



APPENDIX G

Electric and Magnetic Fields Assessment (December 2009)



December 2009

energy2U
Alliance



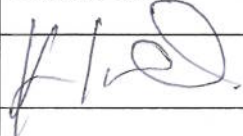
North Sydney Zone Substation
Electric and Magnetic Fields Assessment Report



QUALITY INFORMATION

Document: North Sydney Zone Substation
Ref: 60100174
Date: 2 December 2009
Prepared by: Rodney Urban
Reviewed by: Sylvester Phang

REVISION HISTORY

Revision	Revision date	Details	Authorised	
			Name/position	Signature
1	07/09/2009	Draft	Hemant Kumar / Project Manager	Original signed
2	17/11/2009	Revised substation layout	Hemant Kumar / Project Manager	Original signed
3	02/12/2009	Revised cable layout	Kieran Connell / Project Manager	

Level 4, 799 Pacific Highway, Chatswood 2067 Australia

T +61 2 9414 3333 F +61 2 8339 9456 E energy2uprojects@energy.com.au W www.energy.com.au

The Energy2U Alliance brings partners EnergyAustralia, Leighton Contractors Pty Ltd, AECOM Australia Pty Ltd and PowerServe Pty Ltd together to undertake works for EnergyAustralia's Overflow Infrastructure Project.



CONTENTS

1	Introduction	4
2	Environmental Impact of EMF	4
3	Exposure Limits	5
4	Preliminary Impact Assessment	7
	4.1 Modelling	8
	4.2 EMF Calculations	11
5	Prudent Design Considerations	15
6	Conclusions	16



1 INTRODUCTION

The Energy2U Alliance is to design and construct a new 132kV/11kV zone substation at North Sydney to replace the existing 33kV/11kV substation. This has been necessitated by ageing infrastructure and supply constraints at Willoughby Sub-Transmission Substation (STS). The new substation is to be constructed on a cleared and decontaminated site immediately behind the existing 33kV/11kV substation.

The current arrangement of the 33kV/11kV substation comprises 5x 19MVA transformers, supplied by 5x 33kV cabled feeders from Willoughby STS. This allows for a maximum firm capacity of 114.8MVA. The final arrangement of the new 132kV/11kV zone substation will comprise 3x 50MVA transformers, supplied by 3x 132kV cabled feeders from Willoughby STS via Crows Nest and Mosman substations. This allows for a firm capacity of 105MVA, although under the current licence agreement it is permissible to load the substation to approximately 126MVA (120% of firm). Both initial and final zone substation arrangements comprise 3 groups of double bus 11kV switchgear.

The new substation site is bounded to the west by Ward Street with a 4-storey car parking station on the far side of Ward street and also along the northern boundary of the site. Additionally, the site is bounded by the existing substation to the south, an 11-storey office building to the south-east and residential properties along most of the eastern boundary. Plans have been proposed to link up Harnett Street with Ward Street such that the sidewalk along the western boundary of the proposed substation will become a pedestrian thoroughfare in the future. There are also plans to replace the residential properties along the eastern boundary with a 22 storey multi-use development.

Once the existing substation has been decommissioned, the property may be cleared and sold. It is therefore possible that the adjoining property along the southern boundary of the future 132kV/11kV zone substation may be used for commercial purposes such as a cafe outlet onto Berry Street.

The issue of Electric and Magnetic Fields (EMF) will be an integral part of the planning and design process for the new North Sydney zone substation. This report provides a summary of the EMF management strategy and considerations as part of the Review of Environmental Factors (REF).


2 ENVIRONMENTAL IMPACT OF EMF

EMF is part of both the natural environment (e.g. static magnetic field of the earth's magnetic core and varying electric fields during thunder storms) and also all equipment supplying or using electricity (e.g. home appliances such as stoves and computers, household electrical wiring and distribution and transmission lines).

The level of electric and magnetic field at a location is proportional to the voltage on the conductors and the current flowing through the conductors respectively. It is also dependent on the distance of the location from the energized conductors. The EMF typically decreases very quickly with distance from these conductors. This rate of decrease can be increased by reducing the size of the conductors or their separation thereby greatly reducing the EMF at the location.

There has recently been an increase in public awareness of the potential health impact of prolonged exposure to EMF. This is primarily due to concerns that prolonged exposure to EMF may have adverse health effects and has prompted scientific research, which has in recent years focused on magnetic fields rather than the electric field effects. This research has been reviewed by special inquiries and expert panels in Australia and internationally to establish whether prolonged exposure to EMF is related to adverse health effects in humans.

The Australian Radiation Protection and Nuclear Safety Agency (ARPANSA) is a Federal Government agency within the Health and Ageing Portfolio that has been charged with the



responsibility of protecting the health and safety of the public and the environment from exposure to EMF. After extensive evaluation of all available scientific research, ARPANSA has concluded that:

“The scientific evidence does not firmly establish that exposure to 50 Hz electric and magnetic fields found around the home, the office or near power lines is a hazard to human health. In view of the epidemiological studies, however, the possibility remains that intense and prolonged exposures to magnetic fields may increase the risk of leukaemia in children. If exposure to higher-than-normal magnetic fields does actually cause leukaemia at the level indicated in the Doll report, then, on average, there would be one extra case in Australia every two years. The evidence does not allow health authorities to decide whether there is a specific magnetic field level above which continuous exposure is dangerous or compromises human health.”

[ARPANSA 19 February 2002]

In terms of exposure to magnetic fields in the home, ARPANSA offers the following advice:

“Magnetic fields within homes can vary at different locations and also over time. The actual strength of the field at a given location depends upon the number and kinds of sources and their distance from the location of measurement. Typical values measured in areas away from electrical appliances are of the order of 2mG.”

It is therefore reasonable to expect a magnetic field level in the order of 2mG (milliGauss) to be present in a typical living environment. This will increase at normal user distance from appliances that use large currents such as electric stoves (up to 30mG), kettles (up to 10mG) and hair dryers (up to 70mG due to proximity to the head during normal use). It will also increase in areas of high appliance concentrations such as kitchens or computer rooms at educational institutions. An assessment of the impact of a substation on public health must therefore consider both increases in magnetic field levels in the environment as well as expected public exposure times to any elevated magnetic field levels.


Besides possible health effects, strong power frequency magnetic fields may also affect the performance of Visual Display Units (VDUs) that consist of a cathode ray tube (CRT) with internal frequency generator such as those used for many computer screens. The magnetic field causes additional deflection of the electron beam which results in image distortion, waving and jitter. Generally, the perception threshold sensitivity for a 22" and 10" monitor is 7mG and 10mG respectively. The proposed new zone substation is adjacent to a multistorey office tower. This form of interference must be considered in the EMF assessment. It is noted that flat screens and laptops which have largely replaced CRTs in office environments are immune to power frequency magnetic field interference.

3 EXPOSURE LIMITS

The Energy2U Alliance will ensure, as a minimum, that the North Sydney zone substation design is compliant with all relevant Australian and international health guidelines for public exposure to EMF such that expected magnetic field levels at all adjacent property boundaries are below the appropriate public safety limits.

The International Commission on Non-Ionizing Radiation Protection (ICNIRP) published revised EMF guidelines for public and worker exposure in 1998. The recommended public exposure limit in this revision is 1000mG. The Institute of Electrical and Electronics Engineers (IEEE) published a standard C95.6 in 2002 in which a public exposure limit of 9040mG is specified.

In 1989 the National Health and Medical Research Council (NHMRC) developed interim guidelines for exposure to EMF. The public magnetic field exposure limit recommended by these guidelines is 1000mG (24 hour exposure). For shorter duration exposures, i.e. only a few hours every day, the limit is increased by a factor of 10 to 10,000mG. These guidelines have since been rescinded.



In the absence of an Australian standard, the Australian electricity industry, including EnergyAustralia, has followed these interim guidelines.

ARPANSA released a public consultation draft of the new Radiation Protection Standard for Exposure Limits to Electric and Magnetic Fields 0 – 3kHz in December 2006. The proposed public exposure limit for 50Hz magnetic fields is 1000mG for 24 hour exposure and 3000mG for controlled activity, i.e. reduced exposure. The standard has, as of the date of issue of this report, not been published.

In response to public concern for long-term EMF exposure and the lack of a definitive public magnetic field exposure limit for such circumstances, the Energy2U Alliance will implement all prudent design and equipment layout measures to reduce long-term magnetic field exposure levels in the vicinity of the North Sydney zone substation in accordance with the positions of both EnergyAustralia and the Energy Networks Association.

EnergyAustralia's position on EMF, which recognises both the view of authoritative research reviews (which have concluded that no adverse health effects from exposure to low-level EMF have been established) and also the genuine concern within the community regarding long-term EMF exposure, is to:


- Provide balanced, accurate information to their employees and customers, including electric and magnetic field measurements and advice;
- Take reasonable steps to limit field exposures from new facilities by locating and operating electrical installations prudently within the latest Australian health guidelines;
- Closely monitor engineering and scientific research, overseas policy development and major reviews of scientific, medical and engineering research regarding electric and magnetic fields and health;
- Cooperate fully with any bodies established by governments in Australia to investigate and report about power frequency electric and magnetic fields.

The EnergyAustralia position on EMF mostly reflects the policy of the Energy Networks Association (ENA), the energy industry representative body, as described in its 2006 policy statement:

- ENA recommends to members of the energy supply industry that, within Australian health guidelines, they design and operate their electricity generation, transmission and distribution systems prudently;
- ENA will closely monitor engineering and scientific research, including reviews by scientific panels, and overseas policy development;
- ENA will communicate openly with all stakeholders including assisting its members in conducting community and employee education programs, distributing information material including newsletters, brochures, booklets and the like, liaising with the media and responding to enquiries from members of the public;
- ENA will cooperate fully with any bodies established by governments in Australia to investigate and report about power frequency electric and magnetic fields.

The concept of prudence, as contained in the described EMF positions, embraces a range of actions which are sensible to undertake, having regard for the current state of scientific uncertainty, and has been defined in the Australian context by the former Chief Justice of the High Court of Australia, Sir Harry Gibbs. The Gibbs report, submitted February 1991, dealt with the impact of EMF exposure on public health as follows:

"It then becomes a question of policy what action should be taken to avert a possible risk to public health when it cannot be said either that it is probable that the risk exists or in what circumstances a risk, if one exists, arises. A suggestion has been made in the United States that a policy of prudent avoidance should be adopted."



“It would not be prudent, but foolish, to make radical or expensive changes to existing lines until further scientific studies have resolved the doubts. On the other hand, when new lines are being constructed, it may be prudent to do whatever can be done without undue inconvenience and at modest expense to avert the possible risk, remembering that if that is not done and future research establishes the existence of a real risk to health, serious problems may arise which can be remedied only at great cost.”

It is further noted that in the ARPANSA public draft standard for EMF exposure, section 5.7, the practical implementation of the concept of prudent avoidance is alluded to as follows:

“In view of these factors, and even after fully allowing for the legitimate desire by society to err on the safe side, it seems likely that only very low-cost measures will be justified.”

4 PRELIMINARY IMPACT ASSESSMENT

High voltage cables are compact with energized centre conductors insulated from surrounding metal screens that are either earthed or at very low voltage, thereby eliminating almost all electric fields surrounding the cables. The 132kV cables for the new substation will connect to gas insulated switchgear (GIS) equipment which also has an earthed metal enclosure surrounding the high voltage (HV) conductors. The outer metal shield of this equipment will also reduce the electric fields near the equipment to almost zero. It is expected that the only unshielded HV connections in the North Sydney zone substation will be within the transformer rooms which are only accessed by authorised personnel and shielded from the public by steel reinforcing in the walls. There is therefore no significant public exposure to electric fields from the new substation.

Given that there is no public exposure to electric fields from the North Sydney zone substation and that scientific research into the health effect of exposure to EMF has focused on magnetic fields, the EMF management strategy and design, in terms of impact on the public, will consider only magnetic fields. It is also noted that both the existing and future substations have only cable feeders into and out of the substation and have similar firm capacity. It is therefore not expected that there will be a significant increase in the magnetic field at the property boundaries of the two substations.


The overall EMF exposure management strategy that the Energy2U Alliance will adopt for the design of the proposed North Sydney zone substation will consist of:

- A preliminary impact assessment to determine the maximum extent to which the public will be exposed to magnetic fields produced by the substation;
- Measurements of the ambient fields from the existing and new zone substation to determine if there are any changes in field levels in the area; and
- The definition of “low cost” or “no cost” design measures that can be implemented to mitigate EMF exposure.

The Energy2U Alliance will ensure that all EMF levels are below the most conservative exposure limit as a minimum but will also consider “low cost” and “no cost” design measures that will reduce the levels further.

The proposed zone substation comprises the following energized electrical equipment:

- Single core (132kV) and three core (11kV) cables
- 132kV GIS switchgear, bus and terminations
- Power transformers with cable terminations
- 11kV switchgear and air-insulated bus
- Capacitor banks with air-core reactors



Each component will have a distinct magnetic field level which decreases at a specific rate with distance from it. This rate of decrease depends on the equipment construction and installation. It is not practical to try to model all equipment in detail since sufficient construction detail is often not available and the accuracy of the results would be questionable given the added complexity. A common approach to this problem is to model basic components such as cables and terminations only. The EMF levels of more complex equipment such as transformers and switchgear is then interpolated from measured data taken at varying distances from comparable installations. This approach is adopted in this assessment and will provide accurate results.

The worst case field levels will be determined in the preliminary assessment so that any subsequent design changes will not invalidate the conclusions made in this report. This is achieved by using worst case current levels (maximum firm capacity under normal and contingency supply) and ignoring the reduction in magnetic fields due to electrically continuous metal cable trays and steel reinforcing in the walls and floors of the substation building.

4.1 Modelling

Frequented areas will be identified so that the EMF level at these locations can be determined. The magnetic field contribution from each component at a frequented area will be determined as outlined in this section. All contributions are then added together vectorally to determine the total maximum magnetic field exposure at the location.

Currents induced in conductive soil by the energized conductors may significantly reduce the magnetic field at observation points more than about 100m from the substation. Since all assessments are made near the perimeter of the substation, earth current shielding effects will be ignored in the calculation of EMF contributions from the various components. Shielding provided by the numerous cable trays and continuous steel reinforcing in the substation walls and floors will also not be accounted for in the simplified modelling. The levels calculated in the assessment are therefore worst case and it can be expected that the measured levels will be lower.

4.1.1 Cables


The magnetic fields due to current flow in the 132kV and 11kV cables are calculated in accordance with the method recommended by CIGRE Joint Task Force 36.01/21 as summarized in Technical Brochure 104 – Magnetic Field in HV Cable Systems 1/ Systems Without Ferromagnetic Component. The small amount of shielding provided by copper/aluminium, double point bonded cable screens is therefore ignored and the calculated levels will be worst case values.

The following simplifications are necessary given the calculation method used:

- Sharp bends, which have slightly elevated field levels are not modelled since the bending radii of the HV cables are large. Large bends are modelled as piecewise linear curves since the magnetic field magnitude is dependent primarily on the cable arrangement, current and minimum distance between the cable and point;
- Cable terminations onto GIS and metal enclosed switchgear have elevated magnetic field levels due to increasing phase spacing. These are not modelled since they are mostly shielded by the metal enclosures and localised (insignificant at the perimeter of the substation building);
- The specific phasing is not considered in cable risers with numerous feeders since the spacing between cores is much smaller than the spacing between feeders for the trefoil arrangements. The total magnetic field is therefore insensitive to the specific phasing.

Contributions from cable groups with different orientations are added vectorally to obtain the total maximum field magnitude. The following cable sections are modelled:

- Two horizontal 132kV incoming cable feeders enter the building from the western side of Harnett Street. The third horizontal 132kV incoming cable enters the building opposite the central cable riser from the northern end of Ward Street. All cables enter at a nominal depth



of 0.75m below street level and ramp down to the level 1 cable basement floor, 4.7m below street level. The cables are grouped by feeder in trefoil configuration. The cables are then routed vertically up to the GIS bus on level 3, 10.7m above street level, via segregated 132kV cable risers. Each 132kV feeder comprises three 1200mm² single core Cu/XLPE cables. If all 132kV incoming feeders supply similar current, then the phase current for a maximum firm capacity of 126MVA at 132kV is approximately 180A per feeder cable.

- The 132kV cable feeders are then routed back down the same risers from the GIS bus to the level 1 cable basement, across to the Ward Street side of the building and then up cable risers to the transformer terminations on level 2, ground level. The cables terminate in bushings with large phase spacing appropriate for the air insulation within the transformer room. EMF from these terminations is discussed separately.
- 11kV cables (4 per phase) are routed from the transformer MV bushings vertically downwards to horizontal cable trays suspended from the roof of the level 1 cable basement, at least 0.75m below street level. The 11kV cables are 1000mm² Cu/XLPE and are grouped by feeder in trefoil. The cable trays are then routed towards the central and eastern cable risers and then vertically up the cable risers to the level 3 cable basement at least 10.7m above street level.
- The 12x 11kV cable feeders from the transformers are then routed to the 11kV switchgear on level 3A mezzanine level. The 31 existing and 15 proposed future 11kV output cable feeders are then routed vertically down the three cable risers (grouped by feeder in trefoil) to the level 1 cable basement. Space has been allocated for 18 feeders to exit into Ward Street adjacent to the central cable riser. A further 12 feeders can enter Ward Street adjacent to the southern cable riser. The remaining 16 feeders exit into Harnett Street.
- Six 11kV cables are routed vertically up the eastern cable riser from the 11kV bus to the 6MVA capacitor banks on level 4. A reactive current will flow through these cables and their EMF contribution at street level will not be significant given that the capacitors are installed at least 20m above street level.
- During the switching stage of construction, the exhaust ventilation riser at the south-eastern corner of the substation will be used as a temporary cable riser for 11kV cables from the existing substation to level 3 cable basement. This EMF source will be considered separately for the EMF assessment at the adjacent office building only. The cable riser will be removed before the existing substation property is redeveloped.

4.1.2 GIS Bus and Terminations

The 132kV GIS equipment will generate EMF levels that are much lower than the air insulated equipment and transformers. This is because of the reduced phase spacings and the shielding provided by the continuous, earthed, solid metal outer conductor that encloses the equipment. Furthermore, the magnetic field surrounding GIS equipment decreases rapidly with increasing distance from the equipment and the GIS equipment will be installed on level 3, at least 10.7m above street level and away from the multi-storey commercial building and car-park.

GIS equipment does not have a uniform cross-sectional geometry along its length as do cables (with the exception of short bus sections). Significant detail must therefore be modelled in order to accurately determine the EMF levels. Since the EMF from the GIS equipment is not a significant contribution to the overall EMF at ground level, the contribution will be included in the assessment by considering the EMF measured near a comparable installation. Measurements have been made near EnergyAustralia 132kV GIS installations under heavier load conditions (1100A) than are proposed for the North Sydney installation (i.e. will provide worst case levels). The highest levels were measured adjacent to a 5m long GIS bus section with aerial feeder termination and are summarised in Table 1.

Table 1: Measured EMF levels near a comparable 132kV GIS installation

Distance [m]	0.5	1	2	3
B [mG]	210	93	18	<10

The North Sydney GIS equipment will have sealed cable terminations and lower current. It is concluded, by comparison, that the EMF level for the GIS equipment will be less than a few milliGauss and is therefore insignificant compared to the EMF contribution from other installed equipment. The EMF contribution from the GIS equipment is ignored in this assessment.

4.1.3 Transformers and cable terminations

The three 50MVA 132kV/11kV power transformers are located on level 2 (ground level) on the Ward Street side. They are orientated with the 11kV terminals approximately 3m from the public footpath along Ward Street. Both the 132kV and 11kV transformer terminals are connected to the respective cables via bushings on the same side. These cable tails are major sources of EMF and will be modelled in the EMF calculations with 1.80m (132kV) and 0.65m (11kV) phase spacing.

The transformer cores are strong emitters of EMF, although they are enclosed in a continuous thick mild steel casing which provides significant magnetic field shielding. Detailed modelling of all current carrying conductors and continuous metal shields is required if the EMF from the transformers is to be accurately calculated. This would be a time intensive exercise requiring full details from the manufacturer and would produce results of questionable accuracy given the complexity. A more prudent approach is to measure the worst case EMF at various distances from comparable installations under worst case loading. Such measurements are available from EnergyAustralia for similar 132kV/11kV zone substations. The results from measurements at the Hornsby zone substation transformer is presented in Table 2 and will be used to determine the total EMF level at the various property boundaries and along footpaths. The orientation of the measured magnetic field is worst case but is not specified. As a conservative estimate, the magnitude of the measured transformer contribution will be included with all other contributions using scalar addition. The measured magnetic field level will therefore definitely not be higher than the calculated level.

Table 2: Measured EMF levels near a comparable 132kV/11kV oil insulated transformer

Distance [m]	1	5	10
B [mG]	139	30	11

Other values are derived by interpolating the measured data using an assumed $1/r$ curve. It must be noted that the measured levels include the contribution from the cable tails which will be separately calculated in this assessment. This assessment will therefore provide worst case EMF levels.

4.1.4 11kV Switchgear

The 11kV switchgear is a compact, metal-clad type mounted on the floor of level 3A, at least 15.4m above street level but adjacent to the multi-storey commercial building. All terminations are to compact three core cables. The switchboard busbars will be arranged in spaced arrangement, with 160mm phase spacing, inside the bus chamber, which is surrounded by solid mild steel cladding. This double cladding arrangement provides shielding of greater than 50% (i.e. more than 50% reduction in magnetic field outside the switchgear). This busbar arrangement and 50% shielding effectiveness is used to model the switchgear bus on level 3A.

4.1.5 Capacitors and Air-Core Reactors

It is proposed to install 6MVA capacitor banks in the future on level 4, at least 20m above street level and not adjacent to the multi-storey commercial building or carpark. While the capacitors do not emit significant EMF, they are fitted with air core reactors to limit inrush currents and these do emit significant magnetic fields. The reactors are typically installed in a vertical stack arrangement and the magnetic fields produced will be mainly vertically orientated (axial) but will also have a radial component. The magnetic field strength will be specified by the manufacturer and since the reactors have not been specified for the future installation, their contribution will not be considered.

Should the magnetic field from the future installation be considered excessive, ferromagnetic (e.g. steel) enclosures can be used to provide effective shielding. It is however considered unlikely given the location of the capacitor banks above street level and away from high-rise buildings.

4.2 EMF Calculations

The concept substation design comprises a 4 storey building on property 3-11 Ward Street, North Sydney (Lots 1, 1A, 2, 2A, 4, 4A in DP24474). All electrical equipment is contained indoors and there is no security fence around the perimeter.

EMF exposure locations around the perimeter of the substation are classified according to usage type as follows:

- Residential properties along north-eastern perimeter of the substation. The EMF will be calculated along the property boundary to accommodate the proposed 22 storey multi-use development at an unknown distance from the substation boundary. The assessment is made at various heights above street level to determine the worst case level;
- Office building along south-eastern perimeter of the substation. The assessment is made at 1m above street level along the property boundary and at various heights above street level at the perimeter of the office building to find the worst profile for the multi-storey building;
- Possible future cafe-type location at existing substation location on southern perimeter of the substation. The assessment is made at various heights above street level at the property boundary to accommodate a possible multi-storey building at the existing substation location;
- Car-park along western (across the street) and northern (across the footpath) perimeter of the substation. The assessment is made at various heights above street level for the four storey building;
- Public footpath along the western and northern perimeter of the substation. The assessment will be made at 1m above the street level.

Two supply conditions will be considered in the assessments:

- Normal supply with all three transformers in service and maximum firm capacity of 126MVA;
- Contingency supply with one transformer out of service and the remaining two transformers providing maximum firm capacity of 126MVA.

The calculated worst case EMF levels along the four boundaries of the proposed zone substation are plotted in Figures 1 to 5. The results have been summarized in Table 3.

Table 3: Summary of Calculated EMF levels for the identified exposure hazards

Hazard	Limit [mG]	Max. Calculated [mG]	Compliant
Multi-use development	1000	40	Yes
Office Building	1000	24	Yes

Existing substation	1000	25	Yes
Car-parks	3000	26	Yes
Footpath	3000	261	Yes

The magnitude of the magnetic field 1m from the eastern boundary of the North Sydney substation is plotted in Figure 1. The distance from the South Eastern corner of the substation (i.e. the boundary between the existing and relocated substations adjacent to the office building) is plotted on the horizontal axis. There is a high field point at a distance of 18m along this boundary adjacent to the eastern cable riser, which contains 4x 11kV cables connecting the transformer 3 output to the switchgear on level 3A. The contribution from the 132kV cable risers along the eastern boundary between 39m and 44m are not as significant as the 11kV cables. The elevated magnetic field levels near the Harnett Street boundary (i.e. distance = 56m) is due to the numerous 11kV feeders which exit the substation at this point just below street level. The magnetic field magnitude is also plotted in Figure 2 along a section (section "A" in Figure 1) normal to the substation boundary at this point in the direction of the future multi-use development. The plot indicates the rapid decrease in magnetic field magnitude (vertical axis) with distance from the property boundary (horizontal axis). It is noted that if residential-use areas are more than 3m from the North Sydney substation wall, the worst case magnetic field level is less than 20mG.

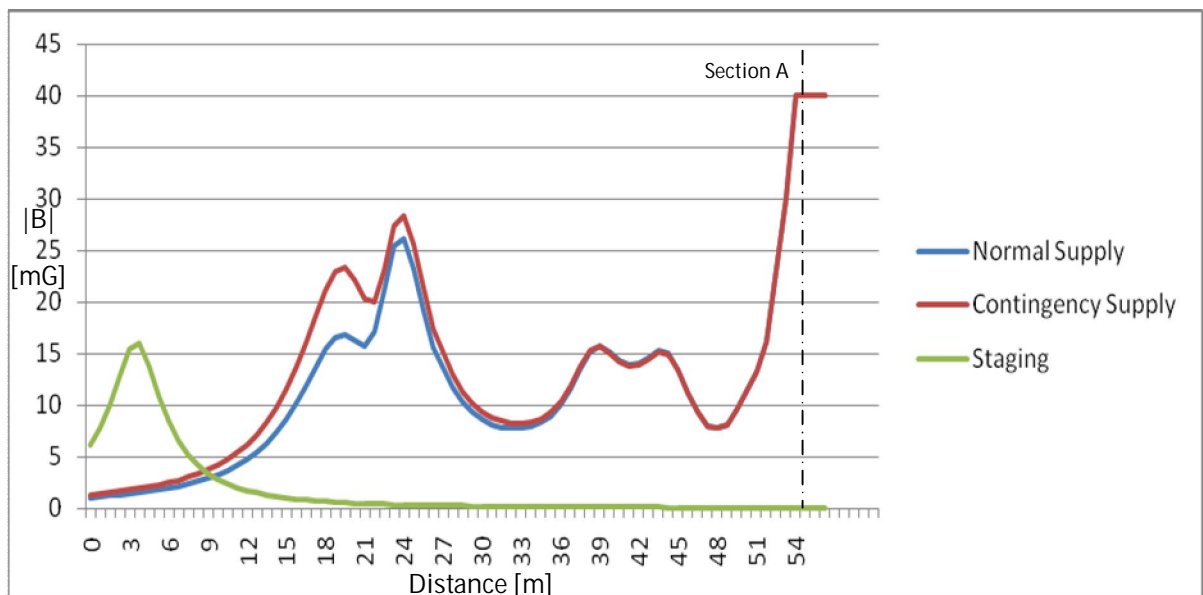


Figure 1: Calculated worst case magnetic field level along the eastern boundary

The boundary between the existing office block and the proposed multi-use development is at 18m on the horizontal axis of Figure 1. The office building is set back about 5m from the substation boundary. The maximum magnetic field level at this location is due to the temporary 11kV between the existing and relocated substations during construction staging and is less than 3mG.

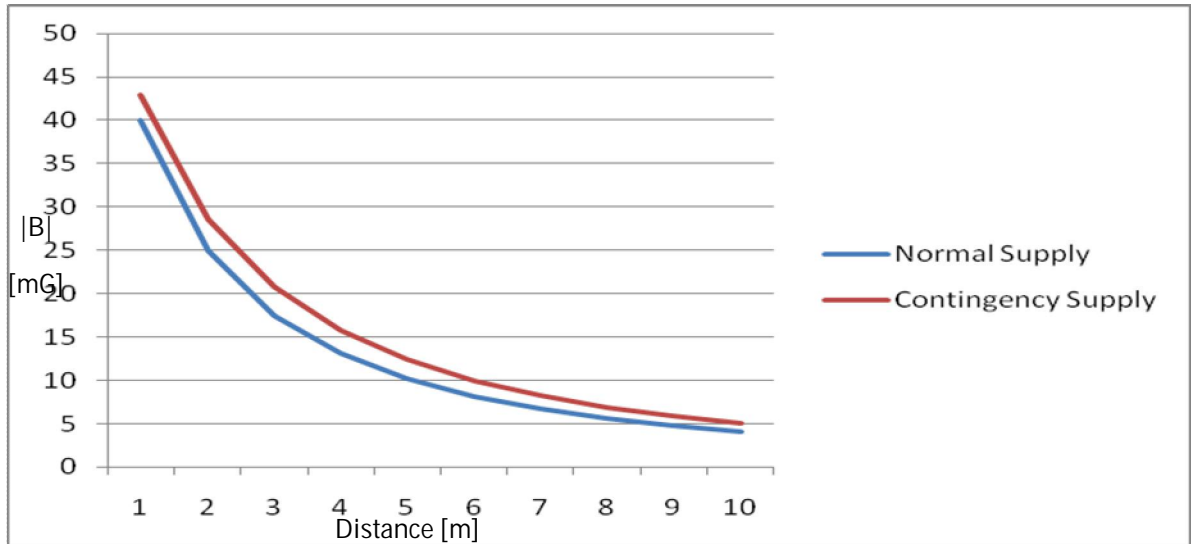


Figure 2: Calculated worst case magnetic field level normal to the substation boundary

The magnitude of the magnetic field 1m from the Southern boundary of the relocated North Sydney substation is plotted in Figure 3. The horizontal axis of the plot is the distance from the South Western corner of the substation (i.e. the boundary between the existing and relocated substations adjacent to Ward Street). There is a high field region from this corner to a distance of about 8m along the boundary and is due to the cable tails at transformer 3. The contribution from the southern cable riser, which contains numerous 11kV feeder cables between the switchgear on level 3A and the level 1 cable basement, is smaller but evident from 8.5m on the horizontal axis.

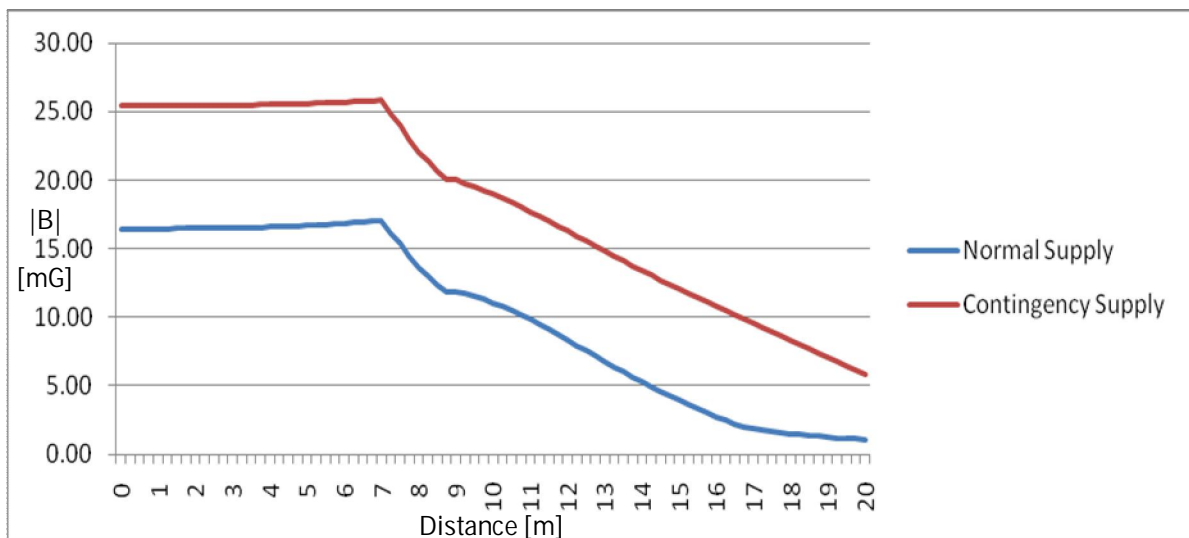


Figure 3: Calculated worst case magnetic field level along the southern boundary

The magnitude of the magnetic field 1m from the Northern boundary of the relocated North Sydney substation is plotted in Figure 4. The horizontal axis of the plot is the distance from the North

Western corner of the substation (i.e. the boundary between the substation and car-park adjacent to Ward Street). There is a high field region from this corner to a distance of about 8m along the boundary and is due to the cable tails of transformer 1. The maximum level is adjacent to the top of Harnett Street and not near residential or commercial properties. It is due to the 11kV feeder cables which exit to Harnett Street just below street level from the Northern boundary.

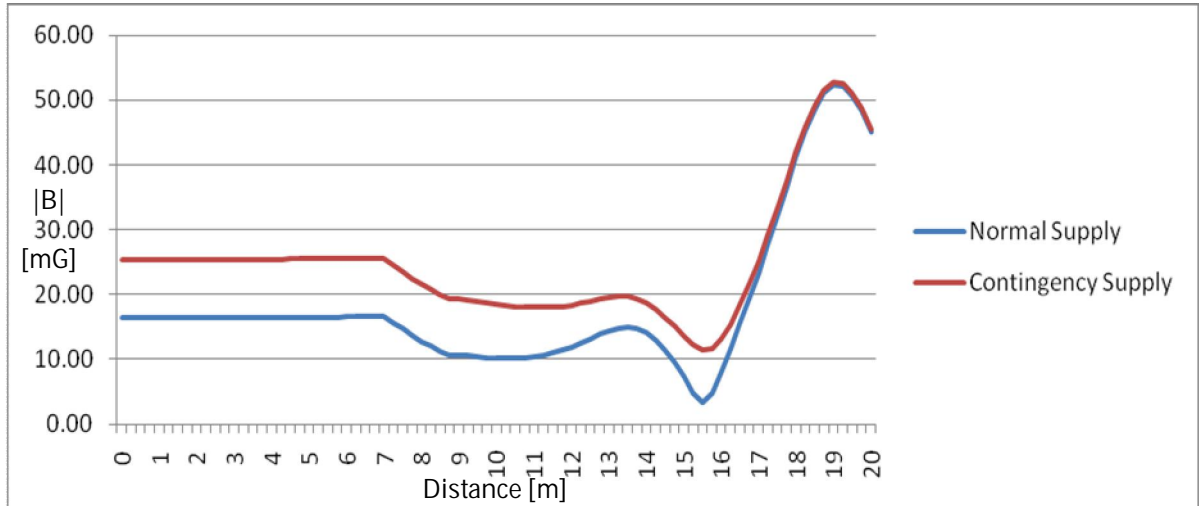


Figure 4: Calculated worst case magnetic field level along the northern boundary

The magnitude of the magnetic field 1m from the Western boundary of the relocated North Sydney substation along the Ward Street footpath is plotted in Figure 5. The horizontal axis of the plot is the distance from the South Western corner of the substation (i.e. the boundary between the existing and relocated substations adjacent to Ward Street). There are high field regions adjacent to the cable tails of each of the three 132kV/11kV transformers. The magnetic field level 10m from the substation boundary (i.e. at the car-park boundary) is less than 25mG.

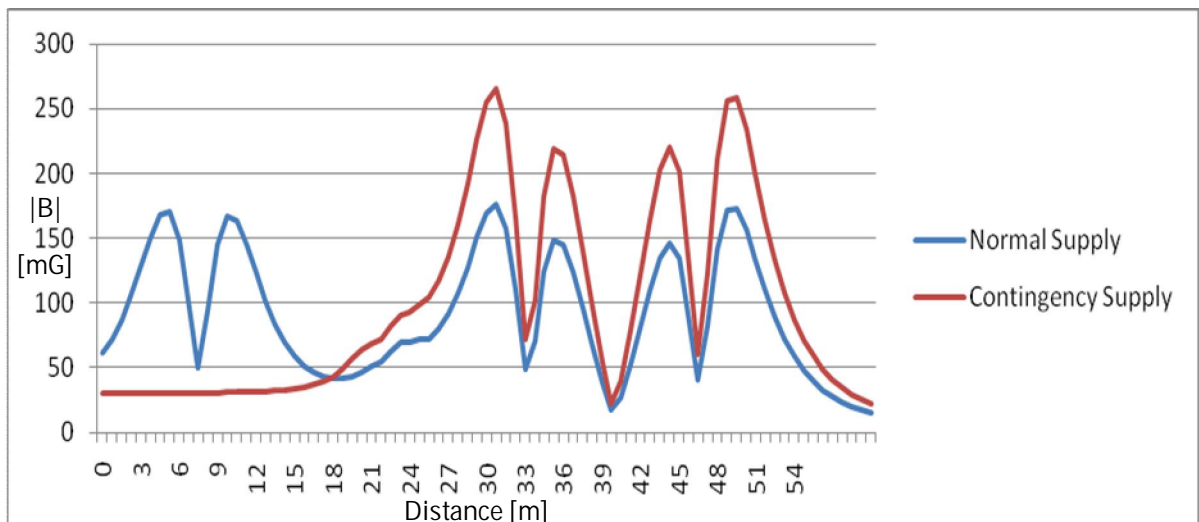


Figure 5: Calculated worst case magnetic field level along the western boundary

5 PRUDENT DESIGN CONSIDERATIONS

The following design measures have been identified as “low cost” or “no cost” and implemented in the 132kV/11kV North Sydney zone substation design:

- Equipment that produces high magnetic field levels has been positioned furthest from sensitive sites. These include: the capacitor banks with air-core reactors which are located near the centre and roof of the building; air-insulated busbars which are located on the third level away from the residential properties; and the transformers with air-insulated terminations which are positioned near Ward street, away from residential and commercial properties;
- Lower voltage equipment has been placed furthest from sensitive sites since the current and therefore magnetic fields surrounding this equipment are higher. The 132kV GIS bus has been located near the proposed multi-use property while the 11kV switchgear and transformer terminations are located near commercial properties and Ward Street respectively;
- Use GIS where possible since the reduced phase spacing lowers magnetic field levels and the metal enclosure of the equipment will provide shielding of the magnetic fields;
- Metal-clad 11kV switchgear has been used so that no unshielded busbars or terminations will be present within the substation apart from those connections within the transformer rooms;
- Incoming and outgoing transformer connections, which produce the highest magnetic field levels, will be installed away from sensitive sites using the most compact construction possible;
- Cables will be arranged by feeder in a trefoil configuration to provide maximum magnetic field cancellation and thereby lower the magnetic field levels at the property boundaries;
- The same phases at the 11kV transformer terminal, terminate into three core cables with the shortest possible transition length to minimize magnetic fields near these locations;
- Lower voltage cables carrying large current have be positioned away from sensitive sites towards the centre of the building;
- Cable trays and reinforcing will be made electrically continuous so that it can provide some magnetic field shielding at the property boundaries;
- The 132kV and 11kV loads will be balanced;

The largest sources of magnetic field at the property boundaries are the 11kV cable terminations in the transformer rooms and the 12x 11kV cables connecting the transformer outputs to the 11kV switchgear. The cable terminations at the transformers have been positioned adjacent to Ward Street rather than near the residential or commercial properties. Eight of the cables between the transformers and the switchgear have been located in the central cable riser and the four cables in the eastern cable riser have been located as close to the centre of the building within that riser as is possible.

Numerous concept design options have considered orientating the transformer cable tails away from Ward Street towards the centre of the building. These options were found to be technically not feasible and involve considerable cost. It is therefore not considered prudent to change the proposed arrangement to reduce the EMF along the Ward Street footpath.

6 CONCLUSIONS

The EMF assessment presented in this report for the proposed 132kV/11kV North Sydney zone substation has been based on the following conclusions which are derived from the available international and national EMF research and guidelines:

- EMFs are associated with all forms of electricity generation, transmission, distribution and usage and are not unique to substations;
- Given the numerous and diverse scientific literature on the subject, it is best to base public policy initiatives on independent and authoritative reviews and guidelines;
- Adverse health effects from long-term low-level human exposure to EMF have not been established but the possibility of such effects cannot be ruled out;
- There is presently no scientific basis to support exposure limits below the guidelines which presently exist as a prudent avoidance measure;
- Prudent avoidance measures must however be implemented in accordance with the principles established by the Gibbs Report.

The EMF assessment has considered only magnetic field levels since there is no public exposure to electric fields from the North Sydney zone substation and scientific research into the health effect of exposure to EMF has focused on magnetic fields.


The relocated North Sydney zone substation will have similar magnetic field levels to the existing substation since both have only cable feeders entering/leaving the building and they have a similar firm capacity.

The worst case magnetic field levels have been calculated along the boundaries of the new substation. By calculating the limits at the boundaries, the EMF compliance is maintained during the life time of the substation (i.e. future developments at unknown distances from the substation are accommodated). The calculations used the worst case current levels (maximum firm capacity under normal and contingency supply) so that any subsequent design changes will not invalidate the conclusions made in this report. Average supply levels will be more appropriate for a long-term EMF exposure assessment and will produce lower magnetic field levels than are reported here. The shielding effect of metal cable trays and steel reinforcing in the walls and floors of the substation building has also not been accounted for in the simplified modelling applied. This will lower the actual magnetic field levels.

The magnetic field calculation results have been presented in the report and indicate that the 132kV/11kV North Sydney zone substation design will comply with public exposure magnetic field limits defined in the following relevant local and international health guidelines and standards:

- Australian Radiation Protection and Nuclear Safety Agency (ARPANSA) (2006). *Draft Radiation Protection Standard for Exposure Limits to Electric and Magnetic Fields 0Hz - 3kHz*
- IEEE (2002), C95.6 IEEE Standard for safety levels with respect to human exposure to electromagnetic fields, 0-3 kHz. New York, NY, IEEE - The Institute of Electrical and Electronics Engineers, 2002 (IEEE Std C95.6-2002).
- International Commission on Non-Ionising Radiation Protection (1998). *Guidelines for limiting exposure to time-varying electric, magnetic and electromagnetic fields (up to 300GHz): Health Physics, April 1999, Volume 74, Number 4; pp 4494-5528.*
- Rescinded National Health and Medical Research Council (NHMRC) (1989). Interim guidelines on limits of exposure to 50/60 Hz electric and magnetic fields.

Additionally, various “low cost” or “no cost” prudent avoidance measures have been implemented in the North Sydney zone substation design to further reduce the magnetic field levels at the property boundaries. These are:

- 
- Equipment that produces high magnetic field levels has been positioned furthest from sensitive sites. These include: the capacitor banks with air-core reactors which are located near the centre and roof of the building; air-insulated busbars which are located on the third level away from the residential properties; transformers with air-insulated terminations which are positioned near Ward street, away from residential and commercial properties; and high capacity 11kV cable which are located in the cable riser at the centre of the building;
 - Lower voltage equipment has been placed furthest from sensitive sites since the current and therefore magnetic fields surrounding this equipment are higher. The 132kV GIS bus, which produce low EMF levels, has been located near the proposed multi-use property while the 11kV switchgear and transformer terminations, which produce high EMF levels, are located near Ward Street rather than residential properties;
 - GIS and metal-clad switchgear has been used since these have continuous metal shields which reduce their magnetic field emissions significantly;
 - Cables will be arranged by feeder in a trefoil configuration to provide maximum magnetic field cancellation and thereby lower the magnetic field levels at the property boundaries;
 - Cable trays and reinforcing will be made electrically continuous so that it can provide some magnetic field shielding at the property boundaries;

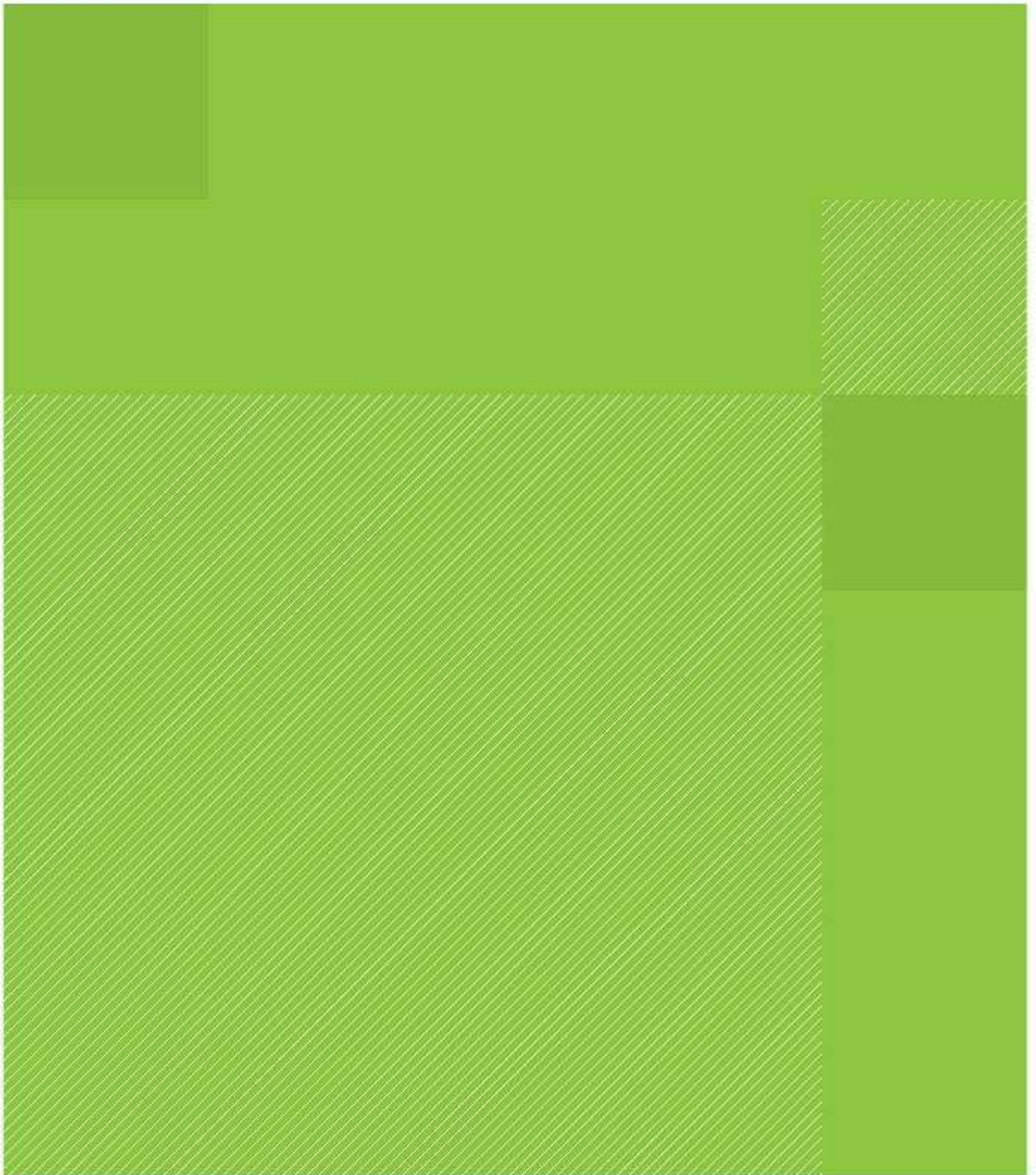
The measures implemented have facilitated magnetic field levels at the various property boundaries that are significantly lower than recommended limits and not much higher than levels measured in a typical household or office environment with the exception of the Ward Street footpath which has higher EMF but limited duration public exposure.



APPENDIX H

Electric and Magnetic Fields Assessment (July 2010)






**North Sydney 132kV Zone
Substation
EMF Assessment
Energy2UAlliance**

Report ref:
209798
19 August 2010
Revision 2

Document prepared by:

Aurecon Australia Pty Ltd
ABN 54 005 139 873
116 Military Road
Neutral Bay
New South Wales 2089 Australia

T: +61 2 9465 5599
F: +61 2 9465 5598
E: sydney@ap.aurecongroup.com
W: aurecongroup.com

Document control						
Rev No	Date	Revision details	Typist	Author	Verifier	Approver
0	29 July 2010	Draft for Review	NA	CB	PF	
0	9 August 2010	Final Draft	NA	CB	PF	
1	12 August 2010	Initial Issue	NA	CB	PF	BK
2	19 August 2010	Figs 1.2, 1.3 and 3.17 updated; minor editing of text.	CB	CB	PF	BK

A person using Aurecon documents or data accepts the risk of:

- Using the documents or data in electronic form without requesting and checking them for accuracy against the original hard copy version.
- Using the documents or data for any purpose not agreed to in writing by Aurecon.

Important Things You Should Know about This Report Exclusive Benefit and Reliance

- This report has been prepared by Aurecon at the request of and exclusively for the benefit and reliance of its Client. Sections of this report may be summarised by the client in producing the EA for the proposed North Sydney Zone Substation 132kV conversion works only¹.*
- This report is not a certification, warranty or guarantee. It is a report scoped in accordance with the Client's instructions, having due regard to the assumptions that Aurecon Pty Ltd can be reasonably expected to make in accordance with sound engineering practice and exercising the obligations and the level of skill, care and attention required of it under this contract.*

Third Parties

- It is not possible to make a proper assessment of the report without a clear understanding of the terms of engagement under which the report has to be prepared, including the scope of the instructions and directions given to and the assumptions made by the engineer/ scientist who has prepared the report.*
- The report is a report scoped in accordance with the instructions given by or on behalf of the Client. The report may not address issues which would need to be addressed with a third party if that party's particular circumstances, requirements and experience with such reports were known and may make assumptions about matters of which a third party is not aware.*
- Aurecon therefore does not assume responsibility for the use of the report by any third party and the use of the report by any third party is at the risk of that party.*

Limits of Investigation and Information

- The report is also based on information provided to Aurecon by other parties. The report is provided strictly on the basis that the information that has been provided can be relied on and is accurate, complete and adequate.*
- Aurecon takes no responsibility and disclaims all liability whatsoever for any loss or damage that the client may suffer resulting from any conclusions based on information provided to Aurecon, except to the extent that Aurecon expressly indicates in the report that it has verified the information to its satisfaction.*

¹ © Aurecon Australia Pty Ltd ACN 005 139 873

Contents

1.	Introduction	1
1.1	Background, Site and Project Description	1
1.2	Scope of Assignment	4
1.3	Structure of Report	5
1.4	General Description of Electric and Magnetic Fields	5
1.5	Overview of EMF and Human Health	6
1.6	Health Standards	6
1.7	Prudent Avoidance	7
2.	Aspects of Field Predictions and Input Information	9
2.1	Magnetic field dependence on load	9
2.2	Information provided by Energy2U Alliance	10
3.	Field Characterisation	11
3.1	Existing magnetic field environment	11
3.1.1	Existing ZS Field Measurement	13
3.1.2	Site of Proposed ZS Field Measurement	16
3.1.3	Field Measurements in the Vicinity of the Proposed Cable Vault	20
3.1.4	Summary of Site Measurements	20
3.2	Modelling of the magnetic field contribution of the proposed ZS	21
3.2.1	Proposed ZS	22
3.2.2	Properties and Proposed Developments in the Vicinity of New Substation	28
3.2.3	Proposed 11kV Cable Vault	32
3.3	Electric fields	33
3.4	Magnetic fields experienced intermittently	33
4.	Compliance with EMF Standards and Prudent Avoidance / Precautionary Principles	35
4.1	Compliance with Health Standards	35
4.2	Dependence on Load	35
4.3	Assessment against Prudent Avoidance Principles	35
5.	Conclusions	37
6.	References	39

1. Introduction

1.1 Background, Site and Project Description

A new 132/11kV multistorey Zone Substation (ZS) is proposed to be built at 3 – 11 Ward Street, North Sydney adjacent to EnergyAustralia's existing North Sydney 33/11kV ZS.


An aerial view of the project area and adjacent properties is shown in Figure 1.1. As shown in this figure, the neighbouring properties include a carpark, a commercial building, residential properties and the existing substation site.

Consent has been granted for a 22 storey mixed use development immediately to the east of the proposed substation (at 136 – 140 Walker Street) but construction activities have not commenced and the residential properties on that site are currently as shown in Figure 1.1.

The existing substation will be fully decommissioned and demolished at the conclusion of the subject project.



Figure 1.1 – Aerial View of Existing ZS and Proposed Works Location

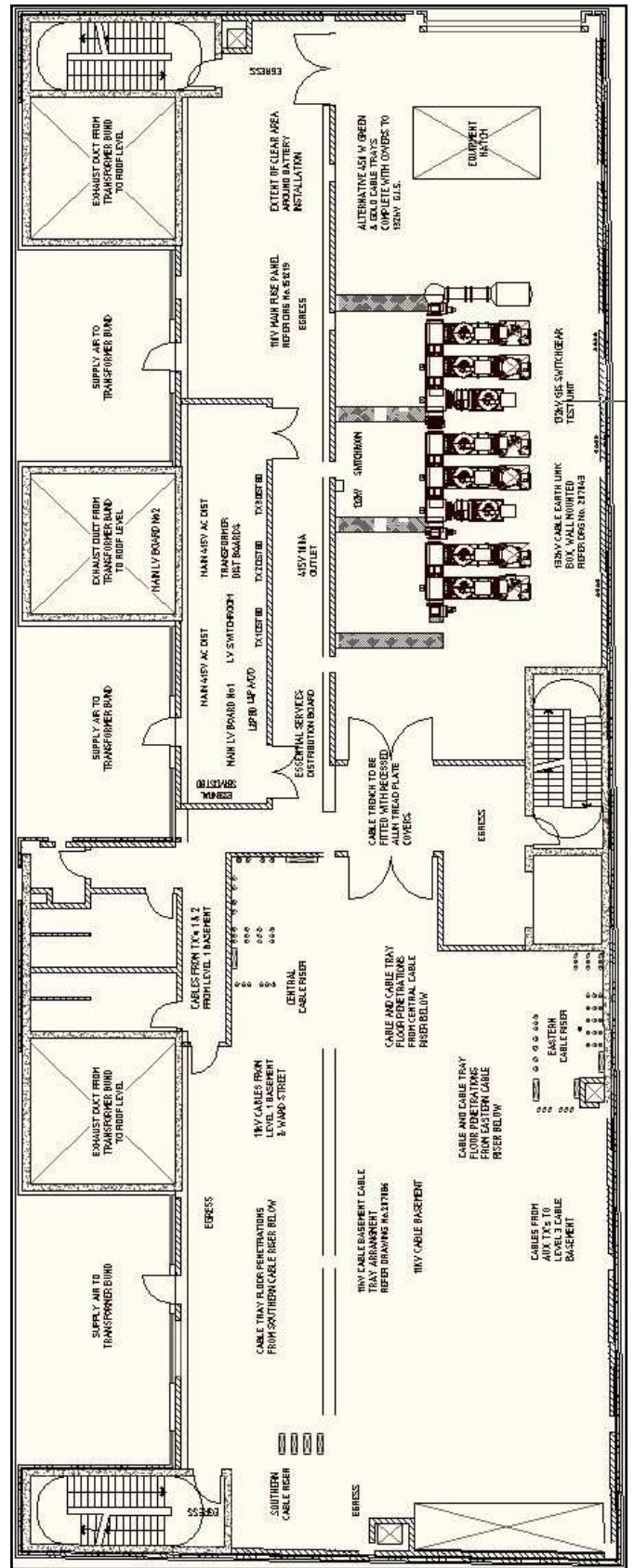
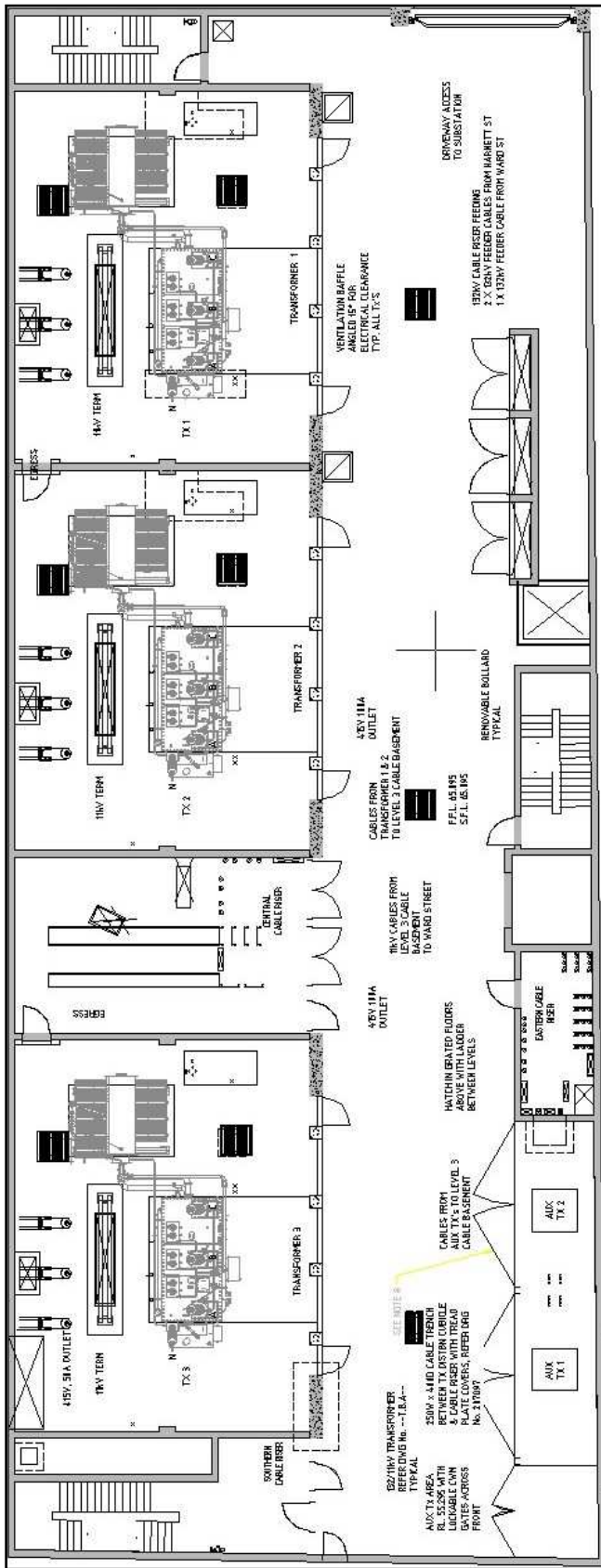


The proposed works include:

- Establishment of a new building;
- Installation of three new 50MVA 132/11kV transformers in the new building;
- Installation of indoor 132kV gas-insulated switchgear in the new building;
- Installation of three groups of indoor 11kV switchgear;
- Installation of transformer tails to the 11kV switchroom;
- Relocation and installation of 31 outgoing 11kV underground feeders;
- Construction of an 11kV cable vault in Ward Street;
- Decommissioning of the existing 33/11kV transformers;
- Decommissioning of the 11kV switchgear.
- Demolition of the existing substation building.

Although not part of the substation works, it is noted that there will be three incoming new 132kV underground feeders (Feeders 9P3 and 9P5 from Crows Nest ZS and Feeder 9P7 from Mosman ZS).

Plan layouts of the proposed work on levels 2 (transformer floor) and 3 (switchgear floor) of the new substation are shown in Figures 1.2 and 1.3 respectively.



The location of the proposed 11kV cable vault in Ward Street is shown in Figure 1.4 below.

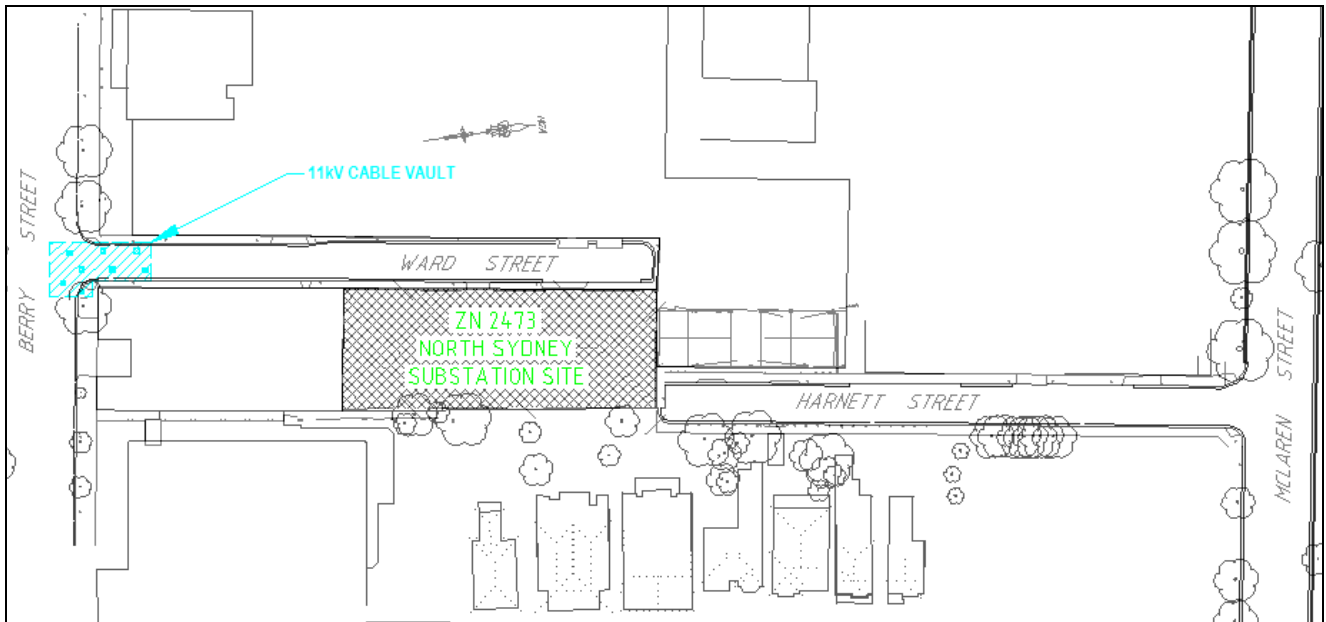


Figure 1.4 – Location of Proposed 11kV Cable Vault

1.2 Scope of Assignment

It is understood that approval is being sought for the project under Part 3A of the Environmental Planning and Assessment Act 1979 and that the Director General's Requirements for the Environmental Assessment have been issued. Among the Key Assessment Requirements is the following:


“Electric and Magnetic Fields – the Environmental Assessment must include an assessment of the risk to human health from electric and magnetic fields associated with the project, with particular reference to the Australian Radiation Protection and Nuclear Safety Agency guidelines/standards. The Environmental Assessment should demonstrate the application of the principles of Prudent Avoidance in relation to electric and magnetic fields.”

In separate correspondence, dated 27 July, 2010, NSW Health has also advised its requirements as follows:

“Electromagnetic Fields (EMF)

- a. *The proponent should provide a detailed assessment of EMF levels produced by the existing North Sydney zone substation and its associated infrastructure (eg cables and conduit) under current operating scenarios. These levels should be related to known sensitive human receptors.*
- b. *The proponent should provide a detailed assessment of the predicted EMF levels that the proposed substation and its associated infrastructure (eg cables and conduit) under likely future operational scenarios. Again these levels should be related to known sensitive human receptors.*
- c. *Should there be any incremental increases in EMF levels these levels should be clearly identified and related to known human sensitive receptors. In addition, options for prudent measures to mitigate these increases should be considered in detail.”*

Aurecon has been engaged by Energy2U Alliance to undertake an independent assessment of the Electric and Magnetic Fields (EMF) associated with the project, to address the Director General's and NSW Health requirements.



Accordingly, specific content of this assessment is to include:

- Discussion of the existing electric and magnetic field (EMF) levels at the site;
- Reasonable predictions of the EMF contribution associated with the proposed works, both under initial and ultimate loading conditions;
- An assessment of compliance of the proposed works against relevant national and international EMF guidelines;
- An assessment of the proposal against precautionary and prudent avoidance principles as defined in the relevant guidelines.

1.3 Structure of Report

The remainder of Section 1 provides background information, including a brief overview of the EMF and human health issue and our modelling is presented in Sections 2 and 3. Section 4 addresses EnergyAustralia's design in the context of compliance with EMF standards and precautionary/prudent avoidance principles. Conclusions are presented in Section 5 and a list of reference documents is contained in Section 6.

1.4 General Description of Electric and Magnetic Fields

The electric and magnetic fields associated with electrical equipment are essentially independent of one another. The electric field is associated with the voltage of the equipment and the magnetic field is associated with the current (amperage). In combination, these fields cause energy to be transferred along electric wires.

An **electric field** is a region where electric charges experience an invisible force. The strength of this force is related to the voltage, or pressure, which forces electricity along wires. Electric fields are strongest close to their source, and their strength diminishes rapidly with distance from the source, in much the same way as the warmth of a fire decreases with distance. Many common materials - such as brickwork or metal - block electric fields, so they are readily shielded and, for all practical purposes, do not penetrate buildings. They are also shielded by human skin, such that the electric field inside a human body will be at least 100,000 times less than the external field (Ref 1).

Being related to voltage, the electric fields associated with transmission lines and electrical equipment in substations remain relatively constant over time, except where the operating voltage changes.

A **magnetic field** is a region where magnetic materials experience an invisible force produced by the flow of electricity (known as the electric current and measured in Amperes). As magnetic fields are related to the current rather than the voltage, high voltage equipment is not the only source of magnetic fields encountered in everyday life. Modern life involves frequent contact with magnetic fields from a variety of sources such as appliances in the home and workplace and electrical machinery.

The strength of a magnetic field depends on the size of the current (measured in amps), and decreases with distance from the source. While electric fields are blocked by many common materials, this is not the case with magnetic fields. This is why locating equipment in enclosures or underground will eliminate any external electric field but not the magnetic fields.

The magnetic field strength resulting from an electrical installation varies continually with time and is affected by a number of factors including:

- The total electrical load
- The size and nature of the equipment
- The design of the equipment
- The layout and electrical configuration of the equipment and its interaction with other equipment.

1.5 Overview of EMF and Human Health

The possibility of adverse health effects due to the EMFs associated with electrical equipment has been the subject of extensive research throughout the world. To date, adverse health effects have not been established, but the possibility that they may exist has not been ruled out.

While EMFs involve both electric and magnetic components, electric fields are relatively constant over time, are readily shielded and, in the health context, are generally no longer associated with the same level of interest as magnetic fields. Accordingly, the major focus of the remainder of this report is on magnetic fields.

Research into EMFs and health is a complex area involving many scientific disciplines - from biology, physics and chemistry to medicine, biophysics and epidemiology. Many of the health issues of interest to researchers are quite rare. In this context, it is well accepted by scientists that no study considered in isolation will provide a meaningful answer to the question of whether or not EMFs can contribute to adverse health effects. In order to make an informed conclusion from all of the research, it is necessary to consider the science in its totality. Over the years, governments and regulatory agencies around the world have commissioned independent scientific review panels to provide such overall assessments.

The most recent scientific reviews by authoritative bodies are reassuring for most potential health issues. However, statistical associations² between prolonged exposure to elevated magnetic fields and childhood leukaemia have persisted. This led the International Agency for Research on Cancer (IARC) (Ref 2) in 2001 to classify magnetic fields as a "possible carcinogen".³

The fact that, despite over 20 years laboratory research, no mechanism for an effect has been established, lends weight to the possibility that the observed statistical associations reflect some factor other than a causal relationship. This point is made in the 2001 report of the UK National Radiological Protection Board's (NRPB) Advisory Group, chaired by eminent epidemiologist, the late Sir Richard Doll (Ref 3).

"in the absence of clear evidence of a carcinogenic effect in adults, or of a plausible explanation from experiments on animals or isolated cells, the evidence is currently not strong enough to justify a firm conclusion that such fields cause leukaemia in children" (page 164).

1.6 Health Standards


As noted in Section 1.2, the Director General's Requirements make particular reference to the Australian Radiation Protection and Nuclear Safety Agency (ARPANSA) guidelines and standards.

Until a few years ago, the relevant Australian health standard was the document called 'Interim Guidelines on Exposure to 50/60 Hz Electric and Magnetic Fields' (1989) (Ref 4), issued by the National Health and Medical

² It should be noted that a statistical association does not necessarily reflect a cause and effect relationship.

³ IARC publishes authoritative independent assessment by international experts of the carcinogenic risks posed to humans by a variety of agents, mixtures and exposures. These agents, mixtures and exposures are categorised into 5 groups, namely:

- Group 1 - the agent is carcinogenic to humans - 108 agents are included in the group, including asbestos, tobacco and ultra violet radiation;
- Group 2A - the agent is probably carcinogenic - 66 agents have been included in this group, including diesel engine exhaust, creosotes and PCBs;
- Group 2B - the agent is possibly carcinogenic to humans - 248 agents have been included in this group, including coffee, gasoline, lead, nickel, petrol engine exhaust and extremely low frequency magnetic fields;
- Group 3 - the agent is not classifiable as to carcinogenicity - 515 agents have been included in this group, including caffeine, coal dust and extremely low frequency electric fields;
- Group 4 - the agent is probably not carcinogenic to humans - only 1 agent (caprolactam) has been included in this group.



Research Council (NHMRC) and based on international guidelines. As the NHMRC has not updated its guidelines since their original issue, they have lapsed and ARPANSA is currently developing a new standard. In December, 2006, ARPANSA issued a Draft Standard on “Exposure Limits for Electric and Magnetic Fields (0Hz to 3kHz)” for public comment (Ref 5). The Draft Standard proposes a 24-hour magnetic field exposure limit (Reference Level) for the general public of 1000 milligauss. This is identical to both the previous (Australian) NHMRC Guidelines and the current version of the international guidelines (Ref 6), upon which they were based.

In the absence of a current Australian standard, we have interpreted the Director General’s reference as relating to the 2006 ARPANSA Draft Standard and acknowledge its appropriateness, noting the similarity of its limits to those in both the previous NHMRC and the current international guidelines.

In applying the ARPANSA Draft Standard, it is important to recognise that the numerical limits, i.e.1000 milligauss, are based on “established biological effects”. The foreword to the Draft Standard notes that:

“..data regarding biological effects, at levels below the limits specified in the Standard, are incomplete and inconsistent. The health implications for these data are not known and such data could not be used for setting the levels of the Basic Restrictions in the Standard.”

Being based on “established biological effects” (which occur at field levels much higher than those normally encountered in the vicinity of electrical equipment), the (numerical) exposure limits in the Draft Standard cannot be said to define safe limits for possible health effects, should these exist, from fields at levels normally encountered in the vicinity of electrical equipment. Nevertheless, in the Foreword to the ARPANSA Draft, the CEO of ARPANSA, Dr John Loy notes that “the incorporation of arbitrary additional safety factors beyond the limits of the Standard is not supported”. It is in this context that precautionary measures such as “Prudent Avoidance” have arisen.

1.7 Prudent Avoidance

With regard to the potential health effects from magnetic fields, while compliance with the relevant guideline is important in protecting people from established health effects, it does not necessarily address possible health effects, should they exist, from fields at levels normally encountered in the vicinity of electrical equipment. The possibility of such effects has been comprehensively studied over several decades worldwide but, to this day, there is no clear understanding of whether or not electric or magnetic fields at low levels can pose a threat to human health.

Since the late 1980s, many reviews of the scientific literature have been published by authoritative bodies. There have also been a number of Inquiries such as those by Sir Harry Gibbs in NSW (Ref 7) and Professor Hedley Peach in Victoria (Ref 8). These reviews and inquiries have consistently found that:


- Adverse health effects have not been established.
- The possibility cannot be ruled out.
- If there is a risk, it is more likely to be associated with the magnetic field than the electric field.

Both Sir Harry Gibbs and Professor Peach recommended a policy of prudence or prudent avoidance, which Sir Harry Gibbs described in the following terms:

“... [doing] whatever can be done without undue inconvenience and at modest expense to avert the possible risk ...”

In 1999, the (US) National Institute of Environmental and Health Sciences (NIEHS) (Ref 9) found:

“In summary, the NIEHS believes that there is weak evidence for possible health effects from ELF-EMF exposures, and until stronger evidence changes this opinion, inexpensive and safe reductions in exposure should be encouraged.” (page 38)



The practice of 'prudent avoidance' has been adopted by the (Australian) Energy Networks Association (ENA) and most Australian power utilities, including EnergyAustralia.

In the Australian context, the Draft ARPANSA Standard addresses the matter of prudent avoidance in an Annex entitled "A Public Health Precautionary Approach to ELF Fields". The Annex states:

[Prudent avoidance] "does not imply setting exposure limits at an arbitrarily low level, and requiring that they be achieved regardless of cost, but rather adopting measures to reduce public exposure to ELF fields at modest cost."

Section 5.7 of the Draft addresses "Protection of the General Public" and relevantly stipulates:

"Measures for the protection of the general public who may be exposed to ELF and/or static fields due to their proximity to high ELF and/or static sources must include the following: Minimising, as appropriate, ELF and/or static electric and magnetic field exposure, provided this can be readily achieved without undue inconvenience and at reasonable expense. Any such precautionary measures should follow good engineering and risk minimisation practice. The incorporation of arbitrary additional prescriptive safety factors beyond the exposure limits of this Standard is not supported."

Internationally, the World Health Organisation has also addressed the notion of prudence or precaution on several occasions, including in its 2007 publication Extremely low frequency fields. Environmental Health Criteria , Vol 238 (Ref 1), which states:

".....the use of precautionary approaches is warranted. However, it is not recommended that the limit values in exposure guidelines be reduced to some arbitrary level in the name of precaution. Such practice undermines the scientific foundation on which the limits are based and is likely to be an expensive and not necessarily effective way of providing protection."

It also states:

"Provided that the health, social and economic benefits of electric power are not compromised, implementing very low-cost precautionary procedures to reduce exposure is reasonable and warranted."

Given the inconclusive nature of the science, it is considered that a prudent approach continues to be the most appropriate response in the circumstances. Under this approach, subject to modest cost and reasonable convenience, power utilities should design their facilities to reduce the intensity of the fields they generate, and locate them to minimise the fields that people, especially children, encounter over prolonged periods. While these measures are prudent, it cannot be said that they are essential or that they will result in any benefit.

2. Aspects of Field Predictions and Input Information

2.1 Magnetic field dependence on load

The magnetic fields from substation equipment depend on the loadings at that particular time. Accordingly, in characterising the magnetic fields, it is necessary to make practical assumptions regarding the substation and feeder loadings.

During a typical day, the amount of load current passing through a substation will vary substantially between a daily minimum, generally in the early hours of the morning and a daily maximum at times of peak demand. Loadings also vary seasonally during the year, generally reaching a peak in either summer or winter. An example of a summer weekday load profile for the North Sydney zone is shown in Figure 2.1. It can be seen that the night-time load (and hence magnetic field) is less than half the day-time load.

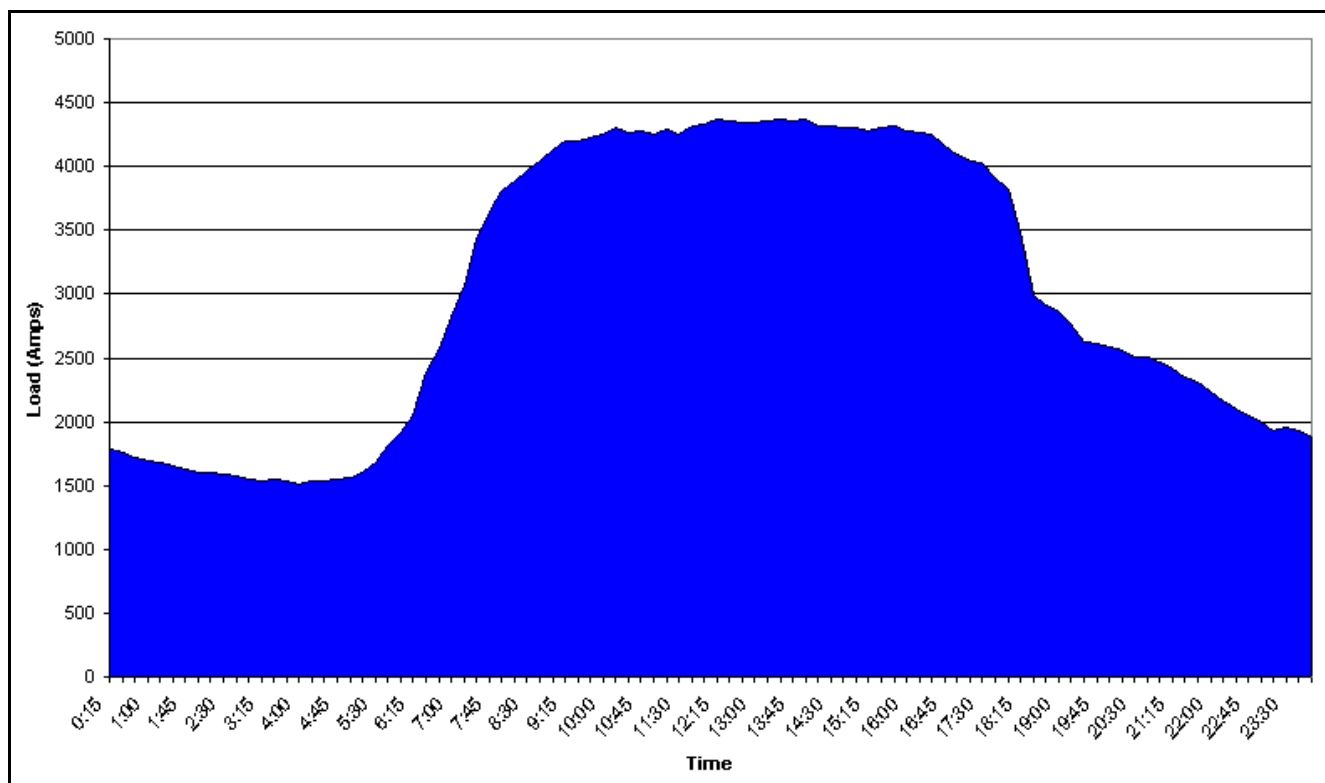


Figure 2.1 – Summer weekday load profile for North Sydney zone (Feb 4th 2010)

Given that the epidemiological associations which underpin community interest regarding magnetic fields tend to relate to elevated "average" magnetic fields, of the various hypothetical conditions one could select for magnetic field characterisation, the most meaningful is to take the long term average load and link this to conservative assumptions regarding other factors. The magnetic fields derived under these conditions are the most appropriate for consideration in the context of the magnetic field/health literature, rather than the maximum capacity of the substation, which may only be required for very short periods, under emergency conditions, a few times over the service life of the substation.

This approach has been followed in our modelling calculations, with the substation loading conservatively assumed to be at the 85th percentile level i.e. that level which is exceeded for only 15% of the year.

For the purpose of this EMF assessment, we have been advised that it is reasonable to share the total 85th percentile loadings of the proposed ZS equally between all thirty-one 11kV feeders. It should be noted that, following completion of the proposed works, the magnetic fields would be dependent on the actual loadings rather than those used for calculation purposes.

2.2 Information provided by Energy2U Alliance

Energy2UAlliance has provided the following information to serve as a basis for the assessment:

- Proposed 132kV North Sydney ZS arrangement drawings.
- 11kV and 132kV cable tray and conduit penetration drawings for each floor in the proposed ZS building.
- Typical cable cross sections, including the spacing between cables (or groups of cables), as well as between cores, to be assumed for each different section of cable.
- Plan and elevation drawings for key electrical infrastructure including the 132/11kV Transformers, 132kV Switchgear, 11kV Switchgear and Capacitor Bank.
- Plan, elevations and arrangement drawings of the proposed 11kV cable vault.
- Load duration curves for the proposed 132kV feeders, showing the forecast peak and 85th percentile loads, upon commissioning and ultimately. These loads are set out in Table 1 below.
- Details of the loadings on the existing zone substation on 8th July, 2010, the date of Aurecon's site measurements.
- For magnetic field calculation purposes, the contribution of the 132kV cables to the zone 11kV current is to be calculated as 10.08 times the total 132kV current.

	85 th % Initial Load upon Commissioning (2011)	85 th % Ultimate Load (2014)
132kV incoming	263 Amps	452 Amps
11kV from existing ZS	1821 Amps	-

Table 1 – North Sydney ZS 132kV Loadings

In relation to the staging of the work, it is understood that the 11kV load will be transferred progressively from the existing ZS to the proposed ZS. For the purposes of this assessment, we have defined the “initial” condition as that which will apply at the time when the new 11kV switchboard is fully commissioned with the whole 11kV load being supplied from the new substation (currently understood to be 2011). At that time, about 40% of the load will be supplied from two 33/11kV transformers on the existing site, with the remaining 60% being supplied from two 132/11kV transformers on the proposed site. The “ultimate” condition has all load being supplied from the new 132/11kV transformers and the substation fully loaded (currently understood to be 2014).

3. Field Characterisation

3.1 Existing magnetic field environment

In order to characterise and understand the existing magnetic field environment, Aurecon visited the site in July 2010 to undertake magnetic field measurements and to view the project area.

Measurements were undertaken along the site boundaries as shown in Figure 3.1. The blue lines show the locations of measurements along the boundaries of the existing ZS, the yellow lines show the locations of measurements along the boundaries of the proposed ZS and the green lines show the locations of measurements around the location of the proposed cable vault.

The measurements were made with an Emdex 2 magnetic field meter, in conjunction with an Enertech linear data acquisition system, at a height of 0.9 metres above ground, as dictated by the (US) equipment used. Internationally, a measurement height of 1 metre is more common but differences, if any, between the two measurement heights would not be material.

The results of these site measurements are shown in Figures 3.2 to 3.4 for the existing ZS boundaries, Figures 3.5 to 3.8 for the proposed ZS boundaries and Figure 3.9 for the area above the proposed cable vault. The boundary between the existing ZS and the proposed ZS was not measured as it was not accessible.

In interpreting these measurements, it is important to recognise that they represent a snapshot in time and that, at other times, fields could be either higher or lower than those measured. Having regard to the loading at the time of our measurements and our understanding of the daily and annual load variation for the North Sydney area, over a year, we would expect the fields to vary between approximately 50% and 150% of those measured.



Figure 3.1 – Aerial view showing locations of site measurements

3.1.1 Existing ZS Field Measurement

The magnetic fields measured at 0.9 metres above ground along the western boundary of the existing ZS (along Ward Street) are shown in Figure 3.2 below.

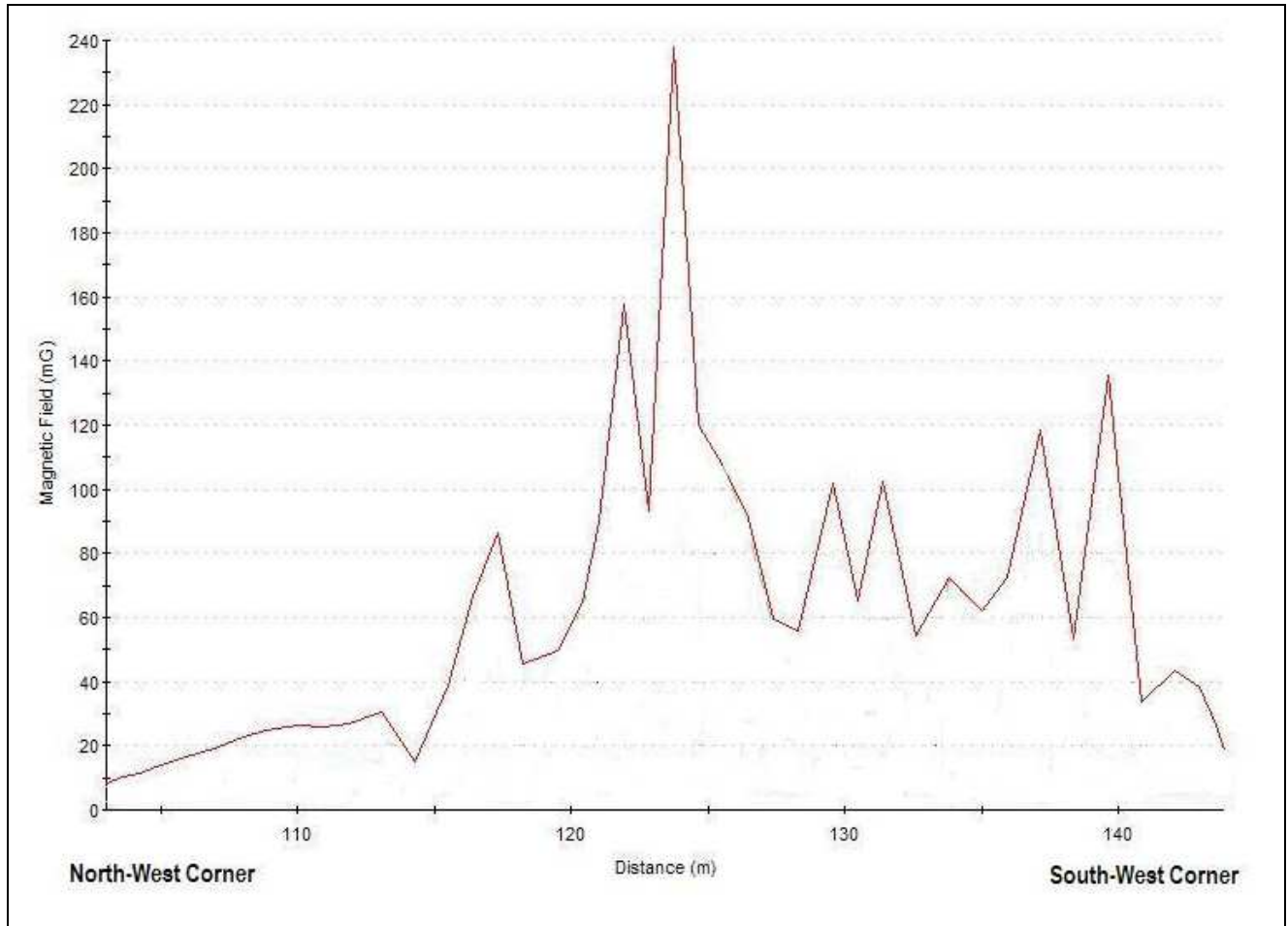


Figure 3.2 – Magnetic field profile along western boundary of existing ZS

It can be seen that the measured fields along the western boundary generally ranged from 8 – 80 mG, with several peaks in the range of 100 – 240 mG. The peaks are likely to be due to the 11kV underground cables in Ward Street.

The magnetic fields measured at 0.9 metres above ground along the southern boundary of the existing substation (along Berry Street) are shown in Figure 3.3 below.

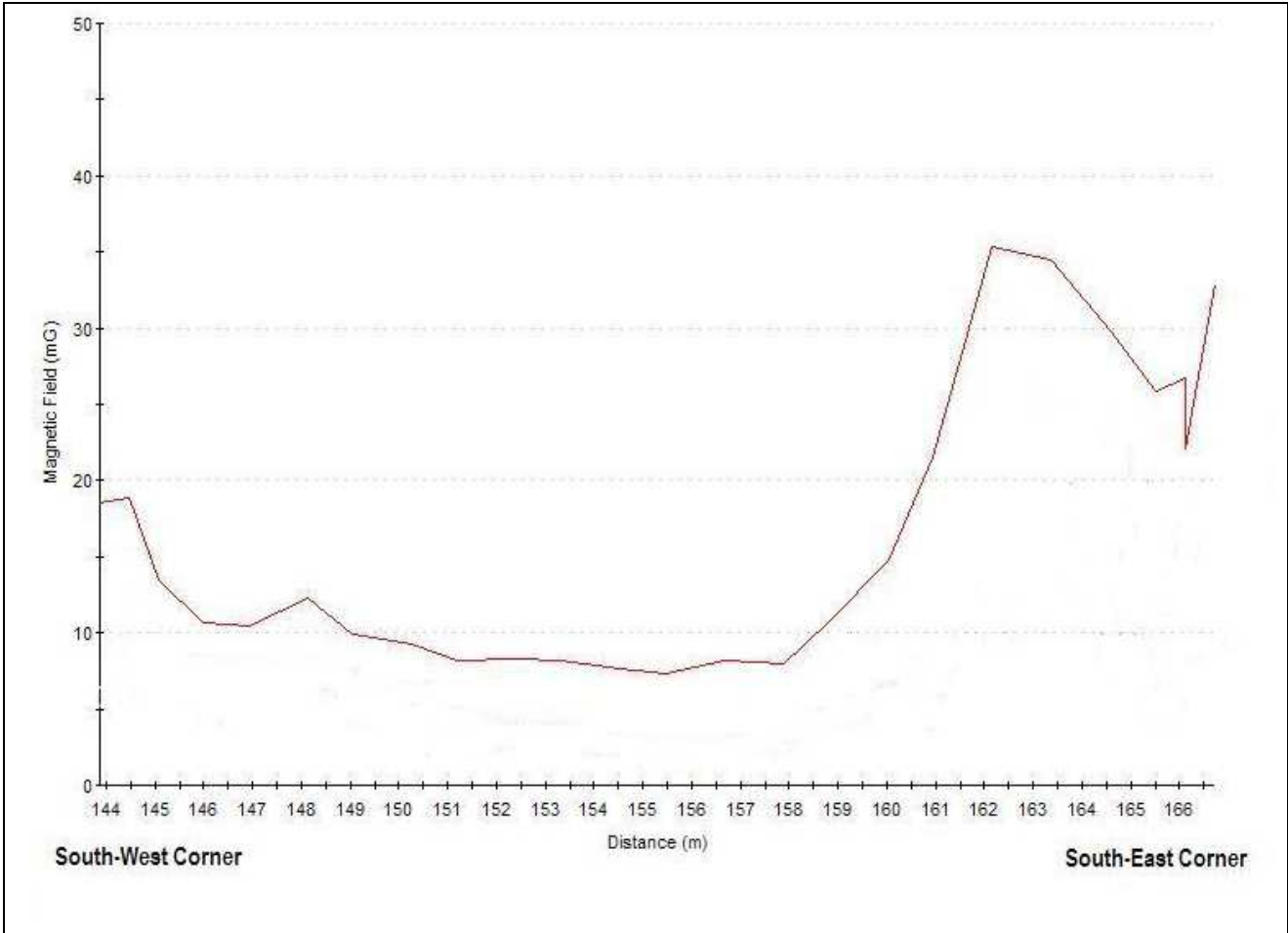


Figure 3.3 – Magnetic field profile along southern boundary of existing ZS

It can be seen that the measured fields along the southern boundary (Berry Street) of the existing ZS were generally in the range of 10 – 20mG, except for the eastern quarter, where they ranged up to 37mG, possibly due to the distribution substation and associated LV feeder cables.

A full set of measurements along the eastern boundary of the existing ZS was not possible, due to the neighbouring commercial building which has limited access. Accordingly, full measurements were taken for the southern 10 metres as per Figure 3.1 and the results are shown in Figure 3.4 below. For the remainder of the boundary, a series of spot measurements were taken at accessible points within the adjacent building (as shown by blue crosses on Figure 3.1). The magnetic field levels for these spot measurements ranged from approximately 6 – 15mG. All measurements were made at a height of 0.9 metres above ground.

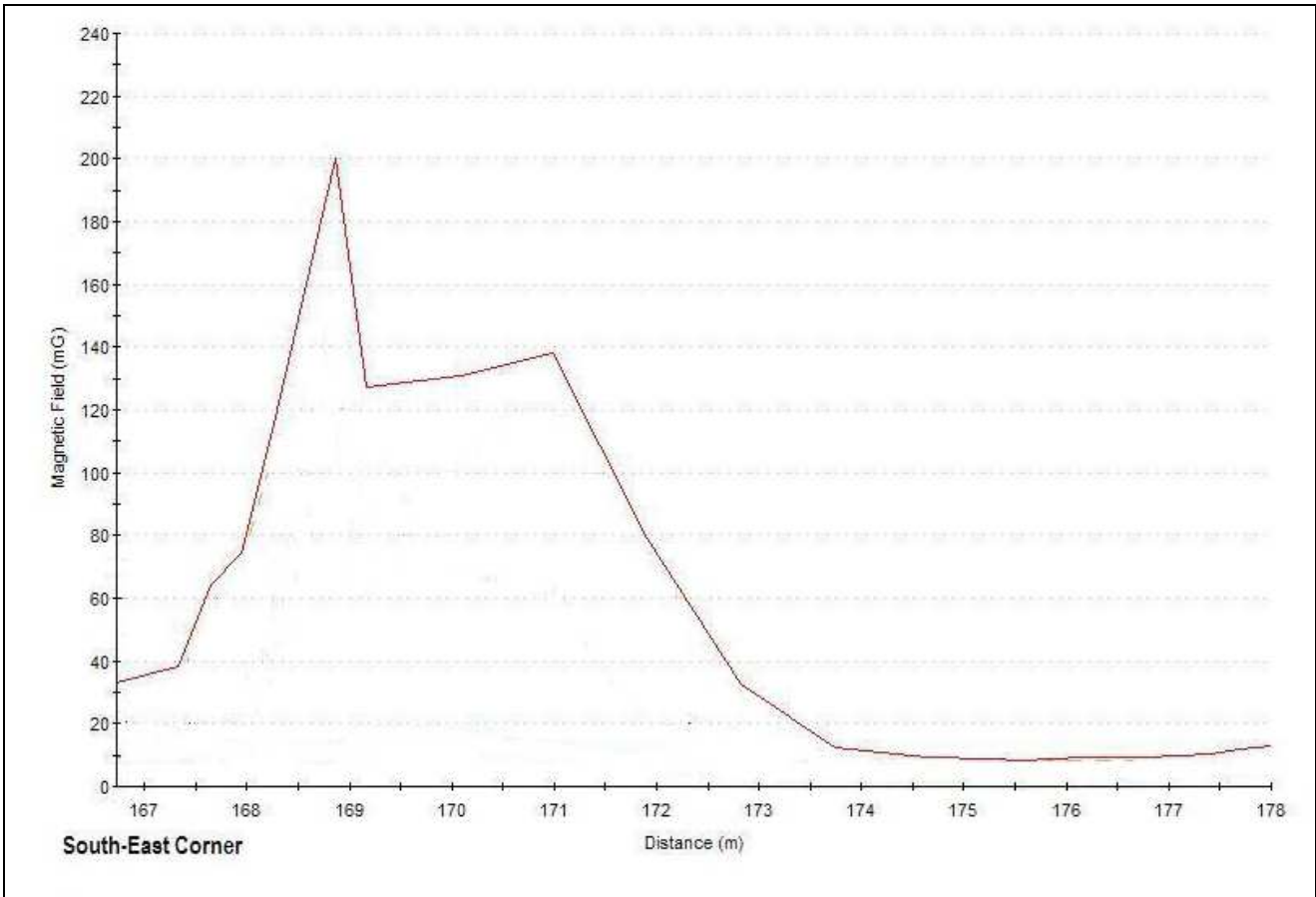


Figure 3.4 – Magnetic field profile along eastern boundary of existing ZS

It can be seen that the measured fields along the eastern boundary of the existing ZS generally ranged from 40 – 140mG for about the first 6 metres from the south-east corner, with one peak of 200mG. Beyond 8 metres from the south-east corner, the fields dropped to around 10mG, which was in the same range as the spot measurements. The localised peak magnetic field toward the southern end of the eastern boundary appeared to be due to the distribution substation and associated LV feeder cables near the south eastern corner of the ZS. With the exception of the localised peak, the main contributor to the magnetic fields along this boundary, in the range of 10mG to 15mG, appeared to be the transformers and associated connections.

3.1.2 Site of Proposed ZS Field Measurement

The magnetic fields measured at 0.9 metres above ground along the eastern boundary of the proposed ZS site are shown in Figure 3.5 below.

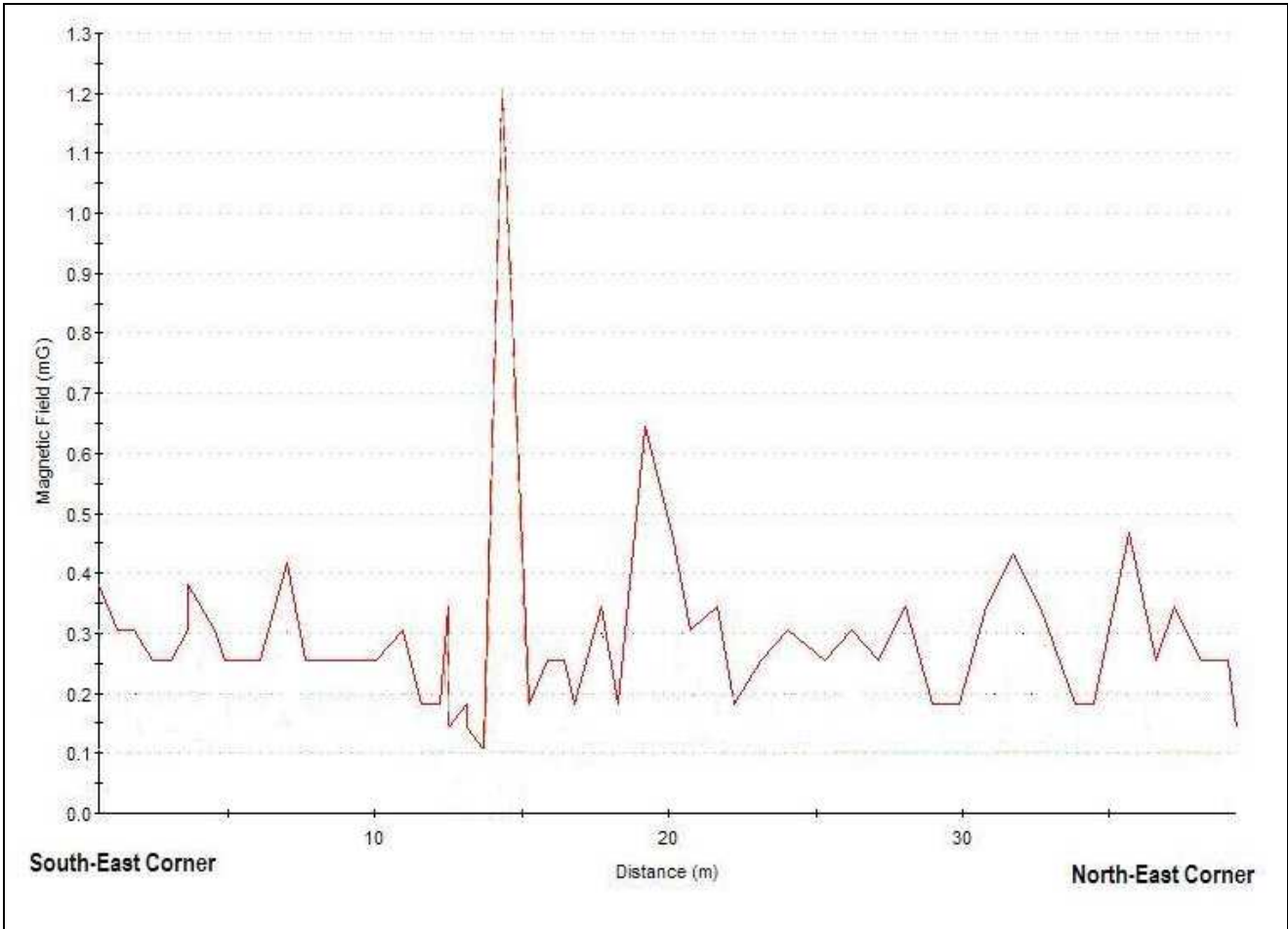


Figure 3.5 – Magnetic field profile along eastern boundary of proposed ZS

It can be seen that the fields measured along the eastern boundary of the proposed ZS were quite low, generally about 0.3mG, with two minor “peaks” of approximately 1.2mG and 0.7mG. The higher “peak” could have been a measurement distortion, possibly caused by the negotiation of a 1 metre step change in ground level at that point.

The northern boundary of the proposed ZS site has two different street levels, with Ward Street being approximately 4 metres higher than Harnett Street. The magnetic fields measured at 0.9 metres above ground along the northern boundary of the proposed ZS are shown in Figures 3.6 (eastern portion, approximately 70%, at Harnett Street level) and 3.7 (western portion, approximately 30%, at Ward Street level) below.

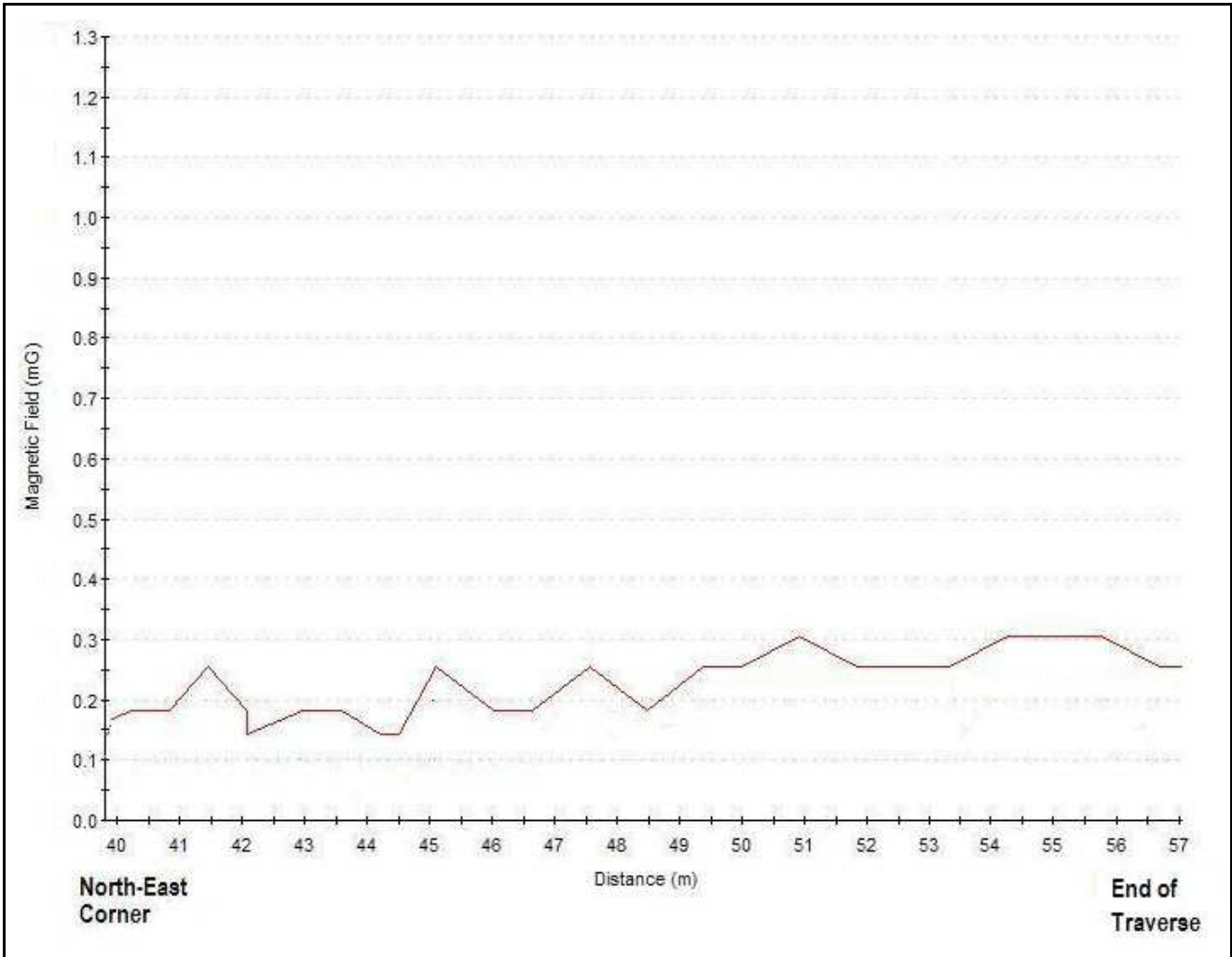


Figure 3.6 – Magnetic field profile along northern boundary of proposed ZS (eastern portion - Harnett Street level)

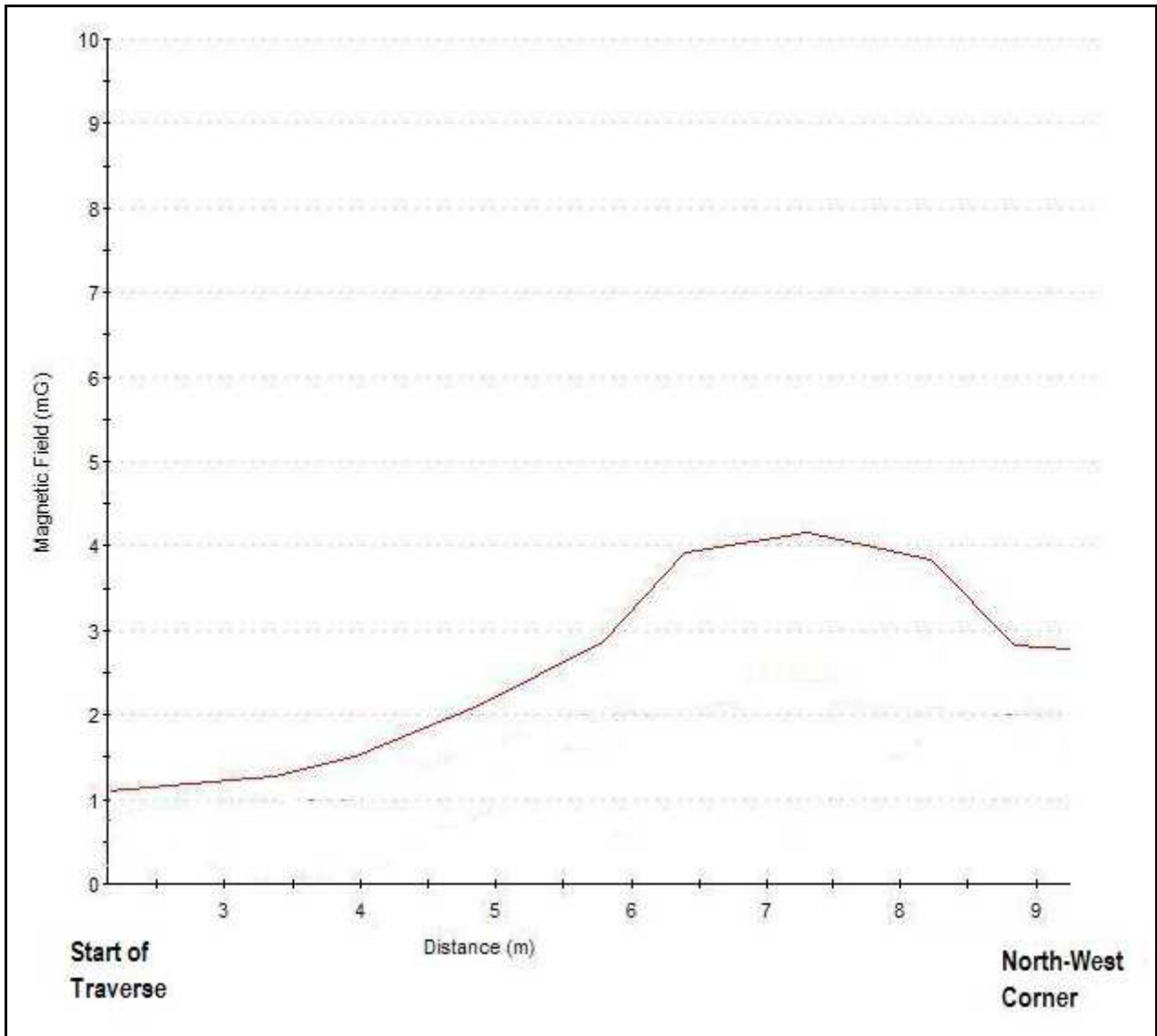


Figure 3.7 – Magnetic field profile along north boundary of proposed ZS (western portion - Ward Street level)

It can be seen that the measured fields along the northern boundary of the proposed ZS varied between 0 and 4 mG, with the higher readings being towards the Ward Street end.

The magnetic fields measured at 0.9 metres above ground along the western boundary of the proposed ZS are shown in Figure 3.8 below.

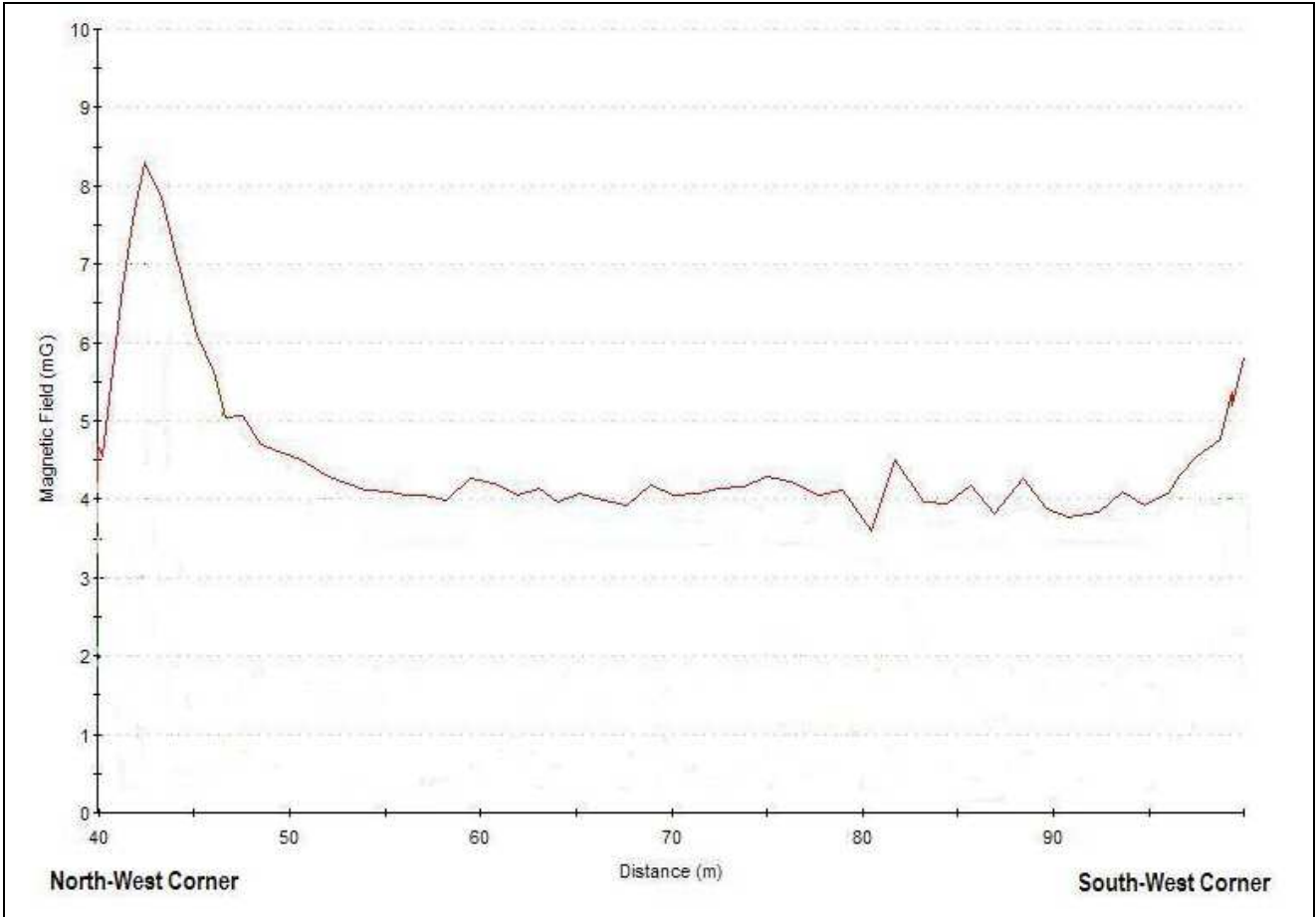


Figure 3.8 – Magnetic field profile along western boundary of proposed ZS

It can be seen that the measured fields along the western boundary of the proposed substation were generally between 3 and 5mG, with a peak of approximately 8mG near the North-West corner. Towards the southern end, the field can be seen to be increasing, presumably due to the influence of the existing substation.

3.1.3 Field Measurements in the Vicinity of the Proposed Cable Vault

The magnetic fields measured in the vicinity of the proposed 11kV cable vault are shown as a contour plot in Figure 3.9 below. Note that the yellow lines indicate the edge of a street (either Ward Street or Berry Street) and the origin of this plot is the street corner near the south west corner of the existing ZS.

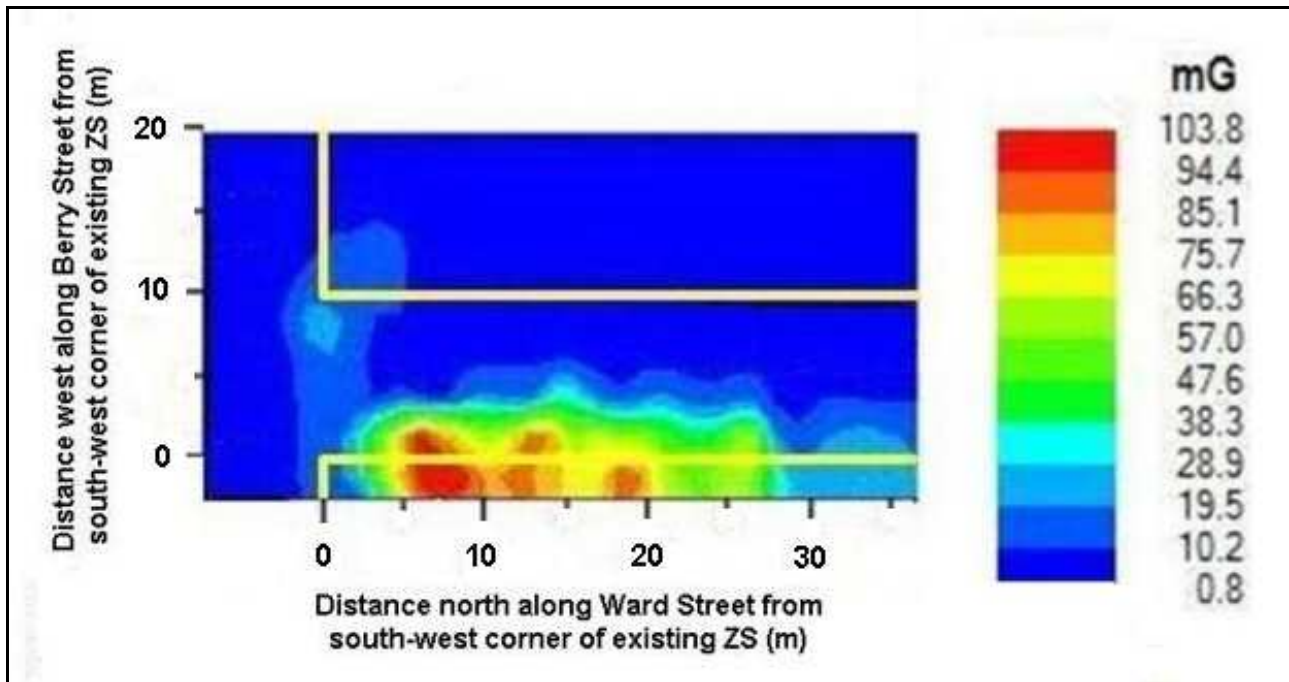


Figure 3.9 – Measured magnetic field contour plot above proposed cable vault

It can be seen that the fields measured on the eastern side of Ward Street at 0.9 metres above ground, in the vicinity of the proposed cable vault, are dominated by the influence of the existing substation and associated cables and range up to 120mG. The fields in the western half of Ward Street and in Berry Street are generally less than 10 mG, except for a narrow band, probably associated with an underground cable, crossing Ward Street at Berry Street, where the field is in the range of 10-20 mG.

3.1.4 Summary of Site Measurements

Approximately half the measurements around the existing ZS boundaries were less than 20mG, with the majority of the remainder being less than 80mG. There were also 8 peaks ranging up to 240mG, including a peak of 200mG towards the southern end of the eastern boundary and a peak of 240mG midway along the western boundary.

Approximately half the measurements around the proposed ZS boundaries were less than 1mG, with the majority of the remainder being in the range of 1 – 4mG. A peak of 8mG was recorded near the north-west corner.

Approximately half the measurements in the area of the proposed cable vault were less than 20mG, with the remainder ranging up to 120mG adjacent to the existing ZS.

Even the highest of the measured magnetic fields was still less than 25% of the relevant health limit.



3.2 Modelling of the magnetic field contribution of the proposed ZS

Based on the available design and loading information, provided by Energy2U Alliance, the magnetic field contribution expected from the proposed ZS, cable vault and underground feeders has been modelled using the CDEGS software package.

CDEGS is an internationally recognised software package pioneered by Safe Engineering Services & Technologies (SES) to provide grounding and electromagnetic and conductive interference analysis involving electrical networks. The software has undergone extensive scientific validation using field tests and comparisons with analytical or published results for over twenty years (Ref.10).

The magnetic field levels were calculated for the 85th percentile of the forecast initial and ultimate load levels, provided by Energy2U Alliance as described in Section 2.2. It should be noted that, following completion of the proposed works, the magnetic fields would be dependent on the actual loading rather than that used for calculation purposes.

Fields have been calculated at a height of 1 metre above street level in accordance with international practice. Two sets of contours were calculated; one related to Ward Street level and one related to Harnett Street level which is approximately 3 metres lower than Ward Street.

A 22 storey commercial/residential development is proposed to be constructed on an adjacent property to the east of the proposed substation and, accordingly, profiles at 1 metre above each floor level from Level 2 to Level 5 of that building have been calculated.

A set of contour plots have also been calculated at 1m above Ward Street at the vicinity of the proposed cable vault.

The total magnetic field level at any point will be the vector sum of all of the magnetic field contributions of the various underground and above ground sources associated with the proposed ZS.

3.2.1 Proposed ZS

Plan and elevation screenshots of the CDEGS model of the proposed works are shown in Figure 3.10 below.

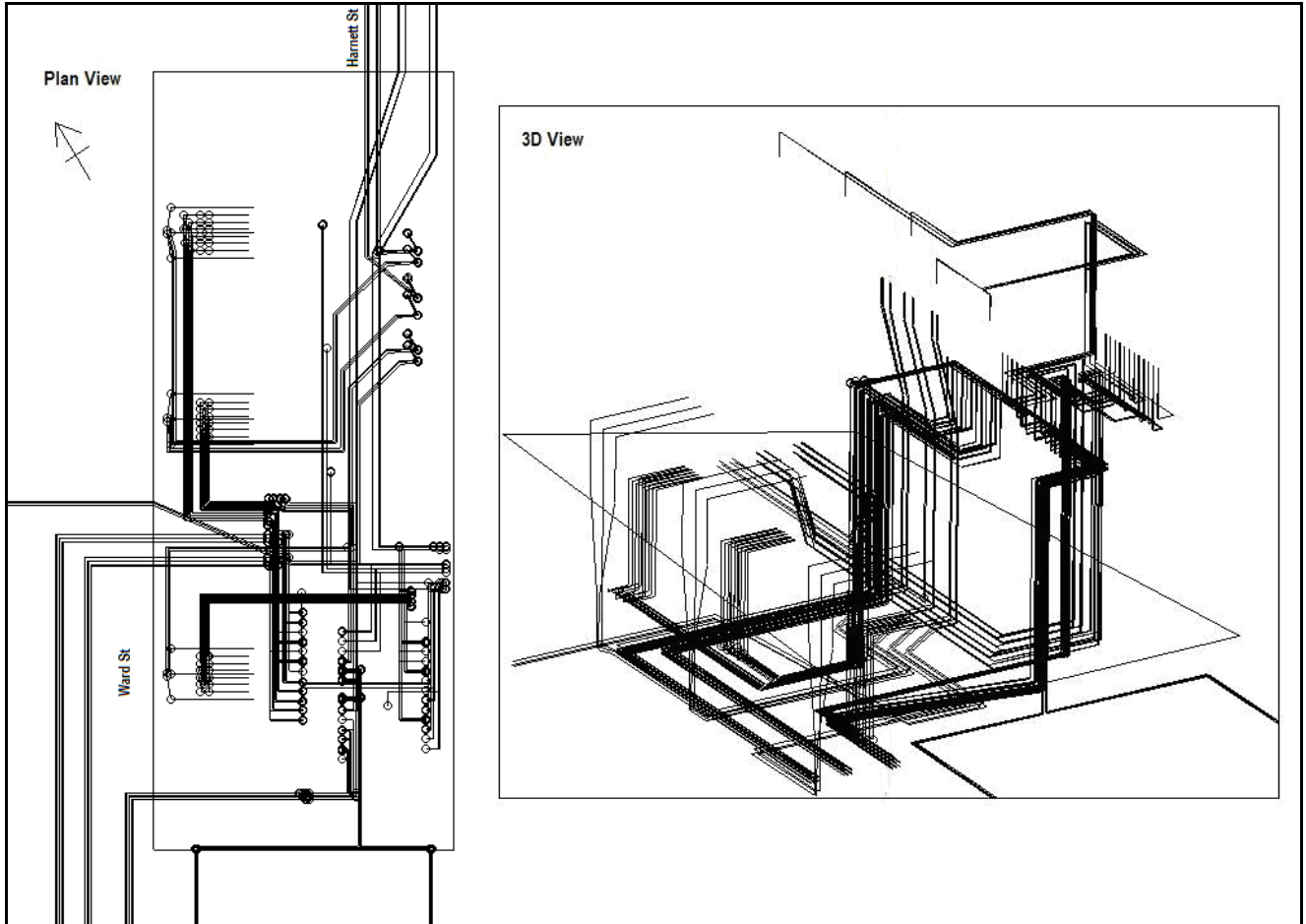


Figure 3.10 – CDEGS Model of proposed ZS

The results obtained from the magnetic field modelling are shown below in the form of surface contour plots for the whole site and profiles along the boundaries. Figures 3.11 and 3.12 show surface contour plots of the magnetic field levels calculated within and around the proposed substation, both under the initial condition (shortly after commissioning as defined in Section 2.2) and under the ultimate loading condition. These contour plots were calculated at 1m above the street level for both Harnett Street and Ward Street levels.

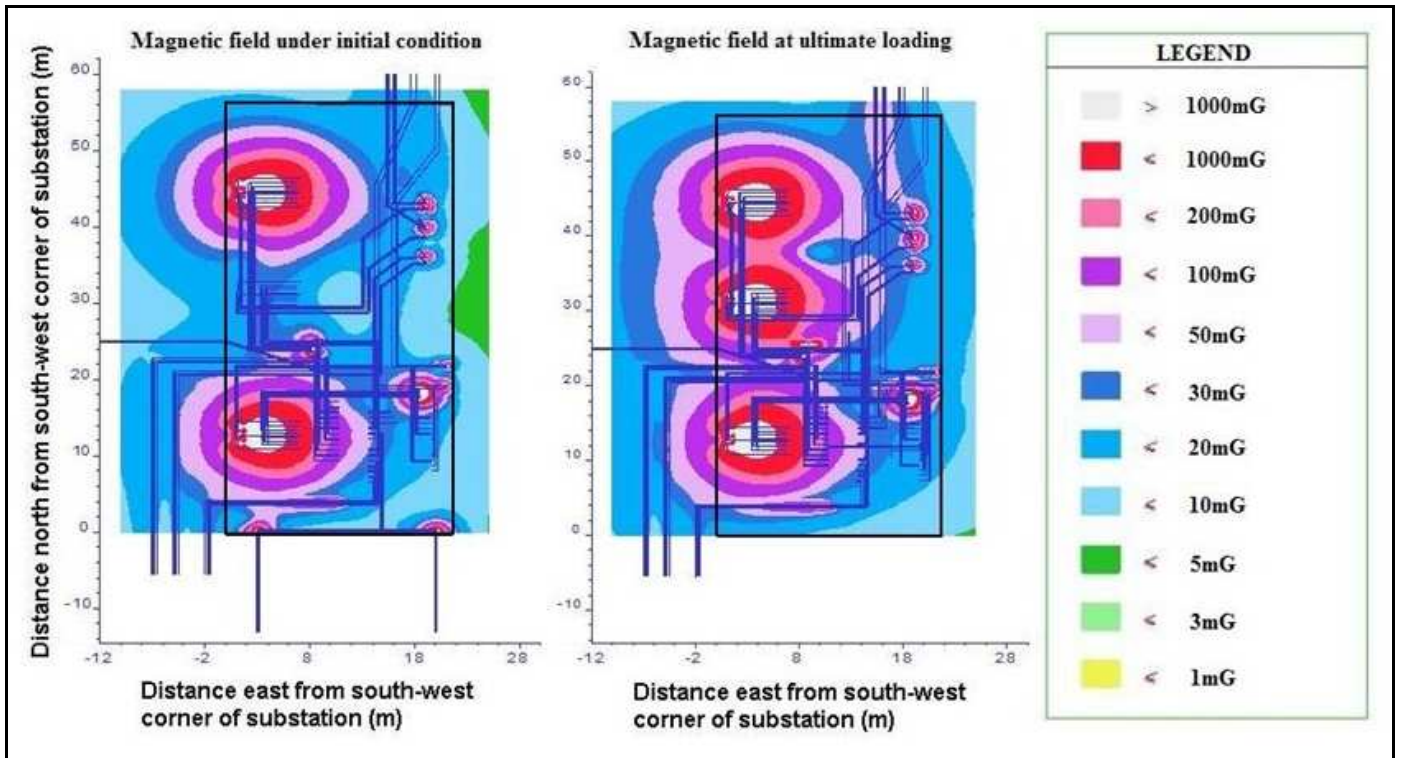


Figure 3.11 – Predicted magnetic field contribution associated with the proposed ZS at 1m above Harnett Street level

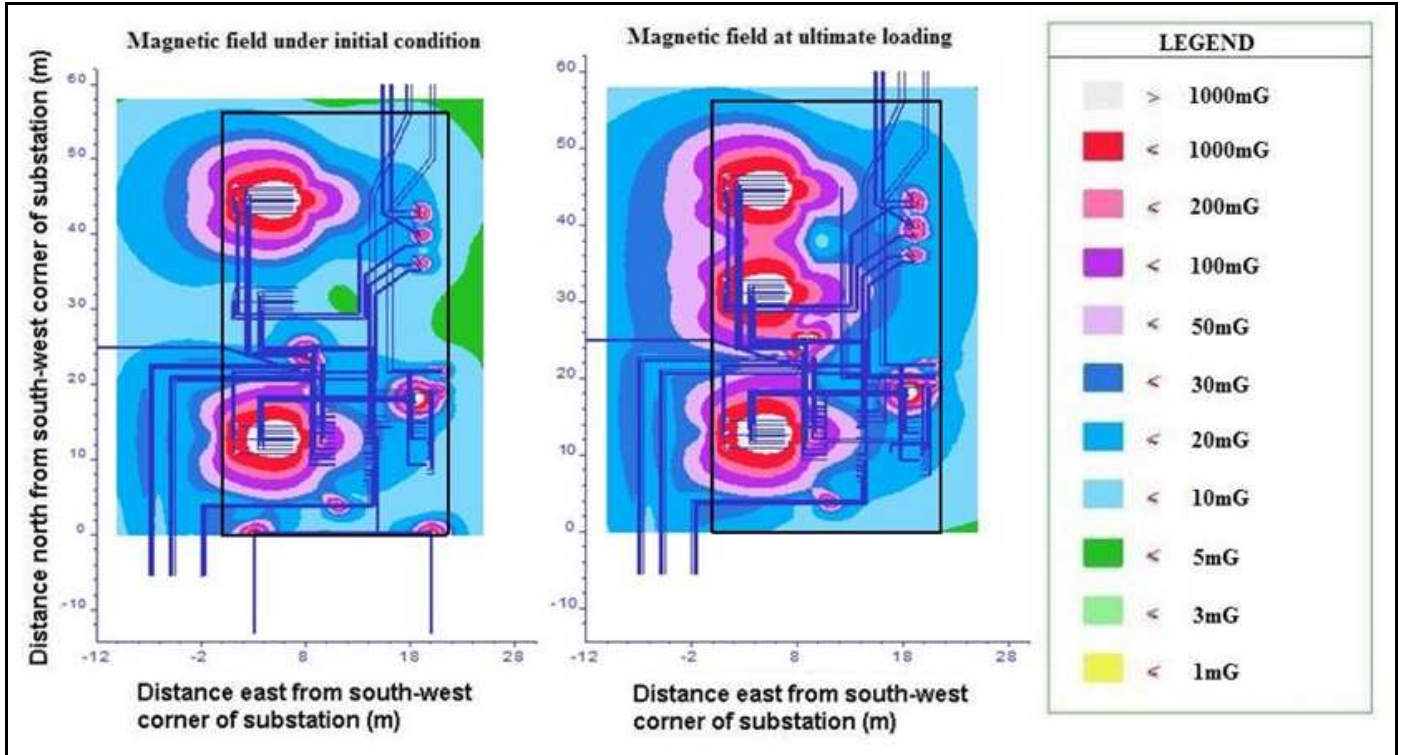


Figure 3.12 - Predicted magnetic field contribution associated with the proposed ZS at 1m above Ward Street level

The expected magnetic field contributions of the proposed ZS along the northern (Harnett Street and carpark), eastern (commercial/residential building), southern (existing ZS) and western (Ward Street) boundaries are shown in Figures 3.13 to 3.16.

In calculating the magnetic fields along the boundaries, it is necessary to select an appropriate height at which to perform these calculations. Accordingly, the magnetic field profiles along the northern and eastern boundaries were calculated at approximately 1m above Harnett Street level (RL66.1) and the magnetic field profiles along the western and southern boundaries were calculated at approximately 1m above Ward Street (RL68.8).

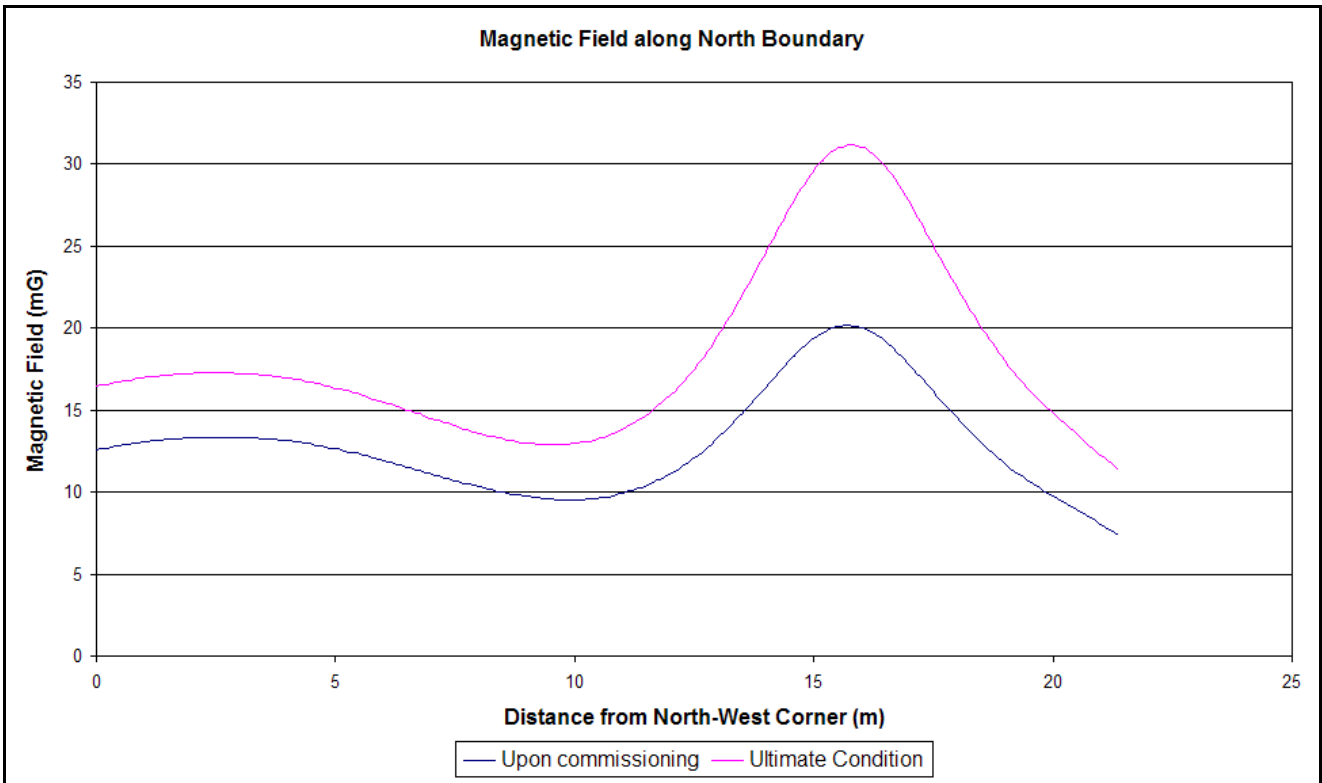


Figure 3.13 – Magnetic Field contribution along northern boundary (Harnett Street and carpark)

The proposed ZS's contribution to the magnetic field levels along its northern boundary is predicted to be in the range of 7 – 20 mG upon commissioning and 11 – 32 mG under ultimate conditions. The peaks along the northern boundary are due to the underground 132kV feeders where they cross it.

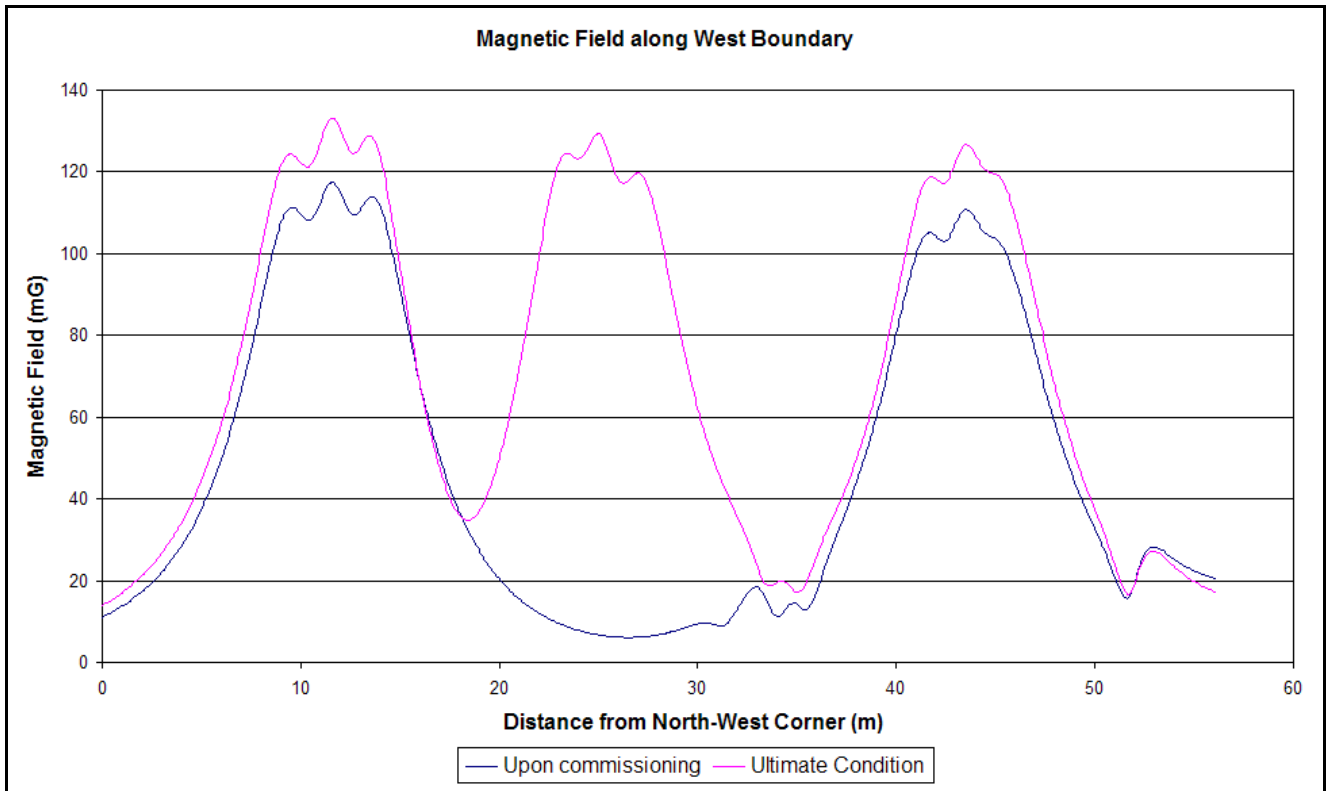


Figure 3.14 – Magnetic Field contribution along western boundary (Ward Street)

The proposed ZS’s contribution to the magnetic field levels along its western boundary is predicted to be generally in the range of 20 – 70 mG, with two substantial peaks of up to 120mG upon commissioning and three peaks of up to 130mG under the ultimate loading condition. The predicted peaks along the western ZS boundary appear to be primarily due to the transformer connections.

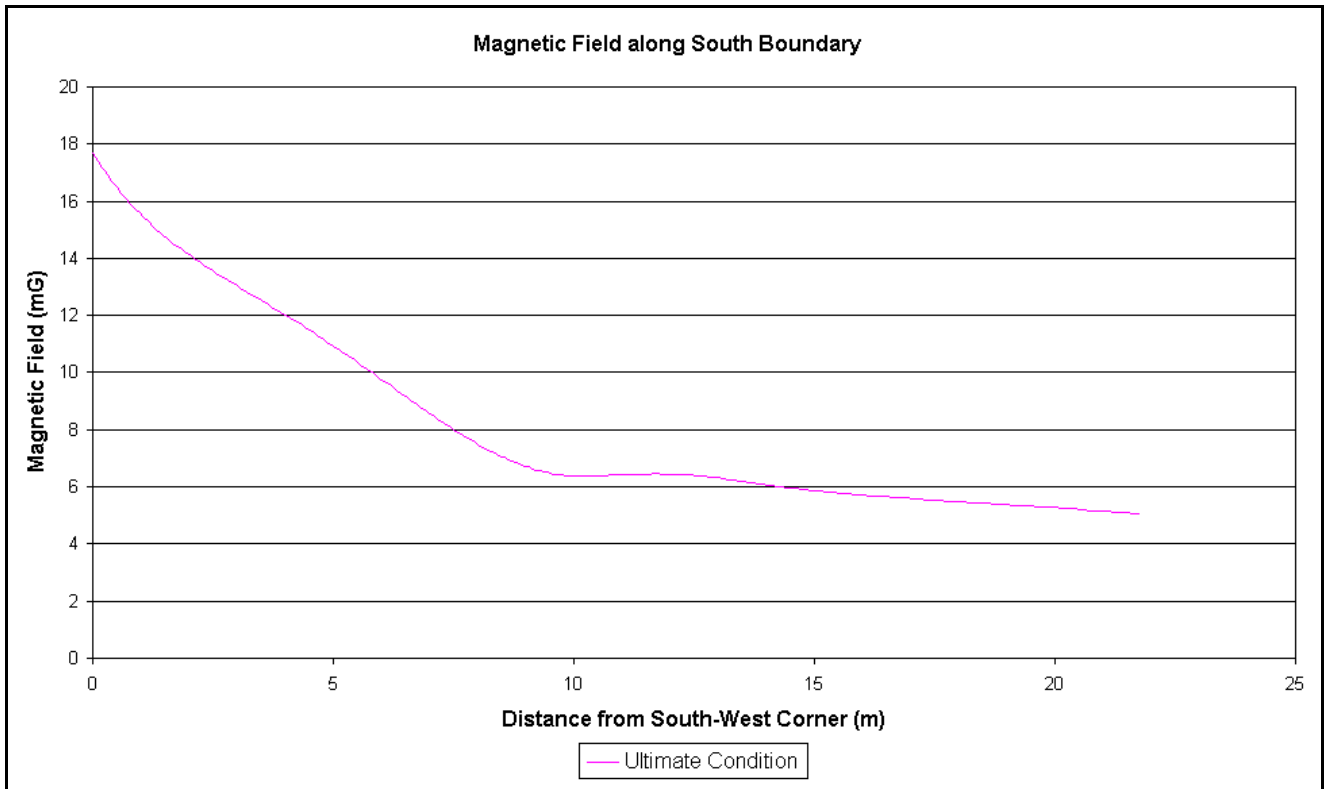


Figure 3.15 – Magnetic Field contribution along southern boundary (adjacent to existing ZS)

The proposed ZS’s contribution to the magnetic field levels along its southern boundary under the ultimate loading condition, at which time the existing ZS would be fully decommissioned is predicted to be in the range of 5 - 17 mG. For the initial condition, the southern boundary of the proposed ZS is directly adjacent to the northern boundary of the existing ZS and is not accessible to the general public. As such, the magnetic fields along the southern boundary were not assessed under the initial loading condition.

Under the ultimate loading condition, the magnetic field levels are highest on the western side, decreasing progressively across the boundary towards the eastern side. The higher magnetic fields along the western side of the boundary, seen in the above figure at the ultimate loading condition, appear to be due to the transformer connections.

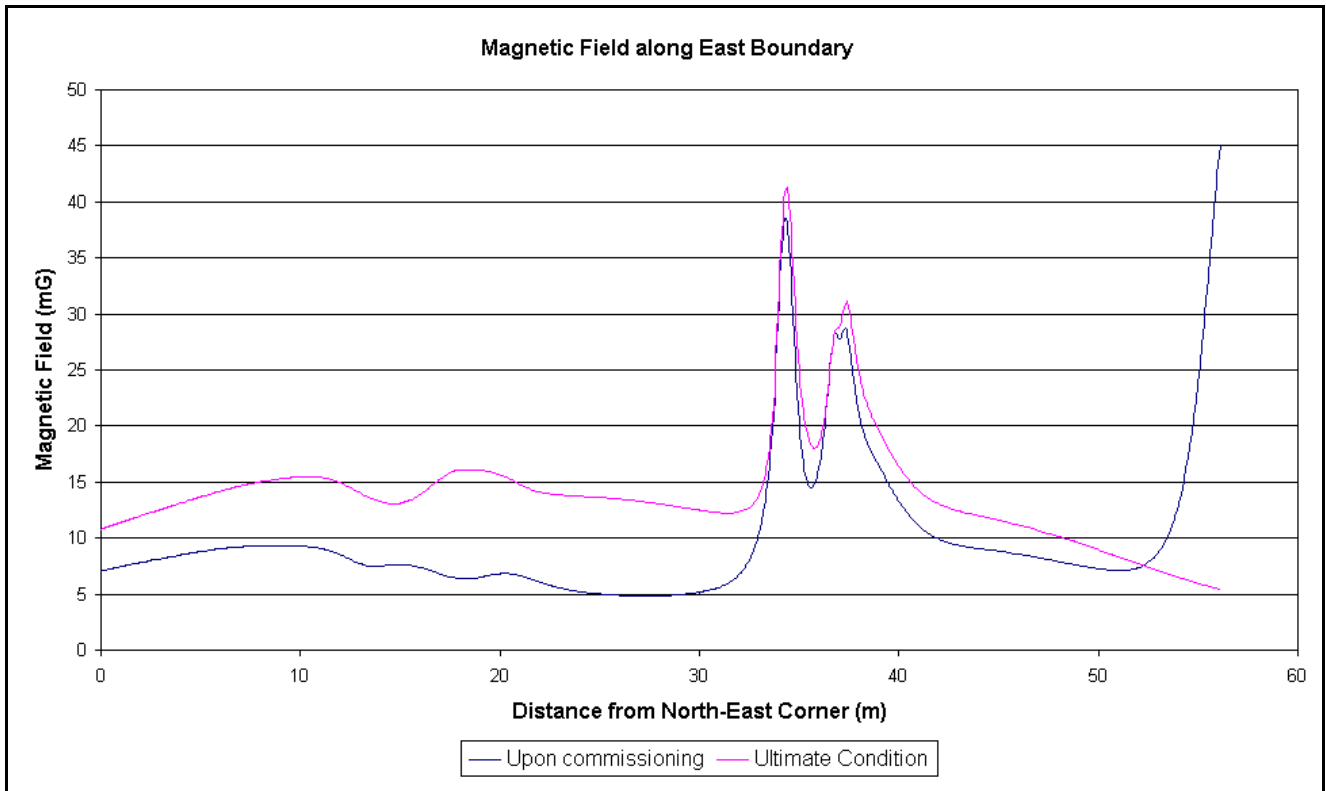



Figure 3.16 – Magnetic Field contribution along eastern boundary

The proposed ZS's contribution to the magnetic field levels along its eastern boundary is predicted to be generally in the range of 6 - 10 mG upon commissioning and 5 - 16 mG under ultimate conditions. There are also predicted to be two peaks, which are within 5m of each other, of up to 35mG under the initial loading condition and 41mG at the ultimate loading condition. These peaks appear due to the eastern cable riser and drop off rapidly with distance outside the boundary. For the initial condition only (prior to the full commissioning of the ZS at 132kV), there is also predicted to be a peak of around 45mG near the southern end of this boundary, due to the 11kV temporary cables.

The following observations are made with regard to the forecast magnetic field contribution from the proposed ZS:

- Within the substation, the highest magnetic fields, which appear to be strongly influenced by the transformer connections, are expected to be in excess of 1000mG⁶ but would reduce to less than 100mG within 5 metres of the connections.
- The fields across the bulk of the remainder of the substation itself would be less than 50 mG, except for the areas in proximity to the transformer connections and those areas directly above or beside underground cables or cable risers.
- Upon commissioning, the substation's contribution to the external magnetic fields would be less than 10mG for approximately half the length of its boundaries, with much of the remainder being less than 30mG. There would also be a number of localised peaks ranging up to 120mG.
- In the ultimate condition, the substation's contribution to the external magnetic fields would be less than 20mG for approximately half the length of its boundaries, with much of the remainder being less than 60mG. There would also be a number of peaks ranging up to 130mG.

⁶ The relevant occupational exposure limit, which applies within the substation, is 5000mG.

- 
- The highest magnetic field levels at and beyond the substation boundary are predicted to occur along the western boundaries. The peaks along the western boundary, near each of the transformer connections, were calculated at approximately 120mG under the initial condition and 130mG at the ultimate loading condition.

3.2.2 Properties and Proposed Developments in the Vicinity of New Substation

It is understood that approval has been granted for a new development at 144-150 Walker Street, a short distance north of the proposed ZS. Our modelling indicates that the dominant influence on the magnetic field environment of this site will be the incoming 132kV cables which are not part of this project and will be subject to their own assessment. The substation itself will have little contribution and its influence on this property is not further assessed.

Part of the property at 142 Walker Street backs onto the eastern boundary of the proposed ZS near the north-eastern corner. Our modelling indicates that the magnetic field environment of this site will also be influenced by the incoming 132kV cables, both in Harnett Street and within the substation. Under the ultimate loading condition, the magnetic field will be approximately 12 mG at the property boundary and a few mG at the building.

Also, as noted in Section 1.1, approval has been granted for a 22 storey mixed use commercial and residential development at 136 – 140 Walker Street to the east of the proposed ZS. An elevation of the proposed development is shown in Figure 3.17.

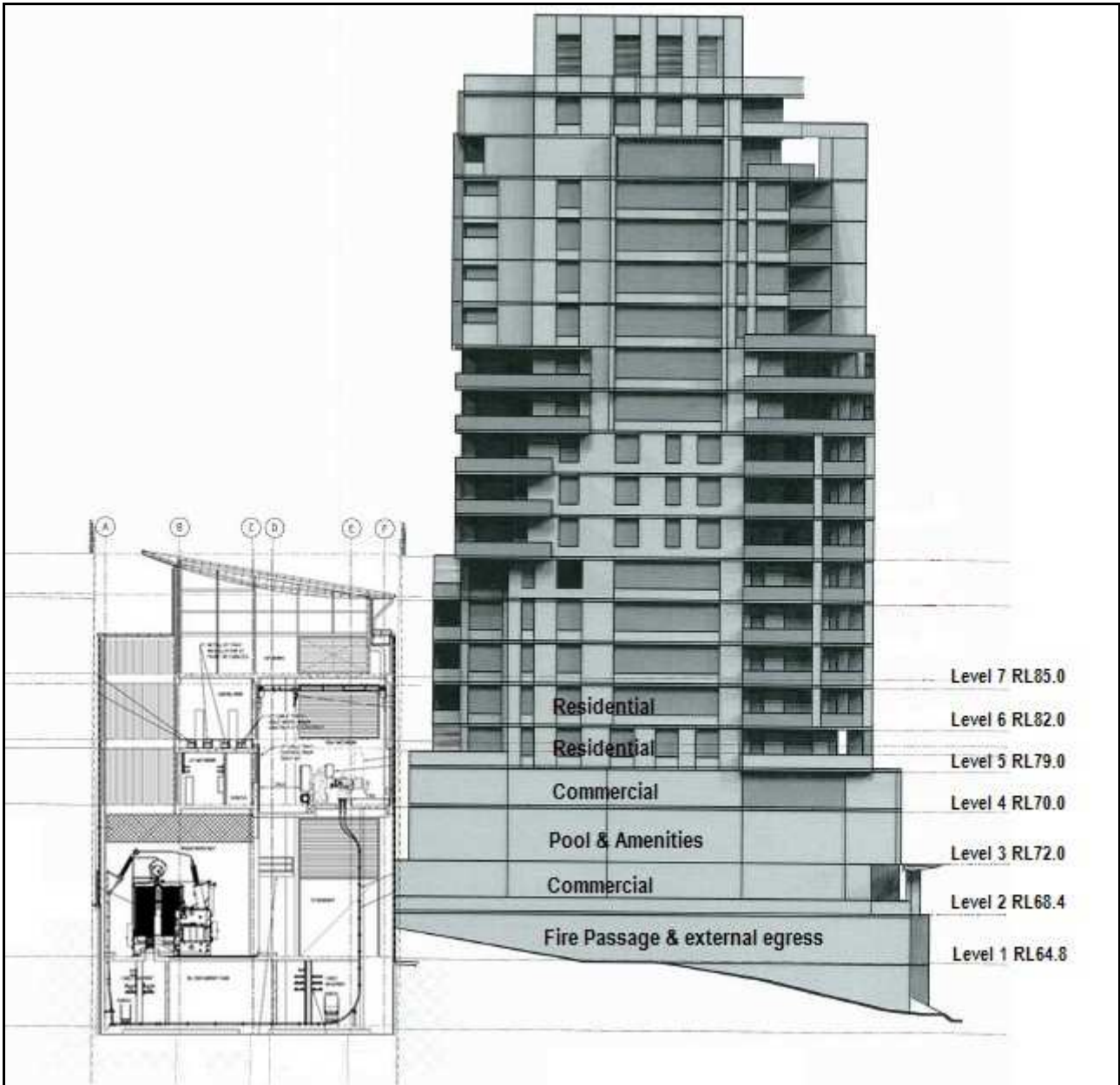


Figure 3.17 – Mixed use Commercial/Residential Development

Magnetic field profiles along the external surfaces of the western walls of the proposed mixed use development have been calculated as follows:

- One metre above floor level on Level 2 (Commercial), (Figure 3.18);
- One metre above floor level on Level 3 (Pool and Amenities), (Figure 3.19);
- One metre above floor level on Level 4 (Commercial) (Figure 3.20);and
- One metre above floor level on Level 5 (Residential). (Figure 3.21).

Profiles have not been calculated for the residential levels above level 5 as the magnetic field would be lower than that on Level 5.

To give an indication of the rate at which the magnetic fields are predicted to decrease inside the proposed development at 136 – 140 Walker Street, we have also calculated profiles at right angles from the eastern boundary of the ZS at the points corresponding to the highest fields at each level.

The expected contribution of the proposed ZS to the magnetic field levels at and beyond the outer western wall of the proposed mixed use development are shown in Figures 3.18 to 3.21. In each of these figures, the right hand plot shows the decrease in the magnetic field with increasing distance inside the mixed use development from the peak on the western wall shown in the left hand plot. Note that the magnetic field levels have been calculated at 1m above the RLs shown in Figure 3.17.

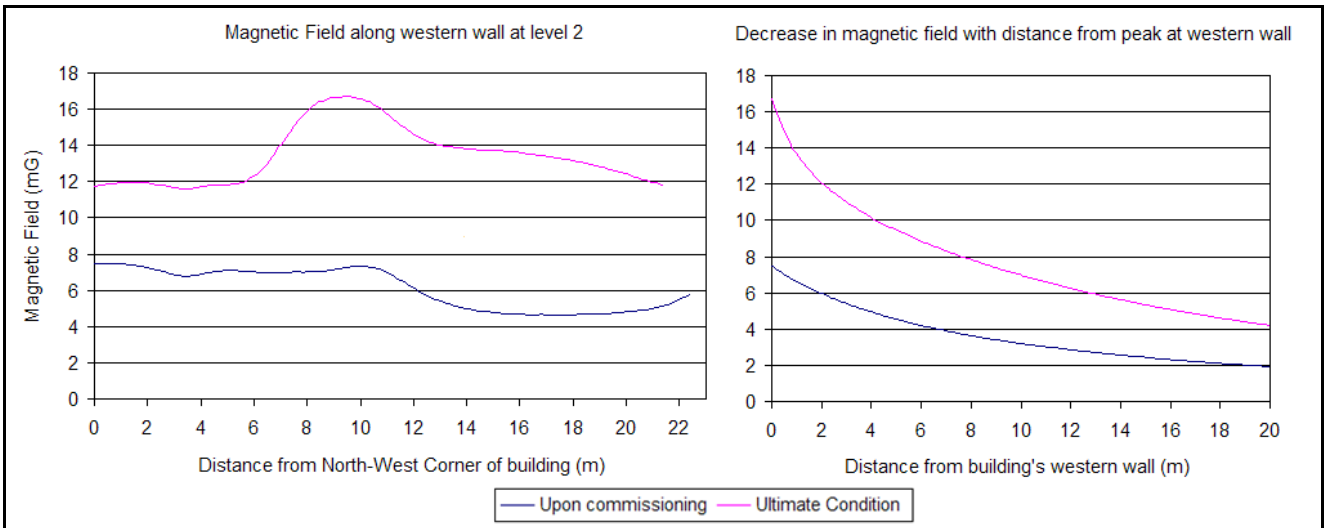


Figure 3.18 – Magnetic Field contribution at Level 2 of the proposed mixed use development (Commercial)

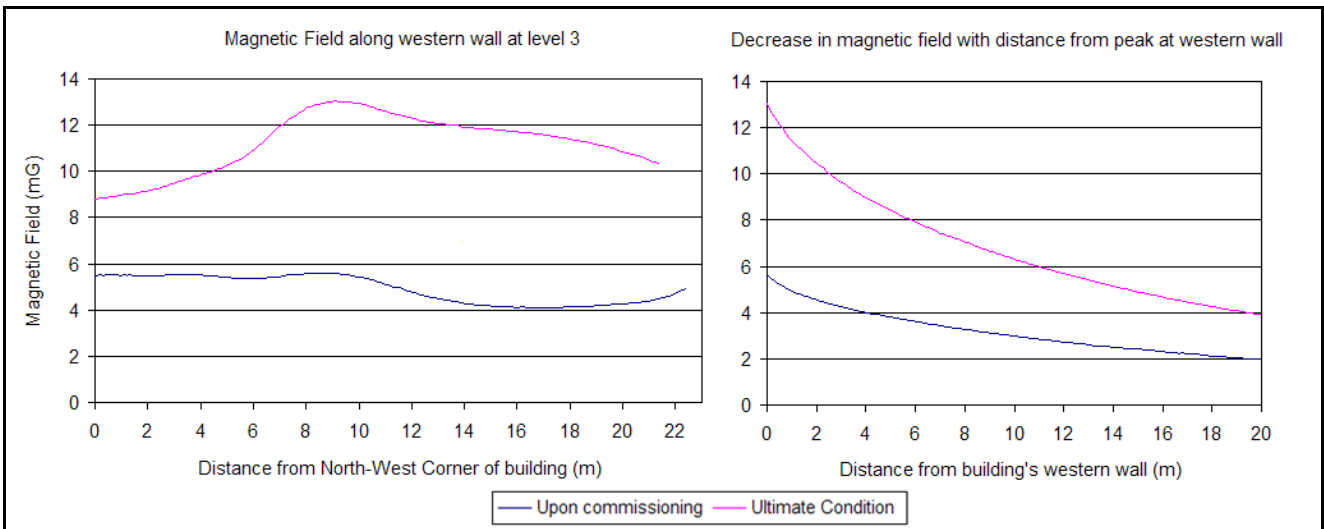


Figure 3.19 – Magnetic Field contribution at Level 3 of the proposed mixed use development (Pool & Amenities)

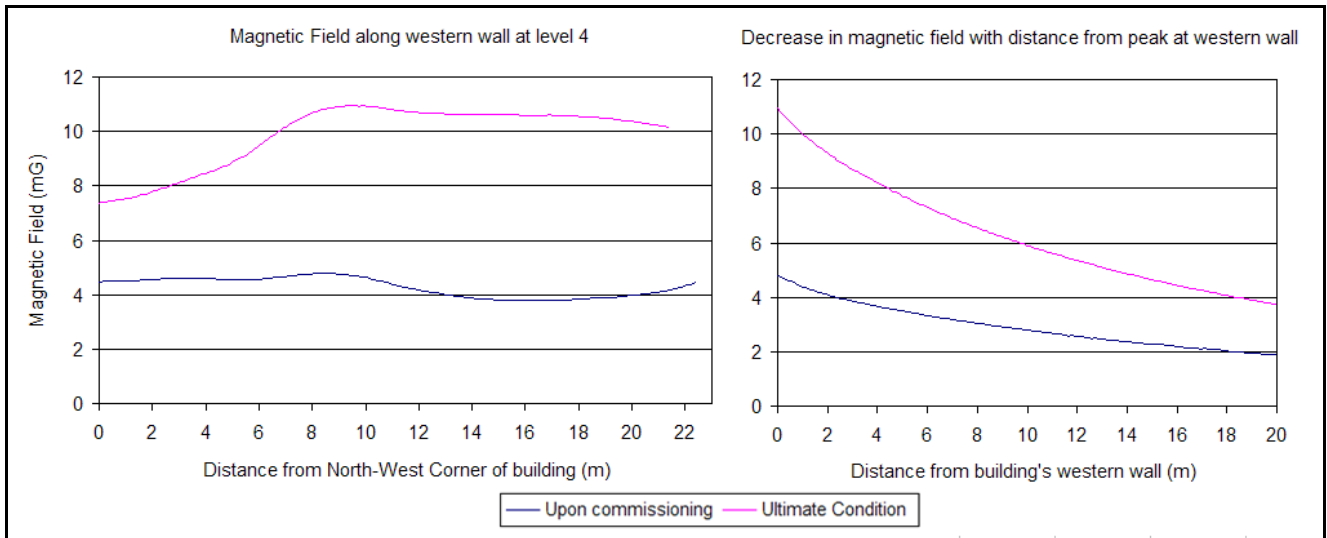


Figure 3.20 – Magnetic Field contribution at Level 4 of the proposed mixed use development (Commercial)

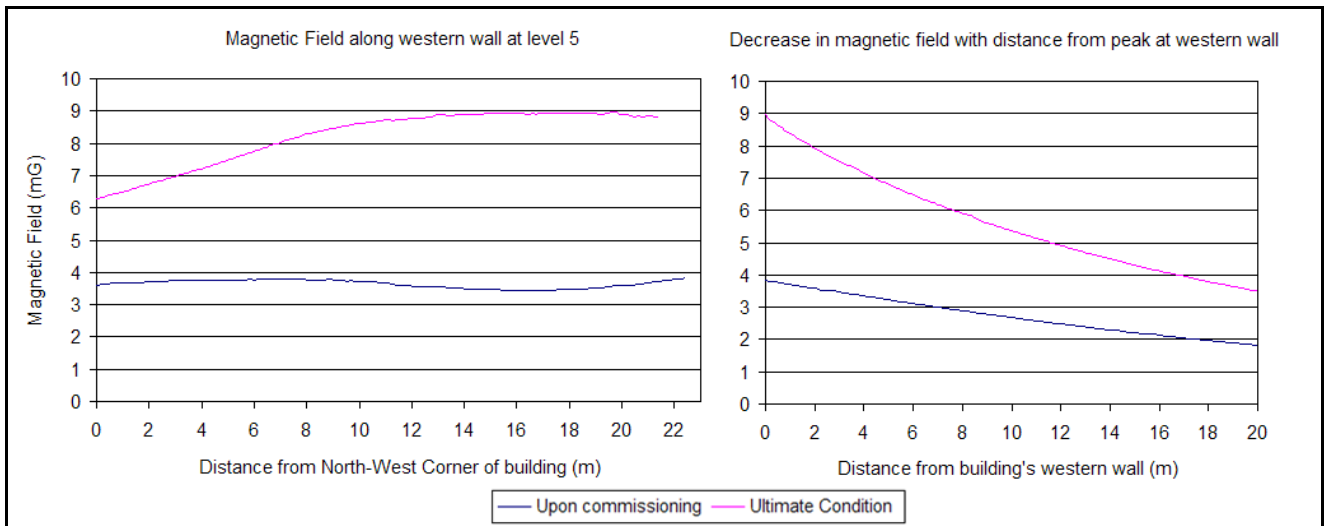


Figure 3.21 – Magnetic Field contribution at Level 5 of the proposed mixed use development (Residential)

The following observations are made with regard to the forecast magnetic field contribution from the proposed ZS to the magnetic fields at and beyond the western wall of the proposed mixed use development at 136-140 Walker Street:

- The highest magnetic fields in the mixed use development are predicted to occur at level 2 (commercial use). At this level, along the outer western wall of this building the magnetic fields are predicted to be in the range of 4mG to 8mG under the initial condition and between 11mG and 17mG under the ultimate loading condition.
- The contribution of the ZS to the magnetic fields at the residential levels is predicted to be highest at level 5. At 1m above this level, the magnetic fields are predicted to be in the range of 3mG to 4mG under the initial condition and between 6mG and 9mG under the ultimate loading condition.
- The contribution of the ZS to the magnetic fields beyond the outer western wall of the mixed use development would reduce with distance from the wall. At 10m from the western wall the peak magnetic field is predicted to be 3mG under the initial condition and 7mG under the ultimate loading condition.

3.2.3 Proposed 11kV Cable Vault

The magnetic fields predicted to be associated with the 11kV cable vault to be constructed below Ward Street have been calculated using the same software as for the substation. A screenshot in 3D view showing the CDEGS model of the proposed 11kV cable vault is shown in Figure 3.22 below.

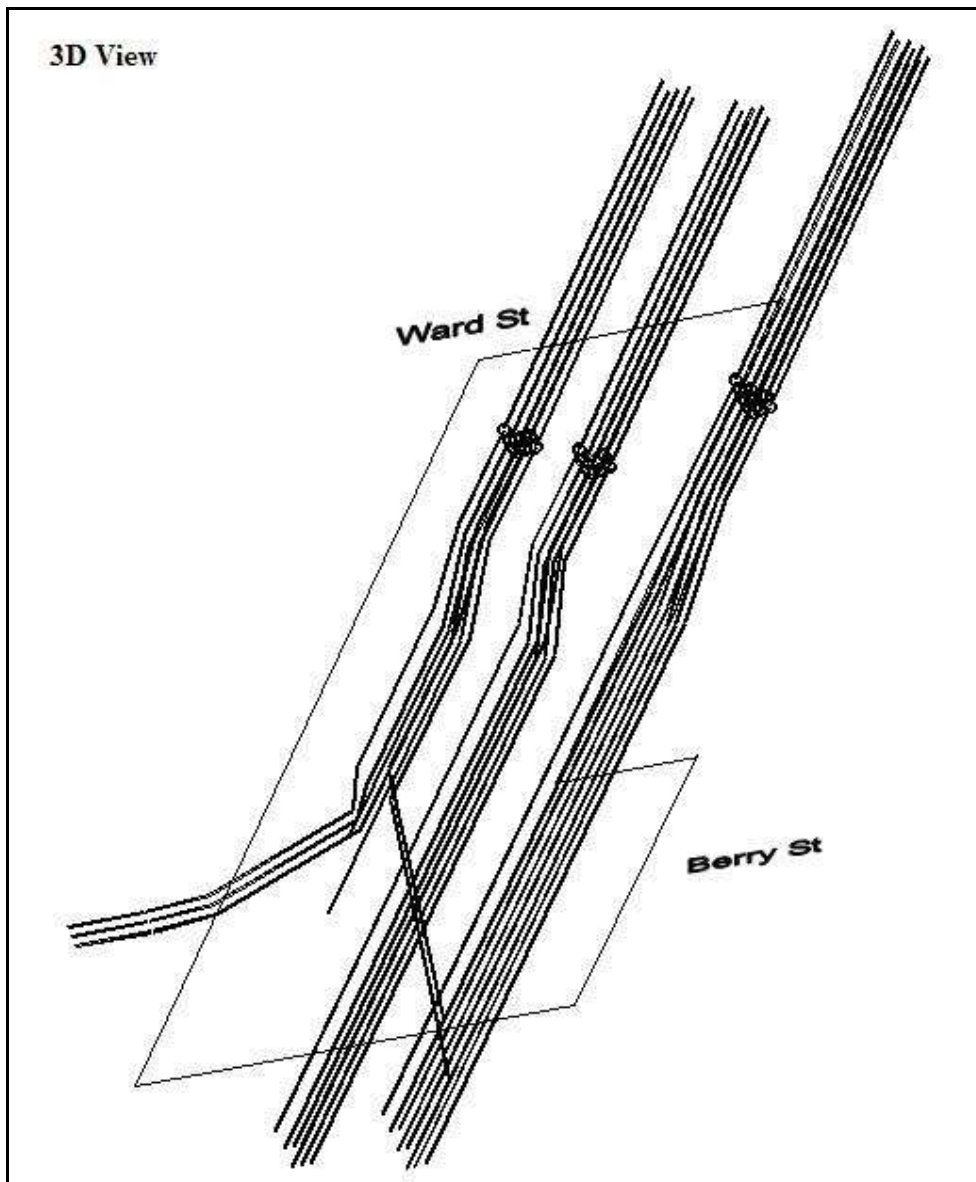


Figure 3.22 – CDEGS model of the proposed 11kV cable vault

The results obtained from the magnetic field modelling are shown below in the form of surface contour plots, both shortly after commissioning and under the ultimate loading condition as shown in Figure 3.23 below. These contour plots were calculated at 1m above Ward Street around the cable vault.

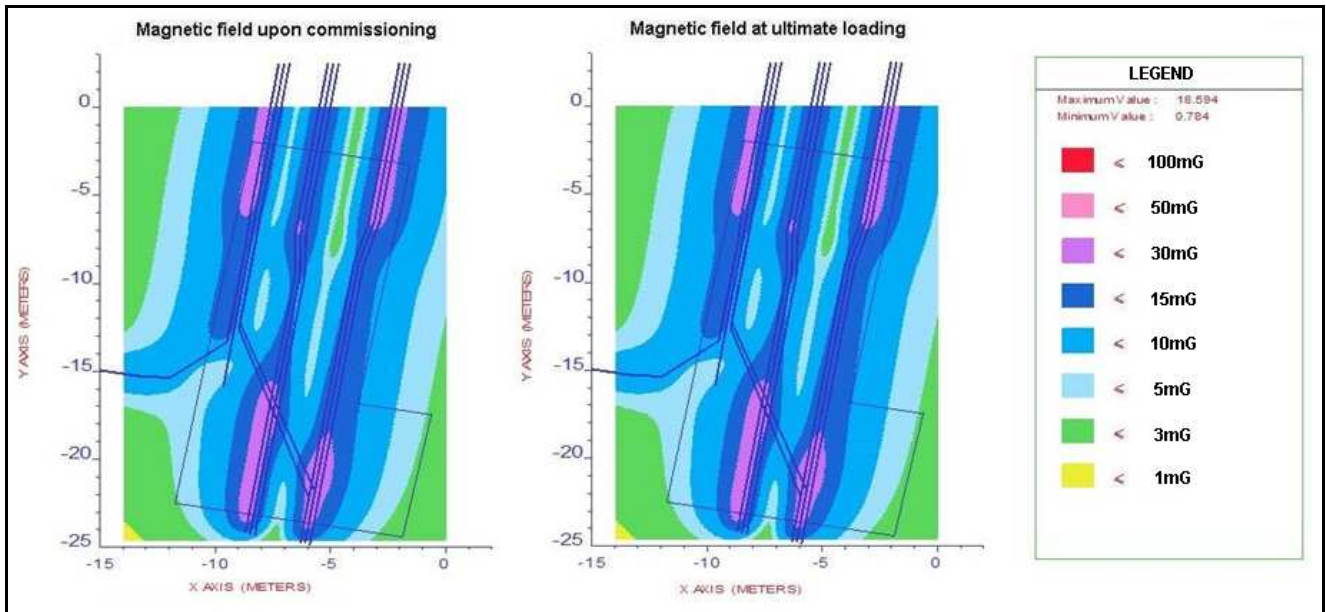


Figure 3.23 – Magnetic Field contribution from the proposed 11kV cable vault

It can be seen from the above figure that the magnetic fields at 1m above ground level, in the vicinity of the proposed cable vault, are largely comparable under both modelled loading conditions. The peak magnetic field directly above the feeders is predicted to be approximately 18mG under the initial loading condition and 19mG at the ultimate loading condition. The magnetic fields are expected to reduce to less than 10mG at a distance of 2m from the underground cables and less than 5mG at a distance of 5m.

3.3 Electric fields

As most of the electrical equipment associated with the substation would be of the indoor variety, it would produce little or no electric field external to the equipment enclosure. It is understood that the only unenclosed high voltage connections within the substation would be short sections within the transformer enclosures. These enclosures would only be accessible to authorised persons. On this basis, the electric fields in these areas, directly under the connections, based on typical equipment characteristics, have been estimated to be within the relevant occupational limits.

No major source of electric field is expected beyond the substation boundary as all of the incoming and outgoing feeders are to be underground.

3.4 Magnetic fields experienced intermittently

As shown in section 3.2 there would be localised areas of higher magnetic field levels outside the substation boundary in the vicinity of the transformers and the underground feeders, and above the cable vault. In considering these localised higher fields, it is important to recognise that these intermittent fields, which may be experienced for short periods of time in the vicinity of the ZS boundary, are of a similar category to those we experience in everyday life. To put this into perspective, the Energy Networks Association (Ref 11) has published a series of typical magnetic field levels associated with particular appliances at normal user distance. These are set out in Table 2 below:

Appliances	Typical Measurement (mG)	Range of Measurements (mG)
Stove	6	2-30
Computer	5	2-20
TV	1	0.2-2
Electric Blanket	20	5-30
Hair Dryer	25	10-70
Refrigerator	2	2-5
Toaster	3	2-10
Kettle	3	2-10
Fan	1	0.2-2

Table 2: Magnetic Field Levels Associated with Appliances

From the above range of fields, it can be seen that the fields along the majority of the boundaries of the substation would be within the range normally encountered in everyday life. In places along Ward Street, the highest calculated fields are predicted to be higher than this range, but are still less than 15% of the relevant health limit.

4. Compliance with EMF Standards and Prudent Avoidance / Precautionary Principles

4.1 Compliance with Health Standards

In addressing Energy2U Alliance's brief, we have interpreted compliance with health standards as relating to the general public rather than to the occupational exposures. Occupational exposures are subject to different (higher) limits than general public exposure and are influenced by work practices etc, as well as the design and operation of equipment. While not addressing occupational limits, we have no reason to expect that EnergyAustralia would not comply with them in operating the substation.

As noted in Section 3.2.1, following commissioning, the predicted magnetic field contribution of the proposed substation at its boundary, at 1m above the adjacent street level, is expected to be generally less than 20mG upon commissioning and less than 30mG under ultimate loading conditions. There are however predicted to be 3 wide peaks along the western boundary in Ward Street, adjacent to the transformer connections. These peaks were calculated to be up to 120 mG upon commissioning and 130 mG under ultimate loading conditions. Even at the highest predicted level, these fields are less than 15% of the relevant health guideline (Reference Level) for the general public. Nevertheless, these peak magnetic field levels are a little higher than those normally encountered in everyday life.

4.2 Dependence on Load

During a typical day, the loading on a substation will vary substantially between a daily minimum, generally in the early hours of the morning and a daily maximum at times of peak demand. Loadings also vary seasonally during the year, generally reaching a peak in summer or winter. Finally, due to general load growth, the loadings on substations tend to grow over time until the substation's "ultimate capacity" is reached. For this reason, if they occur at all, the loadings corresponding to the maximum capacity of a substation are only likely to occur for relatively short periods, a few times over its service life.


4.3 Assessment against Prudent Avoidance Principles

As noted in Section 1.7, given the inconclusive nature of the science, it is considered that a prudent avoidance approach continues to be the most appropriate response in the circumstances. Under this approach, subject to modest cost and reasonable convenience, power utilities should design their facilities to reduce the intensity of the fields they generate, and locate them to minimise the fields that people, especially children, encounter over prolonged periods, provided this can be readily achieved without undue inconvenience and at reasonable expense, and be consistent with good engineering and risk minimisation practice.

It is understood that, along with other members of ENA, EnergyAustralia has adopted the policy of prudent avoidance and is applying it to this project. In this context, Energy2U Alliance, in accordance with EnergyAustralia's policy of prudent avoidance, advises that it has:

- Openly shared information regarding the EMF/health issue and the proposed facility.
- Incorporated compact, indoor switchgear into the design, resulting in reduced magnetic fields when compared with a larger but less expensive outdoor facility.
- Reviewed the location of the 132kV cable risers and made design modifications resulting in a significant reduction in the magnetic fields at the eastern boundary.
- Reviewed the location of the 11kV temporary cables (routed from the existing ZS and in operation until the all of the 132kV feeders are fully commissioned) and made design modifications resulting in a significant reduction in the magnetic fields at the southern end of the eastern boundary.
- Reviewed the orientation of the transformers with a view to further reducing the EMF levels along the western boundary near the transformer connections. Following detailed review, the selected orientation was judged to represent the most practicable option, having regard to its impact on the positioning of other EMF sources and various space constraints.

It is also worth noting that, supplying the substation at 132kV would result in lower magnetic fields than if the same load was supplied at 33kV, as is the case for the existing substation.




Nevertheless, due to the influence of the transformer connections at the western boundary, the fields along parts of this boundary are predicted to be higher than those normally encountered in everyday life.

Given the above, the design of the proposed works is considered consistent with the principles of prudent avoidance. In this regard, it is relevant to note that the highest predicted fields at the boundaries of the proposed substation are considerably less than those measured at the boundaries of the existing substation.

5. Conclusions

The design and layout of the proposed North Sydney ZS has been reviewed and modelled to calculate the predicted electric and magnetic fields associated with the ZS under initial and ultimate loading conditions. These predicted calculations have been assessed against the relevant health guidelines and the principles of prudent avoidance. In summary, our findings are:

- Overall, the contribution of the proposed ZS to the magnetic field levels along its boundaries, at 1m above the relative levels of both Harnett and Ward Street, is predicted to be generally less than 20mG under the initial loading condition and 30mG under the ultimate loading condition, with the exception of peaks in vicinity of the transformer connections along the western boundary and near the 11kV temporary cables (in operation until the proposed ZS has been fully commissioned at 132kV) toward the southern end of the eastern boundary. There is also predicted to be a localised peak along the eastern boundary, near the eastern cable riser, of up to 35mG under the initial condition and 41mG under the ultimate loading condition.
- The highest peaks at or beyond the boundary of the proposed substation are predicted to be up to 120mG initially and 130mG under the ultimate loading condition, but will drop off rapidly with distance. It is noted that while these peaks, which are along the western boundary, may be higher than those normally encountered in everyday life, the peak magnetic field measured at the boundary of the existing ZS (240 mG) was approximately double this figure. Further, had the measurements been undertaken in summer, the measured fields would have been considerably higher.
- The contribution of the proposed ZS to the magnetic field levels at its northern boundary, at 1m above Harnett Street level, is predicted to be in the range of 7 – 20 mG upon commissioning and 11 – 32 mG under ultimate conditions. The peaks along the northern boundary are due to the underground 132kV feeders crossing this boundary.
- The contribution of the proposed ZS to the magnetic field levels along its western boundary, at 1m above Ward Street level, is predicted to generally be in the range of 20 – 70 mG, with two substantial peaks of up to 120 mG upon commissioning and three peaks of up to 130 mG under ultimate loading conditions. The peaks along the western boundary appear to be primarily due to the transformer connections.
- The contribution of the proposed ZS to the magnetic field levels along its southern boundary, at 1m above Ward Street level, is predicted to be in the range of 5 - 17 mG under the ultimate loading condition. Under the initial condition, the southern boundary will not be accessible to the general public. Under the ultimate condition, when the existing substation would be fully decommissioned, the magnetic field is highest on the western side, decreasing progressively along the boundary toward the eastern side. The higher magnetic fields along the western side of the boundary appear to be due to the transformer connections.
- The contribution of the proposed ZS to the magnetic field levels along its eastern boundary is predicted to be generally less than 10 mG under the initial condition and less than 15 mG at the ultimate loading condition. There is predicted to be a localised peak near the eastern cable riser of up to 35mG under the initial condition and 41mG at the ultimate loading condition. For the initial condition only (prior to the full commissioning of the ZS at 132kV), there is also predicted to be a peak of around 45mG near the southern end of this boundary, due to the 11kV temporary cables.
- The contribution of the proposed ZS to the magnetic fields in the adjacent proposed mixed use development at 136 – 140 Walker Street are predicted to be the highest at level 2 (commercial use). At this level, along the outer western wall of the proposed building, the magnetic fields are predicted to be in the range of 4mG to 8mG under the initial condition and between 11mG and 17mG under the ultimate loading condition.
- The contribution of the ZS to the magnetic fields at the residential levels in the adjacent proposed mixed use development is predicted to the highest at level 5. At 1m above this level, the magnetic fields are predicted to be in the range of 3mG to 4mG under the initial condition and between 6mG and 9mG under the ultimate loading condition. These levels would decrease further inside the building.
- The predicted magnetic fields at and beyond the proposed ZS boundaries are less than 15% of the relevant health guideline.
- The electric fields at the proposed ZS boundaries will be negligible.

- 
- The major contributors to the magnetic fields at the ZS boundaries have been identified by computer modelling and it is noted that Energy2U Alliance has incorporated a number of design features that are consistent with the principles of prudent avoidance.

6. References

1. World Health Organisation: Environmental Health Criteria Vol. 238: Extremely low frequency fields. (2007).
2. World Health Organisation, International Agency for Research on Cancer, Lyon, France: IARC Monographs on the evaluation of carcinogenic risks to humans. Non-ionising Radiation, part 1: Static and extremely low frequency (elf) electric and magnetic fields. (2001).
3. National Radiological Protection Board, (UK), ELF Electromagnetic Fields and the Risk of Cancer, Report of an Advisory Group on Non-ionising Radiation, Chairman, Sir Richard Dell, NRPB Vol 12 No.1, 179 pages, 2001.
4. National Health and Medical Research Council: Radiation Health Series No. 30: Interim Guidelines on Limits of Exposure to 50/60 Hz Electrical and Magnetic Fields (1989)
5. ARPANSA: Exposure Limits for Electric & Magnetic Fields – 0 Hz to 3 kHz. Public Consultation Draft. 7 December 2006.
6. International Commission on Non-Ionising Radiation Protection (1998): Guidelines for limiting exposure to time-varying electric, magnetic and electromagnetic fields (up to 300GHz): Health Physics, April 1999, Volume 74, Number 4; pp 4494-5528
7. Gibbs, Sir Harry, Chairman, *Inquiry into Community Needs and High Voltage Transmission Line Development*, Submission to the NSW Government, February, 1991.
8. Peach HG, Bonwick WJ and Wyse T (1992). Report of the Panel on Electromagnetic Fields and Health to the Victorian Government (Peach Panel Report). Melbourne, Victoria: September, 1992.
9. National Institute of Environmental Health Sciences, National Institutes of Health, (USA), NIEHS report on health effects from exposure to power-line frequency electric and magnetic fields, NIH Publication No. 99-4493, 1999.
10. Safe Engineering Services & Technologies Ltd (SES): CDEGS Software Validation
<http://www.sestech.com/products/softwarevalidation.htm>
11. Electric and Magnetic Fields: What we know: Energy Networks Association, June 2006.



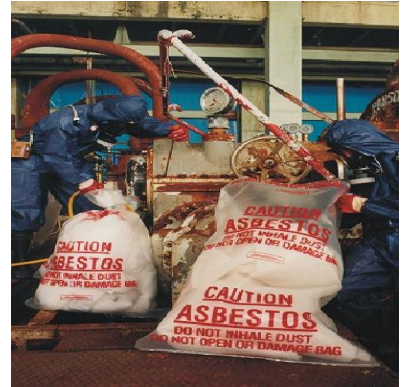
APPENDIX I

Hazardous Material Survey Report



Prepared for:

Energy2U Alliance
C/- AECOM Australia Pty Ltd
Level 11, 44 Market Street
Sydney NSW 2000



Hazardous Materials Survey Report

North Sydney Zone Substation, Berry
Street, North Sydney NSW

Final

AECOM

25 November 2009

Document No: S4139701_Finalrpt_25Nov09.doc

DISTRIBUTION

**Hazardous Materials Survey Report,
EnergyAustralia Zone Substation,
Berry Street, North Sydney NSW.**

25 November 2009

Copies	Recipient	Copies	Recipient
2	Louis Naidoo Associate Director Power & Energy AECOM Australia Pty Ltd Level 11, 44 Market Street Sydney NSW 2000	1	AECOM (Library)


© AECOM Australia Pty Ltd (AECOM)

- * This document was prepared for the sole use of the party identified on the cover sheet, and that party is the only intended beneficiary of the work of AECOM.
- * No other party should use or rely on the document without the prior written consent of AECOM, and AECOM undertakes no duty to, nor accepts any responsibility to, any third party who may use or rely upon this document.
- * Any advice or opinions contained in this document should only be read in the context of the document as a whole, are subject to any stated limitations and any assumptions that AECOM is entitled to make in accordance with sound professional principles, and are considered current as at the date of this document.
- * All rights reserved. No section or element of this document may be removed from this document, extracted, reproduced, electronically stored or transmitted in any form without the prior written permission of AECOM.

By

AECOM Australia Pty Ltd (AECOM)

ABN: 20 093 846 925
Level 5, 828 Pacific Highway,
GORDON NSW 2072



Rohan James
Project OHS Technician

Technical Peer Reviewer:	Date:
	25.11.09
Tim Kulmar Professional EHS Consultant	

Contents

1.0	INTRODUCTION.....	1
2.0	SITE DESCRIPTION.....	2
3.0	NATURE AND EXTENT OF SURVEY	3
3.1	General	3
3.2	Asbestos-Containing Materials.....	3
3.3	Synthetic Mineral Fibre	4
3.4	Polychlorinated Biphenyls	4
3.5	Lead Based Paint	4
3.6	Inaccessible Areas.....	4
4.0	LIMITATIONS	6
5.0	RESULTS	7
6.0	RECOMMENDATIONS	8
6.1	Asbestos-Containing Materials.....	8
6.2	Synthetic Mineral Fibre	9
6.3	Polychlorinated Biphenyls	10
6.4	Lead Based Paint	10

Plates

List of Appendices

Appendix A Hazardous Materials/Asbestos Register
 Appendix B Asbestos Risk Assessment Methodology
 Appendix C Laboratory Analysis Results

1.0 Introduction

AECOM Australia Pty Ltd (AECOM) was commissioned by the Energy2U Alliance to conduct a hazardous materials survey of EnergyAustralia Zone Substation (the Site) located at 70 Berry Street, North Sydney NSW. The survey was completed on 29 October 2009.

The purpose of the survey, which is required to be undertaken prior to any demolition or refurbishment works, is to assist the Energy2U Alliance in meeting their obligations under the *NSW Occupational Health & Safety Regulation 2001*. The objective of the survey was to identify the location and condition of visually accessible asbestos-containing and other hazardous construction materials present throughout the area(s) of investigation.

For the purpose of this report, hazardous construction materials are asbestos-containing materials (ACM), synthetic mineral fibre (SMF), lead based paint and polychlorinated biphenyls (PCB) within fluorescent light capacitors.

Details of the asbestos-containing materials and other hazardous materials identified in this survey have been compiled in **Appendix A**. A description of the asbestos risk assessment and rating methodology is provided in **Appendix B** of this report.

The Energy2U Alliance is advised that the Hazardous Materials/Asbestos Register is not a definitive description of all asbestos/hazardous materials present in the area(s) of investigation.

THIS REPORT SHOULD BE READ IN ITS ENTIRETY.

2.0 Site Description

The Site contains a primary building, located on the western boundary of the Site, four (4) transformers adjacent to the eastern boundary and one transformer in the north-west corner of the Site. Vehicle access is via a driveway through the middle of the Site. The primary building is generally constructed of concrete and brick and consists of two (2) levels and a basement divided into two (2) cable rooms. External ground surfaces are concrete.

For the purpose of this report, Berry Street is taken to be oriented east-west adjacent to the Site.

3.0 Nature and Extent of Survey

3.1 General

The purpose of the survey was to locate, identify and document visually accessible hazardous materials including asbestos-containing materials (ACM), lead based paint, polychlorinated biphenyls (PCB) and synthetic mineral fibre (SMF) materials.

The scope of work covered by the hazardous materials survey included the following:

- 1 A review was undertaken of the existing building plans, where provided.
- 2 A visual inspection was undertaken of the internal and external construction materials and components within the area(s) of investigation, to identify and locate visible above ground, accessible hazardous materials.

The survey was undertaken by visual / “non-destructive” means only unless stated otherwise. Any areas which were inaccessible during the survey are documented in **Section 3.6**

- 3 Materials suspected of containing asbestos were sampled. Samples of suspected ACM were forwarded to a National Association of Testing Authorities, Australia (NATA) accredited laboratory for analysis and issue of NATA endorsed reports.

Samples were collected from discrete locations without damaging the integrity of the material. Samples were not taken from live electrical areas or from within air plenums such as air conditioning fan rooms whilst plant was operating. Samples of internal duct insulation around electric heating elements were generally not able to be taken. Comment regarding inaccessible materials is provided in **Section 3.6**

AECOM did not access high level areas (above the reach of a step ladder). High level areas may be presumed to contain asbestos or other hazardous materials based on the surveyor’s visual assessment and experience.

- 4 SMF materials were identified visually or as a result of asbestos identification analysis.
- 5 Representative painted surfaces were tested for the presence of lead using Lead Check swabs which provide an indication of whether the paint contains lead.
- 6 Representative fluorescent light fittings were visually inspected to assess the presence of capacitors that may contain PCB.
- 7 Suspected hazardous materials were photographed where possible.
- 8 A report was prepared, detailing the location, condition and type of hazardous materials detected. The areas not accessible due to access restrictions are detailed in **Section 3.6**

3.2 Asbestos-Containing Materials

Where samples of materials suspected of containing asbestos were identified, these were collected and sent for analysis to a NATA registered laboratory. The samples were examined using a stereo microscope and selected fibres were further examined using polarised light microscopy supplemented with dispersion staining.

Further analysis by x-ray diffraction was performed on resinous samples (and other samples as determined by the laboratory) as an added means of determining the presence of asbestos. X-ray diffraction detects crystalline substances and minerals (including asbestos-forming minerals). Non-crystalline substances (e.g. glass, most organic compounds) are not detectable by this technique.

The NATA endorsed asbestos identification reports are contained in **Appendix C**.

Sampling is not always possible due to a number of factors, which might include a lack of accessibility, the possibility of damaging finishes or the risk of causing asbestos contamination.

Where sampling was not possible, a determination was reasonably made as to the presence or absence of asbestos. This determination was based on factors such as the age, physical appearance or fixing method (nail and screw heads, cover strips or cover battens). Additionally, a determination might be made by inference from the sample analysis results of similar materials sampled during the survey.

3.3 Synthetic Mineral Fibre

Materials containing SMF were primarily identified by visual means and/or as a result of fibre identification analysis.

3.4 Polychlorinated Biphenyls

The location of suspected PCB-containing capacitors is generally determined by inspecting representative light fittings throughout the survey area and noting and recording details printed externally on the capacitor. Capacitor details are then cross-referenced against *Identification of PCB Containing Capacitors* published by the Australian and New Zealand Environment and Conservation Council (ANZECC) in 1997.

Since a qualified electrician was not provided to isolate the light fittings prior to our inspection, it was not possible to confirm capacitor identification details. Therefore an assessment of the likely presence/absence of PCBs was made based on apparent age of the light fittings and our experience with other similar sites.

3.5 Lead Based Paint

Identification of lead based paints was conducted in accordance with *Appendix 1 – Standard Practice for Identification of Lead Paint* taken from *AS4361.2 – 1998 Guide to Lead Paint Management – Part 2: Residential and Commercial Buildings*.

Suspected lead based paint was assessed using lead indicator test kits upon accessible and representative painted surfaces within the Site. Lead indicator test kits use a colorimetric method to determine the presence of lead within painted surfaces. Painted surfaces were scored or roughened to expose underlying layers of paint. Lead indicator kits were then rubbed across all exposed surface layers to determine the presence of lead in paintwork.

Lead indicator test kits returning positive results were disposed of and not reused on alternative surfaces to determine lead content of paintwork.

3.6 Inaccessible Areas

No access was available to the following areas at the time of inspection:

- The external roof areas; and
- The South East Plant Room located adjacent to the main entry driveway.

For the purposes of risk management it is recommended that areas where access was not possible should also be presumed to potentially contain hazardous materials/asbestos until proven otherwise.

4.0 Limitations

The survey was undertaken by visual inspection using non-destructive means only. Only those area(s) of investigation at the Site that were accessible to AECOM at the time of our inspection are covered in this report. Therefore, AECOM cannot guarantee that each and every hazardous material that exists within the area(s) of investigation has been located, identified and documented.

AECOM prepared this report for the purpose set out in **Section 1.0**. It is not appropriate for this report to be relied upon or used for any other purpose. It is also not appropriate for this report to be released to any other party (either in whole or in part) without AECOM's prior written consent.

If this report is used for a purpose for which it was not prepared, AECOM and its officers, agents and employees accept no responsibility or liability for any outcome of the report's use.

This report should only be read in the context of the document as a whole and is subject to any stated limitations and any assumptions that AECOM is entitled to make in accordance with sound professional principles. It is considered current as at the date of this document.

AECOM has relied upon information identified in this report and have assumed this information to be both adequate and accurate for the purpose of preparing this report for you. AECOM has not, therefore, verified or audited any of the information you, or others, have supplied to us. If there is further information that becomes available, AECOM may need to amend the information contained in this report and AECOM reserves its right to do so should this become necessary.

In addition, this report does not, and does not purport to, give legal advice as to your actual or potential asbestos or hazardous material liabilities, or draw conclusions as to whether any particular circumstances constitute a breach of relevant legislation. You will appreciate that this advice can only be given by qualified legal practitioners.

Finally, AECOM does not make any other warranty, expressed or implied, as to the professional advice contained in this report.

5.0 Results

Details of the hazardous materials identified in this survey are presented in **Appendix A**.

The methodology used in deriving risk ratings for the asbestos risk assessment is provided in **Appendix B** of this report.

The laboratory analysis report is presented in **Appendix C**.

Where possible, a photographic record of hazardous material identified was taken and is presented in the **Plates** section of this report.

The Energy2U Alliance is advised that the Hazardous Materials/Asbestos Register is not a definitive description of all hazardous materials present in the area(s) of investigation.

6.0 Recommendations

Where hazardous materials have been identified, appropriate risk management should be implemented to ensure that the risks are adequately controlled.

Risk management of hazardous materials identified may range from their complete removal to periodical inspection and review of the risks posed by materials left *in situ*.

A summary recommendation relating to the management of each hazardous material identified in this survey is provided in **Appendix A**. The sections below provide further general guidance on appropriate risk management measures. These recommendations are not intended to provide definitive advice or recommendations as to any obligations that arise, or measures that should be taken, as a result of any identified hazardous materials.

6.1 Asbestos-Containing Materials

Friable asbestos is defined within *NSW Occupational Health and Safety Regulation 2001* as:

'... any material that contains asbestos and is in the form of a powder or can be crumbled, pulverised or reduced to powder by hand pressure when dry.'

Bonded asbestos is defined within *NSW Occupational Health and Safety Regulation 2001* as:

'... any material (other than friable asbestos material) that contains asbestos.'

Friable asbestos materials were identified and/or presumed present during the survey as outlined in **Appendix A**.

According to Clause 260 of the *NSW Occupational Health and Safety Regulation 2001*, an employer must restrict access to friable asbestos materials and construction work processes involving friable asbestos material.

All friable asbestos removal work must be undertaken by an AS-1 licensed Asbestos Removal Contractor.

Bonded asbestos materials were identified and/or presumed present during the survey as outlined in **Appendix A**.

Bonded asbestos materials in an intact condition may remain in place provided that they are not disturbed (e.g. sawn, drilled, abraded, or the like). As a precaution, any minor penetrations or damaged edges should be sealed with a suitable sealant material.

Any bonded asbestos materials that become damaged should be repaired and/or replaced with a non-asbestos alternative as soon as possible.

All bonded asbestos work should be undertaken by an AS1 or AS2 licensed Asbestos Removal Contractor. From 1 January 2008 an AS1 or AS2 licence is required for the removal of 10 m² or more of bonded asbestos.

Where practical, the ACM should be labelled to warn of the presence of asbestos in accordance with the *Code of Practice for the Safe Removal of Asbestos 2nd Edition* [NOHSC: 2002 (2005)].

The ACM should also be reinspected on a regular basis or as determined by legislation by a competent person and any change to their condition reported.

An asbestos management plan should be developed and implemented to fulfil the requirements of *NSW Occupational Health & Safety Regulation 2001*, NOHSC asbestos codes of practice, and to help ensure that the risk of human exposure and environmental contamination is maintained at an acceptable level.

If construction, demolition, alteration or maintenance works and the like are likely to disturb the ACM then the ACM should be removed prior to works commencing.

The requirements for the removal of ACM should be specified in a Scope of Works Report (i.e. Work Plan). The Scope of Works report should be developed by a qualified and experienced asbestos consultant.

Removal of ACM is to be undertaken in accordance with the requirements outlined in *NSW Occupational Health and Safety Regulation 2001* and the following NOHSC asbestos codes of practice:

- Code of Practice for the Safe Removal of Asbestos 2nd Edition [NOHSC:2002(2005)]
- Code of Practice for the Management & Control of Asbestos in Workplaces [NOHSC:2018(2005)]
- Guidance Note on the Membrane Filter Method for Estimating Airborne Asbestos Fibres 2nd Edition [NOHSC:3003(2005)].

Airborne asbestos monitoring should be carried out during the removal of friable ACM and all samples should be analysed by a NATA Accredited laboratory.

At the completion of asbestos removal work, a clearance inspection should be conducted by a competent person to assess the adequacy of the removal works undertaken.

In order to avoid any potential conflict of interest, it is recommended that airborne asbestos monitoring and clearance inspections be performed by person/s independent of the asbestos removal contractor.

All asbestos waste must be disposed at a suitably approved waste collection facility. All tipping dockets must be retained.

6.2 Synthetic Mineral Fibre

Materials containing SMF were identified or presumed present during the survey as outlined in **Appendix A**.

Where SMF insulation in walls and ceilings was identified it has been reported in the Hazardous Materials Register. However, generally the presence of such insulation in enclosed wall and ceiling cavities cannot be determined. The presence of SMF in these areas should be determined prior to disturbance.

SMF may be enclosed or removed and replaced to reduce the risk of exposure to humans and environmental contamination.

All SMF work is to be undertaken in accordance with the requirements outlined in *NSW Occupational Health and Safety Regulation 2001* and the following NOHSC documents:

- National Standard for Synthetic Mineral Fibres [NOHSC:1004(1990)]

- National Code of Practice for the Safe Use of Synthetic Mineral Fibres [NOHSC:2006(1990)]
- Guidance Note on the Membrane Filter Method for the Estimation of Airborne Synthetic Mineral Fibres [NOHSC:3006(1989)].

The Safe Work Australia (SWA) 8 hour Time Weighted Average (TWA) exposure standard for airborne synthetic mineral fibre of 0.5 fibres per millilitre of air (fibres/mL).

SMF waste is to be disposed at an approved waste collection facility.

6.3 Polychlorinated Biphenyls

PCBs were identified and/or presumed present during the survey as outlined in **Appendix A**.

PCBs should be handled and disposed of in accordance with the Chemical Control Order In Relation to Materials and Wastes Containing Polychlorinated Biphenyl, 1997, issued by the Environment Protection Authority of NSW) and the PCB Management Plan issued by ANZECC.

6.4 Lead Based Paint

Lead based paint was identified during the survey as outlined in the **Appendix A**. It is possible that some lead paints may have been overlain by more recent, non-lead paint coatings.

According to current standards and guidelines, where lead content in paint (by weight) exceeds 1.0% (10,000 mg/kg), the paint should be stabilised or removed by either chemical means or in a manner that does not liberate dust to the atmosphere.

The current standards and guidelines pertaining to lead paint management, removal, stabilisation and disposal are as follows:

- the Safe Work Australia (SWA) 8 hour Time Weighted Average (TWA) exposure standard for inorganic lead (dusts and fumes) in air is 0.15 mg/m³.
- Australian Standard AS4361.1 – 1995, Guide to Lead Paint Management, Part 1: Industrial
- Australian Standard AS4361.2 – 1998, Guide to Lead Paint Management, Part 2: Residential and Commercial Buildings
- DECC Environmental Guidelines: Assessment, Classification & Management of Liquid & Non-Liquid Wastes.

Plates



Plate 1: Asbestos cement cable troughs to South west cable room



Plate 2: Asbestos cement cable troughs to North West cable room



Plate 3: Typical Fire Door with presumed asbestos insulation core material.



Plate 4: Vinyl floor tiles to Battery room sampled and found not to contain asbestos after laboratory analysis.



Plate 5: Electrical equipment within Battery Room presumed to contain ACMs.



Plate 6: Electrical Equipment to 11KV Breaker Room presumed to contain ACMs.



Plate 7: Distribution Board 1 (DB1) located in the Gas Room showing asbestos containing electrical backing board.



Plate 8: Redundant Electrical equipment containing asbestos cement spark shields and electrical backing boards located in the CLC Room,



Plate 9: Asbestos containing backing board to Distribution Board MDB 69 located externally adjacent to Transformer 5.



Plate 10: Fibre cement debris to the ground surface below Transformer 5 analysed and found not to contain asbestos.



Plate 11: Transformers containing PCB insulating oil.



Plate 12: Lead paint to external brown paint to electrical conduits and pipes.



Plate 13: White lead paint to door frame of lunch room



Plate 14: White lead paint to cement render adjacent to door of South West Plant Room.



Plate 15: Possible PCB leaks indicated by staining to ground surfaces below transformers.

Appendix A

Hazardous Materials/Asbestos Register

Hazardous Materials Survey Results

Client: Energy2U Alliance

Site Address: 70 Berry Street , North Sydney

Job Number: S4139701

Survey Date/s: 29/10/09

Room/ Area	Location	Material Description		Sample Reference	Result		Asbestos Classification	Condition	Activities	Risk of Fibre Release	Location	Risk Rating	Photo No.	Comments & Recommendations	Action Taken
South West Cable Room	Cable Troughing	Cement Products	Profiled	3	Asbestos	Chrysotile and Amosite	Bonded / Non-Friable	Good	Low	Moderate	Moderate	Low	1	R2 - Re-inspect every 12 months. Removal should be undertaken prior to any demolition or refurbishment which may affect the material.	
North west Cable room	Cable troughing	Cement Products	Profiled	Same as 3	Asbestos (visual)		Bonded / Non-Friable	Good	Low	Moderate	Moderate	Low	2	R2 - Re-inspect every 12 months. Removal should be undertaken prior to any demolition or refurbishment which may affect the material.	
South West Cable Room	Floor surface	Dust		4	No Asbestos Detected								1	R1 - No action is required.	
Throughout	Fire Doors	Insulation Products	Fire Door		Asbestos (visual)		Friable	Good	Low	Moderate	Moderate	Medium	3	R2 - Re-inspect every 12 months. Removal should be undertaken prior to any demolition or refurbishment which may affect the material.	
Battery Room	Flooring	Vinyl Products	Floor Tile	1	No Asbestos Detected			Good					4	R1 - No action is required.	
Battery Room	Electrical Equipment	Insulation Board Products	Electrical Backing Board		Asbestos (visual)		Bonded / Non-Friable	Good	Low	Low	Moderate	Low	5	R3 - Label material as containing asbestos. Re-inspect every 12 months. Removal should be undertaken prior to any demolition or refurbishment which may affect the material.	
11KV Breaker room	Electrical Equipment	Insulation Board Products	Electrical Backing Board		Asbestos (visual)		Bonded / Non-Friable	Good	Low	Low	Moderate	Low	6	R3 - Label material as containing asbestos. Re-inspect every 12 months. Removal should be undertaken prior to any demolition or refurbishment which may affect the material.	
Gas Room	Distribution Board 1	Insulation Board Products	Electrical Backing Board		Asbestos (visual)		Bonded / Non-Friable	Good	Low	Low	Moderate	Low	7	R2 - Re-inspect every 12 months. Removal should be undertaken prior to any demolition or refurbishment which may affect the material.	
COC Room	Distribution Board 2	Insulation Board Products	Electrical Backing Board		Asbestos (visual)		Bonded / Non-Friable	Good	Low	Low	Moderate	Low	NA	R2 - Re-inspect every 12 months. Removal should be undertaken prior to any demolition or refurbishment which may affect the material.	
CLC Room	Distribution Board 3	Insulation Board Products	Electrical Backing Board		Asbestos (visual)		Bonded / Non-Friable	Good	Low	Low	Moderate	Low	8	R2 - Re-inspect every 12 months. Removal should be undertaken prior to any demolition or refurbishment which may affect the material.	
External North west	Distribution Board 69	Insulation Board Products	Electrical Backing Board		Asbestos (visual)		Bonded / Non-Friable	Good	Low	Low	Moderate	Low	9	R2 - Re-inspect every 12 months. Removal should be undertaken prior to any demolition or refurbishment which may affect the material.	
Transformer 5	Ground surface	Cement Products	Cement sheeting debris	2	No Asbestos Detected								10	R1 - No action is required.	
Transformer 5	Internal	PCBs			PCB (suspected)			Fair					11	R2 - Re-inspect every 12 months. Removal should be undertaken prior to any demolition or refurbishment which may affect the material.	
Exterior north west	Cable Pit	Rope Cloth Products	Cable Wrapping		Asbestos (visual)		Bonded / Non-Friable	Good	Low	Moderate	Low	Low	NA	R2 - Re-inspect every 12 months. Removal should be undertaken prior to any demolition or refurbishment which may affect the material.	
Old lunch room	Flooring	Vinyl Products	Floor Tile	Same as 1	No Asbestos Detected			Good					NA	R1 - No action is required.	
CLC Room	Flooring	Vinyl Products	Floor Tile	Same as 1	No Asbestos Detected			Good					NA	R1 - No action is required.	
Transformer 1	Internal	PCBs			PCB (suspected)			Fair					11	R2 - Re-inspect every 12 months. Removal should be undertaken prior to any demolition or refurbishment which may affect the material.	
Transformer 2	Internal	PCBs			PCB (suspected)			Fair					11	R2 - Re-inspect every 12 months. Removal should be undertaken prior to any demolition or refurbishment which may affect the material.	
Transformer 3	Internal	PCBs			PCB (suspected)			Fair					11	R2 - Re-inspect every 12 months. Removal should be undertaken prior to any demolition or refurbishment which may affect the material.	
Transformer 4	Internal	PCBs			PCB (suspected)			Fair					11	R2 - Re-inspect every 12 months. Removal should be undertaken prior to any demolition or refurbishment which may affect the material.	
Transformer 5	Internal	PCBs			PCB (suspected)			Fair					11	R2 - Re-inspect every 12 months. Removal should be undertaken prior to any demolition or refurbishment which may affect the material.	
Transformers in general	Staining on adjacent floor surfaces	PCBs			PCB (suspected)			Poor					15	R7 - Assess and rectify any leakages. Consider sampling and analysis of the impacted area for PCBs, and remediate as required. Re-inspect for leakage on a regular basis.	
External	Brown paint to electrical conduits and pipes	Painted Surface	External		Lead	Lead paint (>1%)		Fair					12	R8 - Consider encapsulating (e.g. painting) any damaged/flaking areas of paint. Re-inspect every 12 months. Removal should be undertaken prior to any demolition or refurbishment which may affect the material.	

Hazardous Materials Survey Results

Client: Energy2U Alliance

Site Address: 70 Berry Street , North Sydney

Job Number: S4139701

Survey Date/s: 29/10/09

Room/ Area	Location	Material Description		Sample Reference	Result		Asbestos Classification	Condition	Activities	Risk of Fibre Release	Location	Risk Rating	Photo No.	Comments & Recommendations	Action Taken
Lunch Room	Door frame	Painted Surface	External		Lead	Lead paint (>1%)		Good					13	R2 - Re-inspect every 12 months. Removal should be undertaken prior to any demolition or refurbishment which may affect the material.	
South East Plant Room	White paint	Painted Surface	External		Lead	Lead paint (>1%)		Good					14	R2 - Re-inspect every 12 months. Removal should be undertaken prior to any demolition or refurbishment which may affect the material.	
South West Loading Dock	Walls	Painted Surface	Internal		No Lead Detected								NA	R1 - No action is required.	
South East Plant Room													NA	R9 - Non-accessed room/area. This room/area should be presumed to contain hazardous materials until surveyed by a competent person.	

Appendix B

Asbestos Risk Assessment Methodology

The potential risks posed by ACM in premises are due to a number of risk factors including the:

- ACM classification/friability of the material
- condition of the material
- activities which may affect the material
- risk of fibre release from the material
- location of the material.

The risk assessment methodology used by AECOM is based on the Australian Standard AS4360-2004 Risk Management. The hazard levels for this assessment have been determined according to **Table 1**.

Table 1: Hazard Levels

Risk Factor/Description			Hazard Level
ACM Classification	Bonded or Non-Friable	Materials that contain asbestos in a bonded matrix (may consist of Portland cement or various resin/binders and cannot be crushed by hand when dry).	2
	Friable	ACM which, when dry, is or may become crumbled, pulverised or reduced to powder by hand pressure.	5
Condition	Good	<i>In situ</i> materials that exhibit little or no sign of damage or deterioration.	1
	Fair	Materials that exhibit mild to moderate damage and/or deterioration.	2
	Poor	Materials that exhibit moderate to severe damage or deterioration.	3
Activities	Low	The location of the material and use of the area indicate that the material will not likely be disturbed during normal operations.	1
	Moderate	The location of the material and use of the area indicate that the material might be disturbed during normal operations.	2
	High	The location of the material and use of the area indicate that the material is likely to be disturbed during normal operations. Evidence of prior disturbance may be present.	4
Risk of Fibre Release	Low	Material is not prone to release asbestos fibres (e.g. resins, floor tiles).	1
	Moderate	Material that may release fibres upon disturbance (e.g. cement products).	2
	High	Material likely to release significant fibre concentrations upon disturbance (e.g. spray coating).	3
Location	Low	ACM is present in an open environment (e.g. outdoors).	1
	Moderate	ACM is present within a semi-enclosed environment.	2
	High	ACM is located within an enclosed environment and exposed to forced ventilation.	4

The multiplication of the asbestos type and each risk factor can be then used to determine the Hazard Level as follows:

ACM Classification x Condition x Activities x Risk of Fibre Release x Location = Hazard Level

The recommended health risk/action priority rating for each Hazard Level is provided in **Table 2**.

Table 2: Risk Rating

Risk Rating	Overall Hazard Level
Low	0 – 19
Moderate	20 – 49
High	> 50

Control measure guidelines for each Risk Rating are provided in the **Table 3**.

Table 3: Definitions of Risk Rating and Control Measure Guidelines

Risk Rating		Definition
Health Risk	Low	Products or materials that pose negligible health risk to employees and the general public. They consist of materials that currently are in a good condition, located in areas which are not subject to activities that may impact upon them and are of a type which do not readily release asbestos fibres upon contact. These materials should be identified and warning signs erected. The material does not present a significant risk unless disturbed by intrusive work such as drilling, cutting, breaking or sanding.
Hazard Level	0 – 19	
Action Priority	AP3	
Health Risk	Moderate	Products or materials that pose a risk to employees and the public in their current state. They consist of materials whose condition has degraded, in an area where they may be impacted upon by surrounding activities and of a type that can release asbestos fibres upon contact. Removal or encapsulation and regular reviews or assessments are recommended for these materials.
Hazard Level	20 – 49	
Action Priority	AP2	
Health Risk	High	Products or materials that pose an immediate or elevated risk to employees or the public in their current state. They consist of materials that are in poor condition, may be located within return air plenums or are in an area where activities are very likely to impact upon the material. Immediate actions should be taken for these materials to be removed by a licensed asbestos removal contractor. Alternative management strategies must be considered where removal of ACM is not practicable.
Hazard Level	> 50	
Action Priority	AP1	

The Hazardous Materials/Asbestos Register should form part of the Health and Safety Management System for Energy2U Alliance and will need to be reviewed at least annually or sooner where there is any significant change in circumstances.

It should be noted that any risk assessment presented in this document was made on the basis of the nature of activities observed at the time the survey was undertaken. Changes in circumstances which affect the current Risk Assessment should be notified to your AECOM Consultant.

Appendix C

Laboratory Analysis Results

Amdel Ltd

ABN 30 008 127 802

Unit 2, 35 Cormack Road, Wingfield SA, 5013
 PO Box 552, Port Adelaide BC, SA 5015
 Phone: (08) 8440 7145 Facsimile: (08) 8440 7197

ASBESTOS IDENTIFICATION REPORT

CLIENT: AECOM

DATE: 5 November 2009

ADDRESS: Level 5/828 Pacific Highway, Gordon NSW 2072

REPORT NO: 9AA1022G

PROJECT NO: S4139701

PAGE NO: 1 of 1

PO NO: 1303300

RESULTS:

Sample	Sample size	Description	Asbestos*	SMF*	OF*
1	(a) 10x10x3	Pale green flooring	No**		
2	(a) 10x5x1	Pale grey fibrous sheeting	No		Yes
3	(a) 5x5x2	White fibrous sheeting, painted grey	Chrysotile, amosite		
4	(d) 2mL	Brown and white silt-to sand-sized particles as well as white micaceous flakes	No		

Sample	Location description
1	Vinyl floor tiles
2	Fibre cement debris adjacent to transformer 5
3	Cable throughing in cable room
4	Ground surface dust in cable room

APPROVED IDENTIFIER: Naciye Haliloff

APPROVED SIGNATORY:
Michael Till*m. j. till*

The approximate dimensions (in mm) stated above refer to the size of (a) a single piece (b) largest of several particles (c) largest of many particles (d) volume in ml of unconsolidated particles (e) weight in grams of unconsolidated particles

* Detected by polarized light microscopy. ** No asbestos was detected by polarized light microscopy, but identification may not be possible due to adhering resins. Confirmation by another analytical technique is advised.

Note: Chrysotile is a fibrous silicate mineral commonly known as white asbestos, amosite is a fibrous silicate commonly known as brown or grey asbestos and crocidolite is a fibrous silicate commonly known as blue asbestos. SMF (Synthetic Mineral Fibre) is commonly known as glass fibre and OF (Organic Fibre) includes natural fibres (eg cellulose) and synthetic organic fibre but not high temperature fibres (eg Teflon fibres). A blank in the SMF or OF column implies not detected. Tr in the SMF or OF column indicates identification in Trace amount
The results contained in this report relate only to the sample(s) submitted for testing. Amdel Ltd accepts no responsibilities for the representivity of the sample(s) submitted.

SCOPE OF ACCREDITATION: Class 7.82.31: 31 Qualitative identification in bulk samples by polarized light microscopy (including dispersion staining) of amosite, chrysotile, crocidolite, organic fibres and synthetic mineral fibres



This document is issued in accordance with NATA's accreditation requirements

Accredited for compliance with ISO/IEC 17025.

NATA accreditation number: 1526

This document may not be reproduced except in full.

Amdel Laboratories Ltd

ABN 71 009 076 555

Unit 2, 35 Cormack Road, Wingfield SA, 5013
PO Box 552, Port Adelaide BC, SA 5015
Phone: (08) 8440 7145 Facsimile: (08) 8440 7197

ASBESTOS-FORMING MINERAL IDENTIFICATION REPORT

CLIENT: AECOM

DATE: 5 November 2009

ADDRESS: Level 5/828 Pacific Highway, Gordon NSW 2072

REPORT NO: 9AA1022GX

PROJECT NO: S4139701

PAGE NO: 1 of 1

PO NO: 1303300

PROCEDURE

The sample was analysed by X-ray diffraction, which detects crystalline substances and minerals (including asbestos-forming minerals). Non-crystalline substances (eg glass, most organic compounds) are not detectable by this technique.

RESULTS

Sample	Description	Chrysotile Est. %	Other minerals detected
1	3mm thick pale green flooring	Not detected	Calcite, rutile

TESTING OFFICER: Naciye Haliloff

Note: Chrysotile is a fibrous silicate mineral commonly known as white asbestos. A dash (-) in the Chrysotile column implies not detected. The other minerals listed are fillers or pigments. They may include calcite (calcium carbonate), rutile (titanium dioxide – white pigment), aragonite (calcium carbonate found in shellgrit), kaolinite (white clay), dolomite (calcium magnesium carbonate) and goethite (brown iron oxide).

The results contained in this report relate only to the sample(s) submitted for testing. Amdel Ltd accepts no responsibilities for the representivity of the sample(s) submitted.

Worldwide Locations

Australia	+61-2-8484-8999
Azerbaijan	+994 12 4975881
Belgium	+32-3-540-95-86
Bolivia	+591-3-354-8564
Brazil	+55-21-3526-8160
China	+86-20-8130-3737
England	+44 1928-726006
France	+33(0)1 48 42 59 53
Germany	+49-631-341-13-62
Ireland	+353 1631 9356
Italy	+39-02-3180 77 1
Japan	+813-3541 5926
Malaysia	+603-7725-0380
Netherlands	+31 10 2120 744
Philippines	+632 910 6226
Scotland	+44 (0) 1224-624624
Singapore	+65 6295 5752
Thailand	+662 642 6161
Turkey	+90-312-428-3667
United States	+1 978-589-3200
Venezuela	+58-212-762-63 39

Australian Locations

Adelaide
Brisbane
Canberra
Darwin
Melbourne
Newcastle
Perth
Sydney
Singleton

www.aecom.com