EMF STUDY SEARS REPORT

MULTI-TRADES AND DIGITAL TECHNOLOGY HUB

EMF SERVICES

JHA

JHASERVICES.COM

This report is prepared for the nominated recipient only and relates to the specific scope of work and agreement between JHA and the client (the recipient). It is not to be used or relied upon by any third party for any purpose.

DOCUMENT CONTROL SHEET

Project Number	190224
Project Name	TAFE Meadowbank - Multi-Trades and Digital Technology Hub
Description	Electromagnetic Field Study for SEARS
Key Contact	Marc Estimada

Prepared By

Company	JHA
Address	Level 23, 101 Miller Street, North Sydney NSW 2060
Phone	61-2-9437 1000
Email	Boris Skapik@jhaengineers.com.au
Website	www.jhaservices.com
Author	Boris Skapik
Checked	Brenton Burrows
Authorised	Marc Estimada

Revision History

Issued To	Revision and Date								
Gray Puksand	REV	A							
Mr. Barry Hackett	DATE	23/08/19							
Gray Puksand	REV	B							
Mr. Barry Hackett	DATE	5/09/19							
Gray Puksand	REV	C							
Mr. Barry Hackett	DATE	3/10/19							

CONTENTS

1 EXECUTIVE SUMMARY

This report has been prepared by JHA to identify and summarise the potential impacts of EMF (Electromagnetic Fields) generated from the AusGrid 132/11kV Zone Substation shall have on the proposed Multi Trades Hub Building at the Meadowbank TAFE.

The report demonstrates compliance with the Secretary's Environmental Assessment Requirements (SEARs) which apply to the project and has been prepared to accompany a State Significant Development Application (SSDA) to the NSW Department of Planning and Environment.

The assessment herein will focus on the mitigation of ELF magnetic fields below the 2,000mG (200μT) threshold limitation for the General Public as set in Table 4 "ICNIRP, *Guidelines for Limits Exposure to Magnetic and Electric Fields (1Hz to 100Hz)*", and below the 37.5mG (3.75μT) threshold limitation for electronic equipment in accordance with statutory standards and guidelines such as ARPANSA Health Guidelines, Australia Standards AS/NZS 61000.6.1:2006 and AS2384:1995.

The main sources of ELF magnetic fields assessed in this report is the AusGrid Zone Substation. To analyse the ELF Magnetic Fields from the Zone Substation on-site manual readings were taken along the exterior of the southern side of the substation wall that shall be directly facing the proposed Multi Trades Hub Building. Over 30 readings were taken, 9 readings along the substation 10m apart at 4m, 10m and 15m from the substation wall itself. These readings were taken on the 20/08/19 between 12:20pm till 2pm. A summary of the worst readings at the 4m, 10m and 15m zones are listed below.

It must be noted that ELF magnetic fields is directly proportional to the load flowing through conductors in the substation, hence JHA have considered a conservative figure based of 500% of site reading value to ensure worst case scenario is captured.

Table 1 – Summary of ELF Magnetic Field Readings

Distance	Highest Reading	Conservative Figure
4m	6.39mG (0.639μT)	31.95mG (3.195μT)
10m	4.41mG (0.441μT)	22.05mG (2.205μT)
15m	1.53mG (0.153μT)	7.65mG (0.765μT)
25m	0.41mG (0.041μT)	2.05mG (0.205μT)

The Multi Trades Hub is currently designed to be 12m away from the boundary, based on this information and following JHA's site investigation and assessment as detailed in this report, the measured levels of exposure at the 4m mark are considered to be below the maximum threshold limitations as set by the governing authority bodies for human exposure to ELF magnetic levels even when conservative values are considered.

These readings are well within limits as expected due to the high voltage nature of the substation, ie Higher Voltages = Lower Currents = Lower ELF magnetic fields. It must also be noted that the substation is made up of a number of equipment such as circuit breakers, voltage transformers, disconnectors, earthswitches and so on, which would also help dampen magnetic fields as they limit conductor lengths.

2 QUALIFICATIONS

The report's assumptions are based upon the following known and provided data available at the time of creation:

- Location of the proposed Multi Trades Hub Building
- Guass meter: Tenmars, TM-192D

3 INTRODUCTION

TAFE Meadowbank is one of the largest TAFE facilities in Sydney, which offers an extensive range of educational services. TAFE Meadowbank is located at See St, Meadowbank NSW 2114 adjacent to Meadowbank Train Station, in the local government area of City of Ryde Council.

The project consists of a New Multi-Trades and Digital Technology Hub Building – part of SSDA scope.

The focus of this report shall be the EMF impact the AusGrid Zone Substation has on the New Combined Multi Trades and Digital Technology Hub Building.

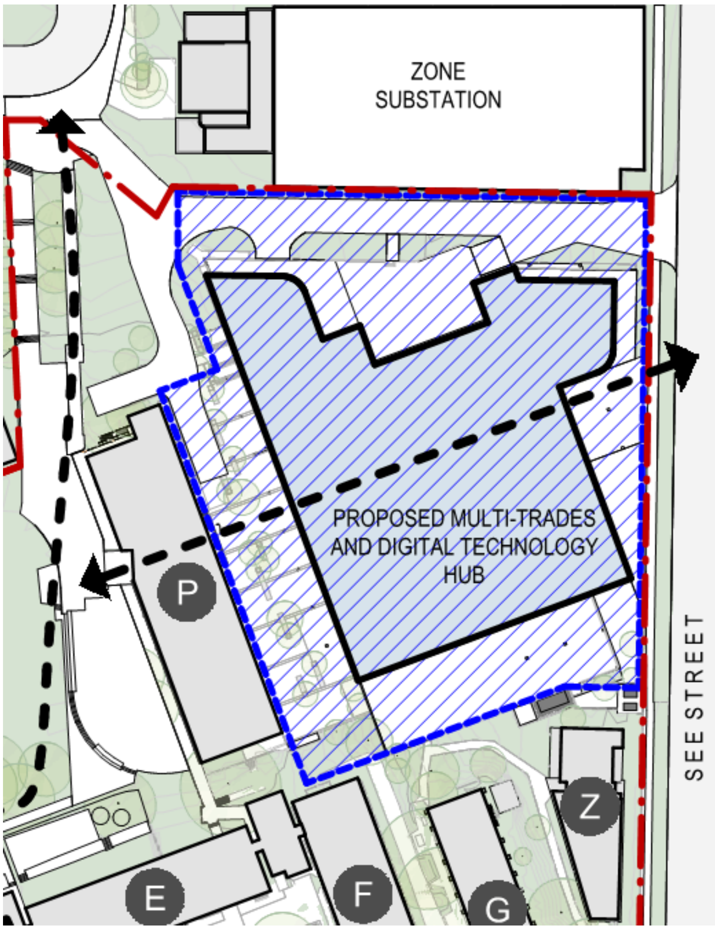

Figure 1 - Proposed New Multi-Trades and Digital Technology Hub Building

Figure 2 - Proposed New Multi Trades Hub Building Superimposed Over Existing Site

This report outlines the issues of extremely low frequency (ELF) 50Hz, magnetic interference, discusses the relevant Australian Standards that exist and provides direction on the available pre-emptive options for mitigating the effects of ELF magnetic interference.

4 ELECTRICAL AND MAGNETIC FIELDS

Everyone is exposed to some form of electromagnetic fields (EMF) of different frequencies from many natural and man-made sources in our environment. Electromagnetic fields consist of electric and magnetic waves travelling together at the speed of light. In recent years, the general public has become increasingly concerned about the potential adverse effects of exposure to electric and magnetic fields at extremely low frequencies (ELF).

Extremely low frequencies are defined as the frequency range from 0 – 300 Hertz (Hz). At these low frequencies, electric and magnetic fields act independently and can be separately measured.

Exposures to these fields arise mainly from the transmission and use of electrical energy at the frequencies of 50/60 Hz. This report is particularly concerned with the 50Hz frequency as this is the frequency established for the electrical power supply throughout Australia.

Electricity generates electrical and magnetic fields as a natural consequence of the use and distribution of power supply.

Electric and magnetic fields are strongest closest to the source and diminish very quickly with an increase in distance.

4.1 ELECTRIC FIELDS

Electrical Energy involves 'voltage' (the pressure behind the flow of electricity and produces an electric field) and 'current' (the quantity of electricity flowing is proportional to the voltage) which remains constant as long as the equipment is energised. The higher the voltage, the higher the electric field. Even if the appliance is 'off' and the power point is 'on' an electric field will be present as the associated cord remains energised.

Electric fields are shielded by most objects including trees, buildings and human skin. For this reason there are negligible electric fields associated with underground cables.

As such, electrical fields have negligible risk at the lower voltages as exhibited by the Main Switch Board in this instance and this report will concentrate on issues associated with magnetic fields only.

Electric fields are measured as electric field strength (Volts per metre, V/m) or kilovolts (1,000 Volts) per metre (kV/m).

4.2 MAGNETIC FIELDS

Whenever an electric charge moves (i.e. whenever an electric current flows) a magnetic field is created that is proportional to the 'current' – the higher the current, the higher the magnetic field. The flow of electrical current through metal conductors produces an electromagnetic field. This magnetic field is created around the supply cable and the equipment when it is operating. This is a major but not exclusive source of electromagnetic fields.

Whenever a piece of equipment is completely turned 'off' there is no flow of current and therefore no magnetic field generated.

Much like electric fields, the strength of magnetic fields drop quickly as you move away from the source. Unlike electric fields however, magnetic fields cannot easily be shielded as these fields pass through most materials.

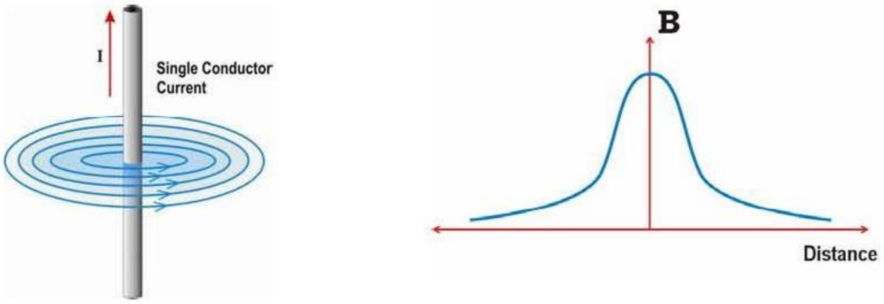

Figure 3 – Reduction of magnetic field strength, B, with distance from the conductor source

Some electrical and electronic equipment is sensitive to and will malfunction in environments of elevated magnetic field.

The sources of magnetic fields in commercial buildings include power supply and distribution equipment, power consumption equipment and other less obvious sources such as structural steel beams or metallic cable trays.

Magnetic fields are measured as magnetic field strength (Ampere per metre, A/m) or as magnetic flux density - microtesla (μT) or milligauss (mG), where 1 μT = 10mG.

Table 2 – Magnetic Field Units' Conversion Table (EMF Management Handbook Jan 2016)

mT	µT	nT	G	mG
10	10^4	10^7	1000	10^5
1	1000	10^6	10	10^4
0.1	100	10^5	1	1000
0.01	10	10^4	0.1	100
0.001	1	1000	0.01	10
10^{-4}	0.1	100	0.001	1
10^{-5}	0.01	10	10^{-4}	0.1
10^{-6}	0.001	1	10^{-5}	0.01

5 SOURCES OF ELF MAGNETIC FIELDS

All electric currents generate electromagnetic fields. Man-made external sources include installations associated with the distribution of electricity, such as power lines and underground cables, open type and indoor transmission and distribution substations or large indoor LV switchboards.

The sources of magnetic fields within buildings can be grouped into three general categories:

1. Power supply and distribution equipment:
    a. Substations – transformers, busbars, HV incoming and LV outgoing cables
    b. LV Switchrooms and Distribution– switchboards, conductors, busducts, earth wires
    c. UPS systems and diesel generator electrical distribution

2. Power consumption equipment;
    a. Air conditioning plant
    b. Lights
    c. Lifts
    d. Fans
    e. Heaters
    f. Hot water units
    g. Refrigerators
    h. Office equipment (computers, printers)
    i. Workshop equipment
    j. Security, intercom and communication equipment drive be AC power.

3. Incidental sources.
    a. Metallic air conditioning ducts
    b. Metallic pipes
    c. Structural beams
    d. Steel reinforcement of concrete beams, slabs and panels
    e. Metallic cable trays

5.1 SUBSTATIONS

For distribution substations, the key sources of magnetic fields within the substation tend to be the low voltage boards, busbars and transformer cables. In most cases the magnetic field has decreased to background levels within a few metres of the substation. For this reason, distribution substations are not a significant source of exposure. Exceptions could include chamber type substations which are typically installed in or adjacent to a building. In these cases the magnetic field exposure will be dependent on the configuration and loading of the substation and uses of adjacent areas (including above and below the substation).

In relation to zone substations the vast majority of the site is outdoor 132kV switchyard, following the convention with higher voltages equates to lower current, we would not expect to measure large EMF readings.

6 STANDARDS & INDUSTRY DOCUMENTS

The following Australia Standards provide the basis for JHA's assessment and proposed mitigation of ELF magnetic fields.

6.1 AUSTRALIAN ELECTROMAGNETIC IMMUNITY STANDARDS FOR ELECTRICAL AND ELECTRONIC APPARATUS – AS/NZS 61000.6.1:2006

The objective of this Standard is to provide designers, manufacturers and testers of equipment incorporating electrical or electronic operation with methods of testing to ascertain immunity to electromagnetic disturbance. The test specifications and maximum acceptable ELF levels for avoidance of interference outlined in the standard are as follows:

- 3 A/m (37.5mG) for all equipment
- 1 A/m (12.5mG) for cathode ray tube (CRT) display based equipment.

6.2 MAGNETIC MEDIA EXPOSURE TO MAGNETIC FIELDS – AS2384:1995

Clause A5.4 of this standard states that magnetic media should not be allowed to come within the influence of or contact with magnetic fields at any time. No field strength should be greater than 4kA/m (50,000mG) intensity as this may introduce noise or cause loss of information (NB. field strengths of this magnitude are not normally encountered).

6.3 SUBSTATION AND HIGH VOLTAGE INSTALLATION EXCEEDING 1KV A.C – AS2067:2016

High Voltage Installations shall be designed with considerations to Electrical and Magnetic Fields (EMF). EMF limits shall comply with those in ICNIRP, *Guidelines for Limits Exposure to Magnetic and Electric Fields (1Hz to 100Hz).*

Appendix D of AS2067 provides (informative) EMF and Safety Issues – Obligations related to the design of the installation. The 2016 update refers to the following guidelines for further information:

- Energy Network Association ENA www.ena.asn.au
- ARPANSA www.arpansa.gov.au

6.4 ENERGY NETWORK ASSOCIATION ENA – EMF MANAGEMENT HANDBOOK

The electricity industry in Australia has an active management program on the issue of Electric and Magnetic Fields (EMFs) at power frequencies (50 Hz) which has been in place for many years. The Energy Network Association (ENA) provides information on EMF policies for the electricity industry as well as other documents which will explain more about the possible effects of EMF on health and ways that EMF may be managed. It will also provide with some links to other websites with information on EMF issues.

The TWO internationally recognised exposure guidelines are ICNIRP and IEEE. For our basis of design, our EMF exposure limits will refer to ICNIRP which provides more stringent values over the IEEE and is recommended by Australian Standard 2067.

ENA documentation highlights ARPANSA's current advice as *"The ICNIRP ELF guidelines are consistent with ARPANSA's understanding of the scientific basis for the protection of general public (including the foetus) and works from exposure to ELF EMF"*.

6.5 HUMAN EXPOSURE

Human exposure limits as defined by the ENA/ARPANSA guidelines categorises ELF magnetic field exposure as per the following summary.

Table 3 – Guideline Summary of Human Exposure Reference Levels at 50Hz

	Magnetic Field ARPANSA - ICNIRP	Electric Field (For reference only)
Occupational	10,000mG (1,000 μT)	10 kV/m
General Public	2,000mG (200 μT)	5 kV/m

Note the allowable limits are applicable to equipment operating at 50Hz. For Substation application and power, this applies to both the HV and LV side as they both operate at the same frequency.

6.5.1 OCCUPATIONAL

Occupational exposure refers to adults exposed to time-varying electric, and magnetic fields from 1Hz to 10MHz at their workplaces, generally under known conditions, and as a result of performing their regular or assigned job activities.

Note that employed people are to be regarded as members of the General Public (refer below) unless their employer chooses to designate them as needing to work in an environment where ELF controls are necessary.

6.5.2 GENERAL PUBLIC

By contrast, the term general population defines to individuals of all ages and of varying health status which might increase the variability of the individual susceptibilities. In many cases, members of the public are unaware of their exposure to EMF. These considerations underlie the adoption of more stringent exposure restrictions for the public than for works while they are occupational exposed.

Below is a summary of typical magnetic field measurements and ranges associated with various appliances the general population is exposed to on a daily basis. (Levels may vary from the range of measurements shown).

Table 4 – Magnetic Field Measurements Ranges of Appliances (ARPANSA, Measuring Magnetic Fields)

Appliance	Range of measurements (mG)
Electric Stove	2 – 30
Refrigerator	2 – 5
Electric kettle	2 – 10
Toaster	2 – 10
Television	0.2 – 2
Personal computer	2 – 20
Electric blanket	5 – 30
Hair dryer	10 – 70
Pedestal fan	0.2 – 2

7 HEALTH EFFECTS OF ELF MAGNETIC FIELDS

Human studies have consistently shown that there is no conclusive evidence that prolonged exposure to weak electric fields, such as those found in the home or in most work places, result in adverse health effects.

The Australian radiation health authorities do not regard the prolonged exposure to 50Hz electric and magnetic fields at the levels commonly found in the environment as a proven health risk. Current studies do not allow authorities to decide whether there is a specific magnetic field strength above which prolonged exposure is dangerous or compromises human health. At this stage, any action to reduce the exposure must rest with the individual / developer.

The overwhelming consensus of the bodies that regulate safety aspects of radiation (e.g. ARPANSA in Australia, ICRNIRP the International Commission on Non-Ionizing Radiation Protection, etc.) is that there is no proven biological effects due to 50Hz radiation (below the 2000mG (200 µT) levels where heating becomes an issue). Correspondingly, no controls have been placed by governments on such radiation.

As such, many Australian Electricity Authorities have a 'Prudent Avoidance' policy which includes taking reasonable steps to limit field exposures from new facilities by locating and operating electrical installations prudently within the latest Australian health guidelines. Practically, 'prudent avoidance' can be achieved with consideration of siting locations of equipment in proximity to receivers such as houses, schools and the like.

8 DESIGN CONSIDERATIONS FOR NEW INSTALLATIONS AND ELF MAGNETIC FIELD MITIGATION OPTIONS

The best possible approach currently available is to use recognised and commonly accepted design practices and recommendations based on experience and where possible use modelling techniques as support to that approach.

There are three basic approaches to ELF magnetic interference mitigation:

1. Maximise the distance between the source of the field and the sensitive device or area.

   All magnetic fields decrease with distance from the source. Generally at a distance from the source (n), the fields will decrease as follows:

   a. Single Current (Cables): 1/n
   b. Single Circuit or Double Circuit Un-Transposed (LV Equipment / Switchboards): $1/n^2$
   c. Double Circuit Transposed or Coil (HV Equipment / Transformers): $1/n^3$

2. Shield the sensitive device, source or area.

In many situations, a combination of these elements can be used to achieve the desired results.

8.1 SHIELDING AGAINST ELF MAGNETIC FIELDS

8.1.1 SHIELDING EFFECTIVENESS

Shielding effectiveness (SE) is measured in decibels (dB) and is calculated as:

$$SE_{dB} = 20log_{10}\left(\frac{H_o}{H_1}\right)$$

Where H_o – magnetic field strength at a prescribed distance.

H_1 – magnetic field strength permissible threshold.

It should be noted that the shielding effectiveness could be much less than that theoretically predicted.

8.1.2 SHIELDING MATERIALS

Shielding is usually constructed from various grades of silicon steel or other special material. The silicon steel is supplied in sheets or rolls and is of different sizes and thicknesses. A shield of the required thickness can be constructed from thin sheets of the same material. The shield can also be constructed from layers of different materials with different physical properties such as a combination of materials with high permeability (high absorption loss – hot rolled steel) and high conductivity (high reflection loss and high conductivity for induced currents).

It is important to use a material that will provide the required screening effectiveness. High permeable materials such as mumetal require annealing after machining and tend to be high cost materials. On the basis of cost and overall shielding effectiveness, silicon steel is probably the most useful material for large affected areas. Many contractors, however, have their own form of proprietary material used for shielding with fairing mitigation properties.

8.1.3 PRACTICAL ASPECTS OF SHIELDING

Typical shielding solutions may consist of several layers of high permeability metal, with each layer being in the order of 3mm thick plates with individual sheets butt-jointed and overlapping.

As shielding is usually constructed from plates or sheets of the selected material, it is important to account for the effect of discontinuity and joints on its overall effectiveness. Any gaps or holes in a shield will reduce its effectiveness. Consideration should also be given to the increased field level at the edge of the material due to "edge effects".

Other aspects of shielding that should be accounted for are as follows:

a. Sheets are manufactured in lengths as long is practical to minimise joints in the sheets. Any gaps or holes in the shielding reduce its effectiveness.
b. Provision of adequate heat dissipation. Heat may be produced by the shielding due to induction currents or by the electrical equipment it is designed to shield.
c. Derating of cables and other conductors surrounded by shielding
d. Provision of noise suppression. It is not uncommon that a shielding plate or an enclosure, if operating in a relatively strong magnetic field environment, will vibrate with the frequency of the induced current.

It should be noted that shielding of a building may not always be practical or visually appealing, if selected at the design stage and implemented at the construction stage is much more cost efficient than if it is applied as a post-construction remedial measure.

9 SITE SPECIFIC ELF MAGENTIC FIELD DISTRIBUTION

9.1 GENERAL

In consideration of the Energy Network Australia (ENA) documentation which compares other relevant standards (ie ICNRP), the following assessment will focus on the mitigation of ELF magnetic fields below the 2,000mG (200μT) maximum threshold limitation for the General Public, which includes adults and children alike.

With the type of use proposed for the building to be workshops and tutorial spaces for a TAFE, children are not expected to spend extended periods of time within the building. As such the report will consider human exposure levels to the threshold limitation of the ENA as above and not the misconceived lower threshold value for children.

This report will also assess the requirements of AS/NZS 61000.6.1:2006 for interference of electrical equipment, to the permissible ELF magnetic field maximum threshold limitation of 3.75 μT (37.5mG).

ELF magnetic fields are inversely proportional the square/cube of the distance, and as such, increasing the distance from the source of the ELF magnetic field has a dramatic effect on reducing the magnetic field strength.

While the estimated ELF magnetic field density values as measured below are the expected maximum values for the individual primary sources under full load conditions, being a limited period occurrence, the mutual addition of the multiple primary sources may produce a resultant ELF magnetic field density higher than those estimated in this report.

Design measures for field mitigation may not be controlled after installation and changes may cause the magnetic field density to be higher than the estimated values stated. For example, balanced loading across all three phases is dependent on the final building fitout and can result in unbalanced loads. It is imperative that the design mitigation measures are maintained for the life of the building.

Any alterations of the building layout will require reassessment of the ELF magnetic field density impacts to the surrounding building areas.

9.2 ELF MAGNETIC FIELD SOURCES FOR ASSESSMENT

The understood primary sources for ELF magnetic fields are summarised as being electrical equipment of high current carrying capacity in close proximity to areas sensitive to human health and electrical equipment as the following:

- AusGrid Zone Substation

Due to the complex nature of the installation it has been determined on site readings would be best suited to analyse the ELF magnetic fields emanating into the TAFE.

9.3 SITE-MEASURED ELF MAGENTIC FIELD DISTRIBUTION

The field measurements were carried out on site using a Gauss meter. The equipment used in recording the ELF Magnetic field is a three axis magnetic field measuring instrument with 3-channel internal measurement sensors (X,Y and Z). This method is to ensure reliable measurements and monitoring of low frequency Electromagnetic Field strength.

The equipment details are as below.

Test unit type: Triaxial Magnetic Field Meter

Brand: Tenmars

Model: TM-192D

Frequency range: 30 Hz to 2,000 Hz

To analyse the ELF Magnetic Fields from the Zone Substation on-site manual readings were taken along the exterior of the southern side of the substation wall that shall be directly facing the proposed Multi Trades Hub Building. Over 30 readings were taken, 9 readings along the substation 10m apart at 4m, 10m and 15m from the substation wall itself. These readings were taken on the 20/08/19 between 12:20pm till 2pm. A summary of the worst readings at the 4m, 10m and 15m zones are listed in the table below.

It must be noted that EMF is directly proportional to the load flowing through conductors in the substation, hence JHA have considered a conservative figure based of 500% of site reading value to ensure worst possible case is captured.

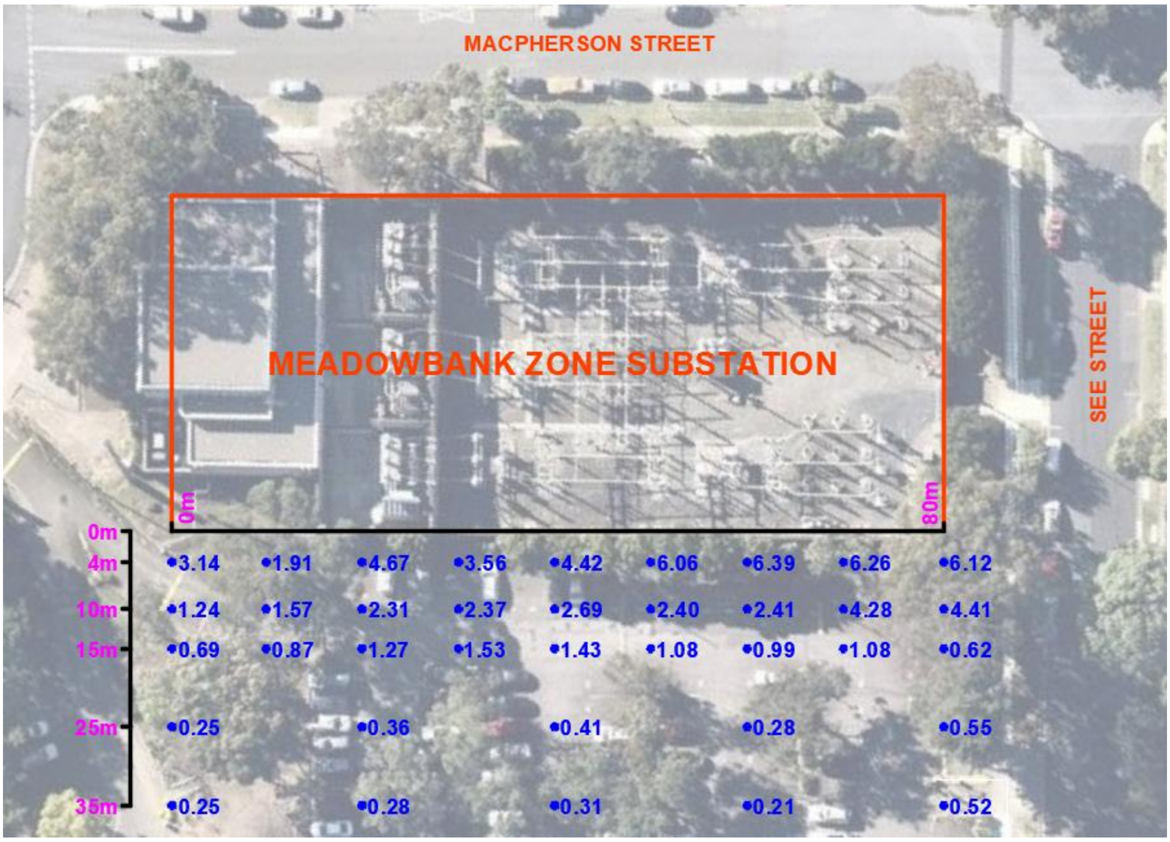

Figure 4 – ELF Magnetic Field Density Readings on site (mG)

Below is a tabled summary of the readings from site and the Conservative Figure based on 500% of the measured reading to cover worst possible case scenario.

Table 5 – Summary of ELF Magnetic Field Readings

Distance	Highest Reading	Conservative Figure
4m	6.39mG (0.639μT)	31.95mG (3.195μT)
10m	4.41mG (0.441μT)	22.05mG (2.205μT)
15m	1.53mG (0.153μT)	7.65mG (0.765μT)
25m	0.41mG (0.041μT)	2.05mG (0.205μT)

9.4 ELF MAGNETIC FIELD ON-SITE SOURCES

The understood primary source for ELF magnetic fields in this assessment is the AusGrid Zone Substation. However, any other electrical devices and equipment also emit ELF magnetic fields. The on-site records of ELF magnetic fields are overall measurements of all sources. Electrical devices and equipment include as following:

a. Overhead Power lines
b. Electrical cables

Figure 5 – One of the readings onsite outside the substation wall (2.59mG)

9.5 SITE-MEASURED FINDINGS

9.5.1 HUMAN EXPOSURE

From the measured ELF magnetic field densities, it is understood there is a negligible risk that the above-mentioned primary sources of ELF magnetic fields will generate field densities greater than the General Public limitations of 2,000mG (200μT) at each of the assessed accessible areas. This would not likely be exceeded even during peak load periods, and hence the risk of continuously exceeding the exposure limitation is low and unlikely. A conservative value of 500% of the measured value is considered to ensure worst case is covered.

The installation of local ELF magnetic field shielding is not considered as required for the installation with fields to adjacent spaces naturally already below the acceptable threshold limits.

9.5.2 ELECTRICAL EQUIPMENT INTERFERENCE

Measured and conservative ELF magnetic field strengths from AusGrid Zone Substation has been determined to not exceed the maximum 37.5mG (3.75μT) permissible level for interference as defined in AS/NZS 61000.6.1:2006.

The installation of local ELF magnetic field shielding is not considered as required for installation with fields to adjacent equipment naturally already below the maximum threshold limits for electronic equipment exposure.

10 SUMMARY OF FINDINGS

JHA has completed Electro-magnetic Field Test assessment of the impacts of ELF Magnetic Fields associated with the existing AusGrid Zone Substation.

Based on the undertaken Electro-magnetic Field Test, the perceived ELF levels generated from the existing AusGrid Zone Substation will be less than the maximums set for public exposure as per the governing bodies in the industry as listed in this report.

Furthermore, the field records of ELF exposure are considered within acceptable limits for interference of electronic equipment as required by AS/NZS 61000.6.1:2006 and AS2384:1995.