Before the Hearing Panel for the Proposed Porirua District Plan

Under	the Resource Management Act 1991 (the Act)
In the matter of	the Proposed Porirua District Plan – Hearing Stream 4: Strategic Directions, Energy, Infrastructure and Transport, General District-Wide Matters
Between	**Porirua District Council** Local Authority
And	**Transpower New Zealand Limited** Submitter 60 and Further Submitter FS04

Statement of evidence of Benjamin Roy Cartwright for Transpower New Zealand Limited

Dated 21 January 2022

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1 Summary of evidence

1.1 Transmission line components require ongoing inspection and routine maintenance, to address aging, wilful damage or corrosion and degradation due to wind, rain and pollutants. Physical access to transmission lines is required for all maintenance and project work, including for staff, vehicles, helicopters and large construction equipment. A regulated transmission corridor is essential for providing adequate access and working space at the poles, towers and mid-span.

1.2 Prudently designing buildings, structures or activities with the transmission line in mind (including beneath conductors (i.e. the wires)) ensures vital National Grid (**Grid**) infrastructure is protected and can be maintained and upgraded. ‘Under-build’ can delay, restrict or compromise the ability of Transpower New Zealand Limited (**Transpower**) to undertake maintenance or project work.

1.3 When a system fault occurs, the Grid would need to be restored quickly to reduce impacts on businesses and communities throughout the Porirua District, and beyond. Restoring supply becomes challenging if transmission lines are difficult to access due to intensive developments that may be constructed under and around them. Undergrounded transmission lines can have significantly longer restoration times.

1.4 Transpower operates its assets as safely as possible, but there are risks due to the high voltages being carried on the network. Lethal electric shocks can be caused by earth potential rise (step, touch and transferred voltages), conductor drop and flashovers. Hazards can also be caused by trees, mobile plant and other materials coming into contact with overhead lines.

1.5 Transmission lines can also cause concern or annoyance, because of how they look, their mechanical or electrical noise, electrical interference, and perceived health effects. These effects can lead to requests for Transpower to underground lines, or relocate lines, or to raise or lower conductors.

1.6 The 12m National Grid Yard (either side of the centreline) is the area (measured horizontally) beneath the conductors in “everyday” wind conditions, being the conditions when line maintenance can be carried out. A 12m setback around each tower or support structure is also required for access, maintenance and safety purposes. The wider National Grid Subdivision Corridor is the area sought for subdivision which extends to the width defined by the swing of the conductors in high wind conditions. These areas are the bare minimum to ensure that Transpower's maintenance, repair, upgrade and operation activities are not compromised.

1.7 A National Grid Substation Corridor is sought for the Pāuatahanui substation, it consists of a 30m setback from the secured yard. This corridor is sought to manage reverse sensitivity and other effects of any new sensitive activities around these sites.

1.8 Sensitive activities, commercial buildings and intensive development (including some farm buildings) should be avoided beneath transmission lines because of electrical risk, annoyance caused by the transmission lines, and the challenges presented by these activities when Transpower needs to access, maintain, upgrade and develop the lines.

1.9 Hazardous substances, in particular, should be managed carefully near transmission lines. Poor management of these substances can lead to unacceptable risks to the wider public.

1.10 Earthworks also need to be managed to take the lines into account in all areas. Earthworks can prevent physical access to transmission lines and undermine the structural integrity of support structures or reduce conductor to ground clearances to unsafe levels.

1.11 Transpower should also be given the opportunity to comment on applications for subdivision in the vicinity of the corridor and lines, as these issues are best addressed early.

2 Qualifications and experience

2.1 My full name is Benjamin Roy Cartwright.

2.2 I am employed by Transpower as an Engineer – Lines within the Tactical Engineering Team.

2.3 I have a Bachelor of Engineering in Mechanical Engineering from the University of Canterbury. I am a member of Engineering New Zealand.

2.4 I have 4 years' experience in transmission line engineering work. I currently work in the Grid Development Division of Transpower. My role involves providing transmission line engineering advice and support, writing and reviewing standards and specifications for design, construction and procurement, supporting projects, reviewing design deliverables and ensuring construction quality.

2.5 I am familiar with the National Grid assets within the Porirua District Council's jurisdiction.

2.6 I have read the statements of evidence of **Ms Pauline Whitney** and **Ms Rebecca Eng** for this hearing and have taken these statements into account in preparing this statement of evidence. I support the planning solutions which their evidence recommends.

3 Code of conduct

3.1 I confirm I have read the Code of Conduct for Expert Witnesses contained in the Environment Court Practice Note 2014.

3.2 As I am employed by Transpower, I acknowledge that I am not independent, however I have sought to comply with the Code of Conduct when preparing this evidence. 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.

4 Scope of evidence

4.1 My evidence will cover:

a The basic components of an overhead transmission line, as well as a description of the factors relevant to undergrounding lines;

b How Transpower operates, maintains and upgrades the National Grid, including the activities commonly carried out;

c Why access and clear working space are important for operating, maintaining and upgrading the National Grid;

d The risks to third party activities arising from the National Grid (such as electric shock, earth potential rise, conductor drop, flashovers and structure failures);

e The risks to transmission infrastructure arising from the activities (such as earthworks or vegetation) of third parties undertaken close to the National Grid;

f The potential impacts of other activities on the National Grid, including those sensitive to the National Grid or otherwise incompatible; and

g How risks can best be managed, including through the use of corridors.

PART A – ACTIVITIES UNDERTAKEN BY TRANSPOWER

5 Basic components of an overhead transmission line

5.1 Overhead transmission lines consist of five basic components (described in greater detail in **Appendix A**):

a conductors (wires);

b structures;

c insulator sets;

d foundations; and

e earthwires.

5.2 Transmission line components are designed to perform particular functions, and it is often difficult (or not possible) to change their look, location, or size to minimise adverse effects, without compromising that function. The majority of components used on a transmission line are manufactured to standard designs which are used all around the world.

5.3 When determining structure requirements, a compromise is made between the number of structures, structure strength and the structure height. The taller and stronger the structures, the fewer structures that are required. This is evident when you compare a typical pole line to a tower line - significantly more poles are required than towers to traverse a given distance. Generally, the higher the voltage of the transmission line, the taller the structures needed to support the conductors, due to electrical clearance requirements.

6 Operation, maintenance and upgrade of transmission lines

Inspections of National Grid assets

6.1 To ensure the National Grid delivers a safe, secure and reliable electricity supply, all assets need to be patrolled and inspected on a regular cycle.

6.2 Transpower carries out routine patrols and condition assessments to determine maintenance, refurbishment or upgrade requirements.

6.3 The frequency of inspections depends on the asset's age and type, its environment and its geographic location. This includes, for example, whether the asset is located in a high risk area, such as where lines are located above major roads, rail or urban areas.

Routine patrols

6.4 A routine patrol involves viewing every asset annually, at a minimum, to identify any defects or situations that may affect the operation or safety of the National Grid in the short term. Items identified on patrols include damaged or broken insulators, impediments on the conductors, vegetation growth, access issues, land subsidence, and developments or activities under or near the lines.

6.5 Unsafe developments or activities under or near the lines may only be identified by Transpower once per year. This assumes that the unsafe activity occurs or is present on the day of the patrol, and that it is noticed by the patrol team.

6.6 The fact that unsafe developments and activities may occur for some time before they are identified is a further reason why Transpower seeks provisions in the Proposed Plan to assist land users to adopt safe operations and practices to begin with.

Condition assessments

6.7 A full condition assessment involves every line component being inspected and, in some cases, tested on a time-based schedule. Condition assessments are undertaken every three to seven years, depending on the asset type and the environment the asset is located in.

6.8 Condition assessments require vehicular access to all transmission line structures and conductors.

How patrols and assessments are undertaken

6.9 Routine patrols and condition assessments of towers are carried out by field staff or contractors using a 4 wheel drive utility vehicle or an all-terrain vehicle to get as close as possible to the base of each structure.

6.10 Transpower's conductor condition assessment inspections also include the use of drones and helicopters for closer observation of developing defects by taking thermal images and high-resolution photographs. This allows more detailed mid-span inspections of conductors, conductor joints and hardware as part of the condition assessment programme.

6.11 Conductor tests are also carried out by a remote-controlled conductor robot that travels down the span taking images and data and relaying this to a computer on the ground. Alternatively, it can be done by line mechanics accessing the conductor via a conductor trolley or by being suspended under a helicopter, mid-span, to measure joint resistance by testing.

Maintenance activities

6.12 From these routine patrols and condition assessment inspections, a wide range of maintenance work is identified and incorporated into a consolidated work programme. The work programmes are developed to ensure components are replaced or refurbished well in advance of their failure point.

6.13 Transmission line structures can be maintained almost indefinitely by practices such as painting of towers, concrete encasement of existing grillage foundations and replacement of insulators and conductors.

6.14 The maintenance activities that occur most frequently (some of which involve earthworks) are:

- a foundation refurbishment;
- b tower refurbishment including abrasive blasting and painting;
- c all aspects of tower conductor and insulator (and associated hardware) maintenance or replacement;

d vegetation and tree control; and

e Earth Potential Rise (**EPR**) mitigation.

6.15 Transpower has an ongoing programme of planned maintenance work to be undertaken in the Porirua District.

6.16 Within Porirua, planned maintenance works include those listed above, noting that the assets will need to be maintained beyond the life of the District Plan and therefore any buildings, structures and activities allowed now (or during the life of the Proposed Plan) will have longer term implications for the Grid.

Foundation refurbishment

6.17 Tower foundations include grillage foundations, i.e. directly buried steel.

6.18 Inspecting these foundations requires the whole foundation to be dug out on all four legs using earth moving machinery such as excavators.

6.19 If the foundation needs to be excavated, the tower must first be supported using props or guy wires before excavation.

6.20 **Figures 1 and 2** below give an indication of the amount of spoil and land disturbance required for a typical grillage foundation strengthening project.

Figure 1: Tower Grillage foundation replacement

Figure 2: Land disturbance during foundation replacement

Tower refurbishment

6.21 Tower painting is a significant on-going maintenance project for Transpower.

6.22 Painted transmission towers have a coating life of approximately 14-18 years. The timing varies, depending on the environment where the tower is located.

6.23 Once the galvanising on a tower reaches its end life, the bare steel shows a combination of alloying with rust breakout in more corrosive areas (see **Figure 3**).

6.24 The longer a tower is left to corrode, the more extensive the steel surface preparation is, therefore increasing the cost of the painting work. Additional tower steel and bolt replacement may also increase with time due to excessive corrosion.

Figure 3: Tower corrosion

6.25 Tower painting can be disruptive for people who live and work near towers because of the preparatory activities required.

6.26 Prior to painting towers, wet abrasive blasting may be undertaken. This can cause material to become airborne. People and property located near this activity (i.e. where lines are "under-built") need to be protected from this material. **Figures 4** and **5** (below) show houses and cars being draped with protective covers during abrasive blasting. As seen from these photos, not all effects (such as debris and emissions of airborne particles) can be eliminated or fully mitigated using covers due to the complex terrain.

Figure 4: Tower painting in an urban setting, note the extensive polythene sheet protection

Figure 5: Tower painting in an industrial setting showing garnet debris falling onto covered cars

6.27 By comparison, in areas where there is no under-build, methods such as geotextile matting laid under the electricity transmission structures can more easily capture debris from tower painting (see **Figure 6** below).

Figure 6: Abrasive blasting in area with no under-build

6.28 In areas with under-build, Transpower's resource consents can direct the use of less intensive blasting, hand tool surface preparation or painting processes. Not only does this increase costs (by $15,000-$20,000 per structure) due to lower productivity, it also reduces the quality and life of the paint system as the surface preparation is of lower specification. As a result, towers need to be painted more frequently (every 7-10 years, instead of every 14-18 years), leading to more frequent disruption to the people living or working under the electricity transmission lines.

Conductor repair and replacement

6.29 Conductor repair and replacement is a significant part of transmission lines management. This is due to conductors reaching their end of life or conductors requiring upgrading to ensure a resilient National Grid.

6.30 Conductor repair and replacement work involves:

a stringing and tensioning work sites to locate pullers and tensioners; laying down sites; storage; as well as an area for working;

b accessing each tower to remove the existing insulators and installing stringing equipment, such as running blocks;

c tower and foundation strengthening, where necessary;

d enabling works, such as parallel body extensions (shown in **Figure 8**), midspan earthworks, new structures and others, as necessary;

e rewiring (using the old conductor to pull out the new conductor);

f sagging operations at each tower to ensure even and consistent sag profiles;

g reinstalling the insulators, including clipping in the conductor; and

h removal of plant and reinstatement of land.

6.31 In order to undertake maintenance work, and upgrades if required, appropriate access to the National Grid must be retained. This is particularly important to consider when consent authorities are assessing proposals to change land use or to subdivide land.

6.32 Access for maintenance work on simplex conductors presents additional challenges compared to working on a duplex conductor[1]. For example, access to simplex conductors is usually limited to ground base operations using elevated work platforms or cranes or lowering the conductor to the ground. In some cases, it is possible to suspend line mechanics (i.e. staff or contractors) from helicopters, but this involves long periods of helicopter time while the work is being carried out below.

Figure 7: Maintenance work being carried out using helicopters

[1] The difference between a simplex and duplex conductor is shown on the diagrams contained in Appendix A. In Porirua both simplex and duplex arrangements currently exist.

Figure 8: Parallel Body Extension being installed on the BPE-WRK-A line

Figure 9: Conductor trolleys on duplex conductor

6.33 For duplex conductors, access can be arranged using line mechanic conductor trolleys or helipods (see **Figure 9** above). Conductor trolleys or helipods are suspended using both conductors of a duplex configuration to hold the trolley in place. The trolleys have four wheels which allows them to move along the spans between towers.

6.34 From time to time, Transpower needs to access the conductors at mid-span for inspection purposes or to carry out repairs. Mid-span damage can be caused by lightning or corrosion damage, or could be caused by third party activities under the electricity transmission line, such as smoke or fires; vehicle or mobile plant contact/flashover;[2] or vegetation touching and causing flashovers.

6.35 Conductor replacement or mid-span conductor repairs include inserting new sections of conductors, new joints, mid-span repair joints or sleeves. This work requires a relatively clear area under the electricity transmission line where the works are carried out. In some cases, such as wholesale reconductoring of the line, this clear area may be along the entire line.

6.36 Conductor repair methods include inserting new sections of conductors, new joints, mid-span repair joints or sleeves and removing impediments such as kites, balloons, and electric fence wires. In all cases, access to the conductor is necessary.

6.37 Mid-span under-build, particularly dwellings and buildings forming part of intensive developments (where people and activities are most inconvenienced), creates significant additional costs for Transpower when carrying out any reconductoring or mid-span repair works.

6.38 There will be cases where this work cannot be undertaken efficiently due to the presence of people or an inability to position plant where required. Alternatives, such as building a new or bypass line, may need to be considered. In some instances, it may be necessary to consider temporarily relocating people living and working under the line - at significant inconvenience and cost to all concerned.

6.39 In an urban environment, a reconductoring operation can cause inconvenience to the community by restricting vehicle and pedestrian access to public or commercial areas such as schools, businesses, and parks. Some

[2] A ‘flashover’ means coming into contact with the line conductors or where the electricity arcs from a conductor onto an object such as a structure or vegetation that is too close to a line.

commercial and industrial activities may need to shut down during conductor repairs, and/or can be affected by helicopter use.

6.40 To provide a safe work site, an area may be closed off, particularly in a span where there is potential for inadvertent loss of control of load or machinery failure.

6.41 Intensively used buildings and commercial operations risk compromising Transpower's ability to maintain the line (as it can be difficult to shut down the premises) and are at higher risk from electrical hazards during their day to day operations (due to number of people on site and the use of large mobile plant). The emissions (such as smoke) produced by the activities undertaken under the line, and large mobile plant operating, can put the line itself at greater risk of damage or deterioration. Examples include high-level storage facilities, factories, large scale industrial buildings, commercial operations that emit dense smoke, dust or chemicals and high-density lifting operations involving forklifts, cranes, tip trucks and similar vehicles.

6.42 If allowed to be constructed under conductors, these intensively used buildings and commercial operations would need to either be vacated during reconductoring operations or protected by constructing high cost scaffolding and nets (see **Figure 10** below[3]). This assumes that there is sufficient space, and air clearance, on site for the construction of such structures, which is not always the case. Constructing and dismantling the scaffolding and netting needed to protect the undercrossing line in **Figure 10**, cost in excess of $350,000.

[3] Figure 10 shows live line scaffolding needed to protect the 110kV network while a 400kV line is being wired overhead.

Figure 10: Scaffolding protection structure for stringing

6.43 Reconductoring a typical existing line section would likely take 2-3 weeks. Even smaller maintenance work typically takes 8-12 hours. So, it is practically very difficult for Transpower to work around intensive industry operations without both parties incurring large time or financial costs.

6.44 I acknowledge that less intensively used agricultural and horticultural buildings are less vulnerable to disruption and may be able to locate beneath conductors – mid-span, subject to compliance with NZECP 34:2001 and provided that any associated activities do not pose risk to either the operator or the line (i.e. mobile plant intruding on the MAD.[4] These types of buildings can easily be vacated (or kept uninhabited) while maintenance activities are undertaken.

Undergrounding transmission lines

6.45 Transmission lines can be undergrounded in some situations to minimise impacts on sensitive activities. Usually lines are undergrounded before residential or commercial development is undertaken, as the process of installing underground cables at transmission voltages can require significant earthworks as shown in **Figure 11**.

6.46 Fault finding and repair on underground cables is significantly more difficult, costly and time consuming than on overhead transmission lines. It can take 6-

[4] MAD refers to the minimum approach distance which the Electricity Code of Practice defines as the minimum approach distances in and around transmission structures and conductors to avoid flashovers.

12 weeks to locate and repair an underground fault (compared to 1-3 days for an overhead line).This can place increased pressure on the rest of the network and reduce its resilience to subsequent events..

6.47 Undergrounding transmission lines may not always be technically feasible, because of ground conditions (such as fault lines, groundwater, streams/wetlands or geothermal activity). Even where is possible, undergrounding can be orders of magnitude more expensive.

6.48 The undergrounding of transmission lines can sometimes compromise the performance of National Grid due to the different electrical characteristics of a cable circuit.

6.49 In addition, where lines are undergrounded, it is important to control structures, activities and vegetation above the cables, to ensure they are not damaged, and can continue to be accessed. Cables are generally placed 1.5m – 2m below the surface and in addition to construction requirements, require an ongoing clear corridor above and around them of approximately 11-14 metres wide for physical and access reasons, and to minimise the impact of magnetic fields.

Figure 11: 110kV underground cable installation

Planning maintenance works

6.50 Transpower seeks to schedule its works, including any outages, to cause the least inconvenience to landowners and occupiers of land, industrial activity and the public. However, this is not always possible, meaning that it is sometimes necessary to access lines at short notice, for example to restore a circuit after an outage.

Maintenance work equipment

6.51 Depending on the type of maintenance work, the use of lifting machinery, stringing equipment, elevated work platforms or helicopters may be involved. Earth moving machinery, such as excavators or diggers, are required to expose or extract tower foundations or carry out tower refurbishment works.

6.52 For substantial works, a wide range of plant and equipment is sometimes necessary (see **Figures 12** and **13** below).

Figure 12: Removal of copper conductor

Figure 13: Crane being used for conductor stringing

Accessing and Clearing Work Areas

6.53 A clear working space and good access is required, particularly around the base of the towers, and in some cases under conductors, to move the plant and equipment in and set it up correctly. Cordons must be installed around the work site to minimise hazards and restrict access to everyone other than the trained work party. When work is carried out on a tower, the effective work area for health and safety purposes includes the spans of conductor either side of that structure.

6.54 For some projects, such as wiring or where alterations are being made to structures, temporary hurdles or bypass lines may be required, or properties may need to be evacuated to protect against potential conductor drop hazards. Replacing a conductor is the time when the risk of conductor drop is greatest.

6.55 **Figures 14** and **15** below show hurdles established at a work site, including the space required, and their mid-span location. Hurdles are installed to protect traffic on access roads from risks associated with dropped conductors (mainly during re-stringing). Similar projects in urban and industrial developments have required the evacuation of residents or workers for periods of up to a week.

Figure 14: Typical hurdles installed to mitigate potential conductor drop during wiring

Figure 15: More substantial hurdles installed to mitigate potential conductor drop during wiring

Figure 16: Reconductoring in an urban setting

Access for Planned Works

6.56 Transpower has:

a statutory rights to access its assets on private land under the Electricity Act 1992 (**Electricity Act**). The Electricity Act provides for access to maintain, inspect and operate the National Grid; and

b in some cases, contractual or property rights to access new assets that are located on private land.

6.57 In an ideal situation, Transpower would have unimpeded physical access to all transmission line structures. In practice, this is not always possible.

6.58 Physical barriers and natural obstacles, such as waterways, valleys, and undulating ground, require Transpower to use alternative access options, for example helicopters and/or walking in are sometimes required.

6.59 Intensive or sensitive developments constitute additional physical barriers to accessing transmission line structures, increasing the costs and difficulties associated with gaining access.

6.60 The quality of access is important as some construction plant, for example cranes and concrete trucks, require wider and lower gradient tracks than what are traversable by smaller vehicles. The existing access is usually the most suitable as it was generally used to construct the line. If the landowner decides that they wish to change the access, Transpower should be consulted to ensure that the new route will not impede future works on the Grid.

6.61 If the planning regime prevents the construction of fences and structures near the National Grid, this will avoid the need (and associated costs and delays) to dismantle fences and other structures, temporarily bridge waterways and/or carry out excavation or vegetation removal, just to access the National Grid.

Figure 17: Example crane access required for cross arm and insulator works

Access for Emergency Works

6.62 In the event of a fault, Transpower must always be able to quickly access its lines in order to find and fix the fault. Businesses and communities are heavily reliant on electricity, so it is crucial that faults are identified and fixed as soon as possible.

6.63 While Transpower's assets perform well in storm events or natural disasters, excessive winds and rivers changing course do at times break or collapse

National Grid infrastructure and emergency repairs need to be carried out to get these back into operation. During these times there is often a heightened requirement for electricity. The National Grid is a lifeline utility.[5]

6.64 Suitable, agreed access routes are important so as to not delay the restoration of services.

Scheduling Electricity Outages for Maintenance Works

6.65 Live line work is sometimes possible, but there are restrictions on the types of activities that Transpower's workers can undertake while a line is live.[6] Mid-span jointing, removing jumpers or conductors, lowering conductors to the ground for repairs, and some insulator replacements cannot be carried out while lines are live, either due to the nature of the work or to restricted worker distances from live equipment. Live line work involves a highly trained work crew and requires the same access, work areas and crew numbers as the traditional de-energised work methods.

6.66 Scheduling outages for maintenance is much easier in districts where the planning framework discourages activities near the National Grid. This is because there are fewer activities impacted by the outage and the maintenance work, and there are likely fewer stakeholders with whom Transpower would engage to schedule an outage.

6.67 The majority of maintenance outages are scheduled 18-24 months in advance. This allows time to co-ordinate the outage with electricity generators and electricity distribution companies, while minimising disruption to end users.

6.68 Limited outage windows make it difficult to maintain certain parts of the National Grid, and therefore make it more likely that costly upgrades will be brought forward as parts wear out more quickly if they are not maintained.

Co-ordinating outages with all stakeholders

6.69 Arranging outages is a complex process. For Transpower to gain access to its electricity transmission lines, it works with all stakeholders to minimise the impact of the works on their activities. This includes:

[5] Under the Civil Defence Emergency Management Act 2002.

[6] In this context, 'line' generally refers to the whole transmission line (ie conductors and support strucures). For double circuit lines (6 conductors) it is possible to have one circuit live and one dead. For single circuit lines (3 conductors) the line can only be switched on and off. The majority of Porirua City transmission lines are double-circuit.

a Landowners – discussed in more detail below;

b Maintenance contractors; and

c Electricity generators, major electricity users and local lines companies – which have requirements with regards to transmission capacity, and security. These stakeholders must be able to manage electricity demand within the remaining available Grid capacity while work is being undertaken.

6.70 Transpower must follow an Electricity Authority Protocol for outages, which includes consultation.

6.71 Coordinating a scheduled outage ordinarily requires Transpower to engage with all affected landowners along the length of a transmission line for each outage.

6.72 Landowner access requirements vary, depending on the types of activities they undertake. Farming or industry landowner requirements can differ to those for residential activities, for example access to some farms during lambing is restricted. The more activities, in number and in type, undertaken under the transmission line, the more differing their requirements.

6.73 Transpower aims to accommodate landowner requirements. This can lead to the fragmentation of work on the electricity transmission line to accommodate individual landowner access requirements, and may result in more outages at various times. This is not always possible to accommodate, because of competing needs of generation, distribution, system security, demand and access.

6.74 An optimised solution, that could meet all third parties' needs and would enable work on transmission lines to proceed, would be for such activities to not be undertaken under the electricity transmission lines in the first place. The district's planning framework could require activities to be located away from electricity transmission lines. This is especially the case for those activities that cannot be easily shut down in case the site must be used for works, or if the activities are likely to have reverse sensitivity effects on the National Grid.

PART B – REGULATING THIRD PARTY ACTIVITIES AROUND THE NATIONAL GRID

7 Managing the activities of others

7.1 The transmission network gives rise to specific risks, such as lethal electric shocks. These risks increase if there are incompatible activities located under the electricity transmission lines or other National Grid assets, or in close proximity to them.

7.2 Preventing sensitive and incompatible activities from establishing under the transmission lines, along with controls on activities that will occur near electricity transmission lines, will assist the National Grid to be reliable and safe while serving future generations.

7.3 A preventative approach to the management of the transmission corridors and a proactive approach to ensure safety for high risk activities regularly occurring under National Grid lines would lead to better outcomes for the National Grid assets and for third parties, as they would suffer less disruption of their activities.

8 Risks arising from the National Grid

8.1 The main hazard associated with high voltage transmission lines is electric shocks. The risk and severity of electric shocks varies depending on the transmission voltage and type of exposure (e.g. direct human contact, mobile plant, or vegetation). Risks are most likely to be highest within 12m of the centreline of a transmission line. However, some associated effects can be transferred beyond 12m.

8.2 Lethal electric shocks can be caused by:

- a EPR;
- b conductor drop;
- c flashovers (coming into contact with the line conductors or where the electricity arcs from a conductor onto an object such as a structure or vegetation that is too close to a line);
- d step and touch voltages; and
- e transferred voltages.

8.3 These hazards can occur as a result of third-party activities (such as mobile plant) encountering conductors, or earthworks occurring too close to structures or mid-span thereby reducing clearance distances. All of these things can endanger safety and compromise the operation of the National Grid.

EPR risks from towers

8.4 EPR ('earth potential rise') is usually caused by an earth fault at a tower. It is also a risk that can occur at substations. An earth fault occurs when an energised conductor comes into contact with, or flashes over to, the tower or any earthed object. This can occur through an insulation failure as a result of lightning, pollution or foreign objects.

8.5 During an earth fault, there is a significant current (5-40 times normal) flowing through the faulted line from the power source into the fault point. 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 and decrease along the ground as you move further away from the faulted tower. The area of risk can vary depending on the soil conditions, line configuration, and nature of the fault.

8.6 The earth fault current causes EPR around the faulted tower, which in turn results in "step and touch" voltage hazards and transferred voltage hazards (discussed below).

8.7 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 serious injury or death.

8.8 Step and touch, and transferred potential hazards from transmission tower structures, are low probability events. However, they are significant hazards because of the possible consequences.

8.9 A touch voltage can occur when a person or animal comes into contact with the structure while standing on the ground, thus causing a voltage difference between the feet and hands. A step voltage can occur when a person or animal is near a structure during a fault evident and a voltage difference occurs between the feet (see **Figure 18** below).

8.10 Transferred voltage hazards can occur where continuous long conductive structures or fences are located close to the tower. High current and voltage may transfer to them from the tower through the ground, and then travel some distance down these structures, causing an electrical hazard some distance from the faulted tower.

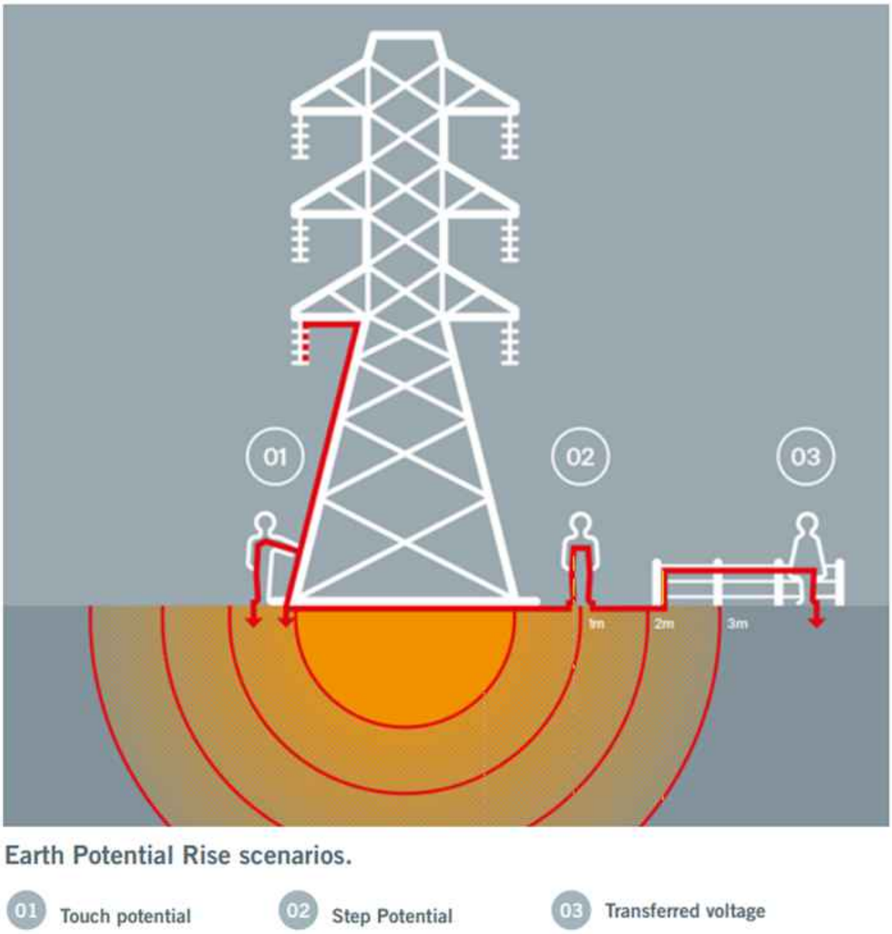

Figure 18: Earth potential rise scenarios

Conductor drop

8.11 The conductor can drop to the ground should a mechanical failure occur to the support structures, insulators and hardware, or the failure of pressed mid-span joints. In addition, electrical failure can lead to the mechanical failure of the conductor or the pressed mid-span joints.

8.12 While it is rare for a support structure, conductor, or the conductor hardware to fail causing the conductor to drop to the ground, it can happen (see **Figure 19** below).

8.13 Historically, most conductor drops have occurred in rural areas. On rare occasions, a conductor drop has occurred in an urban setting. In an urban setting, more intensive development places more people and property at risk.

8.14 The consequences of a conductor dropping can vary depending on the activities undertaken under the line. **Figures 19** and **20** below show the impact within a dwelling following a conductor drop. The internal electrical switchboard and appliances have been damaged by the significant transfer of voltages to earth from an adjacent transmission line.

Figure 19: A conductor drop

Figure 20: Electrical damage following a conductor drop

8.15 A conductor drop poses electrical risks, as well as the mechanical risks of a large load dropping. Conductors on a typical duplex 220 kV line weigh approximately 3 kg/m. For a typical span (300 m), the weight of the conductor at the point of impact could be as high as 900 kg. That weight could cause substantial property damage and risk to human health and safety.

Flashovers

8.16 A flashover is a major electrical discharge. Usually in the form of an electric arc, it leaps or arcs from the conductor across the insulator string to the tower (or from the conductor to another object) resulting in a short circuit.

8.17 Flashovers can occur from lightning strike, contamination of the insulator or when a person or object is too close to, or comes into contact with, the conductors.

8.18 Third party activities involving mobile plant or machinery, such as excavators, hi-abs and cranes, have the potential to reach up to, or above, the height of the conductors. It is essential that the use and location of such machinery is carefully considered to avoid close proximity or contact with the conductor. Coming into close proximity to a live conductor and causing a flashover (i.e. the flashover will occur prior to contact) can:

a compromise the safety of the machinery operators, workers or members of the public in or near the machinery and result in electric shock;

b damage the machinery or the line itself; and

c affect the operation of the National Grid and the security of supply.

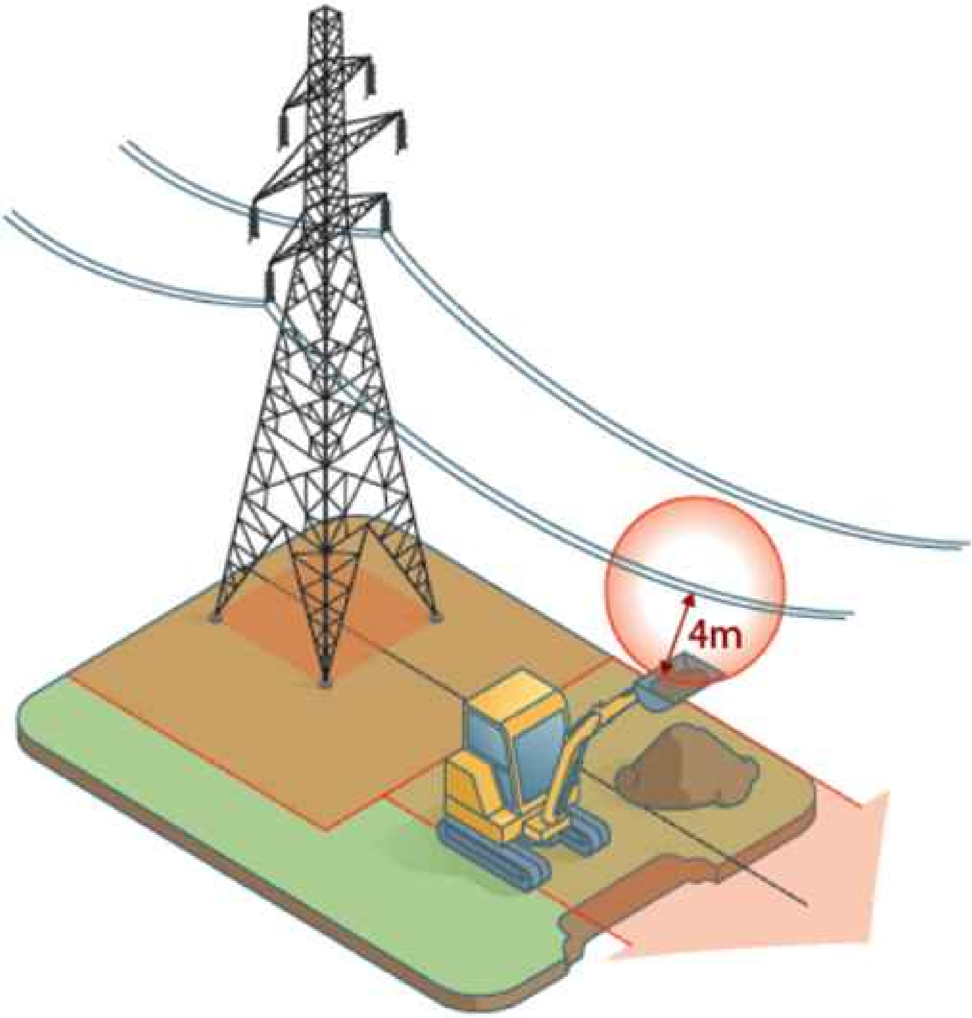

Figure 21: Minimum clearance required between conductor and mobile plant to avoid flashover

8.19 The risk of incidents such as these occurring increases if incompatible activities are allowed to be undertaken or are intensified under or near electricity transmission lines.

Equipment or structure failure

8.20 Transmission lines are designed to withstand specified levels of weather conditions (e.g. wind speed, snow, ice). If these levels are exceeded, it is likely that failure will occur. Failure events include broken or fallen conductors, collapsed towers or any other substantial component failure which results in high risk of property damage, injury and electricity disruption.

8.21 Transpower designs all components of the National Grid to withstand extreme events in accordance with international best practice. Transpower's assets have higher design specifications than lower criticality and consequence assets (such as distribution lines). This is in keeping with Transpower's civil defence responsibilities. In an emergency event, Transpower is required to continue functioning, to the greatest extent possible, both during and after the event.

8.22 Although the probability of a failure event is low, there is the possibility that injury or damage could occur if a person, animal or item of equipment is in the wrong place at the wrong time.

9 Risks arising from third party activities undertaken in close proximity to National Grid assets

Earthworks

9.1 Transpower seeks controls on earthworks near the National Grid.

9.2 Earthworks adjacent to towers or poles can undermine the stability of the structure foundations, causing the structure to lean or, worse, collapse.

9.3 Excavations or mounding mid-span can also increase risks by reducing the clearance between the ground and conductors. **Appendix B** includes some examples of earthworks activities that have created unstable batters or resulted in ground to conductor clearance violations, causing significant safety risks, as well as risks to security of supply.

9.4 One of the reasons Transpower seeks to manage earthworks undertaken by third parties (which includes quarry and landfill operators) is to mitigate, or at least significantly reduce, the safety risks described above. Physical separation from transmission infrastructure greatly reduces the likelihood of harm or damage occurring to people or property. However, Transpower is comfortable with provisions that align with NZECP34:2001 (albeit that the physical separation standards are sought in the plan for broader reasons than safe electrical separation distances, as detailed below).

9.5 Earthworks can cause dust which results in the build-up of material on the National Grid lines and contributes towards the degradation of the equipment, thus reducing its useable lifespan.

9.6 Excavated areas or piles of earthworks soil can also restrict Transpower's ability to access and locate the heavy machinery required to maintain and upgrade support structures. This can lead to potential line component failure and significant constraints on the operation of the lines, such as increased power outages.

9.7 For these reasons, Transpower seeks controls on earthworks near the National Grid.

9.8 In determining appropriate setback distances for earthworks from National Grid support structures, a common assumption is the National Grid is not compromised if the earthworks comply with NZECP 34:2001. This is not the case. The example below (see **Figure 22**) illustrates that NZECP 34:2001, on its own, does not adequately ensure that the National Grid is not compromised.

Figure 22: NZECP34 compliant earthworks around a pole on the ARI-HAM-A line

9.9 **Figure 22** shows earthworks near a transmission line pole that are technically compliant with NZECP 34:2001. As a result of the earthworks near the pole structure, Transpower's ability to operate and maintain the line and structure at that location 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 are required to monitor the effects of erosion and to ensure the stability of the foundations.

Vegetation

9.10 If a tree touches or comes close to touching the conductors and causes a flashover, dangerous voltages may arise on the tree itself or in the ground area around the tree that can result in:

a a circuit fault that affects the operation and supply of the National Grid;

b injury or death to anyone who may be near the tree at the time of the fault; and/or

c damage to the tree, land or property.

9.11 Flashover to a tree where high voltages are involved can cause the tree to ignite and cause a wider fire hazard if the tree is near buildings or forests.

Figure 23: Tree damage from fire caused by a flash over

9.12 It is therefore vital that trees and all other vegetation are trimmed before they grow within 5m of a conductor (in any location). The proximity of vegetation to conductors should also be a consideration for land use activities such as subdivisions. Managed placement, trimming or cutting of vegetation will ensure that the Electricity (Hazards from Trees) Regulations 2003 are complied with. [7]

9.13 Landscaping to shield transmission lines from view is problematic due to the size of the infrastructure. If large trees are planted, care has to be taken to ensure that there will always be sufficient electrical clearance, without requiring excessive trimming, to avoid the issues covered in paragraphs 9.10

[7] For voltages of 110kV or higher, vegetation is considered a hazard once it is 4m from the conductor. A notice to trim or remove the vegetation can be given once the vegetation grows to 5m from the conductor. In practice, Transpower would cut two years growth off vegetation, so that a distance of at least 5m from the conductors is maintained.

and 9.11. There is a risk that if a large tree is not sufficiently distant from the transmission line and it falls, it may contact and damage the transmission line.

10 The potential impacts of other activities on transmission lines

10.1 In addition to potentially exposing people and property to the risks outlined above, third party development and activities in close proximity to overhead transmission lines can impact Transpower's ability to operate, maintain, upgrade and develop its infrastructure. Such activities can also give rise to reverse sensitivity effects.

10.2 Despite the National Policy Statement on Electricity Transmission ('**NPSET**') being gazetted over 12 years ago, under-build and inappropriate development continues to occur under and around National Grid assets and overhead transmission lines in particular (see **Appendix B** for examples).

Activities sensitive to National Grid assets

10.3 There are a range of activities that have sensitivities to Transpower's assets. These sensitivities include:

a electrical interference could have serious implications for places such as hospitals or rest homes which rely on the proper functioning of electrical equipment 24 hours a day;

b radio controlled systems and global positioning systems are also known to be affected by the close proximity of transmission lines. These systems are being used more commonly for communications and automated control systems in industrial processes;

c any residential development or intensification of other activities under transmission lines or close to support structures. As outlined in the evidence of **Ms Whitney**, the NPSET provides specific reference to sensitive activities (which include residential activities). The main hazard associated with high voltage transmission lines is receiving an electric shock. This is a risk which cannot be mitigated from an engineering perspective; it can only be avoided.

10.4 As noted earlier, people living or working in buildings under transmission lines create significant difficulties when Transpower needs to do maintenance, upgrade and development work.

Hazardous substances

10.5 Activities that involve, or introduce, large amounts of hazardous substances near transmission assets are a concern for Transpower in that they introduce substances which may be explosive or flammable in nature and pose significant safety issues, in addition to posing a risk to the operation of the Grid assets.

10.6 Examples of this type of facility are the establishment, or extension, of a service station development, or the storage of gas tanks under a line or adjacent to a substation.

10.7 The high-risk profile these activities could pose to an unknowing public, coupled with known mitigations, mean that Transpower need to be involved in the design and decision making early to ensure the risk is either avoided or mitigated.

10.8 For example, the establishment of a service station, with associated underground tanks, causes concerns from a risk perspective due to the potential ignition of fuel from EPR, transferred voltage or capacitive coupling induced sparking. However, if these issues are presented early on, they can be mitigated through simple design measures, reducing the risk to acceptable levels.

Preventing Transpower's access

10.9 Both land use and subdivision can prevent physical access to structures and the area of mid-span. **Figure 4** in **Appendix B** shows a dwelling constructed in Auckland that prevented Transpower accessing the tower for grillage refurbishment work.

Residential activities

10.10 Reverse sensitivity effects are caused by activities which are located near lines. They often relate to noise, visual, electrical interference, and perceived health and safety effects (humans and animals), as well as the limitations placed on land use in close proximity to the lines.

10.11 Physical separation of third-party activities from transmission lines can reduce the incidence of people who live and work nearby complaining about the line and requesting changes (i.e. limits or restrictions) to its operation.

10.12 The area or distance from the lines within which reverse sensitivity effects can arise may vary according to the type of issue raised, but they are most noticeable in the area to where the conductor swings out. Depending on asset type, this area can be out to 39m either side of the centreline.

Types of concerns raised about transmission lines

10.13 The presence of a transmission line can give rise to perceived health concerns and visual amenity issues, even some distance from the line.

10.14 In addition to general complaints arising from the presence of transmission infrastructure, Transpower also receives requests from landowners to underground existing overhead lines, raise conductors, or restrict future Grid works, particularly if they involve changes in visual appearance.

10.15 At the North Island Grid Upgrade Project ('**NIGUP**') Board of Inquiry into the then proposed 400kV capable Brownhill Road – Whakamaru North A line, a number of submitters raised concerns about both potential mechanical and electrical noise, and the potential effect on milking dairy herds in close proximity to the lines, as well as on the operation of sensitive electronic equipment such as radio-controlled systems. In most cases, these concerns were addressed by Transpower moving existing buildings away from the proposed line. It is noted that in general, Transpower seeks to avoid these existing activities where practical.

10.16 These complaints are much more difficult to address where new activities locate close to an existing transmission line, perhaps without understanding the effects that lines can have.

10.17 Noise can also give rise to complaints. Noise from a transmission line usually comes in two forms: mechanical noise and electrical noise:

a Mechanical noise can come from vibration which causes a rattle of the line hardware (insulator attachments, steel members) or from environmental events such as high winds (wind whistling through conductors or over steel works).

b Electrical noise usually comes from some form of electrical discharge, or leakage. This generally can be heard discharging down insulators when it starts raining after a long spell of fine weather. In some cases this corona discharge may be seen at night when insulators are polluted and electricity is seen discharging down from the conductor to the tower steel.

10.18 In some areas of New Zealand, landowners/occupiers have also raised concerns about electric and magnetic fields ('**EMF'**) from transmission lines. I note that Transpower's assets operate well within the limits in the International Commission on Non-ionising Radiation Protection Guidelines for limiting exposure to time varying electric magnetic fields (1Hz – 100kHz)[8] (known as the ICNIRP Guidelines). These Guidelines are recognised by the Ministry of Health and the World Health Organisation. However, that fact does not prevent people from making misguided complaints and lobbying in opposition to Transpower's activities.

10.19 Transpower's telecommunication assets comply with NZS2772.1:1999 Radiofrequency fields - Maximum exposure levels - 3kHz to 300 GHz. Other users of Transpower sites are also required to comply with this standard.

11 Management of risks

11.1 Transpower manages risks when designing and constructing new assets, and through continuous assessments and maintenance of the existing assets. For example, when earth faults occur, the current is interrupted by protective devices at each end of the line to clear the fault in a fraction of a second.

11.2 However, engineering solutions such as this are only part of the answer. It is also vital that third parties do not interfere with the proper operation of the line, and that appropriate maintenance and upgrade work can be carried out when required.

11.3 This risk can be minimised by ensuring development is either avoided or is compatible with the electricity transmission lines. Where large scale development (such as subdivision) is proposed it can, and in my opinion it should, be designed to ensure that only appropriate activities occur under the lines. Appropriate activities include carparks, roads, stormwater infrastructure, or open space that does not involve buildings or structures.

11.4 Proper design of any underlying activities, including consultation with Transpower, is essential to manage risk.

11.5 I consider that development by third parties should take into consideration the "safety by design" concept when planning and designing a development (such as a structure or land disturbance) near a National Grid asset. "Safety by design" involves:

[8] Health Physics, 99(6): 818-836, 2010.

a understanding and managing the risk throughout the lifecycle of an asset, and

b appreciating that when you create a risk it is your responsibility to manage it.

11.6 Risk should be assessed and designed out of processes, equipment and environments. Where the decision is still to develop in the vicinity of transmission line, consideration should be given to the following issues:

a the safety of workers during any construction or build stages of the development (e.g. builders, earth movers, and electricians);

b the safety of residents, workers and the public who may be working, living or recreating in the area after the development is completed;

c the safety of the line maintenance workers who are required to access the National Grid assets both during the development's construction and after its completion;

d whether the proposed development follows construction industry best practice; and

e access to structures and lines by emergency vehicles (ambulances, fire engines etc).

11.7 In addition, the planning, installation and use of buildings, structures as well as heavy lifting plant operations must take into consideration a number of key elements, including:

a the location and configuration of the transmission line support structures;

b the inductive voltages that may be present and possible mitigation measures that may need to be applied;

c the vehicle movements, location of construction materials and height restrictions of both vehicles and workers necessary to avoid entering the conductor flashover zone;

d the transferred voltage hazards; and

e the EPR issues associated with workers in and around transmission line structures.

11.8 However, as discussed earlier, notwithstanding these measures, I do not consider that it is appropriate for activities where groups of people are present for extended periods to establish under the line. It is better to avoid such activities close to lines in order to minimise risk to people and property.

12 National Grid Corridors

12.1 The importance of transmission corridors has been recognised by Government policy makers. The NPSET, introduced in 2008, requires councils to give effect to its provisions in the plans they adopt under the RMA.

12.2 Transpower seeks to manage the network through a National Grid Corridor approach which is comprised of a National Grid Yard, a wider National Grid Subdivision Corridor and a National Grid Substation Corridor.

12.3 As explained by **Ms Whitney**, Transpower is seeking a National Grid Corridor within Porirua City for undesignated overhead transmission lines, to provide for:

a A 10-12m corridor either side of the centreline, where specified activities are restricted (**National Grid Yard**);

b A 12m setback around National Grid support structures (**National Grid Yard**); and

c A wider corridor (out to 16, 32, or 37m either side of the centreline depending on the line voltage and the nature of the line's support structures) where subdivision is managed (**National Grid Subdivision Corridor**).

12.4 The 10m or 12m National Grid Yard is the general area beneath the conductors in "everyday" wind conditions, being the conditions when line maintenance can be carried out. A 12m setback around each tower or support structure is also sought for access, maintenance and safety purposes.

12.5 A wider area is sought for subdivision which extends to the width defined by the swing of the conductors in high wind conditions. These areas are a bare minimum to ensure that Transpower's maintenance, repair, upgrade and operation activities are not compromised.

12.6 The distance a transmission 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 or poles).

12.7 To calculate appropriate corridor widths, a set of standard line types, based on voltage and structural configuration have been developed by Transpower. Following analysis, it was determined that the swing is most sensitive to the wind speed and span length.

12.8 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. A range of swings was then determined for each line type.

12.9 The width of transmission corridors was then determined by the swing of the 95th percentile span across the country and access requirements for maintenance purposes.

12.10 Transpower also seeks a substation corridor for the Transpower substation at Pāuatahanui, which consists of a 30m setback from the secured yard. This corridor is to manage reverse sensitivity and other effects of any new sensitive activities around these sites.

12.11 The National Grid Corridor approach has several important purposes:

a To enable uncompromised access and maintenance;

b To avoid reverse sensitivity effects;

c To provide a consistent approach to managing the potential for adverse effects in the National Grid;

d To reduce risks of damage to structures and their foundations as a result of adjacent structures and land disturbance; and

e To avoid safety hazards.

12.12 The National Grid Corridor is also important for the following reasons:

a To protect the infrastructure corridor itself. As land uses become more intense, it is increasingly 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.

b To alert landowners to the constraints the National Grid lines impose on land use. It also clearly indicates how they can manage their own activities.

12.13 The corridors Transpower seeks reflect the minimum areas considered necessary for the protection and operation/maintenance of the National Grid. The corridors have not been sized to provide for major rebuilds or new lines. The proposed areas do not *fully* address such matters as amenity and reverse sensitivity.

Ben Cartwright

21 January 2022

APPENDIX A – BASIC COMPONENTS OF AN OVERHEAD TRANSMISSION LINE

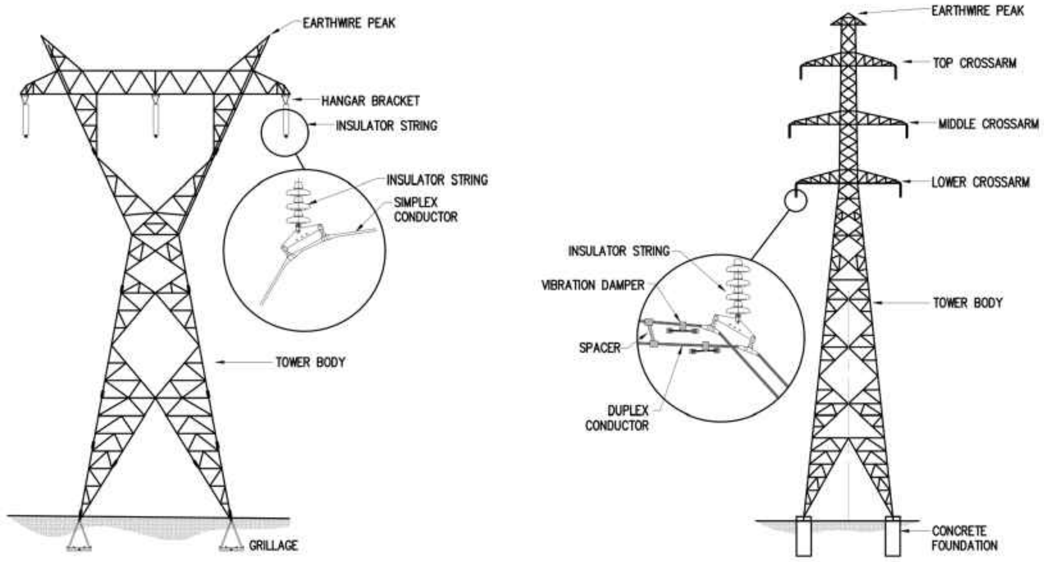

Figure 1: Tower component diagram

Conductors

1 Conductors (wires) are the physical conductive connections that transport live electrical energy at high voltages between substations (that is, between generators and substation supply points). Conductors usually consist of a number of aluminium stranded wires wrapped around an internal stranded steel support wire. In some cases aluminium or hard drawn copper alone is used, the latter being phased out as they age.

2 Conductors are arranged in different configurations and with different spacing between them depending on the structure types and circuit voltage. 220kV lines typically have a 5.5m, and 110kV lines a 3.25m, vertical conductor separation. Where conductors are duplexed (two conductors per phase), sub-conductor spacers are installed to separate the two wires to prevent the two parallel wires twisting and clashing, particularly in windy conditions.

Structures

3 Structures support the conductors and earth wires above the ground or other obstacles to maintain safe electrical clearances. Structures take many forms; for example, self-supporting lattice steel towers, concrete and wood poles, and steel tubular poles (monopoles). In the Porirua District, the structures are predominantly steel lattice towers.

4 Transmission line structures are designed for specific line characteristics, including voltage, conductor size, conductor tension, climatic conditions (wind and snow) and topographic criteria (span length, line angle and tower height). Upgrading of line capacity or replacement of conductors typically requires the strengthening of towers (addition of steel members), raising of towers (insertion of complete tower sections), and in some cases complete replacement of the structure to ensure modern design standards are met.

Insulator sets

5 Insulators electrically insulate the live conductors from the earthed structures and prevent loss of energy to earth. Each phase on each structure requires an insulator set. The sets consist of insulators that may be manufactured from glass, ceramic porcelain or a composite material, and the steel hardware assemblies which attach the insulators to the structure and the conductors. In most cases the insulators are suspended from the pole or tower crossarms.

Foundations

6 Foundations form the base on which each tower sits. Foundations for steel lattice towers typically consist of three main designs:

a Directly buried lattice steel (grillages), where a lattice steel configuration sits on a formed platform below the ground and the entire configuration is directly backfilled and buried;

b Concrete encased buried lattice steel (grillages), where a corroded or understrength buried steel grillage is retrofitted with a buried concrete foundation; and

c Formed concrete foundations that connect the tower by either a bolted base plate arrangement or a concrete encased steel connection.

7 Poles are generally directly buried.

Earthwires

8 Earthwires are used to bond all conductive structures together and form a protective shield to help mitigate lightning strikes on the conductors. In some parts of the Transpower network, fibre optics are encased in the earthwire and serve as a communication system by utilising an internal fibre capability and providing signalling for protection systems and a communication link between substations.

9 Not all assets have full length earthwires installed. They are, however, typically installed in at least the first 5 structures out from all substations and generating sites.

APPENDIX B: EXAMPLES OF THIRD PARTY ACTIVITIES AFFECTING TRANSMISSION LINES

Earthworks

1 Uncontrolled earthworks can undermine the support structures or generate dust. The dust 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.

Example 1: Subdivision earthworks compromising National Grid support structure

2 **Figure 1** shows earthworks that occurred around a tower as part of development for an urban subdivision in Whitby, Porirua. The earthworks were well within 12m of the support structure.

Figure 1: Earthworks in Porirua

3 As well as possibly undermining the stability of the tower structure, the earthworks in the photograph have 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.

4 In this instance, Transpower worked with the developer retrospectively to ensure that the constraints on the line introduced by the developer were mitigated and the long-term stability of the towers would be retained. This required the installation of a shotcrete surface on the cut batter. 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.

Example 2: Hastings District earthworks – ground clearance violations

5 Another example of earthworks adversely impacting on the operation of existing National Grid assets is earthworks undertaken in Hastings. Transpower investigated the clearances from the conductor to ground for two Hastings properties and found the minimum clearance was only 5.3m from the ground to conductor at everyday conditions (instead of 6.5m required under NZECP34). This violation occurred as a result of earthworks – i.e. due to a build-up of soil under the conductors. The soil had been excavated onsite, spread under the line and reduced the required ground clearance to an unacceptable distance. As a result of the earthworks people and property were at risk.

6 Transpower needed to arrange temporary fencing of the two earthworks sites to prevent any further access under the conductors until rectification works were completed. Mitigation included installing a new set of cross arms on the poles. The top and bottom crossarms were changed to shorter steel crossarms with new Horizontal Line Posts (HLPs) attached. This lifts the conductor into a clamp on the end of the HLPs on the same pole by approximately 1200mm and prevented the need to replace the poles. Transpower then carried out ground works to cut the edge of the bench/track back to ensure the regulation 6.5m ground clearance at maximum operating temperature was complied with i.e. remediating the site back to original ground level and achieving compliance with NZECP34:2001.

Figure 2: Hastings ground clearance violations

Figure 3: Hastings ground clearance violations

Buildings and Structures Preventing Access to the National Grid

7 In 2014 a grillage refurbishment crew was carrying out a pre-works inspection at Tower 48 on the Henderson to Roskill 110kV transmission line. The crew discovered a dwelling was under construction directly below the line and Transpower had not been consulted on the proposal. This dwelling blocked access to the tower site, meaning that Transpower had to secure alternative access across

four separate properties. This required the removal of fencing and vegetation. **Figure 4** clearly illustrates the difficulties now arising at the site.

Figure 4: Dwelling blocking access to tower