Taranaki Solar Farm

Taranaki Solar Farm Switch Yard and 110kV Transmission Line Report

Energy Farms LTD

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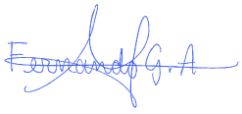
Author signature		Approver signature	
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1 Introduction

1.1 Background

This report documents the concept design of the Taranaki Solar Farm switchyard and options for the 110 kV transmission line corridor for connection the line to the existing Transpower's Opunake transmission substation.

The solar generation station (solar farm) project is anticipated to export approximately 80 MWdc of electricity generated from absorbing energy from the Sun and export to the National Grid. A grid connection of approximately 185 MVA capacity is assumed.

1.2 References, Design Standards and technical Requirements

The following documents have been used as inputs to this design and study.

- AS 2067 Substation and High Voltage Installations Exceeding 1 kV A.C.
- Solar Farm Grid Connection – Preliminary Investigation document
- Solar Farm Site Assessment – Opunake documents
- Transpower Substation Design Standard drawings
- Transpower Regional Single Diagram drawings
- Aerial GIS data maps of Taranaki rural

1.3 Key Assumptions

For the purposes of this report, the following key assumptions are made:

- Energy Farms are connecting to the National Grid at the existing Opunake 110/33 kV Grid Exit Point (GXP) substation.
- The point of connection is assumed to be the line landing gantry at the substation. This point of connection is also assumed to be the ownership boundary.
- Energy Farms are independently designing, consenting, building, owning and operating all HV equipment from the point of connection to the Solar Farm Substation (inclusive).
- Development options may exist for construction of this line but are not part of the scope of this report
- Transpower will need to be engaged to progress the design and construction works with in the Opunake GXP.
- This report focuses on possible options for the grid connection and describes the technical aspects of constructing the grid connection infrastructure for each.

2 Taranaki Solar Farm Switchyard

2.1 General

Taranaki Solar Farm has secured land located within Zone 6 of the Transpower owned National Grid for their solar farm development. The initial concept design of the solar farm provided indicates that the station High Voltage (HV) substation is located approximately 6 km to the North of the Transpower's existing Opunake transmission substation. This transmission substation is connected to the 110 kV transmission network, which it is interconnected to the Stratford Thermal Power Station at Stratford, the power station is connected to the 220 kV and 110 kV transmission networks. The solar farm HV substation is intended to be connected to the Opunake substation via a new 110 kV transmission line.

Figure 1 below indicates the relative location of the solar farm substation within the transmission network Zone 6.

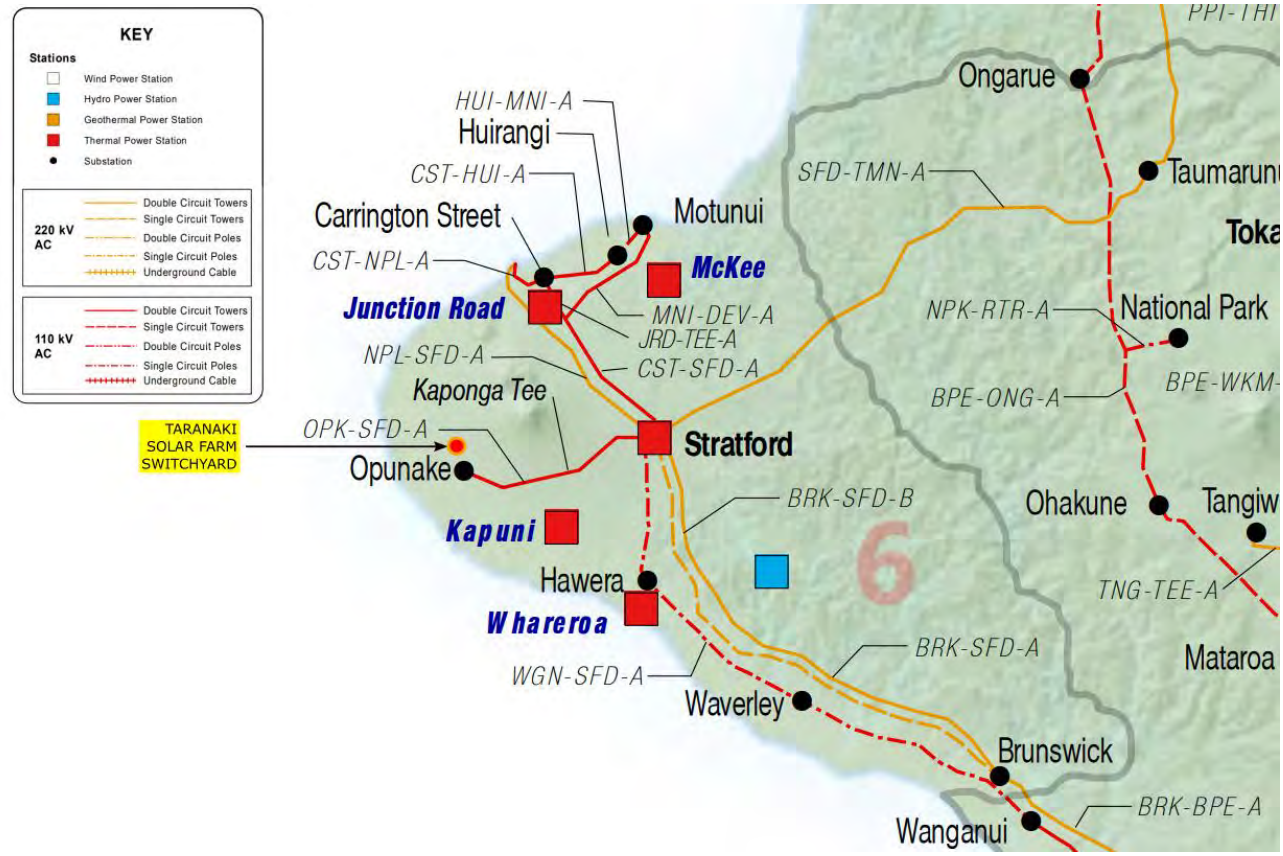

Figure 1: Taranaki Solar Farm Substation Location

Important factors considered for the solar farm HV substation land location included the following:

- Close for connection to the National Grid
- Facilitate access to the existing transmission corridors
- Facilitate access to the existing distribution corridors
- Accessibility to public roads for smooth construction, equipment transportation and equipment installation
- Facilitate access to the existing communication network and other services
- Possible future extension of the Solar Farm in the future
- Safety of the personnel involved both construction phase, operational safety, animals, and the public as per safety rules and regulations framed by the standards and local authorities.

2.2 Solar Farm Substation System Concept Design

2.2.1 General

The concept design of the substation electrical equipment layout (switchyard) is based on the conditions prevailing locally of the land for the Taranaki Solar Farm, Transpower's substation design drawings and the ability to maintain continuity of connection to the National Grid. The switchyard should be as simple in arrangement as practicable to secure the desired flexibility in operation and to provide the proper facilities for inspection of the apparatus.

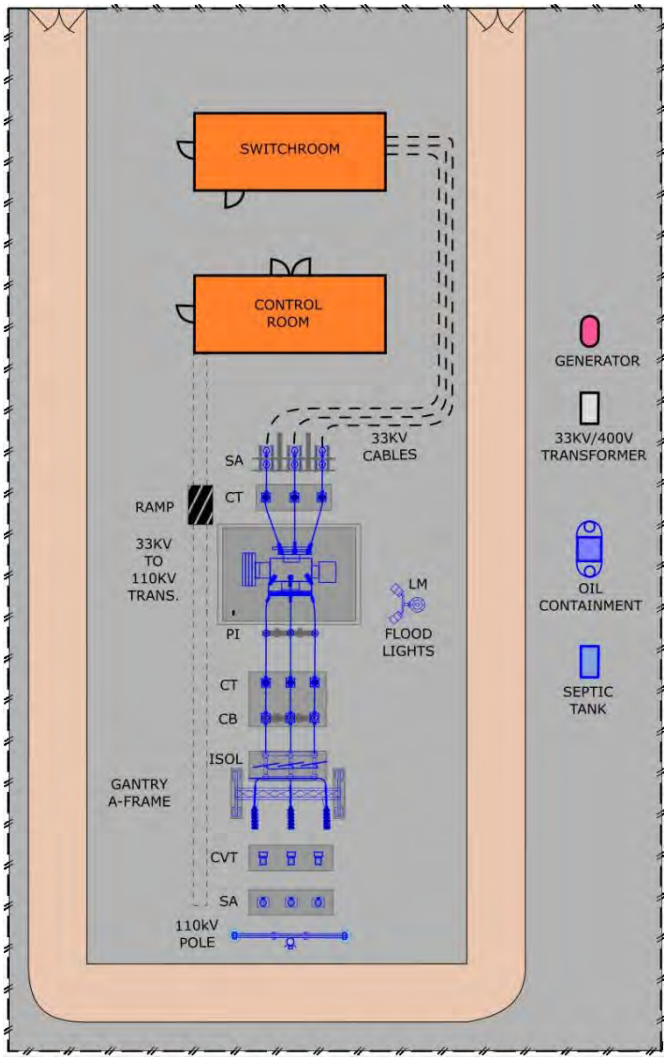

Figure 2: Switchyard Equipment Layout

A single HV circuit scheme is selected for the switching equipment physical arrangement. This scheme emphasis put on reliability, economic, safety, simplicity function and importance of the switchyard.

Substation equipment:

- 33/110 kV Power Transformer, rated for 120% of the full ac output of the solar farm
- Surge Arresters (SA), to protect from overvoltage transients
- Current Transformers (CT), to measure currents and detect fault currents to activate the protection relay
- Circuit Breaker (CB), to provides protection against fault currents and to provide load break facilities to the circuit
- Isolator (ISOL) switch or disconnector, to isolate and electrically disconnect the substation equipment from the 110 kV transmission line

- Capacitor Voltage Transformer (CVT), to provide low voltage signal for measurement and operate protective relay
- Post Insulator (PI), to support conductors, droppers and bus-work as required
- Cable Terminal (C/T), to connect the incoming 33 kV underground cables to the main power transformer
- Lightning Mast (LM), to provide protection against lightning
- Control and relay room – this houses the protection equipment for the outdoor switchgear and provides amenities for personnel.
- 33 kV Switch-room – this is the AC collector switchgear for the solar farm
- 33 kV/415 V local service supply transformer
- Back up local service supply diesel generator
- Flood lighting pole

2.2.2 Earthing System

An earthing system is required for the safety and functional operation of the electrical equipment and the switchyard which will include the following:

- In ground earth grid
- Switchyard surface treatments to meet minimum requirements (e.g. crushed rock)
- Lightning protection system

The final switchyard land location will be determined by transmission line corridor (route) resource consent for the new 110 kV transmission line infrastructure.

Protection Systems.

Protection system required for HV equipment (e.g. power transformer, cables). The protection system will be developed in the detail design (Solar Farms' detailed assessment step process) of the switchyard.

2.2.3 Infrastructure design

Substation civil and infrastructure parts to be completed in the detail design (Solar Farms' detailed assessment step process), but not limited to the items below.

- Design requirement of the steel structures (e.g. gantries)
- Design requirement of equipment structures
- Design requirement of lighting
- Design requirement of demountable buildings (control room and switch-room)
- Design requirement conduit runs and cable trenches
- Design requirement of access road for maintenance
- Design requirement security fencing and access gates

2.3 Proximity to Grid Connection

The Taranaki solar generation station (solar farm) substation proposed site location is located at 574 Upper Kina Road which is approximately 5.12 km straight line distance from Opunake transmission substation located at 909 Ihaia Road as indicated below in Figure 3 .

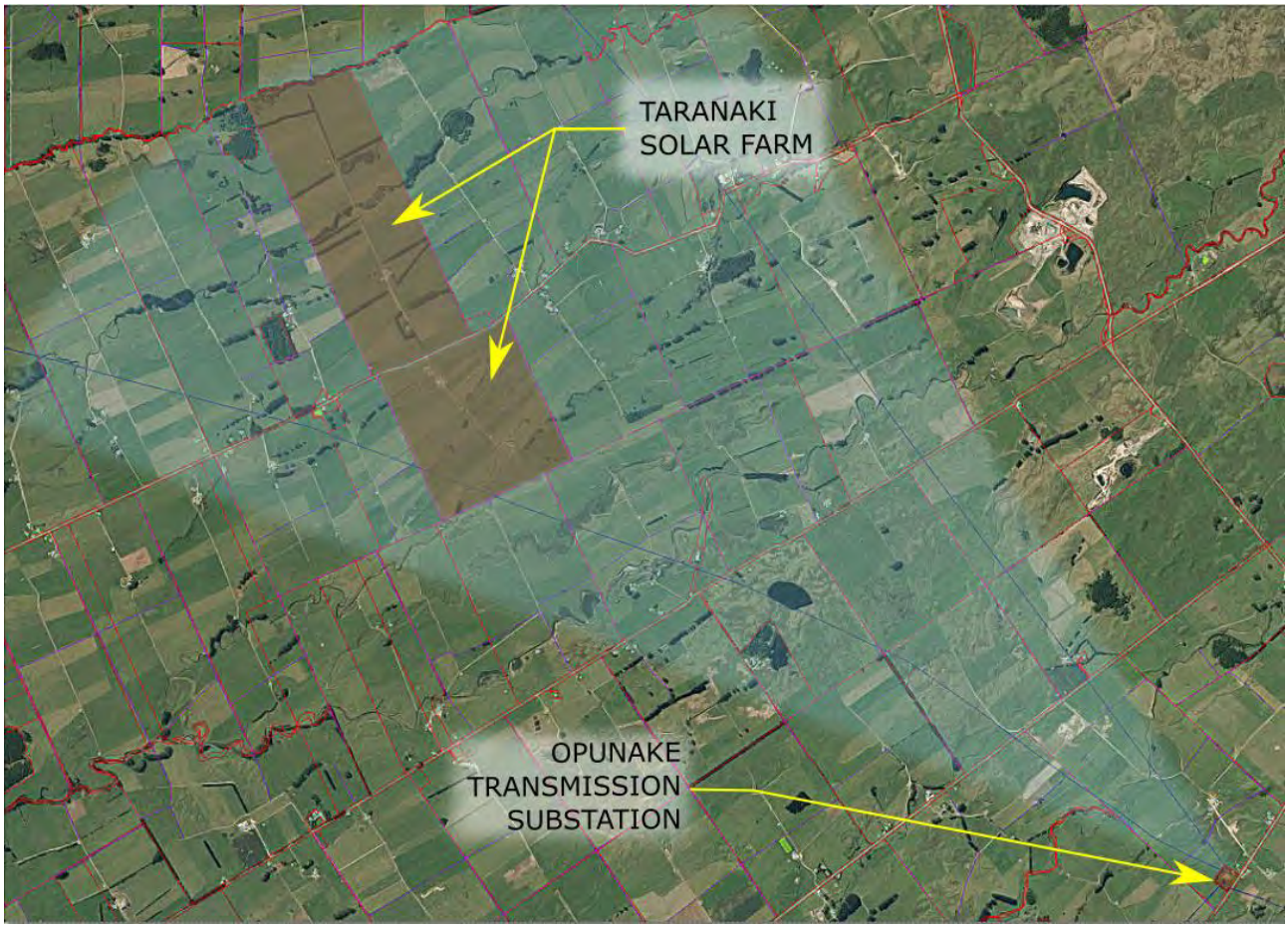

Figure 3: Taranaki Solar Farm site and Opunake Substation in South Taranaki District

This secured land lot will facilitate the construction of the Opunake Solar farm switchyard and a new 110 kV transmission line infrastructure and connect to Opunake transmission substation

2.4 Proposed Solar Farm Switchyard Site Selection

Figure 4: Land Area for the Switchyard Assets Installation

A desktop study of the available GIS maps indicates the proposed switchyard site selection does have several positive aspects that related to development of a substation (switchyard):

- Close to existing main roads
- Good vehicle access for engineers and contractor access for 24 hours a day, 7 days per week the substation
- Good access to existing transmission line buffer corridors
- Safe clearances around the substation
- Good for new transmission line route to connect the National Grid
- Good area of land for building the substation

3 Analysis of Existing Transmission and Distribution Lines Corridors

3.1 General

Planning for the construction of the new 110 kV transmission line infrastructure, a feasibility study has been conducted into the Opunake lands of interest, public roads and, directions of existing transmission and distribution lines buffer corridors between the Taranaki Solar Farm switchyard and Opunake transmission substation.

This study helps identify the options available for a new 110 kV transmission line which will connect the switchyard and substation.

3.2 Existing Transmission and Distribution Assets in the Area

In the zone of land between Opunake Solar farm and Opunake GXP substation there are a number of existing 33 kV transmission and 11 kV distributions lines; also, a 110 kV transmission line which is connected to Stratford power station as shown below Figure 5.

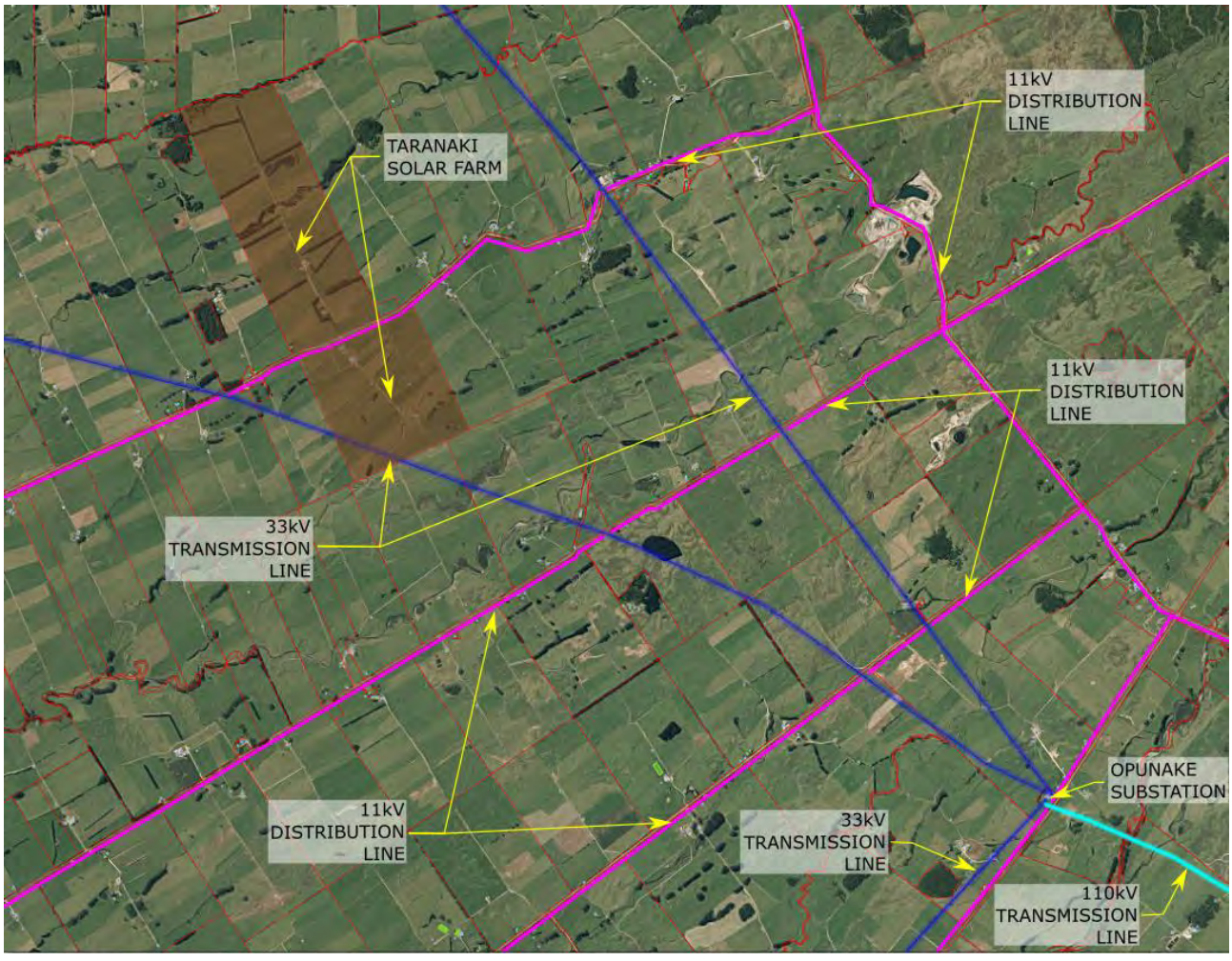

Figure 5: Exiting Transmission and Distribution Buffer Corridors

These existing transmission and distribution infrastructures are installed in transmission and distribution buffer corridors which are in the operative district plan of the South Taranaki District Council. And the National Policy Statement on Electricity Transmission 2008 recognises for operating and maintaining the National Grid as a matter national significance and all councils now need to include buffer corridors in their district plans. These existing distribution and transmission corridors could potentially be used for the new 110 kV transmission line and facilitate the consent application for the transmission infrastructure construction.

3.3 Transmission Buffer Corridor

South Taranaki District Council services plans include transmission buffer corridors to prevent or manage those activities that are incompatible with the national electricity transmission network.

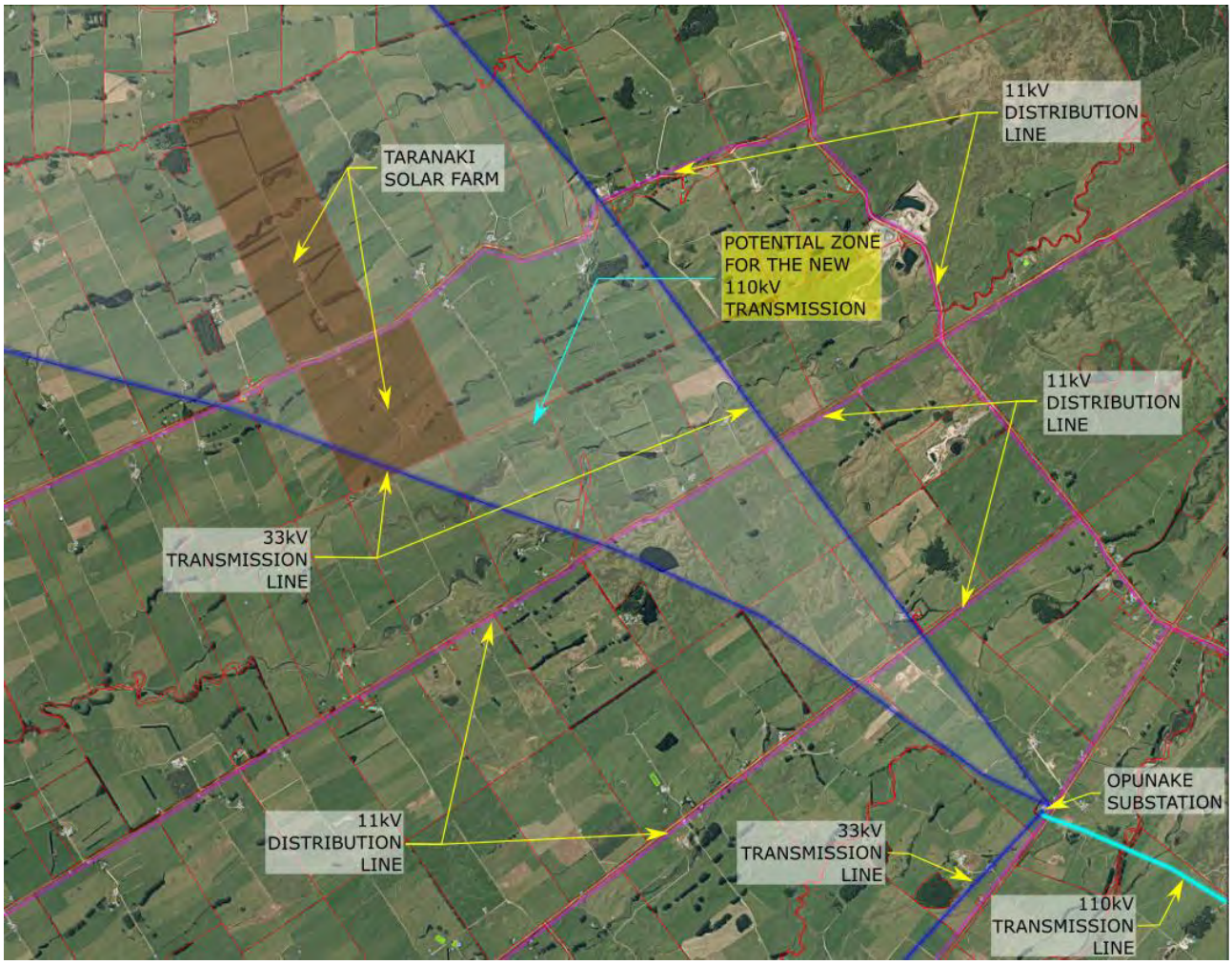

Figure 6: Potential Transmission Corridor Zone for the new 110 kV Transmission Line

Taranaki rural aerial GIS data maps reveal the existing transmission lines buffer corridors (blue lines) and a potential land zone between these line corridors for the new 110 kV transmission line.

These buffer corridors are 33 kV transmission line infrastructures from Opunake substation to Powerco's Rahotu and Pungarehu distribution substations.

It is not clear who these corridors are administered or owned by, but negotiation with either or both Transpower and/or PowerCo is advised if this is intended to be used for the new 110 kV connection.

3.4 Existing Distribution Buffer Corridors

The South Taranaki District Council services plans includes distribution buffer corridors to supply power to homes, business, communities and for farming activity.

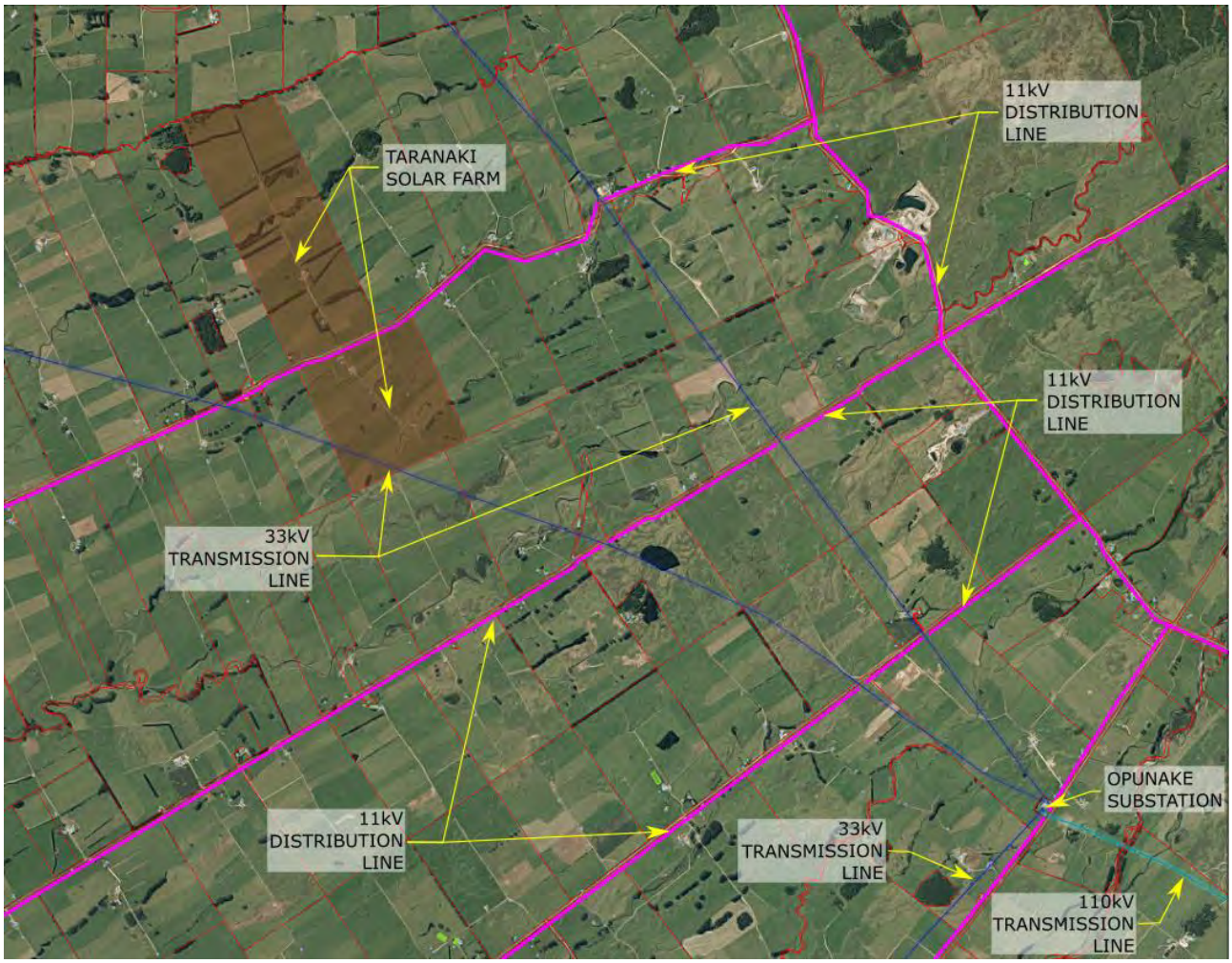

Figure 7: Existing Distribution Buffer Corridors on Public Roads

Aerial GIS data maps of Taranaki rural reveal existing distribution buffer corridors (pink colour lines) along the public roads.

These are existing distribution buffer corridors for the 11 kV distribution line infrastructures that are part of the power supply chain by Powerco.

The distribution corridors connecting Taranaki solar farm and Opunake substation are of interest for installation of the new 110 kV transmission line.

It is expected that these corridors are administered and owned by PowerCo. Negotiation with PowerCo is advised if this is intended to be used for the new 110 kV connection.

4 New 110 kV Transmission Line Route Options

4.1 General

For the planning the infrastructure of the new a 110 kV transmission line to connect the Taranaki solar farm switchyard to Opunake transmission substation, desktop study has been conducted of the existing transmission and distribution buffer corridors in farming lands and public roads; also, for a new buffer corridor close proximity those existing buffer corridor. Three transmission buffer corridors(routs) have been identified and investigated, hierarchy and analysis of these options are numbered subheadings in this section.

Note: each option doesn't affect the design of the switchyard equipment installation layout in the solar farmland.

4.2 Option 1 New Transmission Buffer Corridor

4.2.1 Switchyard location

The Option1 for the new 110 kV transmission line infrastructure corridor, it is proposed the switchyard installation location be located between lots 574 and 564, Upper Kina Road.

Figure 8: Switchyard Location for Option One new 110 kV Transmission Line

At this location, the switchyard is accessible by Upper Kina Road for smooth construction, equipment transportation, equipment installation and maintenance (by contract staff including third parties).

4.2.2 Transmission infrastructure line buffer corridor

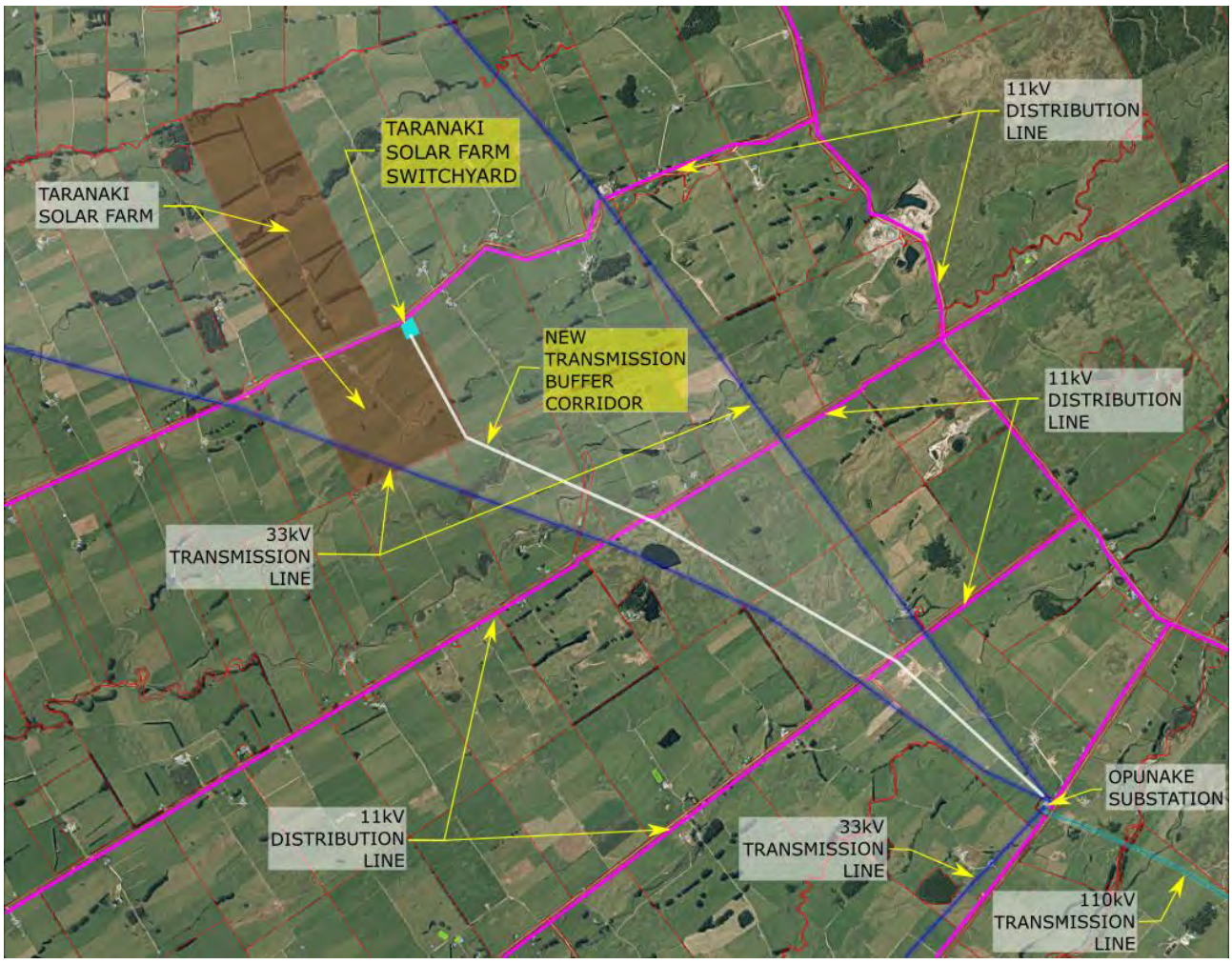

Figure 9: New Transmission Line Buffer Corridor of Option One for 110 kV Transmission Line

It is proposed a new dedicated transmission line corridor (route) for the 110 kV transmission line infrastructure which it is approximately 5.37 km long distance from switchyard location to Opunake transmission substation.

This buffer corridor falls into the National Grid Subdivision Corridor, so it is National Grid Yard. The National Grid Yard is the area beneath and immediately next to the National Grid Line (including the support structures and pole). Incompatible activities and land uses need to be set back from the national Grid Lines as they compromise the ongoing operation, maintenance, upgrading, and development of the National Grid or safety of those living or working around it.

For these reasons, Transpower normally seeks at least a 12-metre setback either side of the centreline of a National Grid line and 12 metres in any direction from the outer edge of a National Grid line structure. This is reduced to a 10-metre setback where the line is a single concrete/wooden pole or steel monopole line, although the distances from the structures remain the same. This arrangement is depicted in Figure 10.

Setback (electrical clearance) distances will also apply to substation and switchyard. Landowners developing adjacent to substation or switchyard should contact Transpower and Energy Farms Ltd.

The new transmission line infrastructures will need steel monopole to support the 110 kV transmission cables. The monopole be equal to Transpower's standard pole structure.

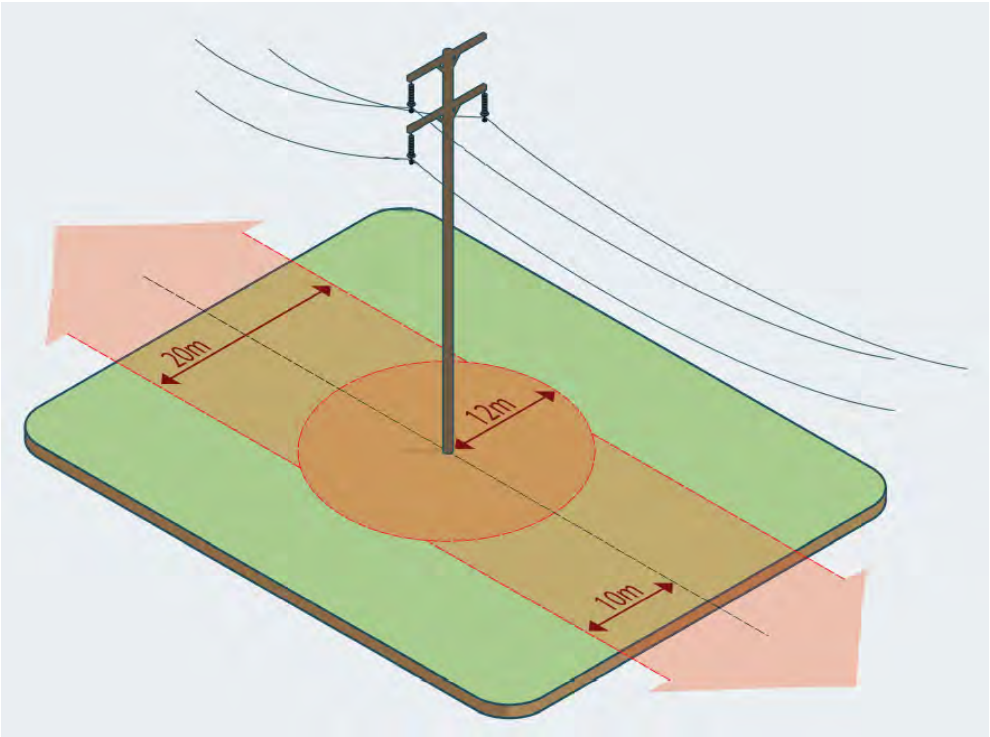

Figure 10: 110 kV Double Crosssarm Steel Monopole

The new corridor would traverse through farmlands and can be access to it via Arawhata and Opua roads, the switchyard via Upper Kina road for ancillary activities.

This route would require a detailed impact assessment against planning criteria for the regional and district councils. This must be undertaken as a next step in the process to obtaining planning consent under the Resource Management Act.

The following technical aspects must be considered in the planning consent process:

- restriction on normal farming activity such as cropping, harvesting, grazing, ploughing etc.
- Must acquire property rights to the land traversed by the transmission line route, this is achieved through an easement with the directly affected landowner
- New buffer corridor affecting farmlands and inconveniences to landowners
- Steel monopole can be visually unattractive
- Potentially 110 kV transmission line cables can emit noise, especially in damp weather conditions
- Some difficulty for require rehabilitation work of the transmission cables
- Potentially transmission lines can emit noise, especially in damp weather conditions
- Electric and magnetic field (EMFs) will increase, but will remain well within the international guidelines set by International Commission for Non-Ionising Radiation Protection, which is endorsed by New Zealand's Ministry of Health
- Corridor will require to have space for conductor blow out

4.3 Option 2 Using Exiting 33 kV Transmission Buffer Corridor

4.3.1 Switchyard location

The Option 2 for the new 110 kV transmission line infrastructure construction, it is considering the switchyard be located close to the existing 33 kV transmission line buffer corridor (route) for accessing this transmission route, this transmission line is connected from Opunake transmission substation to Powerco's Ngariki distribution substation.

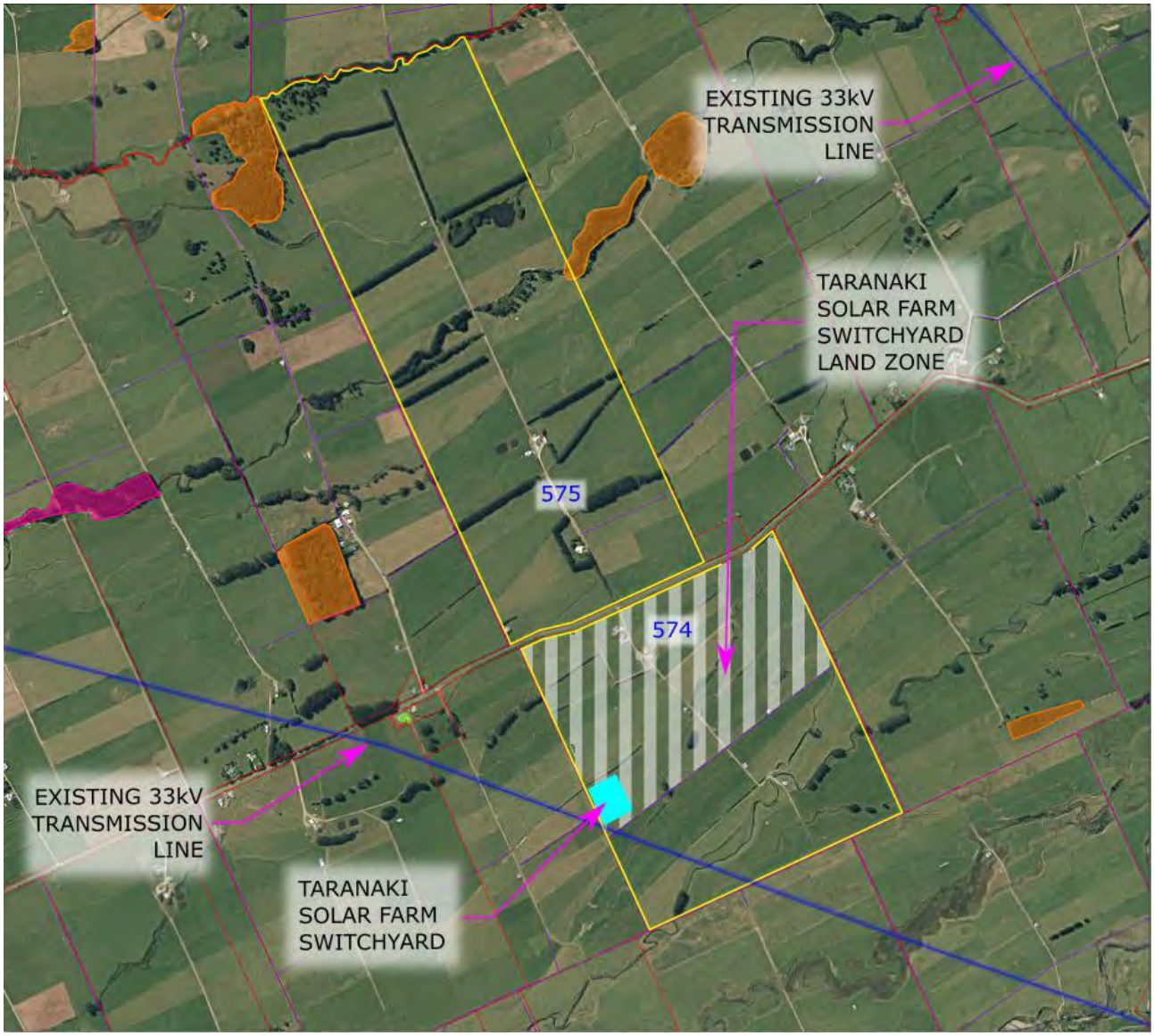

Figure 11: Switchyard Location for Option Two new 110 kV Transmission Line

At this proposed location, the switchyard location will be become part of this buffer corridor.

The switchyard will be access by formed roadway of the solar farm site, this for construction, equipment transportation, equipment installation and maintenance (by contract staff including third parties).

4.3.2 Transmission infrastructure line buffer corridor

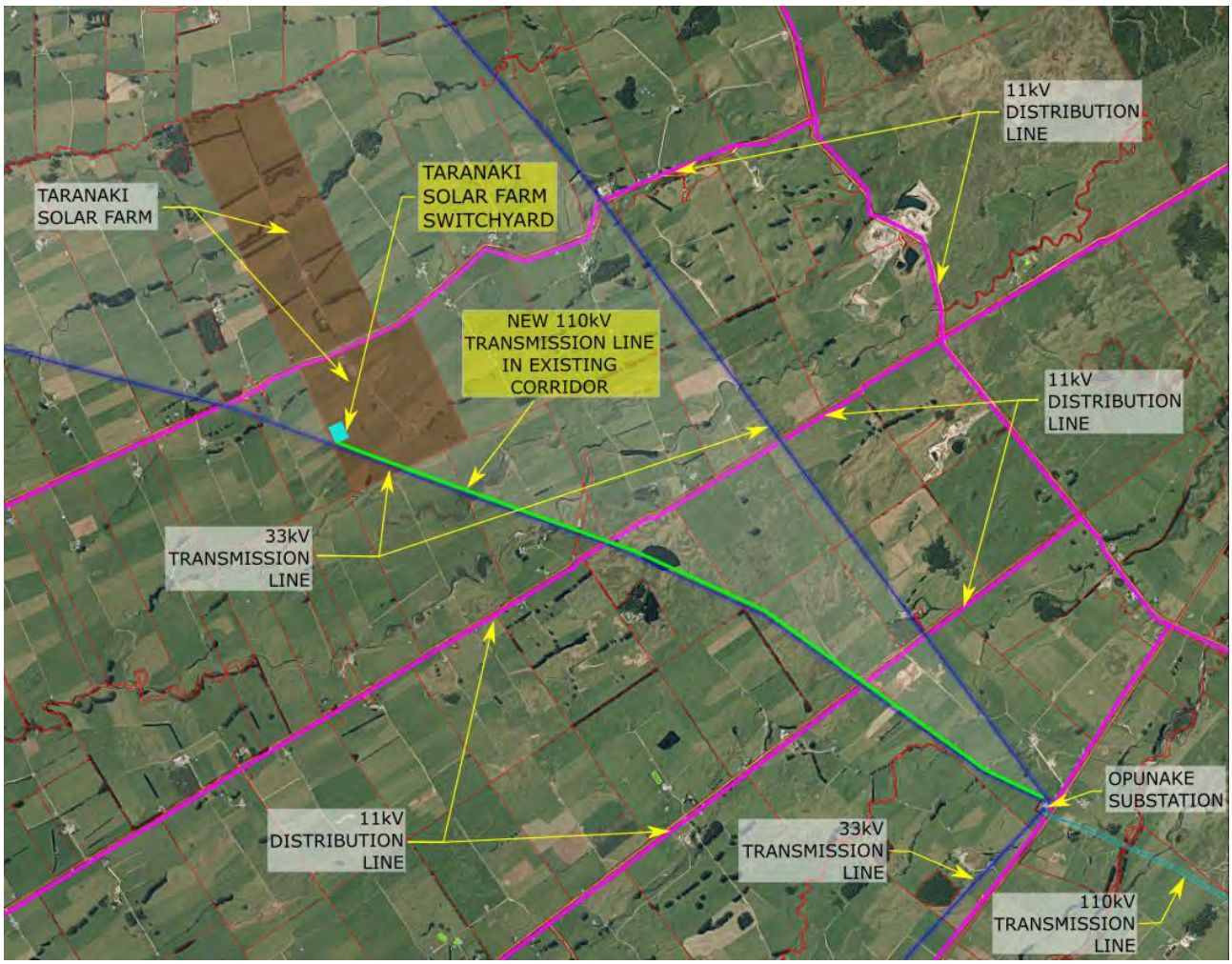

Figure 12: Exiting 33 kV Transmission Line Buffer Corridor for Option Two 110 kV Tranmission Line

To install the new 110 kV transmission conductors, it is needed to upgrade the section of interest of the 33 kV transmission line infrastructure, this is approximately 5.3 km long distance.

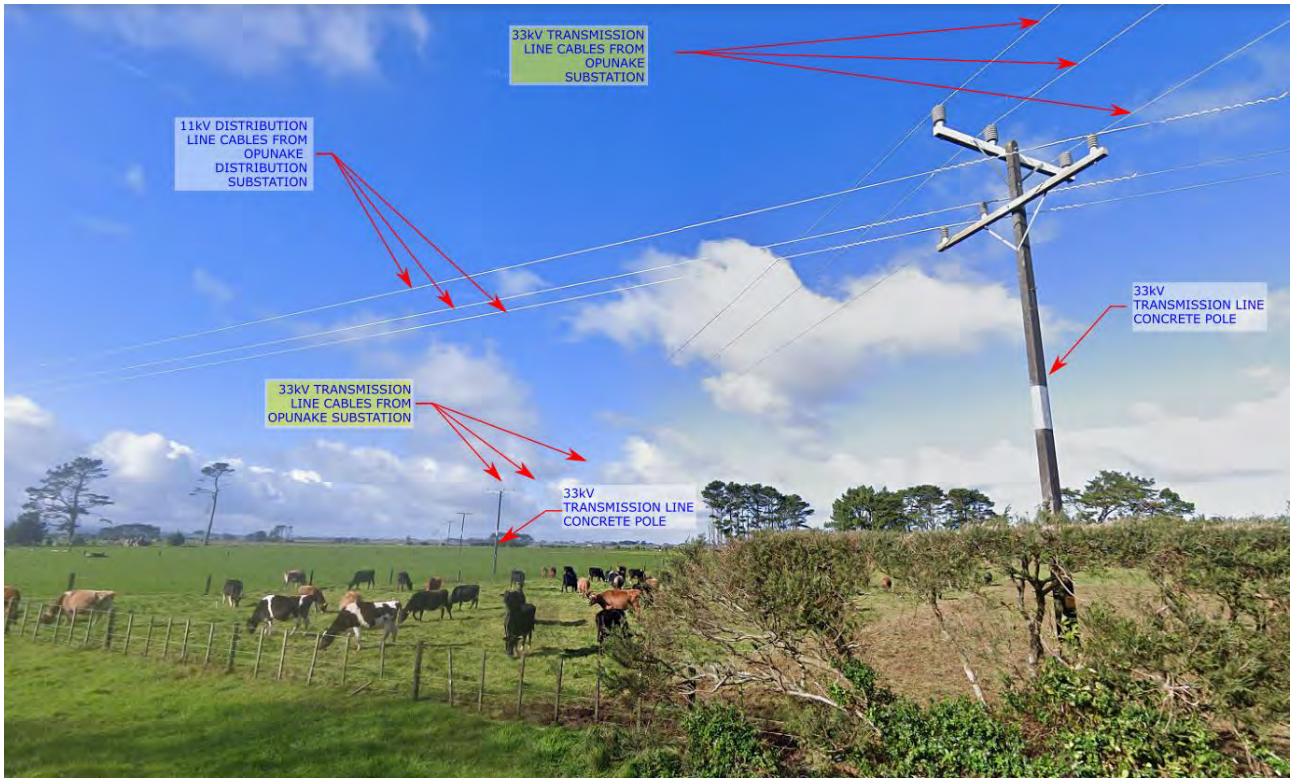

Figure 13: Existing 33 kV Transmission Lines and Concrete Poles to Rahotu Distribution Substation

The line infrastructure section be upgrade by replacing the existing concrete poles with steel monopoles to cater the new 110 kV transmission cables and the existing 33 kV transmission cables installations.

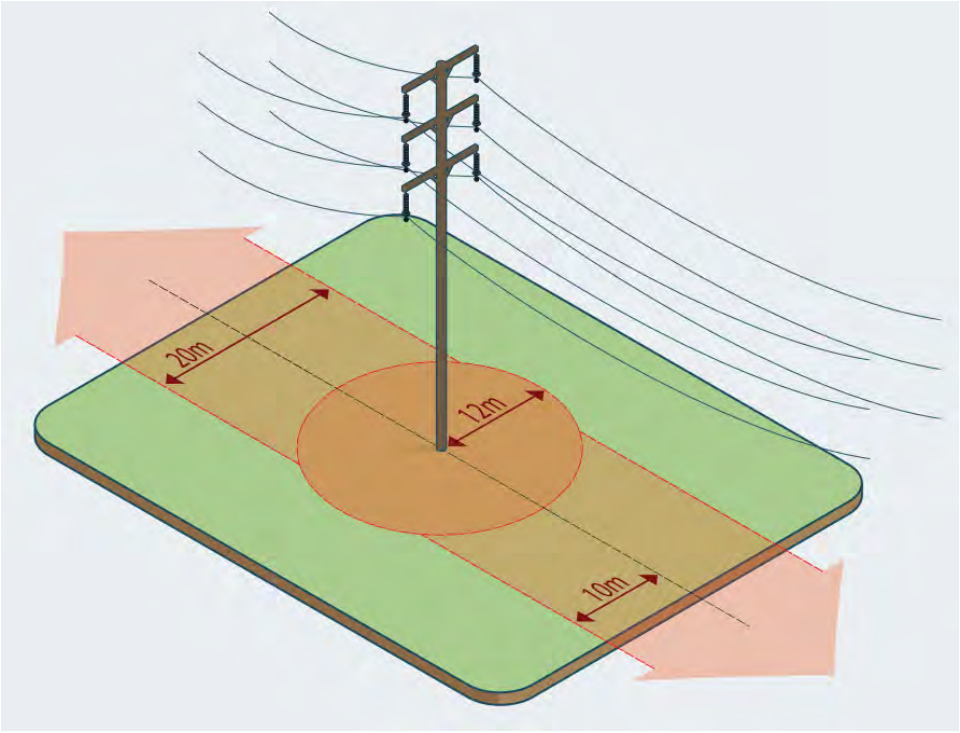

Figure 14: 110 kV Quadruple Crossarm Steel Monopole

In this section of this existing subdivision corridor, its dimension area will not change by the new 110 kV cables installation, this depicts in Figure 14.

The proposed transmission section corridor traverse farmlands and can be access to it by Upper Kina, Arawhata and Opua roads.

4.4 Option 3 Using Exiting 11kV Distribution Buffer Corridor

4.4.1 Switchyard location

Option 3 for the new 110 kV transmission line infrastructure construction offers the transmission line infrastructure build using the existing 11 kV distribution lines buffer corridors along the roads from Opunake substation to Solar Farm switchyard. For this option the proposed switchyard location is situated at 574 Upper Kina Road as depicts Figure 15 below.

Figure 15: Switchyard Location for Option Three 110kV Transmission Line

At this location, the switchyard will be accessible by Upper Kina Road for smooth access for construction, equipment transportation, equipment installation and maintenance (by contract staff including third parties).

4.4.2 Distribution infrastructure line buffer corridor

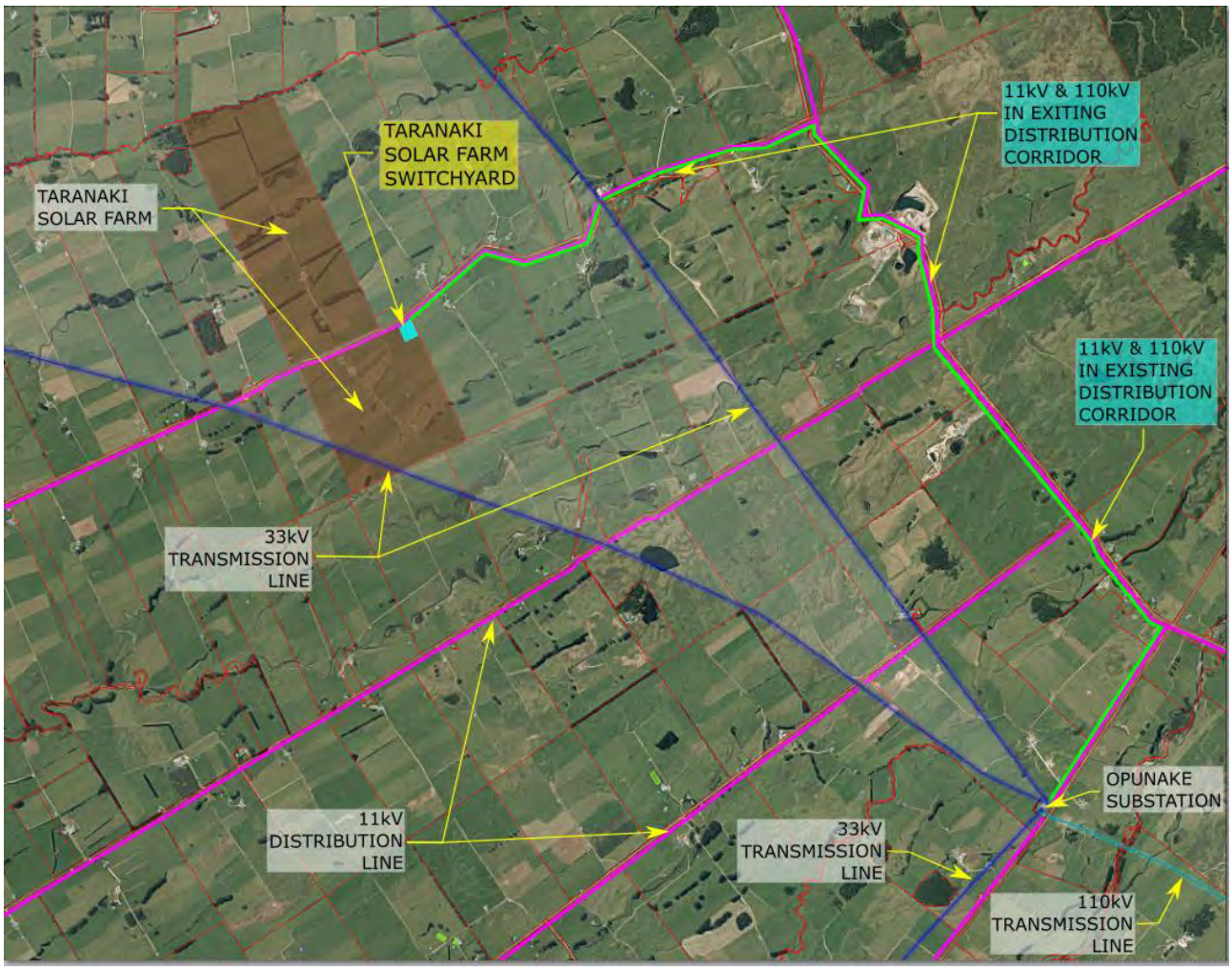

Figure 16: Exiting 11 kV Distribution Line Buffer Corridors for Option Three 110 kV Transmission Line

The new 110 kV transmission line infrastructures be built in approximately 7 km long distance from the switchyard point of connection to the Opunake substation, this is the distance needed of the existing 11 kV distribution corridor (route) along Upper Kina, Wiremu and Ihaia roads which depicts in Figure 16. Figure 17 depicts the 110 kV transmission and 11 kV distribution conductors supported on quadruple crossarm steel monopoles along Upper Kina road.

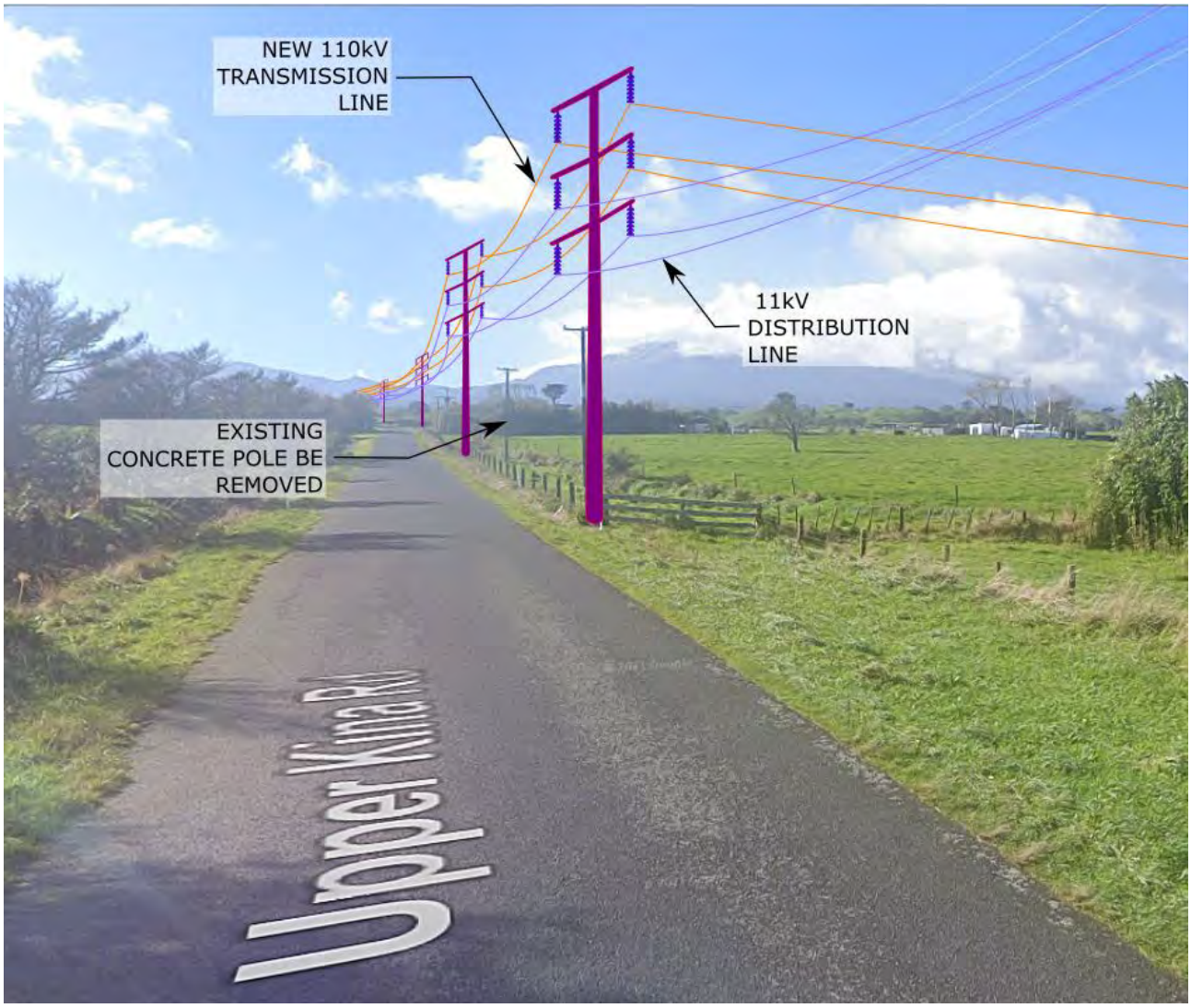

Figure 17: New 110 kV transmission Line and 11 kV Distribution Line in Existing Distribution Buffer Corridor

This 11 kV subdivision corridor, its dimension area will change by the new 110 kV conductors installation. The dimension is determined by the voltage of the transmission line in accordance to Transpower standards.

The proposed section corridor is accessible by Upper Kina, Arawhata and Opua.

5 Opunake GXP Substation Bus Expansion

To connect the new 110 kV transmission line conductors from Taranki Solar Farm switchyard to Opunake transmission substation, the substation is needed extension. New circuit equipment required on the 110 kV primary side bus. No modification of existing switching scheme is necessary.

The new switching equipment installation be as simple in arrangement for flexibility in operation and, installation of structures, bus and switchgear for high voltage spacing and clearances, these in accordance with Transpower's substation design drawings and standards. The equipment arrangement layout proposed is depicted in Figure 18.

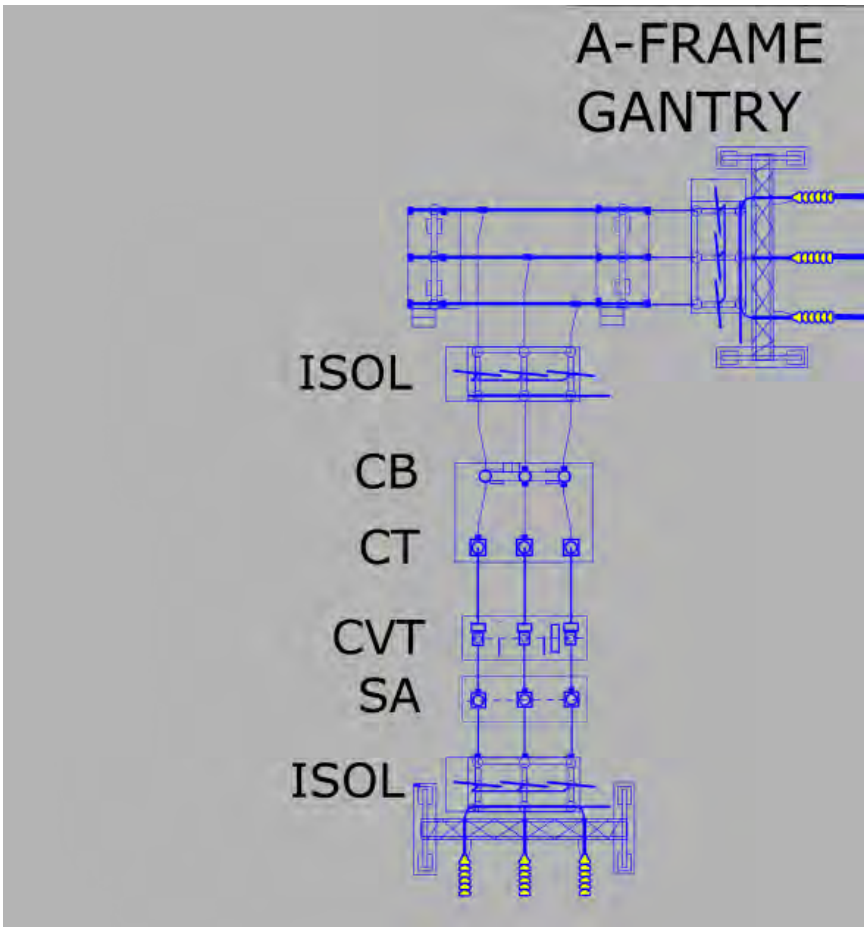

Figure 18: HV Equipment Layout

Substation equipment extension:

- Surge Arresters (SA), to protect from overvoltage transients
- Current Transformers (CT), to measure currents and detect fault currents to activate the protection relay
- Circuit Breaker (CB), to provides protection against fault currents and to provide load break facilities to the circuit
- Isolator (ISOL) switch or disconnector, to isolate and electrically disconnect the substation equipment from the 110kV transmission line
- Capacitor Voltage Transformer (CVT), to provide low voltage signal for measurement and operate protective relay
- Connector system (CS)

Note: location for the equipment installation depends on the installation location option selected and geographical position of incoming new 110 kV transmission line.

Two potential land locations within the substation land lot have been identify and, hierarchy of these options are numbered subheadings in this section.

5.1 Option 1 Equipment Installation Location

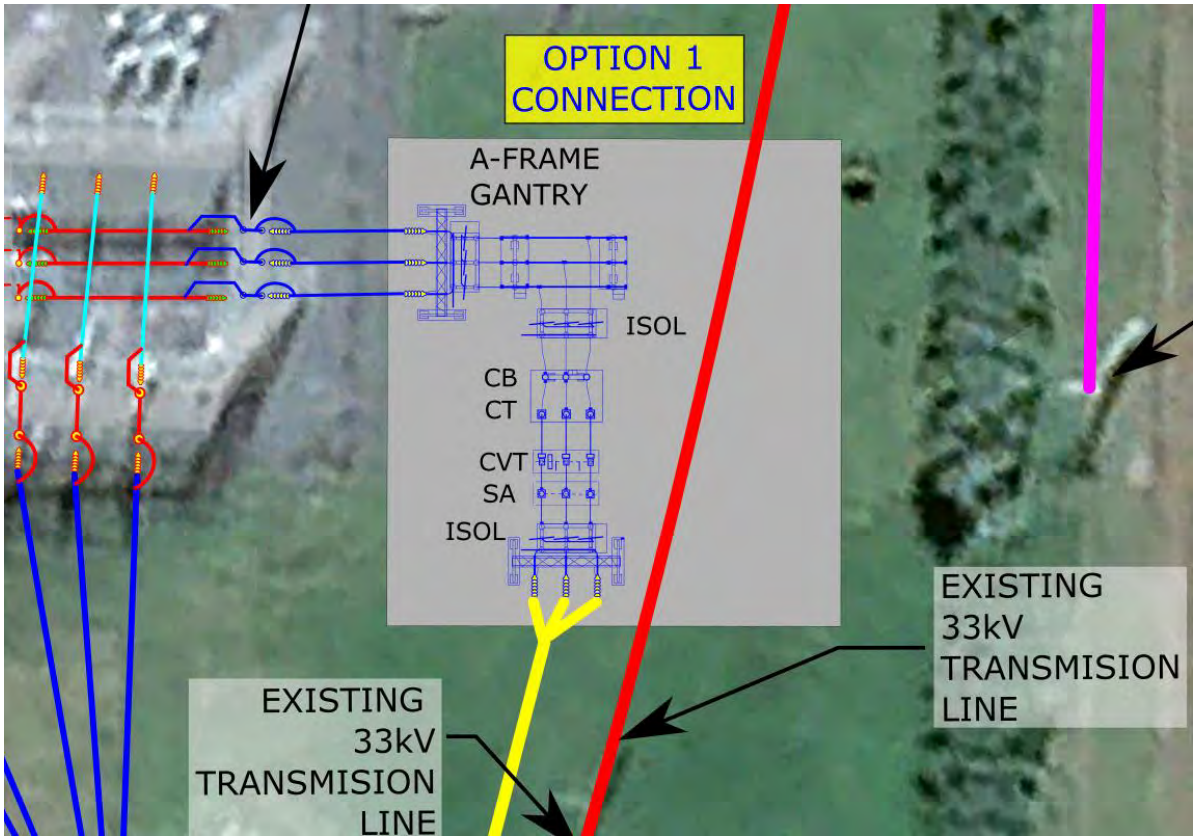

Figure 19: Option 1 HV Equipment Installation Location

In Option 1, the new equipment will be connected to the Stratford Cct1 110 kV primary bus of the substation, for further details refer to Transpower's following drawings.

- TX25634 - Opunake Substation 110/33 kV Single Line Diagram (Operating)
- TP51989 - Regional Single Lien Diagram (Sheet 18 of 40) MKE, OPK, SFD & TMN

Option 1 for the equipment installation location is the prefer by Transpower since they informed that part of this primary side of the transmission circuit is stable (reliability performance at specific point on the grid). It is important the stability limit of the transmission circuit of the Opunake substation for the maximum power flow (maximum energy injecting onto the grid) that Taranaki Solar farm will be exporting power to the National Grid.

Advantage of Option 1

- Option 1 prefer location by Transpower since accessible to the stable primary transmission circuit of Opunake substation
- No impact to the existing equipment Opunake transmission substation
- No impact to the substation land lot
- No impact to the existing 110 kV primary transmission circuits
- No impact to the existing 33 kV transmission poles and 110 kV pylon installations

- Minimum constraints for exporting the power from the solar farm to the National Grid, this information from Transpower

Disadvantage of Option 1

- Portion of the available land will be used for the equipment installation
- Minimum impact for future expansion of the transmission circuit of the substation

5.2 Option 2 Equipment Installation Land Location

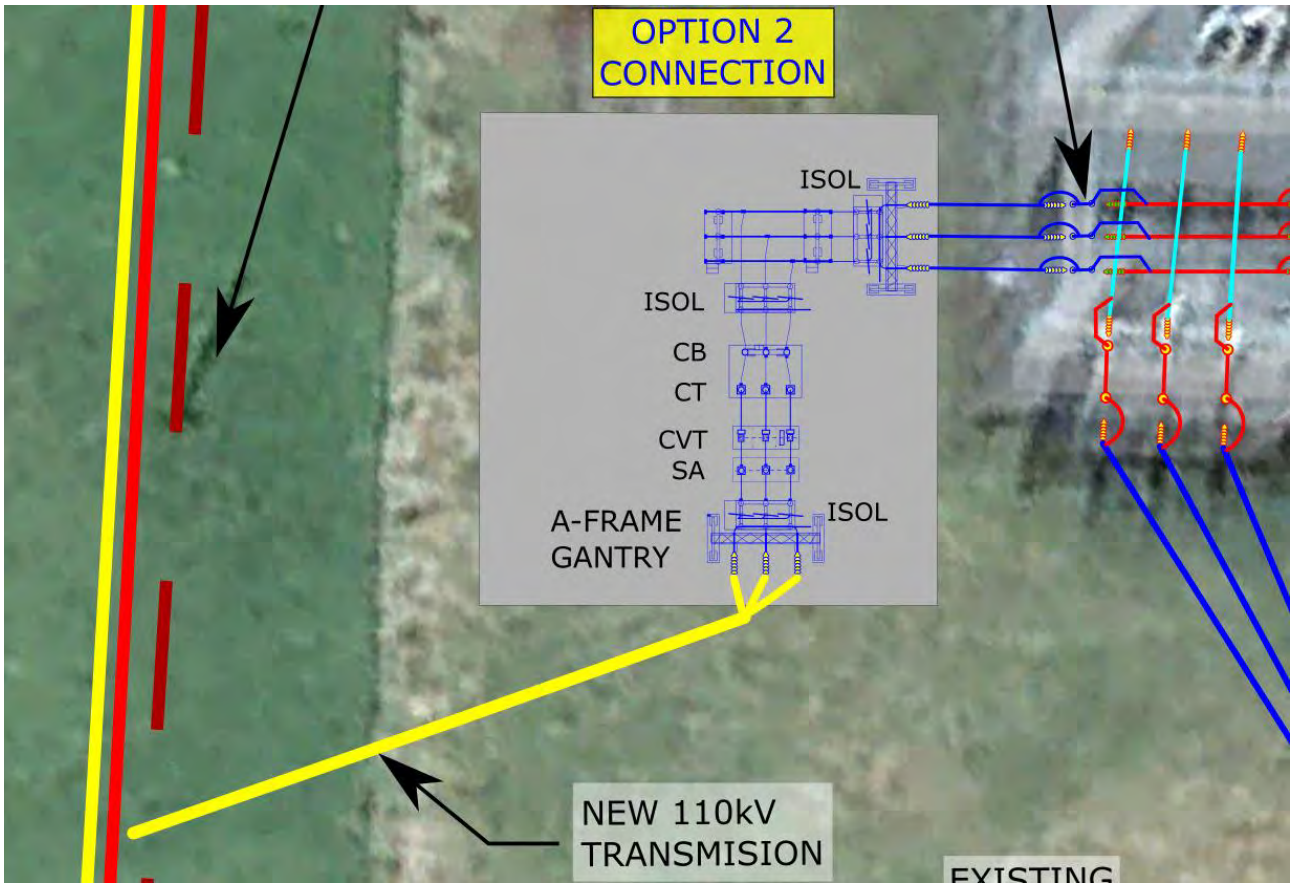

Figure 20: Option 2 HV Equipment Installation Location

In Option 2, the new equipment will be connected to the Kapuni - Stratford Cct2 110 kV primary bus of the substation, for further details refer to Transpower's following drawings.

- TX25634 - Opunake Substation 110/33 kV Single Line Diagram (Operating)
- TP51989 - Regional Single Lien Diagram (Sheet 18 of 40) MKE, OPK, SFD & TMN

Advantage of Option 2

- No impact to the substation land lot
- No impact to the existing 110 kV primary transmission circuits
- No impact to the existing 33 kV transmission poles and 110 kV pylon installations

Disadvantage of Option 2

- Portion of the available land will be used for the equipment installation
- Minimum impact for future expansion of the transmission circuit of the substation
- Constraints for exporting the power from the solar farm to the National Grid, this information from Transpower

6 Summary and Recommendations

6.1 Summary

This design solution report and Taranaki Solar Farm substation(switchyard) and new 110 kV transmission line routes preliminary design drawings are the package for consenting this transmission line grid connection to Opunake substation. Three options for the new 110 kV transmission line route and its associated buffer corridor have been produce and evaluated as result of this preliminary design and desktop study of Transpower's drawings, GIS maps, South Taranaki District Council maps, Google earth etc.

As demonstrated in this report and preliminary design drawings, the major factors in evaluating the three options for the new 110 kV transmission lines route and switchyard are:

- Concept design of the substation electrical equipment layout(switchyard) is based on the conditions prevailing locally, Transpower' design drawings and the necessity to maintain continuity of exporting the energy power to the National Grid.
- Simple arrangement as practical to ensure the desired flexibility on the operation and inspection of the switchyard and the new 110 kV transmission line.
- For the new 110 kV transmission line, a new buffer corridor proximity those existing transmission and distribution buffer corridors.
- The capacity of the existing transmission and distribution line buffer corridors for the new 110 kV transmission line infrastructure.

The hierarchy of these options in order of preference is as follows:

- Option 1 New Transmission buffer corridor – require property rights to the land traversed by the new line route
- Option 2 Using exiting 33 kV buffer corridor – require upgrading the 33 kV transmission infrastructure section of interest for the new 110 kV transmission line
- Option 3 Using existing 11 kV distribution corridor – require upgrading 11 kV distribution infrastructure section of interest for the new 110 kV transmission line

6.2 Recommendation

Recommendation as result this design solution report and Taranaki Solar Farm substation (switchyard) and new 110 kV transmission line routes preliminary design drawings for consenting the construction of the new 110 kV transmission line infrastructure.

Should conduct primary effort to be for the option 1 since the new transmission line buffer corridor will be next to Powerco's existing 33 kV transmission line corridors which will facilitate approval of documents for consenting of the new transmission line. Also, the new transmission line will not affect to those existing transmission lines so no need for long-term planned outage to the existing Powerco's electrical distribution networks.

Should conduct primary effort for the option 2 since may not be needed to submit documents for consenting of the new transmission line and, there is capacity of the existing Powerco's 33 kV transmission line corridor. Also, no creating further restrictions to normal farming activities such as cropping, harvesting, grazing, ploughing etc. And no creating further inconveniences to landowners.

Last effort for the option 3, this to use the exiting 11 kV distribution corridor the construction of the 110 kV transmission line infrastructure.

7 Next Steps

The next step of the project will be to.

- Further detailed discussion with Transpower on the connection arrangement at Opunake Substation
- Contacting to Powerco, Transpower and South Taranaki District Council services for planning the new transmission line
- Undertake resource consent application for construction of the new transmission line infrastructure, where assessment of effects is undertaken

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