BEFORE THE BOARD OF INQUIRY

IN THE MATTER	of the Resource Management Act 1991
AND	
IN THE MATTER	of applications for resource consent and notices of requirement by Transpower New Zealand Limited for the North Island Grid Upgrade Project

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STATEMENT OF EVIDENCE OF GRAHAM WILLIAM FRANCIS WARREN FOR TRANSPOWER NEW ZEALAND LIMITED (NOISE)

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INTRODUCTION

Qualifications and experience

1. **MY** name is Graham William Francis Warren. I am an Acoustical Consultant employed by Marshall Day Acoustics. I have had over 40 years experience in environmental issues, specialising in environmental noise assessment and control. I have a diploma in Public Health from the Royal Society of Health UK and qualifications in Noise Assessment and Control from the University of Western Sydney. I am a Past President of the New Zealand Acoustical Society.

2. **OVER** the last 40 years I have been involved in the investigation, assessment and reporting on numerous environmental noise matters covering a wide variety of noise generating activities including numerous substation noise assessments, roading projects, involving a number of major State Highway projects and other significant infrastructure and development. In recent years major projects have included:

   (a) Auckland Rail Services Upgrading;
   (b) State Highway 1 (SH1) Auckland Harbour Bridge Approaches;
   (c) SH1 Harbour Bridge to City;
   (d) Auckland – Manukau Eastern Transport Infrastructure;
   (e) SH18 Realignment Greenhithe;
   (f) SH1 Newmarket Viaduct;
   (g) SH16/18 Realignment Hobsonville;
   (h) Whangaparaoa Peninsula – Alternative Access;
   (i) SH1 Otahuhu to Waiouru Peninsula – Widening;
   (j) SH1 Northshore Busway;
   (k) Eastern Corridor;
   (l) Viaduct Harbour Development;
   (m) Clifford Bay Inter-Island Ferry Terminal; and
   (n) Pokeno Quarry.

3. **I** confirm that I have read and am familiar with the Code of Conduct for Expert Witnesses in the Environment Court Consolidated Practice Note (2006). I have approached the preparation of this evidence in the same way that I would for the Environment Court.

4. **IN** relation to Clause 5.3.1 (c) of the Code of Conduct, I advise that I am relying to the extent described below, on the expert knowledge of Dr Constantin Wassilieff, who is the manager of the Wellington office of Marshall Day Acoustics Limited. He has a Doctorate of Philosophy degree in Physics from Victoria University of Wellington and has worked in the field of acoustics, noise measurement and assessment, and noise control engineering since 1980. Dr Wassilieff's C.V. is attached to this evidence as **Appendix 1**.

Introduction

5. **I** have been engaged by Transpower New Zealand Limited (Transpower) to provide noise assessment and design advice on all aspects of the North Island Grid Upgrade Project. I have previously been involved with numerous substation noise assessment and investigations of noise from overhead lines for Transpower.

6. **I**, and my colleagues at Marshall Day Acoustics (MDA), have been involved with the Upgrade Project since 2004. Noise assessments have been prepared for Otahuhu and Whakamaru Substations, a review of studies by Maunsell Limited for Pakuranga and the proposed Brownhill Road Substations has been undertaken, and also electrical and wind noise from the proposed overhead lines between Brownhill Road and Whakamaru has been examined. I have read the documents prepared for the Notice of Requirement (NoR) relevant to the area of noise.

7. **THE** following reports which form a part of the application documentation form the basis for much of my following evidence:

   (a) Marshall Day Acoustics report "Noise Effects Associated with Proposed Overhead Line – for the Notices of Requirement", dated 16 April 2007.

   (b) Marshall Day Acoustics report 04W181WKMRC "Whakamaru North Substation Transformer Noise Predictions" dated 16 April 2007.

   (c) Maunsell AECOM Report Ref: 60019424 "NI Grid Upgrade Brownhill Road Substation" dated December 2006.

(d) Marshall Day Acoustics Report No. 04W181BHL/1 "Brownhill Substation Review of Maunsell Report dated December 2006", dated 16 April 2007.

(e) Marshall Day Acoustics Report No. 04W181OTA/6 "Noise Effects Associated with Otahuhu Substation", dated 16 April 2007.

(f) Maunsell AECOM report Ref: 60019630 "Pakuranga Substation Acoustic Assessment Report", dated December 2006.

(g) Marshall Day Acoustics Report No. 04W181PAK/1 "Pakuranga Substation Review of Maunsell Report dated December 2006", dated 16 April 2007.

Scope of evidence

8. **MY** evidence will address the following matters:

(a) Noise associated with the overhead transmission line, and associated effects;

(b) Substation noise;

(c) Construction noise

(i) overhead lines
(ii) substation development
(iii) underground cable construction.

Overview: Noise Sources Associated with the Upgrade Project

9. **THE** Upgrade Project proposed by Transpower would include a new double circuit line constructed for future operation at 400kV, but initially operating at 220kV, connecting substations at Whakamaru in Taupo District and Brownhill Road in South Auckland. The line will consist of 432 double circuit towers and 6 single circuit towers, 25 to 70m high, with an average span of approximately 426 metres. The conductor configuration is triplex. The lines will require an

easement corridor of a minimum of 65m wide to allow for line swing and other operational requirements. This will also ensure audible noise will be at acceptable levels in "worst case" weather conditions.

10. **AN** underground cable section will connect between the Otahuhu Substation and the Substation/Transition Station at Brownhill Road and there is also a cable route from Pakuranga to Brownhill. Noise effects from the cable routes component of the Upgrade Project would be temporary only from the construction of the underground section.

11. **NEW** 220kV substation equipment will be required at the existing Pakuranga and Otahuhu Substations (recognising that the majority of new equipment at Otahuhu has already been consented as part of the Otahuhu Diversity Project). For the present time, the proposed substation at Brownhill Road would be used as a transition station only, to connect the underground cable to the overhead lines. No transformers are required until the eventual operation at 400kV, and hence noise emissions would be at a low level generated by switching equipment and above ground conductors.

12. **ADDITIONS** are proposed to the existing substation at Whakamaru and a new substation is proposed at Whakamaru North.

13. **NOISE** sources associated with the project include:

    (a) construction and maintenance activities;

    (b) wind-induced noise in the overhead conductors and towers;

    (c) Corona discharge noise from the overhead conductors under wet conditions;

    (d) Substation Transformers; and

    (e) Circuit breakers.

14. **I** must note at this point that the term "*noise*" throughout this evidence refers to audible noise, and not electromagnetic or radio noise. Those issues are addressed in the evidence of others.

Noise Sources And Effects: Overhead Line

15. **THERE** are two types of noise associated with power transmission lines:

(a) Corona discharge noise; and

(b) Wind-induced, or aeolian noise.

Corona Effects

16. **CORONA** noise consists of wideband noise (hiss, crackle etc), which is generally only audible under wet conditions such as rain or fog, together with a much lower level of steady 100Hz component (mains hum). During dry weather conditions corona noise from overhead conductors is usually inaudible at ground level and of no appreciable significance. Under wet weather conditions the wideband component dominates over the 100Hz component and any noise limits that control the wideband noise will also limit the 100Hz component. Wideband noise is not subject to a 5 dBa 'penalty' for special audible characteristics.

17. **CORONA** (and the associated audible noise) is due to ionisation of the air surrounding the conductor, and occurs along the length of the conductor. The ionisation is caused by a voltage difference applied across a volume of air. It is the voltage difference and not the actual voltage per se that causes ionisation. High voltages do not necessarily mean high noise levels.

18. **FOR** a round conductor the voltage difference per unit volume of air reduces away from the conductor surface, creating a gradient, with the highest voltage being at the surface of the conductor. The larger the conductor diameter, the lower the surface voltage gradient, and hence the lower the ionisation effects and thus noise. The surface voltage gradient is also affected by conductors arranged in a bundle (i.e. duplex, triplex, etc), and this provides a practical means of reducing the gradient to control corona discharge noise. A triplex configuration is generally better than a duplex configuration in respect of corona noise.

19. **IONISATION** effects are largely determined by the conductor surface conditions. A rough conductor surface (nicks, broken wire strands, bird droppings etc) will create more noise. Under wet conditions, such as very light rain or fog, water drops form on the surface of the conductor, causing increased ionisation and corona discharge noise.

20. **ALTHOUGH** corona discharge noise is most prominent under heavy rain conditions, these occur less frequently with light rain. International best practice in assessing corona discharge noise effects, considers light rain as being comparatively more prevalent and thus of greater nuisance potential. This is particularly relevant for the Waikato, where fog is prevalent.

21. **TWO** levels of rain are generally considered when assessing corona discharge noise:

    (a) Heavy rain (greater than 6.5mm/hr);

    (b) Stable but light rain (less than 0.75mm/hr).

22. **THE** stable rain condition ("wet conductor" condition), would be equivalent to heavy fog in terms of the effect upon corona discharge. The rainfall rate of 0.75mm/hr would be expected to be more noticeable than noise during heavy rain, as heavy rain also raises the background noise level at the receiving environment (such as a nearby residence). Light rain generates corona noise but the background noise remains low. Furthermore light rain generally lasts longer than heavy rain.

23. **THE** EPRI Reference Book[1] provides empirically-derived formulae for predicting audible noise from overhead transmission lines. These formulae are considered to be reliable. MDA has compared these formulae against another noise prediction model (by Yang et al[2]) based upon a "best fit" of a range of prediction models. The EPRI and Yang models agree to within a decibel, giving confidence that the predictions are accurate.

1 EPRI = Electric Power Research Institute, 342 Hillview Avenue, Palo Alto, California 94304

2 The prediction method in the *EPRI "Transmission Line Reference Book, 345kV and Above"* Chapter 6 has been used to predict the noise levels from corona discharge under wet conductor conditions for the 400kV line. These predictions have also been compared against other prediction models described in a paper by Yang et al *(New formulas for predicting audible noise from overhead HVAC lines using evolutionary computations,* IEEE Transactions on Power Delivery, Vol 15, No 4 October 2000)

24. **AS** a further indicative practical check of the EPRI prediction model, noise levels of line conductor corona discharge noise were made at Wairakei, under the Ohakuri-Wairakei B (**OKI-WRK-B**) line. This line was chosen as the surface voltage gradient was similar to that for the proposed line. Although the line is simplex (i.e. single conductor per phase), it nevertheless provides a validation of the model at the surface voltage gradients for the proposed line.

25. **THE** corona discharge noise level under "wet conductor" conditions was predicted to be 43 dBA directly under the centreline. The measured level under conditions of light but intermittent rain was 39 dBA L_{eq}. This is reasonable agreement, considering the vagaries of practical measurement under these conditions, with the model predicting slightly higher than the measured values.

26. **ENGINEERING** solutions exist to limit air ionisation thus ensuring that noise is kept to a practical minimum.

Predicted noise levels: Corona discharge broadband noise: Overhead Line

27. **ALTHOUGH** the overhead line will initially operate at only 220kV, noise predictions have been carried out for a worst case circumstance with the maximum line voltage of 400kV (i.e System Highest Voltage 400kV +5%), which may be required in the future with increased power supply demand.

28. **FROM** the EPRI model, the noise level has been predicted by Transpower engineers out to a distance of 100m from the centreline of the proposed line. The graph below presents the variation of noise level with distance from the centreline. The designation or easement boundary is generally 32.5m each side of the centreline and is marked on the horizonal distance axis as a diamond.

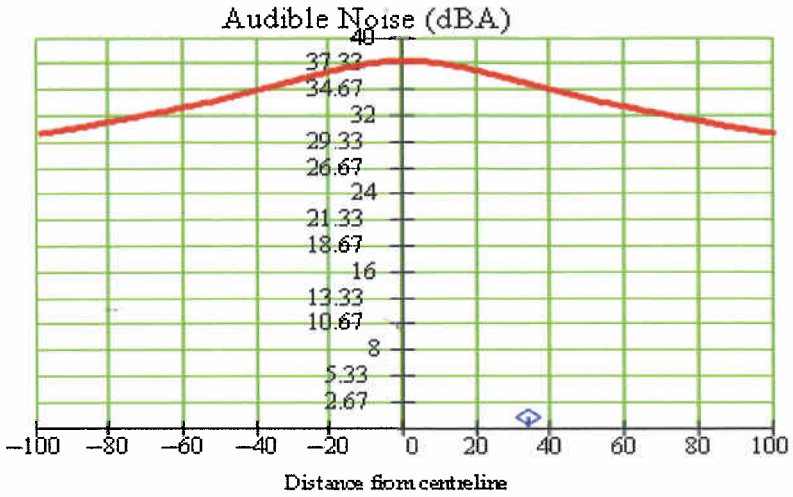

Figure 1: Corona discharge noise levels

29. **THE** noise level at the 65m designation/easement edge is calculated by the EPRI model to be 35 decibels. For wider designation widths it will be lower.

30. **WE** have verified these predictions against both the EPRI and the Yang model with agreement to within one decibel of the Transpower prediction.

Predicted noise levels - Corona discharge 100Hz noise: Overhead Line

31. **THE** 100Hz component (this is the so-called 100 Hz 'hum') of the corona noise varies with distance in accordance with the standing wave pattern generated by the alternating current which is due to phase cancellation and enhancement. These phenomena (cancellation and enhancement) occur due to the various conductors being located at different distances from a particular receiving point. At some points the standing waves will be at opposite phases thus causing cancellation, at other points they will be in phase resulting in enhancement.

32. **HOWEVER**, the average level of noise is in the order of 25 decibels, which is well below the wideband level of 35 decibels, at the edges of the easement width. It is also useful to note that the noise level at the centreline (i.e directly under the lines) is only two decibels higher than at the edge of the proposed minimum width easement boundary. I note that because the predicted corona 100 Hz noise is 10 decibels below the broadband noise there is no cumulative increase above the levels of the broadband noise when both are present simultaneously.

Predicted noise levels: 220kV vs 400Kv: Overhead Line

33. **IT** is intended that the line operate initially at 220kV until approximately 2033 when it is anticipated that increased demand will require operation at 400 kV. Under these conditions (220kV) the noise effects would lessen below the range of validity of the models so an accurate level cannot be predicted. However, at an operating line voltage of 220kV, the noise will be considerably lower than the levels predicted above.

Noise of Non-Electrical Origin - Wind: Overhead Line

34. **WIND-INDUCED** noise includes wideband turbulent noise, and aeolian noise, which are tones or whistles that vary in frequency with the windspeed. Turbulent noise is a characteristic of any obstruction to the wind, artificial or natural, and is not typically considered to be a nuisance. Wind in trees and around house eaves are common examples.

35. **AEOLIAN** tones ("wind-in-the-wires") are caused by vortex shedding (regular air fluctuations) across the conductor and are readily eliminated by a suitable conductor surface profile. The frequency of aeolian tones varies with wind speed.

36. **THE** surface profile of the conductors proposed is similar to those in use elsewhere and is known not to cause any Aeolian noise problems. The triplex conductor configuration is predicted to produce no more noise than duplex conductors.

37. **THE** noise level from Aeolian tones produced by wind on the conductors can be estimated. For a nominal "stiff breeze" wind speed of 10m/s, the noise level from Aeolian tones is estimated to be less than 25 dBA at the easement, at a frequency of 150 Hz (a low tone). At this level, the sound is likely to be masked by other wind noise effects (vegetation etc) depending upon the precise receiver location. As the predicted level would be generally below other wind generated noise, it would not increase the overall ambient noise level.

38. **WITH** regard to certain types of insulators, those with a dished profile can create a strong wind-induced tone at a single frequency. This is different from aeolian tones in that the frequency of the tone does not vary. The type of insulators proposed for the 400kV-capable line have a shed profile that would be established as not producing tonal noise.

Receiving environment characteristics: Overhead Line

39. **FROM** available rainfall data[3] the proportion of days for the year 2005 that had rain that exceeded a rate of 0.75mm/hr was 39% for Hamilton and 42% for Cambridge.

40. **ALTHOUGH** these figures indicate the area is subject to a considerable amount of rain, inspection of the daily rainfall graphs for Cambridge indicates that the proportion of the actual time that rain exceeds 0.75mm/hr is less than a quarter of the percentage figures above, approximately 10%.

41. **HEAVY** fog can also give rise to "wet conductor" conditions. It is not known whether fog days also coincide with rain days but at least some are likely. Data from the National Institute of Water and Atmospheric Research indicates that up to 40 fog days at the northern end of the line, and up to 70 fog days at the southern end, could occur per year. Some of these will be classed as "heavy fog" days.

42. **TAKING** into consideration that half of the heavy fog days also coincide with "light rain" days, I have calculated that weather giving rise to "wet conductor" conditions is 11% for the northern section of the line, and 12% for the southern section.

43. **THE** overhead line traverses mostly rural land with 45 residences within 100 metres of the centreline of the route and a list of these dwellings is contained in the Table in Appendix 2. Of these dwellings, 19 are owned by Transpower and where located within the easement will be removed. The other factor relevant to the consideration of noise effects is the number of existing residences that are potentially affected by corona discharge noise on these wet days. From figure 1 earlier in my evidence, the corona noise level at 100

3 Weather Underground Network

metres is predicted to be 30 dBA. Residences within 100 metres will be exposed to a noise level of between 30 dBA (at 100m) and 35 dBA at the designation boundary.

44. **SEVEN** residences have been identified as being within the easement, and I understand that these will be either relocated or demolished. There are a relatively small number of additional dwellings within 100m of the centreline where, as noted above, noise levels would be at low levels.

Noise performance standards: Overhead Line

45. **THE** transmission line passes through rural areas in seven Districts. Noise limits for these areas, in general terms, are set out below. The district plan noise limits are denoted as "daytime" and "night-time" limits but, in most cases, the night-time limit also applies on Sundays and Public Holidays. The noise descriptor is dBA L_{10} (average maximum) in all cases except Taupo District where it is L_{eq} (average). The limits generally apply at the notional boundary of a dwelling. As corona noise is steady, when it occurs, L_{10} and L_{eq} will be identical in this instance.

District	Daytime Noise Limit dBA L_{10}	Night-time Noise Limit dBA L_{10}
Manukau City	50	35
Franklin District (rural-res limits)	45	35
Waikato District	50	40
Matamata-Piako District	50	40
Waipa District	50	35
South Waikato District	50	40
Taupo District	55 L_{eq}	40 L_{eq}

46. **THE** easement boundary corona discharge noise level of 35 dBA under "wet conductor" conditions meets all District Plan noise limits. At the initial line voltage of 220KV, the noise level will be lower still. There is some uncertainty as to the likely noise level that will result from different equipment arrangement and varying rainfalls and as such it is recommended that L_{Aeq} 40dB be selected as the noise limit to control corona discharge noise applied at the designation boundary.

Assessment of Noise Sources and Effects: Overhead Line

Operational

47. **NEW ZEALAND** Standard NZS6802:1999 "Assessment of Environmental Noise", (and the previous 1991 version still widely cited in District Plans), recommends a night time noise limit in the range of 35-45dBA L_{eq} (or L_{10}). A noise level of 45dBA outside an open bedroom window will result in a level of between 30 and 35dBA inside. This level of noise is considered acceptable in terms of providing for undisturbed sleep.

48. **THE** lower predicted corona discharge noise level of 35dBA outside an open bedroom window at the edge of the easement will result in a level of between 20 and 25dBA inside. This is well below a level likely to cause any sleep disturbance and more than meets the recommended design levels of the Australian/New Zealand Standard AS/NZS 2107:2000 (*Acoustics – Recommended design sound levels and reverberation times from building interiors)* of 25 to 30 dBA for areas with neglible transportation.

49. **IN** a rural environment, the noise limit is normally applied at the notional boundary of a residence, 20 metres away from the wall of a building. This allows noise effects upon outside activities to be assessed. However, in this instance the assessment of noise effects is primarily concerned with sleep disturbance and so the appropriate assessment location is at the façade of the residence.

50. **ANY** noise effects from the operation of the line, at the maximum line voltage of 400kV, is predicted to be less than minor.

Construction

51. **THE** construction methodology used for the new overhead line would depend upon the contractor, but there are typically six main activities associated with transmission line construction projects. These are:

(a) Access construction;

(b) Site preparation and vegetation management;

(c) Foundation construction;

(d) Tower erection;

(e) Conductor/earthwire installation;

(f) Reinstatement.

52. **MOST** District Plan construction noise provisions require compliance with New Zealand Standard NZS 6803:1999 "*Acoustics – Construction Noise*" and in my opinion reference to this Standard is appropriate for the Upgrade Project. These provisions and noise limits of the Standard apply for the control of construction noise where relevant. The generally acceptable level of intrusive noise in the community is assessed under the provisions of district plan activity rules. However, construction noise is assessed differently from normal activity rules because it usually cannot be kept within the specified limits. Although this may mean that the noise is undesirable, it is not necessarily unreasonable when all the relevant factors are taken into consideration. Construction noise is an inherent part of the progress of society.

53. **AS** noise from construction projects is generally of limited duration, people and communities will usually tolerate a higher noise level provided it is no louder than necessary, and occurs within appropriate hours of the day. Construction activity is expected to be spread over two years, however, each site is likely to experience noise for less than one month over three specific working periods (foundations, tower erection and stringing).

54. **THE** preparation stages (earthworks and site preparation) would be of a scale normally anticipated in a rural working environment and any noise effects of a similar nature. The remaining stages are of a greater scale but of temporary duration at any one tower location. Noise effects would be controlled by adherence to a construction noise management plan, and by compliance with the New Zealand Construction Noise Standard for the control of construction noise.

55. **TOWER** foundation construction will involve access to the site by heavy excavation plant, large trucks, or small cranes, and concrete trucks. Pile drilling for each tower is expected to take about five days, with one to five days

to pour the concrete by helicopter or ground-based plant. Some piles may need to be driven rather than bored, depending upon the ground conditions. Some blasting of rock may also be required in certain circumstances.

56. **HEAVY** vehicles will be used to transport tower components to each site and each tower will take approximately five to ten days to erect.

57. **CONDUCTOR** installation will be carried out in sections of between two and five kilometres long. Pilot wires for pulling the conductors will be installed, possibly by helicopter. The conductors will then be pulled through by winching plant (diesel winches etc) using the pilot wires as a pulling rope. The equipment locations are typically 3 km apart and the works anticipated to take two weeks at each site. Implosive jointing of conductors may take place in some locations.

58. **GROUND** vibration may be generated by some activities (eg driving piles or blasting). In addition, and to a lesser extent, other heavy plant used to construct the line will cause ground vibration during construction activities and during access to and egress from work sites. Potential adverse effects of vibration are nuisance and building structural damage.

MITIGATION MEASURES: Overhead Line

Construction noise

59. **THE** contractor selected by Transpower will be required to revise the project management plan as the project progresses so that Transpower will have a continually updated plan showing when work at any particular site is intended. The contractor will use this programme as a basis for the construction and noise management plan, including liaison with landowners and the community.

60. **THERE** will be limited hours of work (ie. generally not at night), and a community liaison plan will be a required part of the construction management plan. Land owners will be made fully aware of the programming of the construction as it affects their land.

61. **SOME** night-time construction work may be necessary where construction activity cannot be undertaken during daytime due to unacceptable disruption

to essential services such as major roads. In such circumstances noisy construction work will need to be effectively managed to control noise levels generated and to minimise the periods when this would take place during noise-sensitive night-time periods. These matters, including communication and liaison with potentially affected occupiers, would be addressed in mitigation measures implemented by means of a construction noise management plan.

62. **THE** achievement of compliance with the provisions of New Zealand Standard NZS6803:1999 "Acoustics - Construction Noise" will ensure that noise effects do not exceed generally acceptable levels.

Construction vibration: Overhead Line

63. **THE** construction contractor will be required to produce a comprehensive mitigation plan covering any blasting activities, including construction blasting and implosive jointing.

64. **IN** most instances, the distance between towers and houses or other occupied buildings will be sufficient to reduce any vibration effects on those buildings to very low levels such that the vibration would not be noticeable by the occupants.

65. **SOME** District Plans (eg Waikato) refer to older versions of NZS 6803 and have vibration standards that must be met for construction and blasting (NZ 4403:1996, "Code of Practice for Storage, Handling, and Use of Explosives"). However, in my opinion German Standard DIN 4150 is more comprehensive and has specific criteria to avoid structural damage from vibration. There is a perception that any ground vibration can result in structural damage but the reality is that comparatively high levels of vibration are needed for this to occur.

66. **IN** the unlikely event of vibration being perceived to be problematic to residents or other activities, arrangements would be made to undertake the activities at times when the impact of the vibration is least problematic. If necessary, alternative arrangements could be made for the affected party to be accommodated elsewhere for the duration of the particular construction activity.

67. **MEASUREMENT** locations for compliance with the criteria would be identified following an initial assessment of the area. This would be done as part of the development of the Construction Management Plan.

68. **VIBRATION** generated during access and egress to construction sites would be localised, transitory, and of short duration and is expected to have minimal impact on other activities. I consider that normal construction activity landowner liaison would be all that is required in relation to these activities.

Substation Noise Sources and Effects

69. **THE** purpose of the various substation noise modellings and assessments that follow is to establish a noise envelope within which the substation activities are able to take place whilst meeting the specified noise conditions of the designations sought by Transpower.

70. **CIRCUIT** breaker noise occurs only very occasionally and not during normal operation. It only occurs to protect the grid in the event of some unusual event such as a lightning strike. The noise generated by circuit breaker operation (SF6) is typically about 90 dBA at 20 metres and has a duration of less than 0.1 seconds.

71. **FOR** this reason the noise predictions should not be taken as final, as the actual noise emissions will be dependent upon the final selection of equipment and precise layout.

72. **DESIGNATIONS** are sought for Otahuhu, Pakuranga, Brownhill, Whakamaru North and Whakamaru Substations.

Otahuhu Substation

73. **THE** Upgrade Project will result in relatively minor works for Otahuhu Substation. This is because the majority of changes to the site result from the Otahuhu Diversity Project and all works associated with that project have already received resource consents from MCC. The actual works proposed for Otahuhu that are associated with the Upgrade Project are limited in extent and will result in no new significant noise generating equipment (other than

during construction activities and those connected with overhead line works and deviations)..

74. **THE** proposed designation is therefore intended to cover the existing and consented operation of the substation, as well as providing for ongoing maintenance and replacement of equipment in future, as is considered necessary. This may involve replacement over time of existing transformers with quieter new equipment, which will provide opportunities for noise from the substation site to be progressively reduced. A condition recognising and providing for this situation has therefore been developed and is addressed in Mr Lloyd's evidence.

Ambient and Predicted Noise Levels: Otahuhu

75. **THE** existing transformers are being progressively replaced with quieter three-phase types. The older single-phase transformers are generally relatively noisy. As these are replaced with quieter equipment over time, dependent on growth in electricity demand and transformer physical condition, the average noise emission levels from the substation will progressively reduce.

76. **THE** existing noise contours around Otahuhu Substation have been predicted from measurements of the sound power level of the existing transformers and compared against measurements of the noise levels made around the perimeter of the substation and adjacent residences. Due to the high ambient traffic noise levels in this area, accurate measurement of substation noise is problematic. Agreement between measured and predicted noise levels is reasonable near the switchyard perimeter fence, but the levels further afield are affected by other noise in the area, even in the early hours of the morning when the noise surveys are undertaken, when special care was taken to exclude non-substation noise as far as possible. Even so, measured levels away from the substation do not represent substation noise because of the dominant contribution from other major noise sources in the area such as the Southern Motorway and the Contact Energy Power Station located immediately to the north.

77. **THE** following plan shows noise contours from existing transformers compared with measurements of the background level (L_{95}) (shown in boxes in Figure 2) at the various locations shown. The background level (L_{95}) was

chosen as this is sensitive to steady noise from transformers and less sensitive to peak events from traffic and other extraneous sounds that greatly affect the L_{10} noise descriptor utilised in the Manukau District Plan noise limits. These noise surveys were carried out on two different occasions between 2am and 5am in the morning, when noise from the motorway was lowest. Night-time and early morning are also the critical times as regards sleep disturbance. At other times (from 4:00 am onwards) the ambient noise increases dramatically, and dominates the noise environment outside the substation site.

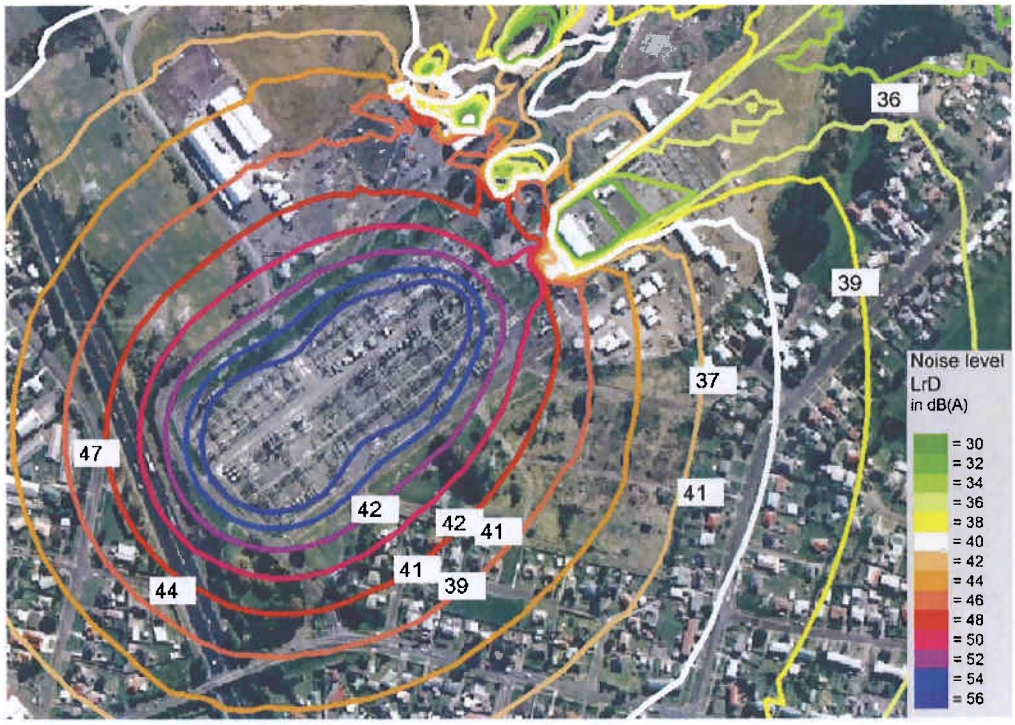

Figure 2 Existing noise contours around Otahuhu Substation

78. **NONE** of the options proposed have yet been modelled for noise, but other transformer scenarios have been modelled to determine the effect such changes would have on noise emission levels beyond the designation boundary. These scenarios allow for a gradual reduction of existing noise from the existing older transformers as they are replaced by quieter three-phase types.

Receiving Environment Characteristics: Otahuhu

79. **THERE** are three schools in the vicinity (Bairds Intermediate School, Clydemore Primary School, and Bairds Road Primary School), but these are