Before a Hearing Panel at Levin

under: the Resource Management Act 1991

in the matter of: The Proposed Horowhenua District Plan - Rural Environment

between: **Horowhenua District Council**
Local Authority

and: **Transpower New Zealand Limited**
Submitter

Statement of evidence of Wayne William Youngman for Transpower New Zealand Limited

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STATEMENT OF EVIDENCE OF WAYNE WILLIAM YOUNGMAN

QUALIFICATIONS AND EXPERIENCE

1 My full name is Wayne William Youngman.

2 I am employed by Transpower New Zealand Limited (*Transpower*) as a Senior Principal Advisor – Lines in the Grid Maintenance business unit of Grid Performance. My role within Transpower involves mentoring, advising on and supporting all of Transpower's transmission line maintenance activities, mainly within Grid Performance but also to the wider Transpower business. I have been employed specifically in this role with Transpower only since March 2013, but held the role of National Transmission Line Manager role since November 2001. I have held similar roles within Transpower since September 1992. I have over 45 years work experience in the electrical industry.

3 I am a registered electrician, hold an Electrical Technicians Certificate and have partly completed the New Zealand Certificate in Electrical Engineering.

4 While this matter is not before the Environment Court, I have read the Environment Court's Code of Conduct for Expert Witnesses, and I agree to comply with it. My qualifications as an expert are set out above. I confirm that the issues addressed in this brief of evidence are within my area of expertise. I have not omitted to consider material facts known to me that might alter or detract from the opinions expressed.

SCOPE OF EVIDENCE

5 My evidence will deal with the following:

5.1 Works required to ensure the operation, maintenance and upgrading of the National Grid, including foreseeable maintenance work for Horowhenua's transmission lines;

5.2 Risks within the transmission corridors (to people, property and the Grid itself), including :

(a) Electric shock;

(b) Earth potential rise;

(c) Step and touch voltages;

(d) Induction voltages;

(e) Conductor drop;

(f) Flashovers;

(g) Vegetation;

(h) Third party activities (Cranes, excavators etc.); and

(i) Electrical interference;

and how these risks can be managed;

5.3 Engineering input into calculating the widths of transmission corridors; and

5.4 Issues relating to undergrounding lines.

6 In summary, this evidence provides factual background to transmission issues, as well as explaining:

6.1 Why transmission corridors are required in the District Plan; and

6.2 Why Transpower is concerned about restrictions on its ability to trim or clear trees near lines.

7 **Appendix A** to my evidence provides factual information about the National Grid, including that part of the Grid which is within Horowhenua District. The Appendix also explains the basic components of transmission lines.

SUMMARY OF EVIDENCE

8 Transpower must be able to operate, maintain, develop and upgrade the National Grid in order to deliver a reliable, secure supply of electricity to the Horowhenua District (and to the country more generally).

9 The National Grid assets (including those in the Horowhenua District) are aging. Due to the aging factor, major maintenance works on the grid assets will be required in the District over the next 10 years. This will include foundation work, pole and tower replacements, corrosion mitigation such as blasting and painting, and conductor work.

10 Unimpeded physical access for both routine and urgent maintenance work is desirable. Under build that restricts access can greatly increase the costs and time required to undertake work (for both Transpower and the landowner) and delay, or in some instances severely restrict, Transpower undertaking maintenance.

11 Maintenance work involves staff, vehicles and at times, large earthmoving or crane equipment. The nature of the works can inconvenience people working or living near the works for extended periods. Most importantly, maintenance work requires adequate working space around the tower or pole, ideally 12 metres.

12 A regulated transmission corridor is critical for providing adequate working space, but also for safety and to minimise effects on landowners and the public. A transmission corridor clear of intensive development reduces the risks associated with the close proximity of high voltage electricity. Separation distances between transmission assets and the buildings and structures of others, greatly reduce the risks of electrical events occurring (from events such as flashovers, step and touch and earth potential rise). Although extremely rare, conductor and hardware drop can, and do, occur. Maintaining a corridor where people are not frequenting on a regular basis reduces the personal risk of injury from such events.

13 Transpower actively manages risks when designing and constructing assets. However, it is also equally important for Property Developers to also minimise risk through "safety by design". In my view, this is best achieved through a resource consent regime to ensure that any sensitive or intensive development near a transmission line takes the transmission line into account and its development occurs in a safe manner.

14 I accept that NZECP34:2001 prescribes the minimum safe distances for buildings; however, it does not apply to other structures and it gives no consideration of the sensitivity of those using buildings and structures. Therefore, NZECP34:2001 does not provide for access, work space, or other activities that might create unsafe situations such as step and touch hazards.

OPERATION, MAINTENANCE AND UPGRADING OF THE NATIONAL GRID

15 To ensure the Grid delivers a safe, secure and reliable electricity supply all assets need to be monitored and inspected on a regular cycle that reflects the asset's age, geographic location and high risk areas such as over major roads, rail and urban areas.

16 As explained above, the maintenance of the National Grid is a key part of Transpower's business. In support of the maintenance strategy, Transpower carries out two main types of inspection activities in order to determine maintenance, refurbishment or upgrade requirements:

16.1 ***Routine patrols***
A routine patrol involves viewing every asset annually, as a minimum, to identify any short term defects or situations that

may affect the operation or safety of the Grid in the shorter term. Items identified on patrols are such things as damaged or broken insulators, impediments on the conductors, broken climb guards, faded signs, vegetation growth, access issues, land subsidence, and inappropriate landowner developments or activities under or near the line.

16.2 ***Condition assessment***
A condition assessment involves every line component being fully inspected and in some cases tested on a time based schedule (mainly 3 – 7 yearly depending on the asset type). Condition assessments require access to all transmission line structures and conductors. From these detailed inspections, a work programme is developed to ensure any necessary component replacements or refurbishment that has been identified is done well in advance of the component's failure point.

17 Occasionally, and as part of the condition assessment programme, Transpower undertakes a mid-span inspection of a conductor. This can be carried out by a remote controlled conductor robot that travels down the span taking images and data and transporting this to a computer on the ground. Alternatively, it can be done by two linemen accessing the conductor via a conductor trolley or by helicopter, or using a helicopter to take thermal images, high resolution photos, or direct visual inspection.

18 From routine patrols and condition assessment inspections, a wide range of maintenance work is identified and incorporated into a consolidated work program. The maintenance activities that occur most frequently are:

18.1 Foundation refurbishment and replacement;

18.2 Tower painting and tower refurbishment;

18.3 All aspects of tower, pole, conductor (and associated hardware) maintenance or replacement;

18.4 Maintenance of access tracks, bridges and culverts; and

18.5 Vegetation and tree control.

Expected maintenance work within Horowhenua District

19 As discussed earlier, Transpower's transmission assets are aging. The youngest asset in the Horowhenua District is the Bunnythorpe – Wilton A Line which was commissioned in 1980. The oldest are the two Mangahao – Paekakariki pole lines which were commissioned in about 1925.

20 While these assets are old, their condition is relatively good, mainly because of the environment they are located in and sound maintenance practices applied to them over the years. However to keep on top of the aging problem, I anticipate that in the next two decades or so, major foundation works and wood pole replacements will be required. In addition, almost all steel towers will require some form of corrosion mitigation (painting or steel replacements), and conductor replacements which I discuss later.

Foundation work

21 Tower foundations on the two Bunnythorpe – Haywards lines are predominantly grillage foundations, that is, directly buried steel. Inspecting these foundations requires the whole foundation to be dug out on all four legs using excavators. If the foundation needs to be replaced, the tower must first be supported via props or guy wires before excavation. Photo 1 below gives an indication of the amount of spoil and earthworks that is required for a typical grillage foundation strengthening project.

Photo 1: Typical grillage foundation strengthening

Pole and tower replacements

22 Wooden pole structures need to be replaced usually after 40-50 years' service usually due to the wood splitting and rotting (although in some environmental conditions wood poles last longer than this). Transpower policy is to replace these poles with the more robust and permanent concrete poles. .

Corrosion mitigation of towers

23 Tower painting is a significant on-going maintenance activity for Transpower. Painted transmission towers have a coating life of approximately 15 years (depending on the environment they are located in). 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. The longer a tower is left to corrode the more extensive the secondary preparation is, therefore increasing the cost of the painting work (additional steel and bolt replacement may also increase with time). Tower painting can range from $50,000-$110,000 per tower, depending on its condition, location and the asset type.

24 Painting as a maintenance option has already started on the Bunnythorpe – Haywards A & B lines in the coastal areas north of Paraparaumu. This work will continue as Transpower attempts to manage the steel corrosion on these assets.

25 Photograph 2 below shows a tower that requires corrosion mitigation.

Photo 2: Tower corrosion

Conductor work

26 Transpower's maintenance work is not limited to structures, as conductor repair and replacement forms a significant and key part of the lines infrastructure. Both the Bunnythorpe – Haywards A & B lines have an emerging conductor corrosion problem and Transpower is currently working on a conductor replacement programme for both these assets. This work activity involves:

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

26.2 Accessing each tower to remove the existing insulators and install stringing equipment such as running blocks;

26.3 Tower strengthening where this is necessary;

26.4 The rewiring process (using the old conductor to pull out the new conductor);

26.5 Sagging operations at each tower to ensure even and consistent sag profiles; and

26.6 Reinstalling the insulators, including clipping in the conductor, removal of plant and reinstatement of lands.

27 Access to work on simplex conductors presents some additional challenges compared to working on a duplex conductor. For example, Transpower cannot use helipods (such as in Photo 3 below) on a simplex line. Some maintenance work on simplex lines involves access from ground base operations using elevated work platforms or cranes, or lowering the conductor to the ground. In some cases it is possible to suspend linemen from helicopters but this involves long periods of helicopter time while the work is being carried out below.

Photo 3: Helipod use

28 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 line from smoke or fires, vehicle or mobile plant, or vegetation touching causing flashovers.

29 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.

Access

30 The transmission lines within the Horowhenua District are typical of the lines operated and maintained by Transpower nationally. These lines are mainly located in, or across, private land where there are a

variety of land use, activities and geographic situations to consider. Lineman, vehicle, plant and machinery access to the Grid's assets is essential to carry out the required maintenance activities.

31 Transpower has statutory rights to access its assets on private land under the provisions in the Electricity Act 1992, for the purpose of maintaining, inspecting and operating the National Grid. In addition, Transpower has contractual or property rights to access new assets constructed on private land. It is important to note that my evidence is instead about *physical ability* to access Transpower's assets. Issues regarding establishing *legal access* are distinct issues that are handled by other divisions in Transpower.

32 In my view, it would be ideal to have unimpeded physical access to all transmission line structures. However from a practical sense access should never be unnecessarily impeded if this can be reasonably avoided. Physical barriers and natural obstacles require Transpower to take alternative access options depending on the type and nature of the work required on the asset. For example, dismantling fences and horticulture structures, temporary bridging of waterways and vegetation removal.

33 Table 1 below gives some indicative details of the equipment Transpower needs to carry out particular maintenance work on private land. The people and equipment indicated below would typically apply to the lines in the Horowhenua District.

Maintenance task	**Frequency**	**Approximate time on land**	**Number of people**	**Number and type of vehicles**
Patrol / Condition Assessment	Patrol -Normally once per year. Condition Assessment normally 5 – 6 yearly.	Less than 1 hour per structure	2	One ute or all terrain vehicle
Vegetation Maintenance	As required following work identification from the annual patrols. Vegetation growths vary depending on tree species, weather and location. As an average	As required	Varies	Cherry-picker, chipper, light truck, service truck

Maintenance task	Frequency	Approximate time on land	Number of people	Number and type of vehicles
	Transpower would attend to most vegetation on a 2 to 3 year cycle.			
Access and track maintenance	As required following work identification from the annual patrols.	1-2 days on average	1-4	Grader or digger and a small truck
Painting towers	Approximately a 10-20 year cycle, although becoming much more frequent in built up areas (as discussed later in my evidence).	About 2 weeks per tower (weather dependent)	4-10	Water blaster, water tanker, air compressor, other vehicles
Foundation refurbishment/ strengthening.	Once every 20-30 years	About 3 / 4 days per tower	4	4WDS, a transport truck, a digger, a concrete truck
Insulator assemblies, hardware, conductor etc. repairs and replacements.	Approximately a 40 year cycle or as identified by damage (rifle shot, lightning)	About 1 day per tower (weather dependent)	4-10	Lifting equipment, elevated work platform (EWP), hoists.
Tower refurbishment (For example, tighten bolts, replace steel members)	Depends on environment and corrosion rates. Normally 30 year cycle.	About 3 days per tower	4	4WDS, and transport truck.
Pole replacements	Approximately a 40 year cycle	About 1 – 2 days per pole.	4-6	4WDS, a transport truck, a digger, compactor.

Maintenance task	Frequency	Approximate time on land	Number of people	Number and type of vehicles
Conductor repairs (Including joint testing, repair and replacements)	Approximately a 40 year cycle	About 2 days per span	4	4WDS, a transport truck, EWP, Helicopter.
Emergency works, including fault response and resulting repair works, structure stabilisation following floods.	As identified and needs priority. Generally Transpower fault response frequency on its network works out at about 0.2 visits per asset per year.	Averages about 30 min for fault inspection purposes and about 4 hour average per fault repair.	4	4WDS, a transport truck, EWP, Helicopter.

Table 1: Maintenance tasks and equipment

Proposed future works

34 Transpower has a number of standard condition assessment related works that will need to be carried out on the lines in the Horowhenua District within the next 10 years. This includes:[1]

34.1 10 - 20 Pole replacements;

34.2 Associated insulator and hardware replacements;

34.3 Conductor replacement of about 360 route km;

34.4 100 – 150 tower paints;

34.5 100 – 150 grillage refurbishment / replacements; and

34.6 Various line access and vegetation works.

35 As described in Table 1, lifting machinery, stringing equipment, elevated work platforms or helicopters are required for some insulator replacement work, but are more likely for conductor or tower and pole maintenance or replacement.

36 Earth moving machinery, such as graders and diggers, are required to expose or extract tower foundations and carry out pole

[1] This is a general list only and a more detailed list can be supplied if requested.

replacement works. Clear working space and good access is required particularly around the base of the towers/poles to move the equipment in and set it up properly. Cordons must be installed around the work site to minimize hazards and restrict access to the public.

37 Underbuilding can cause access and work space issues for much of the works above. By way of example, houses in close proximity to transmission towers or poles require additional safety measures such as traffic management and additional environmental considerations (relating to, for example, water and sand blasting and paint contamination management). Painting preparation may need to be modified depending on the proximity to houses, waterways and/or public areas in order to be compliant with resource consent conditions. Access to towers for corrosion mitigation work becomes more complicated and difficult in urban areas where houses are in such close proximity to towers.

38 Transpower's contracting team recently completed a painting schedule on three lines in Auckland. Some areas of these lines have dwellings very close to towers as can be seen in photos 4 and 5 below.

Photo 4: Tower painting

Photo 5: Tower painting

39 Photos 4 and 5 show a house being draped with polythene sheets in order to aid protection during abrasive blasting associated with the tower painting process. Such methods do not however completely eliminate adverse effects on under-build due to the nature of abrasive blasting and painting processes. Photos 6 and 7 show a similar process in an industrial location.

Photo 6: Tower painting

Photo 7: Tower painting

40 Photo 7 shows the material that becomes airborne during the abrasive blasting process, and the need to carry out this work when people are not present.

41 By comparison, in areas where there is no under-build, Transpower is more easily able to install mitigation measures to catch the debris associated with tower painting. In Photo 8 below, geotextile matting has been laid under the towers, which allows the water to soak through but contains the garnet[2] and any other particle matter off the tower.

[2] Garnet is the material that is used in the abrasive blasting process. For a tower of around $450m^2$ requiring 55% preparation, 30-40 cubic metres of water is required and 1.5 tonnes of garnet.

Photo 8: Use of geotextile matting

42 In my view, adverse effects associated with corrosion mitigation work are likely to be felt in a broader area where there is development close to a line. You can see this by comparing Photos 4-7 with Photo 8 above, which shows more moderate mitigation measures taken where there is no under-build.

43 Transpower's recent experience in obtaining resource consents for tower blasting/painting is that a different blasting process is required in under-built areas. Not only has this change in specification resulted in an increase in costs (of about $15,000 - $20,000 per structure), but also a reduction in the quality of the work. This means that instead of towers being painted every 15 years (depending on the environment), these towers will need to be repainted more frequently (almost every 5–10 years). This more frequent painting will mean that the public living or working under the line will also need to be inconvenienced on a more regular basis.

Conductor work

44 Conductor replacement or mid span conductor repairs ideally require a relatively clear area along the entire transmission line. Mid-span under-build, particularly dwellings (where people are inconvenienced), not only creates significant additional costs for Transpower in carrying out any reconductoring or mid span repair works, but there is also a real chance that this work could not be undertaken and alternatives need to be considered. In some instances it may be necessary to consider evacuating communities living under the line – at huge inconvenience and costs (to individuals and businesses).

45 Photo 9 below shows work on a conductor in an urban setting involving 2 cranes and other large vehicles. The road was required to be partially closed, causing inconvenience to the public. As indicated in the photograph, vehicle access to a dwelling and a school was also prevented.

Photo 9: Conductor work

46 Activities not typically thought of as sensitive can also be disproportionately inconvenienced by mid-span conductor repairs. Some commercial and industrial activities are disproportionately affected by the need to shut down during conductor repairs, and/or are affected by helicopter use. Dairy and milking sheds are also affected in this way. For this reason alone, I consider that further high density under-build should not be undertaken in Horowhenua District, especially where there is the opportunity to avoid it.

47 While there are many examples of landowner developments that have severely restricted or blocked Transpower's ability to effectively access its assets, I wish to focus on a few:

47.1 New building including dwellings, factories, commercial activities and fences that have been built so close to the structures that Transpower is unable to access and/or physically work at the site without major alteration to the private infrastructure or significantly inconveniencing property owners, in particular those living near towers or poles. I accept that lines and structures are unlikely to be built out in this way in rural areas of Horowhenua within the next 10 years. However, in urban or peri-urban areas there is a real risk of new buildings and activities surrounding lines and structures in this way;

47.2 Alterations, upgrading or building of rail, roads, horticulture structures, bridges, signs, fences, ditches, ponds, or planting of new trees. Again, these are not usually an issue in less intensively developed rural areas where there are other options remaining for accessing the lines. However, they are more problematic in more intensively developed areas (or areas with the potential to be intensively developed);

47.3 Subdivisions, where larger properties are broken up into smaller blocks resulting in Transpower's traditional access being physically blocked;

47.4 Sensitive, restrictive or busy sites that require specific controls before Transpower can access them (e.g. biosecurity issues, PSA, issues specific to organic farms);

47.5 Commercial operations where specific health and safety procedures are necessary to ensure worker safety both by Transpower's line crews and site employees;

47.6 Roads and bridges where others have imposed restrictions / constraints etc (weight limits, use restrictions); and

47.7 Dangerous sites such as quarries, rifle ranges, and airport no fly zones.

RISKS WITHIN THE TRANSMISSION CORRIDORS

48 Transmission infrastructure similar to that operated by Transpower is used throughout the world and is generally considered a safe and efficient way to transmit electricity. Transpower operates its assets as safely as possible and seeks to protect, to the extent practicable, its staff, the public, consumers and property from exposure to injury or harm, damage, economic losses and nuisance.

49 Despite taking all care as owner and operator of the Grid, there are residual risks due to the extremely high voltages being carried on lines. Although the probability of an 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.

50 Transpower takes a prudent approach to managing its assets. However, failures and faults do occur. In my opinion, a transmission corridor clear of intensive and sensitive development not only gives an opportunity for ease of access, but more importantly enables any risks both to the Lineman and occupiers of the land to be reduced, by providing a visual and physical separation from live equipment.

51 I discuss some of the hazards associated with transmission lines below.

Electric shock

52 Transmission lines carry electricity at very high voltages. Electricity at these voltages can arc through the air even without direct contact. The main hazard with respect to the voltage is receiving an electric shock. The risk and severity of electric shocks varies depending on the transmission voltage and type of exposure (direct human contact, mobile plant, or vegetation). Incidents are most likely to occur within 12 metres of the line, as I discuss further below.

53 Lethal electric shocks to animals and humans can be caused by:

53.1 Earth potential rise;

53.2 Step and touch voltages;

53.3 Induction voltages;

53.4 Conductor drop; and

53.5 Flashovers (coming into contact with the line conductors).

Earth potential rise (EPR)

54 Earth potential rise (*EPR*) is usually caused by an earth fault at a tower. 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 on a tower as a result of lightning, pollution or foreign objects.

55 During an earth fault, there is a significant current (2-20 times normal) flowing in the faulted line from the power source into the fault point. This current returns to the source (e.g. the power station) through the ground. 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 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 bridges the voltage contours. The earth fault current causes EPR around the faulted tower, which in turn results in step and touch voltage hazards and transferred voltage hazards as discussed below.

Step and touch voltages

56 Step and touch voltages can arise due to a fault at a tower and, as explained above, momentarily raise the voltage at the tower base and the surrounding ground. A step voltage hazard can occur when a step is taken in this area, or a person or animal is in contact with the tower and standing on the ground thus causing a voltage difference between the feet or between the feet and hands. Where conductive horticulture structures or fences, for example, are located close to the tower, high current and voltage may transfer from the tower, via the ground and travel some distances down these structures causing an electrical hazard some distance from the faulted tower and causing the same effect.

Induction voltages

57 Induction voltages can cause irritation and nuisance on conductive materials such as fences or wires. Induction is caused through a magnetic coupling between the conductors and any metallic wires or fences installed over longer distances, generally those running parallel to the circuit itself. People may experience inductive shocks between the metallic wires and ground.

Conductor drop

58 It is extremely rare for a conductor or the conductor hardware to fail causing the conductor to drop to the ground, but it can happen. While the majority of line drops have occurred in a rural area (where few people and property is generally located), there have been rare occasions where a line drop has occurred in an urban setting (where the generally more intensive and sensitive development places more people and property at risk). When a line drop does occur, the consequences can be fairly wide ranging for activities under the line. Photograph 10 below shows impacts within a dwelling, following a line drop. The internal electrical switchboard and appliances have been damaged.

Photo 10: Damage following line drop

Flashovers

59 A flashover is a major electrical discharge, usually in the form of an electric arc, which 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. Flashovers can occur from lightning strike, contamination of the insulator or when a person/object is too close to, or comes into contact with, the conductors.

Vegetation

60 Trees growing close to a line, and which cause a flashover from the conductor to the tree, may cause:

60.1 A circuit fault that affects the operation and supply of the grid;

60.2 Injury or death to anyone who may be near the tree at the time of the fault; or

60.3 Damage to the tree, land or property.

61 If a tree touches or comes close to touching the high voltage conductors and causes a flashover, dangerous voltages may arise on the tree itself or in the ground area around the tree. These voltages have the potential to cause serious injury or death. 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.

62 It is vital that trees and all other vegetation is trimmed or cut to ensure they do not encroach into a "no go" zone around the conductors under all situations (effect of wind on the conductors and

trees, and the sag and swing of the conductors under various ambient temperatures and load). For transmission voltages the tree "no-go" zone is 4 metres from the conductors under worst case conditions.

Third party activities

63 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 this machinery is carefully considered to avoid contact with the conductor and stay outside the permissible distances as outlined in NZECP34:2001. Contact with the conductors can:

63.1 Compromise the safety of the machinery operators or workers or members of the public in or near the machinery;

63.2 Damage the machinery or the line itself; or

63.3 Affect the operation of the grid.

64 Excavations adjacent to towers or poles can undermine the stability of the structure foundations, causing the structure to lean or, worse , collapse. Excavations or mounding mid-span can also increase risks by reducing the clearance between the ground and conductors. Any excavations near lines need to comply with NZECP34:2001.

65 I am aware of a number of incidents where machinery has caused a flashover between the plant and the line conductor. For example:

65.1 A shipping container being carried by a forklift touched a 220kV line in the Otahuhu area disrupting supply to the area north of Auckland including the refinery at Marsden Point for about 15 minutes.

65.2 A concrete truck was involved in a flashover with the construction of a school where the school was being built very close to a 110kV line.

66 The risks of incidents such as these occurring will only increase if incompatible activities are intensified under or near lines.

Electrical interference

67 Interference from a transmission line usually comes in two forms: Mechanical noise and Electrical noise.

67.1 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).

67.2 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 corona discharge may be seen at night when insulators are polluted and electricity is seen discharging down from the conductor to the tower steel.

68 Transpower can put in corrective measures to reduce or in some cases eliminate both mechanical and electrical noise. Transpower's assets comply with the International Commission on Non-ionising Radiation Protection *Guidelines for Limiting Exposure to Time Varying Electric Magnetic Fields up to 300 GHz.* (known as the ICNIRP Guidelines).

Who can manage these risks?

69 Transpower manages risks when designing and constructing new assets. When earth faults occur (rare though they are), the current is interrupted by protective devices at each end of the line to clear the fault in a fraction of a second. Engineering solutions such as this are only part of the answer. It is vital that the infrastructure is also protected in order to further minimise the risks of damage and injury. Protecting the infrastructure means ensuring third parties do not interfere with its proper operation and also allowing appropriate maintenance and upgrade work to be carried out when required. As I describe below, appropriate maintenance requires access to the structures and lines and sufficient working space to allow the maintenance work to be carried out.

70 Risk can also be minimised by ensuring development is either avoided or is compatible with the lines. Where large scale development (such as subdivision) is proposed it should be designed to ensure that only appropriate activities occur under the lines (such as carparks, roads, stormwater infrastructure, or open space).

71 Through proper design of any underlying activities, the example of the forklift carrying the shipping container touching the line could be avoided (by ensuring that the activities under the line did not require forklifts to operate under the line). Options to mitigate this risk would have been to apply height barriers or safe forklift lanes under the line. These alternative uses of the land would have seen the risks and nuisances minimised.

72 Development by others must take into consideration the "safety by design" concept when planning and designing a development (such as a structure or earthworks) near a Grid asset. The key points to consider for this are:

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

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

72.3 The safety of the line maintenance workers who are required to access the Grid assets both during the development's construction and when it is completed;

72.4 Whether the proposed development follows best practice for the construction industry; and

72.5 Access to structures and lines by emergency vehicles.

73 Where resource consent is required for activities under or near lines, Transpower has an opportunity to provide advice to ensure that any development near a transmission line occurs in a safe manner, and the risks posed by the existence of the transmission line are not increased by conductive structures under the lines. There may also be an opportunity to bring large scale transmission work forward (to minimise the disruption to landowners and Transpower).

74 If consent is to be granted for activities close to the line, I consider it appropriate that a condition requiring a construction management plan be imposed, and that the management plan address matters such as how construction methods (including associated vehicles) will occur in a manner that will not result in contact with the line.

75 The construction of metal infrastructure, support structures, heavy lifting plant operations etc. near or under a transmission line must be planned and installed considering a number of key elements:

75.1 The location and configuration of the support structures, support wires, or metal structures;

75.2 The inductive voltages that may be present and possible mitigation measures that may need to be applied;

75.3 The vehicle movements and height restrictions necessary to avoid conductor contact;

75.4 The transferred voltage hazards; and

75.5 The EPR issues associated with workers in and around transmission line structures.

76 However, as discussed earlier, 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 too close to lines in order to minimise risk to people

and property and potential disconnection of electricity to end consumers.

NZECP34:2001 insufficient to address Transpower's concerns

77 NZECP34:2001 prescribes minimum safe distances for the construction of buildings and structures and for excavation near transmission line support structures and overhead lines. Compliance with NZECP34:2001 is mandatory.

78 Clause 2.4.1 of NZECP34:2001 states that:

> *"Except with the prior written consent of the overhead electric line owner, no building or similar structure shall be erected closer to a high voltage overhead electric line support structure than the distances specified in Table 1".*

79 Table 1 states:

MINIMUM SAFE DISTANCES BETWEEN BUILDINGS AND OVERHEAD ELECTRIC LINE SUPPORT STRUCTURES

Circuit Voltage	Pole	Tower (pylon)
11V to 33kV	2m	6m
Exceeding 33kV to 66kV	6m	9m
Exceeding 66kV	8m	12m

80 Therefore, in respect of circuits exceeding 66kV, NZECP34:2001 requires that buildings must be at least 8m from a pole and 12m from a tower.

81 The distances in Table 1 are measured from the closest visible edge of the overhead electric line support foundation, and the nearest part of the outermost part of the building. NZECP34:2001 also specifies minimum safe distances between conductors and buildings and other structures.

82 Regulation 17(3) of the Electricity (Safety) Regulations 2010 states that various people commit a criminal offence if they fail to maintain the safe distances specified in NZECP34:2001, including a person who carries out or controls the construction, building, excavation, or other work and a person who owns or controls any line, works, fittings, building, structures, equipment, or machinery that is the subject of, or involved in, the infringing work. If a conviction is proved, penalties are a maximum of $10,000 (in the case of an individual), and $50,000 (for a corporate). There is also an infringement notice scheme managed by the Ministry of Business,

Innovation and Employment, formerly the Ministry of Economic Development.

NZECP34:2001 does not protect the integrity of the Grid

83 Minimum safety requirements in NZECP34:2001 do not seek to protect the integrity of the National Grid from the effects of third parties, and they do not prevent development (including sensitive development) from occurring directly underneath transmission lines. As discussed above, such development can constrain operational and maintenance activities on lines.

84 NZECP34:2001 requires a building to be no less than 8 metres from a pole and 12 metres from a tower.[3] However, this Code only applies to buildings and does not apply to other infrastructure such as non-conductive fences, pig stys, and kennels for example. As a minimum, a 12 metre distance would be just sufficient to allow adequate working space at the base of each pole or tower to carry out the works outlined in Table 1 on pages 9 to 11 above (and earlier in my evidence).

85 In other words, NZECP34:2001 does not provide for the 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.

86 I understand Federated Farmers wants farm buildings to be permitted in the District Plan, without any height restriction, and rely solely on the distances prescribed in NZECP34:2001 to protect people and the Grid. I am of the view that while NZECP34:2001 may adequately provide for safe distances for smaller buildings and structures, the construction and location of 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 transmission line. Requiring consent for these intensive and sensitive activities gives Transpower the opportunity to provide advice on their construction, location and use.

ENGINEERING INPUT INTO CALCULATING THE WIDTHS OF TRANSMISSION CORRIDORS

87 The engineering input into the calculation of transmission corridors is primarily based on the minimum distance required to operate and maintain the Grid, which in turn is based on the position of the conductor – the 'sag-to-ground' and conductor 'swing' distance.

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3 I note that in some instances, or for some activities, a greater separation distance is required.

88 The distance a transmission conductor swings in the wind is dependent on the ambient temperature, the power being carried, the wind speed, the type of conductor, the tension the conductor is strung at, the structural configuration (cross arm length) and the length of the span (distance between adjacent tower or pole).

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

90 An ambient temperature of 10°, full 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.

91 The width of transmission corridors was then determined by the swing of the 95% percentile span and access requirements for maintenance purposes.

92 The corridors are based on the existing assets, and have not been sized to provide for major rebuilds or new lines.

National Grid Corridors

93 The Red Zone 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.[4] These are the conditions when maintenance would be carried out, as work is not generally done during high wind conditions.

94 In my opinion, most buildings and commercial operations and structures should not be located in the Red Zone, even if they comply with NZECP34:2001. Some buildings and commercial operations pose a risk to the operation of the line, compromise Transpower's ability to maintain the line, and are a risk from electrical hazards. This includes buildings such as swimming facilities, schools, child care centres, medical facilities, commercial operations that emit dense smoke, dust or chemicals and high density lifting operations involving forklifts, cranes, tip trucks and the like.

95 In my expert opinion, the following activities can be located within the Red Zone (noting that they will still need to comply with NZECP34:2001):

95.1 Buildings, provided they do not prevent access to the lines, and provided they do not involve residential, medical, or children (or similarly sensitive activities);

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4 Wind speed of 100 Pascals or 46km/hour.

95.2 Certain structures (e.g. horticultural structures) where the heights and designs do not create an electrical risk to Transpower linemen, landowners, occupiers or the general public;

95.3 Car parks, greenways, low level storage, garden centres etc;

95.4 Alterations or extensions to existing buildings, provided they are not associated with a sensitive use (residential, medical, children), do not create an electrical risk, and do not prevent access to the lines;

95.5 Network utilities; and

95.6 Fences or similar structures up to 2.5m high.

Green Zone

96 The Green Zone is calculated as the distance from the centre line between the support structure (tower or pole) to a point where the conductor would swing under possible high wind conditions.[5] Accordingly, the Green Zone is much wider than the Red Zone.

97 Photos 11 and 12 below illustrate the effect of conductor blowout (on the Opunake-Stratford line). This is not uncommon when strong winds are blowing at right angles to the line.

Photo 11: Conductor blowout

5 Wind speed of 1000 Pascals or 147km/hour.

Photo 12: Conductor blowout

98 From an operation and maintenance point of view, my opinion is that there is no technical reason why buildings, structures or earthworks cannot be located (or carried out) in this area, provided consideration is given to whether they can be constructed safely, have considered a "safety by design" approach, give reasonable access to the lines, and comply with the minimum safety distances set out in NZECP34:2001 (which must be complied with anyway).

CONCLUSIONS

99 The electricity transmission network is critical to the national wealth and economic wellbeing of all New Zealanders. A large part of the Transpower network that traverses the Horowhenua District is key to the reliable and safe supply of electricity nationwide.

100 It is critical for Transpower to be able to operate and maintain its transmission infrastructure, where possible in unison with the landowners and communities the lines are located in. Access to the transmission assets is key, however Transpower acknowledges the wide range of terrain, public and business communities that the lines travel over.

101 Working closely with all landowners and business owners in vicinity of lines is key in delivering outcomes that are suitable to both parties.

Wayne Youngman
3 May 2013

APPENDIX A – THE NATIONAL GRID AND TRANSMISSION LINE COMPONENTS

1 The National Grid comprises some 12,000 route kilometres of transmission lines (approximately 50,000 kilometres of operational conductors) running through many diverse environmental and geographic locations, including urban and industrial areas. In the Horowhenua District alone, Transpower operates three 220kV and two 110kV transmission lines. The two 110kv lines terminate the Mangahoa power station which sits within the Horowhenua District.

2 These lines are:

2.1 Bunnythorpe – Haywards A (BPE-HAY A) 220kV single circuit circuit transmission line on towers;

2.2 Bunnythorpe – Haywards B (BPE-HAY B) single 220kV circuit transmission line on towers;

2.3 Mangahao – Paekakariki A (MHO-PKK A) 110kV single circuit transmission line on single poles;

2.4 Mangahao – Paekakariki B (MHO- PKK B) 110kV single circuit transmission line on single poles; and

2.5 Bunnythorpe – Wilton A (BPE-WIL A) 220kV double circuit transmission line on towers.

3 These lines are made up of about 540 steel towers and 110 poles traversing some 260 route kilometres across the Horowhenua District.

4 The National Grid is constantly developing to address changes in supply and demand. Increased demand for electricity requires overall transmission capacity to be increased. In addition, continuing growth in renewable generation requires the Grid to link to new, geographically diverse generation sites. This all requires the Grid's capacity and reach to be enhanced. Developments in the Grid also occur as maintenance, refurbishment and upgrade work is identified. The National Grid is aging and requires regular assessment and maintenance work to ensure transmission activity remains safe and efficient. The average age of Transpower's lines assets in Horowhenua District is about 50 years for the steel towers and 88 years for the wood pole lines.

5 Before addressing maintenance of the National Grid and the importance of an unimpeded transmission corridor to ensure maintenance work can be carried out, I will first briefly describe, by way of background, the key components of electricity transmission infrastructure.

Components that make up a line

6 Overhead transmission lines consist of five basic components:

6.1 Conductors;

6.2 Structures (including foundations);

6.3 Insulator sets

6.4 Foundations; and

6.5 Earthwires.

These components are all shown on Diagram 1 below.

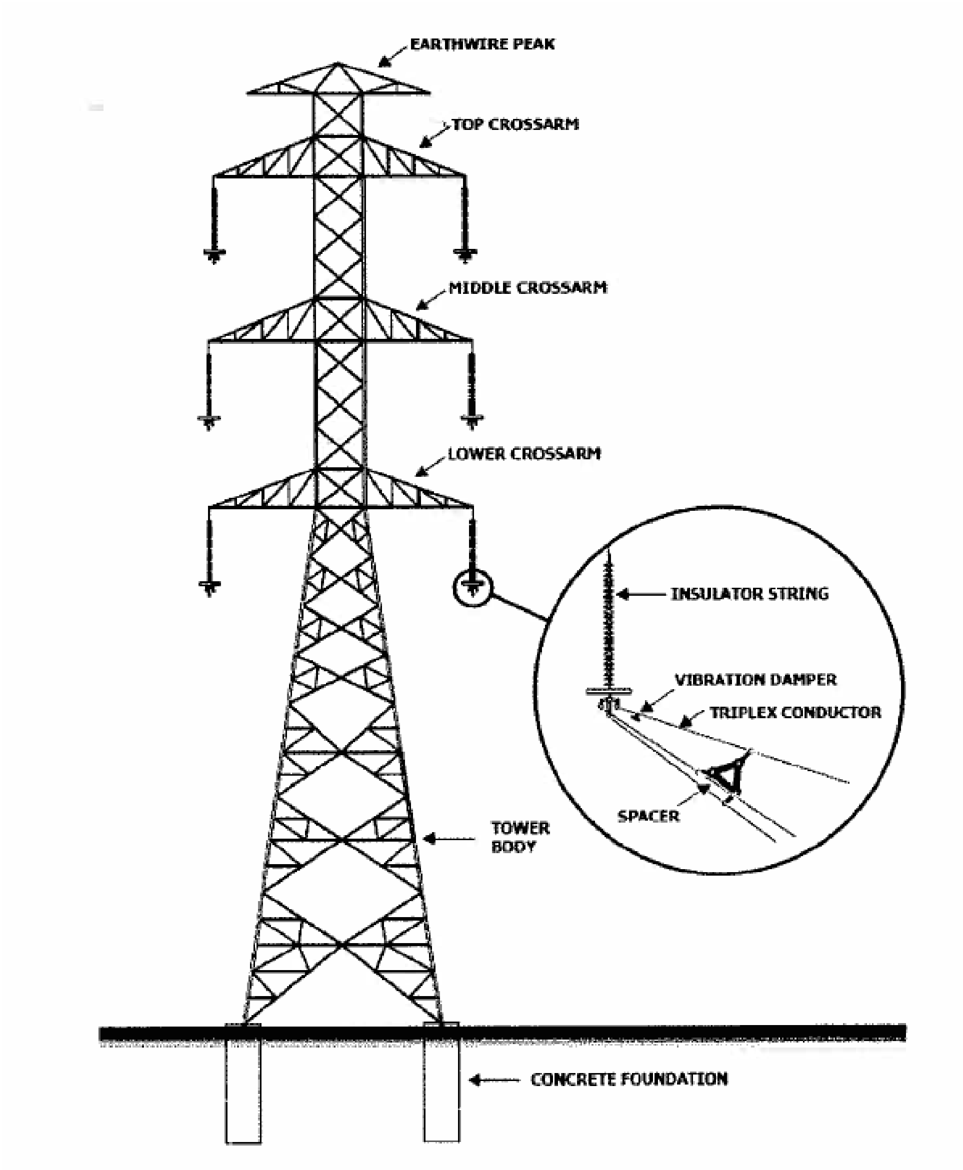

Diagram 1: Transmission line components

Conductors

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

8 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 5.5 metre and 110kV lines a 3.25 metre 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, particularly in windy conditions. Conductors on the 220kV tower lines Bunnythorpe – Haywards A & B and the 110kv Mangahao – Paekakariki A & B are simplex, (single wire per phase) while the 220kV tower line Bunnythorpe – Wilton A is duplex (two wires per phase).

Structures

9 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, wood, and steel tubular poles (monopoles). All lattice steel structures inside or near public areas are fitted with climb deterrent devices to restrict unauthorised climbing. All structures have danger signs and a 0800 THE GRID number for emergency contact.

10 Transpower has a number of transmission line structure and configuration types in the Horowhenua District. **Appendix B** to this evidence contains photographs of typical line structures that can be seen in the District.

Insulator sets

11 Insulators electrically insulate the live conductors from the earthed structures and prevent any 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 or a composite material, and the hardware assemblies which attach the insulators to the structure and the conductors. In most cases the insulators are suspended from the pole or tower arms.

Foundations

12 Foundations form the base on which the tower sits. Foundations come in three main designs:

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

12.2 Formed concrete foundations that connect the tower by either a bolted base plate arrangement or a concrete encased steel connection; and

12.3 Poles, which are generally directly buried.

Earthwires

13 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.

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

APPENDIX B - TYPICAL STRUCTURE TYPES IN THE HOROWHENUA DISTRICT

Photo B1: BPE-MHO-A0304

Photo B2: BPE-HAY-A0247

Photo B3: BPE-HAY-A0250

Photo B4: BPE-HAY-B0221

Photo B5: BPE-HAY-B0235

Photo B6: BPE-MHO-A0266