diversity and pattern.
- Ecological Context: This plant community's ecological integrity is low, and it does not play an important function in terms of ecological networks, linkages or pathways. The presence of tall shelterbelts around the solar farm site, the road, and adjacent highly modified pastures to the south reduces the physical connectivity of the solar farm site to indigenous habitats for indigenous flora and fauna species.
- In summary, we consider that the main paddock scores low-moderate for representativeness, moderate to high for rarity / distinctiveness, low-moderate for diversity and pattern, and low in terms of ecological context (see Table 1).
- Overall, the main paddock area has **Moderate** ecological value (see Table 3).

Figure 5. Main paddock area with fescue tussock / browntop / mouse-ear hawkweed grassland.

4.2.2 Wetland Habitats

Two other vegetation types occur in wetland areas at the centre and southwest of the solar farm site respectively:

- (Soft rush – bog rush) / exotic grass -jointed rush grassland; and
- [Oval sedge – soft rush] / (kneed foxtail) – browntop grassland / mudfield.

These wetland vegetation types are described broadly below, and partial species lists for these areas are provided in Appendix 1, Table 1. They are not within the proposed build footprint of the solar farm but are to be fenced and enhanced as part of the solar farm proposal.

The location and extent of these wetlands within the solar farm site is shown in Appendix 2, and photographs are provided in Appendix 5 (Figures A11-A17).

4.2.2.1 Central Wetland Area

The 'central wetland' (Figure 7) is a palustrine marsh (some lower areas may be better characterised as swamp) and occurs in a roughly triangular area that grades from seasonally wet and faint channels and depressions to a narrower and likely year-round wet area where it discharges from the paddock boundary to the south. This wetland has formed in a meandering channel landform (see photos, Appendix 5) but even in wet conditions water movement is at best a slow seep; there appears to be no bed or sufficiently flowing / deep water to provide permanent stream habitat. The wetland's upper extent sits slightly below the Braemar Rd level (it is connected via culverts to Ministry of Defence land to the north) and is near the level of the main paddock in this area, but sits c.3 m beneath a steep terrace riser at the south end. It is largely a seasonally wet grassland dominated, especially in northern areas, by exotic grass species including browntop, creeping bent, and kneed foxtail. Exotic oval sedge and soft rush are occasional to frequent throughout, and faint pools / depressions and seasonal seepage channels are generally dominated by exotic jointed rush. Indigenous bog rush forms large tussocks generally in southern areas, and channel edges and barer mud areas supported species including indigenous sharp spike sedge, waoriki (*Ranunculus* sp.), glossy plantain, *Gonocarpus micranthus*, *Isolepis* sp., a willowherb (*Epilobium angustum*, At Risk – Naturally Uncommon), and a sneezeweed species (likely *Centipeda minima* subsp. *minima*, Threatened – Nationally Endangered). Small numbers of grassland spaniard (At Risk – Declining) are present within the wetland and at its margins.

The central wetland has likely been somewhat modified hydrologically by historic construction of a ditch / drain (which is barely vegetated and was dry at the time of the survey) that appears to intercept overland flows in large rain events and divert them to the lowest-lying eastern end. Several large crack willow trees are present, and the wetland is accessible to stock and shows sign of stock tracking and grazing damage.

4.2.2.2 Ecological Value of Central Wetland Area

- Representativeness: This area is comprised of a gully system dividing a glacial deposit landform to the east and alluvial deposits to the west. It has been degraded by stock and indigenous wetland vegetation does not form a substantial component of the cover (except for bog rush in southern areas). Upper areas are dominated almost entirely by exotic grass, sedge, and rush species, and a ditch has been constructed to divert any surface water flows from beneath Braemar Rd to the eastern end of the wetland (rather than via natural flow paths). While a small number of indigenous plant and animal species are present, it is unlikely to support indigenous fauna assemblages typical of more natural wetlands of this size. It scores low-moderate for representativeness.

- Rarity and Distinctiveness: The central wetland is not considered distinct. However, wetland ecosystems have been reduced to less than 20% of their former extent at the regional and national scales and are a national priority for protection. Less than 1% of the ED supports wetland habitats (Harding 2009). It supports at least one Threatened wetland plant species (sneezeweed) and at least two At Risk species (grassland spaniard, on the wetland margins, and *Epilobum angustum*). The nationally At Risk - Declining southern grass skink is present in low numbers in the wetland habitat and immediate margins. It scores high for rarity and distinctiveness.
- Diversity and Pattern: This feature has a low to moderate level of diversity of wetland plant species for a feature of this size. Aside from the presence of two skink species and probable use by a small number of wetland birds, the wetland is to modified to support a high diversity of indigenous fauna. There is some variation between wetted channel and small bare mud areas. It scores low-moderate in terms of diversity and pattern.
- This seepage / wetted area is hydrologically connected to the wetland downstream but there does not appear to be substantial continuous wetland habitat upstream (beyond a culvert that crosses Braemar Rd). It is moderately buffered, does not provide good habitat for aquatic fauna. Despite the presence of an ecotone towards modified dryland habitat it is unlikely to have an important function in terms of an ecological linkage for either terrestrial or aquatic fauna. Shallow water and mud areas are very limited in extent and are unlikely to sustain indigenous wetland birds except possible for sporadic feeding when seasonally wet; other areas of wet grassland are likely too densely vegetated to be high quality bird feeding habitat. However, southern grass skink and McCann's skink were observed in connected wetlands to the south, and the central wetland may act as a corridor for skink movements in the area. It scores moderate for ecological context.
- Overall, this feature is of **Moderate** ecological value.

4.2.2.3 Southwest Wetland Areas

These two small areas are two small ephemerally or seasonally wet outlying arms of a larger wetland system beyond the shelterbelt to the west. 1950s aerial imagery shows small areas of patchy ephemeral wetland and / or marsh in this location. These palustrine areas could currently be categorised as either marsh or ephemeral wetlands (but lack the enclosed nature and vegetation zonation of true ephemeral wetlands). At the time of the survey, they were generally sparsely vegetated with large areas of bare mud and cattle / vehicle tracking (with bare mud especially at the northern site). The main vegetation cover was exotic grass. Kneed foxtail was frequent at the southern of the two wetlands, and was occasional at the northern site and browntop was frequent at the southern area and on muddy margins at both areas. Occasional exotic soft rush and oval sedge were scattered at both sites and provide a clear indication of the seasonally wet nature of these areas. The only indigenous plant species recorded were a very small number of sharp spike sedge, rautahi (*Carex coriacea*), and Māori dock at the southern site; these species are further indicative of and / or common in wetland habitats.

4.2.2.4 Ecological Value of Southwest Wetland Areas

- Representativeness: These two small areas are two outlying arms that form a highly degraded upper extent of an ephemerally or seasonally wet wetland system that is present beyond a shelterbelt to the west. They have been damaged by stock and vehicle tracking and indigenous wetland vegetation is almost absent. They score very low for representativeness.

- Rarity and Distinctiveness: Wetland ecosystems have been reduced to less than 20% of their former extent at the regional and national scales and are a national priority for protection. These areas are not distinct but would be score high for this matter if they supported assemblages of indigenous wetland species. However, the sparse plant species present are almost entirely exotic wetland weeds. Hence, they score moderate for rarity / distinctiveness.
- Diversity and Pattern: These features have a very low level diversity of indigenous wetland plant species and are expected to support a low diversity of indigenous fauna. They score very low in terms of diversity and pattern.
- Ecological Context: These wetted areas are hydrologically connected to the wetland to the west, forming its upper extent. In this sense they form an ecotone towards the modified dryland habitat of the main paddock area, but because they are more degraded than the western area (which has a reasonable cover of indigenous wetland species) they are unlikely to have an important function in terms of ecological linkages for either terrestrial or aquatic fauna. They score low in terms of ecological context.
- Overall, these features are of **Low** ecological value.

4.2.3 Threatened, At Risk Plants or Locally Uncommon Plants, and Ecological Value

The At Risk - Declining species mountain twitch and a native orchid (*Pterostylis tanypoda*) were present throughout the main paddock area.

Two individual dryland sow thistle (Threatened – Nationally Vulnerable) plants were recorded at the solar farm site (Figure 6; both in areas of fescue tussock grassland). Further At Risk – Declining species found in very small numbers in the main paddock area include a small number of individual matagouri (grazed seedlings only), an orchid identified in the field as *Pterostylis tristis* (a cryptic orchid species very similar in appearance to *Pterostylis tanypoda*, one individual was observed in one plot), *Leucopogon nanum* (only a few small patches of this species were recorded in the main paddock, pin cushion (noted only on one distinctly elevated moraine hummock), and Celadon mat daisy (a handful of individuals were seen in herbfield areas on hummocks and on a terrace riser east of the central wetland).

Following the EIANZ EcIA method, a nationally Threatened species (dryland sow thistle) is of **Very High** ecological value. At Risk – Declining species are of **High** ecological value.

No species that are nationally Not Threatened but considered locally uncommon were recorded at the solar farm site. Threatened and At Risk wetland plant species incidentally observed in the central wetland area have been noted in Section 4.2.2 above, but are not discussed further.

Figure 6. Dryland sow thistle among typical main paddock vegetation with clover, mouse-ear hawkweed, mountain twitch, browntop and sweet vernal.

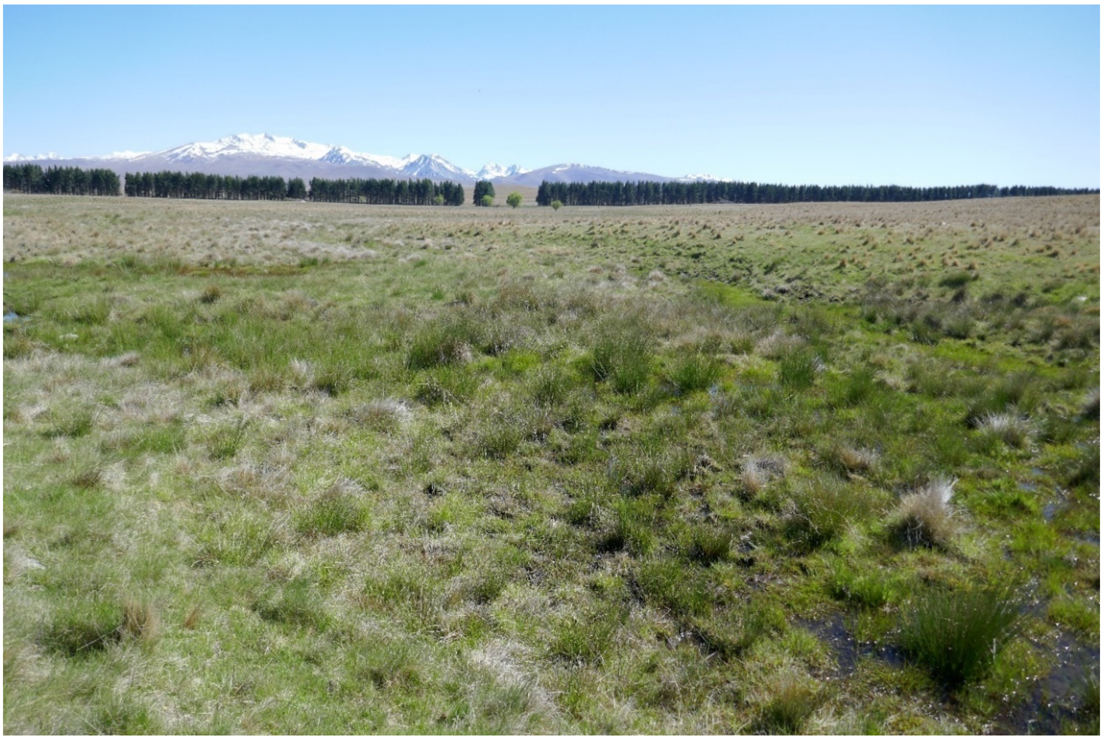

Figure 7. Central wetland area at the solar farm site.

Figure 8. Southwest wetland (mudfield) area. This area is only seasonally wet and the vegetation is sparse exotic grass, sedge, and rush species.

4.3 Birds

Very few bird species or individuals of those species were recorded during site investigations undertaken for this work. In the main, these were exotic passerines (finches), magpies, and skylarks. A list of the bird species recorded, or likely to occur within and adjacent to the solar farm site is provided in Table 7. Information on their conservation status is also included.

This list is derived from:

- Observations during all site investigations; and
- The bird species recorded within the four 10 x 10 km grid squares[16] of the OSNZ's Atlas of Bird Distribution in New Zealand (Robertson et al. 2007) that include and surround the solar farm site, and an assessment of the suitability of the habitat for these species and the likelihood of them occurring within and adjacent to the solar farm site.

[16] DC30 - New Zealand Bird Atlas (ebird.org), DC31 - New Zealand Bird Atlas (ebird.org), DD30 - New Zealand Bird Atlas (ebird.org), and DD31 - New Zealand Bird Atlas (ebird.org)

Table 7. Birds species recorded, or likely to occur, within and adjacent to the solar farm site, sorted by indigenous / introduced species and by threat status (Robertson et al. 2021). An 'x' in the 'Site Visit' column indicates that the species was observed during a field survey. Other species are included based on nearby Bird Atlas records and habitat availability.

Common Name	Scientific Name	Conservation Status	Site Visit
Indigenous Species			
Kakī / Black stilt[17]	*Haematopus finschi*	Threatened – Nationally Critical	
Tarapirohe / Black-fronted tern	*Chlidonias albostriatus*	Threatened – Nationally Endangered	
Ngutu pare / Wrybill[17]	*Anarhynchus frontalis*	Threatened – Nationally Vulnerable	
Pīhoihoi / New Zealand pipit	*Anthus novaeseelandiae*	At Risk - Declining	
Tarāpuka / Black-billed gull[17]	*Larus bulleri*	At Risk - Declining	
Tōrea / South Island pied oystercatcher	*Haematopus finschi*	At Risk - Declining	
Tūturiwhatu / Banded dotterel	*Charadrius bicinctus bicinctus*	At Risk - Declining	
Kahu / Australasian harrier	*Circus approximans*	Not Threatened	x
Karoro / Southern black-backed gull	*Larus dominicanus*	Not Threatened	x
Matuku / White-faced heron	*Ardea novaehollandiae*	Not Threatened	
Pīwakawaka / South Island fantail	*Rhipidura fuliginosa fuliginosa*	Not Threatened	
Poaka / Pied stilt	*Himantopus himantopus leucocephalus*	Not Threatened	
Pūtangitangi / Paradise shelduck	*Tadorna variegata*	Not Threatened	
Riroriro / Grey warbler	*Gerygone igata*	Not Threatened	x
Spur-winged plover	*Vanellus miles*	Not Threatened	
Tauhou / Silvereye	*Zosterops lateralis*	Not Threatened	x
Tētē / Grey teal	*Anas gracilis*	Not Threatened	
Warou / Welcome swallow	*Hirundo tahitica neoxena*	Not Threatened	
Introduced species			
Australian magpie	*Gymnorhina tibicen*	Introduced and Naturalised	x
Blackbird	*Turdus merula*	Introduced and Naturalised	x
Canada goose	*Branta canadensis maxima*	Introduced and Naturalised	
Chaffinch	*Fringilla coelebs*	Introduced and Naturalised	
Dunnock	*Prunella modularis*	Introduced and Naturalised	
Goldfinch	*Carduelis carduelis*	Introduced and Naturalised	x
Greenfinch	*Carduelis chloris*	Introduced and Naturalised	
House sparrow	*Passer domesticus*	Introduced and Naturalised	
Mallard	*Anas platyrhynchos platyrhynchos*	Introduced and Naturalised	

[17] It is possible that small numbers of individuals of these species may at times occupy wetland areas or seasonal tarns in the vicinity of the solar farm site, but the proposed solar farm footprint (main paddock area) itself does not provide habitat for these species, and the wetlands within the solar farm site currently provide poor habitat for these species.

Common Name	Scientific Name	Conservation Status	Site Visit
Redpoll	*Carduelis flammea*	Introduced and Naturalised	
Rock pigeon	*Columba livia*	Introduced and Naturalised	x
Skylark	*Alauda arvensis*	Introduced and Naturalised	x
Song thrush	*Turdus philomelos*	Introduced and Naturalised	
Starling	*Sturnus vulgaris*	Introduced and Naturalised	
Yellowhammer	*Emberiza citrinella*	Introduced and Naturalised	x

Of the 33 species recorded, or considered likely to occur, within and adjacent to the solar farm site, 18 are indigenous. Of these indigenous species, three are classified as nationally Threatened, and four are classified as At Risk – Declining; a further eleven species have a national conservation status of Not Threatened.

Threatened / At Risk species that could possibly occur at the solar farm site are tarapirohe / black-fronted tern (Threatened – Nationally Endangered), and pīhoihoi / New Zealand pipit, tōrea / South Island pied oystercatcher, and tūturiwhatu / banded dotterel (At Risk – Declining).

- The overall paddock area and wetlands may provide feeding habitat for black-fronted tern, which may at times overfly the solar farm site, especially wetland areas, foraging for skinks and invertebrates. The solar farm site does not provide breeding habitat for this species.
- The main paddock area may provide feeding habitat for pipit and likely provides good nesting habitat especially among copper tussock.
- Tōrea / South Island pied oystercatcher and tūturiwhatu / banded dotterel utilise a range of habitats and occasionally feed and breed in working paddocks such as this. However, these species were not recorded during the solar farm site visits (two of which occurred at an optimal time to record breeding pairs of each species). These species more often breed in less densely vegetated areas with gravels / rocks and bare ground, and typically prefer to feed in muddy / shallow water, river and coastal areas. Habitats within the solar farm footprint (main paddock area) are not considered to be good breeding or feeding habitat for these species.

Not Threatened indigenous species considered most likely to use the main paddock area (rather than shelterbelts) are spur-winged plover, kahu / swamp harrier, pūtangitangi / paradise duck (this species would more likely use wetland areas), warou / welcome swallow, and karoro / southern black-backed gull. Only small numbers of these species are expected to use the habitats within the solar farm's footprint.

A small number of other wetland and water bird species, including some that are nationally Threatened and At Risk, have been identified (and are recorded in Table 7) for the sake of completeness. They have also been included here because of the high likelihood of them using wetland habitats near the solar farm site (such as tarns to the east and the large 'Old Man Wetland' to the south) which means that it is possible that they may visit wetlands at the solar farm site itself. This includes nationally Threatened species such as kakī / black stilt and ngutu pare / wrybill (whose ecological value is **Very High**). However, habitats within the actual solar farm footprint or the central and southwest wetlands within the solar farm site lack stony-bottomed waterways or large areas of shallow water and fringing mud habitat that are typical wetland feeding habitat for kakī / black stilt and ngutu pare / wrybill in particular. Bare mud areas at the southwest and central wetlands are considered too small and damaged by tracking to offer good feeding habitat for wading wetland bird species. On the basis of the above, these species are generally not considered further in this assessment (including in Table 9).

Following the EIANZ EcIA method, nationally Threatened bird species are of **Very High** ecological value. At Risk – Declining species are of **High** ecological value.

4.4 Lizards

A review of the DOC Bioweb database found lizard records for five species within 10 km of the solar farm site (Table 8).

Table 8. Lizard species recorded at (or previously recorded within 10 km of) the solar farm footprint.

Common Name	Scientific Name	Conservation Status	Site Survey	DOC Herpetofauna Database*
Canterbury spotted skink	*Oligosoma lineoocellatum*	Threatened – Nationally Vulnerable		x
Mackenzie skink	*Oligosoma prasinum*	Threatened – Nationally Vulnerable		x
Southern Alps gecko**	*Woodsworthia* “Southern Alps”	At Risk - Declining		x
Southern grass skink	*Oligosoma aff. polychroma clade 5*	At Risk - Declining	x	x
McCann’s sink	*Oligosoma maccanni*	Not Threatened	x	x

* Accessed 11/2020). ** Southern Alps gecko were only found outside the solar farm site.

A walkover survey was undertaken and tracking tunnels used to determine if lizards were present within or adjacent to the solar farm site (November 2021). No lizards were observed during this walk-over survey. However, ten tracking tunnels indicated the presence of skinks[18], across three transect lines. Skink tracks were found in tunnels placed in tussockland parallel with a dry water channel (containing fescue tussock and copper tussock), alongside slash piles, and on the edge of the central wetland area (Appendix 4). Other animals detected in the tracking tunnels included one unknown bird species, three European hedgehogs (*Erinaceus europaeus*) and various invertebrates.

During a brief follow up visit (by Jaz Morris) in December 2021 a southern grass skink was incidentally observed near a slash pile at the northwest of the site. During the second lizard survey of the main paddock and wetlands (February 2022), a further twelve skinks including ten southern grass skinks and two McCann’s skinks were identified during visual and manual searches. Three southern grass skinks were observed in the wetlands, eight around the slash piles and three under rocks or cover objects. Two McCann’s skinks were caught in small pockets of rocky habitat in the main paddock to the northwest of the wetlands.

Eight lizards were caught across four nights of pitfall trapping. Five southern grass skinks were caught in trap lines around slash piles and a single individual around a patch of copper tussock along the northern shelter belt. Two McCann’s skinks were captured along both banks of the southern end of the central wetland area.

[18] It was not possible to identify skink species from the tracking tunnel tracks.

A single Southern Alps gecko was caught outside of the solar farm site approximately 40 m from the north-western entrance to the main paddock along Braemar Rd. Suitable habitat is largely absent from the main paddock except for two small rock piles and along a dry manmade water channel, which were hand-searched (and found to be unoccupied) during the second lizard survey. No geckos or sloughed skins and scat were observed within the solar farm site. If geckos are present within the solar farm site, they are likely to be at very low numbers and confined to the habitat types listed above.

An assessment of potential habitat for lizards in the main paddock found that good quality lizard habitat was sparse and patchy. Potential areas of lizard habitat within the solar farm site are mapped in Appendix 4 and include:

- Areas of copper tussock (Figure 9);
- Tree slash piles (Figure 10);
- Around a dry ditch (Figure 11);
- A handful of small rock piles to the north of the central wetland area (Figure 12); and
- Areas along the banks of the central wetland area (Figure 13).

Habitat in the main paddock areas of the solar farm site described above is considered most likely suited for southern grass skink and McCann's skink. However, no lizards were observed outside the habitats listed above and mapped in Appendix 4, and McCann's skink was only observed in slightly northwest of the central wetland. Most rock habitat was deeply embedded, except for two small rock piles and along a dry manmade water channel. These areas were dismantled during hand-searches and deemed likely unsuitable for larger skink species such as Canterbury spotted skink or Mackenzie skink, which prefer complex rocky substrate. The shelter belts may provide lizard habitat but no lizards were observed in these areas during any survey (including in tracking tunnels).

Following the EIANZ EcIA method, nationally At Risk – Declining species are of **High** ecological value. Not Threatened species are of **Low** value.

Figure 9. Copper tussock lizard habitat. Areas of copper tussock primarily located along the northern shelter belt to the east of the central wetland area.

Figure 10. Tree slash pile along the northern shelter belt.

Figure 11. Dry water channel north of the central wetland area.

Figure 12. Small rock pile located north of the central wetland area.

Figure 13. Fescue tussockland and patchy hawkweed herbfield on the eastern bank of the central wetland area.

4.5 Terrestrial Invertebrates

Invertebrate species incidentally observed during the survey included the butterflies New Zealand blue (*Zizinia* sp.), boulder copper butterfly (*Lycaena bolderanum*), common tussock butterfly (*Argyrophenga antipodum*), various unidentified moths (likely including *Scoparia* sp., *Tingena* sp., and *Eudonia* sp.), mānuka beetle (*Pyronota* sp.), spiders, a harvestman, and grasshoppers (likely *Sigaus australis* and possibly one other species).

The site is not considered likely to provide important or distinct habitat for terrestrial invertebrates. This is due to the likely relatively high degree of soil compaction due to cattle grazing (compared generally to surrounding more intact habitats), the relatively low cover of indigenous inter-tussock species (including the near-absence of creeping pōhuehue, a particularly important host for native butterfly species), and the generally modified nature of the plant communities present.

No species observed that could be positively identified to species level are classified as nationally Threatened or At Risk. Due to the modified = invertebrate habitats in the main paddock area, it is considered unlikely that any such species are present.

Following the EIANZ EcIA method, nationally Not Threatened species are of **Low** ecological value.

4.6 Summary of Ecological Values

Table 9 summarises our assessment of ecological values following the EIANZ guidelines (Roper-Lindsay et al. 2018) (also see Tables 1, 2, 3 and 4 in Appendix 5).

Table 9. Summary of ecological values assigned to vegetation, habitats and indigenous fauna within the solar farm site.

Ecosystem Component	Representativeness	Rarity / Distinctiveness	Diversity and Pattern	Ecological Context	Overall Ecological Value
Terrestrial and Wetland Vegetation and Habitats					
Main paddock area	Low-Moderate	Moderate-High	Low-Moderate	Low	Moderate
Central wetland	Low-Moderate	High	Low-Moderate	Moderate	Moderate
Southwest wetlands	Very Low	Moderate	Very Low	Low	Low
Threatened and At-Risk Plant Species					
Dryland sow thistle	Threatened – Nationally Vulnerable				Very High
Other At Risk – Declining species	At Risk – Declining				High
Birds					
Tarapirohe / Black-fronted tern	Threatened – Nationally Endangered				Very High
Pihoihoi / NZ pipit, Tōrea / South Island pied oystercatcher, Tūturiwhatu / Banded dotterel	At Risk – Declining				High
All other indigenous birds	Not Threatened				Low
Lizards					
Southern grass skink	At Risk – Declining				High
McCann's skink	Not Threatened				Low
Southern Alps gecko	At Risk – Declining				High
Terrestrial Invertebrates					
All species incidentally observed	Not Threatened				Low

5.0 Vegetation Status / Ecological Significance

5.1 Mackenzie District Plan Definitions

Under Mackenzie District Plan (MDP, notified in 2004) Plan Change 18 (PC18, notified in 2021) amendments, 'improved pasture' is defined as:

> *"an area of land where exotic pasture species have been deliberately sown or maintained for the purpose of pasture production, and species composition and growth has been modified and is being managed for livestock grazing*."

Under PC18 'indigenous vegetation' means:

> *"a community of vascular plants, mosses and/or lichens that includes species native to the ecological district. The community may include exotic species, but does not include vegetation that has been planted as part of a domestic garden, for amenity purposes or as a shelterbelt, or exotic woody pest plants."*

Because the solar farm site contains *deliberately sown exotic pasture* species and it is *managed for livestock grazing*, but also includes *vascular plants* and non-vascular species (*mosses and / or lichens*) *native to the ecological district* (that have not been *planted*), the vegetation appears to meet the definitions of both 'improved pasture' and 'indigenous vegetation.'

5.2 Significant Sites

The operative MDP does not identify any sites that are ecologically significant under S6(c) of the RMA (Sites of Natural Significance) within or immediately adjacent to the solar farm site. However, the MDP (Appendix I) does not include a complete list of all the sites in the District that are ecologically significant under S6(c) of the RMA. Under MDP PC18 rules, sites are *significant indigenous vegetation and significant habitats of indigenous fauna* if they:

a) Meet the criteria listed in [CRPS] *Policy 9.3.1 and Appendix 3; or*

b) Are listed in Appendix I [of the MDP] *as a Site of Natural Significance; and*

c) *Includes any areas that do not comprise improved pasture within the glacial derived or alluvial (depositional) outwash and moraine gravel ecosystems of the Mackenzie Basin as shown* [in a map (Figure 1 appended to the 'Definitions' section of PC18)].

The entire solar farm site occurs on *the glacial derived or alluvial (depositional) outwash and moraine gravel ecosystems of the Mackenzie Basin* and appears to be mapped as such in Figure 1 of the MDP PC18 Definitions document. While the solar farm site's vegetation meets the definition of *'improved pasture'* (see above), it also meets the '*indigenous vegetation'* definition and we have assumed that it is intended that under PC18 that criterion *c* applies to areas such as the solar farm site. Much of the Mackenzie Basin's glacial derived and alluvial areas clearly meet both definitions and criterion *c* would essentially be meaningless if all such sites were exempt. On this basis, we consider that the entire solar farm site (including the main paddock and wetlands) is ecologically significant by default.

In addition, the solar farm site (both the main paddock and wetland areas) certainly meets or likely meets a number of the ecological significance criteria (such as criteria 1, 3, 4, and 10) in Appendix 3 of the CRPS. However, in light of the above, it is not considered necessary to provide a detailed assessment of the solar farm site against these criteria.

6.0 Assessment of Ecological Effects

This section assesses the potential effects on the terrestrial ecology values of the proposed solar farm. To do this, we assess the magnitude of the effect, which is a measure of the extent or scale of the impact, its duration and the degree of change that the impact will cause (Roper Lindsay et al. 2018, see Table 4). A typical scale of magnitude ranges from **Very High** to **Negligible** (see Table 5).

We then assess the level of effect (**without** implementation of the specific recommendations contained in Section 7.0, but **with** implementation of project shaping and site management recommendations as outlined in Section 2.0), which considers both the magnitude of the effect and the ecological value of the plant community / habitat / ecosystem or species affected (Roper Lindsay et al. 2018). The level of effect provides guidance on the extent and nature of the impact management response required, as outlined in Section 3.7.

<u>Note</u>: The potential ecological effects of the solar farm proposal have been assessed assuming construction of the full proposal, rather than being broken down into an assessment of Phase 1 and Phase 2 impacts.

6.1 Terrestrial Ecosystems and Habitats

6.1.1 Vegetation Clearance

Section 4.1 provides information on the plant communities and habitats within the solar farm site that could potentially be affected by solar farm construction (main paddock area). Because solar panel arrays are installed via piling (3.5 mm curved steel), there is no need to clear the solar farm site except for relatively minor works to install cabling trenches, create temporary laydown areas, create gravel access roads, and install a number of pre-assembled inverter stations. The total area of these works, and hence direct vegetation clearance is understood to be in the vicinity of 2.7 ha (see Appendix 6 for vegetation clearance and earthworks calculations and site diagrams and cross-sections; these are provided by Infratec and - as noted in Appendix 6 - contain a contingency for many works types). We understand the precise layout of works may vary slightly from what is indicated in Figure 1; given the overall similarity of vegetation in the main paddock area, we would not expect slight layout changes to meaningfully affect our assessment.

6.1.1.1 Main Paddock Area

The main paddock area includes all areas of the solar farm site aside from wetlands, and the vast majority (95%) of this area is a fescue tussock grassland (along with other minor vegetation types characterised either by herbfield or the presence of copper tussock). Similar partly modified pastures occur nearby on Balmoral Station, relatively much more intact examples of short tussock grassland (where pasture intensification has hardly occurred) are present in other areas of Balmoral Station and across many thousands of hectares on the immediately adjacent Ministry of Defence land, and relatively much more intact examples of copper tussock grasslands are extensive across Balmoral Station. Within the ED, large examples of protected grassland habitat are notable, such as Tekapō Scientific Reserve and Conservation Area. Approximately 2.7 ha of this vegetation type will be removed or disturbed during solar farm construction, with the permanent loss of 1.3 ha and temporary loss of 1.4 ha (areas disturbed by minor trenching would be remediated and expected to eventually recover to a similar state). An area of temporary disturbance where spoil from cable trenches would be temporarily stockpiled is not included in the above figures. We understand this would amount to an additional 5% temporary disturbance area (Richard Neate, Infratec, *pers. comm*. 2022), but also that spoil (from shallow / narrow trenches, the largest of which would be up to c.0.5 m wide and 0.7 m deep) would be reinstated within only c.1 week and hence is unlikely to particularly affect the vegetation in temporary stockpile areas. This vegetation type is extensive in the wider landscape and common at the level of the ED; combined fescue tussockland, copper tussockland and other tall tussockland generally covers c.60% of the c.110,000 ha Tekapō ED, i.e., c.66,000 ha, with at least a quarter of this total area comprising short tussockland (Harding 2009). The magnitude of the direct loss or disturbance of up to 2.7 ha of a modified example of this plant community (due to vegetation clearance) in relation to the extent of this plant community in the immediate area, within the Tekapō ED and at the national level is considered to be **Negligible** (a *very slight change from the existing baseline condition,* Roper Lindsay et al. 2018). The level of ecological effect is **Very Low** (a **Negligible** magnitude impact on a **Moderate** ecological value).

6.1.1.2 Shelterbelts and Roadside

As described in Section 2.8, four vehicle crossings would be constructed from Braemar Rd into the solar farm site, with a total vegetation clearance of c.100 m^2 (four 4x6 m areas). We have not closely surveyed these areas[19], nor specifically described the shelterbelt and roadside areas in Section 4.2, nor assigned them an ecological value; they are exotic in nature and have extremely limited extent in relation to the project footprint. The pine shelterbelt itself is essentially completely bare of vegetation beneath the trees (see Figure 14), and roadsides (depending on precise vehicle crossing location) comprise fescue tussock and copper tussock areas, but also areas of weeds including Russel lupin and silver birch; spread of weeds (see Section 6.1.4) is likely the greater concern with respect to vehicle crossing construction. Clearance of this quantum of vegetation of this sort is no more than a **Very Low** level of effect and is not discussed further.

[19] The need to clear small areas of shelterbelt and roadside was not anticipated at the time of the botanical surveys. However, for the purposes of this assessment, the incidental observations made in these areas are considered to provide a high degree of confidence that shelterbelt areas are of little (likely **Negligible**) value and roadsides are likely of up to similar general value to the main paddock area, i.e., up to **Moderate** value), hence **Very Low** level effects.

Figure 14. Barely vegetated areas beneath pine shelterbelts. Note the lizard tracking tunnel at lower left; no lizards were found in shelterbelt areas by any search method.

6.1.2 Changes in Vegetation Composition

Aside from direct vegetation clearance, effects to vegetation composition (changes in plant species richness and abundance) could arise across up to a large proportion of the main paddock area due to:

- Solar panel effects, specifically:
  - Alteration of microclimate (temperature / humidity) beneath and between solar panel arrays (for example, the 'solar photovoltaic heat island effect'; see Barron-Gafford et al. 2016); and
  - Shading of vegetation immediately beneath solar panel arrays; and
- Retirement of the main paddock area from cattle grazing, as part of a change to site management that would be necessitated by the solar farm installation, and also exclusion of rabbits and hares from the solar farm site.

We undertook a desktop research exercise to obtain information about the possible effects of constructing and operating a solar farm on the vegetation at the solar farm site. We also reviewed photographs of previous solar farm projects undertaken by Infratec and others. We did not find any peer-reviewed studies reporting the effects of solar farms on vegetation in New Zealand (and it is unlikely that there are any, given that solar farms in NZ are a relatively new phenomena and all similar sized projects of which we are currently aware are presently at design / consenting stage). Studies from overseas largely relate to desert habitats or temperate grassland habitats, and often much larger sites. The study site, ecologically and climatically speaking, sits between these two situations. Therefore, no studies found are directly applicable to this site.

While it is likely that the effects of solar panels (shade and microclimate) and grazing would interact to drive change in vegetation, relevant literature on each aspect are discussed separately below, before a discussion about the possible implications for vegetation at the solar farm site.

6.1.2.1 Alteration of Microclimate

In summary, the findings from previous solar farm studies in peer-reviewed journals (reviewed in a desktop literature search) that may be broadly applicable to the solar farm site are that:

- Studies clearly supported the notion that solar farms can locally influence temperatures and soil moisture in particular, but do not necessarily result in generalised changes across an entire solar farm site; results indicated that such effects would primarily or exclusively arise beneath panel arrays, and elsewhere temperature and humidity changes would be minimal or non-existent (e.g., Armstrong et al. 2016);
- Studies found an increase in summer peak temperatures in solar farm sites relative to control areas, but similar winter temperatures between solar farm sites and control areas (Yang et al. 2017), and almost all reports found that relative increases to temperature in solar farms are greatest during the day (e.g., Broadbent et al. 2019, Suuronen et al. 2017);
- The small number of studies that measured microclimate beneath and between panels found that, during summer, temperatures were lower, and humidity was higher beneath panels compared to the between-panel areas, and between-panel areas were climatically similar to areas outside solar farms (control areas; Armstrong et al. 2016), and all effects to microclimate are essentially confined to the solar farm (Fthenakis and Hu 2013);
- Soil moisture is likely to generally be increased underneath panels, likely because of shading and temperature changes. In two studies (Adeh et al. 2018, carried out in a warm-temperate grassland in Oregon; and Liu et al. 2019, at a very arid site in western China), this could be linked to increased plant growth under panels. However, the presence of panels decreased grass growth levels in another study (Armstrong et al. 2016); this same study (in a cool-temperate grassland in England) also indicated a reduced plant species richness beneath panels.
- Rainfall runoff from panels, while leading to concentrated drip zones, does not appear from the literature to cause erosion or soil damage in sites with good vegetation cover (further, the solar farm site has generally low annual rainfall).

In summary, climatic conditions at the solar farm site are likely to be affected by the solar panel arrays, with a possible overall increase in summertime temperatures across the solar farm site but certainly a relative reduction in temperature and increase in humidity and soil moisture immediately underneath panels. Between panel areas would likely experience similar climatic conditions to the status quo. Effects are therefore limited to being shaded at some times of the day (tending either side of solar noon). Considering the solar farm site likely experiences significant soil moisture deficits and large temperature variations, it is likely that climatic conditions beneath solar panels would be less harsh (moderated) and hence be more favourable for the growth of competitive pasture species, especially exotic grass species and clover.

6.1.2.2 Effects of Shade

Short term vegetation shading experiments in similar habitats near the solar farm site had similar findings in terms of the likely microclimatic effects of solar panels, finding an increase in local humidity and soil moisture under shade (Payne and Norton 2011). In what may be the most applicable study to this proposal, Norton and Young (2016) then assessed the vegetation changes resulting from shading and microclimatic effects in an experiment using partial shading of an area of dryland vegetation somewhat similar to that at the solar farm site. The study was conducted at nearby Glenmore Station, but on an outwash area that has been much less modified than the main paddock area at the proposed solar farm (outwash plant communities in general would reflect, and be suited to, a much harsher habitat than the more sheltered and deliberately modified / fertilised solar farm site). Further, in this study, shade cloth rather than solid solar panels was used. Key findings were:

- A general change in vegetation composition across the six-year experimental period in shaded areas. These changes included increased vegetation cover and indigenous forb (herbaceous plant) species richness, and reduced bare ground and non-vascular (moss and lichen) species cover.
- Responses of individual species (both exotic and indigenous) to shade varied, with a statistically significant increase in cover of indigenous New Zealand harebell and exotic sweet vernal. Cover of mountain twitch (an At Risk – Declining grass species present across the solar farm site) did not change with shade but increased in no-shade treatments (possibly because of grazing exclusion associated with the experimental treatments).
- There was a decrease in the cover of indigenous lichens and wire moss, and no detectable effect for 13 other species. Although indigenous lichens and mosses are generally far less important in terms of cover at the solar farm site compared to the more intact vegetation of the Glenmore Station study area, the findings of this research support the suggestion that indigenous plant communities at the solar farm site are likely to change in composition due to the presence of solar panels. As shade itself shifts throughout the day, it is likely that effects of shade will be most pronounced immediately beneath panels (from a birds-eye view) as these areas will be shaded the most and during hotter (noon) times of day.

The changes observed by Norton and Young (2016) include both adverse and positive effects to indigenous plant species, but shade did not result in dramatic change in the character of the vegetation nor the loss or gain of any species in the six-year study period. No other comparable studies were found during the preparation of this assessment.

6.1.2.3 Effects of Changing Land Management

Across the main paddock area where solar panel arrays would be established, a transition from mixed cattle and sheep grazing to sheep grazing alone is considered an effect of the proposal that is likely to influence vegetation at the solar farm site. In addition, wetland and setback areas would be fully de-stocked and OSTD would cease in these areas. Further, exclusion of rabbits and hares from the wetland / setback areas has been accepted by the applicants.

- No studies could be located that provided a detailed assessment of dryland vegetation change in response to grazing of cattle as compared to sheep, but the generally accepted opinion among ecologists is that cattle grazing is more harmful to indigenous vegetation values than sheep grazing (e.g., Head 2016, Harding 2020). Cattle, being heavier, tend to inflict more trampling damage than sheep (particularly in wetlands, where they tend to also graze more readily than sheep), and whereas sheep dung hardly smothers vegetation at all, widespread cow pats suppress often diminutive and short-lived indigenous plant species. Sheep typically graze vegetation to a shorter sward than cattle and hence maintain open light gaps for indigenous inter-tussock species. Hence, the vegetation values of short-tussock grasslands are broadly compatible with ongoing sheep grazing, and this situation is preferable to cattle grazing, from an ecological perspective.

- Rabbit and hare grazing in habitats such as the solar farm site is broadly negative in an ecological sense (Norbury 1996), with marginal benefits confined to weed reduction and creation of disturbed soils required by some indigenous plant species (natural frost heave and other climatic influences can achieve this effect in areas of naturally sparse vegetation cover where such species are typical). Adverse effects are broader and include browsing of palatable species often to effective local extinction, and considerable damage to soil structure (causing erosion) via burrows. Rabbits and hares would be eliminated and excluded from wetland and setback areas (it is acknowledged that rabbits are unlikely to be affecting the wetter areas at present).
- Wetland and setback areas would be destocked fully. Of this 14.5 ha total unbuilt area, around 5.1 ha is wetland, and the remaining c.9.4 is dryland vegetation. The ecological effects of grazing in high country short-tussock grasslands have been extensively studied and disputed over many decades, with most peer review studies often assessing the relatively lesser impacts of sheep grazing against or in combination with other more clearly harmful practices such as burning. In isolation from other such pressures (e.g., fire, or nutrient application), the effects of typical grazing regimes on indigenous flora cover and diversity are generally accepted as being negative, with the degree of impact depending on the intensity of grazing (see Harding 2020). However, actual assessments of vegetation change following destocking frequently yield ambiguous results as far as recovery of indigenous species (Meurk et al. 2002, Walker et al. 2003), are limited by short study duration and the slow responsiveness of indigenous vegetation to change and may also be limited by confounding factors (e.g., rabbit grazing, fertilisation). Certainly, the impacts of grazing are negative for some vegetation components (e.g., palatable native species; Meurk et al. 2002, Walker et al. 2003) but have been suggested to be mildly positive in a general sense (via suppression of exotic species; e.g., Lord 1990). Indigenous dryland vegetation composition is frequently variable and unstable, and responsive to other factors such as climate; it has been suggested vegetation stabilises over time in the absence of grazing (Allen et al. 1995) and therefore that observation of vegetation recovery requires long-term study with minimal interference in the study period (Walker et al. 2016). In summary, the most useful study to inform the likely effects of rabbit and sheep elimination from wetland setback areas is that of Walker et al. (2016), who demonstrated recovery of indigenous vegetation in the absence of grazing over 18 years at Tekapō Scientific Reserve. This included an increase in indigenous species cover and biomass, especially for palatable species.
- As a whole the condition of the vegetation in wetland areas is likely to clearly benefit from exclusion of stock grazing and rabbits, due to a reduction in trampling damage and browse especially on palatable species (e.g., grassland spaniard), a reduction in livestock dung and associated nutrient runoff, and elimination of stock as a potential agent of ongoing weed introduction. Retiring OSTD in wetland areas may reduce nutrient loading and hence the aggressive growth of exotic grass species, in time. However, in the absence of grazing, weed control will be required especially for existing woody species, and selective control of exotic grasses, sedges and rushes to maintain small open mud areas (e.g., for sneezeweed) may be desired.

In all, changes due to a change from cattle to sheep grazing are likely to be highly favourable for the ongoing persistence of indigenous plant species in the main paddock area at the solar farm site, and in isolation from the effects of solar farm construction would certainly be an ecological benefit. Aside from an immediate reduction in damage by cattle, further enhancement of dryland ecological values in setback areas (due to complete retirement of grazing) are likely to arise slowly over decades, and be difficult to detect. Changes in management and exclusion of rabbits will have generally beneficial effects.

6.1.2.4 Implications for Vegetation in Main Paddock Area

Considering the complex and competing drivers of vegetation change following the implementation of this proposal, some key themes emerge for the main paddock area:

- On balance, it is likely that the climatic influence of solar panel arrays would alter composition of plant species, especially beneath panels, likely to the benefit of exotic grasses (e.g., sweet vernal) that can generally outcompete and overtop indigenous species and herb species. However, tighter grazing by sheep would counteract this effect to some degree, maintaining areas of open, low stature inter-tussock vegetation, and we note that indigenous herbs were among the groups that increased under shade in a nearby study (Norton and Young 2016). The between-panel areas especially may therefore retain a similar physical habitat and relative abundance of competing pasture species, meaning that changes to conditions for existing indigenous species would principally arise from being shaded more often. Immediate beneath-panel areas that experience the greatest climatic and shade changes seem more likely to trend towards greater exotic grass cover because these will experience the greatest microclimatic change, but will likely retain indigenous herbs as well.
- While it is hard to conceive that areas beneath solar panel arrays would remain fully suitable for the existing degree of cover of fescue tussocks (a species that seems to have a clear niche in the most open and harsh high-country sites), the finding from Norton and Young (2016) that shade had no effect on this species (as well as many of the more widespread indigenous species at the solar farm site; e.g., common mountain daisy, *Pimelea oreophila*, blue tussock, pātōtara, and turfy coprosma) is of importance. The relatively short duration of that study (6 years) compared to the solar farm design life (30 years) and other dissimilarities means these findings cannot be wholly relied upon, but they are in fact unsurprising considering that many of these key species are naturally inter-tussock species, i.e., are adapted to growing among the shading and climate moderating influence of tussocks, and hence may be relatively tolerant of shade. Further, fescue tussock, being much less palatable to sheep than exotic pasture species, remains likely to persist. Were the solar farm site proposed to be fully retired from grazing the situation for the indigenous species would likely be quite different.
- Indigenous shrubs (e.g., matagouri) may gain a competitive advantage in the ‘moderated’ climate beneath panels (they are currently essentially absent) but are likely to be kept low stature by sheep grazing (if not by deliberate site management requirements). Nevertheless, any establishment even of low shrubs would be of benefit in terms of vegetation and habitat diversity.
- If the predictions regarding a ‘moderated’ climate beneath the panels are wrong (due to the particular site circumstances here compared to sites assessed oversees), or other effects (such as a ‘photovoltaic heat island’ effect) are overall more influential on plant growth conditions, it is likely conditions would remain stressful for exotic species and that indigenous species would maintain or even increase their competitive niche at the solar farm site.

- Any effects of a 'moderated' climate beneath solar panels may be most pronounced in small moraine hummock areas that likely currently have the most distinct / challenging plant growth conditions. These areas may begin to reflect the overall vegetation of the solar farm site with time and lose their somewhat distinct nature, in that they currently have relatively high cover of bare ground and non-vascular species, which both distinctly reduced under shade in Norton and Young's (2016) study.
- Overall, the competing influences of the overall solar farm proposal on indigenous species, while not being able to be predicted with certainty (due to the lack of precedent), seem likely to tend towards discernible and somewhat adverse effects beneath panels, with neutral effects elsewhere. The predictions of this assessment are that areas beneath panels would become lusher and grassier but there would be little obvious difference between panels and in other areas of the developed site (e.g., around inverter stations). We do not think any evidence points to a total loss of habitat suitability for the indigenous species within the solar farm site in general, nor for any particular indigenous species (see also Section 6.1.3 below).

Approximately 95 ha[1] of the main paddock area will form part of the solar farm (solar panel array area, including 2.7 ha of other developments already assessed in in Section 6.1.1), and hence be subject to change in vegetation composition. Panels would directly overlie around 40% of the solar farm footprint (within arrays, 4.6 m wide panels are separated by 4.9 m wide gaps, see Figure 2), i.e., roughly up to 49 ha and partly shade much of the balance of the solar farm site at some times of day, but areas between panels (as discussed above) are still considered likely to retain a similar vegetation cover. Up to 10 ha of the existing main paddock area's vegetation would form part of the dryland setback area and be subject to beneficial effects of the proposal. As described in Section 6.1.1 above, this vegetation type is extensive in the wider landscape and common at the level of the ED. The likely subtle but at least partly adverse changes in vegetation composition described above (rather than total clearance and loss) in up to 95 ha overall, but with the most discernible effects confined to around 49 ha of this plant community (noting this change would be mitigated to some degree by improvements in indigenous vegetation in the c.10 ha of setback areas over time). In relation to the very wide extent of this plant community in the immediate area within the Tekapō ED and at the regional level, is considered to be of a **Low** magnitude (a *minor shift away from baseline conditions. Change arising from the loss / alteration will be discernible, but underlying character, composition and / or attributes of the existing baseline condition will be similar to pre-development circumstances / patterns,* Roper Lindsay et al. 2018). The level of ecological effect is **Low** (a **Low** magnitude impact on a **Moderate** ecological value).

6.1.2.5 Implications for Wetlands

As described above, effects of the proposal to wetlands (which total c.5 ha at the solar farm site), especially wetland vegetation, are likely to be **Positive**, i.e., a **Net Gain**. No adverse effects in terms of wetland hydrology or extent are expected to arise as a result of solar farm construction or operation, due to the limited degree of earthworks that are located at some distance from wetland areas.

6.1.3 Effects on Threatened and At-Risk Plant Species

The following section incorporates our general assessment above, combined with what is known about the specific habitat requirements for these species specifically.

6.1.3.1 Dryland Sow Thistle

Two individual plants of dryland sow thistle (Threatened – Nationally Vulnerable) were recorded in an area of fescue tussock grassland in the east of the solar farm site. Although it is likely that more individuals are present, the solar farm site is not considered good habitat for this cryptic species owing to the level of prior pasture improvement and existing relatively dense exotic grasses (compared to typical habitat for the species).

This species seldom occupies naturally shady areas (aside from occurring among short and tall tussocks). If, due to direct vegetation clearance or changes in vegetation composition, conditions across most of the solar farm site are no longer conducive to the growth of this species (especially beneath panels), this would likely affect no more than a few individuals of the species, which is widespread (at naturally very low densities) in outwash and short tussock grassland habitats at Balmoral Station and in the Tekapō ED (Jaz Morris, *pers. obs*., and David Norton, *pers. comm*. 2021). This species also has other important habitat strongholds in the Mackenzie Basin and nationwide (for example, in dry western Central Otago high country river valleys where it can be locally common). Further, habitat for this species in c.10 ha of dry setback areas of the solar farm site may be enhanced by exclusion of grazing and rabbits / hares. On this basis, even in the worst case, effects to the species would be of no more than **Negligible** magnitude (*having a negligible effect on the known population or range of the element / feature*), resulting in a **Low** level of effect (a **Negligible** magnitude of effect on **Very High** ecological value).

6.1.3.2 At Risk Species

Other At Risk species at the solar farm site are expected to persist at the solar farm site, especially between panels, owing to the likely modest (**Low** level) changes in vegetation discussed above, and are likely to have improved habitat quality in dryland setback areas.

While species such as mountain twitch and *Pterostylis tanypoda* (both widespread at the solar farm site), as well as *Pterostylis tristis* are all typical of open habitats, we have observed the persistence of mountain twitch and *Pterostylis tanypoda* at least in relatively even more improved pastures elsewhere at Balmoral Station and in the Mackenzie Basin in areas with lush exotic grass species (such as is predicted beneath panels). Reduction in cover of these species would be most likely beneath panels (if it reduces at all), but we note the abundance of mountain twitch did not change due to shade in one study (Norton and Young 2016). Matagouri, along with other indigenous shrubs in general, may benefit from climate moderation beneath panels.

The At Risk species most likely to suffer from a reduction in habitat suitability are Celadon mat daisy, *Leucopogon nanum*, and pin cushion, which are all typical of harsh open habitats (at the solar farm site this is confined generally to small herbfield areas on moraine hummocks and a terrace riser). They are extremely scarce at the solar farm site and indeed the habitat, due to existing land use, may already be quite marginal. Importantly, around 25% of the herbfield (on a terrace riser) would be within the setback area (which is wider and >40 m in width in the herbfield area), maintaining and enhancing habitat for many or at least some of the existing individuals of these species at the solar farm site (possibly excluding pin cushion, which was only found in one location within the solar farm footprint and not in any setback areas).

All of the At Risk species discussed above have large populations and occur extremely widely throughout the Mackenzie Basin, but are generally confined to dry eastern South Island habitats that have undergone substantial habitat loss (for pastoral intensification) in recent years. Their ongoing presence in the main paddock area at the solar farm site (and in other similarly modified pastures) reflects a degree of tolerance for ongoing grazing and other site modifications. On this basis, even in the worst case (where the solar farm site, excluding setback areas, becomes unsuitable and no longer supports the existing very low to low density of all these species), adverse effects to their populations at the local, ED, and national level would be of no more than **Negligible** magnitude (*having a negligible effect on the known population or range of the element / feature*), resulting in a **Very Low** level of effect (a **Negligible** magnitude of effect on **High** ecological values).

6.1.4 Weed Spread and Establishment

Other than mouse-ear hawkweed, there are few problem weeds within the solar farm site. Of note is that Russell lupin is largely absent (one or two plants were recorded in the main paddock area and within the central wetland) despite this species being abundant along Braemar Rd), and lotus, sweet briar, and wilding pines are extremely infrequent. Other typical weeds of the area such as thistles, St John's wort, and woolly mullein (poor man's tobacco) are absent entirely. Several crack willows (previously planted) are present in the central wetland.

There is the potential for weed species, including species not already present in the solar farm site, to be introduced or establish as a result of the proposed activities. In particular, weed introduction / establishment could occur via:

- The use of gravel or other material from an external source;
- The introduction of seeds or plant material on construction machinery;
- The spread of weeds from affected areas of the solar farm site to unaffected areas on construction machinery; and
- The establishment of weeds, and particularly weeds with wind-blown seeds on bare substrates following construction works or following remediation work.

In addition, the retirement of wetland areas (and dryland setbacks) from all grazing, while done to allow recovery of vegetation in these areas, unfortunately means that they are at greater risk of weed spread (stock effectively suppress a range of weeds). However, recommendations to implement weed control in wetland and setback areas have already been adopted by the Applicant as part of the proposal (see Section 2.11.2) and this effect will be avoided.

The establishment of weeds as a result of, or following, construction works (especially trenching and vehicle crossing construction) is a potential risk given the low levels of many exotic weed species across the solar farm site, and the moderate ecological values of the plant communities and habitats within the solar farm site. The magnitude of the impact of the introduction and establishment or spread of exotic weed species is dependent on the weed species, but is potentially low (a *change arising from the loss/alteration will be discernible, but underlying character, composition and/or attributes of the existing baseline condition will be similar to pre-development circumstances/patterns*), for example if sweet briar established and spread across the main paddock. Conservatively, the magnitude of impact of weed establishment and spread in the main paddock area due to construction has been assessed as **Low** (a **Very Low** or **Low** level of effect depending on the plant community / habitat type which range from **Low** to **Moderate** ecological value). Measures to prevent weed introduction, establishment and spread, and for weed surveillance and control in setback areas are recommended.

6.2 Birds

There are four potential effects on avifauna that are considered: permanent habitat modification / loss; displacement resulting from construction disturbance; impacts on breeding birds; and impact trauma (bird strike) with panel arrays.

As described in Section 4.3, only a limited range of indigenous bird species has been observed at, or is likely to use, the main paddock areas of the solar farm site, which generally offers poor habitat for birds. Wetland areas, which offer somewhat better habitat for a small number of wetland and water bird species, are outside of the solar farm footprint. Hence birds in these areas would not be subject to permanent habitat modification or loss; any effects in terms of displacement resulting from construction disturbance or impacts on breeding birds would generally occur at wetland margins only.

6.2.1 Permanent Habitat Modification / Loss

Permanent habitat modification across the main paddock area will arise via installation of extensive solar panel arrays, and this may reduce habitat availability for those bird species that use the main paddock area of the solar farm site. For birds that may presently use the solar farm site transiently (e.g. tarapirohe / black fronted tern for feeding and tōrea / South Island pied oystercatcher for possible breeding), the panels themselves would likely make the solar farm site less attractive for both feeding and nest establishment (but, as noted in Section 4.3, tarapirohe / black fronted tern feeding likely favours the central wetland, which will not change, and the solar farm site does not provide good quality / core breeding area for tōrea / South Island pied oystercatcher). On the other hand, it is likely that some indigenous bird species that may use the solar farm site for longer periods (e.g., warou / welcome swallow) would continue to do so during solar farm operation. This and other foraging species tolerant of modified habitats, such as spur wing plover, would likely habituate to the presence of the static solar panel structures. Because the solar farm site will remain largely in grassland, generally similar feeding opportunities for birds will be maintained, particularly in the open spaces between panel arrays. However, pihoihoi / New Zealand pipit, which may possibly breed especially in copper tussock areas, are unlikely to find the more closed-in panel array area attractive for breeding, and will likely be displaced elsewhere. Central and southwest wetland areas (and dryland setback areas) will remain available to breeding and feeding for species that prefer open / fescue tussock areas compared to the panel arrays, and these areas may become more attractive and productive as breeding and feeding habitat generally due to the exclusion of grazing.

In the context of the quality of the habitat that would be modified, likely low numbers of any bird species present, and the very large extent of surrounding similar feeding and breeding habitat in the immediate area and in the wider ED, the magnitude of effect to all bird species is **Negligible** (meaning *a very slight change from existing baseline condition*, and / or *having a negligible effect on the known population or range of the element / feature*). A **Negligible** magnitude of effect on indigenous bird species with ecological values ranging from **Low** to **Very High** constitutes a **Very Low** to **Low** level of effect.

6.2.2 Disturbance and Temporary Displacement

This section assesses the effect of the general displacement of birds by factors such as construction noise. Effects on nesting birds, including disturbance are assessed in the following section.

Operation of machinery, power tools and vehicle / people movements in an ordinarily quiet site has the potential to disturb and temporarily displace birds that may perceive predator threats or be interrupted in their normal feeding and other behaviours. We note that the construction of phase 2 may require up to 18 months (which would gradually progress across the site). The small number of bird species that may be ordinarily resident at the solar farm site (e.g. warou / welcome swallow, but not wide-ranging foragers such as tarapirohe / black-fronted tern) during the construction period are mobile species that will likely disperse readily into surrounding similar habitats if disturbed, including adjacent wetland / setback areas of the solar farm site itself where there will be no sources of disturbance during construction. Available flight initiation distance information for some key bird species that may use the solar farm site (e.g., tōrea / South Island pied oystercatcher, and wetland species such as poaka / pied stilt) are likely in the vicinity of c.40 m (Glover et al. 2012; these measurements are from an Australian study that assessed a very closely related species and the same species respectively); these birds are therefore moderately tolerant of human approaches (compared to sensitive species, such as goose or swan species that may initiate flight hundreds of metres from an approaching predator). The magnitude of ecological effect of solar farm construction in terms of bird disturbance is expected to be **Negligible** because it will be temporary and restricted only to the vicinity of construction activities. A **Negligible** magnitude of effect on indigenous bird species with ecological values ranging from **Low** to **High** constitutes a **Very Low** level of effect.

6.2.3 Nesting Birds

Potentially, there is a risk to nesting bird species if solar farm construction occurs during the breeding season (generally September to February). This could arise either through construction works damaging nests or via disruption of nesting behaviours due to noise and similar disturbance.

Bird species that could potentially nest within, or immediately adjacent to the construction footprint are pihoihoi / New Zealand pipit, tōrea / South Island pied oystercatcher, tūturiwhatu / banded dotterel, and spur-winged plover, which can all nest in grasslands (aside from NZ pipit, all these species generally prefer more sparsely vegetated sites than the main paddock area). It is considered unlikely that construction works would affect any birds nesting in shelterbelts (Not Threatened species such as riroriro / grey warbler, if any), due to the very limited amount of shelterbelt clearance, the distance between the shelterbelts and the main works area, and the general tolerance of such species to nesting near areas of anthropogenic disturbance. No birds were observed breeding at the solar farm site in three visits during the breeding season, but no specific searches were undertaken, and the solar farm site is large. In this context, and taking a precautionary approach, the likely effects of the proposal on key species are assessed below:

- New Zealand pipit (At Risk – Declining) prefer to conceal their nests in grass or low scrub. The copper tussock areas of the main paddock in particular could provide nesting habitat for this species. If construction works are undertaken outside the bird breeding season, there would be no effect to nesting pipit. Or, if undertaken during the breeding season, the effect of works on this species, if present at the solar farm site, would affect extremely small numbers of breeding pairs, and the level of effect is **Very Low** (a **Negligible** magnitude of effect on High ecological value).

- New Zealand pied oystercatcher (At Risk – Declining) and banded dotterel typically nest in braided riverbeds and sparsely vegetated outwash areas, but they and spur-winged plover (Not Threatened) will also nest in paddocks and open grassland. Again, effects on these species will be avoided if construction works are undertaken outside the bird breeding season. Otherwise, as above, **Very Low** level effects are possible (a **Negligible** magnitude of effect on **High** and **Low** ecological values).

Despite representing **Very Low** levels of effect (if any), a pre-construction check for nesting birds undertaken by an ecologist would ensure that birds are absent prior to construction or that setbacks from any nesting areas are applied until nesting has ceased.

6.2.4 Bird Strike with Solar Panel Arrays

It has been recognised internationally that bird deaths from trauma due to collision with solar photovoltaic structures (panels) are possible (e.g., Kagan 2014, Bennun et al. 2021). It is thought that birds, particularly water birds and wetland birds, may mistake reflected light from solar panel arrays for a lake (the so-called 'lake effect'), attempt to land on the solar panels, and suffer death as a result either of trauma injuries and / or subsequent depredation. For example, deaths of c.20 birds were recorded (over an unknown period) at a c.1600 ha solar farm site in California (Kagan 2014). In that study, it was noted that this effect appeared to largely affect overflying migratory water bird species attracted by actual ponds at the solar farm site's desert location, or may have arisen because the uniformly shaped layout and dense panel arrays possibly appeared as an uninterrupted water feature (Kagan 2014). This possible 'lake effect' is poorly researched (Chock et al, 2021), is not detected at all sites (Visser et al. 2019), and investigations are frequently hampered by an inability to positively identify causes of death (Visser et al. 2019, Kosciuch et al. 2020). Studies to date have attributed essentially any traumatic bird death at a solar facility (for which no other cause is immediately apparent) to the panel arrays without the ability to establish a causal link to either panel collisions or the 'lake effect' directly, and in these cases the presence of other causes, aggravating factors, or natural / unrelated deaths is unable to be evaluated. Further, there is no relevant New Zealand information on which to base a precise assessment.

We note that the solar farm site assessed in this study may be located in the flight path for wetland and water birds travelling between Lakes Tekapō, Alexandrina, and Pūkaki, and dispersive movements of small numbers of these sorts of indigenous birds to wetland and tarn habitats occur in the area generally. Hence, in terms of this possible effect, we have considered that overflights of the solar farm site by a broad range of bird species are possible (i.e., including wetland species and waterfowl that are listed in Table 7), and so we have considered the possibility of trauma / death to the same wide range of birds. This consideration should be read in the context of our assessment that habitat use / overflights by wetland birds, (especially Threatened species such as kakī / black stilt) at the solar farm site would likely be infrequent.

Bearing in mind that solar panels are designed to absorb rather than reflect light, the conditions that may lead to the 'lake effect' may also be limited: this likely requires either particular lighting conditions (low angle light) or requires a bird or group of birds to fly past at particular height / angle.

In terms of this possible effect, there are some likely mitigating factors in relation to the solar farm's proposed solar panel array design and the solar farm site context:

- The solar farm site would have two panel arrays (either side of the central wetland area) that are irregularly shaped and slightly interrupted by a small number of access corridors among the panel arrays. Visual interruption of large solar farm arrays by arrangement into smaller blocks or other breaks is a key recommendation for the mitigation of this possible effect (Bennun et al. 2021).

- Solar panel design data provided by Infratec shows that the proposed solar panels to be used are a ‘high transmission’ type treated with an anti-reflectivity coating. Data supplied by the manufacturer (Appendix 7) states that panels typically reflect less than 5% of light below 60˚ angle of incidence. Reflectance increases rapidly above 60˚ to c. 40% with 90˚ angle of incidence (we presume this equates roughly to mid-afternoon conditions).
- The solar farm site is somewhat distant from very large river corridors and lakes that are likely to be the main flight pathways and main habitats for many birds, but nearby tarns (e.g., a seasonal tarn c.300 m to the east of the solar farm site), the large Old Man Wetland, and Irishman Creek certainly offer high quality bird habitat that will attract birds from the surrounding area at times.
- Tarn habitats in the immediate area (which would be used by wetland bird species that are possibly most vulnerable to the ‘lake effect’, including High or Very High ecological value species) are only seasonally wet, and hence are only seasonally used by wetland bird species. Moreover, when birds such as poaka / pied stilt and kakī / black stilt establish nesting or feeding territories at seasonal tarn habitats, they will frequently remain in close proximity to that site for weeks to months (and often be highly territorial). These two factors mean nearby overflights by wetland birds of conservation concern, which could possibly result in bird strike, would only occur during infrequent bird movements at limited times of the year, and to lead to bird strike would likely need to occur in sunny afternoon conditions to have the greatest likelihood of reflection from the panel array. Outside of these times, and especially at night, there would be no risk of a ‘lake effect.’
- Existing tall site screening (c. 15 m high pine shelterbelts) would render any lake-like reflection less visible at the oblique angle of view of birds flying at low to moderate elevations at much distance from the solar farm site. The solar farm site would not be visible at ground level from nearby tarns and the nearby Old Man Wetland. The height at which indigenous species may overfly the solar farm site / area is not known, and is likely to vary. Very high-flying species (which could be most likely to see and be attracted to the solar farm site from afar) may largely be exotic Canada geese that are not of ecological concern, but at least some other indigenous species (such as tōrea / South Island pied oystercatcher) often fly at sufficient height that the site would be visible to them. But, on balance, the solar farm site may be less likely to be seen (and if seen may be less likely to be perceived as a lake by indigenous birds) than the California desert site noted above, which was not screened by vegetation.

In summary, the likelihood or magnitude of the potential effect of bird strike at this site is not fully known, nor is it known whether indigenous species would be more or less susceptible than exotic species, but it appears likely (based on all the above information) that it would affect only a small number of indigenous birds, if any at all. Taking a precautionary approach, we consider that this effect may be possible, but that the effect to any bird species (in terms of impact to its local or national population, or habitat range) due to the presence of solar panels and subsequent bird strike would, in consideration of all factors above, most likely be a **Negligible** magnitude (having a *negligible effect on the known population or range of the element / feature*). A **Negligible** magnitude of effect on bird species with ecological values ranging from **Negligible** to **High** (or **Very High**, if in a remote occurrence a nationally Threatened species were to overfly the solar farm site and suffer collision) constitutes a **Very Low to Low** level of effect. Nevertheless, monitoring for this possible effect is recommended (see Section 7.1.5).

6.3 Lizards

Effects on lizards have been assessed at a local population (solar farm site) scale and at the ED scale. We note that where species have limited distributions, loss of individuals will have national population scale effects, but this does not apply to the lizard species present at this site as these are widely distributed across the ED and central South Island. For the purposes of this assessment, we therefore consider the ED scale to be the appropriate scale. We also consider the effects to be permanent and, in most cases, ongoing, without mitigation.

6.3.1 Habitat Alteration and Loss

The footprint of the solar panel array in the main paddock is known to overlap with habitat occupied by skinks. Proposed construction will alter lizard habitat in the footprint of the gravel roads and cable trenches (where gravel roads are constructed, habitat would be permanently lost), and potentially under the panels themselves where vegetation composition (species and density) may change, reducing basking site and refuge availability. A proposed construction laydown area overlaps with lizard habitat in a copper tussock area and may temporarily make pockets of suitable habitat unavailable for lizards. Sub-lethal effects of habitat alteration may include displacement of lizards to less suitable habitat, or increased stress to lizards from the loss of refugia and increased exposure to predators.

Given the above, we note that our surveys indicate that the lizard populations within the construction footprint (i.e., roads, cable trenches and laydown area) are likely to be at low density and the area of direct clearance (2.7 ha) is small in relation to the extent of the site. Approximately 54% of the main lizard habitat at the site (mapped in Appendix 4) is avoided fully by construction work and would be within the wetland and setback areas.

We have assessed the magnitude of effect as **Low** on lizards with ecological values ranging from **Low** to **High**, resulting in a level of effect of **Very Low** to **Low**.

6.3.2 Mortality During Site Preparation

Piles of tree slash along the northern and western shelterbelt are known to be occupied by southern grass skinks. The quantity of the slash is approximately sixteen 5 x 10 m piles (800 m^2), and these slash piles are required to be disposed of during site preparation. Ordinarily as part of normal farming practices, slash piles would be burned during winter shortly after felling, but these piles have apparently been left in situ for some years and have accordingly been colonised by skinks and appear to support much of the lizard population at the solar farm site. Where lizards are present, burning or bulldozing the slash piles will likely result in injury or death to lizards. Further, burning would ordinarily occur during winter when lizards are inactive and may not be able to escape.

The magnitude of effects of burning slash or otherwise clearing slash piles is assessed to be High at the site scale based on the number of southern grass skinks located around the slash piles and the high likelihood of lizard mortality, but **Low** at the scale of the ED (records for this species are widespread across this area). A **Low** magnitude of effect on lizard species with **High** ecological value results in a **Low** level of effect with no management. However, indigenous lizards are absolutely protected under the Wildlife Act 1953, meaning that even a Low level of ecological impact requires management. Management recommendations to avoid this risk and hence to avoid or otherwise appropriately manage this level of effect are provided in Section 8.1.3.

6.3.3 Construction Mortality

There is a risk to lizards during construction of the solar farm arising from vehicle and machinery moving throughout the main paddock or via the construction of vehicle tracks. Lizards are behaviourally cryptic and will shelter under available cover (e.g. within tussocks) when disturbed, thus leaving lizards particularly vulnerable to injury or mortality.

In context of the low to very low density of skinks in the main paddocks, the magnitude of effects is determined to **Negligible** (at the site and ED scale), which for lizard species with ecological values ranging from **Low** to **High** results in a **Very Low** level of effect.

6.3.4 Increased Predation

Loss of suitable refugia may result in an increase in the likelihood of skink predation, resulting in localised declines in skink populations at the solar farm site. We consider that current populations of lizards are under some level of predation pressure, with multiple skinks captured showing visible scaring or tail regeneration. No current predator control has occurred on site.

Considering the likely small size of the population of skinks in the solar farm site and likely small shift (if any) from the baseline predator activity during construction, we consider that increased predation will have a **Low** magnitude of effect on lizards with **Low** and **High** ecological value (at the site and ED scale), resulting in a **Very Low** to **Low** level of effect. Predator control is recommended as part of the solar farm site management (Section 8.1.4).

6.4 Terrestrial Invertebrates

As described in Section 4.5, site observations and assessment of the habitat types available suggest a fairly typical terrestrial invertebrate fauna in the main paddock area. In line with our expectation of a broadly similar plant species composition in the solar farm site (Section 6.1.2), we do not expect wholesale change to the quality or availability of terrestrial invertebrate habitat. Conservatively, the magnitude of change may reflect that of the vegetation itself, being a **Low** magnitude of effect, and hence a **Very Low** level of overall effect.

An additional possible impact in terms of the presence of the solar panel arrays themselves is the possibility that invertebrates may mistake panel arrays for water (similar to the ‘lake effect’ for birds). Concern was raised in a Hungarian study by Horvarth et al. (2009) that stream invertebrates were attracted to solar panels (in the study, panels had an uninterrupted uniform matte finish) and displayed maladaptive egg laying behaviour on solar panels near waterways; this was attributed to reflection of polarised light similar to the reflection from natural waterbodies where ordinary egg laying would occur. Subsequent work by the same authors (Horvarth et al. 2010, Száz et al. 2016) has shown that the use of white border / grid lines and antireflective coatings (both of which are to be used on the panels at the proposed Balmoral Solar Farm) reduce the attractiveness of panels to insects 10-26 fold, mitigating this possible issue substantially. Further, these studies generally raise concern for aquatic invertebrates only (species of mayflies, stoneflies, and long-legged flies), rather than the sorts of terrestrial invertebrates that occupy the actual solar farm footprint itself (main paddock area). Even the wetlands at the solar farm site are considered unlikely to support large populations of these stream invertebrate taxa, if any, because flowing stream channel habitat is absent. Wetland areas are to be set back from the solar arrays by >20 m, and the larger central wetland (likely the best potential stream insect habitat) is recessed into a gully generally several metres below panel height. On the basis of the sorts of terrestrial and stream invertebrate taxa that are likely present at the solar farm site, the solar farm site layout, and the use of grid lines and anti-reflective coatings on the panels to be used, we do not believe maladaptive egg laying or similar impacts to invertebrate (insect) breeding is a likely effect of this solar farm proposal.

6.5 Summary of Assessment of Effects on Terrestrial Ecology Values

Table 10 summarises the potential level of effect (assuming no mitigation) of the proposed activities on each of the ecological components.

Table 10. Assessment of level of effect without mitigation (i.e., without implementation of the further recommendations in 7.1, but assuming implementation of project shaping and site management recommendations as described in Section 2.11), for terrestrial ecology components.

Ecosystem Component	Ecological Value	Magnitude of Effect	Level of Effect
Terrestrial Ecosystems and Habitats			
Main grassland area – direct vegetation clearance in solar array area	Moderate	Negligible	Very Low
Main grassland area – change in vegetation composition in solar array area	Moderate	Low	Low
Wetland areas – retirement from grazing	Low-Moderate	Positive	Net Gain
Effects to Threatened plant species	Very High	Negligible	Low
Effects to At Risk plant species	High	Negligible	Very Low
Weed spread and establishment – all areas	Moderate	Low	Low
Birds			
Permanent habitat modification / loss	Low – Very High	Negligible	Very Low - Low
Disturbance and temporary displacement	Low – High	Negligible	Very Low
Nesting birds	Low – High	Negligible	Very Low
Bird strike with panels	Low – Very High	Negligible	Very Low - Low
Lizards			
Habitat alteration	Low – High	Low	Very Low - Low
Mortality during site preparation	High	Low	Low
Construction mortality	Low – High	Negligible	Very Low
Increased predation	Low – High	Low	Very Low - Low
Terrestrial Invertebrates			
Habitat alteration	Low	Low	Very Low

7.0 Recommendations and Residual Effects

7.1 Recommendations

The following impact management measures are recommended to avoid, minimise, remedy or mitigate any adverse effects of the proposed solar farm. These recommendations are in addition to the changes made to the solar farm layout and other site management changes recommended and adopted during the project shaping stage of the project (see Section 2.0, especially Section 2.11).

7.1.1 Avoid and Minimise

Terrestrial Vegetation

- Minimise direct vegetation clearance via press-in piling of solar panel array supports using the lightest possible machinery (to minimise soil compaction and damage to vegetation).
- The change from cattle to sheep grazing and the desire to minimise change to vegetation composition across the main paddock area will likely require an adaptive approach in terms of stocking rates. Precisely how to achieve this will be far better understood by the farmer than an ecologist, but we note that the existing indigenous species are generally highly tolerant of grazing, and in this context a tendency to overstock (rather than understock and allow rampant growth of exotic grasses) may be the preferred initial approach.

Weeds

- To prevent the introduction, establishment and spread of weeds:
    - Ensure all construction machinery is cleaned before it enters the solar farm site, including if machinery leaves the solar farm site temporarily (due to the presence of Russell lupin and other weeds along Braemar Rd).
    - Seed bare soil with grass (exotic browntop is already prevalent and most likely to establish rapid soil cover) following completion of trench installation and back-filling of topsoil.
    - Control weed species that establish along trenching works and vehicle tracks using appropriate control methods.
- Remove crack willow, Russell lupin, lotus, wilding conifers, and woody weeds (gorse, broom, sweet briar) from wetland and setback areas, and control incursions of these species across the entire site throughout the lifetime of the solar farm. This recommendation has already been adopted for wetland and setback areas as part of the proposal (see Section 2.7).

Birds

- Construction of solar panel arrays would ideally occur outside of the main bird breeding season (September – January), to avoid adverse effects to breeding indigenous birds in general, but particularly because there is a slight chance that indigenous bird species (At Risk pihoihoi / NZ pipit and tōrea / South Island pied oystercatcher) may breed at the solar farm site. However, this concern is of low probability and the competing need to avoid effects to lizards via construction when they are active (in the warmer months) makes this impractical. In this case, a pre-construction survey of the solar farm site could be carried out (within the week prior to the commencement of construction of each phase of the solar farm, if works commence during the breeding season[20] by an ecologist, in order to determine whether the above species (or any other indigenous bird species observed during the survey deemed of conservation concern) are breeding within the solar farm footprint. Subsequently;

  - If breeding pihoihoi / NZ pipit and tōrea / South Island pied oystercatcher (or other species of conservation concern) are absent, works could proceed within the breeding season; or
  - If breeding pihoihoi / NZ pipit and tōrea / South Island pied oystercatcher (or other species of conservation concern) are present within the solar farm footprint, works could proceed subject to setbacks from nests or other similar measures to avoid or otherwise manage impacts to breeding birds.

Lizards

- To avoid mortality of lizards during site preparation (disposal of slash piles) for Phase 1 and Phase 2, effective implementation of an appropriate Lizard Management Plan (LMP)[21] will be required to avoid effects. LMP measures may vary between Phase 1 and Phase 2, but regardless the LMP would identify key lizard mortality / injury risks (e.g., slash pile removal) and outline appropriate measures that, when effectively implemented, would avoid those risks.
  - During site preparation, we understand piles of tree slash currently in the main paddock will need to be removed. We recommend that, following appropriate lizard salvage from the slash piles or use of other similar methods by a herpetologist to ensure that slash pile removal is unlikely to cause lizard mortality[22], piles should be moved to another location.
  - This will need to occur in the warmer months (spring – autumn) to allow for lizard activity and effective salvage.
  - Once moved, piles should be burnt or otherwise completely removed from the solar farm site soon after relocation, to prevent recolonisation by skinks. Burning in situ, even following lizard salvage, may still result in lizard mortality (not all individuals

[20] If works commence outside the breeding season this is likely unnecessary because birds would be less likely to commence nesting within an active construction area.

[21] Because indigenous skinks are absolutely protected under the Wildlife Act 1953, such measures would require a Wildlife Act Authority (WAA) from DOC. Ordinarily, an agreed methodology is determined by consultation with DOC and stakeholders (including mana whenua) during preparation of a Lizard Management Plan that would be implemented in accordance with the WAA.

We note that WAAs are usually valid for up to 5 years, but Phase 2 construction may not take place within this timeframe. Further, the Wildlife Act 1953 is likely to be replaced within this timeframe. Accordingly, measures implemented for construction of Phase 1 may not apply to phase two. Further, it would be efficient to remove all slash piles from the entire site during construction of Phase 1, to simplify the process for construction of Phase 2.

While it is therefore not possible to forecast exactly what LMP measures would entail, their purpose would be to avoid lizard mortality resulting from solar farm site preparation and construction.

[22] See Footnote 21.

would likely be caught) and hence the preferred approach combines both salvage and gradual dismantling of each slash pile (uncaught individuals may naturally escape during careful deconstruction). If immediate burning is not possible (e.g., due to the time of year), piles should either be moved to a location away from any lizard habitat or have a lizard proof fence (e.g., polythene plastic pen (Knox and Monks, 2014)) placed around the slash piles, to prevent recolonisation.

  - Appropriate management of the effects of slash pile removal is likely all that is needed for Phase 1, because there is no other important lizard habitat is in this area. Once slash piles are removed, Phase 1 construction is unlikely to require further lizard management measures.

- Where possible, avoid removing areas of rocky habitat that provide quality refugia for lizards (e.g., rock piles, surface rocks, rocks along the manmade drainage ditch) located to the northwest of the wetland during construction of road and trenches or installation solar panels.
- Construction of the road and trenches and the installation of solar panels should be avoided outside of cold months (May – September) during periods where lizards would likely be relatively inactive and unable to move away from machinery or vehicles moving throughout the solar farm site.

7.1.2 Remediation

- Seed bare soil with appropriate grass species (browntop) following completion of any trenching or other earthworks and back-filling of topsoil. Sow grass seed at a time when revegetation is most likely to be successful (e.g., during autumn or spring when grass seed is most likely to strike and provide the best coverage) (the timing of remediation work will be important to minimise exposing bare ground to invasion by exotic weed species).

7.1.3 Mitigation

- Establishment of internal fencing along wetland and setback areas should take place during construction of Phase 1 so that vegetation recovery is well progressed prior to the establishment of Phase 2.
- Considering lizard densities within the main paddocks (excluding the slash piles) are likely low to very low and the size of the project area in both stages of construction, we consider lizard salvage and relocation to be an unsuitable management option and recommend lizard habitat restoration and compensation (Section 8.1.4) as an alternative.
- Lizard habitat enhancement:
  - Limited supplementary plantings along wetland edge areas are recommended to improve habitat for lizards. This would require planting small numbers of copper tussock and appropriate local sedge species (e.g., *Carex kaloides*) along the edge of the central wetland. Fruiting species including porcupine shrub (*Melicytus alpinus* agg.) should be planted on terrace risers to provide addition cover and food for lizards. No initial planting is recommended in the southwest wetland areas (however see Section 7.1.5 below).

- Installation of natural refugia along the edge of the central wetland area or in dry areas, including logs or rock piles will provide additional cover and suitable basking areas for lizards. Appropriately sized logs from the slash piles could be installed in wetland or dry areas to provide refugia. Suitably sized rocks (boulders with a variety of sizes to allow for the creation of crevices) collected into piles should also be placed around the wetland.

7.1.4 Compensation

- Implement predator control along the central wetland, likely in the form of a network of DOC200 traps (or similar, with mouse traps) with monthly bait checks and monitoring for the lifetime of the solar farm. This will ideally reduce predator pressure on lizards in the key habitat areas.

7.1.5 Monitoring

Monitoring **required** for effects management:

- Undertake regular (6 monthly) weed (particularly Russell lupin, broom and wilding conifer) surveillance and control across the solar farm site. It is recommended that surveillance commences 6 months after construction works and finishes 24 months following the completion for each stage of solar farm construction works. Regular weed surveillance and control should remain ongoing in wetland and setback areas for the life of the solar farm.
- To enable an appropriate management response in the event of bird strike by any At Risk or Threatened bird species in the solar farm footprint following construction and during the lifetime of the solar farm, and to generally obtain information about bird strike with solar panel arrays, the following measures are required:
    - Information about the dead or injured bird(s) shall be recorded, including species, number, date, time of day, photographs in situ, GPS location, and the suspected cause of death.
    - If an injured bird is discovered, the Department of Conservation shall be immediately contacted to obtain advice on what further actions to undertake[23].
    - If a dead bird is discovered, the Department of Conservation shall be contacted within 5 working days to arrange collection of the carcass, and conduct post mortem analysis, if required.
    - Records of all dead and injured birds found in the solar farm footprint shall be provided on an annual basis to Mackenzie District Council and to the Department of Conservation, and records kept by the solar farm operator for the lifetime of the solar farm.
    - Review / response measures: 3 years and 10 years following the construction of Phase 1, and 3 years and 10 years following the construction of Phase 2:
        - The solar farm operator should engage an ecologist to undertake a review of all available bird strike records and prepare a Bird Strike

[23] Due to Wildlife Act 1953 requirements, the handling of injured indigenous birds or the storage of dead indigenous birds would require approval from the Department of Conservation.

Report summarising, at a minimum, methods, findings, recommendations, and any further monitoring or mitigation. If there are no bird strike records available in the reporting period (i.e., 0-3 years or 3-10 years), the ecologist should conduct (and base their findings on) their own site surveys conducted at least 3-monthly for a minimum continuous period of 12 months.

- The Bird Strike Report and any recommendations should be prepared in consultation with Te Rūnanga o Arowhenua (or their agreed representatives) and provided to both Mackenzie District Council and to the Department of Conservation.

The purpose of this recommendation is to enable an appropriate response if adverse effects arise to species of conservation concern, and to increase the understanding of possible bird strike with solar arrays. It is not intended to apply to exotic or Not Threatened species, to which any ecological effect is likely to be Very Low and very unlikely to be of any conservation concern. We note that an intensive carcass monitoring programme (such as those typically used in wind farm developments) would be required to detect the precise degree of bird strike impacts with a high degree of confidence. Considering the lower likelihood and predicted Very Low to Low levels of effect, we do not consider that such a programme is required for this proposal.

Monitoring **not required** for effects management:

- Establish a number of vegetation monitoring plots within the solar array areas (under and between panels), in setback areas, and potentially another nearby control site, with monitoring ideally every 5-10 years. Vegetation changes (especially in setback areas) are likely to be slow, but this site provides an ideal opportunity to assess the actual effects of a solar farm on high-country vegetation. As applications for solar farms are likely to increase in coming years, the information gained would have substantial resource management, scientific, and even commercial value.
- The trajectory for establishment of wetland vegetation in the currently largely bare or grassy southwest wetlands is difficult to predict, and planting is not initially recommended. They may naturally develop bog rush communities (similar to the western area they are connected to) or ephemeral turf communities (unlikely given the existing level of grass cover in places and brief period of seasonal inundation), but in either case will likely be susceptible to spread of exotic soft rush and oval sedge (and similar wetland weeds). It is recommended that 5 years following establishment of the southwest wetlands setback area (construction of fencing and stock exclusion), that input is sought from an ecologist on whether a non-interference approach remains appropriate, or whether targeted wetland plantings and / or additional weed control would be of benefit.

7.2 Assessment of Residual Effects

The following table summarises the results of Sections 4, 5, 6, 7, and 8. It provides an assessment of the residual impact with the recommended impact management measures implemented for adverse ecological effects, with emphasis on effects assessed as being greater than 'very low.'

Table 11. Summary of predicted impacts, proposed mitigation and residual effects after the implementation of impact avoidance, minimisation and mitigation measures.

Subject or Location of Impact	Predicted Impact Without Impact Management Measures	Summary of Impact Management Measures Recommended	Residual Effects After Implementation of Impact Management Measures
Terrestrial Vegetation			
Main paddock area	Change in vegetation composition due to microclimatic and shading effects beneath panels; **Low** level effects overall.	Allow vegetation recovery in setback areas, modify stock grazing rates to ensure exotic grasses are regularly supressed.	Effects to vegetation due to solar panels may be unavoidable to a degree; **Low** level effects likely to remain.
Effects to Threatened Plant species	Potential for reduction in habitat quality for dryland sow thistle could be of **Low** magnitude due to this species being nationally Threatened.	No specific actions recommended; habitat for the species in setback areas likely to improve in quality.	Effects to this species would be mitigated in dryland areas but not totally avoided; **Low** level effects.
Weed spread and establishment during construction	Potential for introduction of new weeds or spread of existing weeds on machinery and in disturbed areas (e.g., trenches); **Low** level effect.	Clean machinery before bringing it on site, immediately re-sow backfilled trenches in browntop, monitor 6-monthly for 24 months post construction.	Effects avoided by implementation of recommendations.
Weeds – central and southwest wetlands	Potential for spread of existing weeds due to exclusion of grazing; effect avoided assuming implementation of site management measures.	Weed control in wetland and setback areas has already been adopted as part of the proposal (see Section 2.2.2).	Effects avoided by implementation of project shaping recommendations.
Avifauna			
Nesting birds	Low likelihood of Very Low level impacts to nesting indigenous birds, if present.	Conduct pre-construction nesting bird survey and avoid construction in nesting areas until breeding has naturally ceased.	Effects avoided if either recommendation is adopted.
Bird strike	Unknown but possible bird strike with panels, likely affecting very small numbers of birds if any, but potentially affecting wetland bird species; effects up to a **Low** level if a	Monitoring for actual occurrence of bird strike and a process for a 3- and 10-yearly review of bird strike records (for each of Phase 1 and Phase 2) enables an appropriate	Effects may at worst remain at **Low** levels, but with measures in place to ensure response in the event effects are greater than predicted.

Subject or Location of Impact	Predicted Impact Without Impact Management Measures	Summary of Impact Management Measures Recommended	Residual Effects After Implementation of Impact Management Measures
	Threatened species were to be affected.	response to any detected effect.	
Lizards			
Habitat alteration	Potential for losses in skink habitat due to shading by panels (loss of basking area) and potential for changes to vegetation composition. **Low** level of effect.	Addition of natural refugia in areas of lizard habitat where construction has occurred and around laydown area to supplement temporary loss in refugia. Habitat enhancement, including planting and provision of refugia around retained wetland areas.	Effects to lizards will be minimised with supplementary refugia. **Very Low** level residual effects.
Slash pile burning mortality	Potential for mortality of skinks occupying slash piles from burning. High magnitude of effect at site scale, but **Low** level of effect at ED scale, requiring management.	Dismantle and move slash piles before burning. Capture and relocate lizards within the piles during dismantling (potential methods, to be described in a Lizard Management Plan, LMP). Prevent lizards from re-entering piles by moving piles away from lizard habitat or fencing the pile to exclude lizards.	Effects avoided if recommendations are adopted and implemented via an LMP under authorisation from DOC. **Very Low** level effects at both site and ED scale.
Construction mortality	**Very Low** level of effect to local skink population due to potential of vehicular or machinery movements killing or injuring skinks.	Avoid construction during colder months (May-September).	Effects on lizards would be minimised by implementing recommendations. Residual **Very Low** level effects at both site and ED scale.
Increased predation	Potential for predation on skinks to increase due to lack of refugia following removal of slash piles. **Moderate** level of effect.	Long term predator control for duration of solar farm in key lizard habitat areas (i.e. wetland areas).	Effect of predation pressure would be reduced. **Very Low** to **Low** level effects.

8.0 Summary and Conclusion

Infratec and Lake Tekapō Enterprises are proposing to construct and operate a solar farm that would occupy c.95 ha of a c.111 ha site at Balmoral Station, Tekapo. The solar farm would be built in two stages some years apart, but this assessment largely considers the proposal as a whole. As yet, no such solar farm development has occurred in the Mackenzie Basin, where recent land use changes have caused widespread concern over the loss of important indigenous habitats. Accordingly, the solar farm site selected for this development is an already-modified habitat.

The proposed solar farm site at 'Irishman Paddocks' on Braemar Rd is actively farmed, and the original (pre-European) vegetation of the area has been modified for pastoral improvement (including by OSTD and direct drilling), but the solar farm site has not been fully cleared of indigenous vegetation. Hence, indigenous plant species (particularly fescue tussock, copper tussock, and a range of locally common and widespread inter-tussock species) remain prevalent across the 'main paddock area' of the solar farm site where solar panel arrays and other infrastructure would be constructed. This main paddock area contains three broad indigenous vegetation types including grasslands with fescue tussock or copper tussock, and herbfields on dry raised areas dominated by exotic mouse-ear hawkweed. These vegetation types are of **Moderate** ecological value despite the overall dominance of exotic pasture species. Of note is that several plant species present in the main paddock are classified as being nationally At Risk and one is nationally Threatened. Three wetland areas are present at the site. A central wetland contains Threatened and At Risk wetland plant species, but two more modified southwest areas are of lower value as they are dominated by exotic wetland plants. All wetland areas along with a c.20 m setback of dryland habitat (14.5 ha in total) would not form part of the solar farm development. Instead, these wetland and setback areas would be protected and expected to recover in terms of habitat quality and indigenous vegetation cover in the absence of cattle particularly, and all grazing including by rabbits / hares would be excluded.

A limited range of fauna currently uses the main paddock area, with a small number of indigenous bird species likely to occupy the solar farm site in low numbers. Very low numbers of southern grass skink are present in the main paddock, but it appears that this is almost entirely in artificial habitats (habitats inadvertently created by old shelterbelt slash piles, and construction of a ditch). If lizards occur more widely in central areas of the main paddock it is likely they are in extremely low numbers. In the central wetland, habitat is potentially available for a somewhat greater range of bird species, and low numbers of southern grass skink and also very low numbers of McCann's skink are present. Invertebrates in main paddock areas of the solar farm site appear typical of modified short tussock grasslands; the solar farm site lacks intact or distinctive invertebrate habitat.

The main paddock area where development would take place occurs on moraine and alluvial deposit landforms. The vegetation in the main paddock meets the definition of both 'improved pasture' and 'indigenous vegetation' and is therefore ecologically significant under MDP PC18 rules (it also meets CRPS significance criteria).

The ecological effects of the solar farm to vegetation include direct vegetation clearance amounting to approx. 2.7 ha in total (permanent loss would be around 1.3 ha), a **Very Low** level effect. Clearance of the solar farm site is not required as solar panel arrays are piled directly into the existing substrate. Nevertheless, the panels themselves are highly likely to exert microclimatic effects that may drive changes in vegetation composition towards the growth of exotic grasses and indigenous and exotic herbs, particularly beneath panels. Vegetation in areas between panels (panels would directly cover around half the area) would likely remain largely similar, maintaining habitat for At Risk plant species (which would persist, and would be expected to have improved habitat in time, in proposed setback areas). Effects to vegetation especially beneath panels would be mitigated to a degree by changes to site grazing management (exclusion of cattle). Overall, these indirect effects to indigenous vegetation would amount to a **Low** level of effect. Further, all species and habitats present at the solar farm site are widespread and frequently far more intact across the surrounding area and at the level of the ED. Following construction, weed spread and establishment is possible, and post-construction monitoring and control is recommended.

The solar farm development has the potential to cause the loss of part of a low-quality habitat for some bird species, and construction disturbance to feeding and nesting is possible (avoidance of construction during the nesting season, or pre-construction checks, are recommended). The possibility of bird strike to solar panel arrays has been considered in light of international studies and the local context. We are uncertain whether bird strike effects could occur, but if it does, it may have **Low** level effects. Post construction monitoring and response measures (if this effect were to occur) are recommended.

The effect on lizards (most likely southern grass skink and McCann's skink) due to the construction of the solar farm and the alteration of lizard habitat is likely to be of a Negligible magnitude and **Very Low** level of effect. However, the level of effect in terms of possible lizard mortality during site preparation is considered of potentially **Low** level at the scale of the ED (and higher at the site scale), for example if existing slash piles that currently provide habitat are burnt. However, dismantling and moving piles following appropriate lizard salvage (as proposed) would substantially reduce the level of effect to a **Very Low** level at both scales. Construction mortality due to machinery movements is considered to be of a **Very Low** level of effect and could be minimised by avoiding construction in cold weather. The effect of potentially increased predation rates could be reduced through predator control throughout the wetland areas where lizards are present in higher numbers, and by creation of suitable habitat refugia (to replace that lost by slash pile removal). Effective implementation of these measures would reduce the level of effect to lizard species to **Very Low**.

Effects to invertebrates due to the solar panel arrays have also been considered, but are not of ecological concern in the context of this proposal.

Overall, the level of effect of the construction and operation of the proposed solar farm on ecological values, with implementation of project shaping, site management, and other recommendations, is generally expected to be **Very Low** to **Low** in the solar farm footprint, but would constitute a **Net Gain** in wetland and setback areas. The setting aside of a portion of the solar farm site for habitat enhancement mitigates to a degree the likely changes in vegetation induced by the prolonged presence of solar panel arrays across a relatively large area. Even though the proposal is for a large infrastructure project, our assessment of at-worst **Low** level effects considers the already modified nature of the solar farm site but also the relatively insignificant direct impacts of earthworks and site clearance required to construct the solar panel arrays. Indirect effects to vegetation are the main likely ongoing effect of the proposal; adverse effects to fauna can be avoided or otherwise managed by pre-construction management or post-construction monitoring measures.

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Appendix 1: Plant Species List and Vegetation Plot Data

Overall Species List

Table 1. Plant species list for the main paddock area, central wetland (partial species list) and southwest wetlands (partial species list).

Species name (*exotic species)	Common name	Threat Status	Growth Form	Abundance in main paddock area (fescue tussock grassland / copper tussock grassland / herbfield)
Main paddock area (Solar farm site excluding wetlands, but including dryland setback areas)				
Aciphylla subflabellata	Grassland spaniard	At Risk - Declining	Grass	r (setback areas only) / - / -
*Agrostis capillaris**	Browntop		Grass	f-a / o-f / o-f
*Anthoxanthum odoratum**	Sweet Vernal		Grass	f-a / f-a / o-f
Brachyglottis haastii		Not Threatened	Dicot Herb	r / - / r
*Bromus diandrus**	Ripgut Brome		Grass	r-o / r / r
Carex breviculmis	Grassland Sedge	Not Threatened	Sedge	r / - / -
Carex species	Unidentified Sedge or Hook-grass		Sedge	r / r / r
Carex muelleri	Muellers Sedge	Not Threatened	Sedge	r-o / r / r
Celmisia gracilenta	Common Mountain Daisy	Not Threatened	Dicot Herb	r / r / r
*Cerastium fontanum**	Mouse-ear Chickweed		Dicot Herb	r / r / r
Chionochloa rubra subsp. *cuprea*	Copper Tussock	Not Threatened	Grass	r / a / -
Cladia aggregata		Not Threatened	Non Vascular	r / r / r
Colobanthus brevisepalus	Pin Cushion	At Risk - Declining	Dicot Herb	- / - / r
Coprosma petriei	Turfy Coprosma	Not Threatened	Low Shrub	r / r / r
Craspedia lanata var. *lanata*	Woollyhead	Not Threatened	Dicot Herb	r / r / r
Craspedia uniflora var. *uniflora*	Woollyhead	Not Threatened	Dicot Herb	r / r / -
*Dactylis glomerata**	Cocksfoot		Grass	r / r / r

Species name (*exotic species)	Common name	Threat Status	Growth Form	Abundance in main paddock area (fescue tussock grassland / copper tussock grassland / herbfield)
Discaria toumatou	Matagouri	At Risk - Declining	Shrub / Tree	r / - / -
*Draba verna**			Dicot Herb	r / r / r
Festuca novae-zelandiae	Fescue Tussock	Not Threatened	Grass	f-a / o-f / r
*Festuca rubra**	Chewings Fescue		Grass	o / o / r
Gentianella corymbifera		Not Threatened	Dicot Herb	r / r / r
Geranium brevicaule	Short-Flowered Cranesbill	Not Threatened	Dicot Herb	r / r / r
*Grass species**	Unidentified Exotic Grass		Grass	r / - / -
Hypnum cupressiforme			Non Vascular	r / r / r
*Hypochaeris radicata**	Catsear		Dicot Herb	r / r / r
Lagenophora cuneata		Not Threatened	Dicot Herb	r / r / -
Leptinella pectinata subsp. *villosa*		Not Threatened	Dicot Herb	r / - / r
Leucopogon fraseri	Patotara	Not Threatened	Low Shrub	r-o / r / r-o
Leucopogon nanum		At Risk - Declining	Low Shrub	r / - / r
Lichen species			Non Vascular	r / r / r
*Lotus species**	Lotus		Dicot Herb	r / - / -
Luzula rufa	Red Woodrush	Not Threatened	Rush	r / r / r
Microseris scapigera		Not Threatened	Dicot Herb	r / - / -
Moss species			Non Vascular	r / r / r
Muehlenbeckia axillaris	Creeping Pōhuehue	Not Threatened	Climber/Vine	r / - / -
*Myosotis discolor**	Grassland Forget-Me-Not		Dicot Herb	r / r / r
Ophioglossum coriaceum	Adders Tongue	Not Threatened	Fern	r / - / -
Ozothamnus leptophyllus	Tauhinu	Not Threatened	Shrub	r / - / -
*Pilosella officinarum**	Mouse-ear Hawkweed		Dicot Herb	f-a / a / f
Pilosella piloselloides subsp. *praealta**	King Devil		Dicot Herb	r-o / r / r
Pimelea oreophila		Not Threatened	Low Shrub	r-o / r / r
*Pinus nigra**	Black Pine		Tree	r / o / -

Species name (*exotic species)	Common name	Threat Status	Growth Form	Abundance in main paddock area (fescue tussock grassland / copper tussock grassland / herbfield)
Plantago raoulii		Not Threatened	Dicot Herb	r / r / r
Poa colensoi	Blue Tussock	Not Threatened	Grass	o-f / o / r
Poa lindsayi	Lindsays Poa	Not Threatened	Grass	r / - / -
Poa maniototo	Desert Poa	Not Threatened	Grass	r / - / r
*Poa pratensis**	Kentucky Bluegrass		Grass	r / r / r
Polytrichum juniperinum			Non Vascular	r-o / r / o
Prasophyllum colensoi	Leek Orchid	Not Threatened	Orchid	r / r / r
Pterostylis tanypoda		At Risk - Declining	Orchid	r / r / r
Pterostylis tristis		At Risk - Declining	Orchid	r / - / -
Raoulia parkii	Celadon Mat Daisy	At Risk - Declining	Dicot Herb	- / - / r
Raoulia hookeri var. *hookeri*		Not Threatened	Dicot Herb	r / - / -
Raoulia subsericea	Turf Mat Daisy	Not Threatened	Dicot Herb	r / r / r
Rosulabryum species	Moss		Non Vascular	r / r / r
*Rumex acetosella**	Sheeps Sorrel		Dicot Herb	r / r / r
Rumex flexuosus	Maori Dock	Not Threatened	Dicot Herb	r / - / -
Rytidosperma exiguum	Mountain Twitch	At Risk - Declining	Grass	r-o / r / r
Rytidosperma pumilum		Not Threatened	Grass	r / r / r
Sonchus novae-zelandiae	Dryland Sow Thistle	Threatened - Nationally Vulnerable	Dicot Herb	r / - / -
Stackhousia minima		Not Threatened	Dicot Herb	r / r / -
*Taraxacum officinale**	Dandelion		Dicot Herb	r / r / r
Thelymitra species			Orchid	r / r / r
*Trifolium arvense**	Haresfoot Trefoil		Dicot Herb	r / r / r-o
*Trifolium dubium**	Suckling Clover		Dicot Herb	r-o / r / r
*Trifolium hybridum**	Alsike Clover		Dicot Herb	o / o / r
*Trifolium repens**	White Clover		Dicot Herb	o / o / o
*Veronica verna**	Spring Speedwell		Dicot Herb	r / r / r

Species name (*exotic species)	Common name	Threat Status	Growth Form	Abundance in main paddock area (fescue tussock grassland / copper tussock grassland / herbfield)
Viola cunninghamii	Mountain Violet	Not Threatened	Dicot Herb	r / r / -
*Vulpia bromoides**	Vulpia Hair Grass		Grass	r / r / r
Wahlenbergia albomarginata subsp. *albomarginata*	New Zealand Harebell	Not Threatened	Dicot Herb	r / r / r
Central wetland area (partial species list only)				
Aciphylla subflabellata	Spaniard	At Risk - Declining	Dicot Herb	n/a
*Agrostis capillaris**	Browntop		Grass	
*Agrostis stolonifera**	Creeping Bent		Grass	
*Alopecurus aequalis**	Orange Foxtail		Grass	
Carex kaloides		At Risk - Declining	Grass	
*Carex leporina**	Oval Sedge		Sedge	
Centipeda minima		Threatened - Nationally Endangered	Dicot Herb	
Eleocharis acuta	Sharp Spike Sedge	Not Threatened	Sedge	
Epilobium angustum	Willowherb	At Risk - Naturally Uncommon	Dicot Herb	
Gonocarpus micranthus subsp. micranthus		Not Threatened	Dicot Herb	
Isolepis species			Rush	
*Juncus articulatus**	Jointed Rush		Rush	
*Juncus conglomeratus**	Soft Rush		Rush	
Plantago triandra	Glossy Plantain	Not Threatened	Dicot Herb	
Ranunculus species			Dicot Herb	
Rumex flexuosus	Maori Dock	Not Threatened	Dicot Herb	
Schoenus pauciflorus	Bog Rush	Not Threatened	Rush	
Southwest wetland area (partial species list only)				
*Agrostis capillaris**	Browntop		Grass	n/a
*Alopecurus aequalis**	Orange Foxtail		Grass	
*Anthoxanthum odoratum**	Sweet Vernal		Grass	

Species name (*exotic species)	Common name	Threat Status	Growth Form	Abundance in main paddock area (fescue tussock grassland / copper tussock grassland / herbfield)
Carex coriacea	Rautahi / Cutty Grass	Not Threatened	Sedge	
*Carex leporina**	Oval Sedge		Sedge	
Eleocharis acuta	Sharp Spike Sedge	Not Threatened	Sedge	
*Juncus articulatus**	Jointed Rush		Rush	
*Juncus conglomeratus**	Soft Rush		Rush	
Moss species			Non Vascular	
Rumex flexuosus	Maori Dock	Not Threatened	Dicot Herb	
*Trifolium species**	Clover Species		Dicot Herb	

Plot Data

Table 2. Plot data for vegetation plots in the main paddock area. Species status is denoted in a separate column rather than by use of an '*' for exotic species, as was used above.

					Plot Location Within Main Paddock Area													
					East of Central Wetland							West of Central Wetland						
					Vegetation Plot Number													
Plant Species					**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**
Tier 5A - Species 1 m-2 m tall																		
				Overall cover				**1**										
Species	**Common name**	**Growth Form**	**Species Status**	**Threat Status**														
Chionochloa rubra subsp. cuprea	Copper Tussock	Grass	Indigenous	Not Threatened				1										
Tier 5B - Species 30 cm-1 m tall																		
				Overall cover	**3**	**2**	**1**	**3**	**1**	**1**		**1**	**1**	**2**	**2**	**1**	**2**	**3**
Species	**Common name**	**Growth Form**	**Species Status**	**Threat Status**														
*Agrostis capillaris**	Browntop	Grass	Exotic														1	
Carex muelleri	Muellers Sedge	Grass	Indigenous	Not Threatened								1						
Chionochloa rubra subsp. cuprea	Copper Tussock	Grass	Indigenous	Not Threatened		2		3										
Festuca novae-zelandiae	Fescue Tussock	Grass	Indigenous	Not Threatened	3		1		1	1		1	1	2	2	1	2	3
*Festuca rubra**	Chewings Fescue	Grass	Exotic					1										
*Pinus nigra**	Black Pine	Tree	Exotic			1		1										
Poa colensoi	Blue Tussock	Grass	Indigenous	Not Threatened				1				1	1	1	1		1	1
Tier 6A - Species 10-30 cm tall																		
				Overall cover	**3**	**4**	**3**	**3**	**1**	**2**	**1**	**3**	**2**	**4**	**4**	**3**	**4**	**4**

Species	Common name	Growth Form	Species Status	Threat Status														
*Agrostis capillaris**	Browntop	**Grass**	**Exotic**		1	2			1		1	2	1	1	2	1	2	3
*Anthoxanthum odoratum**	Sweet Vernal	**Grass**	**Exotic**		1	2	1	2		1		1	1	1	1	1	1	2
Carex muelleri	Muellers Sedge	Grass	Indigenous	Not Threatened			1		1	1		2					1	
Celmisia gracilenta	Common Mountain Daisy	Dicot Herb	Indigenous	Not Threatened			1									1		
Chionochloa rubra subsp. cuprea	Copper Tussock	Grass	Indigenous	Not Threatened		3		3										
*Dactylis glomerata**	Cocksfoot	Grass	Exotic		1													
Festuca novae-zelandiae	Fescue Tussock	Grass	Indigenous	Not Threatened	3	2	3		1	2		3	2	4	4	3	4	4
*Festuca rubra**	Chewings Fescue	Grass	Exotic			2		3							1			1
*Pilosella piloselloides subsp. praealta**	King Devil	Dicot Herb	Exotic															1
*Pinus nigra**	Black Pine	Tree	Exotic			1		1										
Poa colensoi	Blue Tussock	Grass	Indigenous	Not Threatened			1	2	1	1		2	2	1	2	1	2	3
Prasophyllum colensoi	Leek Orchid	Orchid	Indigenous	Not Threatened			1					1		1	1		1	
*Trifolium hybridum**	Alsike Clover	Dicot Herb	Exotic													1		
*Trifolium repens**	White Clover	Dicot Herb	Exotic												1	1		
Thelymitra species		Orchid	Indigenous										1	1				
Tier 6B - Species <10 cm tall																		
				Overall cover	**6**	**6**	**6**	**6**	**6**	**5**	**6**	**6**	**6**	**4**	**6**	**3**	**6**	**6**
Species	**Common name**	**Growth Form**	**Species Status**	**Threat Status**														
Aciphylla aurea	Golden Spaniard	Dicot Herb	Indigenous	Not Threatened		1								1				
Agrostis capillaris	Browntop	Grass	Exotic		2	3	2	2	2	3	4	4	4	1	3	3	4	4
Anthoxanthum odoratum	Sweet Vernal	Grass	Exotic		3	4	3	3	2	1	2	3	3	3	3	2	3	3

Carex breviculmis	Grassland Sedge	Grass	Indigenous	Not Threatened				1	1					1			1	1
Carex species	Unidentified Carex (*Carex colensoi*?)	Grass	Indigenous						1									
Carex muelleri	Muellers Sedge	Grass	Indigenous	Not Threatened			1	1	1	1		2		1		1	1	1
Celmisia gracilenta	Common Mountain Daisy	Dicot Herb	Indigenous	Not Threatened			1	1						1	1	3	1	1
Cerastium fontanum	Mouse-ear Chickweed	Dicot Herb	Exotic						1	1	1					1	1	
Chionochloa rubra subsp. cuprea	Copper Tussock	Grass	Indigenous	Not Threatened		4		3										
Cladia aggregata		Non Vascular	Indigenous						1	1	1		1			1		
Colobanthus brevisepalus	Pin Cushion	Dicot Herb	Indigenous	At Risk - Declining					1									
Coprosma petriei	Turfy Coprosma	Shrub	Indigenous	Not Threatened			1	1	2	1			1				1	1
Craspedia uniflora	Woolyhead	Dicot Herb	Indigenous	Not Threatened				2										
Dactylis glomerata	Cocksfoot	Grass	Exotic		2													
Discaria toumatou	Matagouri	Tree	Indigenous	At Risk - Declining											1			
Draba verna		Dicot Herb	Exotic						1		1							
Festuca novae-zelandiae	Fescue Tussock	Grass	Indigenous	Not Threatened	3	2	4		1	2		3	2	3	4	3	4	4
Festuca rubra	Chewings Fescue	Grass	Exotic		2			3					1		1	1		2
Gentianella corymbifera		Dicot Herb	Indigenous	Not Threatened				1										
Geranium brevicaule	Short-Flowered Cranesbill	Dicot Herb	Indigenous	Not Threatened			1					1		1		1		
Grass species (*Bromus diandrus?*)	Unidentified Grass	Grass	Exotic?		2		1			1		1	1	1	1	1	2	1
Hypnum cupressiforme		Non Vascular	Indigenous		1		1						1					
Hypochaeris radicata	Catsear	Dicot Herb	Exotic		1	1	1							1	1	1		1

Leptinella pectinata subsp. villosa		Dicot Herb	Indigenous						1		1							
Leucopogon fraseri	Patotara	Shrub	Indigenous	Not Threatened	1	1	1	1	1	1		1	1	1	1	1	1	1
Leucopogon nanum		Shrub	Indigenous	At Risk - Declining							1					1		
Lichen species		Non Vascular	Indigenous					1	1			1		1	1	1		
Lotus species		Dicot Herb	Exotic											1				
Luzula rufa	Red Woodrush	Grass	Indigenous		1	1	1	1			1				1	1	1	
Microseris scapigera		Dicot Herb	Indigenous	Not Threatened				1										
Moss species		Non Vascular	Indigenous		1		1	1	1		2		1		2		1	1
Muehlenbeckia axillaris	Creeping Pōhuehue	Climber/Vine	Indigenous	Not Threatened					1									
Myosotis discolor	Grassland Forget-Me-Not	Dicot Herb	Exotic						1	1	1		1			1		
Ophioglossum coriaceum	Adders Tongue	Fern	Indigenous	Not Threatened												1		
Pilosella officinarum	Mouse-ear Hawkweed	Dicot Herb	Exotic		4	2	4	4	5	5	4	4	4	3	4	4	4	4
Pilosella piloselloides subsp. praealta	King Devil	Dicot Herb	Exotic		3		2	2	2			2	1	1	2	1	2	3
Pimelea species		Shrub	Indigenous		1													
Pimelea oreophila		Shrub	Indigenous	Not Threatened			1	1		1		1		1	1	1	1	1
Pinus nigra	Black Pine	Tree	Exotic			1		1							1		1	
Plantago raoulii		Dicot Herb	Indigenous	Not Threatened												1		
Poa colensoi	Blue Tussock	Grass	Indigenous	Not Threatened	1	1	1	2	1	2	1	2	2	1	2	1	2	3
Poa lindsayi?	Lindsays Poa	Grass	Indigenous	Not Threatened											1			
Poa maniototo	Desert Poa	Grass	Indigenous	Not Threatened						1	1							
Poa pratensis	Kentucky Bluegrass	Grass	Exotic									2	1					

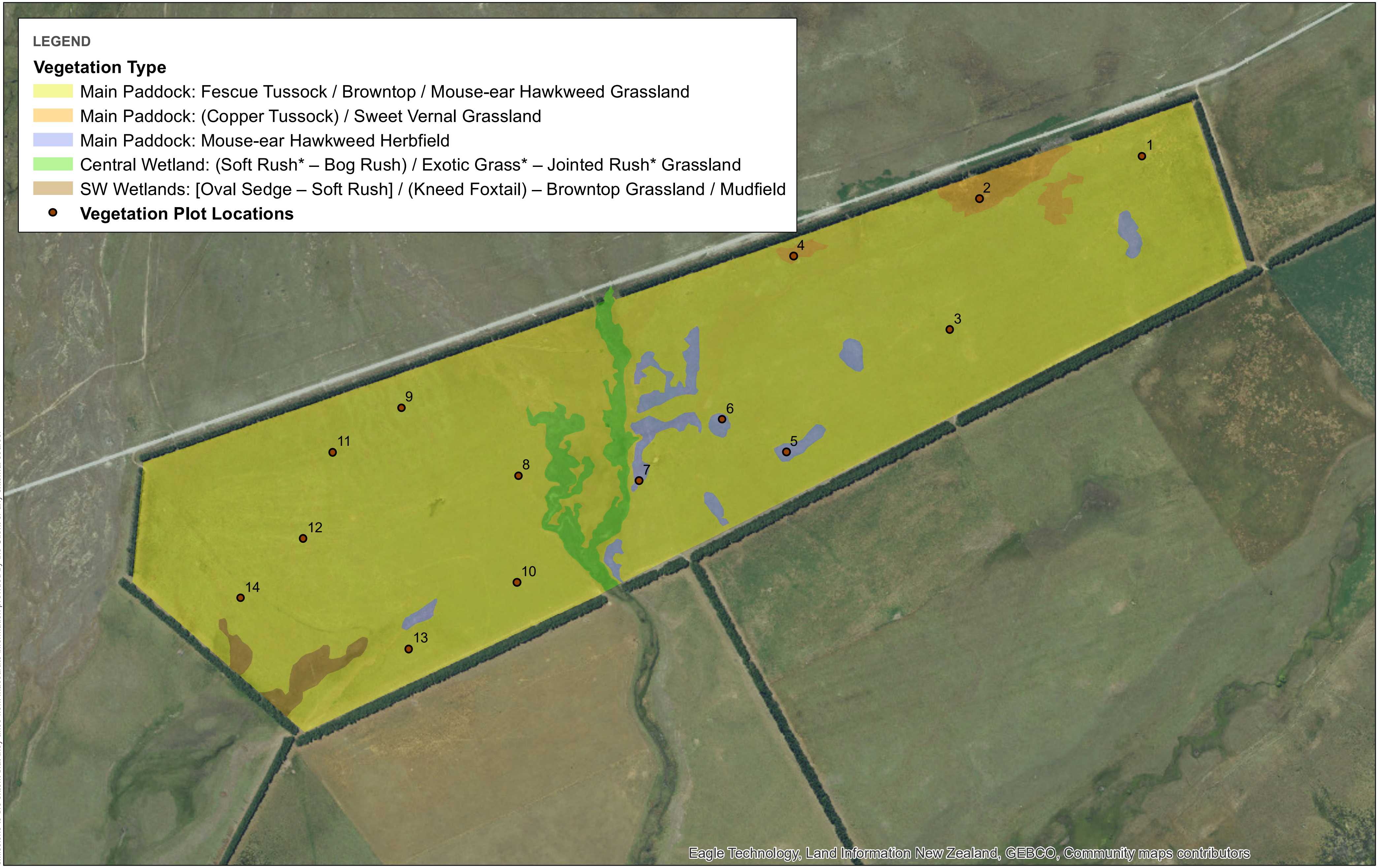
Polytrichum juniperinum		Non Vascular	Indigenous		1			2	3	2	1		3		1	2	1	1
Prasophyllum colensoi	Leek Orchid	Orchid	Indigenous	Not Threatened		1	1	1				1	1	2	1	1	1	
Pterostylis tanypoda		Orchid	Indigenous	At Risk - Declining			1	1	1				1			1		
Pterostylis tristis?		Orchid	Indigenous	At Risk - Declining												1		
Raoulia parkii	Celadon Mat Daisy	Low Shrub	Indigenous	At Risk - Declining					1	1								
Raoulia subsericea	Turf Mat Daisy	Low Shrub	Indigenous	Not Threatened			1							1				
Rosulabryum species	Moss	Non Vascular	Indigenous				1		1				1		1	1		1
Rumex acetosella	Sheeps Sorrel	Dicot Herb	Exotic		1		1		2	2	2		1	1		1	1	
Rytidosperma exiguum	Mountain Twitch	Grass	Indigenous	At Risk - Declining	1		2		2	1	1	1		1	2	3	1	1
Rytidosperma pumilum		Grass	Indigenous	Not Threatened					1	1		1	1					1
Stackhousia minima		Dicot Herb	Indigenous	Not Threatened	1			1										
Taraxacum officinale	Dandelion	Dicot Herb	Exotic		1							1						
Thelymitra species		Orchid	Indigenous								1					1		
Trifolium arvense	Haresfoot Trefoil	Dicot Herb	Exotic						1	1								
Trifolium dubium	Suckling Clover	Dicot Herb	Exotic						1		1		1			1		
Trifolium hybridum	Alsike Clover	Dicot Herb	Exotic		2		1	2	1	1		1	1	1	1	1	1	2
Trifolium repens	White Clover	Dicot Herb	Exotic		2	1	2	1		1		1	3	4		1	1	2
Veronica verna	Spring Speedwell	Dicot Herb	Exotic						1	1	2							
Viola cunninghamii	Mountain Violet	Dicot Herb	Indigenous	Not Threatened				1										
Wahlenbergia albomarginata	New Zealand Harebell	Dicot Herb	Indigenous	Not Threatened	1		1	1				2	1	1	1	1		1

Table 3. Plot descriptions, vegetation types, and overall cover data for vegetation plots in the main paddock area. Vegetation type a: Fescue tussock / browntop / mouse-ear hawkweed grassland; b) (copper tussock) / sweet vernal grassland; and c) mouse-ear hawkweed herbfield.

	Plot Location Within Main Paddock Area													
	East of Central Wetland							**West of Central Wetland**						
	Vegetation Plot Number													
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**
Vegetation type	**a**	**b**	**a**	**b**	**c**	**c**	**c**	**a**	**a**	**a**	**a**	**a**	**a**	a
Cover analysis														
Overall Vegetation Cover (%)	95	95	97	90	77	74	77	93	89	92	94	85	96	87
Non-vascular Vegetation (%)	1	0	0	2	8	5	5	0	6	0	2	3	0	0
Litter (%)	2	2	1	5	1	1	2	5	2	2	1	2	2	8
Bare Ground %	0	0	0	1	10	15	10	0	0	5	0	4	0	1
Rock (%)	0	1	1	1	2	2	4	0	0	0	0	1	0	0
Dung (%)	2	2	1	1	2	3	2	2	3	1	3	5	2	4
Species analysis														
Indigenous species	11	7	17	20	19	12	10	11	13	14	15	21	13	14
Exotic species	12	6	9	8	12	11	9	9	12	10	9	13	10	9
% indigenous species	48%	54%	65%	71%	61%	52%	53%	55%	52%	58%	63%	62%	57%	61%

Appendix 2: Vegetation Map

File Ref: BM200509F_005_A4L_Vegetation_Map.mxd



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Data Sources: Infratec, LINZ Data Service

Projection: NZGD 2000 New Zealand Transverse Mercator

LTE Solar Farm Ecology

Vegetation Types and Plot Locations

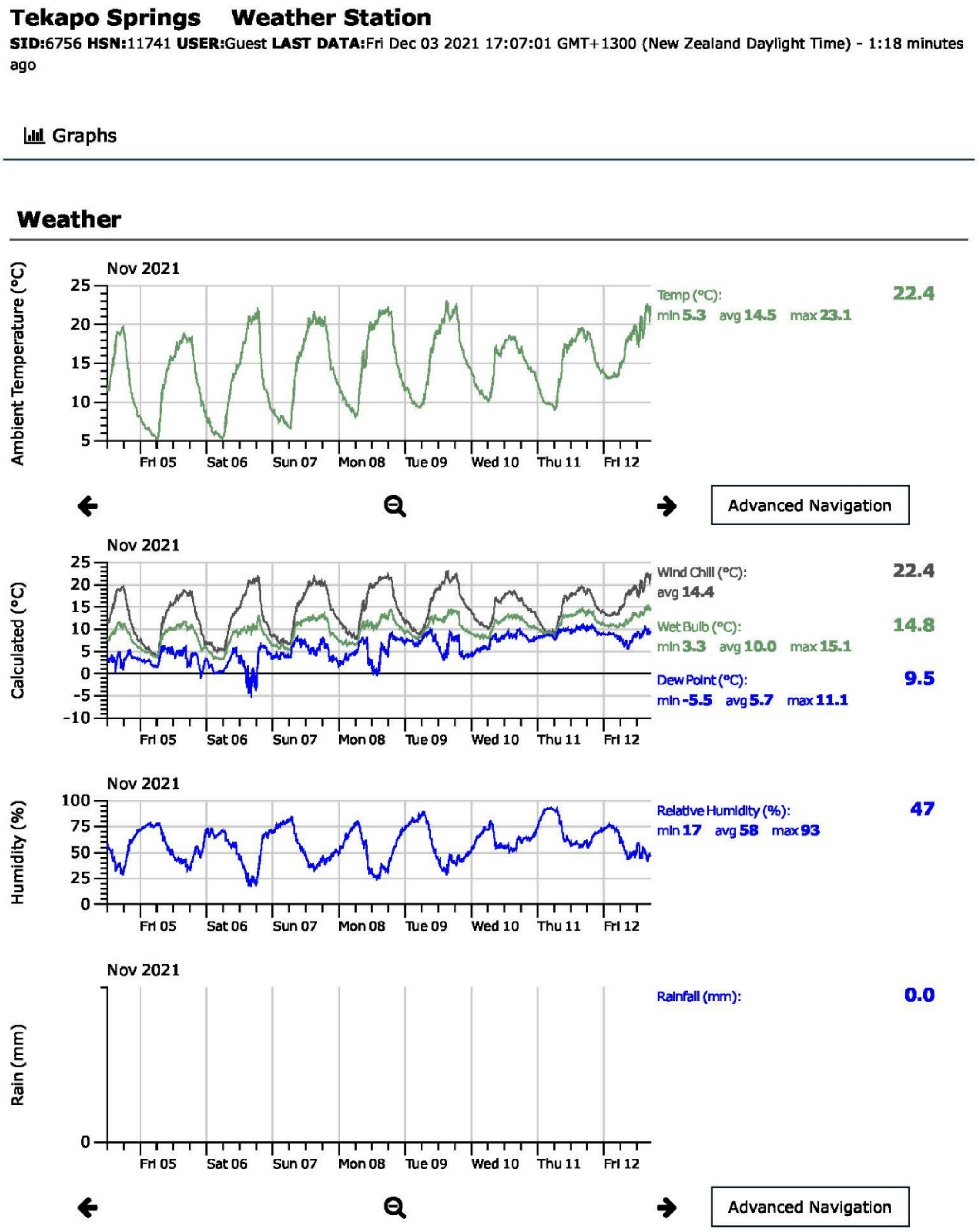
Date: 23 February 2021 | Revision: 1

Plan prepared for Infratec by Boffa Miskell Limited

Project Manager: claire.kelly@boffamiskell.co.nz | Drawn: JMo | Checked: SHo

Figure A1

Appendix 3: Weather Records During Lizard Tracking Tunnel Survey and Pitfall Trap Survey



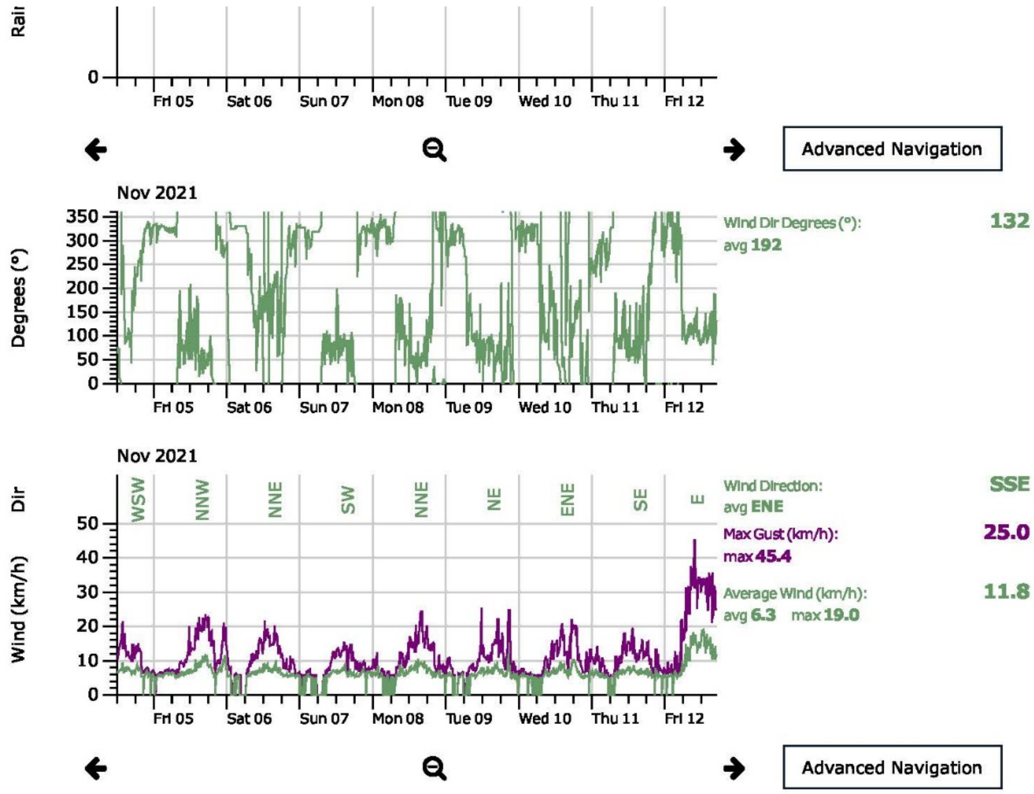


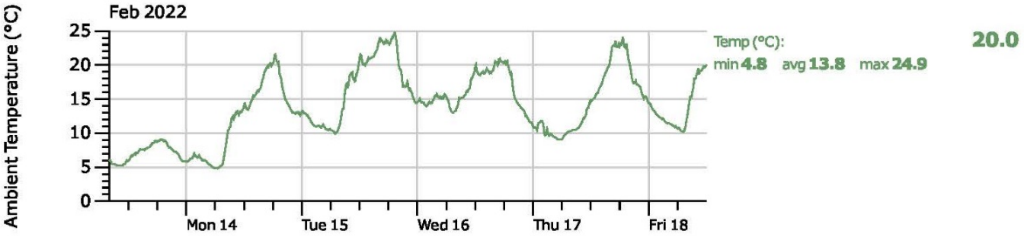
Figure A2. Weather records during tracking tunnel survey.

Tekapo Springs   Weather Station

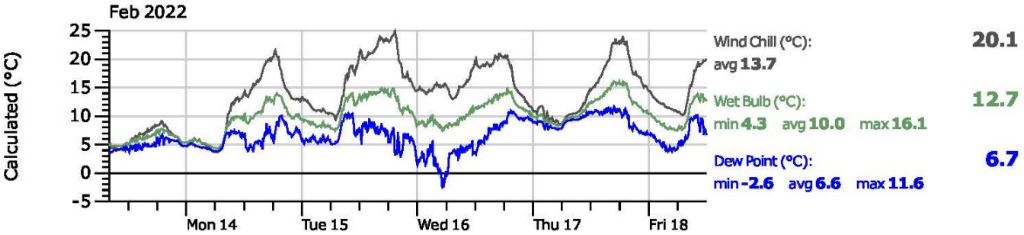
SID:6756 **HSN:**11741 **USER:**Guest **LAST DATA:**Wed Feb 23 2022 17:30:01 GMT+1300 (New Zealand Daylight Time) - 13:56 minutes ago

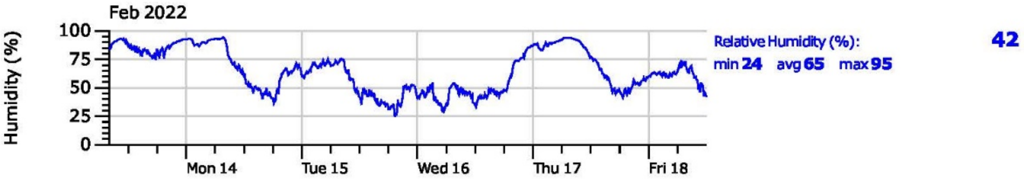
Graphs

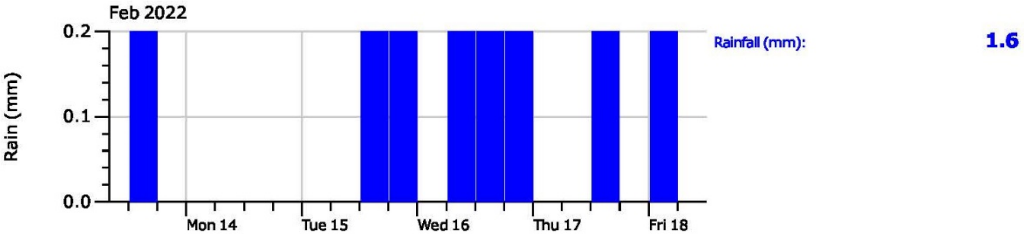
Weather



Advanced Navigation







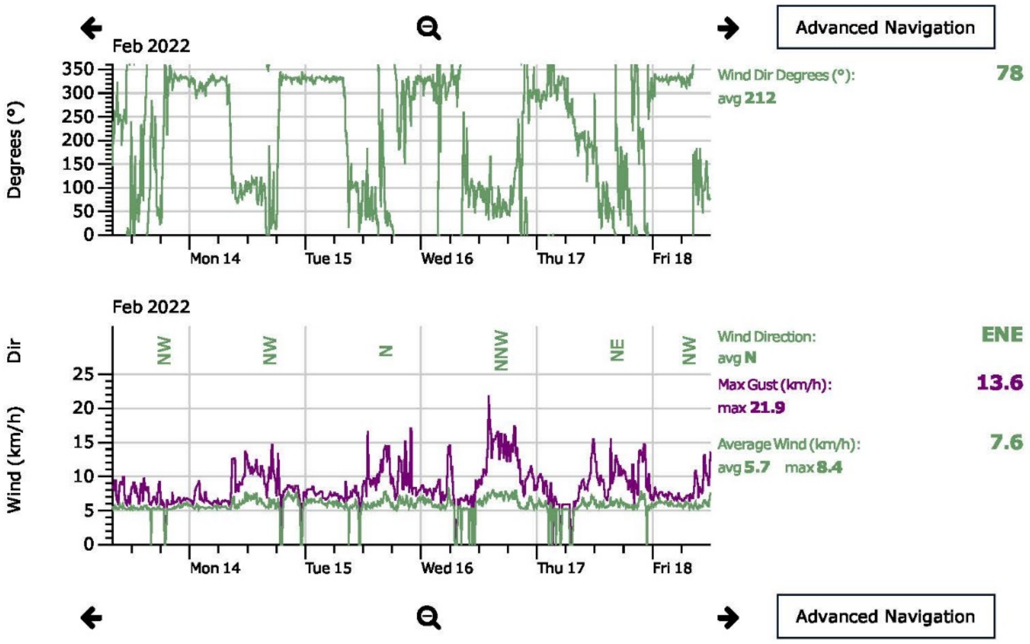
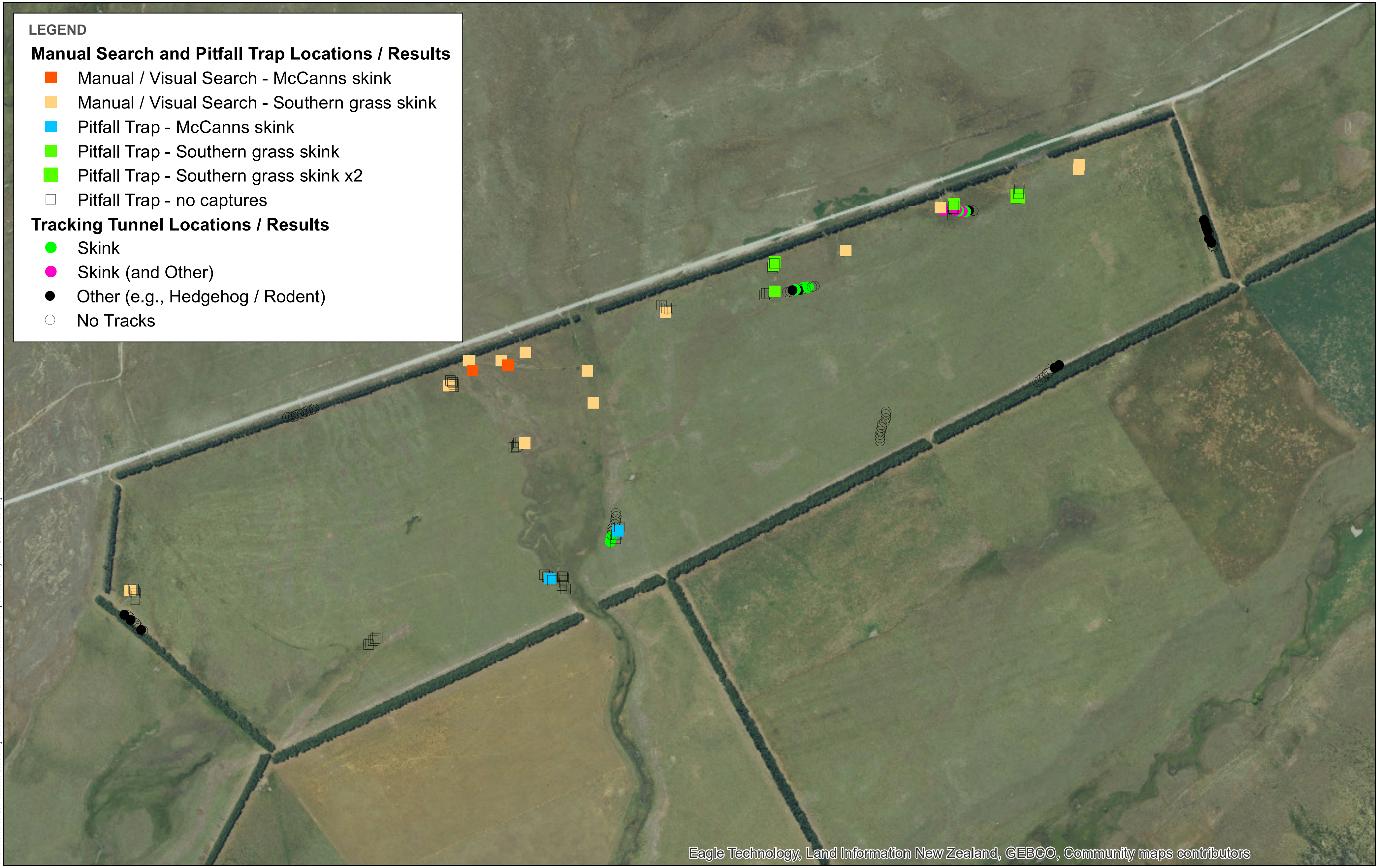


Figure A3. Weather records during pitfall trap survey.

Appendix 4: Lizard Habitat and Survey Maps

File Ref: BM200509F_007_A4L_Lizard_Survey_Results.mxd



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Data Sources: Infratec, LINZ Data Service

Projection: NZGD 2000 New Zealand Transverse Mercator

LTE Solar Farm Ecology

Lizard Survey Results (Nov. 2021 and Feb. 2022)

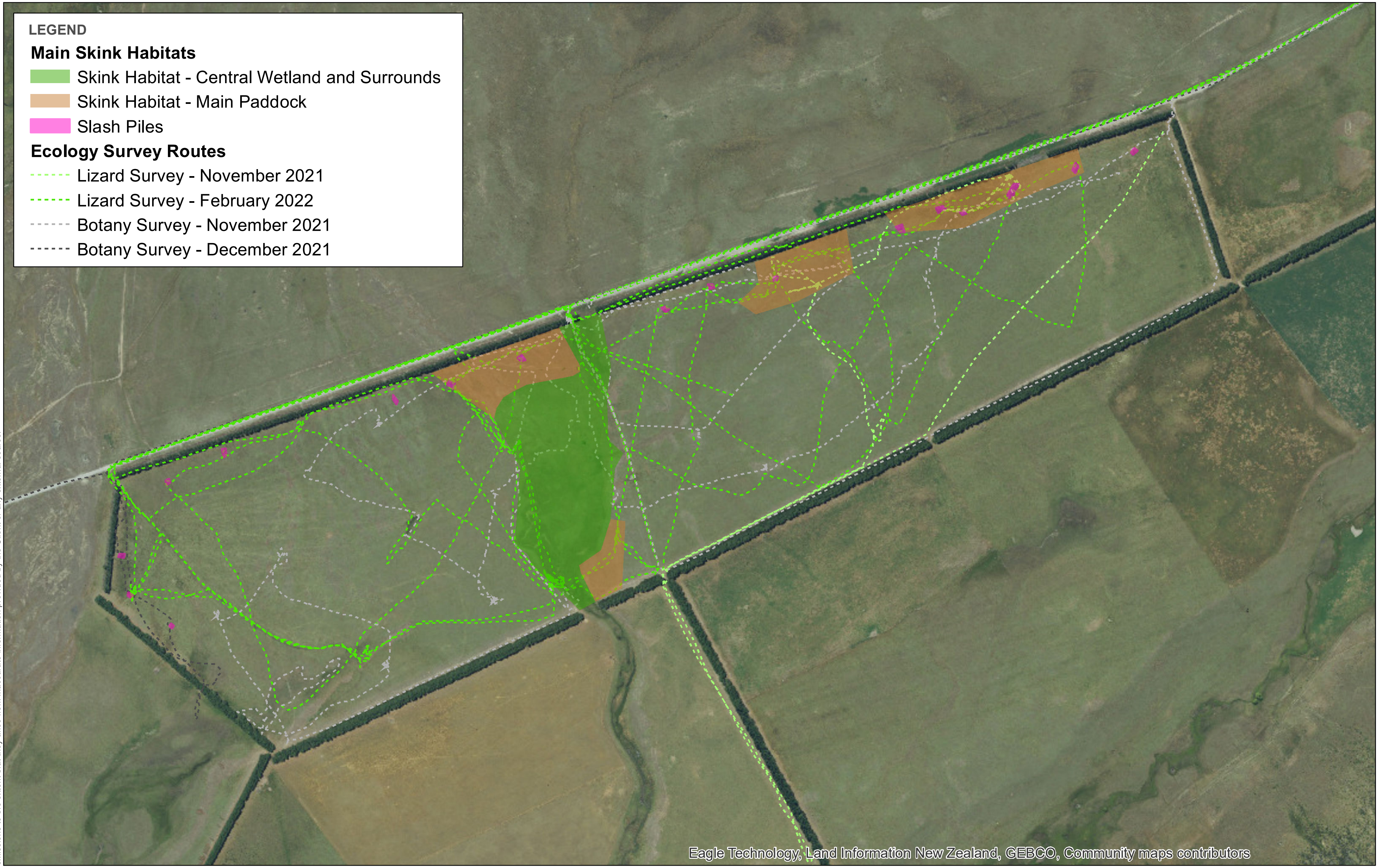
Date: 24 February 2022 | Revision: 0

Plan prepared for Infratec by Boffa Miskell Limited

Project Manager: claire.kelly@boffamiskell.co.nz | Drawn: JMo | Checked: SHo

Figure A4

File Ref: BM200509F_006_A4L_Lizard_Habitat.mxd



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Data Sources: Infratec, LINZ Data Service

Projection: NZGD 2000 New Zealand Transverse Mercator

LTE Solar Farm Ecology

Main Skink Habitat in Solar Farm Area, and Survey Track

Date: 24 February 2022 | Revision: 0

Plan prepared for Infratec by Boffa Miskell Limited

Project Manager: claire.kelly@boffamiskell.co.nz | Drawn: JMo | Checked: SHo

Figure A5

Appendix 5: Additional Site Photos

Figure A6. Main paddock area: fescue tussock / browntop / mouse-ear hawkweed grassland.

Figure A7. Main paddock area near the northwest boundary: fescue tussock / browntop / mouse-ear hawkweed grassland, slash piles, such as at centre image, have been colonised by southern grass skink.


Figure A8. Main paddock area: (copper tussock) / sweet vernal grassland.


Figure A9. Main paddock area: mouse-ear hawkweed herbfield on a moraine hummock.

Figure A10. Main paddock area: mouse-ear hawkweed herbfield (with patchy browntop) on a low terrace riser east of the central wetland.

Figure A11. Main paddock area and central wetland in winter. Much of the area between the obvious wetland channels is dryland vegetation, or a mosaic of wet and dry areas. This distinctly triangular low-lying area would not form part of the solar farm development and instead be a wetland and setback area.

Figure A12. Upper area of central wetland. Wetland areas (largely dominated by exotic grass) are at right, and grade to dryland at left. Note the crack willow tree.

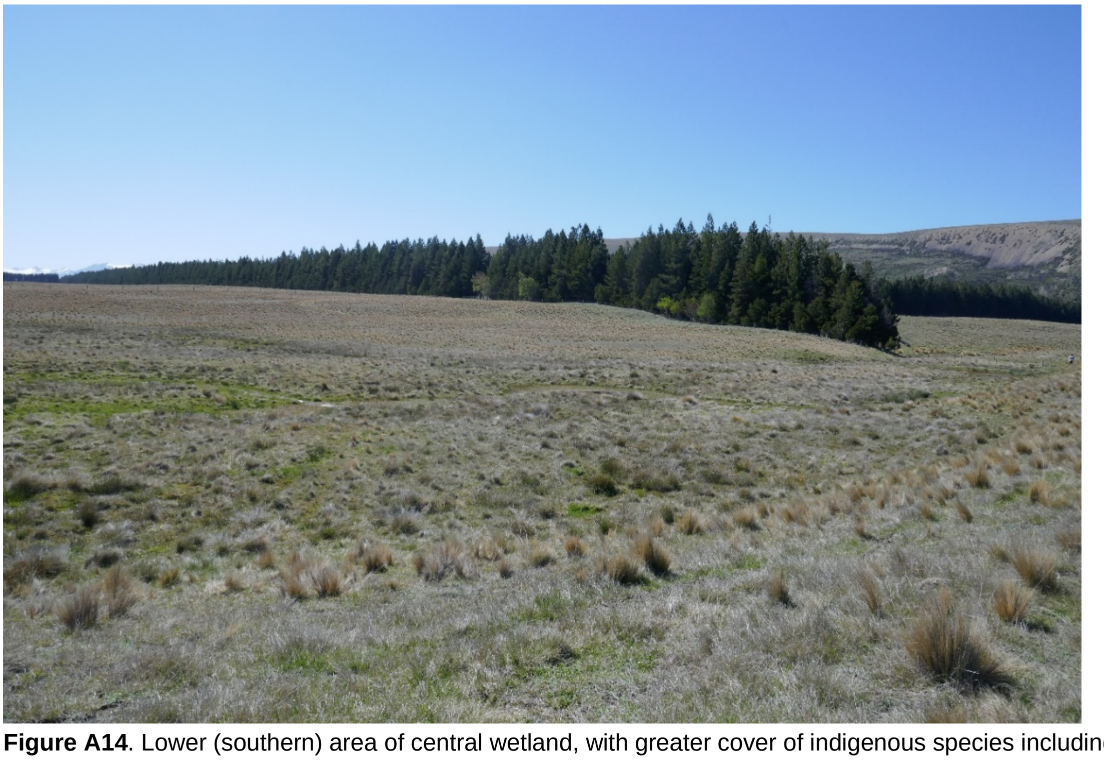


Figure A14. Lower (southern) area of central wetland, with greater cover of indigenous species including bog rush.

Figure A15. Southwest wetland (southern area) showing exotic grass at the margins of a muddy stock trampled area. This area would not form part of the solar farm development and instead be a wetland and setback area.

Figure A16. Southwest wetland (southern area) showing exotic soft rushes and oval sedge.

Figure A17. Southwest wetland areas in winter (southern area at left, with vehicle track, and northern area at right, with pooled water). This area would not form part of the solar farm development and instead be a wetland and setback area.

Appendix 6: Earthworks and Vegetation Clearance (provided by Infratec)

Table A3. Earthworks and vegetation clearance calculations (v3, provided by Infratec on 3 March 2022).

Pile contingency: number of piles	100%
Pile contingency: area	100%
Volume contingency	10%
Area Contingency	10%

3768	piles for 12MWp
314	per MWp
27800	total piles in 88.3MW design
1640	Piles per each of 17 Inverters

			Quantity (unit / m)	W (m)	L (m)	Area (m2)	Depth (m)	Volume (m3)	Comment	Total Area, (m2)	Vegetation regrowth?	
Phase 1	**HV building**	40ft	1	5	12.2		1	67.1	Area accounted for in switchyard	0	No, Permanent	0%
	Switchyard/permanent laydown	gravel	1	50	25	1250	0.2	275		1375	No, Permanent	22%
	Switchyard Earthing	0.15m wide trench	3000	0.15	1		0.7	346.5	Area accounted for in switchyard	0	Yes, regrowth	0%
	Parking	9 spaces	9	2.5	4				Area and volume accounted for in switchyard	0	No, Permanent	0%
	Underground connection cable	MV underground cable	225	0.5	1	112.5	1	123.75	connection to 33kV Line	124	Yes, regrowth	2%
	Preassembled Inverter Stations	20ft	2	2.5	5.9	48.3	1	32.45		53	No, Permanent	1%
	Piles	C section 3.5mm steel	7536	0.0035	0.338	17.830176			Direct driven, no earthwork volume	20	No, Permanent	0%
	MV AC TRENCH MAIN	0.5m wide trench	720	0.5	1	360	1	396		396	Yes, regrowth	6%
	MV AC TRENCH CONNECT	0.5m wide trench	180	0.5	1	90	1	99		99	Yes, regrowth	2%
	DC TRENCH 1	0.5m wide trench	720	0.75	1	540	1	594		594	Yes, regrowth	9%
	EARTH TRENCH North/South	0.15m wide trench	720	0.15	1	108	0.6	71.28		119	Yes, regrowth	2%
	Earth Trench East/West	0.15m wide trench	600	0.15	1	90	0.6	59.4		99	Yes, regrowth	2%
	Security/rabbit fence	2000m 1m intervals	2000	0.1	0.1	20	0.6	13.2		22	No, Permanent	0%
	Stock fence wetland	500m 1m intervals 10cm diameter post	500	0.1	0.1	5	0.6	3.3		6	No, Permanent	0%
	Swale drain road	2m wide 0.5m deep	510	2	1	1020	0.5	561		1122	Yes, regrowth	18%
	Road connect substation	4m wide road	150	4	1	600	0.2	132		660	No, Permanent	10%
	ROAD Entrance	4m x 6m	1	4	6	24	0.2	5.28		26	No, Permanent	0%
	ROAD north/south	4m wide road	360	4	1	1440	0.2	316.8		1584	No, Permanent	25%
Phase 2 block 1	**Preassembled Inverter Stations**	20ft	5	2.5	5.9	120.75	1	81.125		133	No, Permanent	1%
	Inverter earth ring	around container	5	5	11.8	295	0.7	227.15		325	Yes, regrowth	2%
	Pile	C section 3.5mm steel	16400	0.0035	0.338	38.8024			Direct driven, no earthwork volume	43	No, Permanent	0%
	MV AC TRENCH MAIN	0.5m wide trench	560	0.5	1	280	1	308		308	Yes, regrowth	1%
	MV AC TRENCH CONNECT	0.8m wide trench	1650	0.8	1	1320	1	1452		1452	Yes, regrowth	7%
	DC TRENCH 1	0.5m wide trench	1120	0.75	1	840	0.5	462		924	Yes, regrowth	4%
	EARTH TRENCH north/south	0.15m wide trench	1120	0.15	1	168	0.7	129.36		185	Yes, regrowth	1%
	EARTH TRENCH east/west	0.15m wide trench	760	0.15	1	114	0.7	87.78		125	Yes, regrowth	1%
	Swale drain road	2m wide 0.5m deep	560	2	1	1120	0.5	616		1232	Yes, regrowth	6%
	ROAD Entrance	4m x 6m	1	4	6	24	0.2	5.28		26	No, Permanent	0%
	ROAD	4m wide road	560	4	1	2240	0.2	492.8		2464	No, Permanent	12%

Phase 2 block 2	Preassembled Inverter Stations	20ft	5	2.5	5.9	120.75	1	81.125		133	No, Permanent	1%
	Inverter earth ring	around container	5	5	11.8	295	0.7	227.15		325	Yes, regrowth	2%
	Pile	C section 3.5mm steel	16400	0.0035	0.338	38.8024			Direct driven, no earthwork volume	43	No, Permanent	0%
	MV AC TRENCH MAIN	0.5m wide trench	650	0.5	1	325	1	357.5		358	Yes, regrowth	2%
	DC TRENCH 1	0.5m wide trench	1300	0.75	1	975	0.5	536.25		1073	Yes, regrowth	5%
	EARTH TRENCH north/south	0.15m wide trench	1300	0.15	1	195	0.7	150.15		215	Yes, regrowth	1%
	EARTH TRENCH east/west	0.15m wide trench	1150	0.15	1	172.5	0.7	132.825		190	Yes, regrowth	1%
	Swale drain road	2m wide 0.5m deep	650	2	1	1300	0.5	715		1430	Yes, regrowth	7%
	ROAD Entrance	4m x 6m	1	4	6	24	0.2	5.28		26	No, Permanent	0%
	ROAD	4m wide road	650	4	1	2600	0.2	572		2860	No, Permanent	14%
Phase 2 block 3	HV building	40ft	1	5	12.2		1	67.1	Area accounted for in switchyard	0	No, Permanent	0%
	Switchyard/permanent laydown	gravel	1	50	25	1250	0.2	275		1375	No, Permanent	7%
	Switchyard Earthing	0.15m wide trench	3000	0.15	1		0.7	346.5	Area accounted for in switchyard	0	Yes, regrowth	0%
	Parking	9 spaces	9	2.5	4				Area and volume accounted for in switchyard	0	No, Permanent	0%
	Underground connection cable	MV underground cable	110	0.5	1	55	1	60.5	connection to 33kV Line	61	Yes, regrowth	0%
	Preassembly Inverter Stations	20ft	5	5	5.9	207	1	162.25		228	No, Permanent	1%
	Inverter earth ring	around container	5	10	11.8	590	0.7	454.3		649	Yes, regrowth	3%
	Pile	C section 3.5mm steel	16400	0.0035	0.338	38.8024			Direct driven, no earthwork volume	43	No, Permanent	0%
	MV AC TRENCH MAIN	0.5m wide trench	500	0.5	1	250	1	275		275	Yes, regrowth	1%
	DC TRENCH 1	0.5m wide trench	1000	0.75	1	750	0.5	412.5		825	Yes, regrowth	4%
	EARTH TRENCH north/south	0.15m wide trench	1000	0.15	1	150	0.7	115.5		165	Yes, regrowth	1%
	EARTH TRENCH east/west	0.15m wide trench	1150	0.15	1	172.5	0.7	132.825		190	Yes, regrowth	1%
	Swale drain road	2m wide 0.5m deep	500	2	1	1000	0.5	550		1100	Yes, regrowth	5%
	ROAD Entrance	4m x 6m	1	4	6	24	0.2	5.28		26	No, Permanent	0%
	ROAD	4m wide road	500	4	1	2000	0.2	440		2200	No, Permanent	10%
Phase 2 FENCE	Security/rabbit fence	4650m at 2m intervals	4650	0.1	0.1	46.5	0.6	30.69		51	No, Permanent	0%
	Stock fence	1800m at 2m intervals	1800	0.1	0.1	18	0.6	11.88		20	No, Permanent	0%

Phase 1	TOTAL Volume	3096	m3
	TOTAL Area	6298	m2
	Total area, permanent loss indigenous veg	3746	m2
	Total area, indigenous veg regrowth	2553	m2

Phase 2	TOTAL Volume	9978	m3
	TOTAL Area	21074	m2
	Total area, permanent loss indigenous veg	9671	m2
	Total area, indigenous veg regrowth	11404	m2

OVERALL	TOTAL Volume	13074	m3
	TOTAL Area	27372	m2
	Total area, permanent loss indigenous veg	13416	m2
	Total area, indigenous veg regrowth	13956	m2

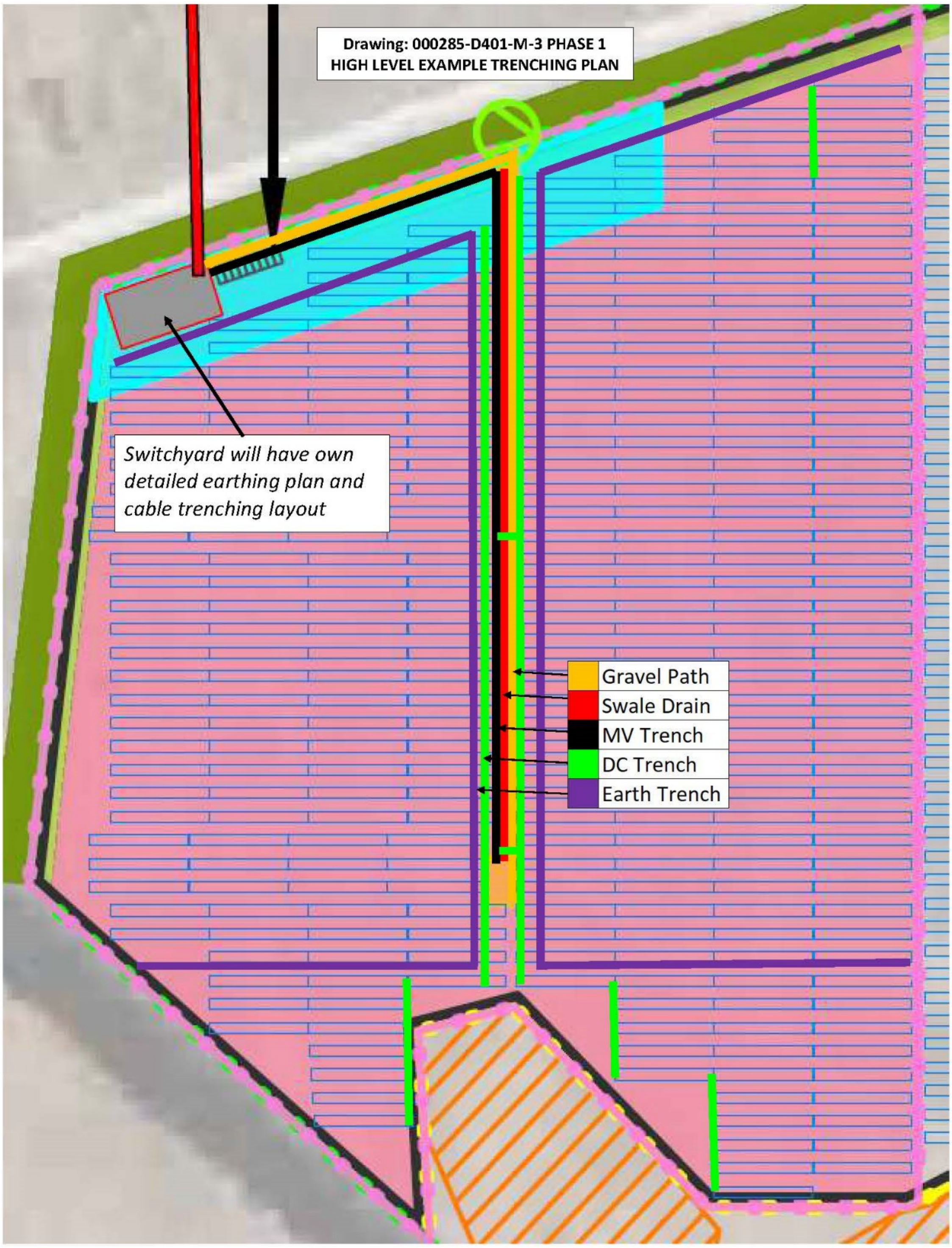


Figure A18. Example trenching plan for phase one.

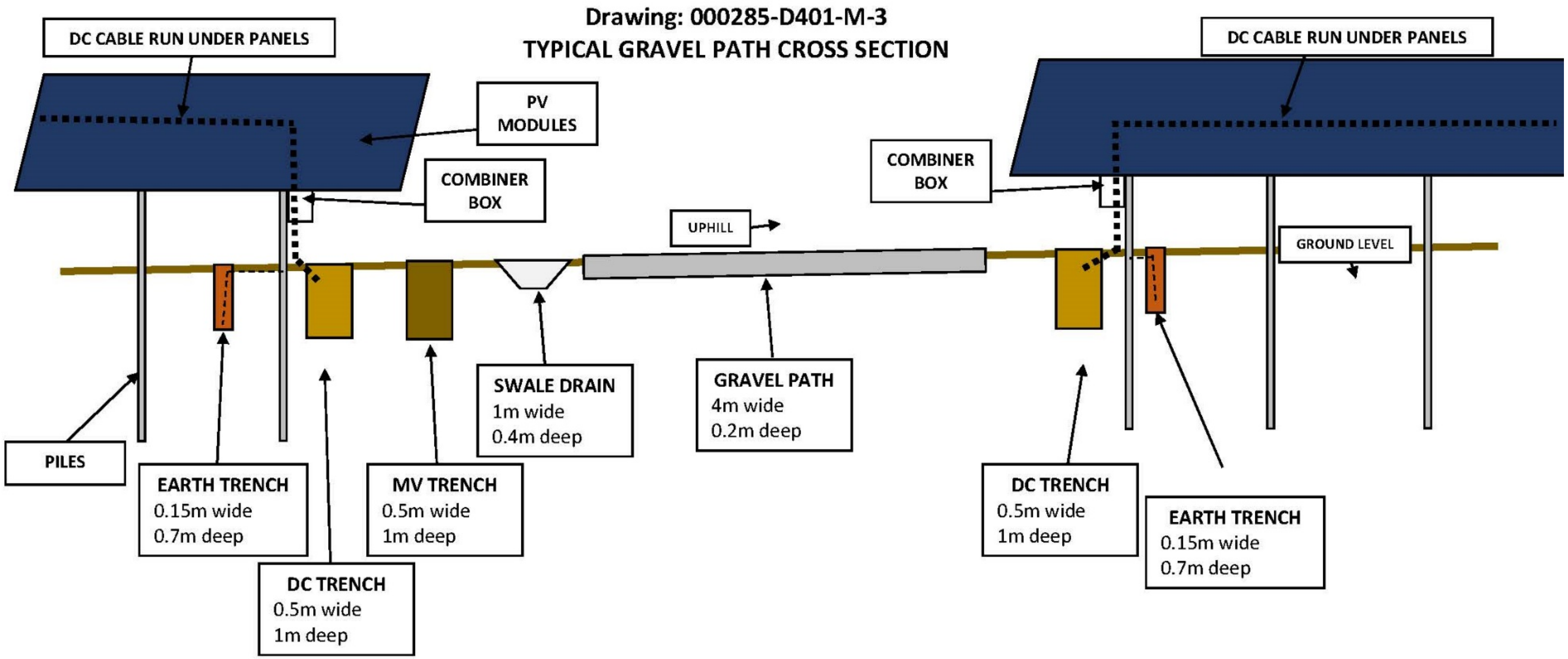


Figure A19. Typical gravel path cross section. Because solar arrays are piled, gravel path construction and trenching for cables are the main direct cause of vegetation clearance.

Appendix 7: Solar Panel Reflectivity Details (provided by Infratec)

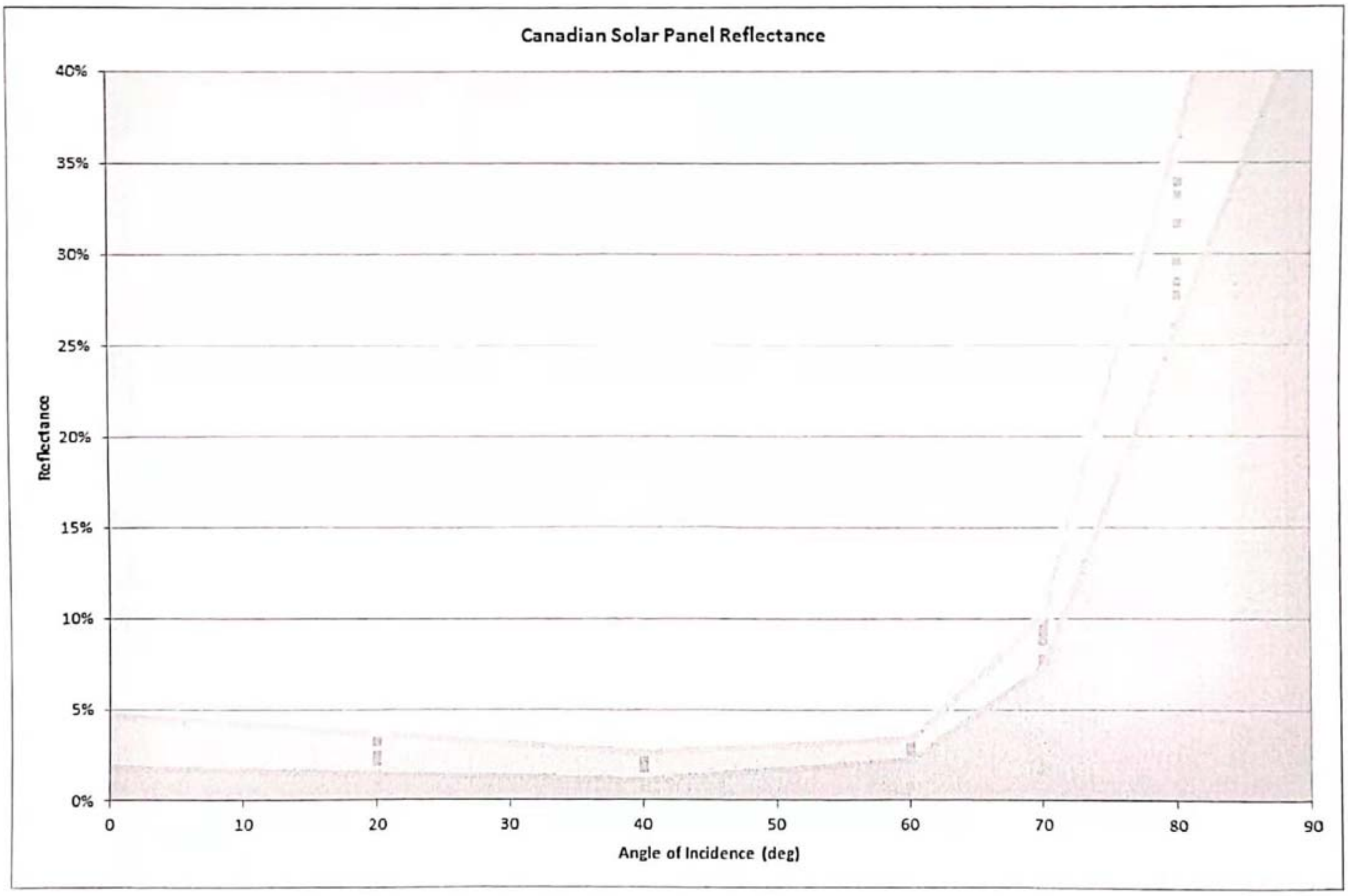
CSI Solar Co., Ltd.
199 Lushan Road, SND, Suzhou, Jiangsu, China, 215129
Tel: +86 512 68965287
www.canadiansolar.com

NO. TS202123792
Date: November 29, 2021

Subject: Statement about modules' reflection

To whom it may concern,

Reflectance is dependent on incidence angle, and becomes very high at large incidence angles (see below picture for reference, test results from SANDIA laboratory), standard module reflectance is likely to plot in the light green area).



Canadian Solar uses "high-transmission low-iron" glass in our solar modules, and narrow down the accepted range of glass surface roughness. This type of glass transmits more light, producing less glare and reflectance than normal glass. This high-transmission glass meets the military's reflectance requirement, where this value has to be less than 10%. Canadian Solar declares that Modules produced using antireflection coated solar glass have a reflectance value below 4% when with up to 60°angle of incidence.

Canadian Solar is committed to guarantee our product quality so that we can deliver high quality modules to our valued customers.

CanadianSolar

CSI Solar Co., Ltd.
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Sincerely,

Zoey Zhang
APAC CS&TS Engineer
Email: zoey.zhang@canadiansolar.com

CanadianSolar
www.canadiansolar.com

Technical Bulletin

CSIRNC-ST-TB-001 A/2

Contents:
Solar glare from PV array
Glaring hazard
Glare evaluation

References:
1. ISO 9050-2003 total solar energy transmittance and related glazing factor.
2. EN 410-2011 Determination of luminous and solar characteristics of glazing
3. Methodology to Assess Potential Glint and Glare Hazards DOI: 10.1115/ 1.4004349]

Jan 2017

Solar Glare Hazard and Evaluation Methodology

Intended Exposure:	External, Internal
Groups:	Product, R&D, Marketing, Sales Technical Support departments Customers
Technical Contact:	PV Product Development Department Jean-Nicolas Jaubert, Jn.jaubert@canadiansolar.com

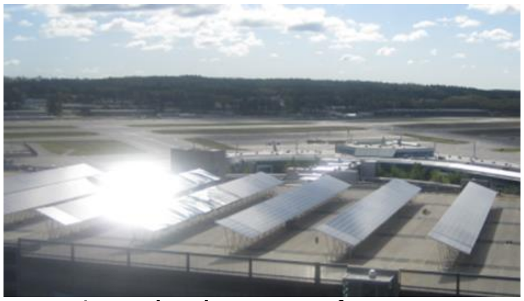

Fig.1 Solar glare scene of PV arrays

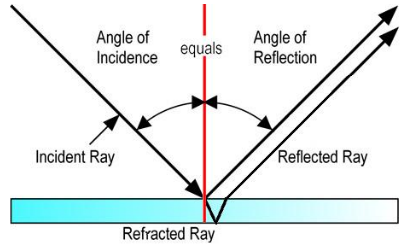

Fig.2 Refraction and reflection

Multiple agencies and governmental bodies such as air force, energy commissions and academies are interested in evaluating potential safety risks brought by emerging energy technologies. Having several large PV plants installed at or close to main airports, Canadian Solar Inc. has been worrying its customers who enquire about aviation safety. In the last few years, we launched various studies and analyses related to glint and glare caused by reflective surface of photovoltaic (PV) arrays. Some approaches involve developing in-house capability for glare risk evaluation, with the glare risk being strongly related to the PV plant design. Meanwhile we keep working on offering total solutions to glint and glare impacts of solar energy, and supporting the aviation community and our customer base by cooperating with well-known laboratories on further research work.

Reflection occurs when a light beam hits a surface. When the beam hits a flat surface at a given angle, the angle of rebound of the beam will be equal to the incident beam angle relative to the surface normal. Refraction is like reflection governed by Descartes law. When the beam hits the surface, it doesn't totally reflect but part of the energy passes through, so the refracted beam now has a different direction relative to the surface normal.

The incident rays that have been reflected are the sources for producing glint and glare phenomena, which are also referred to as light pollution. Standard photovoltaic glass transmits about 91.5% of incident light beam and reflects about 5%, which is under or close to normal incidence.

Other than light beam paths, refraction index is also one of the key parameters that influence the transmission and reflection rate. Air has a refraction index of 1.00 by convention, and reduction of reflection when light coming through air strikes a transparent surface is basically a matter of reducing the refraction index of that surface to or as close to 1.00 as possible. The most familiar reflective material is water, which has an index of refraction of 1.333. Under windless weather condition a quiet pond will have a very smooth, reflective surface. With the information above, one would expect that anti-reflective coated glass should be slightly less reflective than the water (Index 1.25 versus Index 1.333). Surface roughness is another relevant parameter that influences the light reflection mechanisms by modifying the part of specular reflected light (by opposition to–diffuse reflected light, which does not contribute to glare and glint). **Knowledge of the photovoltaic glass reflectivity under different incident light angles is the first stone of a reliable glare evaluation**.

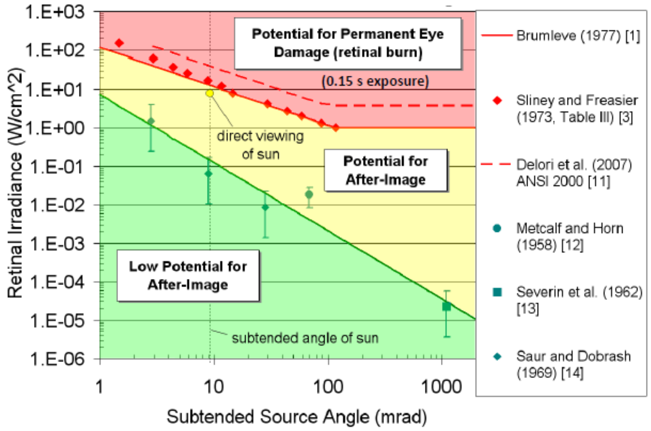

Fig.3 Ocular hazard metrics

Besides intrinsic reflectivity characteristics of the surface evaluated, occurrences of glint and glare will be governed mainly by the respective positions of the sun and observation points (control tower, flights), as well as by the design of the photovoltaic power plant. Based on data inputs covering peak irradiance, source angle and distance between glare spot and observation points, detailed calculations could be done to evaluate the amount of reflected radiant energy that will reach the retina of an observer located at a given place and a given point in time. **This calculation is the core of any glare evaluation performed by Canadian Solar Inc., which requires various input information about the PV plant and airport**.

Fig.3 has been defined by Ho et al. (2010, 2011) from SANDIA Laboratories and aims to correlate glare conditions (retinal irradiance, subtended source angle) to ocular hazard metrics, including potential for permanent eye damage and after-image effect or low potential for after-image effect. Canadian Solar Inc. is applying the metrics established by this third party to its solar glare hazard evaluations. Once we obtain the calculation results of retinal irradiance versus subtended source angle for the various observation points of a given project, we can locate them on SANDIA chart, which can tell us whether the glare impact on pilots or controllers could pose risks.

Canadian Solar Inc. has been characterizing the optical performance of its solar modules, and working with several specialized test laboratories to perform extensive measurements for various solar glasses it uses.

By now, the main reflectivity data has been tested and verified by Sandia National Laboratory, a 3rd party with recognized expertise in the field of glare research.

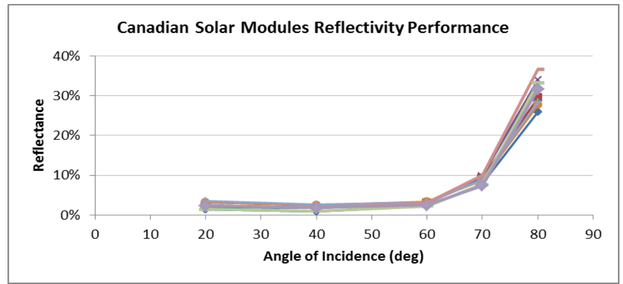

Fig.4 Canadian Solar Inc. Module reflectivity by 3rd parties

In order to estimate potential glare and glint hazards from solar farms under construction, Canadian Solar Inc. has put in place a procedure and a team for performing rigorous and scientific evaluations, on demand of customers or aviation authorities.

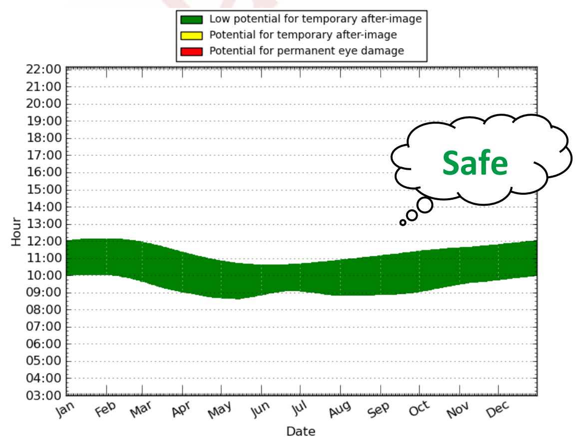

Fig.5 Analyzed spot glare status plot

All the simulations are processed using 3rd party owned software and meteorological data source, along with reflectivity data for Canadian Solar Inc. products. In cases where hazardous glare is detected, proper mitigation methods are proposed, ranging from simple caution boards on risk areas to modifications of the solar array configurations. Detailed analysis is also provided in the latter case, including expected effect on system energy yield.

Fig.6 Caution board

Any further modifications of the photovoltaic array design may cause significant changes to the simulation results.

In the past years, Canadian Solar Inc. team has run analysis on several projects all around the world, and issued 14 engineering evaluation reports. For the first project located in southern Australia, our customer already received a recognition letter for our technical evaluation from CASA (Civil Aviation Safety Authority of Australia).

Beyond all these evaluations, Canadian Solar Inc. has also further experience installing photovoltaic arrays near airports and highways. Within the past decades, Canadian Solar Inc. has been offering modules or turnkey service for solar plants located at proximity from airports of Thunder Bay, Ontario with 8.5MW in February, 2012; San Jose, California with 1.12MW in June, 2010; and Ahlorn, Germany with 27MW in Nov, 2012. Adelaide, AU with 1MW in June. 2015. Longreach, Queensland, AU with 1.5MW in April, 2016.

Regulatory provisions

(US) FAA Guidelines

In the USA, the Federal Aviation Administration published its first guidance on the use of solar energy technologies around airports in November 2010. Chapter 3 of that document lists glare as one of the potential hazards of solar technologies at or near airports. It should be noted that the FAA guide specifically addresses solar technology at or near airports, but it does not address any issues arising from solar energy facilities that is not located in the vicinity of an airport.

The FAA study points out that, while solar collector technology adopts highly reflective surfaces, PV technology is primarily absorptive since the purpose of the PV panel is to absorb as much of the sun energy as possible. The study notes that the degree of reflectivity of a PV panel will depend upon the intensity of the incoming light and the reflectivity of the panel surface.

(UK) CAA Guidelines

The UK Civil Aviation Authority (CAA) issued interim guidance on the impact of solar photovoltaic systems on aviation in December 2010. Following internal review of the FAA guidance, the CAA will issue formal policy and guidance on this issue, including the impact of systems deployed farther than 15km away from aerodromes.

(FR) DGAC guidelines

The DGAC (French equivalent of FAA for airport regulation) also has detailed guidelines for installation of PV modules in airport. The document, very detailed, has specific requirements that luminance should be lower than:

- 10,000 cd/m^2 for PV arrays located in zone B (light beam in direction of the pilot, sight angle -90/+90º between reflected beam and sight axis toward the road, airplane located in zone B itself).

- 20,000 cd/m^2 for PV arrays located in zone A (light beam in direction of the pilot, sight angle -30/+30º between reflected beam and sight axis toward the road, distance below 3000m).

- No PV installations authorized in zone C.

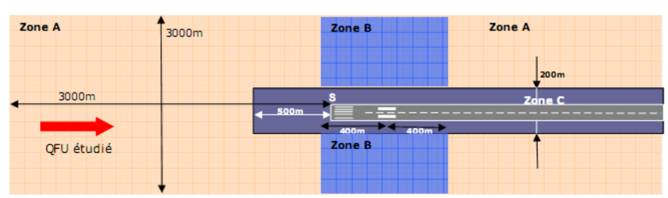

Fig.7 DGAC regulation zoning of airport

MODIFIED RECORD

Version/Revision	Modification description	Prepared/Modified By	Approved By	Date
A/0	Original edition	Emdee XING	Jean-Nicolas JAUBERT	2014-02-25
A/1	Updated info about PV farms using CSI modules. Review English.	Emdee XING	Jean-Nicolas JAUBERT	2014-12-18
A/2	Updated info about PV farms using CSI modules. Review English.	Jun Du	Jean-Nicolas JAUBERT	2014-12-18

About Boffa Miskell

Boffa Miskell is a leading New Zealand professional services consultancy with offices in Auckland, Hamilton, Tauranga, Wellington, Christchurch, Dunedin and Queenstown. We work with a wide range of local and international private and public sector clients in the areas of planning, urban design, landscape architecture, landscape planning, ecology, biosecurity, cultural heritage, graphics and mapping. Over the past four decades we have built a reputation for professionalism, innovation and excellence. During this time we have been associated with a significant number of projects that have shaped New Zealand's environment.

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