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DRAFT Avifauna Management Plan for Proposed Nova Energy Solar Farm at Twizel, Canterbury

Contract Report No. 7414c

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March 2026

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1.0 Introduction

This management plan relates to the development and operation of a proposed solar farm located near the township of Twizel in the Mackenzie Basin. The proposed solar farm site is located within the Pukaki Ecological District and covers approximately 866 hectares. It is characterised by dry outwash plains between Lake Tekapo and Benmore.

Wildland Consultants Ltd (Wildlands) previously prepared an assessment of ecological effects (AEE) on the site, which identified important biodiversity values at the site. These values included Threatened or At Risk plants, birds, lizards, and terrestrial invertebrates. Wetland habitats were also identified at the site. The AEE identified a need for specific management plans to address effects on flora and fauna on-site and to inform future management strategies in the context of the development.

This Avifauna Management Plan (AMP) is one of the five ecological management plans associated with the proposed development and details the measures recommended for minimising the impacts on indigenous avifauna at the site.

This report is intended to be implemented in conjunction with the following reports:

- Wildland Consultants (2026b). *Terrestrial invertebrate management plan for proposed Nova Energy Twizel solar farm*. Wildland Consultants Contract Report No. 7414a. Prepared for Nova Energy Ltd. 33pp.
- Wildland Consultants (2026c). *Lizard management plan for proposed Nova Energy Twizel solar farm*. Wildland Consultants Contract Report No. 7414b. Prepared for Nova Energy. 43pp.
- Wildland Consultants (2026d). *Biosecurity and Vegetation Management Plan for proposed Nova Energy Twizel solar farm*. Wildland Consultants Contract Report No. 7414d. Prepared for Nova Energy. 14pp.
- Wildland Consultants (2026e). *Pest mammal management plan for Nova Energy proposed solar farm, Twizel*. Wildland Consultants Contract Report No. 6905. Prepared for Nova Energy Ltd. 27pp.

2.0 Site Description

2.1 Project site and context

The project site (Lot 3/DP422901/RT489342) is a long, narrow section of land with an area of c.866 hectares to the east of Twizel (Appendix 1). Ōhau River is located along the eastern boundary and Twizel River to the west. The site is mostly flat with an access road through the centre and old river terraces near the boundary. It is currently used as pastoral land for farming in a Rural Zone. The proposed area for development is located on outwash plain and river terraces between the Twizel and Ōhau Rivers and includes areas of historic river channels and old oxbows.

The site is currently operating under a farm lease arrangement, predominantly as cropping and sheep grazing. The area is subdivided into fenced paddocks, and some have been used for hay/baleage production. Most of the site has been cultivated by direct-drilling, and this has led to a widespread distribution of improved pasture species across the site.

Records of fifty-nine bird species have been collated based on a site visit in December 2022 and a desktop survey. These include 40 indigenous species (eight Threatened, nine At Risk, and 23 Not Threatened) and 16 exotic species (Wildlands 2023a).

3.0 Survey Methods and Results

A desktop survey was conducted to identify records of all birds within five kilometres of the site between January 2021 and May 2025. A site visit was undertaken on 14 and 15 December 2022, during which four discrete transects were evaluated. All bird species seen or heard while walking each transect were recorded together with any incidental species detected while on-site.

Sixty bird species and two hybrid taxa were detected during the desktop survey and December 2022 site visit. This included 44 indigenous species (nine Threatened, 10 At Risk, one Non-resident Native – Migrant, and 24 Not Threatened) and 18 exotic species. One *Anas* sp. was not identified to species level. Of these, 38 species were seen during the 2022 field survey, including tarapirohe/black-fronted tern (*Chlidonias albobristatus*, Threatened – Nationally Endangered), pārea/grey duck (*Anas superciliosa*, Threatened – Nationally Vulnerable), pohowera/banded dotterel (*Charadrius bicinctus bicinctus*, At Risk – Declining), tarāpuka/black-billed gull (*Chroicocephalus bulleri*, At Risk – Declining), tōrea/South Island pied oystercatcher (*Haematopus finschi*, At Risk – Declining), kawaupaka/little shag (*Microcarbo melanoleucos brevirostris*, At Risk – Relict), and māpunga/black shag (*Phalacrocorax carbo novaehollandiae*, At Risk – Relict)¹.

During the survey, one tōrea/South Island pied oystercatcher was observed sitting on what appeared to be a nest on the site, though this could not be confirmed.

4.0 Ecological Values for Avifauna

Several areas on the southern margins of the site are important to avifauna, shown collectively in Appendix 1. Large numbers of waterfowl and waders, including the Threatened pārea/grey duck (*Anas superciliosa*) and At Risk pohowera/banded dotterel (*Charadrius bicinctus bicinctus*) and tōrea/South Island pied oystercatcher (*Haematopus finschi*) were present in wetlands between the Ōhau River and the southern margin of the site (opposite the Ōhau B Power Station). The kākī/black stilt (*Himantopus novaeseelandiae*) captive breeding centre is located approximately 250 metres from the south-western edge of the proposed solar farm. The Ōhau River and its delta on Lake Benmore provide important habitat for various Threatened and At Risk species, including māpunga/black shag (*Phalacrocorax carbo*) and kawaupaka/little shag (*Microcarbo melanoleucos*), which were observed feeding in the river during the 2022 site visit. Wetland areas on the Ōhau River are also known habitats for the At Risk kotoreke/marsh crane (*Zapornia pusilla*).

Matuku-hūrepo/Australasian bittern (*Botaurus poiciloptilus*, Threatened – Nationally Critical) are known to occur at several wetland patches near the site, including around the Ōhau and Pukaki rivers. While pūweto/spotless crane (*Zapornia tabuensis*, At Risk – Declining) were not identified during the desktop assessment or field visit, it is likely they could also be present in the area at similar sites to where matuku-hūrepo/Australasian bittern and kotoreke/marsh crane are found.

Tōrea/South Island pied oystercatchers have also been observed feeding and roosting in the browntop-sweet vernal-cover grassland on site and potentially nesting. The short grasslands and open country are suitable breeding habitats for tōrea/South Island pied oystercatcher, pihoihoi/New Zealand pipit (*Anthus novaeseelandiae*) and pohowera/banded dotterel. Tarapirohe/black-fronted terns (*Chlidonias albobristatus*) have been observed flying over the site and foraging in the river along the site's southern border (Appendix 1).

¹ Threat classifications are from Robertson et al. (2021).

While the identified avifauna values are near the proposed solar farm site, they are still some distance from the proposed works. For example, values to the south, south-west (including the Ōhau River and wetland area) of the property border are on Department of Conservation land and are at a lower elevation to the site, while the kakī/black stilt captive breeding centre is several hundred metres from the south-western border. Additionally, due to the large ecological exclusion area incorporated into the concept design, setbacks ensure works will be carried out away from sensitive avifauna areas.

5.0 Potential Effects on Avifauna

There are five potential effects on avifauna from the proposed solar farm construction:

- Loss of avifauna habitat for species, such as tōrea/South Island pied oystercatcher, that forage and breed within open grassland areas.
- Disturbance to indigenous breeding avifauna during construction due to human activity, noise, vibrations, and machinery operations.
- Death or injury to indigenous breeding avifauna from ground clearance and machinery use during construction.
- Ongoing disturbance to avifauna from vehicle movements and maintenance works.
- Risk of bird strike with panel arrays, resulting in the mortality of any birds that collide with panels.

These potential effects are discussed in more detail in the AEE (Wildlands 2023a).

The purpose of this management plan is to avoid, minimise, and remedy adverse effects to indigenous birds, and if necessary, to implement appropriate compensation measures to address any residual effects that remain.

6.0 Management of Effects

6.1 Overview

Under the Wildlife Act 1953, Section 63 (1), it is unlawful to destroy, molest, or disturb the nests of protected birds, with nesting considered to be any stage of a bird building, occupying, or using a nest to house eggs or young. Protection encompasses active nest construction, incubation of eggs, and chick rearing, which typically occur during the main avifauna breeding season of July–March inclusive. All birds in Aotearoa New Zealand, apart from those listed in Schedule 5 of the Wildlife Act 1953, are protected. This includes Threatened and At Risk birds, the majority of Not Threatened indigenous birds, and some introduced birds. Protection statuses of species recorded in the field survey and desktop assessment are summarised in Appendix 2.

6.2 Limit construction during the breeding season

The bulk of the construction work should occur between 2 March and 30 June, outside the breeding season of Threatened and At Risk birds (1 July–1 March), as construction activities could injure or kill breeding birds, eggs, and chicks. Due to the size of the project and the extended breeding season of birds likely to inhabit the area (including open country and braided river breeders), some construction work will inevitably take place during this period, which spans approximately eight months. The following management measures are designed to minimise impacts on breeding and nesting birds during, and outside of the breeding season. Table 1 provides details on the breeding seasons of the Threatened and At Risk birds identified during the site visit or noted from the desktop survey.

6.3 Pre-works surveys

A Suitably Qualified Avifauna Ecologist (SQAE) will undertake pre-works surveys no more than eight days prior to works commencing. If works cease for more than eight days, or move into a new area or stage, a further pre-works survey is required no more than eight days before recommencement. This applies for work commencing within the bird breeding season (1 July–1 March).

The purpose of the pre-works survey is to identify onsite bird foraging and breeding and will be undertaken in accordance with a methodology determined by the SQAE.

The pre-works survey shall record the following information:

- Date and time of survey.
- Location.
- The total number of birds observed across all species.
- The behaviours and habitat use of all birds present (e.g. roosting or nesting, feeding on bare ground, flying overhead).
- For birds flying overhead, the approximate height (e.g. <10 metres, 10-30 metres, >30 metres), and direction of the flight, and size of the flock (if applicable).

6.4 Setbacks

If nests of protected ground-nesting avifauna species are found, in the survey described in Section 6.3 above, or during construction:

- Nests must be avoided by establishing construction setback distances (buffer zones). In open areas, this setback should be a minimum of 100 metres for Threatened, At Risk (threat classifications as per Robertson *et al.* 2021) and protected species, and be clearly demarcated.
- Buffer zone distances may be reduced to smaller exclusion distances for intermittent, short duration work if the nests or chicks are not visible from the source of disturbance (e.g. if vegetation or topographic features screen the source of disturbance from the nest or chicks). This adjustment is subject to approval by a SQAE, will be no less than 50 metres, and should be documented in writing.
- Construction activities must not occur within the setback area until:
 - chicks have fledged and are independent of the nesting site, or
 - the nest has been abandoned, as determined by an SQAE.

A 100-metre construction setback will be applied between the site and the Twizel River to reduce disturbance of braided river birds during the breeding season. No construction is proposed in these areas, so this setback is readily achieved, unless a pre-works survey is undertaken. Setbacks will also be applied along the Ōhau River. Due to the elevational difference between the site and the Ōhau River (approximately 20 metres), 75 metres is sufficient. No construction is proposed in this area, so this setback is readily achieved.

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Table 1 – Breeding seasons of Threatened and At Risk bird species (✓) and potential presence within the Mackenzie basin area (✓). *Asterisk identifies birds that could potentially be encountered at the site.

Bird Species	Breeding/Nesting Habitat	Breeding Season											
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Kakī /black stilt*	Inland braided river	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Pārera/grey duck	Inland braided river								✓	✓	✓	✓	✓
Ngutu pare/wrybill	Inland braided river	✓	✓	✓	✓	✓			✓	✓	✓	✓	✓
Pihoihoi/New Zealand pipit *	Open country/ tussock	✓	✓						✓	✓	✓	✓	✓
Pohowera/banded dotterel*	Open country/ tussock	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Tarāpuka/black-billed gull*	Inland braided river	✓	✓						✓	✓	✓	✓	✓
Tōrea/South Island pied oystercatcher *	Inland braided river	✓	✓	✓			✓	✓	✓	✓	✓	✓	✓
Kawaupaka/little shag	Roosting in overhanging trees	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓
Māpunga/black shag	Roosting in overhanging trees			✓	✓	✓	✓	✓	✓				
Kawau tūi/little black shag	Roosting in overhanging trees										✓	✓	✓

6.5 Avoid the creation of bare ground during construction

All efforts should be made to prevent the creation of areas of bare ground 10 square metres or larger during the construction phase, as this could attract some species to attempt to nest, e.g. poaka/pied stilt (*Himantopus himantopus*, Not Threatened), spur-winged plover (*Vanellus miles*, Not Threatened), and pohowera/banded dotterel.

If areas are being cleared for landscape plantings, then the plantings should be implemented immediately following the site preparation phase, or the area covered until planting can take place.

If creation of areas of bare ground is unavoidable and the area is left inactive for more than eight days, then passive attempts to deter birds from using them must be implemented. The following techniques may be used:

- The use of reflective tape can be very effective in the short term and will deter various bird species (Avery and Werner 2017). Reflective tape can reflect light disorienting or irritating birds and makes noise when the tape flaps in the wind. This is a short-term solution as birds can habituate to the deterrent over time. The tape must be visible to birds accessing the area.
- Barriers and screening could be implemented to restrict or remove access to bare ground. However, it is essential that barriers and screens do not pose an entrapment risk to birds, so mesh type products should not be used.

If passive attempts at deterrence are unsuccessful and protected species start nesting in the area, the setback measures identified in Section 6.4 above must be implemented.

If bare ground is created (both during and outside of the construction period), it should be enhanced with short-stature vegetation. This will help to reduce the likelihood of birds attempting to nest in these areas.

6.6 Reduce construction noise and vibration

To minimise the disturbance to avifauna from construction adjacent to the braided rivers, noise and vibration levels should be kept to a minimum. While construction noise is unavoidable, machinery must not be left running when not in use. Additionally, music from radios should not be played loudly on site as this can disturb nesting or roosting birds and their chicks.

6.7 Reduce the risk of impact trauma (bird strike)

To reduce the risk of impact trauma arising from collision with structures at the solar farm, the following have been incorporated into the project design:

- The panel design incorporates at least five-metre spacing between panel edges, depending on the degree of tilt.
- North and south development areas are segregated by access road and transmission lines.
- Service/access tracks between sections of panels range between five metres wide unpaved service roads, and a six metres wide and unpaved central arterial road.
- Panel tracking systems will vary the distances between panel edges and the angle of panels throughout the day, altering the spatial view (reducing the risk that birds perceive the solar farm as a lake).
- The PV panels include a standard anti-reflective coated front glass.

- The panels will have a 55-degree night rest position to minimise reflectivity at night. After the proposed Glint and Glare mitigation stow position ($\geq 5^\circ$ angle), the tracker will orient to this angle just before sunrise and sunset to avoid glare to nearby receivers. After the sunset holding period, the tracks will move to the night resting position until sunrise. Tracking arrays reduce the frequency of waterbird fatalities compared to fixed arrays (Kosciuch *et al.* 2025).
- If practicable, the panels will be positioned in directions away from sources of polarised moonlight.

In addition to these measures, sections 6.12-6.13 outline proposed live bird and carcass monitoring for avifauna, which will inform the adaptive management process outlined in section 6.13.5, including changes to on-site protocols if specific trigger levels are met during carcass monitoring.

6.8 Manage pest mammal populations

Pest mammal control shall be implemented on site, in accordance with a Pest Mammal Management Plan (Wildlands 2023), with regular bait checks and monitoring for the lifetime of the solar farm. Pest mammal control will reduce predation pressure on avifauna and other significant taxa present within and adjacent to the site. Trapping should focus on high-value areas for avifauna, such as the wetland and along the southern border of the site.

6.9 Prevent encroachment into high-value habitat

To prevent ongoing disturbance to avifauna, including nesting birds, there shall be no encroachment into high value habitat (wetlands, rivers or river deltas bordering the site) during construction. Encroachment into adjacent wetland and river habitat should be prevented by following the setback distances set out in Section 6.4.

6.10 Reduce vehicle speed on site

To prevent disturbance to avifauna nesting on the site during the breeding season, vehicles shall drive slowly within the solar farm, as birds will breed in gravel areas and may use vehicle tracks as breeding sites. All staff on site must be advised of the need to be vigilant for the presence of birds on the site. If birds are incidentally discovered, follow the incidental discovery protocol (Section 6.11.2).

6.11 Implement incidental discovery protocol when necessary

6.11.1 Overview

The following protocols outline the steps for incidental discoveries of nesting birds, nests, and injured birds, during construction and ongoing maintenance. Trigger levels for injury or mortality are discussed in Section 6.14.4.

6.11.2 Incidental nest discovery

- If nests or nesting avifauna are discovered within the footprint of the site, all works within 100 metres of Threatened and At Risk species (as confirmed by a SQAE) must immediately stop, and the discovery must be reported to the Site Manager.

- Record the following details:
 - Date and time of discovery.
 - Location (GPS coordinate marked).
 - Description of the finding (e.g. species identification, nest type, or remains).
 - Photos, if feasible, without disturbing the nest.
- No works shall resume within this area until a SQAE has viewed the photos and/or assessed the nest and associated birds and determined the appropriate setback to avoid adverse effects.

6.11.3 Injured birds

- If an injured Threatened or At Risk indigenous bird is found within the site footprint, the injured bird should be placed in a cool, dark, material-lined box and taken to a vet immediately.
- The local Department of Conservation office or DOC hotline (if after hours) should be contacted no later than two hours after the injured bird is found. The DOC hotline is 0800 DOCHOTLINE (0800 362 468).

6.12 Undertake surveys during construction

A nesting bird survey should be undertaken by a SQAE no more than eight days before commencement of construction under the following circumstances:

- When a new construction phase begins.
- Works cease for a period of eight consecutive days or more during the avifauna breeding season (1 July–1 March inclusive).
- Development begins on areas of the site that were previously undeveloped, as birds may start nesting in areas of the site that have experienced less disturbance.

Any nests of Threatened, At Risk, and protected bird species found during these surveys will have the appropriate setbacks applied as discussed in Section 6.4.

6.13 Bird monitoring

6.13.1 Overview

Avifauna monitoring within the site should occur prior to, during, and post-construction, at intervals specified in Section 6.13.2. Monitoring locations should be designated by a SQAE, based on the avifauna values present. Results from the avifauna monitoring should be reported annually, with a review conducted after three years to determine whether further monitoring should be implemented.

Where possible, monitoring should occur during the early morning or late afternoon, as birds are most active at these times. Birds are typically less active during strong winds or heavy rain, so surveys should be avoided in these conditions where possible.

During monitoring, the following information should be recorded:

- Date and time of survey.
- Location.
- The total number of birds observed across all species.
- The behaviours and habitat use of all birds present (e.g. roosting on panels, feeding on bare ground under panels, flying overhead).
- For birds flying overhead, the approximate height (e.g. <10 metres, 10-30 metres, >30 metres), and direction of the flight, and size of the flock (if applicable).

6.13.2 On-site monitoring

A SQAE will undertake systematic monitoring of the birds present within the site throughout the construction period and post-construction. This will allow for proactive responses. If changes in the abundance or behaviour of Threatened, At Risk, or protected bird species are observed, construction protocols can be modified, and nesting birds or chicks can be avoided at the site.

Avifauna monitoring should be conducted at representative locations within the solar farm as determined by a SQAE. Monitoring locations should have good visibility and ensure good coverage of the solar farm site, including boundary surveys in areas of the site adjacent to important avifauna habitat, such as braided rivers.

Avifauna monitoring should occur **monthly** for the six months prior to construction commencing. This will provide baseline data about bird distributions at the site. **Weekly** monitoring should occur for the first year of the construction phase, as the most significant changes to the site will occur during this period. After this, a SQAE will review the data and recommend whether the monitoring frequency could be reduced to fortnightly for the remainder of construction, or whether it should remain weekly. Once construction is completed, monitoring should continue **fortnightly** for a minimum of three years following the completion of construction. This will be extended under recommendation from a SQAE if Threatened, At Risk, or protected bird species are frequently observed on the solar farm site or have been recorded as fatalities. As adaptive management changes are implemented, fortnightly monitoring may be recommended for the life of the solar farm.

6.14 Carcass monitoring

6.14.1 Preparation of an Avifauna Carcass Monitoring Programme (ACMP)

Prior to commencement of construction and following the completion of pre-construction avifauna monitoring, an Avifauna Carcass Monitoring Programme (ACMP) will be prepared and submitted to the Department of Conservation for certification. The ACMP will be developed by a SQAE in collaboration with a suitably qualified biostatistician and will be designed in advance to ensure statistical robustness. The programme will enable estimation of true collision mortality rates by incorporating appropriate correction factors, including those for detection probability.

The monitoring design will adopt a stratified sampling framework. This framework divides the solar farm into monitoring strata that reflect relative collision risk. At a minimum, these will include high-risk perimeter areas, such as edges adjacent to waterways or wetlands. They also include infrastructure risk areas, such as fencing, substations, buildings, lighting, and above-ground cabling. Interior panel arrays and any additional risk zones identified by the SQAE will be included. Monitoring effort will be proportionally weighted toward higher-risk strata to maximise detection probability and ensure that monitoring intensity aligns with assessed collision risk.

6.14.2 Incidental carcass discovery

- All incidental discoveries of dead birds at the site should be recorded, including the following details:
 - Date and time of discovery.
 - Location (GPS coordinate marked).
 - Species.
 - Signs of injury and cause of death.
 - Photos of the carcass at multiple angles.
- If the bird is identified as a Threatened or At Risk species, the local Department of Conservation office should be contacted.
- If the carcass cannot be identified to species level, swabs should be taken for DNA identification.
- If the cause of death is unclear, the carcass should be kept for autopsy.

6.14.3 Systematic carcass searches

- Systematic carcass searches should be conducted at representative locations throughout the solar farm following the ACMP. The specific methods used for carcass searches will be determined by the analysis of a suitably qualified biostatistician, who will provide advice around factors including:
 - The proportion of the solar farm to be surveyed to detect high-value Threatened species, including kakī/black stilt (e.g. 50%, or 100%).
 - The frequency of surveys.
- Observer efficiency trials, carcass detection trials, and carcass persistence trials should be undertaken and analysed by a suitably qualified biostatistician to inform modelling of bird strike frequency.
- Monthly carcass searches should occur for a minimum of six months prior to construction commencing to determine the baseline number of carcasses at the site. For example, due to birds striking fences, transmission lines, or other structures already present. Following the completion of construction, carcass searches should occur at least monthly for a minimum of three years.
- Results from carcass monitoring should be reported after the completion of each survey to ensure appropriate adaptive management can be undertaken if required, and an annual summary of results should be provided. A review should be conducted at the end of the three-year period to determine whether ongoing monitoring is required. This would apply where collision risk cannot be demonstrated to be low and stable following statistical analysis.
- Monitoring should include risk-stratified sampling with increased effort at the edges of the solar farm and around ancillary infrastructure.
- During carcass monitoring surveys, the following details should be recorded:
 - Date and time of discovery.
 - Location (GPS coordinate marked).
 - Species (if known).
 - Cause of death (if known).
 - Photos of the carcass at multiple angles.

- If the bird is identified as a Threatened or At Risk species, the local Department of Conservation office should be contacted.
- If carcasses of Threatened or At Risk species are identified, this AMP should be reviewed and updated, and a SQAE may recommend that monitoring continue for an additional period.
- DNA samples from any bird carcasses that cannot be identified based on their morphology, along with any signs of bird strike of panel arrays, should be collected following the methodology outlined in Waugh *et al.* (2010). This involves using sterile sampling kits to collect blood or tissue samples, which are then sent to a laboratory for DNA barcoding.
- If the cause of fatality of a bird cannot be determined, the carcass should be collected and sent for autopsy, if deemed sufficiently intact.
- A Wildlife Approval (WA) from the Department of Conservation will be required to retain any located carcasses for identification purposes, carcass detection trials, and carcass persistence trials. While bird strike risk is considered to be low, it is important that a WA is proactively obtained so that if any carcasses are located, they can be retained for identification and sent to Massey University Wildlife Post-mortem Service for necropsy and/or identification as required. Feathers or photos of unknown carcasses can also be taken to museums for identification by comparing them with their reference library.

6.14.4 Trigger levels

An independent review by a SQAE, following the protocols outlined in Section 6.14.5, will be triggered if either of the following is discovered:

- The injury or mortality of one Nationally Critical or Nationally Endangered species.
- The injury or mortality of two Nationally Vulnerable or Nationally Increasing birds within one survey, or of three within a 12-month period.
- The injury or mortality of three At Risk birds within one survey, or of five within a 12-month period.
- The injury or mortality of five Not Threatened indigenous birds within a survey, or of 15 within a 12-month period.

6.14.5 Adaptive management

If one of the trigger levels listed in section 6.14.4 is met, the following adaptive management protocol should be followed:

- The event should be investigated and reviewed by a SQAE, in consultation with the Department of Conservation. The report should be provided to Nova Energy, Department of Conservation, and the Mackenzie District Council for review.
- The site should be adapted as recommended by the SQAE to prevent further fatalities. This may include methods such as using UV paint, flags, or installing bird-balls on transmission lines.
 - UV paint on solar arrays or other structures. UV film or UV-reflective bands can reduce bird strike on windows by breaking up the reflection (Kagan *et al.* 2014, Swaddle *et al.* 2020) and should reduce bird strike on solar panels.
 - Flags, streamers, or similar visual deterrents on solar arrays. Flags and streamers can break up the reflection from the panels, reducing bird strike risk. These deterrents can also be applied to buildings and structures if bird strikes are attributed to them.

- Bird-balls or other flight diverters on transmission lines to reduce bird strike with transmission lines by increasing the visibility of the wires. These typically reduce collision rates, although the effectiveness of different devices varies between species (Jenkins *et al.* 2010). If there are ongoing collisions with wiring in specific areas that are fitted with bird-balls or other flight diverters, these should be moved underground.
- The implementation of any panel technologies or designs that are developed during the lifespan of the solar farm that could reduce bird strike risk.
- Removal of some panels. This may be required if bird strikes remain high in a specific area of the site after implementing of other management measures. For example, if a high level of bird strike persists in an area of the site despite other management methods, targeted panel removal should occur.
- In the event that adaptive management approaches were not fully effective, compensation payments towards off-site conservation initiatives for the affected species would be required. Compensation would also be necessary in addition to on-site management if a strike of high-value Threatened species, including kakī/black stilt, occurred.
- Funding should be allocated to projects that aim to increase reproductive success, enhance adult survival, or improve knowledge of these species. These include:
 - Project River Recovery (a braided river monitoring and restoration initiative).
 - Community-run conservation initiatives such as predator control and monitoring projects along braided rivers.
 - GPS tracking of the species in collaboration with the Department of Conservation and universities.
 - Grants for an MSc or PhD research to increase knowledge of the affected species, especially in the Mackenzie Basin. This could include GPS tracking or nesting success studies.

6.14.6 Evidence-based compensation

6.14.7 The quantum and form of biodiversity compensation will be explicitly linked to quantified ecological risk, as determined through:

1. Collision Risk Modelling (CRM) using the Band collision risk model (or equivalent), and
2. Population Viability Analyses (PVAs) using Vortex.

This approach ensures that compensation is:

- Proportionate to predicted effects.
- Species-specific, reflecting differential vulnerability.
- Adaptive, allowing refinement as empirical data improves.

6.14.8 Collision Risk Modelling

CRM will be conducted using the Band Model¹ or a similar approach to provide the collision risk for Threatened and At Risk avifauna species that use the site, dependent on the availability of necessary species-specific data. Information required to conduct CRM includes:

- Body length.

¹ Band *et al.* (2007).

- Wingspan.
- Bird flight speed and flight height.
- Flight frequency.
- Approximate distance travelled per day.
- Habitat use, including at the site and within a five-kilometre radius.
- Flight and behavioural characteristics (e.g. polarised light sensitivity, nocturnal activity).
- Site characteristics (e.g. panel and infrastructure locations, size of panel area).

6.14.9 Population Viability Analyses

PVAs can be used to model changes to a species or population over time. PVAs will be conducted using Vortex Analysis software to determine population-level consequences if bird strike of Threatened and At Risk avifauna species were to occur. Information required to conduct PVAs includes:

- Individual life spans and ages.
- Fecundity.
- Population sex ratio.
- Population size.

7.0 Summary of Avifauna Management and Timing

By following the prescribed recommendations (Table 2), any potential effects on indigenous avifauna arising from activities during construction and subsequent operation of the proposed solar farm can be appropriately managed.

Table 2 – Summary of avifauna management procedures to be undertaken during the development and operational phases of the solar farm development.

Action	Timing of Implementation	Reference Section
Planning Phase		
Avoid wetlands, rivers and river deltas with setbacks	Complete (solar farm design includes 20-metre setbacks for all wetlands and rivers)	6.4
Design panel array to minimise risk of bird collision	Complete (solar farm plan has incorporated several design features to minimise bird collision risk)	6.7
Plan construction to occur outside of the avifauna breeding season (1 July-1 March inclusive) where possible	During works scheduling	6.2
Identify potential areas where bare ground may be created and plan enhancement with short-stature vegetation	While planning construction	6.5
Pest mammal management	Commencing before development begins, continuing throughout the life of the project	6.8
Plan and implement speed limits	Before construction begins	6.10
Pre-works nest and chick survey	No more than eight days prior to works commencing	6.3
Development Phase		
Avifauna surveys	Between 1 July and 1 March inclusive, no more than eight days before works recommence after stopping for more than eight days, or no more than eight days before works begin in a new area/stage	6.3; 6.12
Incidental discovery protocol	Any time a nest, nesting bird, or injured bird is discovered	6.11
Establishment of setbacks for nesting birds	Any time protected nesting birds are found on site	6.4
Monitor birds on site	Monthly for six months prior to construction, then weekly during construction	6.13
Avoid creation of bare ground	During construction	6.5
Enhance any bare ground created with short-stature vegetation	Any time bare ground is created during construction	6.5
Reduce construction noise and vibration	During construction, particularly when using heavy machinery	6.6
Solar Farm Operational Phase		
Monitor birds on site	Fortnightly for at least three years post-construction	6.13
Pest mammal management	Continuing throughout the life of the project	6.8

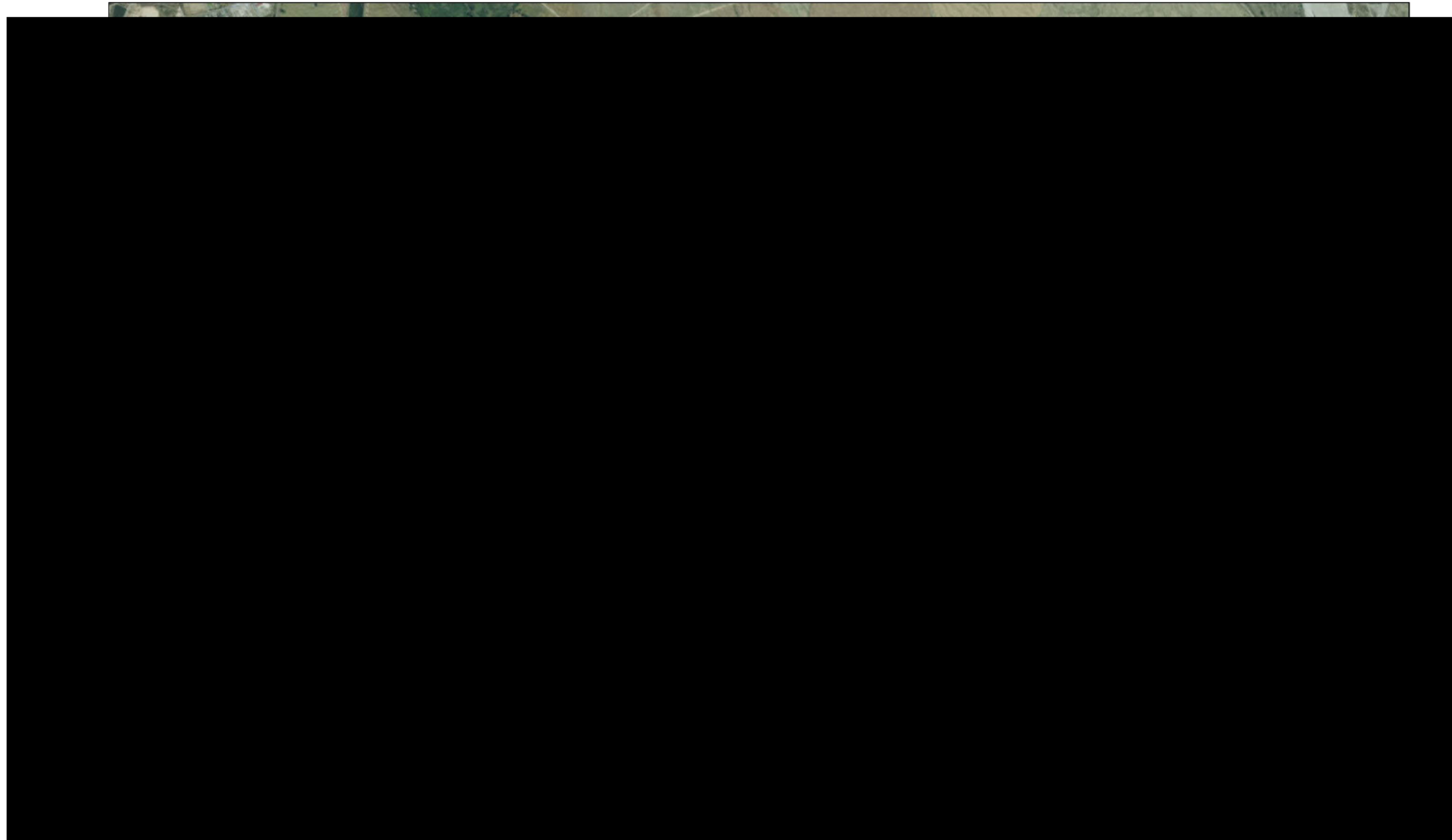
Action	Timing of Implementation	Reference Section
Record bird carcasses	Any time a bird carcass is found throughout the life of the solar farm, it should be recorded	6.14.2
Systematic carcass monitoring	Monthly for a minimum of three years post-construction	6.14.1, 6.14.3
Report injuries or mortalities to Department of Conservation	Any time an injured or dead bird from a Threatened or At Risk species is discovered	6.14.2, 6.14.3
Independent review by suitably qualified avifauna ecologist (SQAE) and adaptive management	Any time an injured or dead bird from a Nationally Critical or Nationally Endangered species is discovered; or two or more injured or dead Nationally Vulnerable or Nationally Increasing, three or more At Risk, or five or more Not Threatened birds are discovered in one survey; or three or more injured or dead Nationally Vulnerable or Nationally Increasing, five or more At Risk, or 15 or more Not Threatened birds are discovered within a 12-month period	6.14.4, 6.14.5
Adaptive management	If trigger levels are met or exceeded, conduct a review, conduct Collision Risk Modelling and Population Viability Analyses, and adapt the site as recommended by a SQAE. In the event that adaptive management approaches were not fully effective, evidence-based compensation may be required	6.14.5-6.14.9

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Appendix 1

Site of the proposed Nova Energy solar farm, with avifauna observed during field visit December 2022 and important habitats for avifauna identified (reproduced from Wildlands 2023a)



Data Acknowledgment
Contains data sourced from the LINZ Data Service
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Maple Technology, Land Information New Zealand, GIBCO, Community maps contributors
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Figure 1. Avifauna and important habitats for avifauna in the vicinity of the site

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Appendix 2

Bird species detected during the desktop assessment and site visit for the proposed Nova Energy solar farm.

Common names, scientific names, and threat classification are from Robertson *et al.* (2021), and protection status from the Wildlife Act 1953.

Common Name(s)	Scientific Name	Threat Classification 2021	Likelihood of Presence at Site	Protection Status
Indigenous				
Kakī/black stilt	<i>Himantopus novaeseelandiae</i>	Threatened – Nationally Critical	Highly likely	Protected
Kōtuku/white heron	<i>Ardea alba modesta</i>	Threatened – Nationally Critical	Possible	Protected
Tarapirohe/black-fronted tern	<i>Chlidonias albostratus</i>	Threatened – Nationally Endangered	Seen during visit	Protected
Kārearea/eastern falcon	<i>Falco novaeseelandiae novaeseelandiae</i>	Threatened – Nationally Vulnerable	Possible	Protected
Kawau tikitiki/spotted shag	<i>Phalacrocorax punctatus</i>	Threatened – Nationally Vulnerable	Unlikely	Protected
Pārerā/grey duck	<i>Anas superciliosa</i>	Threatened – Nationally Vulnerable	Seen during visit	Protected but can be hunted
Pūteketēke/Australasian crested grebe	<i>Podiceps cristatus australis</i>	Threatened – Nationally Vulnerable	Unlikely	Protected
Taranui/Caspian tern	<i>Hydroprogne caspia</i>	Threatened – Nationally Vulnerable	Highly likely	Protected
Ngutu pare/wrybill	<i>Anarhynchus frontalis</i>	Threatened – Nationally Increasing	Likely	Protected
Kotoreke/marsh crake/	<i>Zapornia pusilla affinis</i>	At Risk – Declining	Unlikely	Protected
Pīhoihoi/New Zealand pipit	<i>Anthus novaeseelandiae novaeseelandiae</i>	At Risk – Declining	Possible	Protected
Pohowera/banded dotterel	<i>Charadrius bicinctus bicinctus</i>	At Risk – Declining	Seen during visit	Protected
Tara/white-fronted tern	<i>Sterna striata striata</i>	At Risk – Declining	Protected	Unlikely
Tarāpuka/black-billed gull	<i>Chroicocephalus bulleri</i>	At Risk – Declining	Seen during visit	Protected
Tarāpunga/red-billed gull	<i>Chroicocephalus novaehollandiae scopulinus</i>	At Risk – Declining	Unlikely	Protected
Tōrea/South Island pied oystercatcher	<i>Haematopus finschi</i>	At Risk – Declining	Seen during visit	Protected
Kawaupaka/little shag	<i>Microcarbo melanoleucos brevirostris</i>	At Risk – Relict	Seen during visit	Protected but can be hunted
Māpunga/black shag	<i>Phalacrocorax carbo novaehollandiae</i>	At Risk – Relict	Seen during visit	Protected but can be hunted
Australian coot	<i>Fulica atra australis</i>	At Risk – Naturally Uncommon	Unlikely	Protected

Common Name(s)	Scientific Name	Threat Classification 2021	Likelihood of Presence at Site	Protection Status
Kawau tūi/little black shag	<i>Phalacrocorax sulcirostris</i>	At Risk – Naturally Uncommon	Highly unlikely	Protected but can be hunted
Grey duck – mallard hybrid	<i>Anas superciliosa</i> × <i>platyrhynchos</i>	Not Threatened	Seen during visit	Protected but can be hunted
Kāhu/swamp harrier	<i>Circus approximans</i>	Not Threatened	Seen during visit	Protected but can be hunted
Kakiānau/black swan	<i>Cygnus atratus</i>	Not Threatened	Seen during visit	Protected but can be hunted
Karoro/southern black-backed gull	<i>Larus dominicanus dominicanus</i>	Not Threatened	Seen during visit	Not Protected
Kererū/New Zealand pigeon	<i>Hemiphaga novaeseelandiae</i>	Not Threatened	Possible	Protected
Korimako/bellbird	<i>Anthornis melanura melanura</i>	Not Threatened	Possible	Protected
Kōtare/New Zealand kingfisher	<i>Todiramphus sanctus vagans</i>	Not Threatened	Possible	Protected
Kuruwhengi/Australasian shoveler	<i>Spatula rhynchotis</i>	Not Threatened	Seen during visit	Protected but can be hunted
Matuku moana/white-faced heron	<i>Egretta novaehollandiae</i>	Not Threatened	Seen during visit	Protected
Ngirungiru/South Island tomtit	<i>Petroica macrocephala macrocephala</i>	Not Threatened	Highly unlikely	Protected
Pāpango/New Zealand scaup	<i>Aythya novaeseelandiae</i>	Not Threatened	Seen during visit	Protected
Pied stilt - black stilt hybrid	<i>Himantopus himantopus</i> × <i>novaezealandiae</i>	Not Threatened	Highly likely	Protected
Pīpīwharau/roa/shining cuckoo	<i>Chrysococcyx lucidus lucidus</i>	Not Threatened	Possible	Protected
Pīwakawaka/South Island fantail	<i>Rhipidura fuliginosa fuliginosa</i>	Not Threatened	Likely	Protected
Poaka/pied stilt	<i>Himantopus himantopus leucocephalus</i>	Not Threatened	Seen during visit	Protected
Pūkeko/pukeko	<i>Porphyrio melanotus melanotus</i>	Not Threatened	Unlikely	Protected but can be hunted
Pūtangitangi/paradise shelduck	<i>Tadorna variegata</i>	Not Threatened	Seen during visit	Protected but can be hunted
Riroriro/grey warbler	<i>Gerygone igata</i>	Not Threatened	Seen during visit	Protected
Spur-winged plover	<i>Vanellus miles novaehollandiae</i>	Not Threatened	Seen during visit	Not Protected
Tauhou/silveryeye	<i>Zosterops lateralis lateralis</i>	Not Threatened	Seen during visit	Partially protected
Tētē-moroiti/grey teal	<i>Anas gracilis</i>	Not Threatened	Seen during visit	Protected but can be hunted
Tūi/tui	<i>Prosthemadera novaeseelandiae novaeseelandiae</i>	Not Threatened	Highly unlikely	Protected
Warou/welcome swallow	<i>Hirundo neoxena neoxena</i>	Not Threatened	Seen during visit	Protected
White-winged black tern	<i>Chlidonias leucopterus</i>	Non-resident Native – Migrant	Highly unlikely	Protected
Exotic Species				
Anas sp.	Anas sp.	-	Seen during visit	
Australian magpie	<i>Gymnorhina tibicen</i>	Introduced and Naturalised	Seen during visit	Not Protected

Common Name(s)	Scientific Name	Threat Classification 2021	Likelihood of Presence at Site	Protection Status
California quail	<i>Callipepla californica</i>	Introduced and Naturalised	Likely	Not Protected
Canada goose	<i>Branta canadensis</i>	Introduced and Naturalised	Seen during visit	Not Protected
Chaffinch	<i>Fringilla coelebs</i>	Introduced and Naturalised	Seen during visit	Not Protected
Common redpoll	<i>Acanthis flammea</i>	Introduced and Naturalised	Seen during visit	Not Protected
Common starling	<i>Sturnus vulgaris</i>	Introduced and Naturalised	Seen during visit	Not Protected
Dunnock	<i>Prunella modularis</i>	Introduced and Naturalised	Seen during visit	Not Protected
Eurasian blackbird	<i>Turdus merula</i>	Introduced and Naturalised	Seen during visit	Not Protected
Eurasian skylark	<i>Alauda arvensis</i>	Introduced and Naturalised	Seen during visit	Not Protected
European goldfinch	<i>Carduelis carduelis britannica</i>	Introduced and Naturalised	Seen during visit	Not Protected
European greenfinch	<i>Chloris chloris</i>	Introduced and Naturalised	Seen during visit	Not Protected
House sparrow	<i>Passer domesticus</i>	Introduced and Naturalised	Seen during visit	Not Protected
Little owl	<i>Athene noctua</i>	Introduced and Naturalised	Possible	Partially protected
Mallard	<i>Anas platyrhynchos</i>	Introduced and Naturalised	Seen during visit	Protected but can be hunted
Muscovy duck	<i>Cairina moschata</i>	Introduced, Not Established	Not protected	Unlikely
Passerine sp.	<i>Passeriformes</i> sp.	Introduced and Naturalised	Seen during visit	
Rock pigeon	<i>Columba livia</i>	Introduced and Naturalised	Seen during visit	Not Protected
Song thrush	<i>Turdus philomelos</i>	Introduced and Naturalised	Seen during visit	Not Protected
Yellowhammer	<i>Emberiza citrinella</i>	Introduced and Naturalised	Seen during visit	Not Protected

Appendix 3

Not threatened but protected ground-nesting bird species that are likely to be seen at the proposed Nova Energy solar farm.

Common names, scientific name, and threat classification are from Robertson *et al.* (2021).

Common Name(s)	Scientific Name	Threat Classification 2021
Kāhu/swamp harrier	<i>Circus approximans</i>	Not Threatened
Pied stilt – black stilt hybrid	<i>Himantopus himantopus</i> × <i>novaezelandiae</i>	Not Threatened
Poaka/pied stilt	<i>Himantopus himantopus leucocephalus</i>	Not Threatened
Pūkeko/pukeko	<i>Porphyrio melanotus melanotus</i>	Not Threatened



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