BEFORE THE DISTRICT HEARINGS PANEL

Under the Resource Management Act 1991

In the matter of

Proposed Queenstown Lakes District Plan – Chapter 30 Energy and Utilities

And

Transpower New Zealand Limited (Submitter 805)

Submitter

Statement of Evidence in Chief of Andrew Renton on behalf of Transpower New Zealand Limited dated 2 September 2016

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Introduction

1. My full name is Andrew Charles Renton.

2. I am employed by Transpower New Zealand Limited (**Transpower**) as the Senior Principal Engineer. I have a New Zealand Certificate of Engineering and Bachelor of Engineering (Electrical).

3. I have over 26 years' experience in transmission engineering work. I currently work in the Grid Development Division of Transpower. My role involves investigating and providing holistic, pragmatic and strategic advice to developers and the infrastructure divisions of councils, on suitable and cost effective transmission solutions as well as new developments and technologies. My previous roles at Transpower have included the Asset Development Engineering Manager responsible for all substation and transmission line engineering development work.

4. I am familiar with the National Grid assets within the Queenstown Lakes District.

5. I have previously provided evidence on behalf of Transpower in relation to Chapter 3 Strategic Directions, Chapter 4 Urban Development, Chapter 6 Landscape, Chapter 21 Rural, Chapter 23 Gibbston Character Zone, and Chapter 33 Indigenous Vegetation and Biodiversity of the Proposed Queenstown Lakes District Plan (the **Proposed Plan**). This evidence should be read in conjunction with my earlier evidence. I rely on that evidence, particularly in relation to the critical role of the National Grid, the National Grid as a facilitator of growth for the Queenstown Lakes District, and the potential for adverse effects on the National Grid.

Code of Conduct

6. I confirm that I have read the 'Code of Conduct for Expert Witnesses' contained in the Environment Court Consolidated Practice Note 2014. I agree to comply with this Code of Conduct. In particular, unless I state otherwise, this evidence is within my sphere of expertise and I have not omitted to consider material facts known to me that might alter or

detract from the opinions I express. While I am employed by Transpower, I am providing this evidence in my capacity as an expert in electrical engineering and matters relating to the National Grid.

Scope of Evidence

7. My evidence will address the following matters:

(a) Technical, operational and locational requirements of the National Grid;

(b) National Grid yards and corridors;

(c) Effects on and from the National Grid;

(d) The New Zealand Electrical Code of Practice for Electrical Safety Distances 2001 (**NZECP34**);

(e) Risks and effects associated with substations; and

(f) Appropriate management of risks and effects associated with substations.

Technical, operational and locational requirements of the National Grid

8. The National Grid is extensive, connected and narrow linear infrastructure, reflecting New Zealand's topography. No components of the Grid work in isolation. The National Grid operates in a regional or national scale in terms of the location of assets and the distances over which electricity is transmitted. What happens at one point on the Grid can have consequences much further away, even in another region. Given its extensive and linear nature, Transpower is sometimes unable to avoid locating in sensitive areas.

9. The unique characteristics of the National Grid mean that it is operational requirements and engineering constraints that both dictate and constrain the way it is managed. The operational requirements relating to the Grid are set out in various legislation, rules and regulations governing the National Grid, including the Electricity Act 1992 and the Electricity Industry Participation Code.

10. Transpower's asset strategy for its transmission line fleet is that all lines serving centres of demand have a perpetual life. Some Transpower lines are more than 85 years old. While these assets are aging, their condition and performance is acceptable; due to the environment they are located in and sound condition based maintenance undertaken over the years. Transpower continues to invest in the National Grid both in maintenance and enhancement of its asset base.

11. Transpower's development and investment strategy is centred on maximising the utilisation of existing infrastructure, therefore maintaining the environmental footprint for as long as possible before the introduction of additional lines or substations. Transmission line structures can be maintained almost indefinitely by practices such as painting of towers, pole or cross arm replacement, concrete encasement of existing grillage foundations and replacement of member and insulators. Conductors are replaced and increased in size and, at times, in the number of conductors per phase to meet increased capacity needs. This work can mostly be completed within the parameters of the Resource Management (National Environmental Standards for Electricity Transmission Activities) Regulations 2009.

12. Transpower's asset strategy for its substations is that all sites serving centres of demand are required indefinitely. Substations are maintained by replacing components such as circuit breakers, disconnectors and transformers when they reach the end of their serviceable life, or when their maximum capacity is reached. Transpower has embarked on a programme of moving 22kV and 33kV switchgear from outdoor installations to indoor installations to increase safety and reliability.

13. Operating and maintaining the National Grid is a core part of Transpower's business. To ensure the Grid delivers a safe, secure and reliable electricity supply, all assets need to be patrolled and inspected on a regular cycle that reflects the asset's age and type, its environment and geographic location, and high risk areas (such as where lines are over major roads, rail and urban areas). It is important that appropriate access to the National Grid is retained. This is particularly relevant to changing land-use and subdivisions.

Third party requests

14. Relocating or changing the form of assets to enable development, can be at the request and funding of developers, the Council or road controlling authorities.

15. Recent examples of Transpower being requested to change the form of assets are:

    (a) Highbrook – this involved the movement and undergrounding of high voltage infrastructure within the Highbrook industrial Development to the north-east of Otahuhu. Pragmatic early communication with the developer lead to integration of the National Grid into the development plans.

    (b) Massey North town centre development – this involved the undergrounding 2km of the Albany to Henderson line to facilitate safe and cost effective development of land.

16. Transpower is also working through numerous requests to relocate its assets to enable roading projects in the Auckland Region. These requests include:

    (a) The relocation of the OTA-PEN A 110kV transmission line in the Reeves Rd area. This relocation is to meet the requirements of the proposed Reeves Rd Flyover for the AMETI (Auckland – Manukau Eastern Transport Initiative) upgrade of the Panmure to Pakuranga Highway.

    (b) The relocation of tower 195 of the HLY-OTA A transmission line to enable Auckland Transport's proposed widening of Redoubt and Murphys Road in South Auckland.

    (c) The relocation of the BOB-OTA A transmission line affected by the Southern Corridor widening of SH1 at the Takanini Interchange.

    (d) The potential movement of a number of lines for the conceptual East-West link NZTA project.

(e) The relocation of the OTA-WKM A and OTA-WKM B transmission lines in the area of a new proposed housing development at Flat Bush.

17. While Transpower is willing to discuss and agree line moves with developers, it is essential that any such development activities are subject to appropriate controls that safeguard the National Grid infrastructure. For underground assets, a designation would be sought. Most National Grid line relocations would be consented under the Resource Management (National Environmental Standards for Electricity Transmission Activities) Regulations 2009.

18. Transpower would also not relocate its assets so that the conductors swung out over any buildings. In this regard, when moving its assets, including to enable other's development, Transpower would expect all buildings to be removed.

Effects on and from the National Grid

19. I refer to my earlier evidence which discusses the potential for adverse effects on the National Grid, including:

(a) The health and safety risks associated with National Grid Lines;

(b) Reverse sensitivity effects; and

(c) Challenges for National Grid Corridor management.

20. For the purposes of this evidence, I wish to further discuss Earth Potential Rise (**EPR**) and effects of earthworks on National Grid infrastructure.

Earth Potential Rise

21. EPR occurs when a large electrical current enters the ground and passes through it. Sources of EPR electrical currents are lightning strikes or faults in the electricity system. The effects of EPR are highest where the electrical current enters the ground and reduces as the distance from the fault increases. This effect can be imagined to be like the contours of a hill as shown in the picture below.

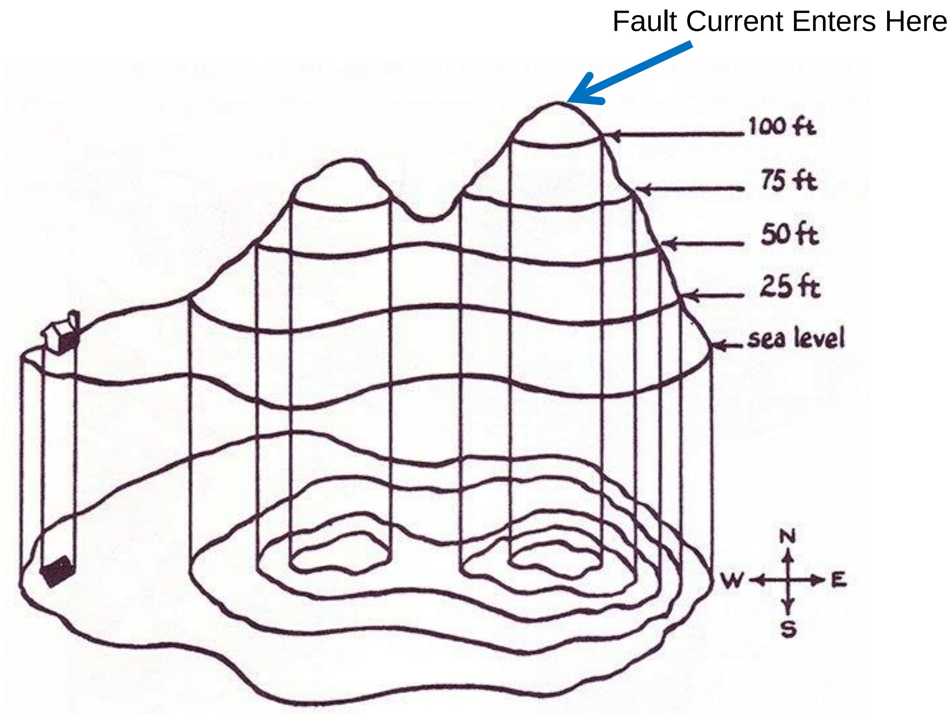

Figure 1: Example of land contours as a representation of EPR effects

22. EPR in electricity systems are usually caused by a earth fault at a tower pole, or transformer. An earth fault occurs when an energised part of the line or transformer such as a conductor comes into contact with, or flashes over to, the tower, pole, or any earthed object. This can occur through an insulation failure as a result of lightning, pollution or foreign objects.

23. During an earth fault, there is a significant current (many times normal) flowing in the faulted line from the power source into the fault point. These fault currents are highest either near the electricity source (generator) or the substation as the current returns through the ground. These currents last for brief periods normally less than a second until the protection equipment isolates the faulted equipment by turning the electricity supply off. The return current causes momentarily high voltages to appear on both the tower and the ground around the base of the tower. The voltages are highest on the faulted tower or pole and decrease on the ground as you move further away from the faulted tower. In other words, the risks of EPR lessen with distance from the support structures. Voltages can appear on any conductive object on the ground (such as a fence) that either is in direct contact with the faulted equipment or bridges or passes through these voltage contours

to a distant location (transferred voltage). These voltages are manifested either as a touch hazard or a step hazard.

Transferred voltage hazards

24. Where conductive, structures such as fences, metal clad buildings, metal water pipes, or power cables for example, are located close to the tower or pole, these voltages will appear at the end closest to the fault and be transferred down the conductive structure to some remote location. This effect is called transferred voltage. The hazard from transferred voltage is the conductive structure is at the same voltage as the faulted equipment but the ground or area around it will be at a much lower voltage. It is this difference that will cause either step or touch voltages effects to be experienced in a remote location. An example of this effect is shown in the picture below.

Photo 1: Fence and surrounding area affected by Earth Potential Rise, near Geraldine, South Canterbury

Step and touch voltage hazards

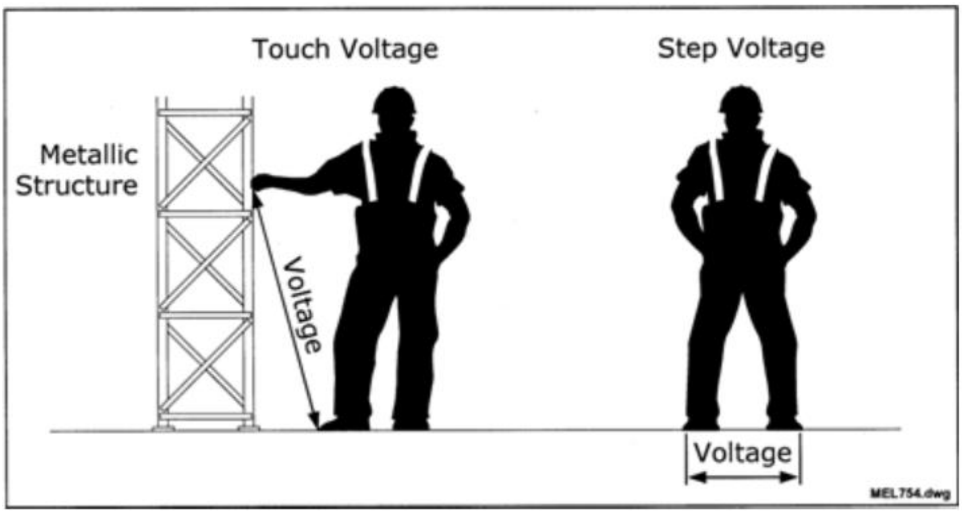

Figure 2: Touch and step voltage measurements

25. Step and touch voltage hazards can arise due to a fault at a tower or pole and, as explained above, momentarily raise the voltage at the tower or pole base and the surrounding ground. A touch voltage occurs when a person is touching the faulted pole, tower or equipment at the same time as the fault occurs and becomes part of the fault path. A step voltage hazard can occur when a large voltage appears between a person’s feet, even if they are not touching the faulted equipment, pole or tower.

Summary

26. All of these hazards can be addressed by suitable designs and controls to ensure that step and touch voltages are managed within suitable limits. These same controls also ensure that transferred voltages are not inadvertently created by third parties works. Examples are ensuring that no exposed metallic pipes, fences or cables transition the EPR hazard zone, or that if they do, that suitable design mitigations such as isolating breaks that prevent the build-up and transfer of dangerous voltages and currents are installed.

27. The key to the successful identification, management and mitigation of these issues overtime is being able to identify to all parties the possible

issues that may exist and thereby give the opportunity for suitable solutions to be applied.

Earthworks

28. Excavations adjacent to towers or poles can undermine the stability of the structure foundations, causing the structure to lean or, worse, collapse. Uncontrolled earthworks can also generate dust which can result in the build-up of material on the National Grid lines and increase the wear on the equipment reducing its useable lifespan. Excavations or mounding mid-span can increase risks by reducing the clearance between the ground and conductors. Excavated areas or piles of earthworks soil can also restrict Transpower's ability to access and locate the heavy machinery required to maintain support structures around the lines, and may lead to potential tower failure and significant constraints on the operation of the lines, such as power outages. For these reasons, Transpower seeks controls on earthworks near the National Grid.

29. I am aware of instances where earthworks carried out by third parties have created unstable batters, potentially threatening stability and causing significant safety risks as well as risks to security of supply. The photo below shows earthworks by a developer as part of development for an urban subdivision in Whitby, Porirua that were marginally within 6m from the outer edge of the tower. This cut impacted the structural integrity of the tower.

Photo 2: Earthworks in Porirua, Wellington

30. As well as possibly undermining the stability of the tower structure, the earthworks in the photograph also restricted vehicular access to the tower and the area where Transpower can place machinery required to maintain the tower. This compromises Transpower's ability to maintain the existing transmission line.

31. Transpower worked with the developer to ensure that the constraints on the line introduced by the developer were mitigated and the long-term stability of the towers is retained. Such works are an example of how earthworks conducted close to the Grid can undermine Transpower's ability to operate and maintain the network effectively and efficiently. Ultimately the manner in which Transpower carries out maintenance at this tower will need to change to address the effects.

32. It is considered that NZECP34 on its own does not give effect to the National Policy Statement on Electricity Transmission 2008 (the **NPSET**) and Policy 10. Photo 3 below illustrates that even earthworks that are technically compliant with NZECP34 have adverse effects on the National Grid. As a result of the earthworks in vicinity of the pole structure, Transpower's ability to operate and maintain the network has been compromised. The batter slope may become unstable as a result of erosion and slipping. Access to the site is now severely restricted

and there is no ability for Transpower to operate heavy plant on the elevated platform. Ongoing engineering checks will be required to monitor the effects of erosion and to check the stability of the foundations.

Photo 3: Excavations compliant with NZECP34 around base of pole

33. Recently, Transpower investigated the clearances from the conductor to ground for two Hastings properties and found they did not comply with the NZECP34. Failure to comply with the code is an offence.

34. The investigation found that the minimum clearance is only 5.3m from the ground to conductor at everyday conditions (instead of 6.5m). This violation occurred as a result of earthworks – i.e. is due to a build-up of soil under the conductors. The soil has been excavated onsite, spread under the line and has now reduced the required ground clearance to an unacceptable distance.

35. Transpower needed to arrange temporary fencing of the two earthworks sites to prevent any further access under the circuit (wires).

36. Letters have been sent/hand delivered to each landowner formally warning them of the issue and the need to keep clear of the lines until the rectification work can be completed.

37. Transpower liaised with Hastings District Council about the earthworks and consenting aspects of the development. As a result of the earthworks people and property are at risk and the lines operation has

been constrained. Methods of mitigation are likely to include remediating the site back to original ground level and compliance with NZECP34, or erecting new taller pole structures. Initial mitigations are restrictions on access and fencing off while more permanent solutions are engineered and installed.

Photo 4: Ground clearance violations in Hastings

Photo 5: Ground clearance violations in Hastings

Photo 6: Ground clearance violations in Hastings

38. It is essential that earthworks in Queenstown are carefully considered given the proximity of National Grid infrastructure. One of the reasons Transpower seeks the provisions and controls in its submission on the

Proposed Queenstown Lakes District Plan is to address or at least significantly reduce the risks and effects I have described above.

National Grid Yards and Corridors

39. Transpower is seeking a National Grid Corridor for undesignated overhead transmission lines, to provide for:

(a) A 12m corridor either side of the centreline, where specified activities are restricted (referred to as the **National Grid Yard**);

(b) A wider corridor out to 32m either side of the centreline for a 110kV line where subdivision is managed (referred to as the **National Grid Subdivision Corridor**); and

(c) A 12m setback area around structures.

40. Taking into account the safety risks, maintenance requirements and other matters I have discussed in my evidence (including on the other chapters), in my view, National Grid Yards and Corridors have the following important purposes:

(a) To ensure that sensitive activities such as residential development, schools, childcare and hospitals are generally not provided for near support structures and lines: Sensitive activities include the establishment of dwellings, schools and papakainga close to the Grid.

(b) To enable safe and efficient access, maintenance and operations: National Grid Yards provide a relatively clear area for line workers to gain access a more efficient and safer access to the line and support structures for maintenance and operational requirements. A relatively clear corridor ensures that Transpower's ability to undertake some limited upgrading or developing of its lines is not compromised. National Grid Yards also limit the need for costly work-arounds (for example, bypass lines), when maintaining and operating the National Grid.

(c) To manage reverse sensitivity effects: Reverse sensitivity effects have significant cumulative potential which may lead to requests for constraints on existing National Grid lines. These effects occur when people undertake activities close to an existing line or structure. For example, National Grid lines can cause noise (especially in damp weather), reduced visual amenity, radio and television interference, perceived effects of electric and magnetic fields from the lines, and interference with landowners' business activities beneath the lines. These effects often lead to requests by neighbouring land users to impose constraints on existing lines. These complaints and constraints are reverse sensitivity effects.

(d) To allow for any future potential upgrade requirements of the asset: For example, Transpower must be able to control "non-sensitive" large scale buildings and buildings that are intensively used (regardless of scale) under the lines, as these can inhibit upgrade activities.

(e) To avoid safety hazards: Electricity transported at high voltages can cause serious, or even fatal, injuries to people who come close to lines. Structures and earthworks too close to a line can affect the stability of that line, and contribute to electricity outages. The presence of these structures can also increase the need for, and thereby risks associated with, mobile plant (e.g. container handling cranes) breaching safe electrical distances and coming into contact with lines.

(f) To provide the residential, rural, commercial and industrial electricity users in Queenstown with a reliable and secure supply of electricity.

(g) To protect the integrity of National Grid structures by reducing risks of damage to structures and their foundations: Structures and earthworks too close to a line can affect the stability of that line, and contribute to electricity outages. The presence of these structures can also increase the need for, and thereby the risk associated with, mobile plant (such as cranes and excavators) and other assets. Transpower wishes to ensure that safe electrical distances are maintained so the risk of coming into contact with the lines is minimised.

(h) To protect the infrastructure corridor itself: As land uses become more intense, it is increasingly more difficult to identify routes for new assets. If a transmission line is compromised by encroaching land uses, it can sometimes be impossible to optimise the capability of existing lines (which defers the need to build new lines). If new lines are required, it can be difficult to identify an alternative route which would disrupt landowners less.

(i) To alert landowners to the national importance of the National Grid and the restrictions it imposes on land use: The use of corridors allows people and property along the length of the lines to recognise both the scale and strategic nature of the resource. It also clearly indicates how they can manage their own activities.

(j) To provide the community, Council and Transpower with the knowledge and confidence that the lines are being managed in a safe and sustainable manner: To provide certainty as to how that management is being achieved within the NPSET framework.

41. **Appendix A** of this evidence explains Transpower's approach to calculating the width of transmission corridors required by the NPSET.

NZECP34

Excavations/earthworks

42. NZECP34 is a mandatory safety code of practice developed under the Electricity Safety Regulations. It seeks to protect persons, property, vehicles and mobile plant from harm or damage from electrical safety hazards by setting out minimum safe distances between conductors, and people, buildings and other structures. It does not attempt to allow for any operation and maintenance activities to occur, only the minimum distance to ensure a person's safety to the asset is not compromised.

43. In particular, the NZECP34 outlines the requirements for excavation near overhead electric line support structures (towers, poles and stay wires).

44. In respect of excavation, clause 2.2.1 of the NZECP34 requires the prior written consent on the pole owner for any excavation near any pole or stay wire of an overhead electric line where the work:

(a) is at a greater depth than 300mm within 2.2 m of the pole or stay wire of the line; or

(b) is at a greater depth than 750 mm between 2.2 m and 5 m of the pole or stay wire; or

(c) creates an unstable batter.

45. However, clause 2.2.1 does not apply to vertical holes not exceeding 500 mm diameter, beyond 1.5 m from a pole or stay wire.

46. Clause 2.2.3 of the NZECP34 requires written consent of the tower owner for any excavation or other interference with the land near any tower supporting an overhead electric line where the work:

(a) is at a greater depth than 300 mm within 6 m of the outer edge of the visible foundation of the tower; or

(b) is at a greater depth than 3 m between 6 m and 12 m of the outer edge of the visible foundation of the tower; or

(c) creates an unstable batter.

47. As discussed above, strict compliance with the NZECP34 in respect of earthworks on its own does not address all potential effects.

NZECP34 does not protect the integrity of the Grid

48. While NZECP34 may adequately provide for safe distances for smaller buildings and structures, the construction and location of new intensive development and buildings for sensitive activities may not always be sited in such a position that complements the operational or

maintenance activities of the existing transmission line. Requiring consent for these intensive and sensitive activities gives Transpower the opportunity to provide advice on their construction, location and use.

49. NZECP34 does not address the other electrical safety hazards and the potential effects of the line on activities in close proximity to the line. NZECP34 does not prevent mid-span underbuild provided the minimum vertical clearances are not breached. This means even development (including underbuild) that complies with NZECP34 can constrain maintenance activities on lines, which can have consequential effects on safety and can result in increasing the number of people potentially at risk and exposed to adverse effects.

50. In other words, NZECP34 does not provide for all access, work space, step and touch hazards, and other matters I have discussed above where activities or infrastructure cause restrictions or create unsafe situations, especially during work activities on either Transpower's assets or works by a member of the public under or near a line.

51. It is these effects that the NPSET requires be addressed in order to achieve sustainable management. NZECP34 is unable to address these effects, and it is perhaps not surprising therefore that NZECP34 is not referenced in the objective or any of the policies of the NPSET. Additional controls are required in the form of District Plan rules.

52. In addition, in Transpower's experience, many people are unaware NZECP34 exists, let alone its minimum setback requirements. The document is also very technical and will often require engineering advice to interpret. While NZECP34 is a good base document for the determination of safe clearances, experience has found that the document is not well understood by the public or council staff. Even relatively sophisticated commercial entities often do not understand compliance requirements, let alone lay people.

53. NZECP34 does not provide an opportunity for the Ministry of Business, Innovation, and Employment (or Transpower) to be involved in consenting processes. At the consenting stage, unsafe or poorly

designed developments can be screened and prevented. By comparison, Transpower only becomes aware of breaches of NZECP34 once developments are in place, when the cost of mitigating the associated risk is usually very high.

54. The transmission corridors sought by Transpower do not replace the requirement to comply with NZECP34 (as this is mandatory), although they do in some respects mirror and/or complement the requirements of that Code, and will raise awareness of it. This is an important step towards ensuring that the transmission lines can be safely and efficiently managed and operated, and that electrical safe distances are met. However, Transpower considers simply relying on NZECP34 would fail to give effect to Policy 10 of the NPSET.

Risks and Effects associated with Substations

Overview

55. As I have discussed, the assets in the National Grid are an extensive, linear, and connected system of lines and substations. Therefore, activities or changes on one part of the system can affect other parts. As such, it is important that National Grid substations, like National Grid transmission lines, are protected.

56. Substations are a critical component of the National Grid. Power transformers and other equipment at substations step electrical voltage up and down so that it can be used by distribution companies who then deliver the lower voltage electricity to homes, businesses, schools and communities. The infrastructure of those companies such as 33kV feeder circuits (both underground and overhead) has also therefore been located in and developed around the existing National Grid substations. **Appendix B** of my evidence outlines the basic components of substations.

57. If intensification is carried out without taking the substation into account, inconvenience and nuisance effects may be experienced by our neighbours. Transpower may, in turn, be negatively affected by having to constrain the way the National Grid is operated in order to

mitigate these effects. Electricity consumers ultimately meet the additional costs.

Risks and effects

58. There are various inherent risks associated with operating, maintaining, developing and upgrading the National Grid. These risks include buildings located under and next to overhead transmission lines hindering or blocking Transpower's access and making routine maintenance or emergency work more difficult. There are also significant risks from people and communities locating close to the infrastructure, and then seeking to constrain its regular operation. Constraints resulting from neighbour complaints present a real risk to security of supply. In my experience, these effects can be particularly acute with substations.

59. Substations contain transformers, circuit breakers, disconnectors and other equipment. Upgrade and maintenance work at substations can generate noise and dust emissions. Transpower tries to minimise these effects wherever possible, for example by notifying neighbouring residents in advance, by restricting works to day-time weekday hours and by dampening down and covering stockpiles and weighing down covers with sandbags to reduce dust emissions. However, it is impossible to eliminate all of the effects of the work.

60. Substations also generate effects such as noise and stormwater runoff, and cause concern or annoyance because of how they look, electrical interference and perceived electric and magnetic field (**EMF**) issues. Constraints resulting from neighbour complaints are minimised in rural environments which is why, historically, Transpower located substations on the perimeter of population centres. Overtime, through land rezoning and population growth, development has occurred around substations and effects have occurred on neighbouring landowners. These effects have resulted in complaints to Transpower and requests to alter the way Transpower operates its infrastructure.

61. Noise effects can be difficult to mitigate and depend on factors such as the type of equipment, wind and the surrounding natural and physical

environment. Noise emissions can be within acceptable standards but because substations operate 24/7, some people can be particularly sensitive to the continuous presence of transformer noise even if it is within acceptable limits.

62. I am aware of landowners' concerns with nuisance effects such as noise, but Transpower is also required to operate its infrastructure in order to keep lights on.

63. Transpower has looked into the options available for reducing noise effects. Transformer technology is constantly improving and quieter transformers have been recently installed at Frankton substation when the existing transformer capacity needed to be increased. Transformers are imported from overseas and are very expensive. It is uneconomic to replace transformers ahead of their replacement schedule. It would cost approximately an additional $2 million dollars to bring forward a transformer replacement by 10 years. Such costs are ultimately borne by the local electricity consumers.

64. As a State Owned Enterprise, Transpower's funding is subject to regulatory constraints and Transpower is required to spend its approved funding efficiently. The Commerce Commission has approved a base capex amount for Transpower. This amount has been calculated on the basis of specific maintenance and replacement assumptions. If funding is not allocated in accordance with these assumptions, Transpower could face funding issues when immediate and scheduled maintenance or upgrade work is required. There is a real risk to security of supply if Transpower cannot carry out scheduled work when required.

65. Substations also present EPR risks and have EPR contours around them. As discussed above, EPR occurs when a large short circuit fault current flows from the source into the ground. It exists for parts of a second until the protective devices within the power system can disconnect the faulted equipment and remove the fault current. As the ground has resistance, a voltage or potential is briefly created at the point of injection when compared to some other point. This potential difference can cause hazardous voltages to appear many meters or

tens of meters away from the actual fault location. Many factors determine the size of the potential rise and therefore the level of hazard. These factors include the size of the fault current, soil type, soil moisture, temperature, underlying soil structure layers, the system configuration and the time to interrupt a fault.

66. EPR can cause electric current to flow through people in the affected area at the time. The impact of that ranges from a discomforting feeling through to a serious injury or death. Although the likelihood of an EPR event occurring and injuring a person near a substation is extremely low, the potential consequences are high. I consider that in order to mitigate the risks of EPR events it would be prudent to manage subdivision and new sensitive land use around substations.

67. In my experience, the effects discussed above are experienced mainly by people occupying the space near substations. The effects reduce the further away people are located from a substation.

68. In my view, engineering solutions such as premature replacement of equipment, hardware and substation components, and property agreements (such as so-called 'no complaints' covenants registered against titles) are not a complete or enduring solution. There are other, more enduring ways of avoiding or minimising effects such as noise while enabling development to occur and still ensuring the substation can operate as efficiently as possible. The more enduring and proactive approach is to control the location of subdivision and new sensitive land use around substations.

Appropriate Management of Risks and Effects

69. Transpower prefers, wherever possible, to manage risks and effects proactively. Engineering design can only offer a partial solution to issues arising from intensification. Proactive management through appropriate planning rules such as setbacks (or buffers) is the most effective way of ensuring development occurs in a manner that is compatible with the National Grid. Compatible development benefits both parties. Development can still occur and Transpower can make the best use of its substation in the long-term.

70. The most efficient way of avoiding noise issues is, wherever possible, to locate buildings and sensitive activities away from substations. I have been involved recently with substation and subdivision developments in Kaiapoi, Piako and Cambridge. Transpower worked with the developers to ensure adequate setbacks, buffer areas such as wetlands and stormwater ponds, and no-complaints covenants were in place at the subdivision planning stage. Transpower can work with developers to determine appropriate sound and visual barriers (such as hedging and bund fences) so that landowners are not exposed to unreasonable noise, visual and other effects from substations. Through working with developers Transpower can, in turn, continue to supply a reliable and cost-effective supply of electricity to the community while minimising our effects on its neighbours.

71. Transpower takes a prudent approach to managing its assets and is willing and happy to work with the community to achieve sustainable and compatible development around the National Grid. Proactive management of effects will defer the need for new equipment and infrastructure and, in turn, help to minimise the cost and environmental footprint of the Grid for future generations living in Queenstown.

The need for setbacks from Frankton substation

72. The Frankton Substation located at 93 Frankton-Ladies Mile Highway, Frankton and has a total site area of 2.4559 hectares. **Appendix C** of this evidence provides an annotated aerial photograph of the Frankton substation. I consider that a 45m setback is appropriate around the boundaries of the Frankton substation. This will effectively manage the reverse sensitivity effects of substation operation, maintenance and upgrade and the small EPR risk. Within this corridor, buildings and new sensitive land use should be carefully designed and planned.

73. The recommended 45m setback around the Frankton substation is shown in **Appendix D**.

74. The area does not need to be a clear area where nothing can occur. If Transpower is notified of a new sensitive land use within this area, Transpower will be able to work with developers and landowners to

ensure development is appropriately designed and does not compromise the National Grid or give rise to safety issues.

75. Consultation and appropriate design can result in improved outcomes for all parties. For example, Transpower may be able to suggest layout options such as the location of bedrooms away from the substation which may in turn minimise noise effects. Similar management measures include double glazing of windows and the location of stormwater infrastructure and greenbelts which can make efficient use of the space between a substation and adjoining development. Measures such as this can go a long way to ensuring enduring outcomes that benefit Transpower and our neighbours.

76. For example, Transpower has worked for a number of years with the developer of a major residential development around the Kaiapoi substation. The mitigation for the substation included a commercial development with a solid wall against one substation boundary which shielded the residential development from the substation. In another boundary the car parking for the commercial centre is being developed. On the boundary where residential development is occurring immediately adjacent to the substation the mitigation includes an earth bund and acoustic fencing being installed and a minimum 35m setback from the substation yard. A no complaints covenant is also being placed on the titles to protect the operation of the substation. Transpower supports responsible and integrated development like this.

77. Appropriate design that takes the substation into account can still allow development to occur while also minimising hazard risks, reverse sensitivity and other effects.

Conclusions

78. The National Grid is enduring critical infrastructure, both locally and nationally. Transpower does not want to prevent development, but development under and near to National Grid infrastructure does present risks and needs to be managed carefully and proactively.

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Andrew Renton

2 September 2016

APPENDIX A: CALCULATING THE WIDTH OF TRANSMISSION CORRIDORS REQUIRED BY THE NPSET

1. To calculate appropriate corridor widths to address the NPSET, a set of standard line types, based on voltage and structural configuration have been developed. The location of the conductors for various asset types was used as the basis for calculating the corridor widths. Following analysis, it was determined that the conductor location (swing) is most sensitive to the wind speed and span length.

2. The distance a conductor swings in the wind is dependent on the ambient temperature, the power being carried, the wind speed, the type and size of conductor, the tension the conductor is strung at, the supporting structure configuration (cross arm length) and the length of the span (distance between two towers).

3. An ambient temperature of 10ºC, a wind pressure of 100Pa (46km/hr), full electrical load and the conductor type applicable for the line type were assumed for each transmission corridor. This is described as "everyday condition". A range of swings was then determined for each line type.

4. The width of transmission corridors was then determined by the swing of the 95th percentile span and access requirements for maintenance purposes. The 100th percentile span would have resulted in a much wider corridor, even though this is not necessary for the majority of spans.

5. The photo below illustrates the effect of conductors swinging out on the Benmore-Haywards A line. This is not uncommon when strong winds are blowing at right angles to the line. The amount of transverse conductor swing is not well understood be people outside the transmission line engineering community. The calculation of this swing is a complex calculation, however is essential to manage activities within the National Grid Corridor.

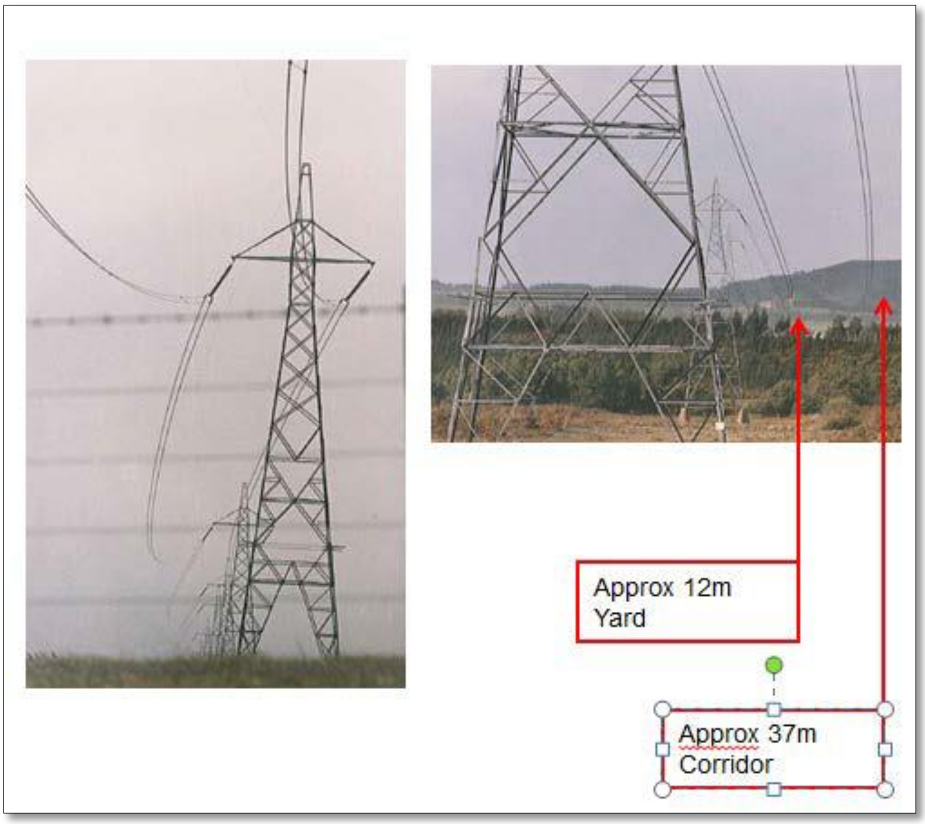


Photo 1: Conductor swing in high wind

National Grid Yard

6. This analysis resulted in the identification of a 12m National Grid Yard that would apply to land use for tower lines (coinciding with the everyday wind conductor position) and a wider corridor for subdivision (ranging from 32-39m (depending on the line) either side of the centreline).

7. The 12m National Grid Yard is calculated as the distance from the centreline between the support structures (tower or pole) to the point where the conductor would swing under everyday conditions. These are the conditions when maintenance may be carried out, as work is not generally undertaken during high wind conditions. Structures and activities within the 12m National Grid Yard are effectively directly under the conductors under low winds.

12m setback around structures

8. Transpower seeks a 12 metre setback around structures. This will usually provide just enough access and working space for most of our planned maintenance activities. In some cases, especially for large scale maintenance or upgrade work, linesmen will require a larger area than 12m around structures. If that is not available, they will need to come up with an alternative 'workaround' solution (for example bypass lines) which could take longer, cost more and could also present a riskier working environment for them.

9. Transpower acknowledges that large scale maintenance and upgrade work happens infrequently and so a pragmatic approach needs to be taken. Provided there is reasonable access and a space of at least 12 metres around structures (and 12 metres either side of the centreline), most foreseeable maintenance work can be carried out. Where space is naturally or historically restricted, Transpower would consult with the landowner to find an alternate solution.

10. The 12m buffer area around structures has a range of other purposes, as identified in my evidence. A 12m buffer area around structures will assist to:

    (a) provide sufficient room to get in mobile plant, drilling rigs, concrete machines, piling rigs, cranes and the like around the site to work and makes Transpower's activities more efficient;

    (b) better manage external effects through clear working spaces (e.g. catching falling debris, paint spatter and other contaminants);

    (c) provide access for inspections, maintenance and upgrades by preventing buildings within that area;

    (d) reduce the risks of third party excavations damaging structure foundations and threatening the stability of the towers and poles; and

    (e) minimise the risk of electrical hazards such as flashovers and step and touch voltage transference.

11. Transpower's maintenance and upgrade activities also increase the risk of damage to third party buildings and structures in this area, and land uses that have any particular sensitivities to transmission lines are likely to suffer the highest sensitivity in this area. A 12m buffer area will minimise damage to third party buildings and structures, and reduce the sensitivity experienced by those land uses. A 12m setback around structures also closely aligns to mandatory distances prescribed in NZECP34.

National Grid Subdivision Corridor

12. The Subdivision Corridor is calculated as the distance from the centreline between the support structure (tower or pole) to a point where the conductor would swing under high wind conditions. Accordingly, the Subdivision Corridor is much wider than the 12m Yard. Structures and activities within the Corridor could be under the conductors in high winds. The relevant distances from the centreline for the Corridor are as follows:

(f) 14 metres for 110kV transmission lines on single poles;

(g) 16 metres for 110kV transmission lines on pi poles;

(h) 32 metres 110kV transmission lines on towers (including tubular steel towers where these replace steel lattice towers); and

(i) 37 metres for 220kV transmission lines.

New Build

13. The corridors Transpower seeks to give effect to the NPSET are different from the corridors Transpower would seek for new build.

14. For new build Transpower seeks a clear corridor, that generally coincides with maximum swing of the relevant line – as this is the area where the effects of, and on, Transpower's assets are greatest. Corridors for recent new build include:

(a) Brownhill – Whakamaru North - The corridor width is 50 metres wide along the line, but is wider where additional width is needed (for example in the South Waikato District it is 130 metres minimum);

(b) Wairakei - Whakamaru C – The corridor width is 50 metres wide along the line, but is wider where additional width is needed;

(c) Gore Hard Tee – The corridor width is 50 metres wide along the line and 69 metres wide for the tee area; and

(d) Paraparaumu Tee – The corridor width is 90 metres wide along the line.

15. Transpower seeks a corridor that is clear of buildings and structures (other than fences) and restricts all earthworks unless Transpower agrees. Such a restrictive approach is not considered appropriate for the corridors that are required to implement the NPSET – those corridors are the minimum Transpower requires, and are a compromise position.

APPENDIX B – BASIC COMPONENTS OF SUBSTATIONS

1. The primary purpose of a substation is to connect two or more transmission lines together and change alternating current (ac) power from one voltage to another (e.g. 220 kV to 110 kV). This needs to be done because it is inefficient to directly connect electricity consumers to the main transmission network, unless they use large amounts of power. A substation reduces voltage to a level suitable for local distribution.

2. Key substation facilities, and their functions, are:

   (a) **buildings** to house protection relays, communications equipment, miscellaneous electronic equipment, battery banks and high voltage indoor switchgear;

   (b) **circuit** describes a power carrying electrical connection between two locations. An overhead transmission line typically carries either one or two circuits;

   (c) **circuit breakers** to switch lines, cables and transformers in and out of service (see **Photo 1**);

   (d) **disconnections** and **earthing switches** to isolate and earth items of high voltage equipment for maintenance;

   (e) **electrical busbars (busses or buswork)** that span stations to interconnect overhead lines and underground cables;

   (f) **instrument transformers** to measure power system voltage and current;

   (g) **lightning protection masts and wires** to shield the substation equipment from direct lightning strikes;

   (h) **power transformers** to step the electrical voltage up and down between generation, transmission and distribution systems (see **Photo 2**);

(i) **protection relays** to detect electrical faults on the electricity transmission grid and automatically remove an individual line, transformer or able circuit from service during an electrical fault;

(j) **shunt capacitor banks** and **static var compensators (SVCs)** to generate or absorb reactive power for the purpose of power system voltage control;

(k) **substation gantries –** inverted U-shaped steel structures to support the ends of incoming transmission line conductors and substation strung busbars;

(l) **surge arresters** to absorb fleeting voltage spikes such as lightning that may otherwise cause electrical flashovers or damage insulating materials inside the high voltage (**HV**) or extra-high voltage (**EHV**) electrical equipment;

(m) **switchgear –** a general reference to all types of circuit breakers and disconnectors; and

(n) **switchyard**, which generally describes the area bounded by a security fence containing HV/EHV electrical equipment.

3. The term “substation” is usually defined as an electricity station that has power transformers. An electricity station without power transformers is often called a “switching station” although not as common in New Zealand. A “cable transition station” is a small station to connect an overhead line to underground cables. Some Transpower substations are located at and called “power stations” because they were originally built by the New Zealand Electricity Department, or its predecessors (the State Hydro Department and the Public Works Department), which owned and operated all major power stations, substations and transmission lines before 1990.

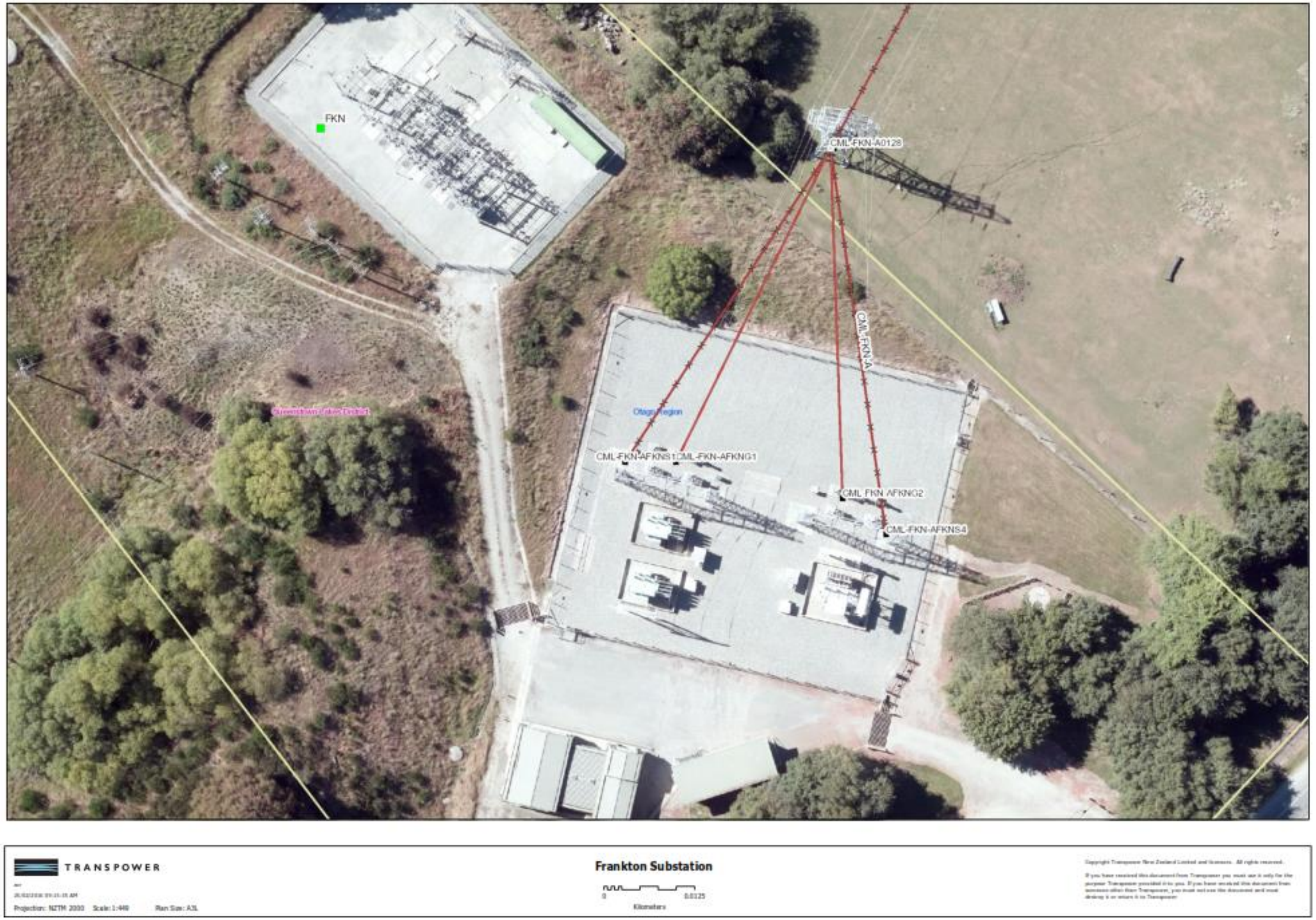
4. Two substation equipment technologies are in common use today. They are air-insulated switchgear (**AIS**) and gas insulated switchgear (**GIS**). AIS has been in use for over a century and is still being installed around the world today. GIS technology was developed in the 1960s and is becoming more common as power utilities build substations on

smaller sites, in the basements of city buildings and even beneath city car parks. However, being considerably more expensive, GIS equipment generally is used only where AIS is unsuitable.

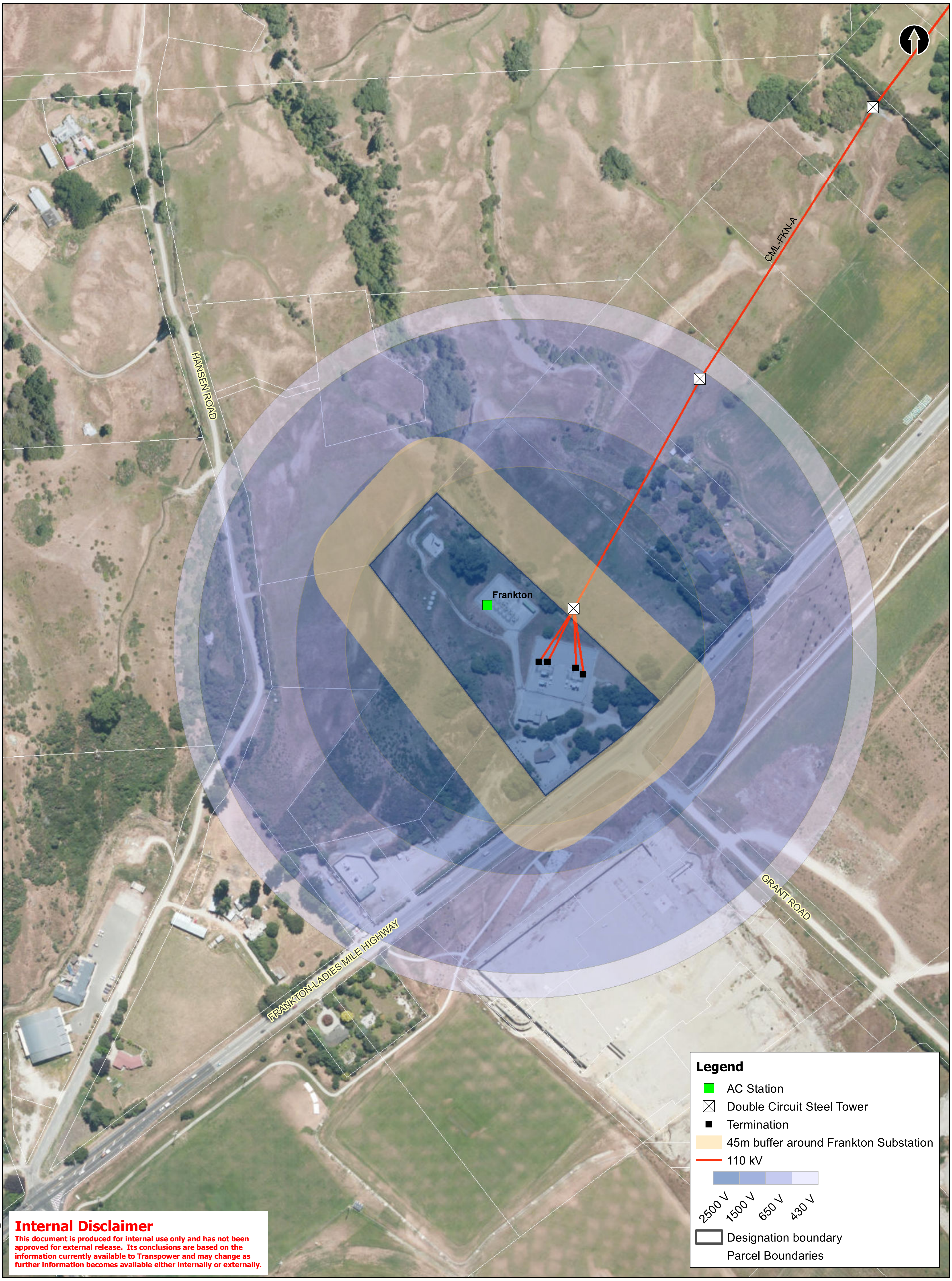
Photo 1: Circuit breaker, Current Transformer, Disconnector

Photo 2: Marsden, Power Transformer

APPENDIX C – FRANKTON SUBSTATION



APPENDIX D – FRANKTON SUBSTATION AND SURROUNDS



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TRANSPOWER
Prepared by: Geospatial & Drawings

Frankton Substation and surrounds

Projection: NZTM 2000 Scale: 1:2,740 Plan Size: A3P

0 0.04 0.08 Km

Date: 1/09/2016 *Drawn by: amara*