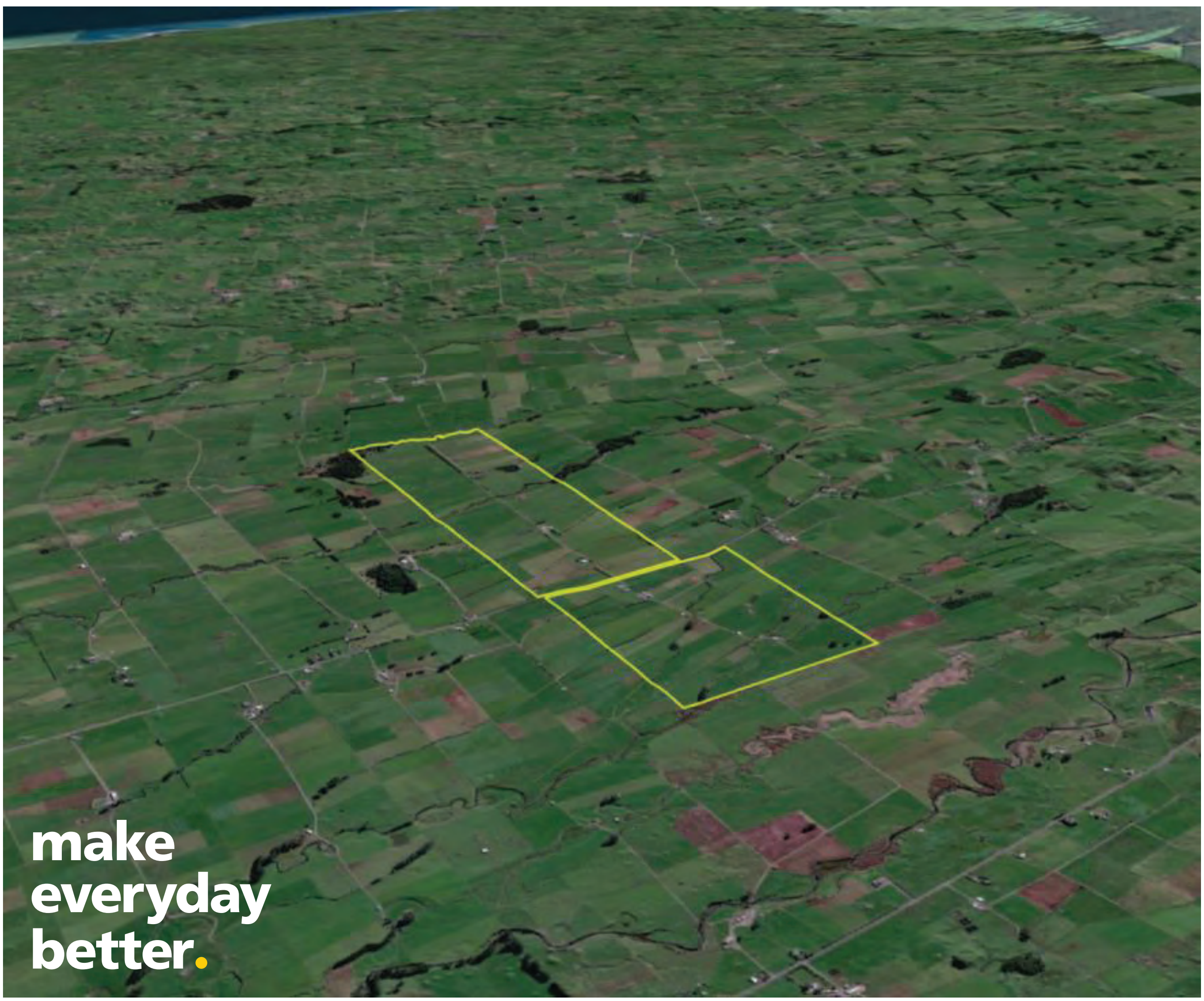
Sensitivity: General

Solar Farm Site Assessment - Ōpunake

Civil Report – Proposed Solar Farm at 574 and 575 Upper Kina Road, Ōpunake

Prepared for Energy Farms Ltd

Prepared by Beca Limited
28 February 2022



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Revision History

Revision Nº	Prepared By	Description	Date
1	Dale Paice, Kent Thomas; Kerry Overington	For Client Review	25/02/2022

Document Acceptance

Action	Name	Signed	Date
Prepared by	Dale Paice, Kent Thomas, Kerry Overington	Dale Paice	28/02/2022
Reviewed by	Ross Paterson, Roger Seyb	Roger Seyb p.p.	28/02/2022
Approved by	Tony Connolly	T. Connolly	28/02/2022
on behalf of	Beca Limited		

1 Executive Summary

Energy Farms Limited (EFL) is considering the development of 188.6 hectares of land at 574 and 575 Upper Kina Road in the South Taranaki District for solar farm generation.

Beca Limited (Beca) have been commissioned by Energy Farms Limited (EFL) to undertake a preliminary investigation of stormwater and geotechnical issues taking into account the potential constraints to development expected from the topography, the stormwater, geotechnical, ecological and contamination issues on the site. This study is intended to inform issues that could be raised during the consenting of the solar farm.

An initial Ecological Constraints Assessment (Beca 2022) and a Contamination Assessment (Beca 2022), also undertaken for EFL, have been used to inform the constraints (and potential constraints) to the solar farm layout. A landscape assessment has yet to be undertaken but this is expected to have no significant effect on the farm layout other than making sure there is adequate space for any planting required to screen the farm from neighbours or the public.

The resulting layout is presented in this report and results in approximately 152,000 (+/- 5%) panels. Note that this yield is based on is a high-level desktop assessment based on coarse topographic information and only considers the civil constraints. It does not take into account any shading from existing or new planting and it is acknowledged that other factors beyond the civil scope may influence the final number of panels. The assumptions used to calculate yield are set out in Section 7.1.

The ecological assessment has highlighted that there is a risk that a large part of the northern farm could be classified as wetlands. If they are, it will not be possible to place panels on those areas and accessways and the layout will likely need to be modified. This will result in a significant reduction in the panel yield.

An assessment of the potential earthworks and stormwater effects has been carried out with measures to manage potential effects described. The key finding from the desktop geotechnical study is that the presence of cobbles and boulders in the underlying soils present on the site pose a risk for installation of the solar panel supports by driven or bored piles. There is potential for adverse effects from land disturbance and sediment runoff during construction, however this can be managed through standard erosion and sediment control practices. The long-term effects on stormwater are predicted to be negligible (on the basis that vegetation is to be maintained underneath panels) with potential for betterment if riparian planting and protection is provided along the streams. An adaptative management approach has been proposed to monitor and maintain vegetation and repair erosion if and when it occurs.

Potential risks and opportunities identified by this report are provided in section 9 of the report.

2 Introduction

Energy Farms Limited (EFL) is considering the development of 188.6 hectares of land comprising two farms at 574 and 575 Upper Kina Road in the South Taranaki District.

Beca Limited (Beca) have been commissioned by EFL to undertake a preliminary investigation of stormwater and geotechnical issues relating to the site and to develop a layout for the solar farm, taking into account the potential constraints to development, expected from the topography, the stormwater management and the geotechnical, ecological and contamination issues on the site.

An initial Ecological Assessment Report *(Beca 2022)* and a Contamination Assessment Report *(Beca 2022*), also undertaken for EFL, have been used to inform the constraints to the solar farm layout. A landscape assessment has yet to be undertaken but this is expected to have no significant effect on the farm layout or solar panel yield - other than making sure there is adequate space for any planting required to screen the farm from neighbours, or the public, and to preserve notable areas of native or exotic vegetation.

This report will also inform EFL's Planning Consultant on likely issues that could be raised during the consenting of the solar farm.

3 Site Description

The site is located in the South Taranaki District, some eight kilometres inland from the west coast and approximately 14 kilometres by road, N-E of the coastal town of Ōpunake. The land consists of two farms opposite each other at 574 and 575 Upper Kina Road, as depicted on **Figure 1**. The northern property at 275 Upper Kina Road has an area of 112.0473 hectares and the southern property an area of 76.5462 hectares.

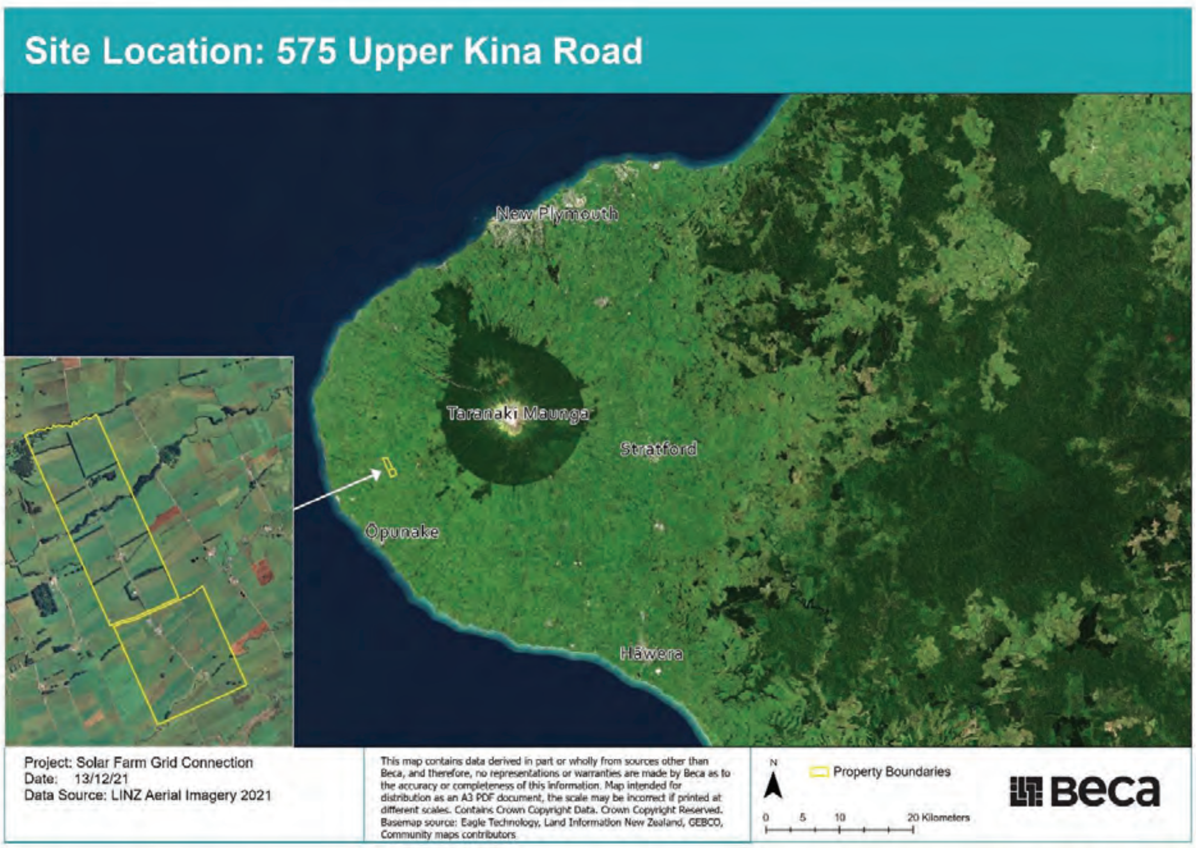


Figure 1 – Site Location, 574 and 575 Upper Kina Road, South Taranaki

Retrolens' imagery establishes that the site had been converted to a farmland well before 1954. The current use is cattle farming, with the farm being mainly grassed.

The only topographic information for the site is from the Regional Council, with contours at 10 metre intervals. The ground slopes moderately from east to west at about 1 in 20 to 1 in 30 and it is dissected by seven permanent and six intermittent streams and a series of artificial drainage ditches on the northern property. Refer to Figure 2**.**

The highest part of the site is at RL 140 about midway along the eastern boundary of the northern farm and the lowest is in the three main watercourses on the western boundaries at a level of RL 120 at the northern, Motiti Stream; about RL 114 at mid-site of the northern farm (the Oaoiti Stream); and about RL 117 in the stream at the southern end of the southern farm (the Manganui Stream). The various water courses are in parts deeply incised from about 0.8m to 5.0m (refer ecologist's report). There are two large ponds on the northern farm plus ponds that appear to take washdown water from a cow shed.

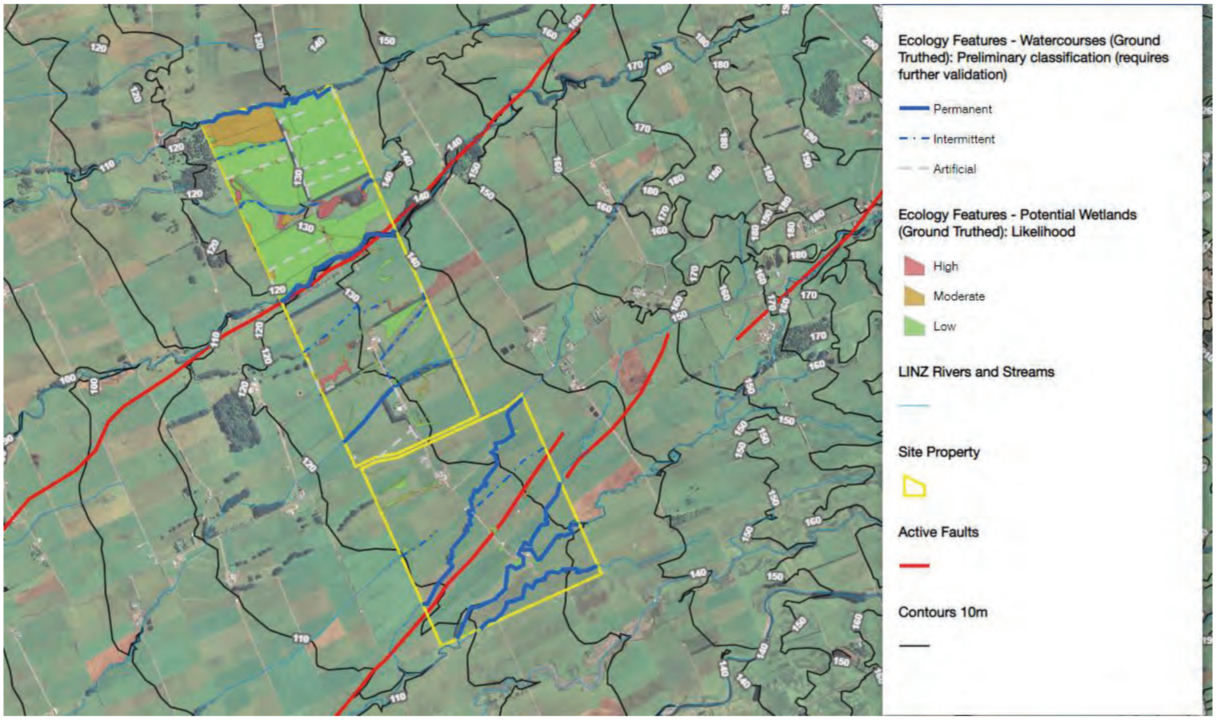


Figure 2 – Site Features

There is stand of native trees in the north- west corner of the site and a mixture of native and exotic vegetation along various watercourses and shelter belts as described in the Ecological Report. There are farmhouses on both farms plus milking sheds and other farm buildings all accessed off Upper Kina Road.

3.1 Historic Aerials

A review of publicly available aerial imagery obtained from Retrolens was undertaken. Two images, from 1954 and 1970 are presented in Figure 3 and Figure 4 below. These images show several streams traversing the site, some of which are no longer visible. It is likely that these have been infilled either by natural or man-made processes. The nature of the infill is unknown. Most of these infilled tributaries are in the northern lot of the site. The images also suggest no major changes in land use and no other significant past modification.

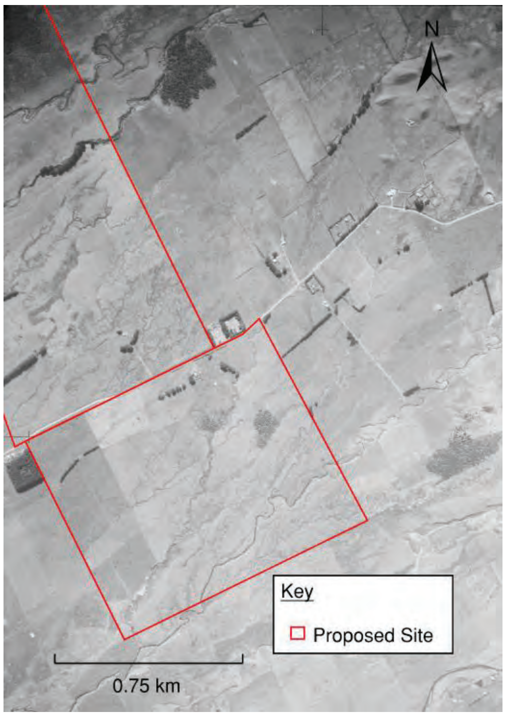


Figure 3 – Imagery from 1954

Figure 4 – Imagery from 1970

4 Ecology, Landscape and Contamination Assessments

The findings of both the Beca Ecological and the Contamination Reports for Ōpunake have been included on the GIS data map for the site together with photograph locations taken by the Ecologist, with the likely areas of constraints plotted. These areas have been taken into account in laying out the solar farm.

Because of the coarse spacing of the contour information it is not possible to accurately determine actual widths of watercourses or how deeply incised they are, just from the photographs or the existing contours, and, therefore in most instances solar panels have been kept away from ecological areas with high or moderate classification risks.

The Ecological Report has highlighted that there is a Low to Moderate risk that a large part of the northern farm could be classified as wetlands (which have particular requirements for protection under the NPS Freshwater). For the layout of the Solar Farm these areas have been included as part of the panel yield. There would be a significant loss or yield (in the order of 54,400 Panels), if those parts of the farm could not be used.

5 Geotechnical Assessment

5.1 Published Geology

The relevant published 1:250,000 geological map (Townsend et al., 2008), indicates the site is underlain by two geological units, The Opua Formation and the Warea Formation, the distribution of which are shown in Figure 5. Opua Formation is described as lahar deposit comprising andesite blocks and boulders in a clay-rich matrix, forming prominent hummocky surface. The Warea Formation is described as poorly consolidated andesitic conglomerate with sand derived from pyroclastic flows.

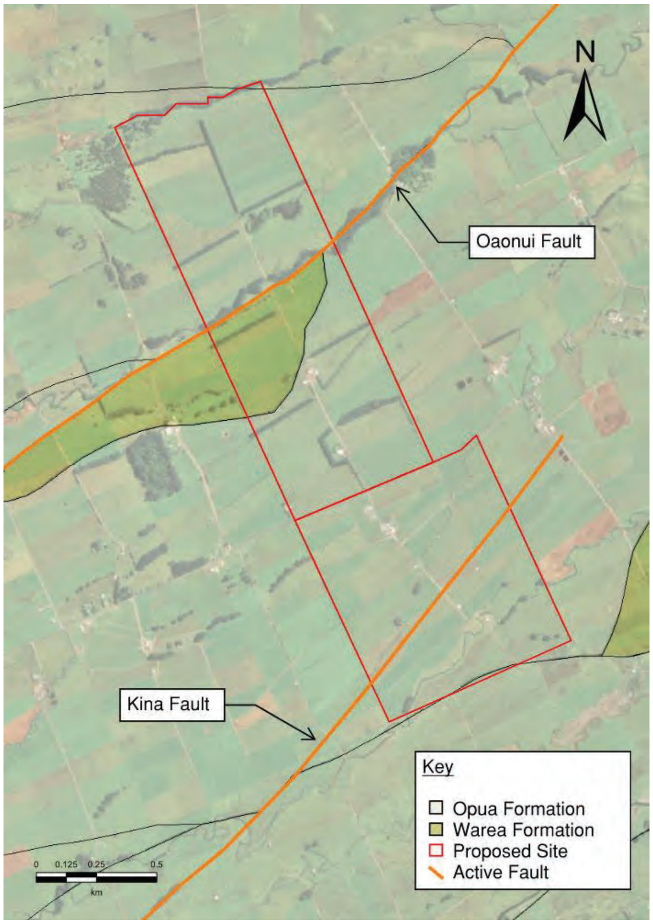


Figure 5 – Proposed site and geological units

5.2 Nearby/Historic Investigations

A review of nearby historic investigations from the New Zealand Geotechnical Database and the Beca internal database show that no investigations have been undertaken in the immediate vicinity of the site. The nearest investigation – 6.6km west of the site, described Opua Formation as sand with variable clay and boulder content. Hand augers undertaken 7.6km northwest of the site indicate Opua formation to consist of stiff silts and sandy silts with variable gravel content. The depth to groundwater recorded in these investigations varied between 1 and >4.1mbgl possibly indicating the presence of perched water tables.

5.3 Site Photographs

During a recent ecological site walkover (Beca 2022) photographs taken along and adjacent to watercourse channels show near surface soils contain gravel and cobbles (50-200mm), with some boulders (>200mm). This is consistent with the described geological units for the area. Watercourse channels were observed as having steep sides with signs of bank undermining and failure. The image below provides an example of a watercourse containing cobbles and boulders, bound by steep banks where a small scale failure has undermined a fence post.

Figure 6 – Site image showing cobbles in riverbed and failing steep banks.

5.4 Geotechnical Constraints

A qualitative assessment of the geotechnical issues which may affect development of the site is provided in Table 1.

Table 1: Qualitative assessment of geotechnical risks

Geotechnical Constraints	Assessment	Risk Rating
Seismic - Fault rupture.	The GNS active faults database shows that the Kina and Oaonui fault, run through the site. These faults are estimated to have a return period of <5000 and <10,000 years respectively. As such the risk of fault rupture occurring on the site is considered to be high. The Ministry of Environment generally recommends a setback for development of 20m from active faults. A site walkover could help determine their location and allow for setbacks to help minimise displacement.	High

Geotechnical Constraints	Assessment	Risk Rating
Seismic - Liquefaction	The Taranaki Regional Council state that there is no potential for liquefaction (Dellow, 2013) at the site. The lahar deposits are not considered liquefiable because of their emplacement by high-energy processes and they also contain a range of grain sizes.	Low
Seismic - Ground Shaking	The National Seismic Hazard Model (2012) estimates 0.2-0.3G of Peak Ground Acceleration for a 1 in 500-year earthquake event.	Medium
Volcanic	The site is located <20km from Mt Taranaki. Mt Taranaki is a large active volcano which began erupting about 130,000 years ago, with large eruptions occurring on average every 500 years and smaller eruptions about 90 years apart. The site is located on volcanogenic materials derived from Mt Taranaki and would therefore likely be vulnerable to future large eruption events. Dellow et al., (2016) estimate around 5-10mm of ashfall could be expected in a 1 in 500-year event, with up to 500mm of ashfall in a 1 in 2500 year event.	Medium
Debris flow	The site geology is a result of a historic debris flow. Mt Taranaki has had at least three large landslides or lahars in its history. It is feasible more could occur, triggered by heavy rain or volcanic activity, which could completely inundate the site with debris.	Medium
Tsunami/Coastal Erosion	With the site approximately 8 km away from the coast at 130m elevation there is no risk of a tsunami and coastal erosion at the site.	N/A
Rockfall/Slope instability	The relatively flat topography of the site means slope stability hazard is low. Small scale failures may still occur in steeper slopes present on stream banks. Development in proximity to gullies should utilise a setback to manage the risk of slope stability issues.	Low
Foundation Risks	The unconsolidated nature of the underlying materials at the site means settlement may occur when loaded. Infilled gullies identified in historical imagery could contain areas of softer or unsuitable material where settlement could occur when load is applied. The presence of cobbles, boulders, and dense gravel material within the soils may also prove difficult for driven or bored pile foundations. A geotechnical investigation will need to be undertaken to inform foundation design.	Medium to High

5.4.1 Foundation Considerations

The presence of cobbles and boulders in near surface soils are likely to cause some difficulty in installing the solar panel supports – we understand these are usually driven or bored steel poles.

The number of piles required for the panel supports could be in the order of 12,500, assuming a six metre spacing. As such, the most effective way of installing that quantity of piles needs to be found. We recommend EFL first discuss with the current property owner any history of difficulties in the installation of fence posts. Panel supports are likely to be installed deeper than fence posts so a field trial would also be beneficial.

If driven or bored piling proves difficult, possible options to be explored include:

- Adjusting of pile spacing if driven piles cannot attain desired depth due to unseen obstructions.
- Provide larger steel piles than normal to allow for high driving forces to be used.
- Precast pad footings in excavated and backfilled foundations.
- Poured footings with posts bolted to footings.

5.4.2 Summary

- The site is underlain by lahar debris flow deposits from the nearby active volcano (Mt Taranaki) and is mapped as having the active Oaonui and Kina Faults running through it. The location of the faults could be better identified in a site walkover.
- Seismic related hazards, and settlement are considered the prominent geotechnical risks to development on the site. A walkover to identify the location of active faults is recommended and key components of the development on the site should be set back from active faults.
- The presence of cobbles and boulders in the underlying soils on the site poses a risk for installation of the solar panel supports by driven or bored piles.
- EFL should contact the current landowner to enquire on any previous difficulties with the installation of fence posts on the property.
- Site specific geotechnical investigations will be required for design to confirm underlying material characteristics, inform risk to foundation design and quantify other geotechnical risks such as settlement.

6 Stormwater Assessment

The stormwater assessment has considered the following:

- Flood hazard areas within or nearby the site to inform the solar farm layout.
- The influence of the solar farm on stormwater runoff and potential effects arising from changes in runoff.

6.1 Flood Hazard

The Site is located about halfway between Egmont National Park and the coast with watercourses passing down from east to west draining from Mount Taranaki to the sea as shown on Figure 7. There are no mapped flood hazard areas within or downstream of the Site. The landuse downstream is generally rural.

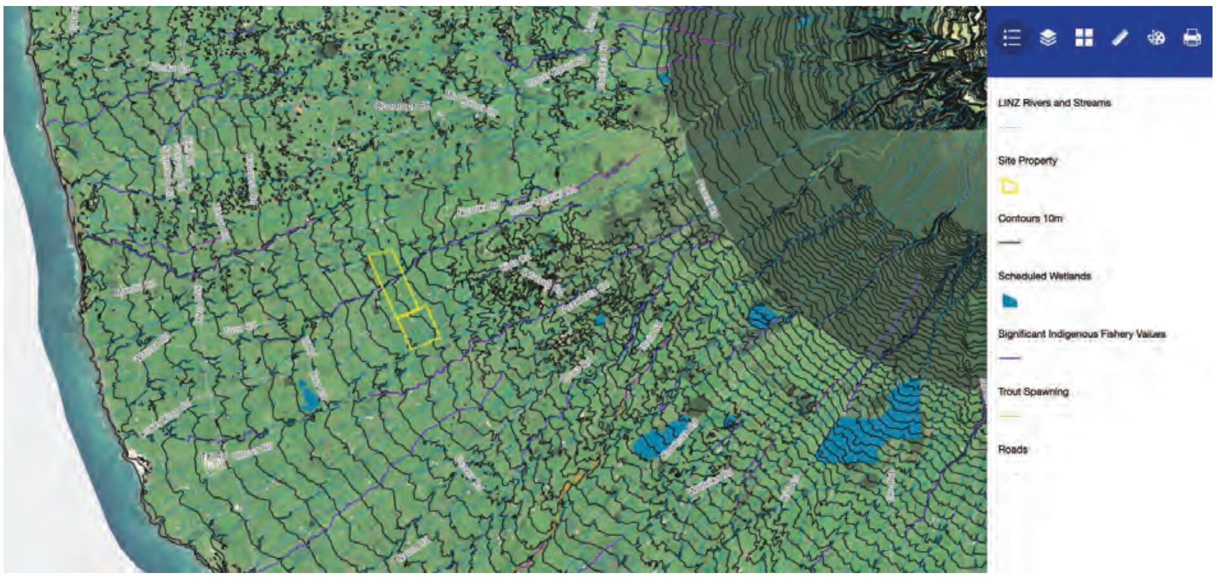


Figure 7 – Watercourses (source: NIWA)

6.2 Stormwater Runoff

The impact of development on stormwater runoff is significantly influenced by change in ground cover. That is, the amount of impervious surface and the type of vegetation of pervious surfaces. Impervious surfaces, such as parking lots or roads, will have greater runoff volumes with faster rates than pervious surfaces like pastures or parks. Bare soil paddocks will have greater runoff with faster rates than dense bush areas. If a proposed development reduces the percentage of pervious area within a site or changes the type of vegetation, stormwater runoff will be impacted. The rate or extent at which runoff will be impacted depends on the type and extent of development proposed, but also the pre-existing conditions at the site.

Increases in runoff can potentially:

- Create or exacerbate downstream flood hazard.
- Increase stream bank erosion potential in receiving environments.

Solar panels can cover approximately half of the land area (that is, 50%) when panels are horizontal, similar to the impervious coverage of an urban catchment. The implications for runoff can be vastly different to an urban catchment though. As the panels are elevated above the ground, runoff tends to be diverted beneath adjacent panels where infiltration occurs. There have been some studies on the hydrological response to solar farm development (Cook and McCuen, 2013) which have investigated whether stormwater management is required to mitigate runoff rates and flow volumes. Cook and McCuen (2013) have suggested that "the addition of solar panels over a grassy field does not have much of an effect on the volume of runoff, the peak discharge, nor the time to peak". The study also found that when the land-cover type underneath the panel changed from pastures to bare earth, gravel, or concrete, the runoff increased significantly with peak discharge increasing by 100%.

For these reasons, it is concluded that there will be no significant change to stormwater discharge volumes or rates and therefore attenuation of runoff from the site is not considered to be necessary.

While runoff from the site is unlikely to be increased, there are likely to be changes with how runoff is conveyed through the site. There is potential for flow to concentrate and channelise locally as it discharges from panels or from access tracks. This can lead to local soil erosion. As the site is quite flat and as pasture will be maintained, the potential for this is quite low. Where it does occur, it could be managed through reactive revegetation or local rock protection.

If large piling equipment is required to form tracker foundations, some compaction could occur and slight increases in the rate of runoff occur.

6.3 Proposed Stormwater Management Measures

The following stormwater management measures are proposed:

- Avoid works immediately adjacent to the existing watercourses through the site.
- Drain new tracks, all-access roads, switchyard and any other formed areas by sheet flow overland into vegetated area or via planted swales to nearby watercourses.

Adopting a monitoring and adaptive management approach to:

- Maintain pasture (or other vegetation) throughout the site, including underneath the panels.
- Where scour or soil erosion is identified, place rock rip-rap or re-vegetate.
- Encourage riparian margin re-vegetation and measures to prevent stock entering watercourses (to minimise potential for stream bank erosion effects).

Attenuation of runoff is not considered necessary as long as adequate vegetative cover is maintained underneath the panels. Consideration has been given to what sort of attenuation would be recommended if vegetation were not, for some reason, maintained underneath the panels. These potential attenuation areas are shown on the proposed layout (in Appendix B). The size and location was calculated based on:

- Catchment delineation based on topographic information was collected from Land Information New Zealand (LINZ) data service and NIWA's watershed database.
- Design rainfall data from NIWA's High Intensity Rainfall Design System V4 (HIRDS).
- An SCS calculation of runoff volume based on Auckland Regional Council's guidelines for stormwater runoff modelling (TP108) using the 10-year and 100-year average recurrence interval (ARI) events.
- The assumption that pre-development conditions were 100% precent pervious pastureland and post-development conditions where 100% bare-earth (ie. no vegetation).

The potential attenuation areas have been located at low points upstream of existing or proposed culvert crossings on the eastern boundary of the Site. If monitoring over time showed that there was significant vegetation loss or that there was evidence of stormwater discharge effects from the solar farm, the upstream end of the culvert could be modified so that flow attenuates upstream in the areas indicated. The predicted ponding depths in a 100 year ARI storm are less than 1.5 metres deep so panels could still be located in these areas above flood level.

7 Solar Farm Layout

7.1 Criteria Used for Laying Out the Solar Farm

In developing the layout for this solar farm some of the main considerations have been to:

- produce layouts that minimize the effects relating to landform and the need for earthworks;
- preserve the ecology of the area;
- minimize works required in watercourses and provide setbacks from watercourses;
- mitigate any potential scour or stream degradation;
- produce a facility that is compatible to both solar energy production and sheep farming;
- produce adequate access to run both the solar farm and a sheep farming operation.

The following section sets out the key assumptions that have been made in determining the layout of the farm.

7.1.1 Panels

The solar panel layout is based on Trinasolar Vertex 500Wt, Bifacial Duel Glass, Monocry, panels (as per the data sheet in Appendix A), arranged in 2P (portrait). The dimensions of each panel are 2.187m high x 1.102m wide. A 20mm gap has been allowed for between each 2P sets of panels. To be clear, a panel has been allowed for every 1.102m + 10mm (1/2 the gap) along the tracker rail in a north-south direction. The panels face due east-west. Each panel is assumed to have a 50 Volt open circuit voltage.

7.1.2 Trackers

The tracker used is a TrinaTracker, Vanguard – 2P, single row, multi drive system. (Refer to data sheet in Appendix A). This system is designed with panels two-in portrait configuration (2P), up to 4-strings of 1500V each per row. That is, a maximum of 120 panels per tracker.

[NOTE: 1 string = 1500V = 30 panels at 50V each]

Therefore 1 string = 30 panels in 2P = 30/2 x 1.112 long = 16.68m

MINIMUM ROW LENGTH PER TRACKER = 2 string = 33.36m

Say 34m

TRACKING RANGE:

+/- 55 degrees from horizontal

TERRAIN ADAPTABILITY:

15% ground slope, or 1 in 6.7, N-S

It is assumed that where ground is steeper than 1 in 6 the terrain is too steep to utilize.

7.1.3 Distance Between Rows

A 10.0m offset between rows has been adopted. This provides a minimum gap between panels in adjacent rows of 5.6m when panels are horizontal.

*[**NOTE**: If the spacing between rows is reduced to 9.0m then the gap for access reduces to 4.6m when panels are horizontal. This is considered sufficient on flat terrain but on steeper slopes, where there is a risk of sliding sideways on wet grass, then 10m between rows (or more) would be prudent].*

7.1.4 Panel Row Length

For the purpose of this assessment, a minimum panel row length of 34m (two strings or 60 panels) has been assumed.

7.1.5 Existing Access Tracks Around the Farm

Where possible existing farm tracks have been utilized to minimize land disturbance and to make use of existing watercourse culverts and thus minimize works in watercourses.

7.1.6 All-weather Access:

A minimum road width of 4.0m is considered adequate for all-weather access around the farm as all inspections, maintenance and replacements can be carried out using farm tractors and trailers, farm bikes or utility vehicles. These roads will have a gravel surface. A width of 12m each side of the all-weather road centreline to the first rows of solar panels has been adopted to provide for table drains along each side of the road.

7.1.7 Tractor Access:

A 5m wide access strip has been provided for at the ends of the solar panel rows for manoeuvring between rows or for access to specific areas. These will remain as grassed areas. Where the length of rows exceeds between 200m to 300m, an intermediate gap of 10m, in the North-South direction has been provided for tractor access and turning.

A 10m wide tractor access has been provided along external boundaries and this strip will contain a perimeter security fence and manoeuvring around the farm.

7.1.8 Steep Ground:

It has been assumed that where the existing terrain is steeper than 1H in 6V, at right angles to the direction of travel, that this slope is the maximum slope required to safely access a tractor between rows of solar panels. Areas steeper than 1 in 6 have been excluded from the area available for installing panels, as extensive earthworks would be required to reduce these slopes.

*[**NOTE:** It is recommended that EFL test the validity of this assumption as a flatter slope would further reduce panel yield. Safe traveling across slopes depends on many factors, such as soil cover, dew on grass, wet or muddy slopes, the type of vehicle, the centre of gravity of the vehicle and its load, speed of travel and roughness of terrain to name a few].*

7.1.9 Planting to Screen the Solar Farm:

In addition to a 10m wide tractor access around the boundary perimeter of solar panel areas, an additional 7m planting strip could be provided if required to screen the solar farm from neighbours.

> [***NOTE:*** *Not all neighbours may want their views screened so this will only be done through consultation with them*].

7.2 Layout and Solar Panel Yield

The layout of the solar farm at Upper Kina Road is shown on **Figure 8.** The site area is 188.6 hectares. The farm is bisected by numerous watercourses generally running from east to west, some of which are quite deeply incised. There is a main farm access track running through the spine of both farms accessed off Upper Kina Road and running from north to south. The terrain slopes gently at approximately 3 to 4 % except adjacent to watercourses which have steeper banks. A topographic survey will be required to define the stream banks and slopes and to confirm panels are not located on ground steeper than 1 in 6. It is assumed that only the house on the northern farm will remain and all other buildings will be removed and the pond adjacent to the cow shed on the northern farm filled in.

No allowance has been made for shadows from vegetation or proposed planting for screening.

As noted above the potential wetlands at the north of the site has been utilised for the solar panels.

7.2.1 Access

Tractor access on all-weather roads has been located to enable all solar panel areas to be accessed from these roads. Grass access strips located between rows; across rows at between 200m and 300m intervals; along the perimeter boundaries; and alongside the watercourses and artificial drains for maintenance of both solar equipment and the watercourses.

7.2.2 Watercourse Crossings

Generally, the all-weather access crossings will require culverts where they do not currently exist. Because of the permanent and intermittent nature of the many watercourses on this site the number of watercourse crossings has been limited, with access to solar panel areas being from the all-weather spine road to each solar panel area/ paddock being via tractor access around its perimeter, and between rows, without crossing the watercourses between areas/paddocks.

It is noted that the topographical information available is too coarse to determine the watercourse crossing details required and detailed topographical levels will be required for detailed design. Also, existing culverts should be checked for hydraulic capacity and structural integrity if they are to be used.

7.2.3 Riparian Margins

<u>Setbacks have been provided for alongside each identified watercourse of least 10 metres either side to allow for riparian planting and provide for maintenance access.</u>

7.2.4 Site Clearance

There is little vegetation other than grass over most of the farm. A stand of exotic trees at the southern end of the farm are to be retained, and exotic hedge rows around the house lot, will be partly removed.

The eastern farmhouse on Wellington Road will be removed to make way for the solar panels.

Existing internal fencing will be removed and replaced to suit both the solar farm and sheep farming operations.

It is noted that the grass cover over the farm varies in height and in some paddocks is up to 600mm high. Also, vegetation along the waterways is also relatively high. This variation in height will make it difficult to accurately obtain LIDAR (**Li**ght **D**etection and **R**anging) topographical data using a drone. The areas of high vegetation should therefore be mown, or slashed, before undertaking any survey.

7.2.5 Solar Panel Yield

The layout for the Ōpunake solar farm provides for some **152,000 panels** +- 5%, based on the layout indicated on **Figure 8.**

Note that this yield is based on is a high-level desktop assessment based on coarse topographic information and only considers the civil constraints. It does not take into account any shading from existing or new planting and it is acknowledged that other factors beyond the civil scope may influence the final number of panels. The assumptions used to calculate yield are set out in Section 7.1.

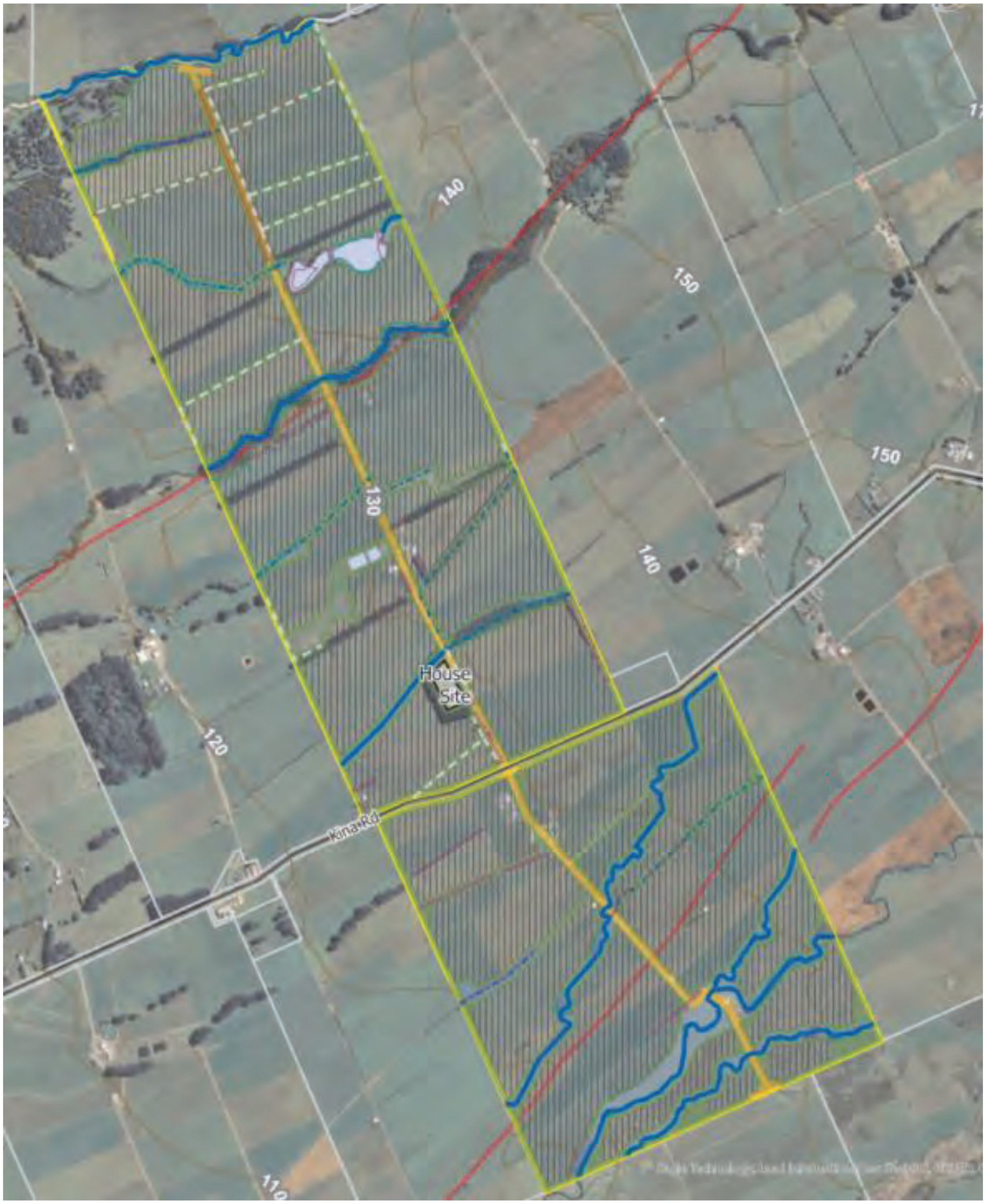


Figure 8 – Concept Layout

8 Assessment and Management of Potential Effects

8.1 Earthworks

Earthworks will be required to construct the all-weather access roads; to construct the switch yard, and to provide platforms for the inverters required to convert the solar power from DC to AC.

The central spine road is located mainly along existing gravel farm tracks that have culverts at all the watercourse crossings. Allowance has been provided to upgrade the existing farm access to provide for a minimum 4-metre-wide gravel road that will provide all-weather access for trucks and tractors to run both the solar farm and the sheep farming operations.

The switch yard will be earthworked to form a platform overlaid with gravel.

Inverters will be package units placed on concrete slabs.

The initial assessment for the extent of earthworks is given in the table below:

Table 2 – Estimated bulk earthworks quantities (excluding trenching)

Facility	Area of disturbed Ground (m^2)	Topsoil removal (m^3)	Bulk Earthworks (m^3)	Respread topsoil (m^3)
All- Weather access roads. (2.7 km)	25,000	8,000	4,000	8,000
Switch Yard	5,700	1,700	2,000	1,700
Inverters	I,000	300	300	300
Total	**31,700**	**10,000**	**6,300**	**10,000**

The topsoil will be reused to reinstate disturbed areas or in areas of the farm where topsoil can be spread and regrassed without disturbing watercourses.

Bulk excavated material will be spread in suitable locations away from watercourses and re-topsoiled and grassed.

Sediment controls will be put in place to prevent sediment laden runoff entering watercourses. These will comprise grass filter strips and silt fences; decanting earth, bunds; diversion cut-off drains to direct runoff away from earthwork areas; stabilising road areas, inverter pads and the switch yard subgrade with gravel progressively and grassing any exposed bare areas as soon as possible.

8.1.1 Trenching

In addition to bulk earthworks there will be a significant amount of trenching required for the laying of power cables connecting solar panels to the inverters and the inverters to the switch yard. Generally, cable trenches will be 300 to 500mm wide and 1.0m deep. It is proposed that these trenches will be dug by hydraulic excavator with cables being progressively installed as the excavation proceeds and the trench immediately backfilled. Only sufficient trenching will be opened up in any day that backfilling can be completed by the end of that day. In the event that it is necessary to keep parts of the trench open or rain occurs before the trench is backfilled then the contractor will be required to cover the remaining excavated material with polythene to restrict runoff.

*[**Note**: there will be some 77 km's of solar panels so cable trenching will involve significant trenching. The method of trenching suggested above could slow installation. It is not known what the District Council's view is on trenching and it is recommended that the Planner advise prior to offering such a methodology].*

8.1.2 Installation of Panel Supports

It is proposed to install the solar panels tracker support rails on driven steel piles. This operation will be carried out by tracked machine with materials being transported by tractor. This operation will be carried out on the existing grassed surface and little, if any, significant land disturbance is anticipated.

8.1.3 Works in Watercourses

Installation of culverts will be undertaken in summer conditions when there is low flow in the permanent or intermittent watercourses and ditches. Dirty water diversion bunds will be installed around the work site to divert any runoff around the area of exposed soil in rainfall events.

8.2 Stormwater

Subject to the management measures set out below, the proposed solar farm is proposed to have negligible effect on stormwater runoff and flood risk. There is opportunity for a positive stormwater effect in terms of stream health and stream bank erosion potential reduction if riparian margin restoration is included.

The following stormwater management measures are proposed:

Adopting a monitoring and adaptive management approach to:

- Maintain pasture (or other vegetation) throughout the site, including underneath the panels.
- Where scour or soil erosion is identified, place rock rip-rap or re-vegetate.
- Encourage riparian margin re-vegetation and measures to prevent stock entering watercourses (to minimise potential for stream bank erosion effects).
- If monitoring over time showed that there was significant vegetation loss or that there was evidence of stormwater discharge effects from the solar farm, the upstream end of the culvert could be modified so that flow attenuates upstream in the areas indicated. The identified potential stormwater management areas could be used to attenuate runoff. This would be achieved through modification of the culverts immediately downstream of each area.

9 Risks and Opportunities

The Table below sets outs some of the key identified risks and opportunities related to site constraints which may affect the number of solar panels that can be accommodated on the farm, consenting and construction timeframes.

Table 3 – Risks and opportunities.

RISK/ OPPORTUNITY	EFFECT	POTENTIAL MITIGATION OPTIONS	RISK CATOGORY
1. Lack of accurate topographic information to define actual extent of ecological constraints.	Could reduce, or increase panel yield.	Undertake a detailed survey by LIDAR after mowing or slashing vegetation and grass cover.	Low
2. Weather Conditions.	Wet weather likely to delay programme. In NZ average dry weather days for earthworks about 100 days in an earthworks season between 1st October and 30th April.	Realistic programme to be set taking into account the type of construction and likely weather conditions.	Moderate
3. Wetlands.	Recently introduced regulations significantly constrain works in, or in proximity to, areas that are defined as “wetlands”. Parts of the Site have moderate to high risk of falling into this definition. If they did, there would be a loss of some 54,400 panels.	Detailed wetland delineation surveys.	High
4. Significant trenching earthworks.	Delay to consenting due to earthworks requirements and delay to construction.	Requires comment from Planner. Consider suspending cable from tracker rail where practicable.	Moderate

10 References

Beca 2022, Ecological Constraints Assessment – Proposed Solar Farm at Upper Kina Road.

Beca 2022, Contamination Assessment Memorandum – Proposed Solar Farm at Upper Kina Road.

Dellow, G., Ries, W. 2013. Liquefaction Hazard in Taranaki Region. GNS Science Consultancy Report 2013/57.

Hurst, T., Smith, W. 2010. Volcanic ashfall in New Zealand – probabilistic hazard modelling for multiple sources, New Zealand Journal of Geology and Geophysics, 53:1, 1-14

Townsend, D.; Vonk, A.; Kamp, P.J.J. (compilers) 2008: Geology of the Taranaki area: scale 1:250,000. Lower Hutt: GNS Science. Institute of Geological & Nuclear Sciences 1:250,000 geological map 7. 77 p. + 1 folded map

Cook, L & McCuen, R. (2013) Hydrologic Response of Solar Farms. Journal of Hydrologic Engineering.

11 Limitations

This report has been prepared by Beca Ltd solely for Energy Farms Limited (the client). This report is prepared solely for the purpose of the assessment of a solar farm layout, based on limited Ecological Investigations, Desktop studies of potential Contamination, Geotechnical and Stormwater Management issues that the Solar Farm could experience in consenting the development and based on the scope of works outlined in the Beca proposal. The report has been prepared to support a resource consent application and may be used by the Client and others in subsequent processes to consider the application to which the assessment pertains. The contents of this report may not be used by the Client for any purpose other than in accordance with the stated Scope.

This report is confidential and is prepared solely for the Client. Beca accepts no liability to any other person for their use of or reliance on this report, and any such use or reliance will be solely at their own risk.

This report contains information obtained by inspection, sampling, testing or other means of investigation. Unless specifically stated otherwise in this report, Beca has relied on the accuracy, completeness, currency and sufficiency of all information provided to it by, or on behalf of, the Client or any third party, including the information listed above, and has not independently verified the information provided. Beca accepts no responsibility for errors or omissions in, or the currency or sufficiency of, the information provided. Note that this yield is based on is a high-level desktop assessment based on coarse topographic information and only considers the civil constraints. It does not take into account any shading from existing or new planting and it is acknowledged that other factors beyond the civil scope may influence the final number of panels.

The contents of this report are based upon our understanding and interpretation of current legislation and guidelines (“Standards”) as consulting professionals and should not be construed as legal opinions or advice. Unless special arrangements are made, this report will not be updated to take account of subsequent changes to any such Standards.

This report should be read in full, having regard to all stated assumptions, limitations and disclaimers.

A

Appendix A – Data Sheets

Mono Multi Solutions

THE Vertex

BIFACIAL DUAL GLASS MONOCRYSTALLINE MODULE

500W+
MAXIMUM POWER OUTPUT

21.0%
MAXIMUM EFFICIENCY

0/+5W
POSITIVE POWER TOLERANCE

Founded in 1997, Trina Solar is the world's leading total solution provider for solar energy. With local presence around the globe, Trina Solar is able to provide exceptional service to each customer in each market and deliver our innovative, reliable products with the backing of Trina as a strong, bankable brand. Trina Solar now distributes its PV products to over 100 countries all over the world. We are committed to building strategic, mutually beneficial collaborations with installers, developers, distributors and other partners in driving smart energy together.

Comprehensive Products and System Certificates

IEC61215/IEC61730/IEC61701/IEC62716/UL1703
ISO 9001: Quality Management System
ISO 14001: Environmental Management System
ISO14064: Greenhouse Gases Emissions Verification
ISO45001: Occupational Health and Safety Management System

Trinasolar

High customer value

- Lower LCOE (Levelized Cost Of Energy), reduced BOS (Balance of System) cost, shorter payback time
- Lowest guaranteed first year and annual degradation; 30-year warranty
- Designed for compatibility with existing mainstream system components
- Higher Return on Investment

High power up to 505W

- Large area cells based on 210mm silicon wafers and 1/3-cut cell technology
- Up to 21.0% module efficiency with high density interconnect technology
- Multi-busbar technology for better light trapping effect, lower series resistance and improved current collection

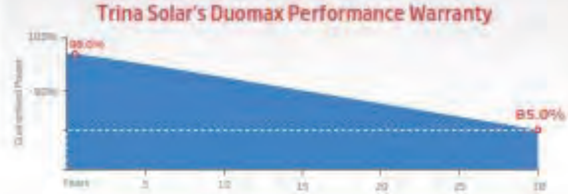
High reliability

- Minimized micro-cracks with innovative non-destructive cutting technology
- Ensured PID resistance through cell process and module material control
- Resistant to salt, ammonia and sand
- Preferred choice in harsh environments such as desert and high humidity areas

High energy yield

- Excellent light absorption throughout the day (IAM) and low light performance, validated by 3rd party certifications
- Lower temperature coefficient (-0.35%) and operating temperature
- Up to 25% additional power gain from back side depending on albedo
- Optimized power output under inter-row shading conditions

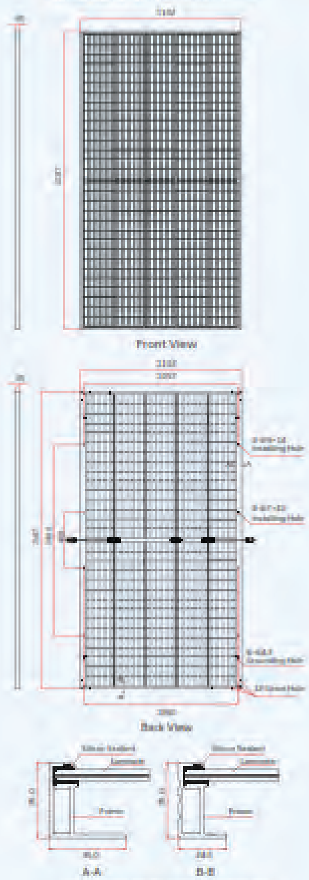
Trina Solar's Duomax Performance Warranty



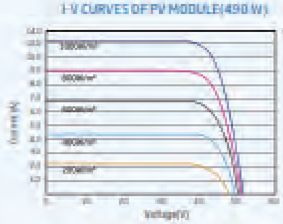
Vertex

BIFACIAL DUAL GLASS | TSM-DEG18MC.20(II)

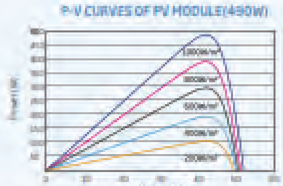
DIMENSIONS OF PV MODULE(mm)



I-V CURVES OF PV MODULE(490 W)



P-V CURVES OF PV MODULE(490W)



ELECTRICAL DATA (STC)

Peak Power Watts-P_{MAX} (Wp)*	475	480	485	490	495	500	505
Power Output Tolerance-P_{MAX} (W)				0/+5			
Maximum Power Voltage-V_{MPP} (V)	41.9	42.2	42.5	42.8	43.1	43.4	43.7
Maximum Power Current-I_{MPP} (A)	11.34	11.38	11.42	11.45	11.49	11.53	11.56
Open Circuit Voltage-V_{OC} (V)	50.5	50.7	50.9	51.1	51.3	51.5	51.7
Short Circuit Current-I_{SC} (A)	11.93	11.97	12.01	12.05	12.09	12.13	12.17
Module Efficiency η_m (%)	19.7	19.9	20.1	20.3	20.5	20.7	21.0

STC: Irradiance 1000W/m², Cell Temperature 25°C, Air Mass AM1.5.
*Measuring tolerance: ±3%.

ELECTRICAL DATA (front side at irradiance 1000 W/m², back side at 100 W/m², Cell Temperature 25°C, Air Mass AM1.5)

Total Equivalent power -P_{MAX} (Wp)	508	514	519	524	530	535	540
Maximum Power Voltage-V_{MPP} (V)	41.9	42.2	42.5	42.8	43.1	43.4	43.7
Maximum Power Current-I_{MPP} (A)	12.13	12.18	12.22	12.24	12.29	12.34	12.37
Open Circuit Voltage-V_{OC} (V)	50.5	50.7	50.9	51.1	51.3	51.5	51.7
Short Circuit Current-I_{SC} (A)	12.77	12.81	12.85	12.89	12.94	12.98	13.02
Irradiance ratio (rear/front)				10%			

ELECTRICAL DATA (NMOT)

Maximum Power-P_{MAX} (Wp)	360	363	367	371	374	378	382
Maximum Power Voltage-V_{MPP} (V)	39.5	39.8	40.0	40.2	40.5	40.8	41.0
Maximum Power Current-I_{MPP} (A)	9.09	9.13	9.18	9.21	9.25	9.28	9.33
Open Circuit Voltage-V_{OC} (V)	47.7	47.9	48.1	48.3	48.5	48.7	48.8
Short Circuit Current-I_{SC} (A)	9.61	9.64	9.67	9.70	9.73	9.77	9.80

NMOT: Irradiance at 800W/m², Ambient Temperature 20°C, Wind Speed 1m/s.

MECHANICAL DATA

Solar Cells	Monocrystalline
No. of cells	150 cells
Module Dimensions	2187×1102×35 mm
Weight	30.1 kg
Front Glass	2.0 mm High Transmission, AR Coated Heat Strengthened Glass
Encapsulant material	POE/EVA
Back Glass	2.0 mm Heat Strengthened Glass (White Grid Glass)
Frame	35mm Anodized Aluminium Alloy
J-Box	IP 68 rated
Cables	Photovoltaic Technology Cable 4.0mm² Portrait: 280/280 mm Landscape: 2000/2000 mm
Connector	TS4

TEMPERATURE RATINGS

NMOT (Nominal Module Operating Temperature)	41°C (±3K)
Temperature Coefficient of P_{MAX}	- 0.35%/K
Temperature Coefficient of V_{OC}	- 0.25%/K
Temperature Coefficient of I_{SC}	0.04%/K

MAXIMUM RATINGS

Operational Temperature	-40 to +85°C
Maximum System Voltage	1500V DC (IEC)
Max Series Fuse Rating	20A

(Do not connect Fuse in Combiner Box with two or more strings in parallel connection)

WARRANTY

12 year Product Workmanship Warranty
30 year Power Warranty
2% first year degradation
0.45% annual degradation

(Please refer to product warranty for details)

PACKAGING CONFIGURATION

Modules per box: 30 pieces
Modules per 40' container: 600 pieces

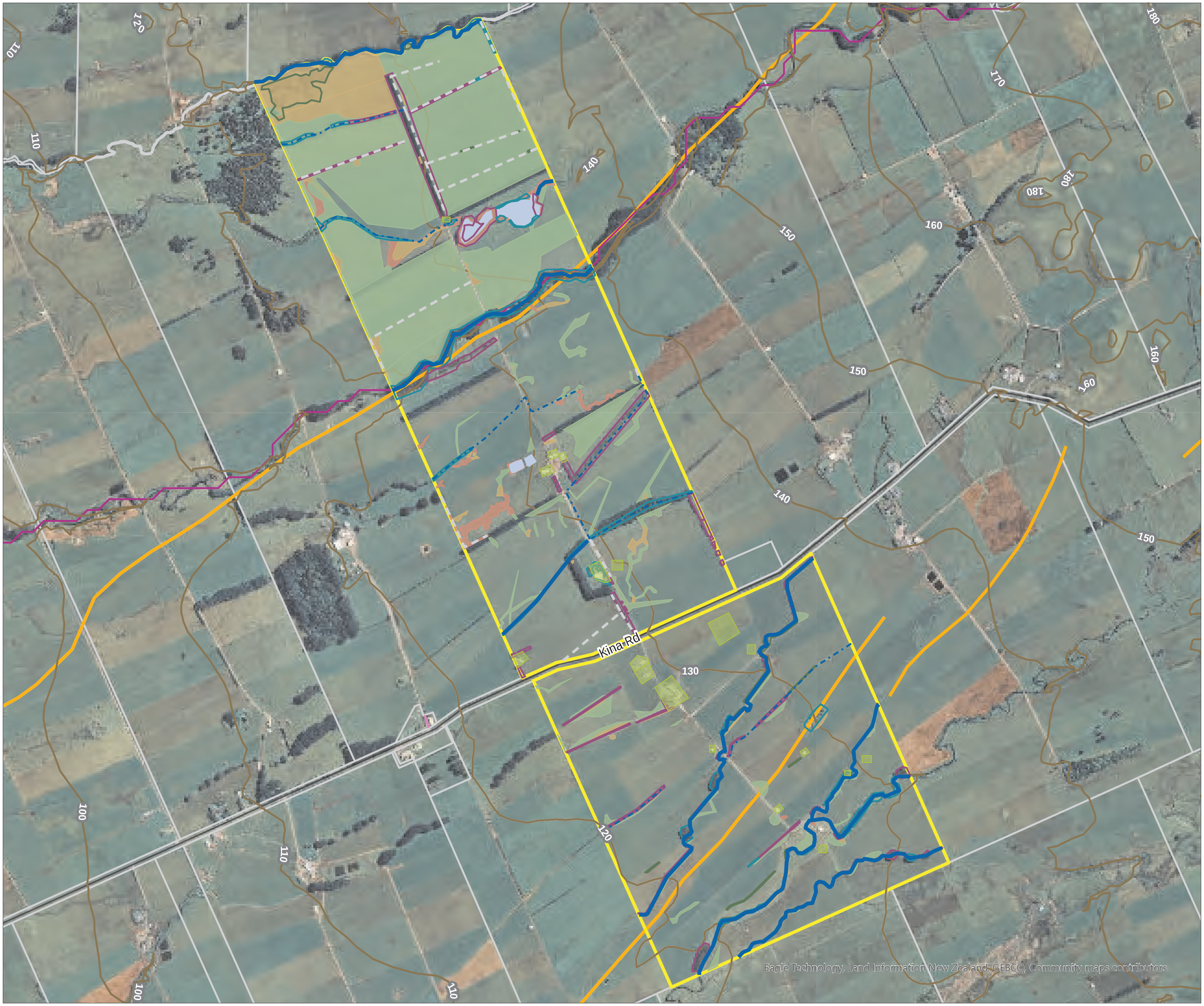
Trinasolar

CAUTION: READ SAFETY AND INSTALLATION INSTRUCTIONS BEFORE USING THE PRODUCT.

Version number: TSM_EN_2020_A
www.trinasolar.com

B

Appendix B – Constraints Map & Layout Plan



Solar Farm Site Constraints

Ōpunake

- Ponds (Ground Truthed)
- Potential Soil Contaminating Activities
- Easements
- Site Property
- Significant Indigenous Fishery Values
- Active Faults
- Contours 10m
- Public Roads
- Primary Parcels

Watercourses (Ground Truthed)
- Permanent
- Intermittent
- Artificial

Woody Vegetation (Ground Truthed)
- Exotic
- Mixed native-exotic
- Native

Potential Wetlands (Ground Truthed)
- High
- Moderate
- Low

Map Scale @ A3: 1:10,000

0 125 250 500
Metres

Revision	Author	Verified	Approved	Date
2	RG681	BMM2	JBF	28/02/2022
1	RG681	BMM2	JBF	28/02/2022

N

Client: Energy Farms Ltd

Discipline: GIS

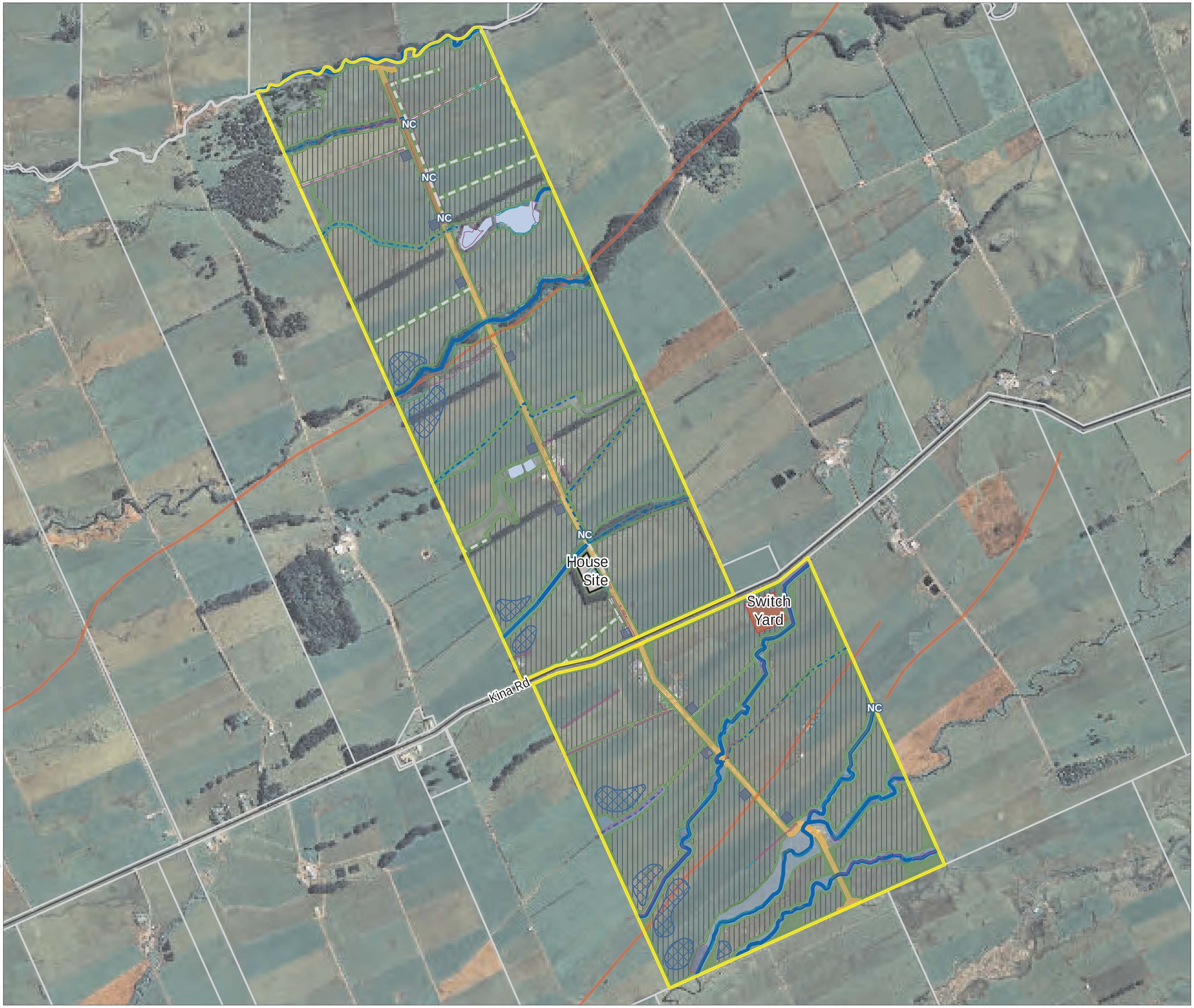
Project: Solar Farm Grid Connection

Drawing No: GIS-2867656-01

Beca

File: P:\286\2867656\1-WIP\WG-GIS\01-Map\2867656 Solar Farm Sites\2867656 Solar Farm Sites.aprx Author: RG681 Date: 28/02/2022

GIS@beca.com



Solar Farm Site Layout

Ōpunake

- Solar Panel Layout
- Inverter Locations
- Switch Yard
- House Site
- Potential Stormwater Management/Attenuation Areas
- Ponds (Ground Truthed)
- Site Property
- Contours 10m
- Active Faults
- Public Roads
- Primary Parcels

Site Access Roads

- Access Road
- Grass Access Between Rows (10m Width)
- Grass Buffer & Access

Open Watercourse & Access

- Access Path
- Open Watercourse

Crossing

- NC New Culvert

Watercourses (Ground Truthed)

- Permanent
- Intermittent
- Artificial

Woody Vegetation (Ground Truthed)

- Exotic
- Mixed native-exotic
- Native

This map contains data derived in part or wholly from sources other than Beca, and therefore, no representations or warranties are made by Beca as to the accuracy or completeness of this information.

Eagle Technology, Land Information New Zealand, GEBCO, Community maps contributors

Map intended for distribution as a PDF document.
Scale may be incorrect when printed.

Map Scale @ A3: 1:10,000

0 125 250 500
Metres

Revision	Author	Verified	Approved	Date
2	BMM2	RG681	KJO	28/02/2022
1	RG681	BMM2	JBF	25/02/2022

N

Client: Energy Farms Ltd

Discipline: GIS

Project: Solar Farm Grid Connection

Drawing No: GIS-2867656-03

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