Assessment of Cumulative Ecological Effects for the Proposed Twizel Solar Project

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1.0 Introduction

Nova Energy (Nova) has applied under the Fast-track Approvals Act (FTAA) to establish a new solar farm (the **Twizel Solar Project**) on a site directly southeast of Twizel township at the northern end of Lake Benmore, in the Mackenzie District, Canterbury.

The **Haldon Solar Project**, also located around the northern end of Lake Benmore, has recently been granted consent under the FTAA. The Twizel Solar Project and the Haldon Solar Project ("the two projects") are shown in Figure 1. The two projects are two of several solar farms currently proposed within the Mackenzie Basin. It is unclear how many of the additional proposed projects may proceed; therefore, they are not considered further in this report.

Cumulative effects are most likely to arise where sites of proposed development have high connectivity between habitat patches and are spatially clustered, which is particularly relevant in the context of high-value ecosystems such as braided riverbeds, wetlands, and drylands. As part of the FTAA consenting process, ecological values for the Twizel Solar Project will be assessed separately by the FTAA Panel. However, due to its proximity to the Haldon Solar Project, effects from the two projects may interact and become cumulative, so that the total ecological impacts from the two solar farms are greater than the sum of the impacts from each site considered individually. The following equation was used to guide the effects assessment:

$$CE_{th} = E_t + E_h$$

Where:

E = Direct effects of an individual solar farm

CE = Cumulative effects

t = Twizel Solar Project

h = Haldon Solar Project

This equation illustrates that cumulative effects (as assessed here) are the effects of combining the direct impacts of each solar development, which have previously been described in the assessments of ecological effects provided for each individual impact. In this assessment, we provide evaluation of the **cumulative effects** only.

Although the loss and modification of ecosystems within each proposed solar farm individually may be minor, the overall habitat impacts across multiple developments has the potential to substantially reduce the diversity, connectivity, and function of these habitats and the biodiversity they support.

Effects management that aims to address direct effects of an individual solar farm can also address cumulative effects, as they are directly related to effects on site. Spatial positioning of effects management in relation to neighbouring solar farms impacts its ability to address cumulative effects.

Nova has engaged Wildland Consultants (Wildlands) to undertake an assessment of the cumulative effects of the Haldon Solar Project and the proposed Twizel Solar Project in the Mackenzie Basin.

2.0 Scope

Cumulative ecological effects are inherently complex and unpredictable, particularly for indirect and landscape-scale effects. This is exacerbated by key knowledge gaps around (i) how indigenous fauna and flora will respond to potential issues surrounding bird strike and microclimate changes, (ii) uncertainty over flora and fauna present at some sites, and (iii) effects management strategies which are likely to vary across sites.

Ultimately, these projects represent the first solar farm developments in the Mackenzie Basin. A precautionary and conservative approach to interpretation is appropriate and has therefore been adopted in this assessment.

Ecological effects for the Haldon Solar Project have been considered based on publicly available information to provide a high-level overview of the ecological values present at the Haldon Solar Project site. An assessment of the individual ecological effects associated with the Haldon Solar Project is beyond the scope of this report.

3.0 Ecological Context

3.1 Overview

A combination of environmental and geological factors in the Mackenzie Basin have created a landscape of distinctive ecosystems supporting a relatively high percentage of locally endemic flora and fauna. Over centuries, human use of the landscape has intensified, leading to highly modified landscapes where nationally rare ecosystems and threatened flora and fauna persist in fragments of suboptimal habitat with little or no connectivity. Many species found in the Mackenzie Basin are locally endemic, so that habitat within the Mackenzie Basin is vital to the species' survival. In this context, incremental losses of indigenous biodiversity may result in disproportionate ecological consequences.

3.2 Landscape-scale effects

Cumulative effects encompass both direct and landscape-scale effects[1]. Landscape-scale effects can be more challenging to quantify than direct effects due to their complexity, detectability and scale. The extent of landscape-scale effects depends on the type of development, spatial factors, and biodiversity being considered. Due to their complicated nature, landscape-scale effects are relatively poorly understood and are extremely challenging to quantify.

While precise quantification is often not possible, this addendum report aims to transparently acknowledge, and conservatively interpret landscape-scale effects, which should be addressed through avoidance, mitigation, and remediation where practicable.

[1] Developments can impact biodiversity through both *direct effects* (impacts resulting directly from activities related to the development, e.g. physical loss of habitat through vegetation clearance) and *landscape-scale* effects (impacts resulting from broad environmental changes related indirectly to the development, e.g. progression of edge effects due to vegetation clearance).

3.3 Spatial considerations

The Twizel Solar Project and Haldon Solar Project are located around Lake Benmore. Connectivity across the two projects is likely to vary significantly for different taxonomic groups, due to the Tekapo River separating the sites. Connectivity between the sites for ground-dwelling fauna such as lizards and flightless invertebrates is currently likely to be low, with populations isolated within and between each site. Avifauna, highly mobile invertebrates, and many types of indigenous plant are likely to disperse across the river more easily, with shared populations across both sites.

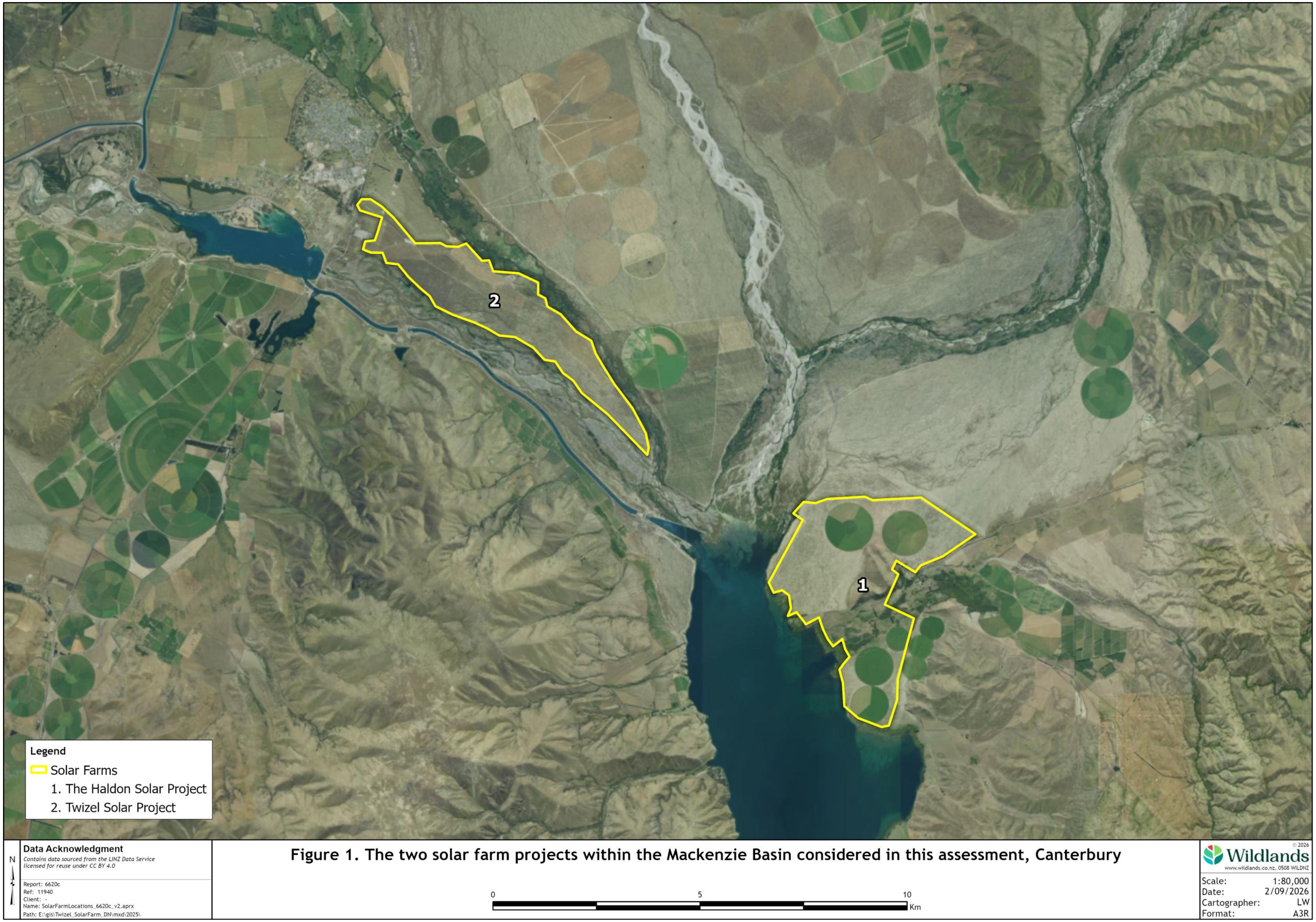

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Figure 1. The two solar farm projects within the Mackenzie Basin considered in this assessment, Canterbury

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Scale: 1:80,000
Date: 2/09/2026
Cartographer: LW
Format: A3R

3.4 Nearby values

The two projects are immediately adjacent to an Important Bird Area (IBA) which includes the Ōhau, Pukaki, Twizel, and Tekapo Rivers. These rivers flow into the Ōhau-Tekapo Delta, where the Ōhau and Tekapo Rivers enter Lake Benmore. These rivers and in particular the delta provide habitat for at least seven Threatened indigenous bird species, including kakī/black stilt (*Himantopus novaezelandiae*, Threatened – Nationally Critical). Fewer than 200 kakī/black stilt remain in the wild.

The two projects lie within catchments with notable braided river environments and inland outwash gravel plains. Braided rivers and their associated gravel beds, as well as inland outwash gravel plains, have been identified as naturally uncommon ecosystems (NUEs; also termed "historically rare ecosystems") on a national basis (Williams et al., 2007). Braided river ecosystems are classified as 'Threatened – Endangered' (Holdaway et al., 2012). The braided rivers of the Mackenzie Basin drain into the Waitaki River; braided rivers and wetlands of the upper Waitaki Basin are under active restoration as part of Project River Recovery, a local initiative run by the Department of Conservation and funded by Meridian Energy and Genesis Energy under a compensatory agreement that recognises the impact of hydroelectric power development on these rivers and wetlands (Nelson et al., 2020).

Vulnerable ecological systems and values near the two projects substantially elevate the sensitivity of the local environment, increasing the likelihood that otherwise low-level effects may assume greater significance when considered cumulatively. Given the high ecological values present within the Mackenzie Basin and the existing pressures associated with intensification, even a relatively minor cumulative ecological effect requires careful consideration.

Haldon Solar Project

The Haldon Solar Project is located directly across the Tekapo River delta and adjacent to the northeast shoreline of Lake Benmore (Figure 1). The proposed solar farm covers part of a 320-hectare site, with ~36 % solar panel cover. The site for this solar farm is located on an ecologically significant Naturally Uncommon, Critically Endangered and Critically Under protected glacial outwash plain ecosystem that contains Threatened and At Risk species of High and Very High ecological value (Milner 2026).

The botanical assessment of the outwash plain habitat on the site described vegetation comprised predominantly exotic ruderal species including hawkweed (*Pilosella officinarum*), *Rumex acetosella*, *Echium vulgare*, *Trifolium arvense* and *Festuca filiformis*, along with a suite of indigenous lichen species, notably At Risk resurrection lichen (*Xanthoparmelia semiviridis,* At Risk – Declining) and common cladia (*Cladia aggregata*), and occasional indigenous vascular plants including *Carex breviculmis*, *Muehlenbeckia axillaris,* and At Risk *Poa maniototo* (At Risk – Declining). Less common indigenous species recorded included At Risk *Convolvulus verecundus* f. *verecundus*, *Raoulia australis* and *R. parkii* (all At Risk – Declining) and the National Threatened *Lepidium solandri* (Threatened – Nationally Critical; Milner and Roper 2026). However, Milner (2026) acknowledges that there were limitations to the botanical survey of the site and there are possibly additional species at the site that have not yet been detected, in particular spring annual species.

As the site contains High and Very High ecological values, including intact outwash gravel habitat and the Threatened – Nationally Critical *Lepidium solandri*, the level of effect on these values was assessed by Milner (2026) to be:

- Very High after mitigation for the potential loss of extent of up to 304 hectares of outwash gravel habitat;
- Very High after mitigation for the loss *of Lepidium solandri*;
- High after mitigation for the loss of at least nine At Risk plant species; and
- High after mitigation for the potential loss of ecological value of at least 16 hectares of outwash gravel habitat.

Sixteen bird species (eight indigenous and eight introduced) were observed at this site. Tarapirohe/black-fronted tern (*Chlidonias albostriatus*, Threatened – Nationally Vulnerable) was the only bird species seen at the site with a threat classification of At Risk or higher. This species was seen flying across the site, which may act as terrestrial feeding habitat for the species. No indigenous birds were observed nesting at the site. A survey comprising pitfall trapping, checks of Artificial Cover Objects (ACOs), Manual Habitat Searching (MHS), and Visual Encounter Surveying (VES) was undertaken for lizards, which detected McCann's skink (*Oligosoma maccanni*; Not Threatened[1]) on site. Two additional species, southern grass skink (*Oligosoma chionochloescens*; At Risk – Declining) and Southern Alps gecko (*Woodworthia* "Southern Alps"; At Risk – Declining), were not detected during the survey but were considered to have a low likelihood of being present. Indigenous terrestrial invertebrates were not formally assessed, however the indigenous grasshopper *Sigaus australis* var. "semi-arid" was noted on site. Rare grasshoppers (specifically minute grasshopper; *Sigaus minutus* Threatened – Nationally Vulnerable and robust grasshopper; *Sigaus robustus* Threatened – Nationally Endangered) were searched for but not seen, though the surveys were conducted at a suboptimal time of year for observing these species. A subsequent survey found *S. minutus* on site along with habitat for several Threatened and At Risk invertebrate species[2]. Habitat for indigenous grasshoppers on the Haldon site is likely to be more extensive and higher quality than on the Twizel Solar Project site due to the relative absence of cultivation.

4.0 Assessment of Cumulative Effects

4.1 Method of assessment

The following process was used to assess cumulative effects:

- Cumulative effects for the proposed solar farms **before** effects management was applied were reviewed by considering the magnitude of each effect and the ecological values impacted:
  - The magnitude of each effect was determined by considering the area covered by the effect and the permanence of the effect. The magnitude is increased for effects that cover a large area or that last a long time.
  - The ecological value impacted by each effect was determined by considering the severity of impact the effect would potentially have on Threatened, At Risk, protected, or otherwise notable flora and fauna.
- A level of effect was then assigned based on the overall expected cumulative effects (guided by the equation in Section 1) of the solar farms after management has been applied.
- The contribution of the Twizel Solar Project was considered after the effects management in the Twizel Solar Project AEE (Wildland Consultants, 2026a) and the Haldon Solar Project has been applied.
- Where effects or magnitudes differ depending on taxon or location (e.g. collision with solar panels impacts avifauna more than other taxa), the highest level of potential cumulative effect is reported.
- Results of the assessment are outlined in Table 1. Further detail, including a description of the mechanism by which the potential effect could occur, is provided in Sections 4.2-4.12.

[1] Conservation statuses for lizards from Hitchmough et al. (2026).

[2] SLR Consulting New Zealand Limited "Draft Terrestrial Invertebrate Assessment" 20 January 2026; cited from a comment by the Department of Conservation on the Haldon Solar Farm Project FTAA application.

Table 1 – Summary of potential cumulative effects considered in this assessment.

Potential Effect	Duration[1]	Magnitude[2]	Potential Cumulative Level of Effect Before Management	Potential Cumulative Level of Effect After Management	Certainty
Loss of indigenous vegetation.	Permanent	Moderate	Significant	Negligible	Moderate
Habitat fragmentation.	Permanent	Moderate	Less than minor	Negligible	Low
Habitat loss.	Permanent	Moderate	Significant	Minor	High
Habitat modification.	Permanent	High	Minor	Less than minor	Low
Predation by introduced mammals.	Permanent	Moderate	Negligible	Net gain	Moderate
Direct mortality of fauna and flora from human and vehicle activity.	Permanent	High	Significant	Minor	Moderate
Fauna disruption during construction.	During construction	Low	More than minor	Negligible	Low
Water quality degradation.	During construction	Low	Less than minor	Negligible	High
Displacement of fauna from within the panel area.	Permanent	High	More than minor	Minor	Moderate
Avifauna collision with solar panels.	Permanent	High	Significant	Minor	Low
Changes in herbicide use.	Permanent	Moderate	Less than minor Negligible	Negligible or Net gain	Low
Increased disruption associated with solar farm operation.	Permanent	Low	Minor	Negligible	Moderate
Modification and loss of inland outwash gravel ecosystem.	Permanent	Moderate	Significant	Negligible	Moderate

[1] EIANZ guidelines (2018) Table 9. Permanent Effects – effects continuing for an undefined time beyond the span of one human generation (taken as approximately 25 years). As Haldon consent has been granted for 35 years, effects expected to last for the duration of the projects are considered permanent.
[2] Magnitude of effect considers the spatial extent and temporal duration of each effect. It is determined by assessing the area covered by the effect multiplied by permanence.

4.2 Loss of indigenous vegetation

Mechanism: Loss of indigenous vegetation could occur through earthworks, shading, and edge effects associated with the two solar projects. This could result in a loss of Threatened and At Risk indigenous dryland vegetation at both sites and has the potential to contribute to landscape-level declines in dryland vegetation species in the Mackenzie Basin.

Magnitude: Indigenous vegetation is uncommon at the Haldon Solar Project site and is confined to the edges and exterior of the Twizel Solar Project site. The ecological value of the vegetation is Very High, but as a condition of consent the Haldon Solar Project must undertake pre-construction baseline surveys to identify and protect any Nationally Threatened plants. At the Twizel Solar Project site, nearly all indigenous vegetation has been avoided, and a preconstruction survey is proposed to identify and avoid any that was overlooked. Therefore, the magnitude has been conservatively assessed as **moderate**.

Level of cumulative effect: The cumulative effects of indigenous vegetation loss will be **negligible.** Indigenous vegetation is limited to the margins of the Twizel Solar Project site and will be avoided as part of the design.

Certainty: There are limitations to the botanical surveys undertaken at both sites, but this has been considered in the effects assessments and consent conditions. Some unknowns remain around what edge effects may occur from solar farms in this landscape (including microclimatic changes) and how far these edge effects will reach beyond the panel areas. Therefore, the certainty of conclusions regarding indigenous vegetation loss is **moderate**.

4.3 Habitat fragmentation

Mechanism: Fragmentation can occur in each solar farm site as earthworks and vegetation clearance remove habitat, and the solar panels, roads and infrastructure modify vegetation and habitat types on site. With each solar farm built within the two projects, the local environment becomes further modified and specific habitat types reduced in size and extent, further decreasing species' ability to move, disperse and access resources across both sites. Cumulative effects result from an increased overall area of suboptimal habitat between habitat patches, and the increased number of suboptimal patches caused by both projects close together.

Magnitude: Fragmentation potentially occurs over large areas of land where solar farm infrastructure and roads create a new barrier between patches of habitat. The habitat will not be reconnected until after the solar farm has been decommissioned and for some flora and fauna, the vegetation reverts to its original state, if this is possible. Therefore, the magnitude of this effect is **moderate**.

Level of cumulative effect: The potential level of effect will be higher in scenarios where stonefield and dryland habitats act as refugia in the surrounding developed and modified landscape. The cumulative effects of habitat fragmentation will also vary according to species. Species that are highly mobile, such as avifauna species, are generally least likely to be affected by habitat fragmentation. The greatest impact of increased habitat fragmentation will likely be on terrestrial invertebrates, which may have metapopulations across both sites with low levels of connectivity. Increasing habitat fragmentation across the two sites may sever the connections between some of the populations, leading to genetic isolation and possibly loss of viability for smaller populations. Cumulative landscape-scale fragmentation is considered unlikely to significantly affect lizards or lizard populations as the sites are already separated by large barriers to lizard dispersal (Tekapo River), and therefore populations at each site are likely to have little to no connectivity in the current state of the habitat.

The cumulative effect of fragmentation at both sites is likely to have **less than minor** impact before effects management is applied. Cumulative effects are likely to be **negligible** for all taxa once effects management has been implemented, as described in the AEE (Wildland Consultants 2026a) due to the avoidance and habitat restoration around the edges of the site where most of the ecological values are. The consent conditions[1] for the Haldon Solar Project also reduce the level of effects for all taxa through its approach. This includes salvage and relocation of species into an off-site Compensation Area, which will be managed through an overarching Ecological Management Plan to achieve no net loss of biodiversity. The effects on invertebrates at the Twizel Solar Project are managed in the AEE to sufficiently reduce the contribution of the cumulative effects. Fragmentation of lizard habitat from the Twizel Solar Project panel areas is currently likely to be low due to low numbers of lizards within the panel area. The lizard population at the Twizel Solar Project is most dense around the edges of the site (along river terrace scarps) which are proposed to be avoided by the development. Since these are the closest areas of contact between the sites, this habitat will remain available if dispersal does occur between sites. Habitat for indigenous dryland vegetation is confined to the edges of the site, which have been avoided, allowing connectivity to remain intact.

Certainty: Targeted lizard surveys have been undertaken at the Twizel Solar Project and at Haldon, and targeted invertebrate surveys have been undertaken at the Twizel Solar Project. However, survey effort at Haldon is overall lower, particularly for invertebrates, which increases uncertainty. The habitat requirements of Tekapo ground wētā (*Hemiandrus fabella*; Threatened – Nationally Endangered) are not well understood, further increasing uncertainty. The status of connectivity between metapopulations of invertebrates which are theoretically on site is unknown and the genetic structure of lizard and invertebrate populations is not understood across metapopulations and populations over the two sites. Targeted vegetation surveys of the terrace edges outside of the Twizel Solar Project site have not been undertaken and these values have not been assessed. Therefore, the certainty of conclusions regarding population connectivity is **low**.

4.4 Habitat loss

Mechanism: Removal of habitat through earthworks will be associated with solar farm development in the Mackenzie. This could result in a lower landscape-level diversity in plant communities and habitats and has the potential to drive declines in habitat availability for ground-nesting avifauna, lizards and invertebrates, and drive losses in landscape-level diversity for fauna.

Magnitude: Habitat loss affects relatively small areas at each site, although the shading impacts of the panels (covered mainly in habitat modification, Section 4.5) are more widespread. The effect will last for the duration of the project and sometime after, as vegetation and habitats will be slow to recover. Therefore, the magnitude of this effect is **moderate**.

Level of cumulative effect: The panel area of the Twizel Solar Project site is dominated by exotic plant species and relatively low-quality habitat for flora and fauna. The high-value habitat within the Twizel Solar Project site has been avoided, including areas of dryland stonefield and stoney scarps, which are located near the property boundaries. However, the Mackenzie Basin is under pressure from agricultural expansion and intensification, and any loss of indigenous vegetation (particularly dryland scarps and stonefields with Threatened and At Risk plants) associated with the development of solar farms in the area could contribute to a greater cumulative effect due to the habitat loss and modification that has already occurred due to other land use pressures.

While the direct effects of habitat loss at Haldon are expected to be significant before management due to the Very High habitat values, these will be managed through its Compensation Area and Ecological Management Plan, which incorporates habitat enhancement, salvage and translocation, and

[1] Appendix A: Mackenzie District Council resource consent conditions.

compensation informed by further surveys and monitoring. The cumulative effects of the Twizel Solar Project after management are expected to be **negligible**.

Certainty: Certainty of this effect is considered **high** due to the simplified nature of the habitats within the wider area. Some uncertainty remains surrounding the quantity and distribution of indigenous species and habitats within the other solar farms.

4.5 Habitat modification

Mechanism: Modification of habitat through changes in microclimate is primarily caused by shading from solar panels. The Mackenzie Basin is characterised by dry, exposed dryland environments, and increasing shade in these areas is likely to modify the availability of habitat for flora and fauna. Vegetation in the proposed panel areas is mostly exotic grassland; However, indigenous vegetation communities are likely to become homogenised beneath the solar panels. Additionally, if there are inadequate buffers between the solar arrays and areas of indigenous dryland vegetation and habitats, shading by solar arrays may exacerbate habitat simplification in high-value areas. This could result in lower landscape-level diversity in plant communities and habitats and has the potential to drive declines in habitat availability for ground-nesting avifauna, lizards, and invertebrates, as well as drive losses in landscape-level diversity for fauna.

Magnitude: Habitat throughout both sites will be modified as the solar panels cover most of each site. Habitat modification will persist for the duration of the projects, and habitats are likely to recover slowly once panels are removed. Therefore, the magnitude of this effect is **high.**

Level of cumulative effect: Much of the high-value habitat within the footprint of proposed solar arrays of the Twizel Solar Project has been avoided, including areas of dryland stonefield and stoney scarps, which are typically located near the property boundaries. However, the Mackenzie Basin is under pressure from agricultural expansion and intensification, and any modification of indigenous habitat (particularly dryland scarps and stonefields with Threatened and At Risk plants) associated with the development of solar farms in the area could contribute to a greater cumulative effect due to the habitat modification that has already occurred due to other land use pressures.

The overall cumulative effect of habitat modification for both sites is expected to be **minor.** The magnitude of the effect for the combined sites increases this cumulative effect level compared with the others assessed in this report, but the quality of habitat that is being shaded out by the solar panels, and the ecological value it represents, is relatively low. Cumulative effects on invertebrates and vegetation will be greater than for avifauna or lizards due to modification of a large amount of habitat such that it may become unusable for Threatened and At Risk species. While this effect is potentially significant at the Haldon Solar Project site, as the soil has not been cultivated and At Risk and Threatened species (such as minute grasshopper) are found throughout the site, it has been managed by avoiding certain habitats and the enhancement of the Compensation Area.

The cumulative effect of habitat loss is considered likely to be **less than minor**. The habitat within the development area is already considered to be of low to very low quality for lizards. Areas of pasture, stonefield, and dryfield within the solar farm sites can provide breeding and foraging habitat for several Threatened and At Risk avifauna species. These habitat types are found elsewhere within the surrounding Mackenzie Basin, and nearby braided rivers also provide attractive habitat for many species. However, some Threatened, At Risk, and protected avifauna species may still breed onsite or visit the site to forage.

Certainty: Certainty of this effect is considered **low** due to the unknown effects of solar panels on Mackenzie Basin vegetation and microhabitats.

4.6 Predation by introduced mammals

Mechanism: Human activity can cause increased pest mammal numbers on site. Food and litter scraps attract pest mammals, and increased movement creates tracks which mammals use to move across landscapes. Disturbance, habitat modification and weed growth are all potential contributors to an increase in pest mammal activity. Effects become compounded with increased pest mammal abundance over a short space of time throughout both sites, combined with fauna becoming more vulnerable to predation due to loss of habitat, displacement and disturbance.

Magnitude: Pest mammal activity may be increased by human activity across both sites for the duration of the project. However, cumulative impacts will be focused along the edges and adjoining borders of the sites, and on the tracks, as these will enable predators to move between sites. Therefore, magnitude of this effect is **moderate**.

Level of cumulative effect: Pest mammal numbers in the local area where the two sites are located are already high. The two projects are not likely to raise pest mammal numbers significantly and effects will mostly be non-cumulative. Therefore, the level of effect will be **negligible.**

The Twizel Solar Project is planning to control and monitor pest mammals under the guidance of the Pest Mammal Management Plan (Wildland Consultants 2026c). This will involve site-wide control (868 hectares), with potential to enhance connectivity between sites where predator control is carried out (e.g. on the adjacent riverbeds). The Haldon Solar Project will control predators within a predator-proof fence at the Compensation Area (180 hectares).

In addition to the benefits of pest mammal control on site, potential collaboration between the solar farms and knock-on benefits of pest mammal control for biodiversity around the edges of the site (including the riverbed) could result in a **net positive** cumulative effect. Pest mammals are the primary cause of decline for many species in the Mackenzie Basin, including kakī/black stilt and tarapirohe/black-fronted tern, so controlling pest mammals could potentially benefit many species. If monitoring of pest mammals could be done collaboratively across both sites, monitoring results would be more statistically robust, making pest mammal monitoring more reliable and trends in mammal abundance and activity easier to follow. The Twizel Solar Project plans to use trail cameras to monitor the bird carcasses used in carcass detection trials, which will provide information around the presence of pest mammals.

The Haldon Solar Project consent conditions include the preparation of a Pest Animal Management Plan that will include fencing requirements and elimination or reduction targets for pest animals, as well as monitoring and reviewing the management outcomes.

Certainty: Certainty of this effect is considered **moderate** because while predator management is a well-understood method for controlling predators locally, its efficacy on larger scales is not understood very well, and opportunities for collaboration have not yet been discussed.

4.7 Direct mortality of fauna and flora from human and vehicle activity

Mechanism: Potential mortality of regionally or nationally Threatened or At Risk flora or fauna occurs during construction and operational activities. Direct physical effects of vehicles, machinery, and earthworks are most likely to cause mortalities. While the number of deaths of plants and animals at each site will be low, the combined site activities may impact population resilience within the wider area by killing a higher percentage of individuals. This effect is compounded if both sites commence construction at the same time, given that the construction stage is when mortalities are most likely to occur due to heightened vehicle and human activity and large machinery on site. Cumulative effects could be reduced to negligible by staggering construction activities so that populations have time to recover between each development.

Magnitude: Mortality of individuals has the potential to impact populations of flora and fauna across both sites, and even outside the sites for avifauna populations. Death is permanent, and though numbers can recover through recruitment, the loss of genetic diversity (particularly important for kakī/black stilt which has a very small wild population) is permanent. The magnitude of this effect is therefore **high**.

Level of cumulative effect: The overall level of cumulative effect for avifauna may be **significant** if not adequately managed. Based on the population viability analysis modelling (PVA; Wildland Consultants 2026d), kakī/black stilt are at such low numbers that they would suffer significantly from the loss of one individual. Matuku-hūrepo/Australasian bittern (*Botaurus poiciloptilus*, Threatened – Nationally Critical) and kōtuku/white heron (*Ardea alba modesta*, Threatened – Nationally Critical) populations would experience significant negative effects from the loss of one individual. Significant negative population-level effects are modelled in the event of ongoing losses of tarapirohe/black-fronted tern, pūteketeke/Australasian crested grebe (*Podiceps cristatus australis*, Threatened – Nationally Vulnerable), māpunga/black shag (*Phalacrocorax carbo novaehollandiae*, At Risk – Relict), pohowera/banded dotterel (*Charadrius bicinctus bicinctus*, At Risk – Declining), tarāpuka/black-billed gull (*Chroicocephalus bulleri*, At Risk – Declining), and tōrea/South Island pied oystercatcher (*Haematopus finschi*, At Risk – Declining). The fact that activity across two sites may cause mortality at the same time compounds the level of effect beyond the sum of effects from both sites individually due to the potential loss of a larger percentage of individuals at one time. However, the cumulative effect of mortality on avifauna will be reduced by measures such as pre-works surveys and setback distances, as set out in more detail below.

The cumulative effect of direct mortality is likely to be **minor** after management. As described in the Twizel Solar Project AEE, the development avoids key habitat. Effects management for both the Twizel Solar Project and Haldon Solar Project includes pre-works surveys and setbacks during the avifauna breeding season, which will mean mortality of avifauna is unlikely. The Twizel Solar Project proposes an avifauna collision monitoring programme, with adaptive management and, if required, compensation payments linked to specific trigger levels. The Haldon Solar Project will also implement an avifauna collision monitoring programme linked to adaptive management and will provide compensation as an initial upfront payment. Effects management for the Haldon Solar Project also includes undertaking lizard salvage within impact areas prior to works, which will minimise the direct mortality of lizards from activities on site.

Certainty: Habitats within the Twizel Solar Project are degraded; however, Haldon Solar Project has Threatened vascular plants within the footprint. There is **moderate** certainty surrounding this effect.

4.8 Fauna disruption during construction

Mechanism: Disturbance, such as earthworks, noise, dust, vibration, human presence and temporary habitat loss can cause non-fatal disruptions to fauna in and around the site. Effects can be cumulative when construction happens concurrently for both sites.

Level of cumulative effect: The cumulative effect of disturbance during construction on fauna differs by biodiversity type. Cumulative effects on:

- ***Avifauna*** is considered less than minor. Disturbance would reduce the amount of habitat for foraging and nesting birds, particularly if construction happens concurrently across both sites. It could affect birds both within the sites and in adjacent habitats and could cause nest abandonment. Birds disturbed by construction activities may need to travel further to find suitable alternative breeding and foraging habitat if construction was occurring concurrently at both sites. Cumulative effects on birds will be managed using avoidance, through pre-works avifauna surveys, and implementing setback distances from nesting birds.

- ***Terrestrial invertebrates*** is likely to be more than minor across both sites due to the localised distribution and current knowledge gaps of species such as Tekapo ground wētā. Disturbance may cause increased stress and behavioural changes and effectively increases habitat fragmentation for invertebrates. However, effects are temporary, localised, and (at both sites) managed through Terrestrial Invertebrate Management Plans. They are also unlikely to interact between the two sites.
- ***Lizards*** during construction is negligible due to the low density of lizards present within the development area in comparison to surrounding areas of habitat (old river terraces). A relatively minor proportion of the population will therefore be impacted by disruption.

Accordingly, we assess the overall level of effect prior to effects management as **more than minor**. However, if the construction of solar farms is staggered, and with enough time to monitor and adapt the effects management at the two sites, this could lead to a reduced cumulative effect.

Certainty: The cumulative effects of all fauna disruption during construction is not well understood, and it is unclear whether the two solar farms will ultimately be constructed concurrently. Therefore, there is **low** certainty surrounding this effect

4.9 Water quality degradation

Mechanism: Across both proposed solar farm developments in the Mackenzie Basin, construction disturbance and permanent changes in land use have the potential to alter sediment and contaminant loads entering receiving environments. Construction activities may mobilise sediment through earthworks, vegetation clearance, vehicle movements, and trenching, while operational phases may involve the use of herbicides for weed management. Solar panel arrays may modify the surface hydrology at a site by concentrating rainfall along panel drip lines, which could increase runoff velocities. Compacted surfaces associated with access tracks and infrastructure may also impact hydrology.

The effects noted above are expected to be localised and short-term for individual solar farms. A cumulative effect has the potential to occur if construction of the two projects occurs at the same time and where runoff pathways from the solar farms converge towards major waterways, causing one large increase of sediment inputs into the receiving environment rather than two small separate increases.

Magnitude: Effects on water quality will occur during construction only, and waterways only cover a small portion of each site. Therefore, this effect has a **low** magnitude.

Level of cumulative effect: When considered collectively, the two projects have the potential to contribute to a **less than minor** cumulative effect on water quality.

While individual solar farms are expected to make only negligible contributions, during construction and where multiple developments operate within the same catchments, the cumulative impacts have the potential to be less than minor. Management of water quality at the Twizel Solar Project site includes a sediment management plan and spill management plan as well as offsets from wetlands. The consent conditions for the Haldon Solar Project include the provision of an Erosion and Sediment Control Plan to Council (district and regional) prior to the commencement of construction works. These management measures will ensure there is a low cumulative effect on waterways and should result in **negligible** cumulative effects**.**

Certainty: The potential cumulative effect on water quality will depend on the timing of the construction for the two projects (e.g. whether they are staggered) and both projects implementing the appropriate controls set out in their plans. However, certainty is **high** because the efficacy of proposed sediment management interventions, such as riparian buffers and sediment controls, is well understood.

4.10 Displacement of fauna from within the panel area

Mechanism: Displacement effects may result from large areas of habitat being lost from vegetation clearance, construction and long-term operation, as some animal species within each impacted area are likely to leave and seek habitat elsewhere. The cumulative aspect of this effect results from compounded removal of options for where a displaced animal can go. Individuals displaced from both solar farms at the same time are likely to temporarily impact surrounding populations more than individuals displaced from both solar farms at different times.

Displacement effects are likely to be greatest for moderately good dispersers such as many flying insects, as they are more likely to respond to habitat loss by moving elsewhere, but may not be able to move very far. Displaced animals are more vulnerable to predation and other dangers, while the stress from displacement is likely to affect breeding, feeding, and general survival rates. Populations external to the sites may experience increased pressures from receiving displaced individuals. Avifauna present on-site will be able to disperse to nearby high-quality habitats but may temporarily experience increased stress and energy expenditure as a result.

Poor dispersers may attempt to move away from the area but will be less able to move through suboptimal habitat.

Magnitude: Displacement of fauna impacts populations on site and receiving populations in the wider area. The effect will persist for as long as the habitat on site is lost or modified, which may be longer than the duration of the project and the magnitude of this effect will be **high** before effects management.

Level of cumulative effect: Displacement effects are likely to be **minor**, as most ecological values at the Twizel Solar Project have been avoided as they are concentrated around the perimeter of the site, outside of the panel area. At the Haldon Solar Project site, displacement effects have also been managed through avoidance of high value habitats as well as the ecological enhancement of the Compensation Area. Dispersal-limited species such as grasshoppers persisting within the panel areas are unlikely to be displaced. Similarly, lizards are only present at low densities within the Twizel Solar Project site and therefore the number and density of displaced lizards is also likely to be low. Consequently, any displacement will have minimal impacts on lizards present in relatively higher quality habitat around the edges of the site (old river terraces).

Further, populations of less mobile species such as lizards and some invertebrates at each solar farm site are separated by a significant barrier (the Tekapo River), and interaction and connectivity between populations is very low. Displacement effects at one site are therefore highly unlikely to influence or be exacerbated by effects at the other site.

For more mobile taxa, such as avifauna, cumulative displacement effects will be limited because there are plenty of alternative comparable habitats nearby. In addition, avifauna in this area are thought to be primarily limited by predation and invasive weeds, rather than competition for habitat.

Certainty: Displacement effects are not well-understood and population dynamics of fauna within and adjacent to the panel areas of all sites are not well-known. However, abundance and diversity of indigenous flora and fauna on site have been surveyed and are relatively well-understood, raising the certainty of this effect level to **moderate**.

4.11 Avifauna collision with solar panels

Mechanism: The mechanism for avifauna collision with the reflective surfaces of solar panels remains unclear. One possible mechanism is the 'lake effect', where birds mistake the reflective surfaces of solar panels for waterbodies, resulting in death or injury (noting that there is currently no evidence that the lake effect applies in New Zealand). Another possible mechanism is that birds may be attracted to the polarised or ultraviolet light reflected from solar panels.

A larger reflective surface, created by both solar farms close together, may prove more attractive to waterbirds as opposed to two smaller, spatially separated solar farms. Two solar farms close together will be visible to birds from a further distance away, increasing the distance from which birds may come to land on the perceived water body or be attracted by polarised or ultraviolet light.

Birds may strike the solar panels accidentally, or try to land on the panels, regardless of the lake effect. This potential impact is likely to be incidental and occasionally harmful, but the size of the two sites combined compounds the effect due to birds needing to fly further to leave the site and therefore seeking landing places if they are flying over the area when they are fatigued or during inclement weather.

Magnitude: The solar panels, and therefore the threat of collision, will cover all both sites for the duration of the project and therefore the spatial and temporal extent of the effect is large. The magnitude is therefore **high**.

Level of cumulative effect: Based on the PVA and current avian behavioural research, the cumulative impacts of avifauna collision are expected to be **significant** if not managed appropriately. The presence of kakī/black stilt nearby is the main driver for this effect level, as the loss of even one individual is significant due to the very small population and its low genetic diversity. Matuku-hūrepo/Australasian bittern and kōtuku/white heron also contribute to this effect level, as both species are critically threatened and have small population sizes, and would thus experience significant negative effects from the loss of just two individuals.

Multiple waterbodies already present in the area should prove more attractive to waterbirds than the solar farms, limiting the likelihood of this effect occurring. The nearby rivers, wetlands, and deltas are important breeding, foraging, and roosting habitats for a variety of Threatened and At Risk avifauna species, including kakī/black stilt, matuku-hūrepo/Australasian bittern, and kotoreke/marsh crake (*Zapornia pusilla affinis*, At Risk – Declining). However, these birds do not land directly on water but will alight on land before foraging within a waterbody. Avifauna will also regularly overfly the site, with some species flying at night.

Planned mitigation and adaptive management proposed for both the Twizel Solar Project and the Haldon Solar Project is likely to limit the overall cumulative effect to **minor**. Nova intends to install tracking array solar panels with anti-reflective panel surfaces, which should significantly reduce avifauna collision risk. The Avifauna Management Plan (Wildland Consultants 2026e) and Avifauna Carcass Monitoring Programme (Wildland Consultants 2026f) include post-construction monitoring, with adaptive management to manage the potential effects of collision if trigger levels are met. Similarly, the Haldon Solar Project also plans to install tracking array panels with anti-reflective surfaces and follow an avifauna collision monitoring programme, with adaptive management to be undertaken if mortality trigger levels are met.

Certainty: Overall, there is a **low** level of certainty regarding how indigenous species in New Zealand will respond to this effect. International studies indicate the collision risk is generally low if appropriate management measures (such as tracking arrays) are used, although we have low certainty about this in a New Zealand context.

4.12 Changes in herbicide use

Mechanism: Pest plants and ecological weeds, particularly woody weeds, may become problematic due to changing microclimates at the site as a result of shading from the panels and changes in grazing regime and pest animal control. Herbicide is likely to be used at all sites, and there could be an adverse effect on indigenous plant and invertebrate diversity if Threatened or At Risk grasshopper or plant species are close to herbicide use. Over time, repeated and spatially extensive herbicide application can also alter soil biota and nutrient cycling, increase weed resistance, and reduce ecosystem resilience, even where individual applications appear minor. The cumulative effect of herbicide use across the Mackenzie Basin could have greater negative outcomes when combined with other pressures associated with agricultural intensification.

Magnitude: Magnitude for this effect is **moderate**, as spray use in the Mackenzie Basin can cause permanent damage to habitat and fauna populations, but weeds only cover a relatively small area of each property.

Level of effect: This effect is considered to be **less than minor**, with potential for a **net gain** in biodiversity resulting from reduced use of agrichemicals due to the change in the way the land is used. The use of agrichemicals may be lower than if the land were used for agriculture, noting that sheep can be used to graze grass around the solar arrays.

If herbicide use at the Twizel Solar Project is minimised by replacing herbicide sprays with mechanical, manual, or cut and paste-based methods as in the AEE and Biosecurity Management Plan (Wildland Consultants, 2026b), the cumulative effect associated with herbicide use will be **negligible**.

Certainty: The extent to which pest plants and ecological weeds will spread across the solar farm sites is not fully understood. The extent to which Haldon Solar Project will employ herbicides is unknown. Therefore, the level of certainty is **low**.

4.13 Increased ongoing disruption associated with the operation of solar farms to fauna

Mechanism: Ongoing disturbance and disruption will be associated with the operation of the two projects, including increased human presence, vehicles, and disruption from maintenance and pest plant control.

Magnitude: The increased disturbance would be limited to the parts of the sites that have not previously experienced much vehicular or human disturbance. Considering the sites are currently used for farming and disturbance from humans, dogs, and vehicles is part of running the farms, the effects and therefore cumulative effects are only likely to cover a small area. However, disturbance will continue throughout the life of the project. Magnitude of this effect is therefore **low**.

Level of cumulative effect: The levels of vehicle use, noise, and human disturbance during the solar farm operation is expected to be limited and sporadic and is therefore expected to have a minimal impact on flora and fauna compared to what is already occurring across both sites. The cumulative aspect of these effects is expected to be **negligible.**

Certainty: The cumulative impacts of disturbance across the solar farms are difficult to discern and to extricate from the impacts if both projects were commissioned in isolation. However, activity across both sites would have to increase significantly to raise the cumulative effects above negligible, so the certainty for this effect is **moderate**.

4.14 Modification and loss of inland outwash gravel ecosystem

Mechanism: Soil disturbance and modification to soils and character of inland outwash gravels (a historically rare ecosystem) is associated with earthworks and construction. The effects of modification are compounded when a larger area is impacted due to the loss of a larger area of contiguous outwash plain.

Magnitude: Soil disturbance will occur only for roading and installation of solar panels and will not involve disruption to the entire panel footprint. Modification will be permanent, so magnitude is therefore **moderate**.

Level of cumulative effect: Both sites are currently grazed by livestock, but the Haldon Solar Project site has never been cultivated (e.g. ploughed, tilled, drilled etc.) and the outwash plain habitat remains relatively intact. However, the Twizel Solar Project site has been cultivated (drilled and tilled), which has disrupted the soils and the outwash plain habitat is significantly modified from its original state. Therefore, while direct effects at Haldon are expected to be significant, the cumulative effects are considered **negligible** before offsetting and compensation.

Certainty: The Haldon Solar Project site will result in ~4% permanent loss (roads, buildings or panel footprints) of the outwash plain habitat with ~36 % solar coverage and the outwash habitat's ability to recover and therefore support the regrowth of dryland flora is not known. Similarly, there is no certainty the 'Enhancement Site' proposed as part of the management actions for the Haldon Solar will deliver any benefits to the outwash plain habitat. Outwash plain habitat and indigenous dryland plants are nearly completely absent from within the panel area at the Twizel Solar Project, so long-term effects on dryland plants will not be cumulative. Therefore, certainty is **moderate** for this effect.

5.0 Conclusions

The cumulative effects of the two solar farms are likely to be greater when clustered, as is the case with the Haldon Solar Project and the proposed Twizel Solar Project.

Several cumulative effects are driven mainly by the timing of construction. If construction activities were staggered between projects, the cumulative level of effects would be significantly reduced.

When effects are combined and assessed on a cumulative basis, the effect levels increase. This could result in less than minor to minor impacts on dryland ecosystems and indigenous vegetation, lizards, invertebrates, and avifauna without appropriate management. Overall, when the effects management proposed by Nova and Haldon is considered, the cumulative effects of these two projects are less than minor and, in most cases, negligible. No further effects management is required by Nova to manage adverse ecological effects resulting from cumulative effects. The Twizel Solar Project's effects are disproportionately low relative to the property size, as most ecological values lie outside the panel area and are further managed through the AEE. Effects management planned for the Twizel Solar Project is thorough and well-considered, following the effects management hierarchy based on advice from a team of suitably qualified ecologists.

Uncertainty remains high for several effects mechanisms, particularly for avifauna collision with solar panels, cumulative habitat fragmentation, and habitat modification. Although the assessments of cumulative effects are based on ecologists' current understanding, a conservative approach has been adopted and the high residual uncertainty associated with many of the effects listed in the report could result in lowered effects levels once the mechanisms and effects are better understood. Cumulative effects could increase in level as a result of unforeseen interactions between the direct effects of each solar farm. This is most likely to occur from effects that result in the mortality of vulnerable avifauna populations, such as rare kakī. However, a robust effects management regime is proposed to address the potential effects on these species.

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