Solar Farm Site Assessment - Marton

Civil Report – Proposed Solar Farm at 1618 Wellington Road, Marton

Prepared for Energy Farms Ltd

Prepared by Beca Limited
10 February 2023

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Contents

Appendices

Revision History

Revision Nº	Prepared By	Description	Date
1	Dale Paice, Kent Thomas; Kerry Overington	For Client Review	23/02/2022
2	Dale Paice, Kent Thomas; Kerry Overington	Updated to include the latest changes to the site layout	10/02/2023

Document Acceptance

Action	Name	Signed	Date
Prepared by	Dale Paice, Kent Thomas; Kerry Overington		10/02/2023
Reviewed by	Roger Seyb	pp.	10/02/2023
Approved by	Raymond Chang		10/02/2023
on behalf of	Beca Limited		

1 Executive Summary

Energy Farms Limited (EFL) is considering the development of 193 hectares on 1618 Wellington Road, Rangitikei District, Manawatū - Whanganui Region for solar farm generation.

Beca Limited (Beca) was 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 inform the project planner. 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 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 230,000 (+/- 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.

An assessment of the potential earthworks and stormwater effects has been carried out with measures to manage potential effects described. There is potential for adverse effects from land disturbance 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.

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.

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 193 hectares on 1618 Wellington Road, Rangitikei District, Manawatū - Whanganui Region for solar farm generation.

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 of a solar farm, from the topography, the stormwater management and the geotechnical, ecological and contamination issues expected on the site. Potential stormwater and earthworks effects have been considered.

An initial Ecological Constraints Assessment *(Beca 2022)* and a Contamination Assessment *(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.

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 Rangitikei District Council region, approximately 4 kilometres south of Marton, and about 5.5 kilometres north of Bulls, at 1618 Wellington Road, Marton (Figure 1).

Figure 1 – Site Location, 1618 Wellington Road, Marton

The current use is cattle farming, and the farm is mainly in grass. Topographic information for the site is from the NZ Topographical 1:50,000, series, with contours at 20 metre intervals. The ground slopes moderately from west to east and is dissected by 3 ephemeral and 3 intermittent streams. The highest land is at the Northeast boundary, at mRL 120, and the lowest is in the watercourse at the intersection of Kilkern and Reads Roads in the S-W corner of the property, at about mRL 97. The landform is gently rolling with moderately incised watercourses and in some cases the watercourses are only depressions in the farmland. The site is predominately grassed with a stand of pine trees at the southern end. There are two farmhouses, a milking shed and other farm buildings about mid-site along the Wellington Road frontage. A Transpower 110 kV overhead transmission line crosses the northern part of the farm from Northwest to Southeast.

Key site features are shown on Figure 2.

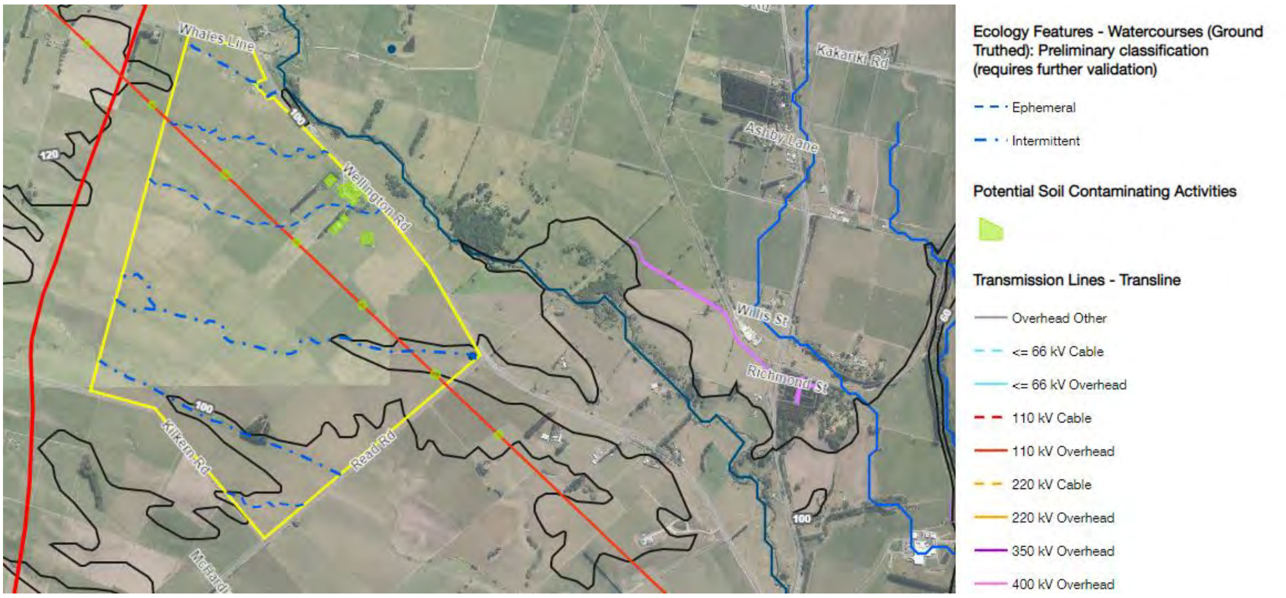


Figure 2 **– Site Features**

A review of publicly available aerial imagery obtained from Retrolens was undertaken. Retrolenimagery establishes that the site had been converted to farmland well before 1942, with the exception of one patch of exotic pine vegetation established after 1942. From these images transient overland flow paths can be identified traversing the site (still visible today). No other major changes in land use can be identified and the site has likely only been used for agricultural purposes with no significant past modification.

Figure 3 shows aerial imagery from 1942. Figures 4 **Error! Reference source not found.** to Figure 10 are photographs of key features on the site from the January 2022 site visit.

Figure 3 – 1942 Aerial Photography

Figure 4 – The Stand of Pine Trees at Southern End of Farm

Figure 5 – Watercourse 1 – Refer Figure 15 for watercoarse location

Figure 6 – Watercourse 2 – Refer Figure 15 for watercoarse location

Figure 7 – Watercourse 3 – Refer Figure 15 for watercoarse location

Figure 8 – Watercourse 4 – Refer Figure 15 for watercoarse location

Figure 9 – Watercourse 5 – Refer Figure 15 for watercoarse location

Figure 10 – Watercourse 6 – Refer Figure 15 for watercoarse location

4 Ecology, Landscape and Contamination Assessments

The findings of both the Beca Ecological Constraints Assessment and the Contamination Report for Marton 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 considered in laying out the solar farm (refer to Appendix B).

Because of the very 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. Solar panels have been kept away from ecological areas with high or moderate classification risks and have been setback from the assumed edge of watercourses. The 3 intermittent and 3 ephemeral streams that run through the property are shown in Figure 2**.** At the time of the site visit by the Beca Ecologist (January 2022) all stream channels were dry and had no waterflow. At all six watercourses, thistle (*Cirsium spp.)* is sparsely scattered along the channel banks. The channel for all watercourses, except Watercourse 4, are well defined and in some places incised; although the channel forming processes for the ephemeral watercourses (watercourses 1, 4, and 5) were unclear at the time of the site visit. All watercourses are subjected to disturbance due to stock access. No watercourse on the site had notable riparian margin or shading. The watercourses have had anthropogenic modification although the majority of the channels appear to follow the landform and contour. Watercourse 6 has had some modification and appears to also be used as a stock access track and underpass under the local road.

A landscape assessment has not been carried out. The value of trees located within the farm have not been specifically assessed in terms of the visual effect the farm will have on neighbours and the public; and the need to provide screening if desirable. It is at present assumed that the significant stand of pines at the south end of the site will remain. However, the health and amenity of these trees have not been assessed and it may prove necessary to remove or trim trees around the perimeter of this stand of exotic pines to reduce the potential for shadowing solar panels. If the stand is considered of no value, the area could be used as part of the solar farm.

5 Geotechnical Assessment

5.1 Published Geology

Published geological maps for the area (Townsend et al., 2008) indicate the site to be underlain by several soils of the Pouakai Group. Underlying most of the site is Marton alluvial terrace deposits (Q6a) comprising weathered, poorly to moderately sorted gravel with minor sand and silt. Ohakea alluvial terrace deposits (Q2a) comprising poorly to moderately sorted gravel with minor sand and silt is indicated at the northern margin of the site, and Q5b - Beach Deposits comprising shallow marine conglomerate, shell beds, dune sands and peat are mapped on the southern margin of the site. The distribution of these units is shown in Figure 11 below.

5.2 Nearby and Historical Investigations

A review of nearby historical 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 – 3.3km north of the site undertaken by Beca in 1979 comprised of 6 boreholes to depths between 3 and 10mbgl within the Q6a unit. These investigations indicate the soil profile is comprised of stiff clay and silts with a layer of dense gravel material at depth of about 4mbgl. No groundwater was encountered in these investigations.

5.3 Site Photographs

During a recent ecological site walkover, (Beca, 2022), photographs taken along and adjacent to watercourse channels indicate the near surface soils may contain gravel and cobbles (50-200mm), with some boulders (>200mm), as shown in Figure 12 below. Steeper slopes on the banks of watercourses also show some evidence of small-scale instability as presented in Figure 13 and Figure 14.

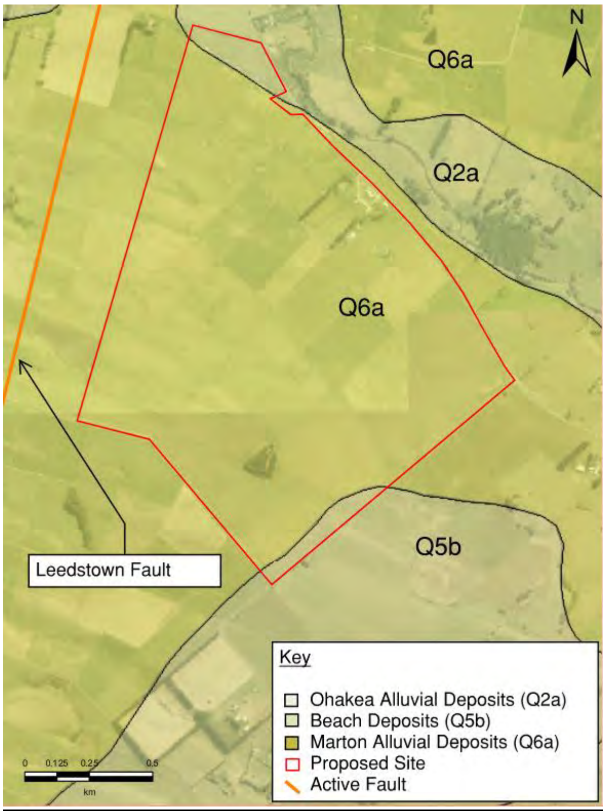


Figure 11: Geological map of site as described by Townsend et al., 2008

Figure 12: Site photograph showing the presence of cobbles in the near surface soils.

Figure 13: Example watercourse where steeper slopes can be seen.

Figure 14: Example of over steepened slopes near watercourse resulting in small scale failures.

5.4 Geotechnical Constraints

The following table provides a qualitative assessment of geotechnical constraints which may affect development on the site:

Table 1 – Geotechncial Constraints

Geotechnical Constraint	Assessment	Risk Rating
Seismic - Fault rupture	The GNS active faults database shows that the Leedstown Fault runs adjacent to the northwest boundary of site, although no scarps or similar features are visible in the site geomorphology or historic aerials to confirm its' location. The reoccurrence interval of this fault is estimated to be between 5000 and 10000 years. Because of this there is a chance the fault, or one of its splays, may rupture within the site.	Medium to High
Seismic - Liquefaction	Dellow et al. (2016) zone the site as not prone to Liquefaction.	Low
Seismic - Ground Shaking	Hazard maps produced by Dellow et al. (2016) suggest the site may be subject to 0.3-0.5G of peak ground acceleration during a 1 in 500-year earthquake event.	Medium to High
Volcanic	The site is located over 100km from Mt Ruapehu and Mt Taranaki. Dellow et al. (2016) indicate that in a 1 in 2500-year eruption (Maximum Credible Event) from Mt Taranaki, the site could expect 5-10mm of ashfall.	Low
Tsunami/Coastal Erosion	With the site approximately 20 km away from the coast at 100m elevation there is no risk of a tsunami and coastal erosion at the site.	N/A
Rockfall/Slope instability	The generally flat topography of the site means slope stability hazard is low. Small scale failures may still occur in steeper	Low

Geotechnical Constraint	Assessment	Risk Rating
	slopes present on stream banks. Development in proximity to gullies should utilise a setback to manage the risk of slope stability issues.	
Foundation Risks	The relatively young (<200,000 years), unconsolidated nature of the underlying material means that they may experience settlement when loaded. Organic/peat layers within the Q5b unit may be highly compressible and vulnerable to both primary and secondary settlement under loading. The possibility of cobbles, and dense gravel material within the soils may also prove difficult for driven or bored piles. 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 - usually driven or bored steel poles.

The number of piles required for the panel supports will be in the order of 19,500, assuming a six-metre spacing. As such, the most effective way of installing that quantity of piles needs to be found. We recommend EFL 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 Quaternary age alluvial and shallow marine deposits and is proximal to the active Leedstown Fault.
- Seismic related hazards, and settlement are considered the prominent geotechnical risks to development on the site.
- 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.
- 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

Key features within, and in the vicinity of, the site are shown on Figure 15, including watercourses and flood hazard mapping. The watercourses (three intermittent and three ephemeral) that run through the property have relatively small catchments and are not associated with significant floodplains. The 100-year ARI flow width for those streams is expected to be contained within the setbacks from watercourses (understood to be more than 5 metres either side) proposed for ecological reasons. There is a dam on watercourse 3 at the corner of Read Road and Wellington Road; the flood event ponding extents associated with that dam were provided by Horizons Regional Council.

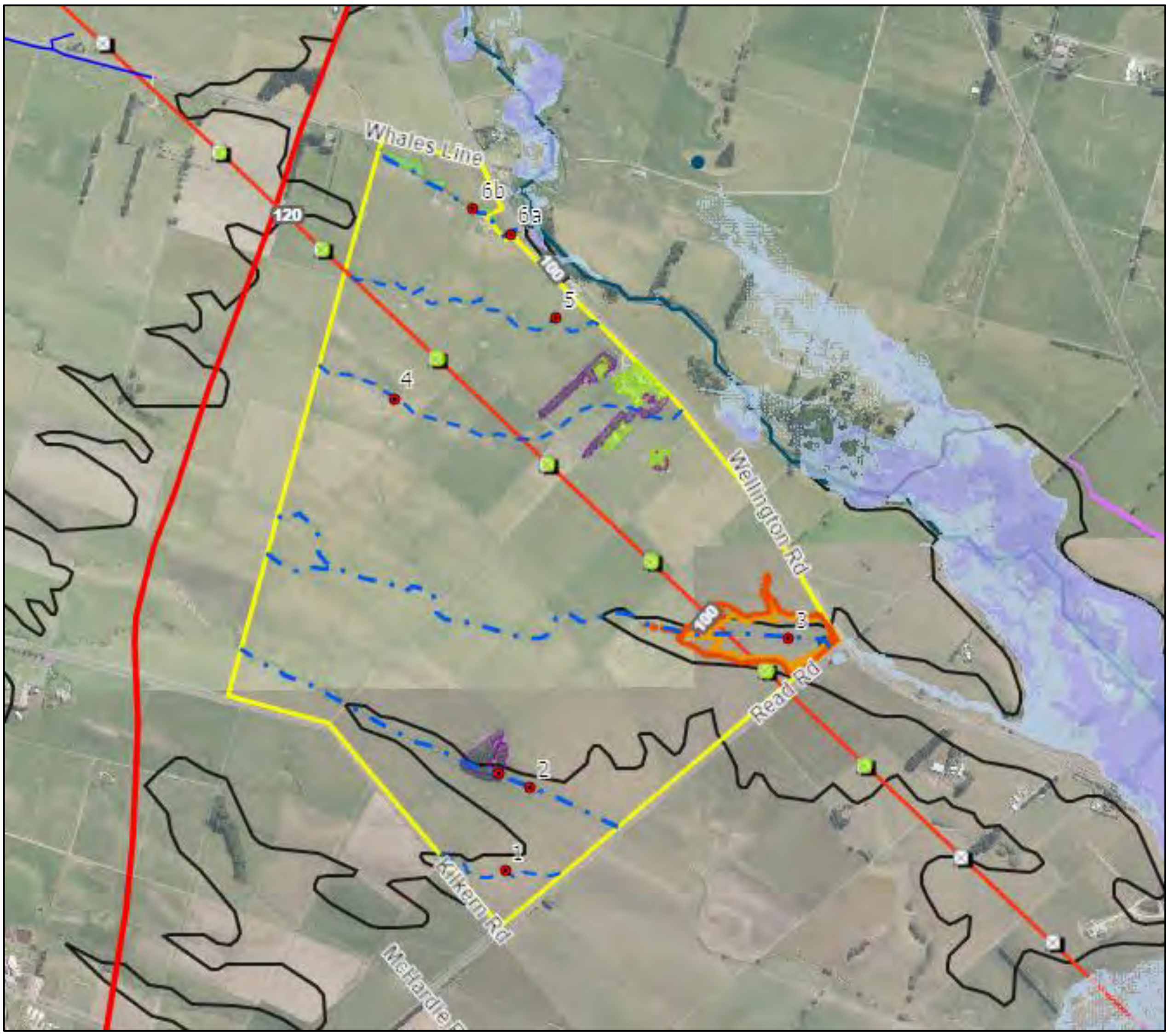


Figure 15: Watercourses and flood hazard mapping (source: Horizons Regional Council)

The site is about midway along the Tutaenui Stream approximately 1 kilometre downstream of the site. The floodplains of the Tutaenui Stream are typically farmland. That is, a landuse that is less vulnerable to flood hazard impacts from stormwater discharge. The Tutaenui Stream catchment is shown on Figure 16.

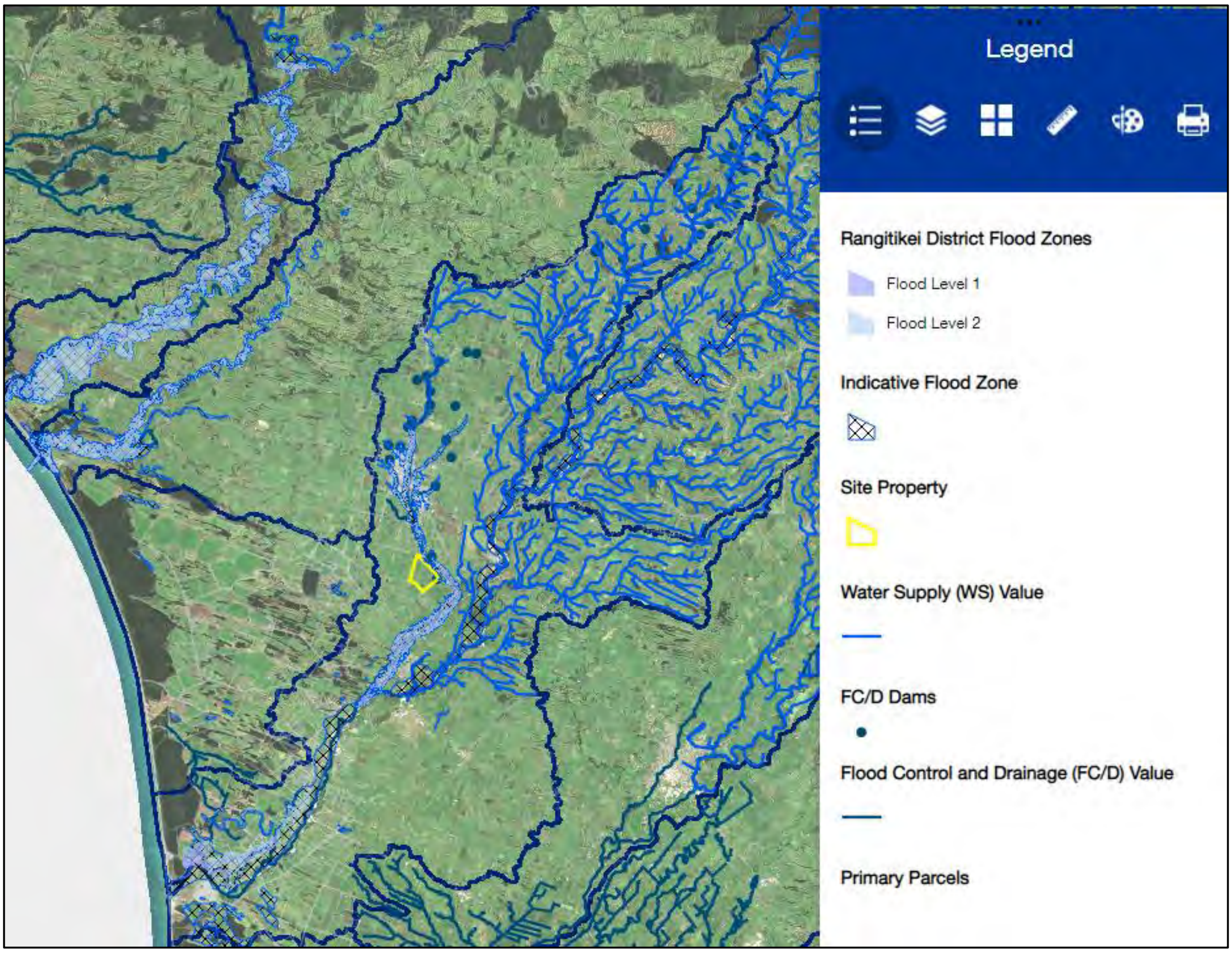


Figure 16: Tutaenui Stream catchment, floodplain, dams and overland flow paths (source: Horizons Regional Council)

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%.

The site at 1618 Wellington Road is presently low gradient pastureland. It is understood that EFL is planning to maintain pastures underneath solar panels to allow livestock grazing and therefore there will be no change in groundcover. If the land-surface cover of the site will remain the same as pre-development conditions, there should be no significant impact to stormwater runoff. New impervious areas for switch yards and less pervious gravel services roads may result in a marginal effect on stormwater runoff but the total impervious groundcover proposed for the site is understood to be less than the relevant Council limits and similar to a typical agricultural land use.

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.

6.3 Proposed Stormwater Management Measures

The following stormwater management measures are proposed:

- Avoid works within the ponding associated with the existing dam.
- 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) using the Greatford climate site (Site ID: E05144).

- 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. 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;
- 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). It has a tracking range of +/-55 degrees from the horizontal and has a terrain adaptability of 15% ground slope, or 1 in 6.7 N-S. It has been assumed that where ground is steeper than 1 in 6, the terrain is too steep to utilize.

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. So, 1 string at 1500 V is 30 panels at 50 V each. Based on the above configuration, this gives a length per string of 30 panels in 2P = 30/2 x 1.112 long = 16.68m. Then, the minimum row length per tracker, with 2 strings, is 33.36m

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 1 in 6, 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 should only be done through consultation with them*].

7.2 Layout and Solar Panel Yield

The proposed layout of the solar farm at Marton is shown on the plan in Appendix B (and on Figure 17).

The farm is crossed by several watercourses generally running from west to east. There are several farm access tracks within the area, but these are generally very narrow except around the home site and cow shed, close to Wellington Road. The site has public road frontage along all boundaries except the western boundary; being Whales Line to the north, Wellington Road to the north-east; Read Road to the south-east and Kilkern Road to the south-west. The terrain slopes gently at approximately 1 in 150 (0.67%), from Northwest to Southeast. A 110kV overhead transmission line crosses the northern part of the farm from Southeast to Northwest.

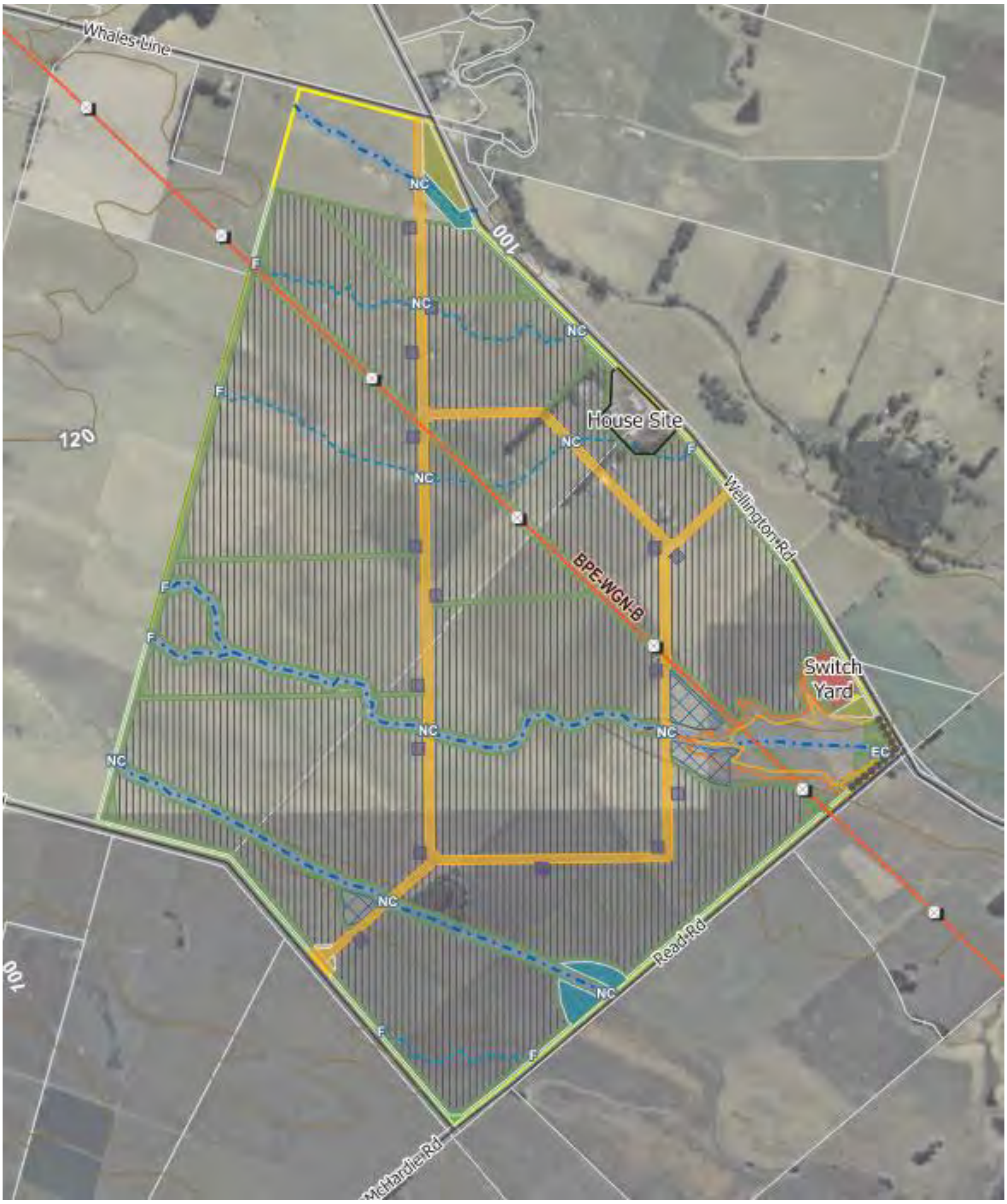


Figure 17: Proposed Solar Farm Layout

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 larger watercourses for maintenance of both solar equipment and the watercourses.

The all-weather access tracks will have gravel surfaces with a 4-meter running width. There is a total of 4km of all-weather access tracks.

7.2.2 Transpower 110 kV Overhead Transmission Line

Transpower requires a 12m wide clearance each side of their lines and structures unless permission is attained to access or build within such a corridor. It is not intended to construct solar modules within this corridor, but access roads will cross under, and the grassed corridor will be used for tractor access and farm grazing.

7.2.3 Watercourse Crossings

There are several watercourse crossings required for both the all-weather access tracks and the grassed tractor access.

Generally, the all-weather access crossings will require culverts where they do not currently exist, while the grassed access strips will use fords where the watercourse are narrow, and short culverts (10-12m long) where the watercourse Is incised.

It is noted that the topographical information available is too course to determine what type of watercourse crossing is 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.

7.2.4 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 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 Marton solar farm provides for some 230,000 panels +- 5%, based on the layout indicated in Appendix B.

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.

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 initial assessment for 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. (4km)	40,000	12,000	6,000	12,000
Switch Yard	5,700	1,700	2,000	1,700
Inverters	I,600	500	300	500
Total	**47,300**	**14,200**	**8,300**	**14,200**

The topsoil will be reused to reinstate disturbed areas or in areas of the farm where topsoil can be spread and re-grassed 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 left open 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. Alternatively, trenching may be carried out using a cable installation machine which buries and backfills the trench progressively.

The volume and area of earthworks associated with trenching has not been calculated. It is likely to exceed the estimated bulk earthworks quantities significantly.

*[**Note**: there will be some 120 km's of solar panels so cable trenching will involve significant trenching. The method of trenching suggested above could slow installation].*

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 no flow in the ephemeral or intermittent streams. 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 risks and opportunities to the number of solar panels that can be accommodated on the farm and the potential risks involved in the construction of the farm.

Table 3 – Risks and opportunities.

RISK/ OPPORTUNITY	EFFECT	POTENTIAL MITICATION 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. Ground conditions and the effect cobbles or boulders could have on installation of piles for the tracker supports.	Difficulty in installation with time and cost factors involved in construction.	Check with current owner if any difficulties previously experienced with fencing. Undertake investigative investigation to determine soil characteristics. Undertake trial installation.	Moderate to High
3. 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. [Note. With 120,000 m of panels to install in say 200 days would require 600m of panels per day}.	Realistic programme to be set taking into account the type of construction and likely weather conditions.	Moderate
4. Remove stand of Pine Trees.	Increase of Panel yield.	Requires comments from Landscape Consultant and Planning Consultant.	Moderate (About 1200 panels)
5. Utilisation of land under transmission line for panels.	Increase in Panel yield.	Requires liaison with Transpower.	Moderate (About 3,000 Panels)
6. Utilise the land within the dam flooding area. (Future)	Future increase in Panel yield if attenuation not required.	Depth of water to be assessed and tolerance for water around panels.	Moderate (Gain of some 6,000 panels)
7. 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 1618 Wellington Road Marton.

Beca 2022, Contamination Assessment Memorandum – Proposed Solar Farm at 1618 Wellington Road Marton.

Dellow, S., Abbott, E. R., Heron, D. W., Scott, B. J., Ries, W. F., Lukovic, B. (2016) Update of Hazard information for 2015 Lifeline Risk and Responsibilities Report. GNS Science Consultancy Report 2016/40.

Townsend, D., Vonk, A., & Kamp, P. (2008). Geology of the Taranaki area: scale 1:250,000. Lower Hutt: Institute of Geological & Nuclear Sciences Ltd.

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

Sensitivity: General

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

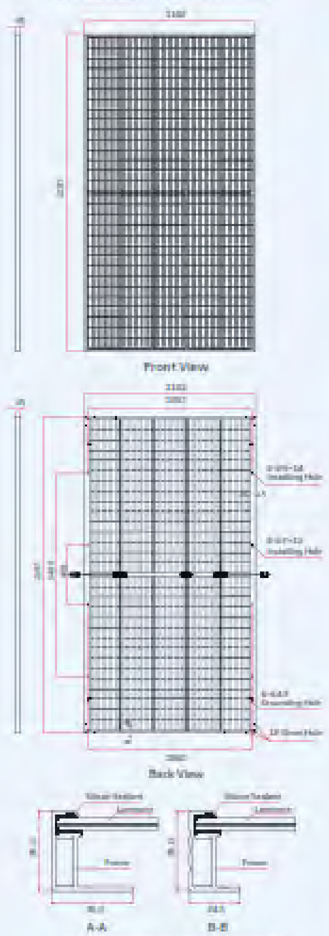
High energy yield

- 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

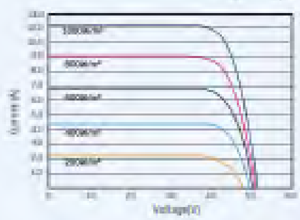
Vertex

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

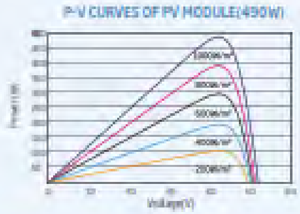
DIMENSIONS OF PV MODULE(mm)



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

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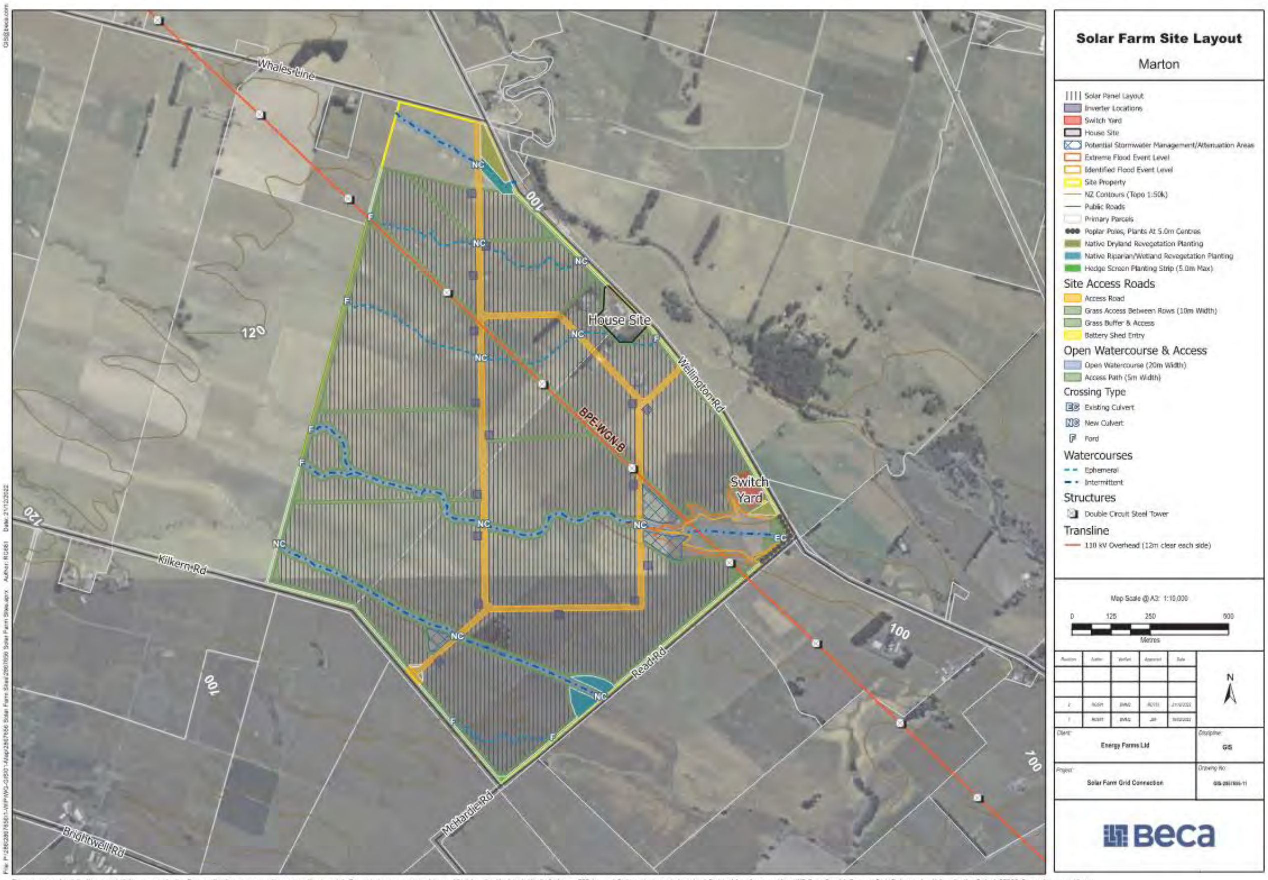
B

Appendix B – Constraints Map & Layout Plan


Solar Farm Site Layout
Marton
Solar Panel Layout
Inverter Locations
Switch Yard
House Site
Potential Stormwater Management/Attenuation Areas
Extreme Flood Event Level
Identified Flood Event Level
Site Property
NZ Contours (Topo 1:50k)
Public Roads
Primary Parcels
Poplar Poles, Plants At 5.0m Centres
Native Dryland Revegetation Planting
Native Riparian/Wetland Revegetation Planting
Hedge Screen Planting Strip (5.0m Max)
Site Access Roads
Access Road
Grass Access Between Rows (10m Width)
Grass Buffer & Access
Battery Shed Entry
Open Watercourse & Access
Open Watercourse (20m Width)
Access Path (5m Width)
Crossing Type
EC Existing Culvert
NC New Culvert
F Ford
Watercourses
Ephemeral
Intermittent
Structures
Double Circuit Steel Tower
Transline
110 kV Overhead (12m clear each side)
Map Scale @ A3: 1:10,000
0
125
250
500
Metres
N
Client: Energy Farms Ltd
Discipline: GIS
Project: Solar Farm Grid Connection
Drawing No:
Whales Line
Kilkern Rd
Wellington Rd
Reid Rd
Mcdonalds Rd
Brightwell Rd
House Site
Switch Yard
BPE-WGN-B
120
100