Appendix I-2
EMF Report

TransGrid

Predicted EMF Levels for 330kV Transmission Lines

Dumaresq – Tenterfield & Tenterfield – Lismore Lines

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1. Introduction

The following EMF calculations are based on the maximum load flows along the proposed 330 kV Dumaresq – Tenterfield and Tenterfield – Lismore transmission lines. The load values used in this report have been taken from the projected load profiles provided by Network Planning. The field calculations were performed assuming that MVA loads equalled MW loads due to limited information available. The electric and magnetic field profiles were calculated using TransGrid's "Spider" program.

2. Background

In December, 2006, ARPANSA issued a Draft Standard on "Exposure Limits for Electric and Magnetic Fields" [1]. This draft proposes implementing an exposure limit for the general public. The limits stated in the standard are as per below table:

	General Public Limit	**Controlled Activity Limit**
Electric Field	5 kV/ m	10 kV/ m
Magnetic Field	1000 mG	3000 mG

Table 1: Limits Stated in ARPANSA Standard

2.1 Magnetic Fields

In order to determine the expected magnetic fields, the loads that are expected to be on the line need to be established. The magnetic fields are mainly affected by loading conditions of the line rather than variations in system voltage. The following loads that have been selected by TransGrid are defined in the ENA Standard [2] and the National Institute of Environmental Health Sciences [3].

2.1.1 Short Term Emergency Load

The short term emergency load is the maximum load that is expected to occur on the transmission line. This short term load was calculated to be 500 MVA by Network Planning.

2.1.2 Infrequent High Load

The infrequent high load for the transmission line represents an upper limit for long-term exposure to magnetic fields. To be consistent with industry practice, the infrequent high load has been taken to be the load in the transmission line that is exceeded for not more than 15% of the time.

The variation in load on the new transmission line can be represented by a load duration curve as indicated in Figure 1. For the Dumaresq – Tenterfield – Lismore transmission lines the infrequent high load was determined by Network Planning to be 300 MVA.

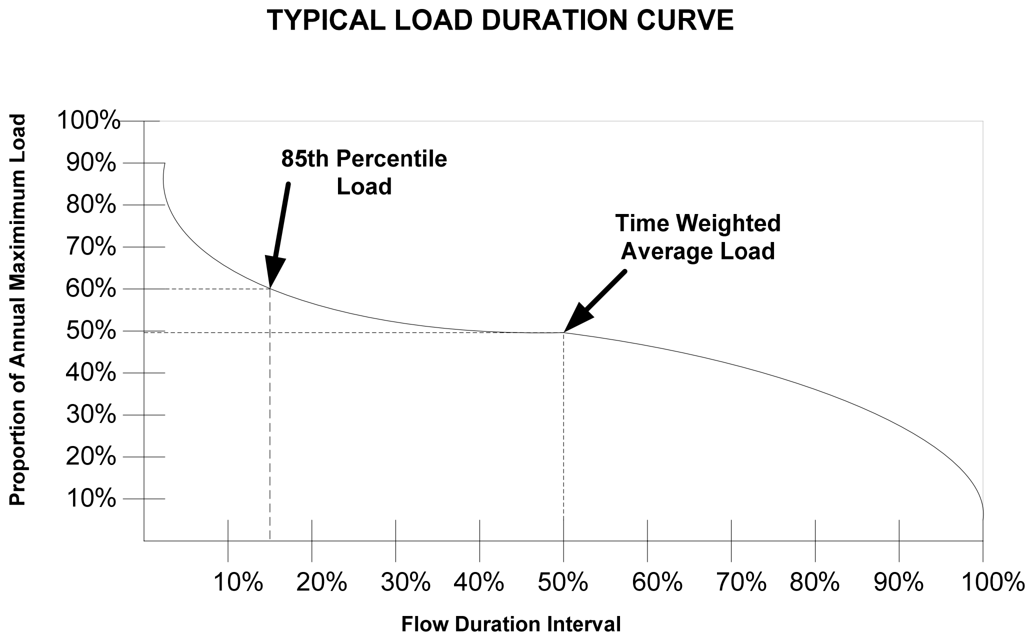

Figure 1. Typical load duration curve

2.1.3 Time Weighted Average Load

Time weighted average has been defined as "A weighted average of exposure measurements taken over a period of time that takes into account the time interval between measurements. When the measurements are taken with a monitor at a fixed sampling rate, the time-weighted average equals the arithmetic mean of the measurements. " *(The National Institute of Environmental Health Sciences, refer to website http://www.niehs.nih.gov/emfrapid/booklet/effects.htm).*

The time-weighted average load was determined to be 250 MVA by Network Planning.

2.2 Electric Fields

Electric fields are mainly determined by the system voltage on the transmission line and the conductor clearance to ground. Also, the conductor clearance to ground is dependent on the temperature of the conductors.

2.2.1 System Voltage

The typical system voltage at Dumaresq was advised to be 357 kV by System Operations. This value is close to the maximum voltage of the line, therefore the maximum system voltage of 362 kV was used in the electric field calculations as this would be the worst case condition.

2.2.2 Conductor Clearances to Ground

The ground clearances along a transmission line vary with the terrain, load, and conductor temperature. The Lismore – Dumaresq transmission line is designed to have a minimum ground clearance of 9.6m for conductor temperatures of 85°C. However, System Investigations [4] have advised that the conductor temperatures for the Dumaresq – Lismore line are not expected to exceed 55°C. This can be seen in Figure 2 [4] which is a plot of the probability of the line exceeding expected conductor temperatures. At this reduced maximum operating temperature of 55°C, the conductors will sag less resulting in an increased ground clearance of 10.8m. The electric fields have been calculated for three different operating temperatures as detailed in Section 4.2.

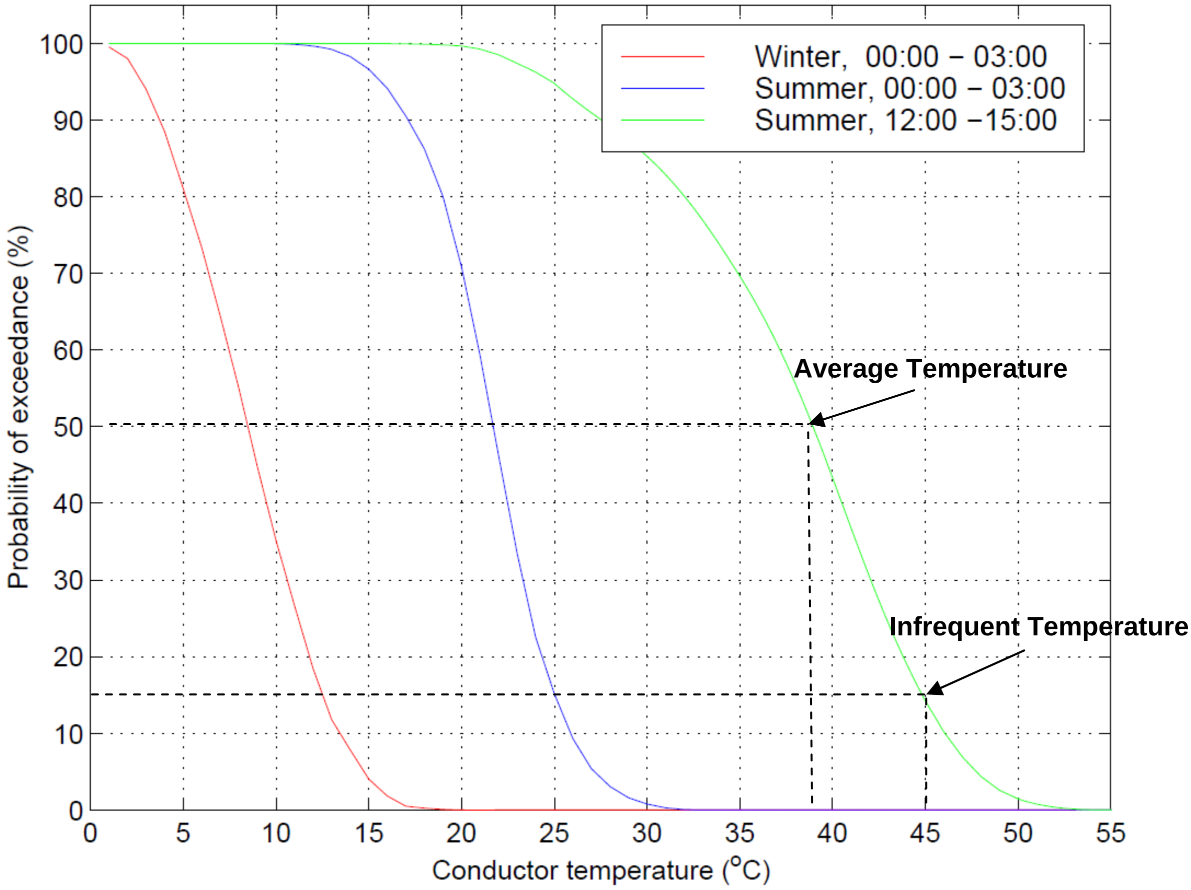

Figure 2. Probability of Expected Conductor Temperatures

3. Design Data

The electric and magnetic field calculations of this report are based on a single circuit steel structure QSU configuration proposed for use in the new transmission line. Refer to drawing TL-813818 for an outline of the structure. The system typical operating voltage is set at 357 kV with a maximum system voltage of 362kV.

A system voltage of 357 kV was used for calculating the magnetic fields. Although the voltage may vary up to a maximum of 362 kV, the magnetic fields are mainly affected by loading conditions of the line rather than variations in system voltage.

The system voltage for all the electric field calculations was set to the system highest voltage of 362 kV.

The average span of the line was advised to be 370m by Projects Group.

4. Results

4.1 Magnetic Fields

The three different loads detailed in Section 2 were used in TransGrid's Spider program. The ground clearance was set to 10.8m for the maximum operating temperature of 55°C and the lateral profile of the magnetic field was calculated at a height of 1m above ground level. The results for the new line with system typical voltage of 357 kV are shown in Figure 3 and summarised in Table 2.

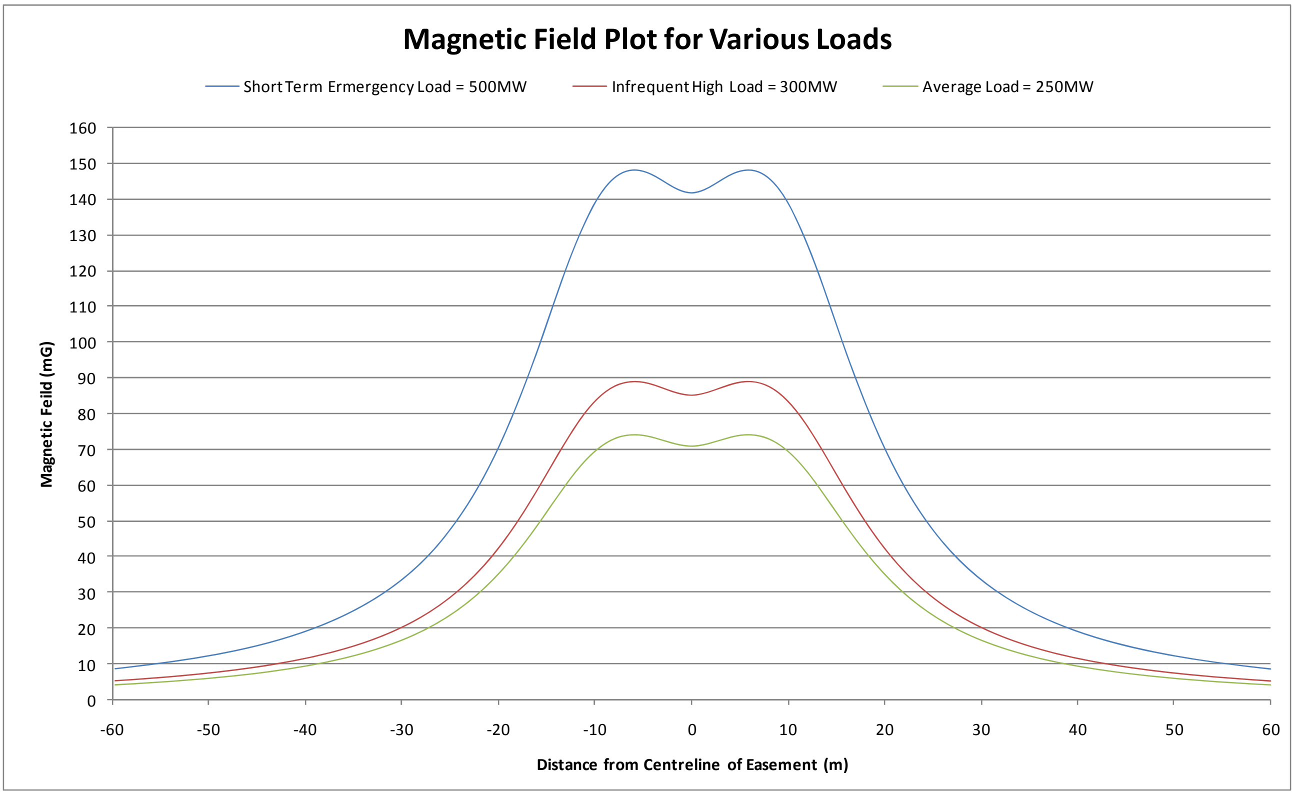

Figure 3. Magnetic field profiles (lateral) for various loads

Load condition	Maximum Magnetic Field on easement (mG)	Magnetic Field at 30 m easement edge (mG)	Magnetic Field at 60m from centreline mG)	Distance from centreline to where Magnetic Field drops below 4mG level (m)
Short Term Emergency Load	148	34	8.4	86
Infrequent High Load	89	20	5.0	67
Time Weighted Average Load	74	16.7	4.2	62

Table 2. Summary of results for magnetic field for various Loads

4.2 Electric Fields

The lateral profile of the electric field was calculated at 1m above ground level for following temperatures (refer to Figure 2):

- **Maximum Conductor Temperature:** The maximum expected conductor temperature is 55°C. This temperature is expected to occur less than 1% of the time. The resulting ground clearance of the line conductors is 10.8m when the line is operating at 55°C.

- **Infrequent Operating Temperature:** The infrequent conductor temperature along the transmission line is the temperature that is exceeded for not more than 15% of the time, referring to Figure 2 this corresponds to an operating temperature of 45°C. The resulting ground clearance of the line conductors at this temperature is 11.2m.

- **Average Operating Temperature:** The average conductor temperature along the transmission line is the temperature that is exceeded for not more than 50% of the time, referring to Figure 2 this corresponds to an operating temperature of 39°C. The resulting ground clearance of the line conductors at this temperature is 11.4m.

The electric field results are shown in Figure 4 and summarised in Table 3.

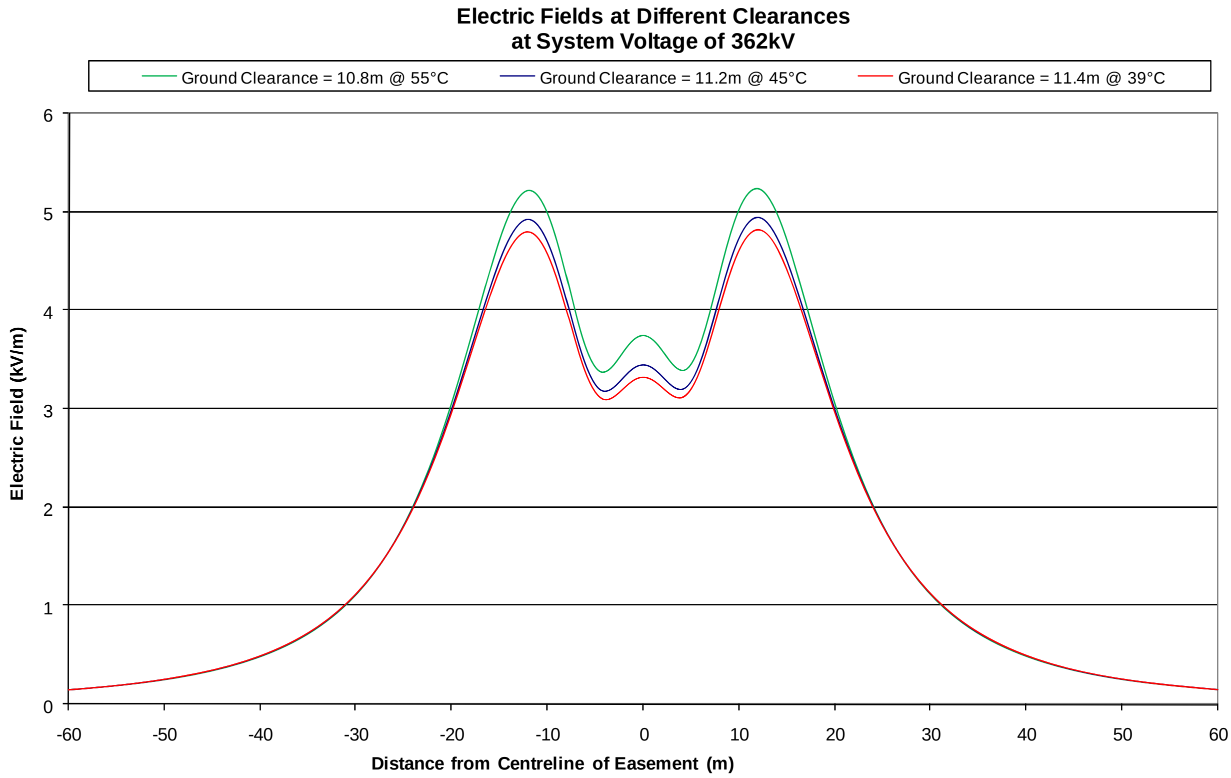

Figure 4. Electric field profile (lateral) for system highest voltage

Temperature Type	Transmission Line Operating Temperature (°C)	Maximum Electric Field on easement (kV/m)	Electric Field at 30m easement edge (kV/m)	Electric Field at 60m from centreline (kV/m)
Average	39	4.8	1.1	0.14
Infrequent	45	4.9	1.1	0.15
Maximum	55	5.2	1.1	0.15

Table 3. Summary of results for electric field profile

5. Conclusion

From the results, we can conclude the following about the expected magnetic and electric fields for the new 330kV transmission line:

- The magnetic fields are below the General Public exposure limit of 1000mG at all times
- The electric fields are below the General Public exposure limit of 5kV/m at majority of times with the exception of short periods when the line operates at the maximum expected temperature of 55°C.

- The electric fields are below the Controlled Activity exposure limit of 10kV/m if the line were to operate at 55°C, though this line is expected to operate at 55°C less than 1% of the time.

REFERENCE DOCUMENTS

[1] Australian Radiation Protection and Nuclear Safety Agency (ARPANSA), "Exposure Limits for Electric & Magnetic Fields – 0Hz to 3kHz". Draft Standard – 2006.

[2] ENA - Standard Basis for Quoting Transmission Line Magnetic Fields, March 2006.

[3] National Institute of Environmental Health Sciences (website) *http://www.niehs.nih.gov/emfrapid/booklet/effects.htm*.

[4] Conductor Temperatures on 330kV Line 8H (Dumaresq-Lismore), March 2010, Systems Investigations Branch, TransGrid.