FIRE RISK ASSESSMENT

The Point solar farm

Commissioned by Far North Solar Farm Ltd
Prepared by Renewable Engineering Group

17 April 2025
V0.3

Contents

1. Executive Summary

This report focuses on evaluating the principles and conclusions reached in a specialised Beca Ltd Fire Risk Assessment (Beca Report)[1] prepared for Far North Solar Farm (FNSF) in relation to a proposed solar farm in Greytown, Wairarapa, and then demonstrates how these have been applied to FNSF's proposed 'The Point' solar farm development. The Beca Report was prepared to support expert evidence presented to the Environment Court in relation to the resource consent application for a proposed solar farm in Greytown. The full Beca Report is available in *Appendix 1*.

The purpose of a fire risk assessment as recorded in the Beca Report is to provide technical detail to support the following matters:

- *Assessment of fire risk from the construction and operation of a solar farm itself and from adjoining rural/ domestic activities in the context in which it is located*
- *Assessment of any additional risk associated with screen planting and revegetation activities which are planned for the site*
- *Mitigation proposals to reduce identified risks*
- *Protocols for fire containment depending on source and site factors*
- *Protocols for communication/warning in event of fire.*[2]

The focus of the Beca Report was the consideration of fire risks posed by a solar farm to the surrounding rural context. Conversely, fire spread from surrounding rural land uses to the proposed solar farm itself was also considered.

2. Renewable Engineering Group (REG)

Renewable Engineering Group (REG) is a specialist engineering consultancy firm providing advanced design and technical advisory services in the renewable energy sector, with an emphasis on utility-scale solar farm developments in New Zealand and Australia. REG is currently engaged by FNSF to support the engineering development lifecycle of its New Zealand solar development portfolio, including The Point, through comprehensive design, compliance assessments, and technical studies essential for obtaining regulatory and stakeholder approvals.

As part of this engagement, REG has taken the lead in preparing site-specific plans that integrate safety, accessibility, and emergency response considerations in line with the Fire and Emergency New Zealand (FENZ) framework. Previous close collaboration with FENZ has ensured REG has been able to embed best practices and key learnings into The Point site layout and engineering design documentation.

Furthermore, development of The Point has been designed from the ground up with regulatory compliance in mind, incorporating relevant New Zealand Fire Service

[1] Proposed Greytown Solar Farm – Fire Risk Assessment, Beca Limited, 13 September 2024.

[2] Beca Report, page 2.

Firefighting Water Supplies Code of Practice SNZ PAS 4509:2008, local planning provisions, and infrastructure standards.

3. Methodology and Standards

The assessment in the Beca Report referenced international standards such as NFPA 551[3] and ISO 16732-1[4] which specifically cover fire risk assessments. The SFPE Guide to Risk Assessment (2nd Ed. 2022)[5] also provides extensive guidance on fire risk assessment. The methodology of the Beca Report was taken from these standards and customised to suit a fire risk assessment that meets the need of a utility-scale solar farm within the rural New Zealand context.

Beca defined risk as *"the paired probabilities and consequences for possible undesired events associated with a given facility or process" (NFPA, 2022)*.[6] A qualitative approach was adopted in the Beca Report in characterising the probability and consequences, and therefore risk posed by a solar farm. REG understands that Beca adopted a qualitative approach because it provides sufficient characterisation to support Beca's expert opinion and is supported by referenced research and data. A relative risk approach was chosen as it assists with risk comprehension by comparing the new risk(s) with already known existing farmland baseline risks. For these same reasons, REG adopts the same approaches in this assessment.

While the Beca Report was prepared to support a solar farm development in Greytown, the similarities between the design elements and receiving environment of that project and The Point provide confidence, in REG's opinion, that the conclusions on Greytown are highly transferrable to The Point. These similarities are characterised below.

Design & Environment	**The Point solar farm**	**Greytown solar farm**
Solar module design	Bi-facial panels in 1P Single Axis Tracker formation	Bi-facial panels in 2P Single Axis Tracker formation
String combiner monitoring box (SMB)	SMBs include temperature sensors, electrical arc fault detection, thermal imaging.	SMBs include temperature sensors, electrical arc fault detection, thermal imaging.
Orientation	East-West Tracking	East-West Tracking

[3] National Fire Protection Association (2022). *NFPA 551 Guide for the Evaluation of Fire Risk Assessments* (Version 2022).
[4] International Organisation for Standardization. *Fire safety*, Subcommittee SC 4, *Fire safety engineering*
[5] Society of Fire Protection Engineers (2022). *Guide to Fire Risk Assessment, 2nd Ed.*
[6] Beca Report, page 3.

Module row spacing	6m pitch, 4m when panels level	12m pitch, 6m when panels level
Module height	2.m	4.5m
Inverters	SMA Sunny Central 4200 Up MVPS Power Inverters (or equivalent)	SMA Sunny Central 4200 Up MVPS Power Inverters
Switchyard	Newly created onsite. Will meet Transpower NZ's "Substation Fire Mitigation Design Standard"	Newly created onsite. Will meet Transpower NZ's "Substation Fire Mitigation Design Standard"
Monitoring	CCTV full site coverage. Thermal imaging cameras cover perimeter	CCTV full site coverage. Thermal imaging cameras cover perimeter
Screening vegetation	Selected from FENZ approved species list with site species considerations. Screening only present on west and south of site	Selected from FENZ approved species list. Screening around entire boundary
On-site vegetation	No existing trees on site. Regeneration areas planned for east of site	Existing trees on site removed
Current land use	Pastoral farming	Pastoral farming
Surrounding Environment	Single farming neighbour to north. River and lake to east, west and south	Multiple houses and lifestyle blocks

4. Fire and Emergency NZ Consultation

FENZ is aware of the increasing presence of solar farms in rural areas of New Zealand and is in the process of developing a national firefighting procedure for solar farms. REG and FNSF have engaged in detailed consultation with FENZ through the development of its national solar portfolio. This includes sites at Greytown, Waipara, Waiotahe, Pukenui, Marton, Edgecumbe, Taranaki and at The Point.

As a result, an Emergency Response Plan (ERP) and a Construction Fire Risk Management Plan (CFRMP) will be developed by the site operator in consultation with FENZ and implemented prior to construction commencing at all sites, including at The Point. These will inform fire fighters of site-specific risks and facilities, allow site familiarisation as well as enable FENZ to develop a pre-determined plan should a fire occur.

Site ERPs will be developed by the appointed Engineering, Procurement and Construction (EPC) contractor. In line with FENZ guidance, they will confirm whether firefighting activities would likely be limited to containing any fire within gravel access roads doubling as fire breaks. The FENZ current default position is to treat fires at solar farms in a similar way to how it treats fires at electrical substations. FENZ will mobilise to the site and wait at the site entry until met by a site representative, enter the site when advised it is safe to enter and undertake firefighting activities after electrical hazards have been mitigated. The site representative is required to advise FENZ which assets to protect, as well as handle any media queries and take control of the site once the fire is extinguished. FENZ noted that a site representative is expected to be available to attend the site within 1 hour. Local staff for The Point will be located at Twizel and will be able to be at the site entrance in approximately 20 minutes or less.

However, in accordance with a pre-determined Emergency Response Plan (ERP), the FENZ Officer in Charge (OIC) may choose to enter the site prior to the arrival of a site representative to undertake firefighting. Protocols for facilitating this are described later in this report.

The combined REG and FNSF consultation with FENZ has led to the development of best practice fire safety guidelines for solar farm design, development and operation being developed and designed for all FNSF solar farm sites, including The Point.

5. FENZ Fire Safety Guidelines for FNSF Solar Farm Development

5.1 Screening vegetation

- Trees should be selected as either ‘low flammability species’ or ‘low/moderate flammability species’ from the “Flammability of Plant Species” guidance published by FENZ (2024).
- Planting should be maintained between 4-5m tall.

- Regular inspections and maintenance of the screening should occur to ensure fallen or dry material which could act as a fuel load is removed.

5.2 Site Access and Navigation

- Gravel access track roads should be provided around the full perimeter of each area of the solar farm, and internally within the farm itself. These 4m wide gravel roads should effectively subdivide the solar farm area into smaller blocks *(Fig 1)*.
- Appropriate turning circles to accommodate 12,000L, 8.5m fire fighting vehicles.
- Roads should be able to withstand a laden weight of up to 25 tonnes with an axle load of 8 tonnes, per “Designers’ guide to firefighting operations - Emergency vehicle access” F5-02-GD (FENZ, 2021).
- Where the access track roads cross the water canals using culverts, the road should continue straight over the culvert, without a bend/turn immediately before/after.

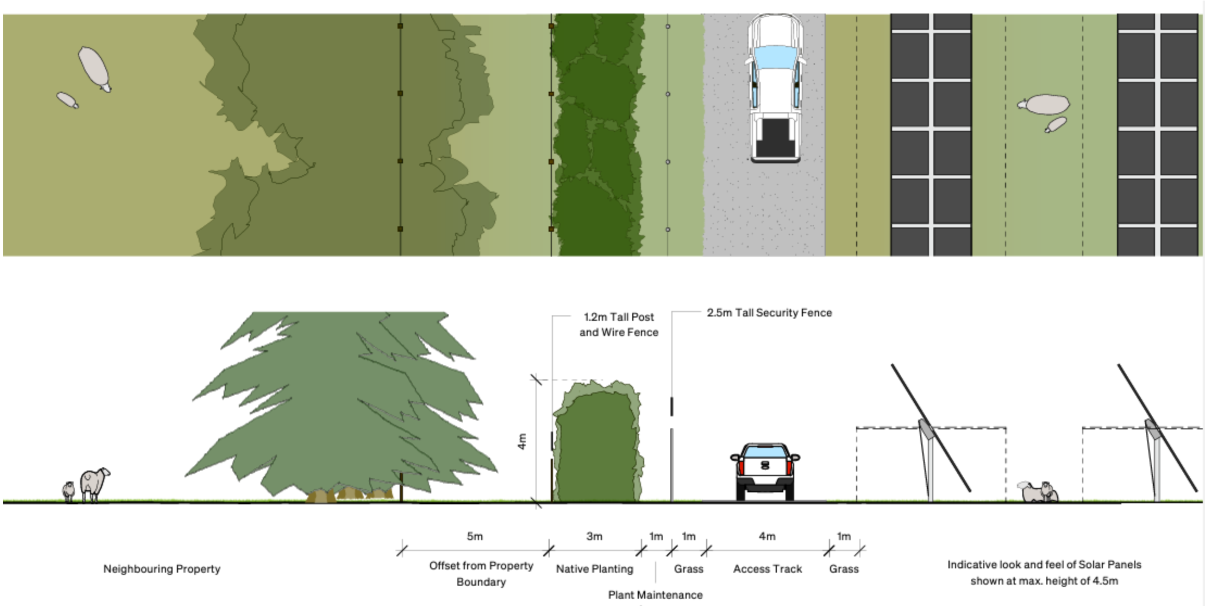

Figure 1. Example of suitable access roads and firebreaks design

5.3 Firefighting

- Dedicated 30,000L fire water tanks should be located within areas of the farm for exclusive firefighting use.
- If dual tanks are specified, they should be interconnected with a 100mm pipe.
- Each fire water tank is to be provided with a compatible FENZ hose coupling outlet (100mm diameter threaded suction coupling), to enable FENZ to draw water from the tanks.

- Each tank should have a highly visible float indicator (typically the case for rural farm tanks) so each tank's water level is easily observed and filled if required.
- The fire water tanks should be sited on gravel surfaced hard stand areas, approximately 20m x 30m in dimension. This separates them physically from the grassed area (limiting potential fire impingement on the plastic water tanks). It also provides an area where fire trucks can pull over while filling up from the tank, so that the road remains free for other fire fighting vehicles to pass by.
- Distances from hardstand to coupling should be less than 5m if the tanks are not located on hardstand.
- Tanks should be located at intersections of internal roads, near entrances and upwind of the site if there is a prevailing wind direction.
- Tanks should be separated from buildings and inverters to enable access to the tank if the item is on fire.

5.4 Operation & Maintenance

- Where it is practical to do so, extinguishers should be always carried on vehicles on solar farm sites and this expectation should be recorded in all management plans.

6. Fire Zoning Management

The Point design layout has been segmented into zones to assist in identifying areas of the site clearly in the event of an emergency. This provides quick identification of specific areas where automated monitoring or visual identification has observed a fire event allowing a response to be appropriately deployed to the correct area. The Fire Zone Management Layout *(Fig 2)* will be included in the ERP and CFRMP and form part of any FENZ site familiarisation Programme. *Figure 3* shows the layout without zoning for easier identification of water tank locations, internal roading and site entrances.

The Point solar farm Fire Zoning Identification Layout

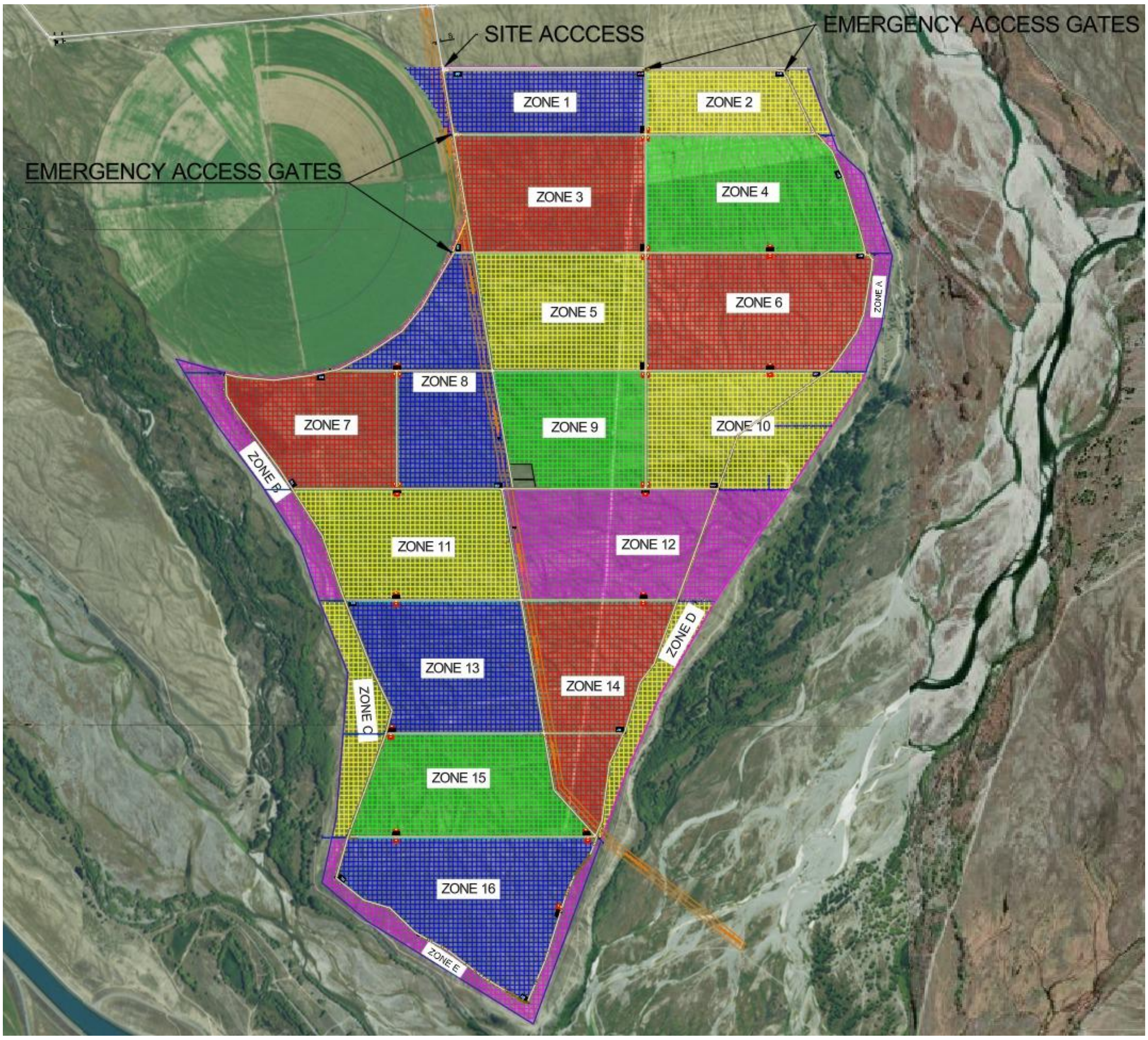

Figure 2. The Fire Zone Management Layout for The Point solar farm. Entire site boundary is shown as blue line.

These zones allow for access to the water tanks for working both in the solar farm area and the restoration area by utilising the emergency access gates between the two areas.

The Point solar farm Access, Roading and Water Tank Layout

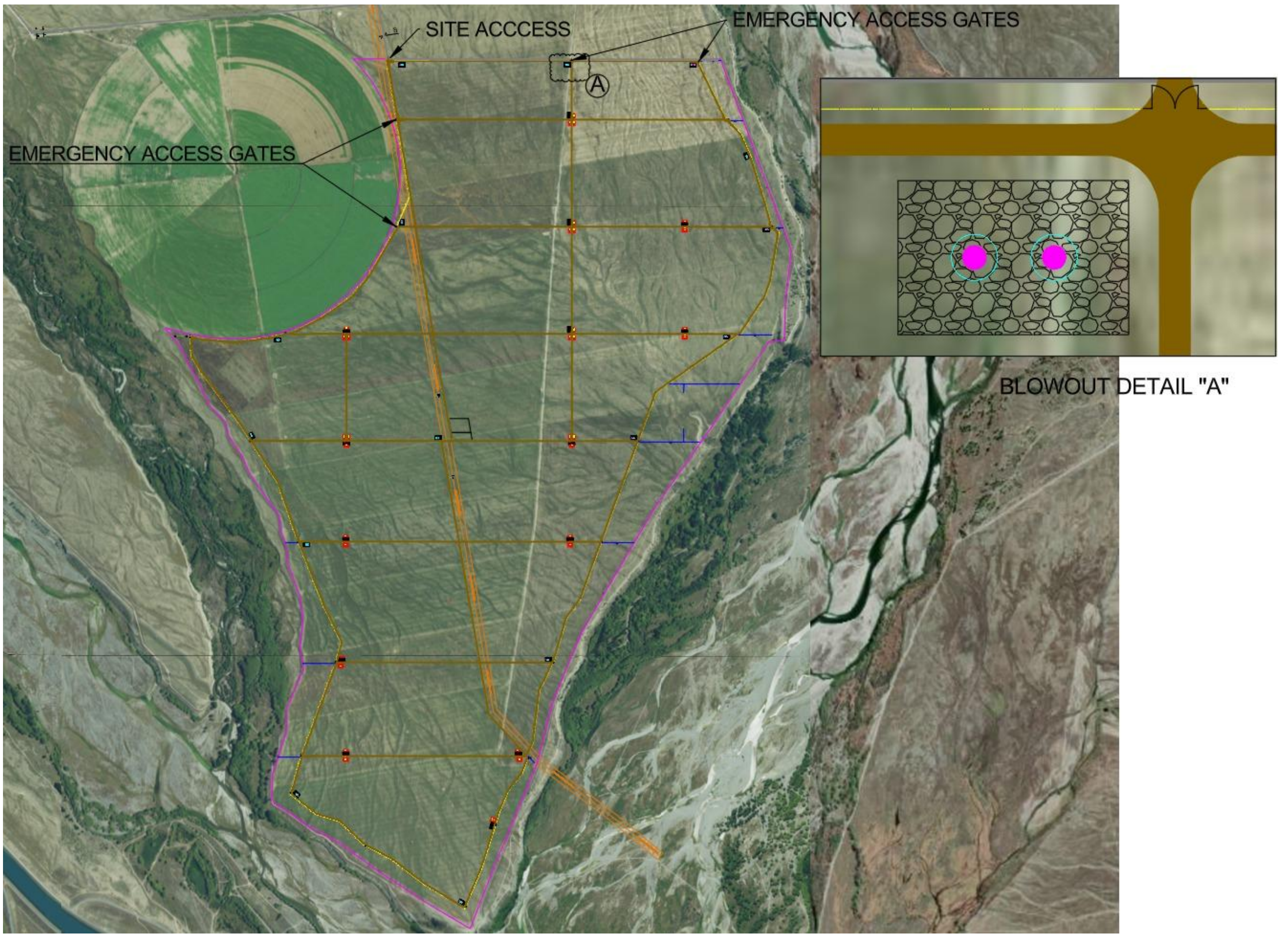

Figure 3. Perimeter and internal roading seen as yellow lines. Triple yellow lines through centre of site show the Transpower 220KVa transmission lines which traverse the property. Water tank locations seen as red squares (including detail of hard stands). The area outside the perimeter road, but still within the entire site boundary, is the proposed regeneration area.

7. Beca Risk Characterisations & Recommendations

7.1 Vehicle or Mobile Equipment Fire Risk

Vehicles can start fires in various ways, and this risk exists under both the current rural and proposed solar farm uses of the site. Since vehicle ignition risks are already present due to the existing rural land use, this assessment focuses on how often and what types of vehicles are used, rather than detailing the specific mechanisms by which a vehicle might ignite a fire.

The types of vehicles expected to be used during normal operation of The Point solar farm present less risk than the current use of heavy machinery such as tractors, harvesters and general working machinery that might create an ignition source through contact with the ground or other objects. In most instances it is expected only light vehicles will enter the solar farm site during operation and will remain on the gravel roads created as part of the solar farm layout; consequently, any fire originating from that source would be less likely to spread or create a grass fire.

Therefore, during routine solar farm vehicle operations, such as those for sheep management, general monitoring or panel cleaning, and in the absence of high fire hazard cargo, the potential consequences of a vehicle fire are generally comparable, or less, than those under the current land use and pose no elevated risk.

The Point design response:

- Vehicles expected to be used for normal operations will be either new or maintained to a high level of safety thereby greatly reducing the likelihood of any ignition occurring through fault.
- Fire extinguishers carried on all vehicles on site as part of ERP and CFRMP requirements.
- Expected vehicle movement post construction of three per day on site anticipated to be no greater than current usage on site.
- Creation of gravelled roads to provide access and navigation around the site, and the normal expectation that vehicles will, for the most part, remain on these roads, lowers any potential risk.
- Significantly improved firefighting facilities will be provided onsite making any fire consequently easier to control and limiting risk should one occur.
- Creation and implementation of ERP will ensure FENZ is familiar with the site, facilities available and methodology for any anticipated response.
- Ability to monitor the entire site, and identify specific zones within it, ensures any response is able to be clearly and immediately directed to the appropriate area.
- The site has one main entrance and two emergency access gates on the northern boundary, including one on the north-east corner. There is no site access possible from other directions due to steep topography.
- All roads have exits and lead in the direction of travel. There are no dead ends or loop backs that would cause confusion.
- Road corridors are wide enough for vehicles to pass.
- There are areas at the water tank hard stands to allow vehicles to be clear of the roadway while filling, as well as being able to turn.

These points are included in the proposed resource consent conditions, shown in the design layouts or will be part of the EPC contract obligations.

7.2 Electrical Equipment Fire Risk

Electrical equipment in a solar farm setting includes the components of the solar arrays such as PV panels, cables, connectors, isolators, string combiner boxes and inverters. A 2018 study by the Building Research Establishment (BRE) on “Fire and PV Systems” in the UK[7] investigated historic incidents and incidents that occurred during the study. They found "80 potential PV related fire incidents, representing approximately 0.01% of the current number of installations installed in the UK" (Coonick, 2018).[8]

While the presence of a solar farm introduces an elevated potential for electrical equipment fires, the probability of this occurring is small but remains constant. The BRE study showed that although a fire can occur at any point in the electrical system, evidence suggests that these are frequently "localised" ie caused some damage to the point of origin but not beyond.[9] Ultimately, the risk posed by a fire in this category is less than when a larger grassfire is considered.

The Point design response:

- Audited engineering reports on equipment status and compliance standards carried out at all stages of the supply chain.
- Audited engineering scrutiny of installation methodology and prior to construction and again on completion required under the EPC contract.
- Automated fault monitoring and alerts built into the electrical systems to detect faults before any fire risk can occur.

7.3 Substation Fire Risk

While the introduction of a substation on the site again produces a higher fire risk than if it was not present, robust national standards around design and operation are in place that provide comprehensive fire risk mitigations. It should be noted that there are hundreds of substations located throughout New Zealand, many of which are in similar rural locations to The Point and the fire risk is considered acceptable.

The Point design response:

- The substation design will meet Transpower's "Substation Fire Mitigation Design Standard".[10]
- The substation will be built on its own hard stand area and include appropriate spatial setbacks to boundaries.
- The entire substation is surrounded by hardfill with no vegetation nearby.
- FENZ response tactics for dealing with a substation fire are known and accepted and will be implemented in a separate ERP tailored to managing risk at the substation.

[7] Pester, S., Woodman, S., & Coonick, C. (2017). *Fire and Solar PV Systems—Literature Review* (P100874-1000 Issue 3.4). BRE National Solar Centre.
[8] Beca Report, page 28.
[9] Ibid.
[10] Transpower, 2011. *Guidelines and information for substation design.*

7.4 PV Module Fire Risk

Bi-facial panels of the type planned for use at The Point do not contain a plastic backing sheet which is known to be the most flammable component of mono-facial panels. The top and bottom surfaces of the panel are glass/silicon. While the panels themselves do contain some combustible components, these are embedded within the panel, where their contribution to fire severity and spread is limited. Bypass diodes are also incorporated into bi-facial PV modules to prevent hotspots in cells developing which may cause an ignition source – they allow electrical current to flow around groups of cells with a high resistance preventing resistance heating. The PV modules are also mounted on non-combustible steel structures. On this basis, neither a severe solar array fire, nor fire spread over the solar arrays as a whole is expected due to the low fuel load contained in the PV modules.

The Point design response:

- Use of bi-facial panels.
- Gaps between rows of panels of 6m limits any fire spread from one row or string directly to another.
- FENZs current firefighting approach is unlikely to see water applied directly to panels in event of fire (therefore no toxic runoff).

7.5 Screen Planting & Reserve Area Fire Risk

Plants selected for screening will be in line with FENZ guidelines on low to low/moderate flammability species[11]. As discussed above in section 5.1, plant heights will be maintained, and regular inspections and maintenance of the screening should occur to ensure fallen or dry material which could act as a fuel load is removed.

The probability of a fire within the screen planting is likely to be higher than in the surrounding rural context due to the increased density of vegetation. However, the consequences of such a fire are expected to be lower than those associated with shelterbelts or other mature trees such as wilding pines commonly found in some environments. Overall, given the limited flammability of the proposed screen species, the planned firebreak gaps and the planned maintenance protocols, the fire risk associated with the screen planting is considered comparable to that of similar vegetation in the surrounding rural area.

The Point design response:

- Appropriate species selection in line with FENZ flammability guidelines.
- Perimeter roading around the entire site allows quick and easy vehicle access to screening tree areas meaning any fire in these areas can be much more easily extinguished.
- Firefighting water tanks will be located on the perimeter road providing ready access to available water.

[11] Fire and Emergency New Zealand. (2024). *Flammability of Plant Species*.

- Gaps in the planting and the internal firebreaks within the screening areas.
- The perimeter road serves as an effective fire break helping to prevent fire spread from either within the solar farm to the screening trees, or vice versa.

While the presence of screen planting increases fire risk, this risk has been pragmatically reduced by the design measures described above and improves firefighting ability compared to what is possible on adjoining rural areas.

7.6 Fire Risk During Construction

The probability of a fire will probably be greater during construction than when the solar farm is in operation, due to increased activity on the site. However, the construction phase is of limited duration (two years) and will be supported by a CFRMP which will reduce risk to an as-low-as-possible level. Solar farm construction does not involve large usage of 'hot works' such as welding, or cutting, and primarily involves bolts and clips. This reduces potential ignition sources.

During construction, some fire risk mitigation measures may still be incomplete, potentially making firefighting efforts less effective and increasing the consequences of a fire. However, construction personnel may be able to carry out first response firefighting and help contain a fire in its early stages.

The likelihood of fire is higher during the construction of the solar farm compared to the surrounding rural environment. However, with appropriate measures to be outlined in the CFRMP, the consequences of a fire can be reduced to a reasonably practicable level - comparable to, or better than, those in the existing rural setting. Fire risk during construction will evolve as permanent fire hazards are introduced, and mitigation measures are progressively implemented. This elevated risk is limited to the finite construction period, which is expected to be approximately two years.

The Point design response:

- CFRMP designed in consultation with FENZ in place prior to construction to deal specifically with fire risk or occurrence.
- ERP including protocols, agreed by FENZ.
- Firefighting equipment installed in all vehicles and at locations of active works.
- Grass and other vegetation actively managed on site to keep levels low (200mm or less).
- Formation of internal gravel access roads which act as fire breaks, and improve access around the site, will be created before other works take place.
- Firefighting water tanks in place and filled ready for use.

7.7 Fire Risk During Operation

The probability of fires is influenced by factors such as the type of electrical equipment, the quality of installation, the effectiveness of facility monitoring and maintenance, and the volume of vehicle movements on site. During operation of the solar farm, activity on the site will be minimal and relatively predictable however overall, the presence of the solar farm does result in an increased fire probability compared to the existing land use.

The Beca Report notes the following fire risks during solar farm operation.[12]

7.7.1 Smoke plumes

Research into solar farm fires indicates that electrical equipment fires typically involve a single component rather than large-scale events. While the smoke plume from such fires, or from a vehicle fire for instance, is generally smaller than that of a grassfire, it may contain higher levels of toxic substances due to the combustion of plastics on cabling and other synthetic materials. The proposed bi-facial solar panels have a lower combustible content compared to plastic-backed alternatives, as described in section 7.4, which helps reduce fire load. Additionally, any heavy metals present are chemically bonded, limiting their potential release during a fire and are unlikely to pose a potential health risk in fire.

7.7.2 Firefighting water run-off

All fires can result in firefighting water run-off and those involving electrical equipment will contain more toxic combustion elements than grassfires. However, as stated in section 7.4, the FENZ general firefighting approach is to avoid applying water directly to electrical fires and instead focus on containing spread along the ground thereby reducing or eliminating the potential for toxic run-off.

7.7.3 Grassfire

The risk of grassfire depends on the local climate and nature of the vegetation present on site. Fire restrictions in the Mackenzie Basin are generally implemented based on seasonal fire risk assessments, and the specific dates can vary each year. Typically, during the summer months, the area experiences heightened fire danger due to dry and windy conditions.

Grassfire severity is closely linked to available fuel loads. The vegetation planned to be present at The Point is a mix of exotic grasses and native tussocks endemic to the area. Vegetation heights over the entire site should be maintained at a maximum height of 200mm during the hotter months (December to March) and no higher than 300mm for the remainder of the year. Vegetation heights maintained at these levels will lower the available fuel load which in turn has an impact on the rate of spread of any fire, as well as severity.

Within the ecological enhancement zone, we expect the species selected to be low fire risk, and of low height, with wide spacings. Invasive species will be removed by spot

[12] Beca Report, pages 41 to 43.

spraying or hand weeding, and limited grazing will be programmed in some areas to manage weeds.

The screening areas will have additional fire breaks within them (separate from the internal roading of the solar farm area) for access and maintenance, and the species will be suitable for the dryland environment. Tree maintenance will be performed only in low fire risk times and all trimmings will be collected and removed from the site.

While the presence of potential new ignition sources may slightly increase the likelihood of a fire starting, the chance of a fire spreading beyond the solar farm is likely to be lower than under the current land use once mitigation measures are in place.

7.7.4 Conclusion

While the probability of a fire occurring within the solar farm during operation is higher than in the surrounding rural context, acknowledging that the rural context itself includes a wide range of fire probabilities, the proposed facility incorporates many mitigation measures. These include grass-height management, firefighting vehicle access, on-site water storage, an Emergency Response Plan (ERP) and Construction Fire Risk Management Plan (CFRMP), all of which serve to reduce the potential consequences of a fire. Firefighting in general on the site is expected to be easier and more effective than on the surrounding farmland because of the better firefighting vehicle access, maintained fire breaks and the availability (accessibility and quantity) of firefighting water on site. Overall, the operational fire risk of the solar farm is assessed as being no greater than that of the surrounding rural environment.

The Point design response:

- Potential ignition sources through use of automated fault detection monitoring systems will be used to identify issues of concern before a fire is created.
- Remotely monitored CCTV systems will cover the site. Staff on site can also observe any smoke plume immediately leading to quick action and control of fire spread.
- Perimeter firebreaks and internal breaks in the form of 4m wide gravel roading will divide grassed areas into sections, limiting fire spread across the entire site. These roads will be in place as part of early works on site and before construction begins.
- Roading improves emergency services response times and increases effectiveness on site.
- Creation of CFRMP and ERP will ensure FENZ are adequately prepared through site familiarisation, and plans are in place to deal with any fire event.
- Firefighting water tanks will be installed and filled once the roads are formed, and before constructions begins.
- The current plan is for approximately 15 pairs of interconnected 30,000L water tanks to be installed on site. This will be reviewed and increased if considered necessary during reviews and audits of design.

- Segmented, fenced areas within the solar farm site will allow active grass height management via sheep grazing during operation. Stock numbers can be increased leading into the high growth season to ensure low fuel loads are maintained and then reduced going into the dry months.
- During the construction phase the vegetation will be managed by temporary fencing with stock being removed from the site progressively.
- Mechanical vegetation management will be used as required to preserve the low fuel loading until widespread grazing commences.

8. Additional Fire Risk Mitigation Options

The proposed solar farm design for The Point incorporates a range of fire risk mitigations and protocols, which have been addressed throughout this report. The Beca Report, however, outlined additional mitigation measures and protocols that could be considered to further reduce fire risk.

8.1 Consideration of Construction Phase Risks

Due to the elevated level of activity during the construction phase, the risk of fire ignition may exceed that of the site's current rural use. To address this, a pre-determined emergency response plan could be developed in collaboration with FENZ before construction begins. This may include providing FENZ with secure access to the site.

- *It is expected that high level engagement with FENZ will continue in development of The Point and through the creation of the ERP and CFRMP. If appropriate, measures and protocols will be developed to allow FENZ with independent access to the site.*

8.2 Quality Control

Literature on solar farm fires[13] indicates that many incidents stem from poor design or substandard installation practices. Maintaining strict quality control throughout the design, construction, and operational phases is essential to minimise fire risk.

- *The Engineering, Procurement and Construction contractor (EPC) for The Point will be selected on a tender process and will include a thorough evaluation of previous work in the field and health and safety audits to prove capability.*

8.3 Maintenance of Fire Safety Features

The effectiveness of proposed fire safety features depends on ongoing maintenance. For instance, vegetation overgrowth or debris accumulation on access tracks can

[13] Coonick, C. (2018). *Fire and Solar PV Systems—Investigations and Evidence* (P100874-1004 Issue 2.5). BRE National Solar Centre.

diminish their function as firebreaks. Similarly, if firefighting water tanks are allowed to empty or dry out, their availability in an emergency would be compromised.

- *The Operation Management Plan developed to support The Point on completion shall ensure systems are in place to ensure appropriate levels of maintenance to support all fire mitigation plans and procedures.*

8.4 Remote Monitoring

Electrical systems can detect anomalies in solar farms - such as those caused by fires - and relay this information to monitoring personnel. Defining and enhancing the monitoring framework could improve early detection and response effectiveness.

- *The capability is built into the design of The Point and will be implemented in development and through into operation.*

8.5 Strengthening Other Existing Mitigation Measures

Lower Grass Height Limits: Reducing allowable grass height across the site can further decrease the available fuel load. This lower height could also be extended into the shoulder seasons.

- *A grazing contract will be developed for this purpose.*

Widen Firebreaks: Increasing the width of gravel access tracks, which serve as firebreaks, could reduce the likelihood of fire spread. Wider breaks are generally more resistant to being breached during a fire.

- *The current width of 4m is considered adequate.*
- *Fire breaks will be maintained to be vegetation free.*

Fire extinguishers will be installed near inverters.

Proposed Greytown Solar Farm - Fire Risk Assessment

Commissioned by Far North Solar Farm Limited
Prepared by Beca Limited

13 September 2024

Contents

Appendices

Revision History

Revision Nº	Prepared By	Description	Date
A	Kevin Weller & Paul Horne	DRAFT for FNSF & FENZ review	16/8/2024
B	Kevin Weller & Paul Horne	For Information	13/9/2024

Document Acceptance

Action	Name	Signed	Date
Prepared by	Kevin Weller & Paul Horne	KWeller P Horne	13/09/2024
Reviewed by	Etienne Hermouet		13/09/2024
Approved by	Hamish Denize		13/09/2024
on behalf of	Beca Limited		

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Executive Summary

The purpose of this fire risk assessment document is to provide the technical background to support Hamish Denize's 'Statement of Evidence' opinion to the Environment Court in relation resource consent application RM220103. The application relates to a proposed new solar farm located on Moroa Road, Greytown, Wairarapa.

This fire risk assessment has considered the fire risk associated with the solar farm in its context and the additional fire risk from the screen planting. Risk is the combination of probability and consequences which are contingent on the specific fire development. The proposed solar farm contains a significant number of electrical components (e.g. solar panels, switchgear, inverters, cabling and substation, etc). Large battery energy storage systems, which have been a hazard in past solar farm and electrical infrastructure system fires, are not part of this proposed solar farm.

The probability of fire ignitions within the solar electrical system is predominantly related to the quantity of components, quality of installation and ongoing maintenance. The significant consequences of a solar farm fire are the same as fires in the site's context – smoke plumes containing combustion products, potential firefighting water run-off and potential fire spread to neighbouring property. The proposed solar farm design contains fire risk reduction design and plan mitigation features including limiting the grass height, firefighting vehicular access, firefighting water storage, gravel access tracks which act as firebreaks, an Emergency Response Plan (ERP) and active risk management by the construction contractor and facility operator.

The proposed Solar Farm has many fire risk reduction mitigations, in the form of design features and an Emergency Response Plan ("ERP"). A Construction Fire Risk Management Plan ("CFRMP") and an Operational Management Plan ("OMP") have also been considered.

Based on the fire risk assessment carried out:

- The fire risks emanating from a fire event in the proposed Solar Farm while operating, is no more than compared with the existing rural context.
- The fire risks emanating from a fire event in the proposed Solar Farm while under construction presents an elevated fire risk, which could be addressed as part of an effective ERP and CFRMP, to a reasonably practicable level that is also comparable or better than the existing rural context.
- For a fire originating outside the proposed Solar Farm, the fire risk reduction mitigations are of limited benefit to prevent fire spread into the Solar Farm. The risk of an external fire such as a neighbouring grass or wildfire penetrating into and passing through the proposed Solar Farm is likely to be less than the risk of fire spreading through the surrounding rural context.
- The presence of new screen plantings and the new substation introduce fire risks. Similar features and fire risks are already present in the existing rural context. The proposed fire risk reduction mitigations may lower the fire risk of these features to a reasonably practicable level that are also comparable or better than the existing rural context.
- Protocols for fire containment have been considered in the proposed fire risk reduction mitigations to reflect source and site factors. It is expected that the EMP, CFRMP and OMP would contain emergency protocols, construction protocols and operating protocols to mitigate fire risk.
- Protocols for communication and warning in the event of fire have been considered in the proposed fire risk reduction mitigations. The fire detection, communication and warning features are likely better than the existing rural context. The fire risk reduction mitigations include features that are able to be used to notify FENZ of a fire in the proposed Solar Farm, sooner than from a fire originating in the surrounding rural context.

1 Introduction & Purpose

Beca Ltd (Beca) has been engaged by Far North Solar Farm Limited (FNSF).

The purpose of this fire risk assessment document is to provide the technical background to support Hamish Denize's Statement of Evidence to the Environment Court in relation resource consent application RM220103. The application by FNSF relates to a proposed new solar farm located on Moroa Road, Greytown, Wairarapa.

The Court has identified the following fire risk assessment matters (in Environment Court minute dated 9 July 2024) where further information is required:

- *Assessment of fire risk from the construction and operation of the solar farm itself and from adjoining rural/ domestic activities in the context in which it is located*
- *Assessment of any additional risk associated with screen planting*
- *Mitigation proposals to reduce identified risks*
- *Protocols for fire containment depending on source and site factors*
- *Protocols for communication/warning in event of fire.*

The focus of this assessment is the consideration of fire risks posed by the solar farm to the surrounding rural context property. Assessment of fire spread from the rural context of the site to the proposed solar farm has also been considered.

Fire damage or loss of the solar farm itself is asset/business continuity risk consideration for the site owner/operators so was not considered in this risk assessment.

2 Approach

2.1 Objectives

Following the direction of the Court's minute, the objectives of this technical report are to:

1. Assess the risks from:
    a. *"construction and operation of the solar farm itself and from adjoining rural/domestic activities in the context in which it is located"* , and
    b. *"any additional risk associated with screen planting" .*
2. Identify:
    a. *"mitigation proposals to reduce identified risks"* , and
    b. protocols for *"fire containment depending on source and site factors"* , and
    c. protocols for *"communication/warning in event of fire" .*

The following sections explain the methodology to achieve each objective.

2.2 Available Risk Assessment Methodologies

The specific methodology of a risk assessment needs to be tailored to suit the particular objectives and needs of the subject matter application. The general risk management guidelines in AS/NZS ISO 31000 and NZS HB 436 cover the whole process of risk management, of which the risk assessment is only part, and are very broad as they are intended to cover risks from financial risks to outdoor pursuit risks, etc. They contain little guidance on the methodology of a Fire Risk Assessment which is a specialised risk assessment task. However, there are international standards such as NFPA 551 and ISO 16732-1 which specifically cover Fire Risk Assessments. The SFPE Guide to Risk Assessment (2nd Ed. 2022) also provides extensive guidance on fire risk assessment. The methodology for the Fire Risk Assessment carried out and documented herein, is taken from these standards and customised to suit a fire risk assessment that meets the above objectives.

2.3 Methodology

2.3.1 Risk Characterisation Approach

The definition of Fire Risk Assessment used here is "A process to characterize the risk associated with fire that addresses the fire scenario(s) …, their probability and their potential consequences" (NFPA, 2022). This report did not determine the acceptability risk threshold or evaluate whether the characterised risks meet this acceptable level.

Risk is "the paired probabilities and consequences for possible undesired events associated with a given facility or process" (NFPA, 2022). Low-probability high-consequence events such as fire can pose a greater risk than more common but lower consequence events. It is often impracticable, unfunctional or uneconomic to eliminate all risk. Rather, mitigations which reduce either the probability or consequences can be employed to reduce the risk. Ultimately, some level of residual risk remains when elimination is not achievable.

A relative qualitative approach has been carried out in characterising the probability and consequences, and therefore risk within this assessment. A qualitative approach was chosen because it provides sufficient characterisation to support the expert opinion and is supported by referenced research and data where relevant. A relative risk approach was chosen as it assists with risk comprehension by comparing the new risk(s) with already known existing farmland baseline risk(s).

2.3.2 Fire Risk Assessment

The process followed was:

1. Define the exposed target that will be subject to harm or loss if the risk eventuates (i.e. what is being exposed to the risks?). Refer to Section 2.4.
2. Review the proposed solar farm site, its context, the PV system and proposed fire risk mitigation features. Refer to Section 4. Firefighting was discussed with FENZ, refer to Section 5.
3. Identify hazards. Hazards are "conditions that present the potential for harm or damage to people property, environment or cultural heritage" (NFPA, 2022). Refer to Section 6.
   - The components of the solar farm were reviewed to identify potential fire hazards during the (i) construction and (ii) operation of the solar farm.
4. Develop fire scenarios that could eventuate from the previously identified hazards. Refer to Section 7.
5. Characterise the consequences and probability of each fire scenario. Refer to Section 8.
   - Consequences have been considered within and up to property boundaries (impact to neighbouring properties) of the solar farm.
   - Other than identifying where it could occur, no further consideration was given to fire development or propagation beyond the boundary of the solar farm, which could be subject to vegetation, structures and other factors which are outside the control of the solar farm.

Following this assessment, the fire risk relative to the current pastoral farming land use on which the solar farm is proposed was summarised. Refer to Section 9.

Compared to other engineering activities, risk assessment requires a greater exercise of subjective assessment and engineering judgement. Particularly for fires which are very scenario dependent, and the consequences depend on the actions taken by people (e.g. by detection or first-aid firefighting). In many cases there can be scarce data, track-records or other evidence to strongly support conclusions. Furthermore, there is uncertainty in almost every aspect of fire dynamics and variability in all the parameters.

Therefore, any numbers presented herein should be considered as estimates with an accompanying uncertainty. This assessment has identified the major hazards and subsequent risks, it is not an exhaustive assessment of all risks. To increase the robustness of this assessment a review of available literature and information has been carried out, and consultation with Fire and Emergency New Zealand (FENZ) has occurred.

2.3.3 Mitigations and Protocols

The potential mitigations and protocols (documented in Section 10) were identified from:

- considering how either the likelihood or consequences of the risk could be reduced after the completion of the risk assessment,
- discussions with Fire and Emergency New Zealand, and
- discussions with Far North Solar Farm.

2.4 Target Exposed to Risk

The exposed target must be identified so that the hazards and risks to it can be identified. Based on Clause 5(2) of the Resource Management Act (1991) we understand the exposed target is the local environment around the solar farm. The primary fire stimuli to which this local environment is exposed is fire spread and smoke and combustion gases. Potential water contamination resulting from a fire has also been considered.

The risks to FNSF's own solar farm equipment or the property it is proposed to be situated on, is outside the scope of this assessment. External hazards (those outside the area covered by the proposed resource consent) are also outside the scope of this assessment.

It is emphasised that fire is not part of a business-as-usual operation for a solar farm including the substation, rather it is an undesirable and avoided event. Compared to other solar farm damage events (for example environmental, weather related, etc), fire is a low probability but potentially high consequence event. Furthermore, many consequences of fire are not unique to a solar farm - any substantial fire in a rural environment will involve a smoke plume and firefighting water for extinguishment.

3 Referenced Information

Information used in compiling this fire risk assessment report is captured within Table 1.

Design information on the solar farm has been provided by FNSF. It is understood this information conveys the overall design intent for resource consent purposes, however the detailed design is to be completed by a specialist firm yet to be engaged under an engineering, procurement and construction (EPC) contract model which would carry out the detailed design and construction.

Table 1. Reference information

Originator	Description / Title	Date	Rev
VirtualTour	Photos of site (from RMA application records)	07/12/2022	-
Aquila Capital	Module General Arrangement Layout (ACRA-NZD-GT-001, 3 sheets)	26/06/2023	Rev K
Smart CCTV	CCTV view plan for Pukenui Project *(indicative only for Greytown)*	30/05/2024	Rev A
Ergo Consulting	Project Pukenui LP – Solar Farm, 33kW Switchroom Fire and Security Layout, PUK-L-1057-SWG *(indicative only for Greytown)*	23/05/2024	Rev 1
Hanmore Land Management	Further Statement of Evidence of Ian Charles Hanmore (Soil) & Soil and Resource Report for the Proposed Greytown Solar Farm	19/07/2024 & 15/07/2024	-
RMM Landscape Architects	Rough Milne Mitchell (RMM) Landscape Architects near final “Proposed Solar Farm - Greytown, South Wairarapa Landscape Design Package - For Resource Consent” emailed to Beca by RMM’s Mr Paul Smith on 12 September 2024.	Received by email on 12/9/2024 (Sections C, E, F, K & L are copied into this report)	-

4 Description of Solar Farm Installation

This section outlines our understanding of the proposed solar farm installation based on several FNSF briefings and the documentation provided (see Table 1 above).

For the purposes of this assessment, the boundary of the solar farm is taken as indicated in the following Aquila Capital drawings:

- ACRA-NZD-GS-GT-001, Sheet 1 of 3, Rev K
- ACRA-NZD-GT-001, Sheet 2 of 3, Rev K
- ACRA-NZD-GT-001 Sheet 3 of 3, Rev K

4.1 Site Description and Context

The proposed solar farm is located on Moroa Road, Greytown, Wairarapa. It consists of three distinct areas, referred to as Area 1, 2 and 3 (see Figure 1).

There are currently a number of existing trees on the proposed solar farm site and Beca has been advised by FNSF that trees in the vicinity of the solar farm on the same property will be removed.

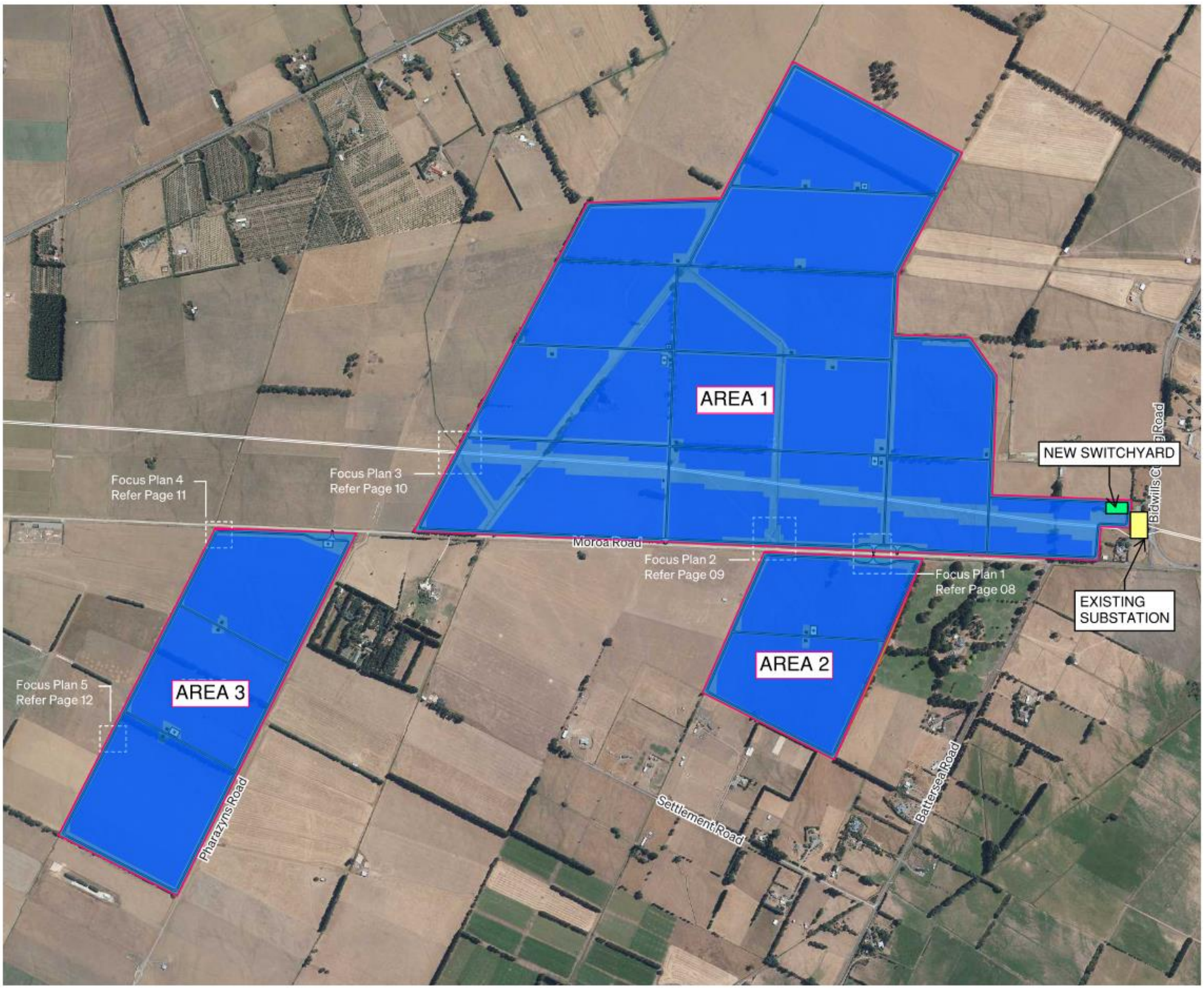

Figure 1: Indicative Areas of proposed Solar Farm (North top of page, modified from RMM Landscape Package)

Based on the photos supplied by FNSF and Mr Ian Hanmore's Further Statement of Evidence (dated 19/07/2024 and referenced report dated 15/07/2024), it is understood the proposed solar farm physical site is currently pastoral farming on flat contour.

Isolated, groups and rows of trees (shelterbelts) are present on the surrounding farmland some of which are located adjacent the proposed Solar Farm property boundary.

There are no peat soils underneath the proposed Solar Farm site (as confirmed by Mr Hanmore) or existing plantation forestry in the near vicinity (as reviewed from Google maps). The summer months are prone to low rainfall. Note: The absence of peat soils underneath the proposed solar farm areas effectively rules out the risk of in-ground peat fires in the vicinity, hence in-ground fire risks have not been assessed further.

The proposed solar farm location has existing overhead power transmission lines and Moroa Road transecting the site.

Houses and their ancillary buildings, lifestyle blocks and farm buildings are present in the surrounding rural context. Several of the existing buildings are located close to the proposed solar farm site, but not directly adjacent. Reviewing the RMM Landscape Package it is understood the nearest existing residential dwelling is located approximately 50m from the proposed solar farm site boundary (in the vicinity of the existing Greytown substation).

The existing Greytown substation is situated adjacent the proposed solar farm site and the proposed solar farm switchyard (substation) is proposed to be situated adjacent to the existing substation (see Figure 1).

There is a fire risk aspect to the local context in which the solar farm is to be located. Since there is a range of activities with different fire risk, this fire risk context is a spectrum. For example, on the lower fire risk spectrum, two neighbours may have their properties separated by a simple boundary stock fence and both have low height pastoral grass either side with infrequent farm machinery activity ignition sources. While on the higher fire risk spectrum an example would be where neighbours have shelterbelts or trees close to, or overhanging across property boundaries, with frequent farming machinery used (eg: haylage or baling in dryer summer months).

4.2 Solar Power System Description

As briefed by FNSF, our high-level understanding of the solar panels and infrastructure installation proposed is described as follows. A high-level schematic of the photovoltaic (PV) system from PV module (solar panel) to national grid is shown in Figure 2 (a simplification of the electrical line diagrams provided by FNSF).

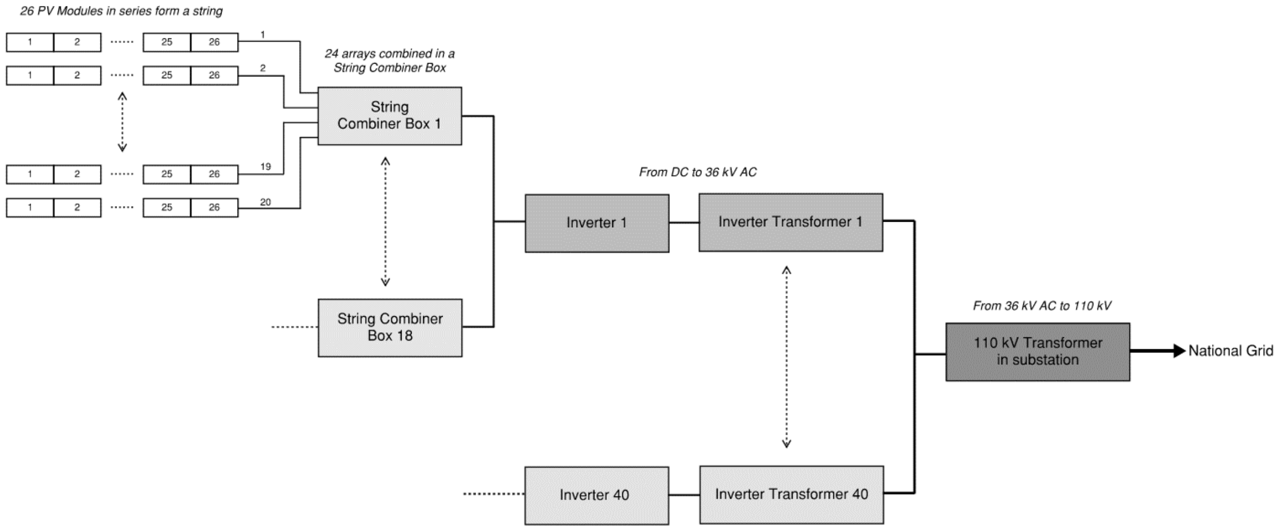

Figure 2: High-level schematic of Proposed Greytown Solar Farm Development (based on electrical line diagrams ACRA-NZ-GS-GT-001 - ACRA-NZ-GS-GT-003, Rev A, provided by FNSF)

4.2.1 Solar photovoltaic modules / arrays

- Bi-facial solar panels are proposed, meaning that both the top and bottom surfaces are photovoltaic panels.
- Panels are mounted on galvanized steel frames, in a 'single axis tracker' formation to track the sun's position. A small lithium-ion battery may be incorporated to power the tracking motors.

4.2.2 String Combiner Monitoring Box (SMB) / String Combiner Box

- Panels are wired to the SMBs via direct current (DC) cables. About 20 to 40 panels would be connected to each SMB. Cables from the panels to the SMBs are mounted on the underside of the panels (approx. 1.5m above ground).
- SMBs include temperature sensors, electrical arc fault detection devices and thermal imaging.
- The intent of the sensors is to enable pre-emptive actions to mitigate the impact of faults on power generation. The sensors will be configured for teal time, remote monitoring.
- Arc Fault Detection Devices (AFDDs): Installed inside junction boxes, AFDDs will continuously monitor for arc faults. These devices will automatically disconnect affected circuits upon detection of a fault.
- Temperature Sensors: These sensors will monitor the heat levels within critical components such as inverters, junction boxes, and the substation. Any significant rise in temperature will trigger an alert to the monitoring team.
- While these are not 'fire detectors', FSNF advise that the presence of a fire would trigger these sensors to raise an alert on the on the solar farm monitoring.

4.2.3 Inverters

- There are approximately 40 DC to AC inverters proposed on the site which are likely to be skid-mounted.
- Cables from SMBs to the inverters run underground.
- FNSF have advised that they are proposing to use SMA Sunny Central 4200 Up MVPS Power Inverters or similar.
  - o These are skid-mounted inverters (see Figure 3) on a concrete pad, which include electrical equipment, contained within metal housings, and contain an oil-filled transformer (middle portion of unit shown in Figure 3).

  - These inverters are approximately 6.1m long, 2.9 high and 2.4m wide (i.e. approximately a 20-foot standard shipping container size).
- Inverters incorporate various telemetry and monitoring.

Figure 3: Example Inverter. Source: SMA (supplier) brochure for MV Power Station (4000 series)

4.2.4 Substation & Switchyard

A single new solar farm substation is proposed next to the existing Greytown Substation on the East end of Area 1 (per Figure 1). The solar farm's substation contains electrical equipment which carries the highest electrical energy loads, in particular the external national electricity grid step-up transformer and electrical switchgear.

Figure 4: Existing Greytown Substation on Bidwills Cutting Road (Google Streetview)

FNSF have confirmed that the solar farm substation design will meet Transpower NZ's "Substation Fire Mitigation Design Standard" (Transpower reference TP.DS 61.06, October 2023). This standard has comprehensive fire risk mitigations and is summarized in Appendix B, which includes equipment spatial setbacks to boundaries, FENZ response/tactics, firefighting provisions and an Emergency Response Plan (ERP) with FENZ familiarisation.

There are hundreds of Transpower and private utility substations located in NZ, of which many are in similar external rural contexts (such as the existing adjacent Greytown Substation). Given the proposed substation design will meet Transpower's comprehensive standard, the fire risks will be mitigated to at least these good practices.

For this reason, no further substation fire risk assessment has been carried out as part of the Beca risk assessment process because by meeting the Transpower standard this is considered to appropriately mitigate fire risks.

4.2.5 Control Building Housing SCADA

A control building will be positioned adjacent the substation. This is a normally un-manned electrical and controls building. FNSF have advised this will have a remote monitored automatic fire detection and alarm system.

4.2.6 CCTV

Integrated CCTV monitoring is proposed for full site coverage for security and business continuity purposes, which includes monitoring the generation equipment. Camera feeds are monitored in real time (i.e. in a centralized control centre).

Thermal imaging cameras are proposed around the perimeter of the solar farm. FNSF has advised that these are located to monitor temperatures in SMBs and inverters.

Visible light cameras are placed with coverage of the perimeter of the farm for security purposes, and across the remainder of the farm for general monitoring.

4.2.7 Boundary Vegetation and Setback Design

Screen planting is proposed between the access track and the property boundary. FNSF has provided indicative perimeter boundary arrangements as part of the Landscape design. Figure 5 shows a cross-section through Moroa Road and the solar panels on both sides. Figure 6 shows a cross-section through the most common perimeter configuration and Figure 7 shows a variation with the planting on a mound. Figure 8 shows an example of a cross-section where there are trees on the other property close to the boundary and Figure 9 shows the mounded variation.

The solar panels are set-back from the property boundary by a 10 or 12 m perimeter buffer zone (see RMM landscape design package). The screen planting grows within the 5 or 6 m wide zone between the property boundary and the perimeter security fence. The 4 m wide perimeter access track separated from the security fence by 1 to 2 m depending whether the perimeter buffer zone is 10 or 12 m respectively. The same distance separates the perimeter access track from the edge of the solar panels (for the different perimeter buffer zones).

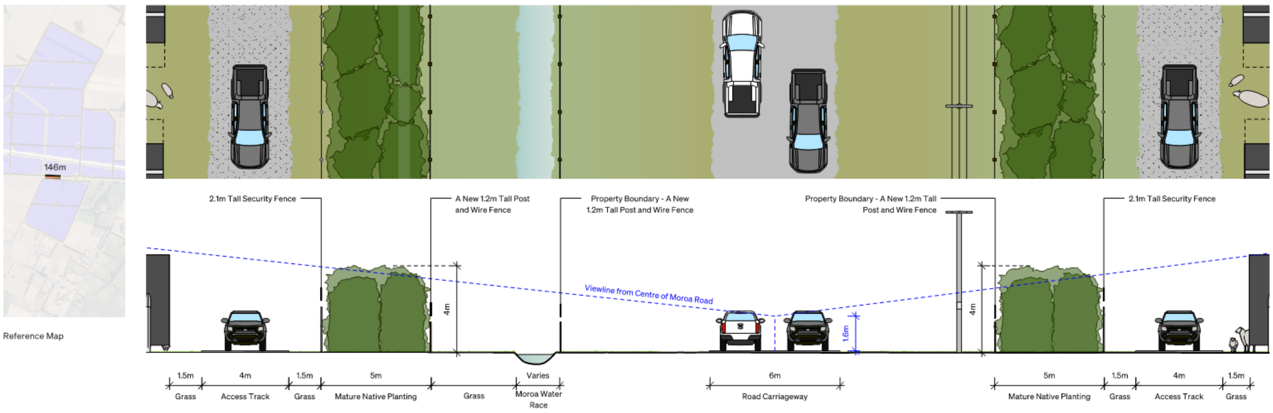

Figure 5: Cross-section C from landscape Design Package (RMM, 12 September 2024)

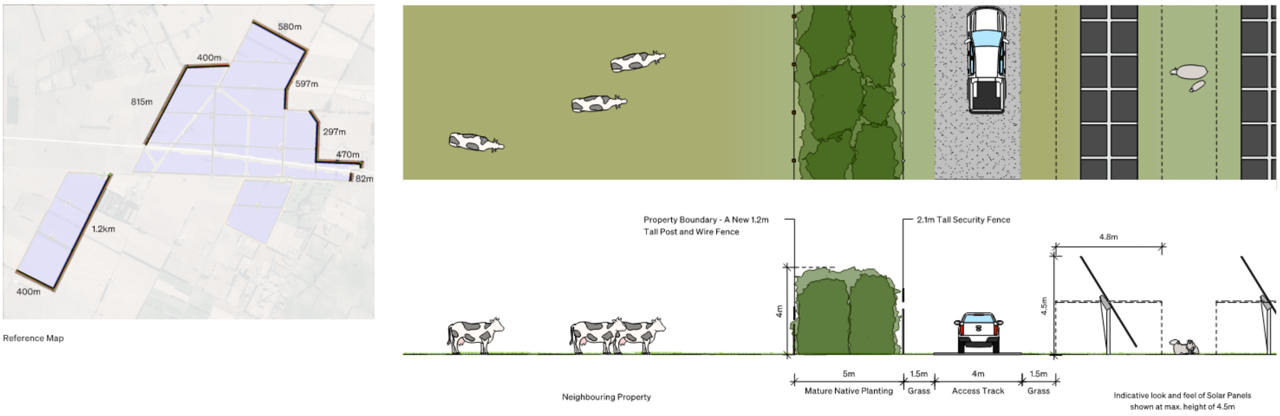

Figure 6: Cross-section E from landscape Design Package (RMM, 12 September 2024)

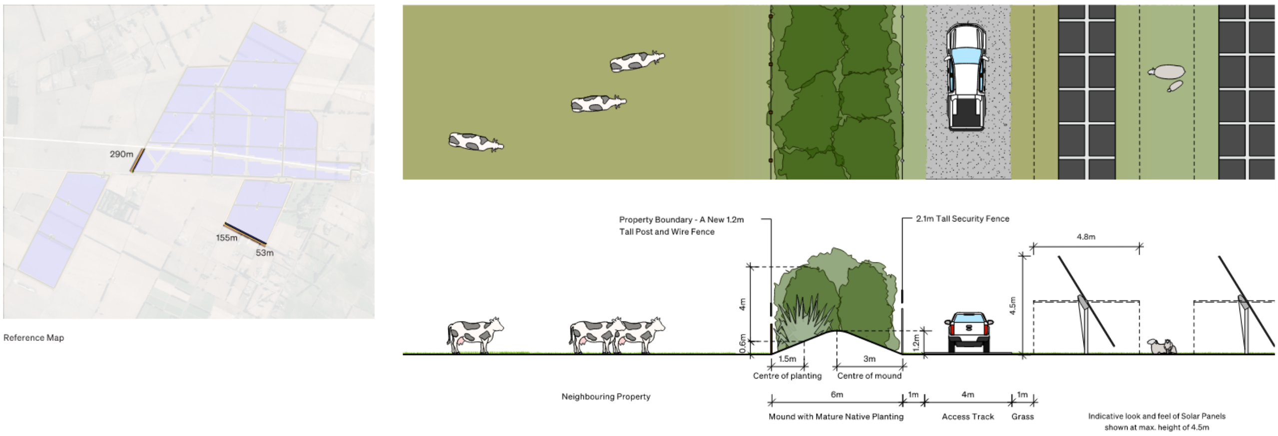

Figure 7: Cross-section F from Landscape Design Package (RMM, 12 September 2024)

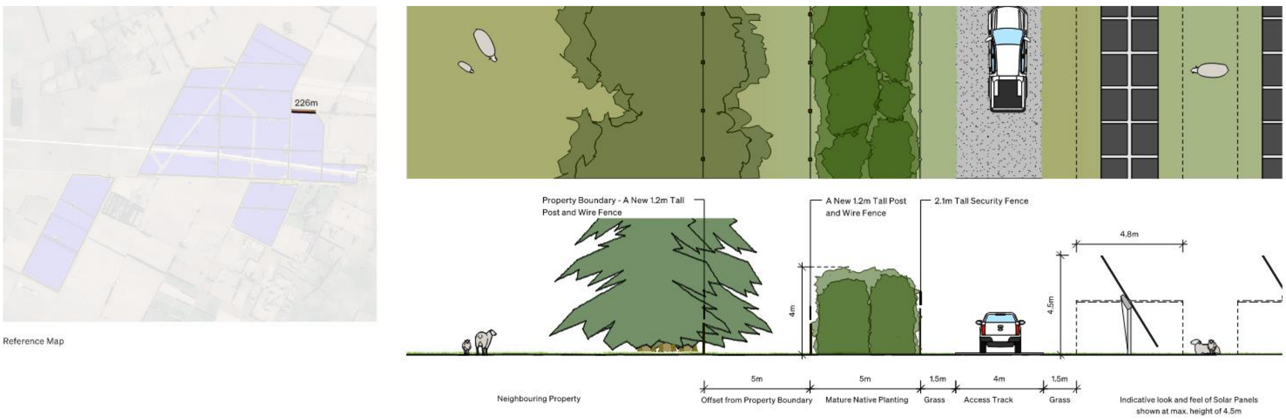

Figure 8: Cross-section K from Landscape Design Package (RMM, 12 September 2024)

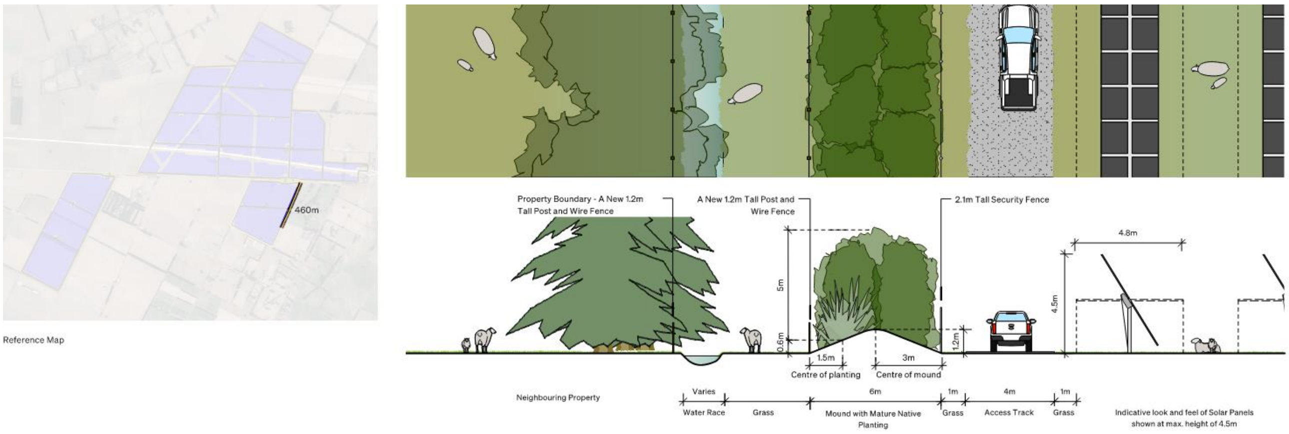

Figure 9: Cross-section L from Landscape Design Package (RMM, 12 September 2024)

The landscape designer, RMM, have advised that:

- *'All shrubs and trees that form the final planting plan will have a "low flammability" or "low-moderate flammability" rating as published by FENZ. https://checkitsalright.nz/reduce-your-risk/low-flammability-plants'*
- Screen planting will be able to grow to 5-6 m wide, the width between the fences. 6 m applies when they are on an earth mound. Planting will be maintained between 4-5m tall. The only exception to this is the eastern boundary of Area 2 which will between 5 and 6 m.
- Trees are being selected as either 'low flammability species' or 'low/moderate flammability species' from the "Flammability of Plant Species" guidance published by FENZ (2024).
  - This guidance categorizes NZ native plants into 5 categories, Low, Low/Moderate, Moderate, Moderate/High and High.
  - 'Low' flammability species are defined as follows:
    - *Suitable for green breaks or defensible space, but when in the immediate vicinity or structures, there should be at least 3-4m break between the crowns to reduce fuel continuity.*
  - Low/Moderate flammability is described as follows:
    - *Not recommended for planting in green breaks. If planted in defensible space, elevated dead material and litter should be removed regularly, greater than 4 m should be left between tree crowns, and trees or shrubs in this category should not be within 10 m of structures.*

The FENZ guide "Get Fire Safe at the Interface" (FENZ, 2018) notes a number of plant species as being highly flammable, including conifers (pine, fir, etc), eucalyptus, kanuka and manuka trees. Site photos identify a number of conifer trees within and in the vicinity of the solar farm site, lines of trees including strips of trees/shelter belts. These are defined as being a higher risk than the species proposed for screen planting.

4.3 Access Features

Two site access routes are provided to Area 1 of the solar farm from Moroa Road, and one access point is provided from Moroa Road to each of Area 2 and Area 3 (as depicted in Figure 1).

FENZ has noted that where possible, two access points should be provided. This provides resilience, should a fire spread to make one access route unsafe to use. This feature is provided for the larger block (Area 1), with a single access point for each of Area 2 and Area 3.

Gravel access track roads are provided around the full perimeter of each area of the solar farm, and internally within the farm. These 4m wide gravel tracks subdivide the area into smaller blocks. These blocks vary in size. The widths and lengths of these areas range between approximately 100m and 400m.

In consultation with both FENZ and FNSF, it is understood the following access features have been considered:

- FENZ would likely need to use a water tanker vehicle as part of firefighting.
- 12,000L tanker, 24 tonne vehicle weight, 8.5m long.
- FENZ advised the turning circles for an aerial appliance should be applied, as these are comparable to the tanker characteristics – see Figure 10.
- Roads shall be able to withstand a laden weight of up to 25 tonnes with an axle load of 8 tonnes, per “Designers’ guide to firefighting operations - Emergency vehicle access” F5-02-GD (FENZ, 2021).
- Within Area 1 of the site, culverts under access tracks for the water races shall be able to withstand these weights.

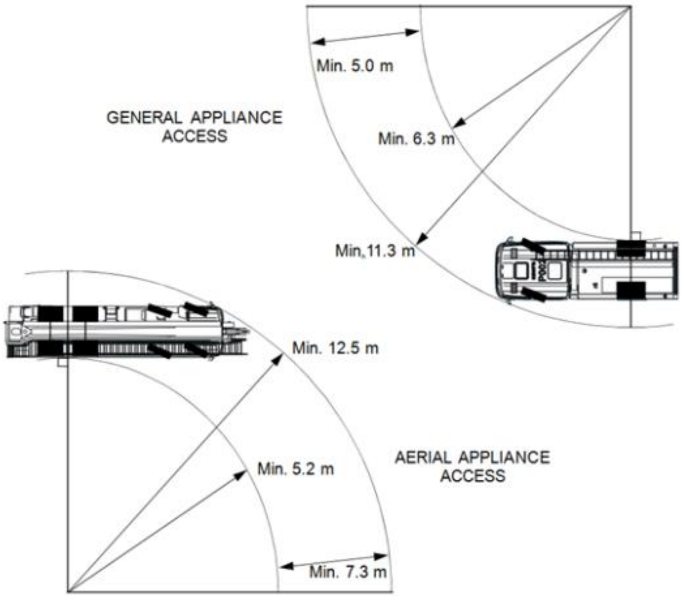

Figure 10: Turning circle for a general and aerial appliances, taken from FENZ guidance document “Designers’ guide to firefighting operations - Emergence vehicle access, F5-02-GD” (FENZ, 2021).

- Where the access track roads cross the water canals in Area 1 using culverts, FENZ and FNSF have already coordinated for the road to continue straight over the canal / culvert, without a bend/turn immediately before/after to enable the tanker to drive through the site. See example in Figure 11.

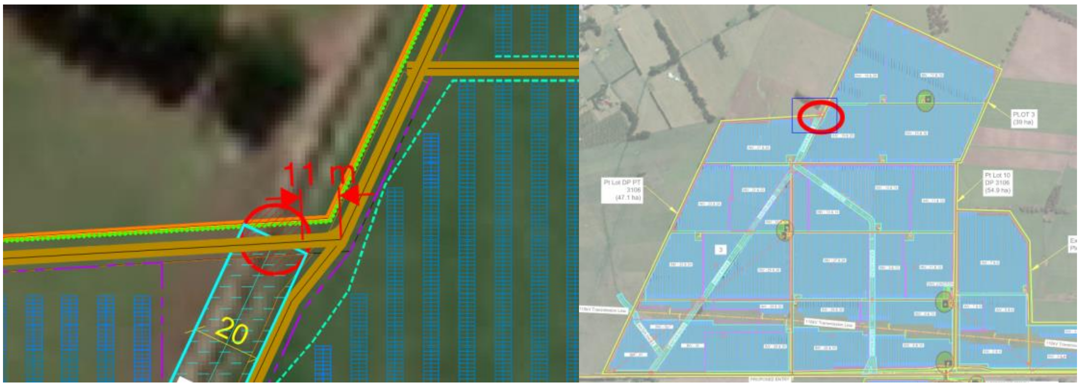

Figure 11: The road continues over the culvert approximately the length of a truck before turning the corner (extracts from drawing ACRA-NZD-GT-001 Rev K)

4.4 Firefighting Features

Dedicated 30,000L fire water tanks are proposed on all three areas of the farm, specifically for firefighting use. Each fire water tank is to be provided with a compatible FENZ hose coupling outlet (100mm diameter threaded suction coupling), to enable FENZ to draw water from the tanks. The tanks will be filled up or periodically topped up by a water tanker and are not connected to a reticulated supply. Each tank will have a highly visible float indicator (typically the case for rural farm tanks) so each tank's water level is easily observed.

- Area 1: 6 water tanks (180,000L water)
- Area 2: 2 water tanks (60,000L water)
- Area 3: 2 water tanks (60,000L water)

Figure 12: Area 1 showing water tank locations (yellow dots) and site entrances (extract from drawing ACRA-NZD-GT-001 Rev K)

The fire water tanks are sited on gravel surfaced hard stand areas, approximately 20m x 30m in dimension (Figure 13). This separates them physically from the grassed area (limiting potential fire impingement on the plastic water tanks). It also provides an area where fire trucks can pull over while filling up from the tank, so that the road remains free for other fire fighting vehicles to pass by. While hard stands are not large enough for a fire vehicle to drive around (refer turning circle in Figure 10), it would allow for a multiple-point turn.

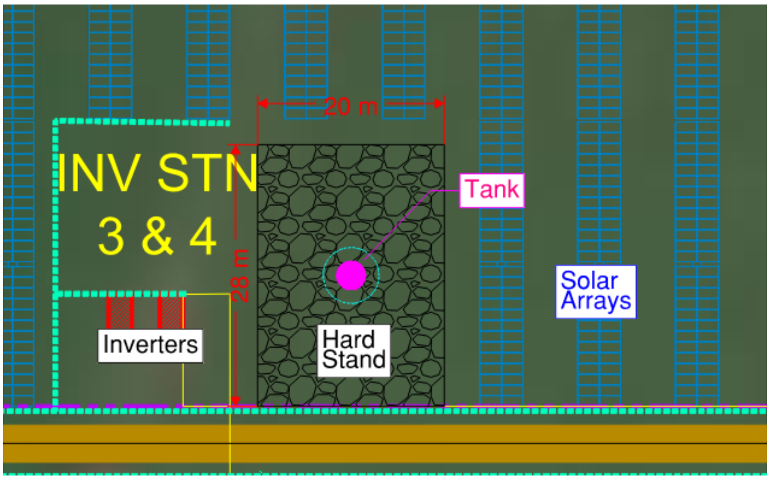

Figure 13: Typical Fire Water tank and gravel hard stand, with the road along the bottom of the image (extract from drawing ACRA-NZD-GT-001 Rev K)

Water races in Area 1 could also be used as a possible fire water supply if they are flowing at the time of a fire event. FENZ noted that they would be able to construct a portable dam to enable drafting of water from the canal. This may be advantageous but could not be relied upon in times of drought.

The more remote areas of the site are several hundreds of meters from a fire water tank. In our consultation with FENZ, we discussed their procedures, and how they would access the water tanks. FENZ said that for rural areas, they use water tankers, including their 12,000L tanker and the fire appliances (which carry a little over 2000 l) to shuttle the water to where it is needed. A portable dam could be established near the fire, allowing the tankers to rapidly discharge their load and return for more water. This approach allows fire fighters to use tanks which are more remote to the fire, rather than pumping water from the closest supply, including tanks on further areas of the solar farm. FENZ could also potentially use water from the solar farm water fire tanks for a fire event in the surrounding area. Based on this approach, the availability of water from the tankers is relatively good, with a greater firefighting water availability, comparative to other rural areas.

As FENZ vehicles may be required to shuttle water to the fire, FENZ noted that there may be a need for vehicles traveling in different directions to pass one another. A 6m access track road width was suggested by FENZ to allow space for their vehicles to be able to pass each other without using the non-formed flat ground next to the gravel access tracks. The landscape design shows there is at least 1 m clear zone (2 m in many areas) either side of the 4 m wide access track, which would allow vehicles to pass using this “off-track” zone. FNSF have provided approximately 20m x 30m gravel hard stand areas around the water tanks as space for one vehicle to pull off and allow the other to pass. Whether the frequency of such pull over spaces is sufficient is not clear. However, it could reasonably be expected that the dry areas are available alongside the roads were a vehicle could pull over, particularly in dry periods when the fire risk is elevated.

4.5 Solar Farm Construction

It is understood that the solar farm is largely of modular construction, with prefabricated components being assembled on site. For example, support posts will be installed in the ground, solar panels and their supporting frame bolted / clipped together in situ. Whilst FSNF were not able to identify any hot works (welding, grinding, etc) which would be required on site, a low amount of hot works would be expected.

Implementing a Construction Fire Risk Management Plan (CFRMP) is expected to be developed by the EPC (Engineering, Procurement and Construction) contractor which will address construction fire risks and mitigations, for example addressing 'hot works'. Our expectation is that this plan would establish the site access, gravel perimeter access tracks and water tanks as early possible so these firefighting provisions are available.

4.6 Grass Management

Beca has been advised that there will be grass for sheep grazing beneath the solar panels. A grazing plan will be in place to keep the height of the grass to no more than 300 mm high except for December, January, February and March in which the maximum height will be 200 mm. It is understood this requirement will be maintained through the operational life of the solar farm through a leasing contract.

4.7 Solar Farm Operation & Maintenance

An Operational Management Plan is a proposed consent condition. FNSF have advised the following routine maintenance actions for the solar farm are anticipated:

- Screen planting around the farm will be trimmed (i.e. using agricultural machinery) to keep plant / tree heights to those outlined in the landscaping design. Trees need to be kept to this height to limit shading on the solar arrays.
- Solar panels will be cleaned a few times a year. This is expected to include an employee on a light agricultural vehicle with a small water tank and a brush.
- Grass within the solar farm will be used for grazing. It is expected that farmers monitoring or moving stock will use vehicles.
- FNSF has advised that routine maintenance will be carried out on the gravel access track roads to keep these free from grass and debris.
- FNSF has indicated that it expects approximately 3 vehicle movements per day in the solar farm.

FENZ recommended that fire extinguishers be considered to be carried by vehicles on the proposed Solar Farm site. It is considered where it is practical to do so, extinguishers should be included on vehicles as part of the CFRMP and OMP.

4.8 Features Not Proposed for the Solar Farm

Battery Energy Storage System (BESS) commonly use lithium batteries to store large amounts of energy, with a high energy density. BESS fires, such as the Victoria Big Battery fire in July 2021, can develop into large fires, which burn for extended periods of time, pose firefighting challenges and release significant levels of toxic contaminants. Some solar farm fires reported on in the media relate to BESS fires, rather than a fire involving the solar power generation components.

The proposed Greytown solar farm does not contain a battery energy storage system.

5 Fire Fighting Policies and Procedures

5.1 FENZ Consultation

FNSF had previously consulted with Fire and Emergency New Zealand (FENZ) about the proposed solar farm and obtained general agreement particularly around access site provisions and firefighting water tanks.

As part of this risk assessment process, Beca also discussed the solar farm development with FENZ on 23 July 2024. This engagement focused on understanding the FENZ likely firefighting approach to solar farms fires and the firefighting needs for the proposed development. The FENZ staff in attendance were:

- Brendon Allen: Advisor Risk Reduction, Wellington District, Masterton Fire Station
- Esitone Pauga: Response Capability Advisory Manager, Commander, National Headquarters
- Keith Pedley: National Operations Advisor - Fleet & Equipment, Alternative Energy – National Response Capability

In addition to comments captured in Section 4 of this report, this section records information provided by FENZ in this interview. FENZ also provided comment on the Draft “Revision A” of this report which were incorporated (eg: recommending fire extinguishers be considered to be carried on vehicles).

FENZ is aware of the increasing presence of solar farms in rural areas of New Zealand and is in the process of developing a national firefighting procedure for solar farms.

FENZ noted that its current default position is to treat fires at solar farms in a similar way to how it treats fires at electrical substations. FENZ will mobilise to the site and wait at the site entry until met by a site representative, enter the site when advised it is safe to enter and undertake firefighting activities after electrical hazards have been mitigated. The site representative would also be required to advise FENZ which assets to protect, as well as handle any media queries and take control of the site once the fire is extinguished. FENZ noted that a site representative is expected to be available to attend the site within 1 hour.

FENZ noted that an Emergency Response Plan (ERP) needs to be developed with the site operator and is a proposed consent condition (which is also consistent with the Transpower substation standard – discussed above). This will inform fire fighters of site-specific risks and facilities, as well as enable FENZ to develop a pre-determined plan should a fire occur.

With a pre-determined Emergency Response Plan, the Officer in Charge (OIC) may choose to enter the site prior to the arrival of a site representative to undertake firefighting. Based on plans developed for other sites, the firefighting activities would most likely be limited to containing the fire within access tracks doubling as fire breaks. FENZ has advised FNSF to provide a minimum gravel access road width of 4m wide as a fire break. Fire fighters will not conduct firefighting on or beneath the solar arrays.

FENZ noted a recent fire at a substation in the vicinity of the proposed solar farm which was successfully contained.

5.2 Responding Fire Stations

Table 2 describes the fire stations in the vicinity of the proposed Greytown solar farm, the types of trucks/appliances they have available and the approximate distance they would need to travel to respond to a fire at the solar farm.

Table 2: Fire Stations in vicinity of the Proposed Greytown Solar Farm (from www.111emergency.co.nz)

Fire Station	Station type	Fire trucks	Approximate Distance from Site
Greytown	Volunteer	2 pump appliances	6 km
Featherston	Volunteer	2 pump appliances	9 km
Carterton	Volunteer	2 pump appliances 1 tanker	15 km
Martinborough	Volunteer	2 pump appliances	15 km
Masterton	Composite (paid and volunteer crews)	3 pump appliances 1 rural medium tanker (5800 l)	30 km
Hutt City	Paid	1 pump appliance	45 km

As the majority of fire fighting vehicles within the vicinity of the solar farm are pump appliances, which carry a moderate quantity of water (in the order of 2000 l), numerous vehicles may be involved in transporting / shuttling water to and from the fire. The presence of dedicated fire water tanks within the solar farm is advantageous, as the distances vehicles will need to travel, and transport time will be relatively short.

Fire vehicle turning circles, as discussed in Section 4.3 are based on the Carterton water tanker, being the closest tanker to the solar farm.

5.3 Fire Fighting Water Supply

The publicly available specification SNZ PAS 4509:2008 “New Zealand Fire Service Fire Fighting Water Suppliers Code of Practise” has been considered. “*This code of practise sets out… water pressure and volume* [requirements] *for fire fighting in structures in urban districts*”. The standard is used to determine a firefighting water supply, based on the size and use of building structures. It is sometimes required for homes or lifestyle blocks as a resource consent condition. The standard does not determine water quantities for external features such as the solar farm, and therefore is of limited relevance to this proposed solar farm.

Per SNZ PAS 4509, a non-sprinkler protected single family dwelling or multi-unit dwelling requires a FW2 water supply classification. A FW2 water supply is a minimum of 45,000L of water storage, where a reticulated supply is not available. The dedicated firefighting water supply tanks provided on the solar farm is approximately 300,000L, with at least 60,000L on each of the three areas of the site. SNZ PAS 4509 also requires that half of the required water be within 135 m of the building and the remaining half within 270 m. The tanks are proposed to be distributed throughout the solar farm with vehicle access to remote parts of the solar farm. The proposed firefighting water tank locations do not meet these requirements (which are intended for buildings) but are understood to have been discussed by FNSF and agreed as being acceptable with FENZ.

6 Hazard Identification

6.1 Introduction

Risk characterisation requires defined fire scenarios for which the probabilities and consequences can be defined. An ordered way of developing fire scenarios is to identify the fire hazards and then generate scenarios based on the hazards eventuating. A hazard is “a condition that presents the potential for harm or damage to … environment” (NFPA, 2022).

Hazards can be classified into three types (Society of Fire Protection Engineers, 2023):

- Precursor – hazards that may or may not cause a fire but could increase the likelihood or consequences.
- Ignition – hazards that can directly lead to fire event ignition.
- Propagation – hazards that directly supports the continuation or escalation of fire event consequences.

Hazards identification was split into two phases: during construction and during operation.

Since this assessment is based on a relative risk approach, only new hazards or changes to existing hazards were identified.

6.2 During Construction

Some hazards identified in and during operation phase are also present during the construction phase (e.g. grassfires) so are not repeated here. During the construction phase there will be much greater activity on-site than during its regular operation, although it is only for a limited time. Only hazards unique to the construction phase were identified, which included:

- Construction machinery, equipment and plant which may be both sources of ignition and fuel for fires.
- Stores of construction materials which are fuel for fires and may result in fire spread between stores.
- Construction methods which may be ignition sources (e.g. incidental hot works, power tool battery).
- Electrical faults as a result of installation errors (e.g. inadequate plug contact) as sources of ignition.
- Accidental fire hazards (e.g. discarded cigarette).
- Incomplete firefighting measures with reduced/no functionality which may result in greater fire consequences than if fully functional. Fire risks during construction are to be managed by the EPC contractor as part of their site safety management plan.

6.3 During Operation

For the purposes of identifying hazards during operation (including maintenance), hazards were grouped into either PV system and electrical related hazards or mechanical, natural and other hazards.

6.3.1 PV System & Electrical Hazards

NFPA 850 “Recommended practice for fire protection for electric generating plants and high voltage direct current converter stations” identifies the major electrical hazards associated with PV generating plants as (NFPA, 2022):

- Electrical fires associated with a failed PV module or string cabling,
- Inverter, switchgear and cable fires
- Transformer failure fires

In addition, the Victoria Australia Country Fire Authority (CFA) “Design Guidelines and Model Requirements: Renewable Energy Facilities” identifies:

- Electrical hazards, such as panel/inverter electrical faults; power surges; lightning strikes; water ingress; retained DC electricity in solar panels after shut-down/isolation.
- Potential fire spread and limited emergency response due to proximity of panel banks to each other, on-site infrastructure and vegetation (including screening vegetation).

NFPA 850 also identifies tracking system hydraulic oil, however FNSF has advised the proposed Greytown tracking system is battery-motorised (ie no hydraulic oil).

Both the CFA and NFPA guidance identify wildfires as a hazard; either “ignition from fire within the facility, or external ignition of site infrastructure from embers or radiant heat” (CFA, 2023). Wildfires originating outside the facility are an owner’s asset protection concern so are outside the scope of this risk assessment. Grassfire hazards originating within the facility are identified in Section 6.3.2.

The PV system and electrical hazards identified for this specific site are:

- Electrical faults as sources of ignition. It is possible for these to occur in every electrical component including connections, junction boxes, panels and inverters. There are a range of possible causes of the electrical fault which results in ignition.
- Electrical equipment as fuel for fires. Plastics are the main combustibles (Note: metallic conductors, panel support frames and most electrical housings like the containerised DC-AC invertors are non-combustible).
- The DC-AC inverters and electrical substation contain transformers which can be ignition sources and the transformers contain coolant mineral oil, which is a fuel.
- Batteries which are sources of ignition and provide for fast fire growth. There will be many small batteries distributed throughout the facility:
    - Small batteries power the PV tracking modules in lowlight conditions. There could be approximately 1500 across the facility.
    - Batteries in Uninterruptible Power Supplies for the inverters/transformers.
    - Miscellaneous small tool batteries e.g. power tools, etc.
    - Note: No Battery Energy Storage System is proposed – so this large battery type risk is not present.

6.3.2 Mechanical, Natural and Other Hazards

Other hazards identified are:

- Vehicles and agricultural farming equipment used during the operation of the facility and may be greater than current vehicle operations. While much of this will be on the site’s gravel access tracks, vehicles and equipment will need to drive off the formed tracks to clean, maintain and repair the PV system and to muster grazing stock and undertake other general farming activities. These can be sources of ignition and fuel as well as sources of ignition for nearby fire fuel loads (e.g. hot exhaust igniting grass/vegetation).
- Natural causes of ignition (e.g. lightning).
- Accidental ignitions such as a discarded cigarette.
- The grass underneath the PV modules is a source of fuel and fire spread.

- There is a control building housing the SCADA system in Area 1 next to the substation. This building will be required to comply with the New Zealand Building Code (NZBC) as a minimum, however it will include fire detection with remote monitoring. The NZBC contains provisions to protect other property, which mitigate fire spread to boundaries.
- Arson.

6.4 Causes of Wildfires

The causes of wildfire in New Zealand have been reported by FENZ, see Figure 14 and Figure 15 (Gross et al., 2024). A substantial portion of wildfires begin with activities undertaken by people - pile burns; prescribed burns; cooking and heating; cigarettes, matches and candles, and explosives and fireworks were the attributed cause of approximately 88% in the 2021/22 season and with a historical average of 84%. Many of these factors could be reduced through the introduction of controls on the solar farm, such as prohibiting or controlling smoking, fires and hot works.

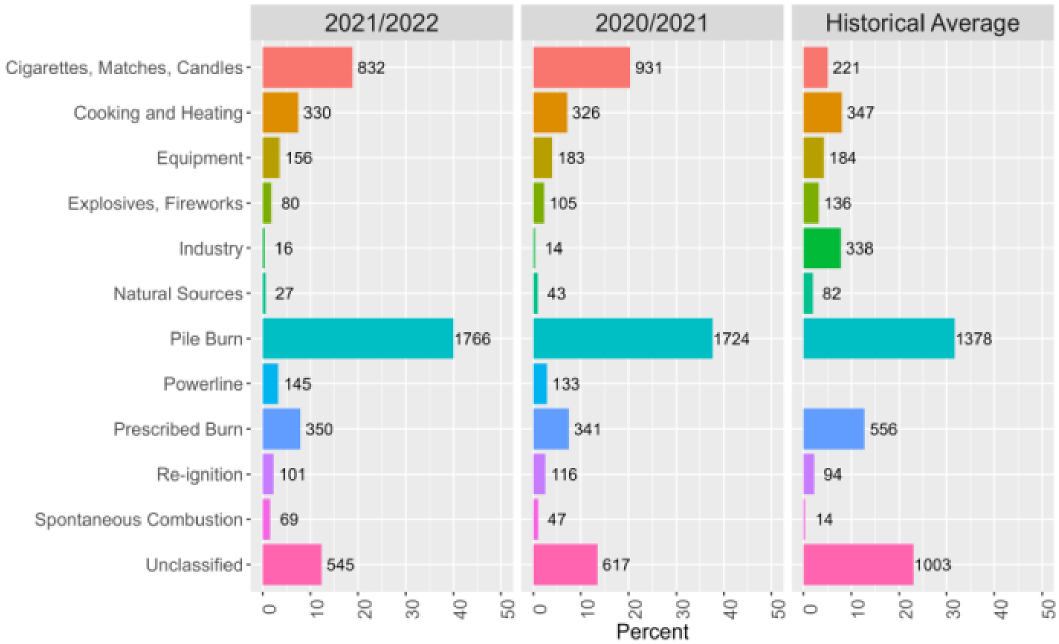

Figure 14: Percent of wildfires by cause for the 2021/2022 (left), 2020/2021 (middle), and 34-year historical average (right) (from Gross et al., 2024). Note that powerlines were included as a new category in 2020/2021.

Cause Group	HeatSource
Cigarettes, Matches, Candles	Cigarette, Cigar or Smoking materials
	Cigarettes, matches and candles – Other
	Lighters
	Matchers or Lighters(Suspicious)
Cooking and Heating	BBQ
	Embers, Ashes
	Outside fire for cooking
	Outside fire for warmth / Campfire
	Umu / Hangi
Equipment	Chainsaws
	Exhaust heat / Spark
	Farm machinery
	Malfunction
	Motorbike, Truck or Car
	Mowers and slashers
	Welding, grinding, cutting
Explosives, Fireworks	Fireworks / Pyrotechnics
	Flare: Warning, Safety, Boat
	Incendiary devices, Molotov cocktail
	Sky / Chinese lanterns
	Tracer ammunition
Industry	Bee-Keeping smoking tool
	Earthwork or forestry machinery
	Electrical Fence
	Maintenance crews
	Oil and gas exploration
Natural Sources	Animals
	Geothermal Activity
	Lightning discharge
	Solar heat: Sun (magnified through glass etc)
Pile Burn	Debris burning
	Outside bonfire
	Refuse burning
	Windrow / slash pile
Powerline	Clashing / Arching power lines
	Static electrical discharge
	Trees
Prescribed Burn	Agricultural fire or burn off
	Broadcast slash burn
	Crop burn
	Deliberate – scrub and tussock
	Scrub and tussock burn
Re-ignition	Re-ignition, Rekindle from previous fire
Spontaneous Combustion	Bark or sawdust spontaneous ignition
	Hay/silage spontaneous ignition
	Skid site spontaneous ignition
	Spontaneous ignition
Unclassified	Exposure Fire – unable to classify
	Information not recorded/Unknown
	Outside fire – unable to classify

Figure 15: Broad wildfire cause categories and the underlying individual heat source categories used for analysis of the 2021/2022 and 2020/2021 incident statistics (from Gross et al., 2024).

6.5 Screen Planting

Beca understands the primary purpose of the screen planting is to reduce the visual impact of the solar farm. However, by meeting this primary purpose, a new fire hazard (and resulting risk) is introduced. The screen planting is located in the 5-6 m wide zone between property boundary fence and the security fence (for example, see Figure 6). These trees increase the fuel over pasture grass, particularly any dead and dried material. The fire risk from this screen planting is discussed in Section 8.6.

7 Fire Scenarios

Risk requires the characterisation of probability and consequences of specific events, called Fire Scenarios, occurring. The Fire Scenarios are developed from the hazards previously identified. These Fire Scenarios have been generalised to capture the range of similar possible circumstances. The scenarios which have been selected are those where the risk profile from the current use of the land may have changed, either potentially raising existing risks / hazards, or incorporating new ones. The risk associated with each scenario is characterised in Section 8.

7.1 Fire Scenarios for Risk Characterisation

The following Fire Scenarios from the Solar Farm were developed from the source hazards identified in Section 6 and are shown in an event tree in Figure 16. The Fire Scenarios considered the fire being confined to the source hazard or spreading to a grassfire. Additionally, the scenario of a fire spreading to the Solar Farm from an adjacent property has been considered.

Fire Scenario 1 – Confined Vehicle or Mobile Farm Equipment Fire

Source Hazards
Vehicle (or mobile farm equipment) movements which may increase.

Scenario Description
A fire is ignited in a vehicle (or mobile farm equipment) which grows to involve the whole vehicle. The fire stays confined to the vehicle of origin until it runs out of fuel or it is extinguished by firefighting.

Fire Scenario 2 – Confined Electrical Equipment Fire

Electrical equipment means all components of PV system excluding the PV modules (and their junction boxes) i.e. including and “downstream” of the String Combiner Box. It includes inverters and transformers.

Source Hazards
Electrical equipment hazards are being added to the site as part of the solar farm.
Electrical faults as sources of ignition. Electrical equipment as fuel for fires (plastics and miner oil).

Scenario Description
A fire begins in the solar farm electrical equipment (e.g. PV module, combiner box, inverter, transformer, PV modules battery, etc) and grows eventually consuming all fuel in the equipment. It remains confined to the one piece of equipment.

Fire Scenario 3 – PV Module fire

Source Hazards
PV modules and their tracking system as the ignition and fuel for fires.

Scenario Description
An electrical fault ignites a fire in a PV module. This can spread to adjacent panels. Since elected firefighting approach elected by FENZ is not to apply water to the PV system, it could potentially consume all the panels bounded by an access track. FENZ are considered to undertake exposure protection.

Fire Scenario 4 - Fire during construction

Source Hazards
Construction equipment and methods, materials, accidental ignitions and incomplete firefighting features.

Scenario Description
A fire during the construction phase. One stack storing materials, vehicle, or equipment is ignited (potentially an accidental ignition) and fire spreads to adjacent stacks of equipment/materials. The fire is extinguished by FENZ.

Note: The possibility of this fire spreading to become grassfire is addressed in Scenario 5b.

Fire Scenario 5a – Grassfire during operation of solar farm

Source Hazards
Fire spread to the grass from: Scenarios 1-3, natural sources, accidental ignitions.

Scenario Description
A grassfire begins from any ignition source and spreads. The severity depends on the weather and grass conditions. The access tracks can act as firebreaks and firefighting occurs.

Fire Scenario 5b – Grassfire during construction of solar farm

Source Hazards
Fire spread to the grass from: Scenario 4.Scenario Description
Same as Scenario 5a except firefighting features may be incomplete.

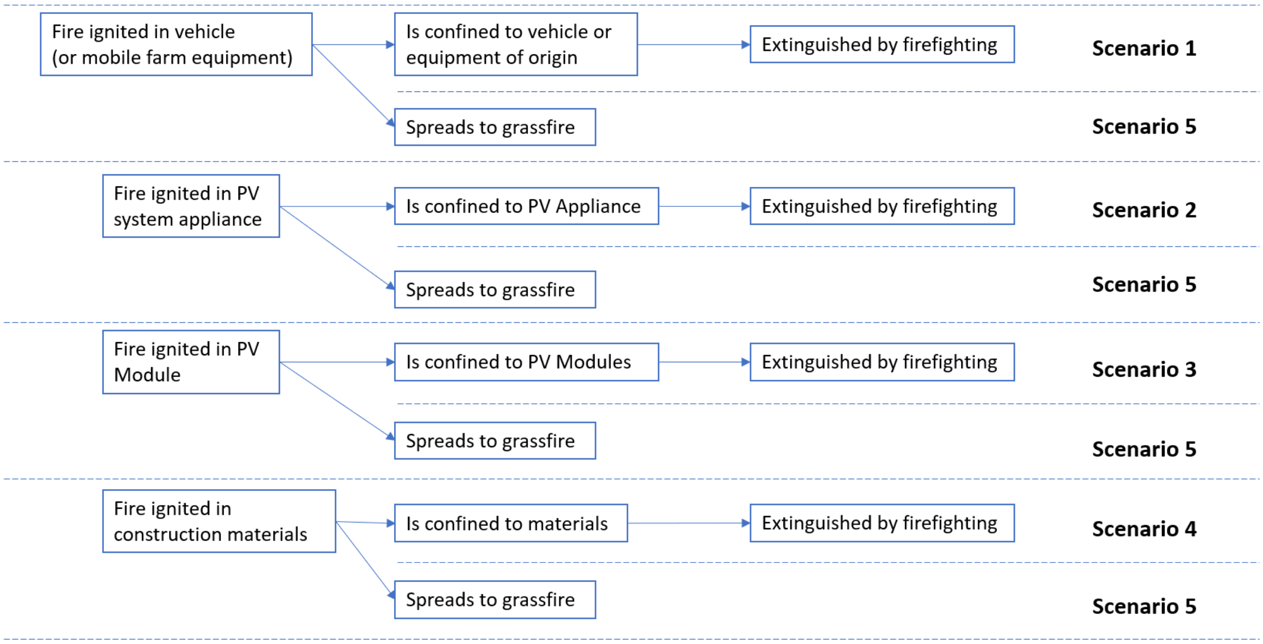

Figure 16: Event Trees of Scenarios 1 to 5

7.2 Other fire Scenarios

7.2.1 Deliberate Fires within Solar Farm Site

With the existing use of the site and surrounding area, deliberately lit fires are a consideration. As captured in Section 6.4, more than 80% of wildfires in NZ were caused by deliberate fires or heat sources. Many of these can be omitted through controls on the solar farm.

The solar farm has an approximately 2m high secure perimeter fence and is therefore expected to be a well-controlled environment and workplace. Deliberate fires are not expected due to the people who are allowed access, the use of the site and the potential damage to the solar farm assets if a fire did escape containment.

Arson is another potential ignition source. A single arson ignition event will most likely behave similarly to fires ignited by other means, for example starting a grassfire or PV equipment fire. However, severe malicious arson attacks (e.g. using petrol drums), multiple ignitions or disabling fire risk mitigations are beyond the scope of this assessment.

7.2.2 Consideration of Fires Outside the Solar Farm Site

There is also fire risk posed to the solar farm from the surrounding rural context. A wide range of activities are possible on the adjacent land including grazing beef, cattle, cropping or hay production. Additionally, a small plantation or shelterbelt can be planted without restriction or if a field is neglected the grass can grow to a tall height. These activities increase the external fire risk to the solar farm. All the various activities possible in the surrounding land (e.g. farming, lifestyle/housing) are potential ignition sources for fire. These fires will produce a smoke plume and there may be run-off of firefighting water. They could also lead to grassfires if the grass is ignited. If anything, the features of the solar farm (low flammability trees, fire breaks, firefighting vehicular access and firefighting water storage) will reduce the impact of an outside fire on the solar farm.

8 Risk Characterisation

For each Fire Scenario the probability and consequences have been characterised.

8.1 Scenario 1 – Confined Vehicle or Mobile Farm Equipment Fire

This scenario is of a fire beginning in a vehicle (or mobile farm equipment) and remaining confined to the vehicle until it is extinguished.

It is difficult to comment directly on the probability and consequences of a vehicle fire within the solar farm because there is a lot of uncertainty in the underlying parameters (e.g. vehicle age, condition etc). Given this greater underlying uncertainty only a higher-level risk characterisation is possible. There are numerous ways in which a vehicle could start a fire, which are present in both the existing context and proposed use of the solar farm site. As vehicle ignition risks are present in the existing use of the land, the risks of a vehicle fire have been considered based on the frequency and type of vehicle use, with limited consideration to how a vehicle may cause a fire.

The probability of a vehicle fire depends on the vehicle, its condition, type and how frequently vehicles are driven within the facility. No comment can be made on the vehicle condition given the uncontrolled nature and uncertainty involved. However, several characteristics can be contrasted between the solar farm and the previous farming activity (also the predominant adjacent land use).

We understand from FNSF briefings that during normal operation, the type of vehicles used within the solar farm for routine maintenance and operations (utes, trucks, side-by-side/quad bikes, etc) are similar to the current land use. Typical vehicle usage during the operation of the solar farm is expected to consist of:

- A vehicle will be used as part of the sheep grazing operations,
- A light vehicle such as a side-by-side or quad bike will be used to transport water for cleaning the solar panels,
- Vans and trucks for the maintenance of the PV system.

Beca understands from FNSF briefings that vehicle usage within the solar farm perimeter could be expected to be approximately three vehicles per day, which could be more frequent than the current land use. However, in many instances, these vehicles are expected to stay on the gravel access tracks. A vehicle fire occurring on a gravel access track is also less likely to spread beyond to a grassfire.

The consequence of a confined vehicle fire will be smoke released into the local environment until all the fuel is consumed or it is extinguished. Depending on the amount of water used in extinguishment, there is the potential for contaminated water to enter waterways. The magnitude of these consequences primarily depends on the vehicle and any cargo. As raised previously, we understand the type of vehicles used within the solar farm for routine maintenance and operations are similar to the current land use. Therefore, during regular driving operations (such as driving for sheep management and spraying panels) without high fire hazard cargo, the consequences of a vehicle fire are broadly similar to those of the current land use.

Given the consequences of a vehicle fire are broadly similar to those of the current use, the difference in risk is mainly in the change in probability of a vehicle fire which depends on the frequency of vehicles and movements. FNSF have advised that there will be approximately three vehicles per day. The current vehicle frequency is unknown, uncontrolled and could range from one a month to many times per day. Overall, the risk of a vehicle fire is no more than the surrounding rural context because fire spread is less likely if it occurs on the gravel access tracks and the better firefighting facilities make it easier to control the fire and limit consequences.

8.2 Scenario 2 – Confined Electrical Equipment Fire

This scenario considers a fire beginning in an electrical equipment and remaining confined to the equipment. Electrical equipment considered are the components of the PV system which are described in Section 4.2. Fire in the PV modules (panels) are addressed in Scenario 3 in the next section.

8.2.1 Ignition Sources

A 2018 study by the Building Research Establishment (BRE) on "Fire and PV Systems" investigated historic incidents and incidents that occurred during the study. They found "80 potential PV related fire incidents, representing approximately 0.01% of the current number of installations installed in the UK" (Coonick, 2018). PV systems were identified to have caused the fire in 58 of these incidents, the cause was unable to be determined in six incidents and the remaining fires spread to the PV system from other ignition sources.

The BRE Study recorded six fire incidents occurring in solar farms with the majority occurring to PV installations fixed to buildings (domestic and non-domestic). However, the authors "strongly suspect a degree of under-reporting, especially amongst solar farms". "Anecdotal evidence indicates that many solar farm incidents have occurred that have not been reported. This is because the Operation and Maintenance companies, usually on rapid response service level agreements, tend to deal with issues as they arise and buildings and people are often not affected" (Coonick, 2018). These six identified solar farm incidents are detailed in Table 3. Most of the fires were classified as localised fires which "caused some damage to areas around the point of origin, mainly affect PV system component, but did not spread beyond that or threaten the building" and one incident was a thermal event consisting of "components that over-heated, often observed to be smouldering or producing smoke, but did not develop into fires".

Table 3: Summary of solar farm fire incidents identified in BRE Study (adapted from Appendix B - Coonick, 2018)

Site Type	Cause attributed to PV system	Severity	PV components involved	Most likely root cause
Solar farm	Yes	Localised	Unknown	Unknown
Solar farm	Unknown	Localised	Unknown	Unknown
Solar farm	Yes	Localised	Inverter	Unknown
Solar farm	Yes	Localised	Inverter	Faulty product
Solar farm	Yes	Thermal event	DC connectors	Poor installation
Solar farm	Yes	Localised	DC combiner box	Poor installation

A literature review as part of the same BRE Study identified that arc faults "undoubtedly represent the greatest fire hazard in PV systems" (Pester et al., 2017). Arc faults are "where current flows across an air gap by ionising the air." These arcs have a high temperature which can ignite surrounding materials. Due to established electrical standards, practices and experience, arcing is not seen as a hazard in conventional AC systems. Most distinctly, arcs in AC systems tend to self-extinguish as the voltage alternates many times per second, whereas the voltage in DC systems is continuous, maintaining the arc once established. Arcs are frequently preceded by ground faults "so it is important to detect as they arise and take appropriate action.” Inverters do contain ground fault detectors but are not universally effective and can have “blind spots” (Pester et al., 2017).

The BRE Study identified certain PV components that if incorrectly selected, installed or contain flaws are common locations of electrical arcs and therefore fires:

- DC Connectors,
- DC Isolators,
- Inverters,
- PV modules and their junction boxes.

This aligned with PV incident data which found 75% of fires occurred in DC isolators, DC connectors and inverters (Coonick, 2018). The study also investigated the most likely root cause of fires that started in the PV system – 36% were attributed to poor installation practice, 10% to design errors and 5% to faulty products. The cause of the remaining 50% was unable to be determined (Coonick, 2018).

8.2.2 Risk Characterisation

Clearly the presence of the solar farm introduces the potential for PV equipment fires that do not exist when no solar farm is present. Although the probability of a fire in PV equipment is small, the underlying fire hazards are present all the time, but more so while the solar PVs are generating. However, determining a fire probability is not straightforward, especially when it depends on a wide range of parameters, not least of which is the quality of the installation which is unknown until the EPC contractor procures equipment. The probabilities and consequences vary between the different equipment in a PV system.

The dataset is not large with only 6 of 58 PV fire incidents identified in the study occurring at solar farms (although this is a much smaller proportion of fires per generation capacity than building PV system fires). Although the real probability is higher than this statistic because of likely non reported fires and incidents that were quickly resolved by Operating and Maintenance (O&M) contractors, it indicates that responsive O&M attendance can resolve preceding fire events and fire events.

PV fires can occur in almost any part of a PV system, however, the reported most common locations are DC Connectors, DC Isolators, Inverters and PV modules and their junction boxes. Inverters are located on concrete pads with a separation distance from other PV system components. The DC isolators are located in each string combiner box, which are located in the field and DC connectors are located throughout the system. Although a fire can occur throughout the system, evidence from the study suggests that these are frequently “localised” ie caused some damage to the point of origin but not beyond. The probability can also change through time, as some fault initiators (e.g. moisture ingress) take some time to develop. We understand much of the solar farm equipment life is expected to be 35 years or more, and consider that over this timeframe that it is likely that at least one fire in a PV equipment occurs.

As evidenced by all six reported solar farm fires being classified as localised fires, the consequences of a single burning piece of equipment are minor. Such a fire will release smoke into the local atmosphere until all the fuel is consumed (given FENZ’s approach it is unlikely to be extinguished by firefighting operations). The toxicity of the smoke will depend on the specific equipment fire composition but will generally be incomplete combustion of plastics and other hydrocarbons. If any water is used in extinguishment, the water becomes contaminated in a similar way it would for any water suppressed fire incident.

The consequences of a localised PV fire are relatively limited – a smoke plume (and perhaps firefighting water). Ultimately, the risk from this scenario is less than Scenario 5 when a larger grassfire is considered.

8.2.3 Substation Fire Risk

The substation presents a higher fire risk than if it was it was absent. FNSF have confirmed that the substation design will meet Transpower's "Substation Fire Mitigation Design Standard". This standard has comprehensive fire risk mitigations, which includes equipment spatial setbacks to boundaries, FENZ response/tactics, firefighting provisions and a substation specific ERP with FENZ familiarisation. There are hundreds of substations located in NZ, many are in similar external rural contexts (such as the existing Greytown Substation adjacent to the solar farm site). Given the proposed substation design will meet Transpower's comprehensive standard, the fire risks will be mitigated to at least these good practices. The residual fire risk is accepted for substations throughout New Zealand, it is considered acceptable here also. 4.2.4

8.3 Scenario 3 – PV Module fire

8.3.1 Ignition and flammability of PV Modules

The ignition source in PV modules (i.e. the panels) is the formation of so called "hotspots" which are a symptom of a number of causes. A hotspot occurs when a solar cell (or group) is "forced into reverse bias and must dissipate power that can result in abnormally high cell temperatures in a restricted area of the surface" (Aram et al., 2021). Hotspots can originate due to partial shading, production flaws or damage to the cells. Bypass diodes are incorporated into modules to prevent hotspots developing – they allow electrical current to flow around groups of cells with a high resistance (e.g. as a result of shading) preventing resistance heating. However, bypass diodes can be damaged, e.g. by lightning strikes or electrical surges, removing any protection they offer (the damage is usually not obvious to a visual inspection). It is also possible for a difference in module performance (a "mismatch") to cause a reverse current to occur between whole PV modules resulting in power loss and hotspots.

The PV modules also use electrical motors with lithium-ion batteries (approximately 3500 mAh) to rotate the modules in low-light conditions. These batteries are relatively small; for comparison a Samsung S24 smart phone has a battery capacity of 4000 mAh. One of the key factors in batteries that catch fires is preceding mechanical damage and abuse. These batteries are stationary (fixed in place) so the risk of mechanical shock or damage is very low, reducing ignition risk compared to batteries in mobile equipment.

The main materials of PV modules are glass, silicon solar cells, the aluminium frame, copper wiring and EVA encapsulant. The proposed PV modules are bifacial i.e. there are cells and glass on both sides. This is different to mono-facial panels which have a plastic backing sheet. This backing sheet, which is not in the proposed panels, is the "most flammable component and has the potential to exacerbate the spread of fire" (Pester et al., 2017). The EVA encapsulant is the main combustible component in the bifacial PV modules.

Two studies investigating potential cadmium exposure from PV modules by fire and leaching found that emissions from fire are unlikely to pose a potential health risk to residents, works or emergency personnel because the cadmium is chemically bound within the solar cells (Sinha et al., 2008, 2011).

8.3.2 Risk Characterisation

Although the probability of an ignition and fire per PV module is low, the overall probability is much greater due the number of panels installed across the three areas. Given the 35-year or more estimated lifetime of the farm, it is likely that there is a PV module fire throughout this lifetime.

The probability of panel-to-panel spread depends on the amount of combustible material in the installation, this has been reduced as:

- The bi-facial panels have no plastic backing. The top and bottom surfaces of the panel are glass / silicon. While the panels do contain some combustible components, these are generally embedded within the panel, where their contribution to fire severity and spread is limited.
- The PV modules are mounted on a non-combustible metal structure.

On this basis, neither a severe solar array fire, not a fire spread over the solar array fires is expected. This conclusion is supported by studies of existing solar array fires (refer to Section 8.2.1) which show that solar array fires in land based solar farms are typically localized and have occurred in PV equipment rather than the modules.

However, if fire does spread from panel-to-panel, this is likely only to occur along a row of panels, as panels rows are separated by approximately 6 m. This relatively large distance along with the small fuel load in the PV modules reduces the risk of fire spread by radiation to modules in adjacent rows.

The consequences of a PV module fire are a smoke plume from burning EVA and plastics (e.g. cable wiring). Given FENZ’s firefighting approach it is unlikely that water will be applied to the panels (and therefore no run-off).

Overall, although this scenario is likely over the life of the farm, the consequences are low given the low fuel load in the PV modules. The risk from this scenario is lower than if a PV modules fire spreads to the grass, in which case a much larger fire is possible.

8.4 Scenario 4 – Fire During Construction

Only general commentary on the risk from fire during construction can be given without detailed construction specifics. Although the probability of a fire per day will probably be greater than when the farm is in operation, the construction phase is of limited duration. FNSF have informed Beca that the construction period is expected to be approximately 2 years. A Fire Risk Construction Management Plan is to be in place to reduce fire risks to an as low as reasonably practicable basis. Beca have been informed that much of the construction of the panel arrays will be done with bolts and clips without hot works, reducing the potential ignition sources. Some ignition hazards are unavoidable e.g. sparking during post installation. Without automatic detection, fires must be manually detected. With more people onsite during construction the chance of earlier manual detection of a fire is greater.

During construction, fire risk mitigation measures may not be complete. The consequences from fires may therefore be greater as firefighting may not be as effective as when these measures are complete. On the other hand, the construction staff may be able to undertake first aid firefighting and limit the fire early in its development.

Overall, the risk of fire starting during the construction period is likely to be greater than the existing use of the land.

8.5 Scenario 5 – Grassfire

Scenarios 1 to 3 capture fires which remain confined to the objects of fire origin. Given the size of these fires, the fact they remain confined to the object of fire origin and favourable firefighting features (e.g. access and on-site water tanks), the consequences are relatively small. However, these fires could lead to a grass fire (see Figure 17) which could grow relatively quickly and spread to neighbouring property.

Figure 17: Grassfire under an Australian solar facility in December 2022 (from CFA, 2023)

Two events within this scenario were considered (see Figure 18 which shows a more detailed event tree for this scenario):

a. Whether the fire spreads a little before it is extinguished, or whether it becomes substantial before firefighting occurs, and

b. If it grows to become substantial, whether the roads acting as fire breaks are breached by the grassfire (assuming no FENZ intervention).

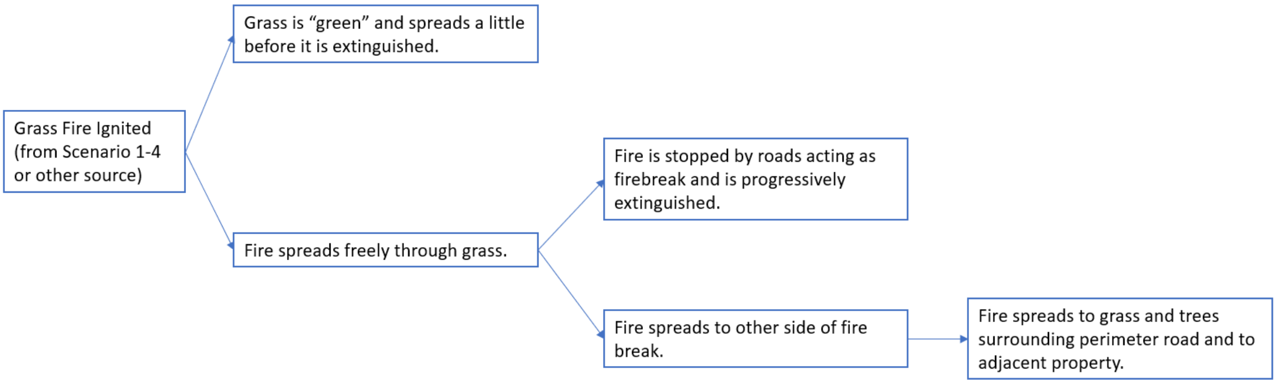

Figure 18 Detailed Event Tree for Scenario 5

8.5.1 Fire spread through Grass

The risk of grassfire depends on the local climate. For this assessment, the meteorological data from the Masterton Airport is used (see Figure 19). Fire and Emergency New Zealand has historical wildfire risk index data for this site from 1991 to 2021. Historical data is a record of previous events and future events will be the same as the past. Particularly, wildfire risk indices which depend on the weather at a specific location and time, which may be subject to longer term changes in climate. No slope correction factor has been applied as the solar farm will be located on generally flat land.

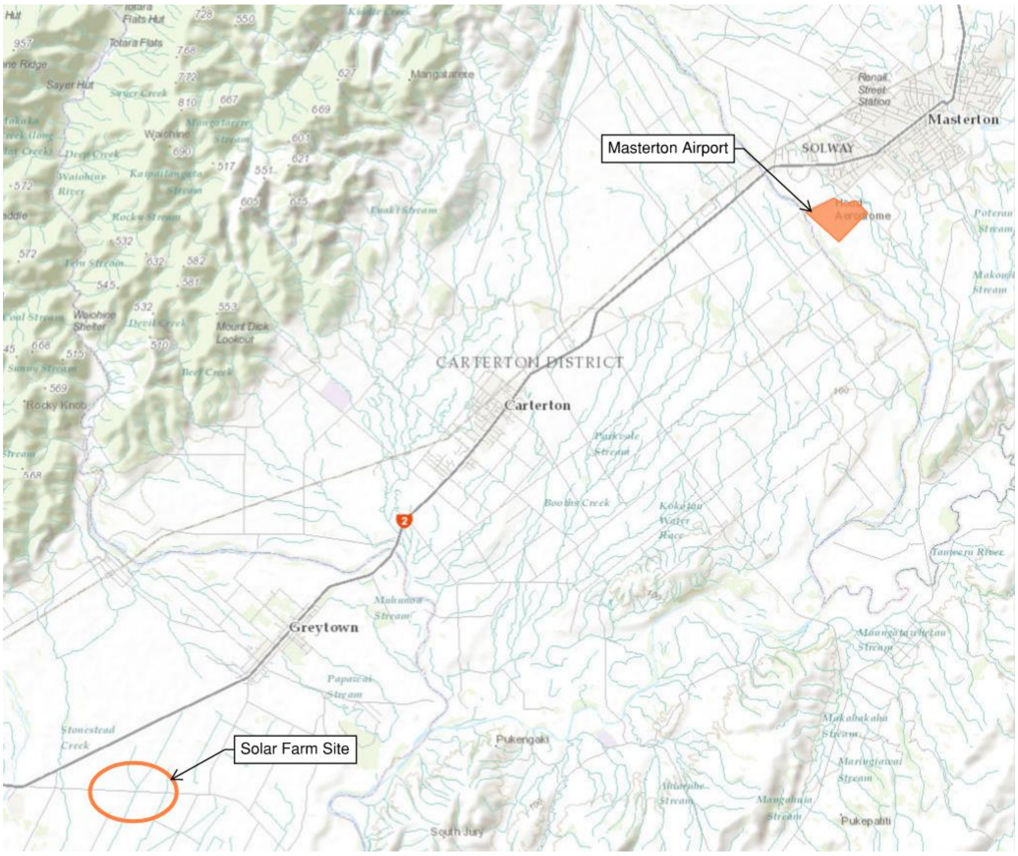

Figure 19: Locations of Masterton Airport and the Solar Farm site (basemap from Masterton District Council)

The basic measure of grassfire risk is given by the Grass Fire Danger Classification, which changes with the weather and the degree of grass curing (see Figure 20). Each Class is described and the suppression interpretation is presented in Table 4. From May to September the Grass Fire Danger Class is Low or Moderate for 90% of the month. However, between December and March, Low and Moderate account for less than half of the days of the month and there are approximately 11 days classified as High and 3-5 days as Very High and up to 4 days as Extreme.

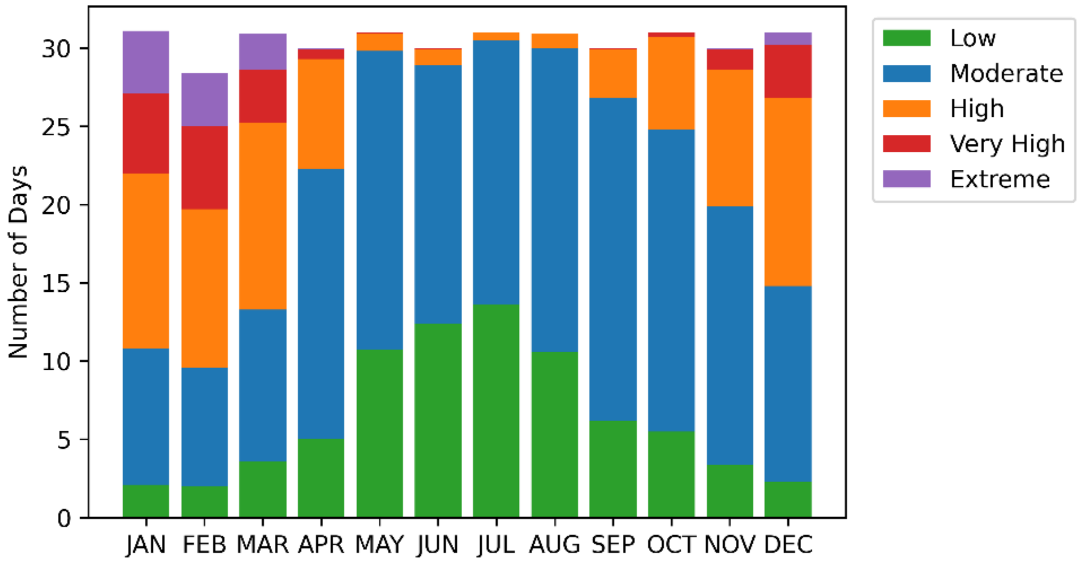

Figure 20: Mean number of days for each Grass Fire Danger Class for Masterton Aero from 1991-2017 (Very Extreme has been grouped with Extreme)

Table 4: Suppression interpretations of Fire Danger Class criteria (Appendix 3D of Pearce et al., 2012)

Fire Danger Class	Description of Probable Fire Potential and Implications for Fire Suppression	Nominal Maximum Flame height
Low	New fire starts are unlikely to sustain themselves due to moist surface fuel conditions. However, ignitions may take place near large and prolonged or intense heat sources, but the resulting fires generally do not spread much beyond their point of origin and, if they do, control is easily achieved. Mop-up or complete extinguishment of fires that are already burning may still be required provided there is sufficient dry fuel to support smouldering combustion.	No visible flame
Moderate	From the standpoint of moisture content, fuels are considered to be sufficiently receptive to sustain ignition and combustion from both flaming and most non-flaming (e.g., glowing) firebrands. Creeping or gentle surface fire activity is commonplace. Control of such fires is comparatively easy but can become troublesome as fire damages can still result and fires can become costly to suppress if they aren't attended to immediately. Direct manual attack around the entire fire perimeter by firefighters with only hand tools and back-pack pumps is possible.	Up to 1.3 m
High	Running or vigorous surface fires are most likely to occur. Any fire outbreak constitutes a serious problem. Control becomes gradually more difficult if it's not completed during the early stages of fire growth following ignition. Water under pressure (from ground tankers or fire pumps with hose lays) and bulldozers are required for effective action at the fires' head.	1.4-2.5 m
Very High	Burning conditions have become critical as the likelihood of intense surface fires is a distinct possibility, torching and intermittent crowning in forests can take place. Direct attack on the head of a fire by ground forces is feasible for only the first few minutes after ignition has occurred. Otherwise, any attempt to attack the fire's head should be limited to helicopters with buckets or fixed-wing aircraft, preferably dropping long-term chemical fire retardants. Until the fire weather severity abates, resulting in a subsidence of the fire run, the uncertainty of successful control exists.	2.6-3.5 m
Extreme	The situation should be considered "explosive". The characteristics associated with the violent physical behaviour of conflagrations or firestorms is a certainty (e.g. rapid spread rates, crowing in forests, medium- to long-range mass spotting, fire whirls, towering convection columns, great walls of flame). As a result, fires pose an especially grave threat to persons and their property. Breaching of roads and firebreaks occurs with regularity as fires sweep across the landscape. Direct attack is rarely possible given the fire's probable ferocity except immediately after ignition and should only be attempted with the utmost caution. The only effective and safe control action that can be taken until the fire run expires is at the back and along the flanks.	3.6+ m
The above should not be used as a guide to firefighter safety, as fires can be potentially dangerous or life-threatening at any level of fire danger.		

The heat released by a wildfire is quantified by the Intensity (kW/m) which depends on the fuel load and the rate of spread of the fire. Since a lower grass height is proposed from December to March, when the fire risk is greater than the rest of the year, the two parts of the year will be investigated.

The fuel load was determined using the Grazed Pasture fuel model (Pearce et al., 2012) and a 100% grass cover was assumed. As detailed in Section 4.6, grazing management will be in place to maintain maximum grass heights of 200 mm from December to March (available fuel load of 3.1 t/ha) and 300 mm from April to November (available fuel load of 4.1 t/ha). The fuel load, which is governed by the height of the grass, is a determining factor in the grassfire severity. For example, Figure 21 shows the difference between the fire head of grassfires in fields with a grass height of 100 mm compared to 240 mm.

Figure 21: Photos from grassfire experiments in Australia showing effect of fuel height and fuel load on flame height (Top: grass height of 240 mmm, fuel load of 4.9 t/ha and a 3 m flame height. Bottom: grass height of 100 mm, fuel load of 2.4 t/ha and 0.5 m flame height. Mean wind speed of 22.5 km/h) (From Cheney & Sullivan, 2008).

One of the key parameters is the rate of spread as this is one of the leading factors in the size of the grassfire when FENZ arrives. Similarly to the Grass Fire Danger Class, the rate of spread changes throughout the year depending on the weather and the degree of curing of the grass (see Figure 22).

The median and 95th percentile rate of spread values for the two parts of the year are given in Table 5. The 95th percentile rate of spread value from 1991-2021 was 3140 m/hr from December to March and 575 m/hr from April to November. Note this is the rate of forward spread, the rate of spread at the flank and back of the fire are less.

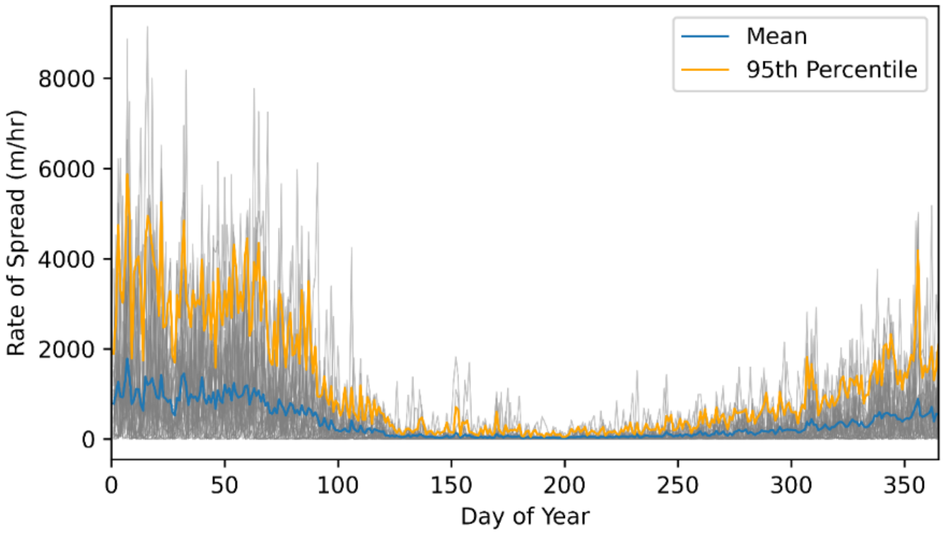

Figure 22: Grassfire rate of spread from 1991 to 2021

Table 5 summarises the fuel load and rate of spread parameters. The rate of spread is low from May to September (see Figure 22), so a grassfire at this time of year is expected to be small and relatively easily contained by firefighters. However, From December to March, the rate of spread is much greater so the fire will be greater by the time firefighting efforts begin. April and November are shoulder months where the rate of spread of a grassfire lies between the “winter” low and summer “high”.

Table 5: Fuel load and rate of spread

	December - March	April – November
Maximum grass height under grazing management	200 mm	300 mm
Available Fuel Load	3.1 t/ha	4.1 t/ha
Median rate of spread from 1991-2021	450 m/hr	30 m/hr
95th Percentile rate of spread from 1991-2021	3140 m/hr	575 m/hr

8.5.2 Fire Spreads across fire break

The Intensity of the head of a fire can be calculated from (Pearce et al., 2012):

$$Intensity\ (kW/m) = 18000\ (kJ/kg) \times Fuel\ load\ (kg/m^2) \times rate\ of\ spread\ (m/s)$$

The direction of a grassfire on flat land (such as the solar farm location) is generally determined by the wind direction. The approximate intensity around the perimeter of the fire is shown in Figure 23. This assumes an elliptical shaped fire front which is a general representation for wind-driven fires originating from a point ignition provided the wind direction remains relatively constant. The intensity around this fire vary as a result of the different spread rates at the head, back and flanks of the fire (Pearce et al., 2012).

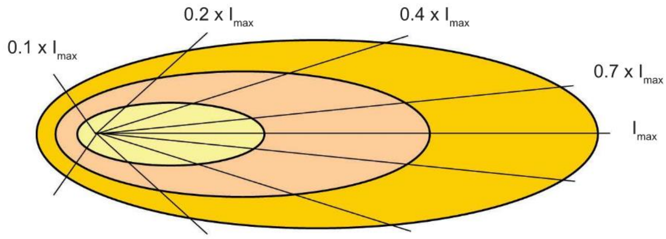

Figure 23: Elliptical-fire perimeter and area-intensity distributions (From Pearce et al., 2012)

The flame length corresponding to the intensity can be estimated by (Pearce et al., 2012):

$$L(m) = 0.0775 \times I^{0.46} \ (I \ in \ kW/m)$$

Note that the observed flame height is frequently less than this calculated value as of the wind driven flame angle.

The fire intensity and flame length for the various cases are presented in Table 6. The intensity was correlated to a Fire Danger Class and the minimum fire suppression resources for a direct head fire attack according to Section H of Pearce et al (2012). Note that this correlation is only a guide for more tangible understanding of the intensity.

Table 6: Calculated fire intensity, flame length, Fire Danger Class and supression interpretations

	December – March (200 mm grass height)		April – November (300 mm grass height)	
Rate of Spread	Median	95th Percentile	Median	95th Percentile
Intensity (kW/m)	700	4900	60	1175
Flame Length (m)	1.6	3.9	0.6	2
Fire Danger Class	High	Extreme	Moderate	High
Minimum suppression resources for direct head attack	Water under pressure and heavy machinery.	Head fire attack not likely to be effective, and it will be too dangerous for ground crews.	Ground crew and back-pack pumps.	Water under pressure and heavy machinery.

One of the firefighting features of the solar farms is the roads which act as firebreaks and locations for firefighting activities supported by a pumping appliance. There is a perimeter road around all three solar farm areas and there are internal areas which divide the areas into smaller divisions.

Wilson (1988) developed a correlation to estimate the probability of a firebreak being breached from a number of grass fire experiments in Australia. Trees on the fire side of the break (within 20m) significantly increase the chance of the break being breached through the production of brands. This probability does not consider any firefighting to occur from the firebreaks. This correlation was applied to quantify the probability of the roads (acting as firebreaks) being breached by a grassfire (see Table 7). Since the risk being examined is of the fire escaping through the breaks outside and there are no trees are proposed on the inside of the perimeter road (see landscaping plan), no spotting effect from trees was considered. The width of the fire break was taken as the width of the road (4m).

Table 7: Probability of roads as fire break being breached according to Wilson (1988)

	December – March (200mm grass height)		April – November (300mm grass height)	
Rate of Spread	Median	95th Percentile	Median	95th Percentile
Probability of 4m firebreak being breached	10%	30%	8%	12%

8.5.3 Scenario 5a - Risk Characterisation for grass fire during operation

Given that fire from Scenario 1 to 4 ignites adjacent grass, the probability that it spreads beyond the localised area varies throughout the year.

- May to November - A very low probability that it spreads beyond this localised area as the grass curing is low prohibiting the spread,
- December to March – Spread beyond the ignition area is likely,
- During the shoulder months of April and November, fire spread beyond the area of ignition is possible and will depend on the specific weather and grass conditions and the magnitude of the ignition energy source.

In the scenario that a grassfire has begun and is spreading through the grass, the probability that it breaches the 4m wide roads acting as firebreak depends on the specific weather and grass conditions (see Table 7). Based on historic data measured at Masterton Airport from 1991 to 2021, there is approximately 10% probability that the firebreaks are breached based on the median historic grassfire rate of spread value and a 30% probability based on the 95th percentile value. Note that historic data can only provide an indication of how future conditions may impact on the probability of fire spread. This percentage does not consider any firefighting efforts that may also be undertaken from the firebreak roads.

If grass is ignited, the probability of spread is small in May to November but expected between December to March. There is a perimeter firebreak around all areas of the solar farm, and the grass fuel throughout the solar farm is divided by firebreaks which avoid a grassfire growing to the size of the whole area. Firefighting is expected to be easier and more effective than on the surrounding farmland because of the better firefighting vehicle access and the availability (accessibility and quantity) of firefighting water on site. The combination of the firebreaks and firefighting activities are expected to limit the size of a grassfire.

Overall, while the probability of a grass fire may be higher due to introduced potential ignition sources, the probability of a grass fire spreading beyond the solar farm may be lower than compared to the current land use.

8.5.4 Scenario 5b – Risk characterisation for grassfire during construction

Scenario 5b considered a grassfire during construction. During the construction phase the probability of a grassfire will be greater than during normal operations due to the increased activity onsite. The weather and grass condition factors discussed for Scenario 5b (grassfire during operation) also apply to this scenario. However, depending on the construction methodology, fire risk mitigations may be incomplete, eg access tracks and firefighting water tanks. In this case, the firefighting ability will be reduced and the consequences of a fire greater. If the firefighting features are constructed as early as possible, the impact on firefighting ability will be small and the consequences closer to those during the operation period. Similar conclusions can be reached about other construction factors such as poor fuel hazard housekeeping allowing fire to “skip” firebreaks.

8.6 Fire Risk from Screen Planting

The fire risk from screen planting is compared to a similar fire risk in the context of the solar farm – a shelterbelt like those found on the land adjacent to the solar farm. On the adjacent land, there is no restriction on what trees currently exist or could be planted as part of a shelterbelt. Fast growing tree species are often chosen, but many of these have a high flammability. There are also no requirements on the maintenance of these trees.

Whereas the screen planting are being selected as either ‘low flammability species’ or ‘low/moderate flammability species’ from the “Flammability of Plant Species” guidance published by FENZ (2024) as described in Section 4.2.7 of this report. The width of the screen planting will be maintained to withing the property boundary and security fences and to heights of 5-6 m depending whether on mounds or not.

A fire in the screen planting of the solar farm can be much more easily extinguished by firefighters as there is vehicle access via the adjacent perimeter gravel access track. Firefighting access to a fire in a shelterbelt on adjacent land will be poorer in many cases. The proposed solar farm site also contains a substantial amount of stored firefighting water. This allows greater firefighting suppression than a fire on adjacent land where firefighting water will more likely need to be brought by tanker to the site.

While the presence of screen planting increases fire risk, this risk has been pragmatically reduced by selecting lower flammability tree species, tree size maintenance and the improved firefighting vehicular access and water storage compared to what is possible from the adjoining rural/ domestic activities.

8.7 Fire Risk to and from Adjacent Residential Dwellings

Houses and their ancillary buildings, lifestyle blocks and farm buildings are present in the surrounding rural context. Reviewing the RMM Landscape Package it is understood the nearest existing residential dwelling is located approximately 50m from the proposed solar farm site boundary (in the vicinity of the existing Greytown substation). A residential dwelling offset 50m from a property boundary is comparatively much further than allowable for typical residential dwellings which are permitted in the building code compliance document to have a 1m offset. Property damage risk from a vegetation fire on the same property could likely be higher, compared to the 50m+ limited flammability screen planting and solar farm.

9 Summary

This section summarises the risk assessment documented in Sections 6 to 8. Each aspect of fire risk of the solar farm requested by the Court is compared against the fire risk of its context.

9.1 Fire Risk During Construction of Solar Farm

	Solar farm	Surrounding Rural Context
Probability	Greater probability of fires due to construction activity.	No change to normal probability of fires (refer to table below)
Consequences	Without any mitigations, the consequences of a fire in construction could be substantial. The following risk mitigations are proposed: - Emergency Response Plan to be agreed with FENZ (including protocols) - Construction Fire Risk Management Plan to be completed by construction contractor shall identify and mitigate construction fire risks to a reasonably practicable level. The fire risk mitigations (access tracks, firefighting water etc) should be constructed as early as possible.	No change to normal consequences of fires (refer to table below)

Conclusion: The probability of fires is greater during the construction of the solar farm than in its surrounding rural context. With appropriate CFRMP mitigations the consequences of fire during construction can be reduced to a reasonably practicable level that is also comparable or better than the existing rural context. The fire risk during construction changes as more permanent hazards are introduced and as mitigations are constructed. The fire risk during construction is for the finite construction period, which FNSF advise is expected to be approximately 2 years.

9.2 Fire Risk During Operation

	Solar Farm	Surrounding Rural Context
Probability	The probability of fires depends on the electrical equipment, quality of installation, facility monitoring and maintenance and the quantity of vehicle movements on the site. The activity on the site is relatively fixed. Overall, the probability of fires increases with the presence of the solar farm.	There are a wide range of ignition sources as part of the broad spectrum of activities within the surrounding rural setting. This could include discarded cigarettes, fires ignited by vehicles and farm machinery, deliberately lit fires, building and shed fires, or those which may escape containment (barbeques, etc). Therefore, there is a range of fire occurrence probability depending the particular activity being undertaken within the surrounding rural context.
Consequences	**Smoke Plume**	
	The size of the fire plume depends on the size of the fire; larger fires result in larger plumes. Research on solar farm fires reveals that fire of electrical equipment generally involve a single item. The smoke plume from a fire involving a piece of electrical equipment or a vehicle will be smaller than a grassfires, but may contain more toxic from the burning of plastics and other materials. The proposed bifacial solar panels have a smaller combustible content than the plastic backed alternatives. Heavy metals chemically bonded to the silicon are unlikely to pose a potential health risk in fire. Grassfires can grow larger than electrical fires but the smoke plume is expected to less toxic since the fuel is cellulosic. The solar farm does not contain large lithium batteries (i.e. a BESS). Smoke from BESS fires would be a hazard but are not present.	Smoke plume depends on the burning fuel of which there is a wide range in the context around the solar farm. Smoke from vehicle or farm or residential building fires will contain toxic products from the burning of plastics and other materials. Grassfires can grow larger than electrical fires but the smoke plume is expected to less toxic since the fuel is cellulosic.
	Firefighting water run-off	
	Firefighting water run-off depends on the amount of water applied and the combustion products produced. All fires could result in firefighting water run-off. Electrical or vehicle fires will contain more toxic combustion products than grassfires.	All fires could result in firefighting water run-off. Vehicle, farm equipment or building fires will contain more toxic combustion products than grassfires.

	Solar Farm	Surrounding Rural Context
	Although FENZ's general firefighting approach is to avoid applying water to electrical equipment fires.	
	Detection - Earlier detection leads to earlier firefighting when the fire severity is less.	
	Preceding conditions may be detected by monitored electrical systems, fires may be detected by the remotely monitored CCTV system or by people in the vicinity observing the fire or smoke plume. FENZ will have to be notified by phone call.	Detection is by people in the vicinity observing fire or smoke plume. FENZ will have to be notified by phone call.
	Grass fuel load control - A lower fuel load reduces the fire severity of a grassfire.	
	Vegetation fuel load control – Grass height in the solar farm will be controlled by a grazing contract. FNSF proposed limits are 200 mm from December to March and 300 mm from April to November. The fuel load is lower during the times of the year of greater wildfire risk.	Vegetation fuel load control - There is no requirement to manage or control grass heights, tree or other vegetation fuels on the surrounding farmlands at any time of the year.
	Firefighting Response and Vehicular Access – Better response and vehicular access improves firefighting ability reducing the consequences of a fire	
	Emergency Response Plan that has been developed and agreed is in place. FENZ can also undertake site familiarisation activities. FENZ is unlikely to extinguish the fire if it is in proximity to electrical equipment until a solar farm representative attends and advises that the area is safe for firefighting. This may take some time - FENZ expect that a site representative attend within 1 hour. Area 1 (the largest) has two vehicle entrances from Moroa Road. Areas 2 and 3 have a single vehicle entrance each. 4 m gravel access track is provided around the perimeter as well as the internal tracks which have no dead-ends. FENZ can undertake firefighting activities from these tracks.	Once FENZ is aware of the fire, they will need to locate the fire and attend. Locating the fire may be challenging, if it is not clear which property the fire is on, which delays firefighting. Many properties may only have one entrance from a public road suitable for firefighting vehicular access (if any due to trees, bends, load-bearing capacity etc). No specifically design vehicular access, therefore, firefighting vehicular access can be challenging. In many instances, it may be necessary for firefighters to carry equipment (often cross neighbouring properties and rural fences to reach the fire) delaying firefighting.

	Solar Farm	Surrounding Rural Context
	Firefighting Water Availability – More accessible firefighting water allows better firefighting operations reducing the consequences of fire	
	Dedicated firefighting water supply tanks are provided across the solar farm site. • Area 1: 6 water tanks (180,000L water) • Area 2: 2 water tanks (60,000L water) • Area 3: 2 water tanks (60,000L water)	It may be challenging to locate and access a suitable firefighting water supply. It is often necessary for tankers to transport water significant distances between a water source and the fire.
	Fire containment and spread to other property – Containment limits how large a fire can grow	
	The perimeter gravel access track acts as a firebreak to avoid a grassfire spreading outside the solar farm. The internal access tracks divide the site into smaller areas to limit the size of a grassfire. FENZ can undertake containment activities from the gravel access tracks.	No requirements for firebreaks, so a fire may spread un-inhibited across several properties. Fire containment may be completely reliant upon firefighting operations.

Conclusion: The probability of a fire within the solar farm is greater than in the surrounding rural context acknowledging that activities within the context have a wide range of fire probabilities. The proposed solar farm facility contains a number of mitigations (grass-height control, firefighting vehicle access, firefighting water storage, an ERP, etc) which reduce the consequences of a fire compared to the context. Overall, the fire risk of the solar farm in operation is considered to be no more than the surrounding context which has a broad range of fire risks. Furthermore, the solar farm is exposed to the risk of a fire entering the solar farm site from the neighbouring property.

9.3 Fire Risk from Screen Planting

	Solar Farm	Surrounding Rural Context
Probability	The solar farm has screen planting around the perimeter which is more than what is currently on the site. If the probability is considered to scale with the amount of planting, then the probability of a fire is increased.	There are a number of trees and shelterbelts on the surrounding properties. There current probability of a fire is unchanged.
Consequences	Existing trees on the site are to be removed. The screen planting around the perimeter of the site is selected from the "low" or "low-moderate" flammability lists published by FENZ. Screen planting is to be maintained to the applicable width and height. Refer to table above for solar farm firefighting facilities.	There are no plant flammability requirements. Photos of the area show pines and other plant species classified as more flammable planted up to or along the boundary. Refer to table above for firefighting facilities in surrounding context.

Conclusion: The probability of a screen planting fire is likely to be greater than in the surrounding rural context given the greater number of plants involved. The consequences of a screen planting fire on the solar farm are expected to be less than in a shelterbelts/trees observed in the existing context. Overall, given the limited flammability of the screen planting and the proposed protocols for maintenance, the additional fire risk of the screen planting is no more than posed by similar planting within the surrounding rural context.

Sensitivity: General

10 Potential Mitigations and Protocols

The proposed solar farm design includes fire risk mitigations and protocols have been considered within this report. As requested by the court, other potential mitigations and protocols have been considered and are listed in this section if further reduction of fire risk is desired (in no particular order).

10.1 Consider Construction Phase Risk

Given the extent of activity on the site during the building of the solar farm, it is expected the risk of a fire starting during the construction period may be higher than the current use of the land. Consideration could be given to developing a predetermined response plan with FENZ prior to commencing construction, including providing FENZ with security access to the site.

10.2 Quality Control

Many of the solar farm fires identified within literature are the result of poor design or installation practises. Maintaining a high level of quality control during the design, construction and operation of the farm will reduce the risk of a fire starting.

10.3 Maintenance of Fire Safety Features

A number of fire safety features are proposed for the solar farm. If not maintained, the effectiveness of the features may be undermined. For example, vegetation growth or build-up of debris on access tracks will compromise their effectiveness as fire breaks. If water tanks drain or dry out, their ability to provide firefighting water will be reduced.

10.4 Remote Monitoring

One of the features associated with the solar farm electrical system monitoring is the potential for the solar array system to detect fires as faults, and relay this information to monitoring staff. Developing and defining the extent and nature of staff monitoring could increase the effectiveness.

10.5 Strengthening Existing Mitigation Measures

- Lower the grass height limits to further reduce the available fuel load for grassfires. The lower grass-height could be extended to the shoulder months.
- Increase the width of the gravel access tracks that act as fire breaks. Wider firebreaks have a lower probability of being breached. This could be applied to the perimeter track or all tracks.
- Install fire extinguishers near power converting units.

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A

Appendix A – Benchmark against CFA Design Guidelines

Benchmark against Australian Design Guidelines for Renewable Energy Facilities

The State of Victoria Country Fire Authority has published Design Guidelines for Renewable Energy Facilities (CFA, 2023) covering wind, solar and battery energy storage systems. These guidelines "provides standard considerations and measures for fire safety, risk and emergency management in designing, constructing and operating new renewable energy facilities." Ultimately risk reduction measures are customised to a particular facility through its Risk Management Plan. The Fire Risk Management Principles are:

1. Effective identification and management of hazards and risks specific to the landscape, infrastructure, layout, and operations at the facility.
2. Siting of renewable energy infrastructure so as to eliminate or reduce hazards to emergency responders.
3. Safe access for emergency responders in and around the facility, including to renewable energy and firefighting infrastructure.
4. Provision of adequate fire-fighting infrastructure for safe and effective emergency response.
5. Vegetation sited and managed so as to avoid increased bushfire and grassfire risk.
6. Prevention of fire ignition on-site and spreading to adjoining properties.
7. Prevention of fire spread between site infrastructure (solar panel banks, wind turbines, battery containers/enclosures).
8. Prevention of external fire impacting and igniting site infrastructure.
9. Provision of accurate and current information for emergency responders during emergencies.
10. Effective emergency planning and management, specific to the site, infrastructure, operations and hazards (including bushfire).

To achieve these principles, model requirements are given, however, modifications to these model requirements can be made in consultation with the CFA.

The following sections benchmark the proposed facility against these requirements at a high-level. Some requirements have been generalised, for example, the specific Australian vehicle access requirements, and external risks have not been considered (i.e. outside fires travelling in).

Facility Location

Generalised Recommendation or Requirement	Proposed Greytown Solar Farm
Renewable energy facilities are to be located in low-risk environments wherever possible, to reduce the risk of external fire impacting the facility and its consequences. CFA considers indicators of a lower risk environment include: • Grassland.	The site and the surrounding land is pastoral farming as the dominant vegetation type, with isolated, groups or limited amounts of shelterbelt trees scattered among the rural context. Site is generally flat with small natural undulations. Site is located on Moroa Road which is accessible at either end.

Generalised Recommendation or Requirement	Proposed Greytown Solar Farm
• No continuous other vegetation types within 1-20km of the project site. • Generally flat topography, some undulation may be present. • Slopes are less than 5 degrees. • Good road access with multiple routes available to and from the project site.	
Where practicable, solar energy facilities can be sited on grazed paddocks. Vegetation throughout the facility must be managed in line with planning permit conditions and vegetation requirements (below).	Site is to be grazed. Limits on vegetation controlled as part of resource consent. In this case screen planting trees are selected from low or low/moderate FENZ listed species.

Facility Design

Generalised Recommendation or Requirement	Proposed Greytown Solar Farm
Provide a perimeter access road. Roads are constructed to meeting firefighting vehicle access requirements including load-bearing capacity, weather trafficability, width, slope, passing bays and turning requirements. Provide two access points to the facility and roads allow emergency access to all areas within the facility. Access should be agreed with the fire service authority.	Perimeter gravel access tracks provided. Access tracks suitable for firefighting vehicles. 2 access points to larger area. Only 1 access provided to each of the two smaller areas. An Emergency Response Plan with FENZ input is to be developed for the solar farm.
Where solar energy facilities are designed over several land parcels separated by private or public roads, overhead powerlines, and/or water courses, vehicle entrances are to be provided into each section.	There are three sections each with their own access.

Firefighting Water Supply

Generalised Recommendation or Requirement	Proposed Greytown Solar Farm
Firefighting water access including identification, signage, location, vehicular access (e.g. unobstructed, hardstand etc), connectivity. Note that CFA requires steel or concrete tanks.	Firefighting water and access stand provided. Tanks are plastic, but are separated from grass area by hardstand to limit fire impingement on the tank.
At least 45,000L static water tank at the primary vehicle entrance to each the part of the facility.	300,000L of stored water is provided across all three areas of the site, which is 220Ha. This exceeds the recommendation.

Generalised Recommendation or Requirement	Proposed Greytown Solar Farm
Additional static fire water tanks of at least 45,000L capacity for every 100ha.	

Fire Detection and Suppression Equipment

Generalised Recommendation or Requirement	Proposed Greytown Solar Farm
Buildings constructed to comply with the Building Code	Buildings required to comply with NZ Building Code.
Storage of hazardous goods complies with legislation.	(if any) Storage of hazardous goods will be required to meet relevant legislation.
Fire extinguishing located near power converting units. Also within vehicles during Fire Danger Period.	Recommended in vehicles (see Section 4.7).

Landscape Screening and On-Site Vegetation

Generalised Recommendation or Requirement	Proposed Greytown Solar Farm
Where landscape screening is required, the design must consider any potential increase in fire risk due to the type (species), density, height, location and overall width of the screening.	Fire risk of screen planting has been considered, using low or low/moderate flammability species with width and height restrictions.

Fire Breaks

Generalised Recommendation or Requirement	Proposed Greytown Solar Farm
A fire break must be established and maintained around the perimeter of the facility and the perimeter of substations and buildings. These must have a minimum width of 10 m and avoid ignition of on-site infrastructure.	4m wide maintained perimeter gravel access tracks are provided. Access tracks within the solar farm provide a clear strip of 8m from solar array to solar array (includes 2m setback from road on each side). Perimeter roads provide a clear strip of 10m or greater from security fence.

Solar Energy Specific Requirements

Generalised Recommendation or Requirement	Proposed Greytown Solar Farm
Solar energy facilities are to have a minimum 6 m separation between solar panel banks.	Panel banks are separated by 8m (4m road, with 2m separation either side.

Generalised Recommendation or Requirement	Proposed Greytown Solar Farm
Recommended that separation wherever possible: - Is between each 'bank' of solar panels, where a 'bank' is that connected to a single power conversion unit/inverter, or - Is provided so that no unbroken area of solar panels is greater than 25ha, or - Is designed in consultation with CFA. This zone is to be cleared of trees and scrub and grass must be no more than 100mm during the Fire Danger Period.	Panel banks / unbroken area of solar panels are up to approximately 15ha. Vegetation fuel load control – Grass height in the solar farm will be controlled by a grazing contract. FNSF proposed limits are 200 mm from December to March and 300 mm from April to November. The fuel load is lower during the times of the year of greater wildfire risk.

Vegetation Management

Generalised Recommendation or Requirement	Proposed Greytown Solar Farm
Solar energy facilities must have grass maintained to no more than 100mm under solar panels during the Fire Danger Period.	Vegetation fuel load control – Grass height in the solar farm will be controlled by a grazing contract. FNSF proposed limits are 200 mm from December to March and 300 mm from April to November. The fuel load is lower during the times of the year of greater wildfire risk.

B

Appendix B – Transpower's Substation Fire Mitigation Design Standard

Appendix B – Summary of Substation Fire Mitigation Design Standard

FNSF have confirmed that the substation design will meet Transpower NZ's "Substation Fire Mitigation Design Standard" (Transpower reference TP.DS 61.06). Beca contacted Transpower and obtained a copy of the current TP.DS 61.06 standard (dated October 2023).

The various fire risks and mitigations which the Transpower standard addresses is summarised below:

- *This design standard has been developed by Transpower and represents international practice and customisation for the New Zealand power system and environment.*
- *It is not practical to eliminate the possibility of a fire completely, so measures to mitigate the potential consequences of a fire are important to managing fire risk.*
- *Transpower's approach to substation fire mitigation is to incorporate a mix of passive fire protection, fire detection, active fire protection, good housekeeping, and documentation of requirements, as appropriate into all substations.*
- *Transpower's approach to substation fire mitigation is essentially around the following:*

  a. Providing resilience to ensure the safe and reliable transmission of electricity

  b. Keeping workers safe when they are on site

  c. Minimising the risk of consequential damage to the surrounding environment.
- *The purpose of this standard is to outline design requirements and guidance to achieve consistent and appropriate fire mitigation practices at Transpower substations.*
- *Some of the key Safety by Design considerations for substation fire mitigation related to our critical risks are:*

  a. Conscious consideration of the possible effects of any fire during the initial design stages when the site layout is being determined or altered.

  b. Procurement of assets with low combustibility and low toxic smoke.

  c. Ensuring that plant items which can provide a fuel or energy source are either avoided or are suitably located/separated. An example of this is the placement of assets with the highest fire risks downwind of the site's prevailing winds to minimise damage caused by the transfer of fire plumes, high temperatures, smoke and soot.

  d. Ensuring that designs include appropriate emergency egress, access routes and assembly points.

  e. Fire stopping of penetrations (cables, metal pipes, plastic ducts etc.) that pass through firecell boundaries (where firecells are deemed to be required).

  f. Fire stopping of cables leading into buildings or passing nearby oil bunding around transformers, to mitigate fire spreading from the switchyard to buildings (and vice versa) via cable insulation. Fire stopping of power cables from transformers can be achieved by direct burying or sand filling of a length of the cable trough. This needs to be balanced with any reduction in cable rating incurred due to the enclosure of the cables.

  g. Ensuring accessibility to inspect and maintain equipment without creating undue risk to personnel (e.g. avoiding locating fire suppression system cylinders down in cable basements which can require careful manoeuvring over/around power cables and under cable trays etc.).

  h. Ensuring that any cable ducts into the bund are fire resistant and terminated no lower than the top of the bund wall.

i. Ensuring that LV cable fire stops in cable troughs are reinstated after any cable maintenance, addition, or removal, throughout the life of the facility.

j. Ensuring there are no possible burning oil paths from bunds that could spread fire (e.g. through leaks of inadequately rated or poor condition bund walls or non- bunded/sealed ducts/pipes leading directly into buildings).

k. Where diesel generators are permanently installed at a site, they must be located where a fire in the generator or its fuel storage facility, will not affect other primary/secondary plant or buildings.

l. Placement of assets inside buildings such that emergency egress is not blocked or impeded.

m. Placement of outdoor assets to facilitate fire-fighting efforts and not block access for appliances (FENZ vehicles).

n. Avoidance of installing batteries, LVAC switchboards or any other electrical equipment inside cable basements.

o. Specification of Low Smoke Zero Halogen (LSZH) cables to significantly reduce the amount of toxic and corrosive gas emitted during combustion compared to PVC insulation.

p. Consideration in the design of the fire temperatures, heat release rates, fire durations, and smoke damage that could be expected in the event of a fire occurring.

q. Allowance in the design for separation between cable types (e.g. power and low voltage cables) and separation of cable containment systems (e.g. avoidance of stacking multiple cable trays in close proximity).

The Transpower standard addresses FENZ emergency response criteria and practices, including:

- FENZ response times
- the local brigade capability (eg: mix FENZ equipment and volunteers Vs professional)
- tactics and logistics to be considered and documented in a site Emergency Response Plan (ERP) and practiced with FENZ during site familiarisation activities
- site access, trafficable and manoeuvring accessway design (widths, weights and turning radius etc)
- hardstanding area size and manoeuvring areas
- hose run distances
- water supply provisions

The Transpower standard addresses outdoor equipment design criteria, with other fire risk mitigation factors including:

- transformer minimum safe separation distances to other substation equipment, to buildings and to property boundaries, determined from the electrical equipment size and oil capacity
- transformer bunding requirements with fire stopping drainage to oil interception facilities