Appendix H Electric and Magnetic Fields (EMF) Assessment

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More Trains More Services Stage 2
Transport for New South Wales
28 Oct 2019
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Mortdale Maintenance Centre - Power Supply Upgrade

EMF Assessment

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EMF Assessment

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Acronyms

AC	Alternating Current
AIMD	Active Implantable Medical Device
ARPANSA	Australian Radiation Protection and Nuclear Safety Agency
CNS	Central Nervous System
EEG	Electroencephalography
ELF	Extremely Low Frequency (taken as 0-3kHz)
EMF	Electric and Magnetic Field
EN	European Standard
ENA	Energy Networks Association
HV	High Voltage (typically 132kV$_{AC}$ or 330kV$_{AC}$, in NSW)
IARC	International Agency for Research on Cancer
ICNIRP	International Commission on Non-Ionizing Radiation Protection
IEEE	Institute of Electrical and Electronics Engineers
ISMSB	Installation Supply Main Switchboard
kV	Kilovolt
LV	Low Voltage (<1kV$_{AC}$)
MF	Magnetic Field
mG	Milli-Gauss
mT	Milli-Tesla
REF	Review of Environmental Factors
RHS	Radiation Health Series
RMU	Ring Main Unit
RPS	Radiation Protection Series
Std	Standard
µT	Micro-Tesla
UGOH	Underground to Overhead
WHO	World Health Organisation

1.0 Introduction

1.1 Background

Transport for NSW (TfNSW) has identified the need to upgrade the maintenance capabilities at Mortdale Maintenance Centre as part of More Train More Services Program. This upgrade will increase the capacity for maintenance of the Tangara fleet at this location.

The Mortdale Maintenance Centre Upgrade includes power supply upgrades. Figure 1 shows the location of the existing and proposed Mortdale Maintenance Centre substation and surrounding buildings.

Figure 1 Mortdale Maintenance Centre – Substation Site Layout

1.2 Site and Project Description

The existing substation is an outdoor HV substation supplied via Sydney Trains 33kV Feeder 705 with the following details:

- Two 33kV/415V, 500kVA transformers
- Busbars and termination structures for two 33kV incoming feeders
- 11kV cable trench from underground to overhead (UGOH) Pole 44 to Pole 45

The proposed upgrade works relevant to this assessment include:

- Decommission the existing 33kV/415V substation and convert the area into carparking
- Two new 11kV/415V, 800kVA transformers (Transformer 1 & 2)
- One new 11kV/415V, 500kVA transformer (Transformer 3)
- Each transformer will have a Ring Main Unit (RMU)
- Re-configuration of UGOH transition Pole 44 and Pole 45 for 11kV supply to the new transformers

- New 33kV aerial conductors from Pole 44 to Pole 45
- New 11kV cable trench
- One 3C x 95mm2 11kV cable from UGOH Pole 44 to Transformer 1
- One 3C x 95mm2 11kV cable from UGOH Pole 45 to Transformer 3
- New LV cable bridge from proposed substation to the Mortdale Maintenance Centre workshop
- New Mortdale Maintenance Centre Installation Supply Main Switchboard (ISMSB)

1.3 Scope

The Review of Environmental Factors (REF) for TfNSW requires a specialist report to determine the level of electric and magnetic fields (EMF) produced by the substation and aerial line modifications into surrounding areas and, if necessary, to implement measures to reduce EMF levels. In addition, the existing substation will also be assessed to analyse the change of EMF levels from the existing arrangement.

1.4 Limits and Exclusions

The following limits and exclusions have been applied in defining the extent of the EMF model:

- No load flow study was provided for this assessment. All load assumptions are based on typical values during normal operation.
- The modelling will include the cable circuits within the substation and in the immediate vicinity of the substation only. The extent of the EMF sources to be modelled is the equipment (both existing & proposed) within the substation boundary and between Pole 44 and Pole 45. Beyond these extents the existing electrical supply infrastructure will remain as is.
- No modelling of the DC feeders or the railway tracks has been included, as these are not being modified.

2.0 Overview of Magnetic Fields

2.1 Description

Electric and magnetic fields exist wherever electric current flows – in power lines and cables, residential wiring and electrical appliances. Electricity is widely used in modern life, which means magnetic fields are all around us and exist wherever electricity is used,

The Australian Radiation Protection and Nuclear Safety Agency (ARPANSA), an Australian Government agency, is responsible for the regulation of EMF. ARPANSA provides the following definition of Extremely Low Frequency (ELF) electric and magnetic fields (EMF):

> *"Extremely low frequency (ELF) electric and magnetic fields (EMF) occupy the lower part of the electromagnetic spectrum in the frequency range 0-3000 Hz. ELF EMF result from electrically charged particles. Artificial sources are the dominant sources of ELF EMF and are usually associated with the generation, distribution and use of electricity at the frequency of 50 Hz in Australia or 60 Hz in some other countries. The electric field is produced by the voltage whereas the magnetic field is produced by the current."*

The strength of the force associated with an electric field is related to the voltage: the higher the force/voltage, the stronger the electric field. The level of electric field is measured in thousands of volts per metre (kV/m). Electric fields are strongest closest to the source but reduce quickly with distance. In addition, most materials act as a barrier to electric fields.

Magnetic fields are produced by the flow of an electric current: the higher the current (measured in Amperes), the greater the magnetic field. The strength of magnetic fields is measured in milliGauss (mG). Like electric fields, magnetic fields are highest closest to the source but also reduce quickly with distance. The magnetic field strength resulting from an electrical installation varies continually with time and is affected by several factors including: the total electrical load, and the layout and arrangements of the conductors.

In October 2005, the World Health Organisation (WHO) convened a Task Group of scientific experts to assess the potential human health risks associated with exposure to electric and magnetic fields in the frequency range 0 to 100,000 Hz (100 kHz) (WHO, 2007). The Task Group concluded that there are no substantive health issues related to electric fields at levels generally encountered by members of the public as most materials act as a barrier to electric fields. However, the Task Group did identify potential for adverse health effects associated with short-term and long-term exposure to magnetic fields (as discussed in Section 2.2). Therefore, magnetic fields are the primary hazard for consideration in an assessment of potential human health risks associated with the Project.

2.2 Magnetic Fields and Human Health

A number of animal and human studies have been undertaken to assess the potential health effects of exposure to magnetic fields, including that published by WHO (2007)[1] and the International Commission on Non-Ionizing Radiation Protection (ICNIRP, 2010)[2]. A summary of the short-term and long-term health effects identified within this assessment and relevant guidelines are discussed below.

ICNIRP (2010) notes that "*the main interaction of magnetic fields is the Faraday induction of electric fields and associated currents in the tissues. Electric fields may also be induced by movement in a static magnetic field*". Potential human health effects are therefore associated with internal electric fields induced by magnetic fields.

It is important to note when reviewing the following information, that ARPANSA has stated that:

- "*The scientific evidence does not establish that exposure to ELF EMF found around the home, the office or near powerlines and other electrical sources is a hazard to human health*"; and

[1] WHO (2007) Extremely Low Frequency (ELF) Fields – Environmental Health Criteria Monograph No. 238
[2] ICNIRP (2010) ICNIRP Guidelines for Limiting Exposure to Time-Varying Electric and Magnetic Fields (1HZ – 100 kHZ)

- "*There is no established evidence that the exposure to magnetic fields from powerlines, substations, transformers or other electrical sources, regardless of the proximity, causes any health effects*".

2.2.1 Short-term effects

At high levels of short-term exposure, ICNIRP (2010) and WHO (2007) reported that there are established health effects including:

- Direct stimulation of nerve and muscle tissue,
- Induction of retinal phosphenes, and
- Changes in nerve cell excitability in the central nervous system (CNS).

There was also indirect scientific evidence that brain functions such as visual processing and motor co-ordination can be transiently affected by induced magnetic fields.

ICNIRP (2010) states that *"the most robustly established effect of electric fields[3] below the threshold for direct nerve or muscle excitation is the induction of magnetic phosphenes, the perception of faint flickering light in the periphery of the visual field, in the retinas of volunteers exposed to low frequency magnetic fields. The minimum threshold flux density for the induction of retinal phosphenes is around 5mT (50,000 mG) at 20Hz, rising at higher and lower frequencies*".

Health guidelines (discussed further in Section 2.3) are based on this effect because ICNIRP (2010) state that "*avoiding retinal phosphenes should protect against any possible effects on brain function. Phosphene thresholds are a minimum around 20 Hz and rise rapidly at higher and lower frequencies, intersecting with the thresholds for peripheral and central nerve stimulation at which point limits on peripheral nerve stimulation should apply. For workers who are not trained and who may be unaware and not in control of their exposure status the basic restriction is set at the phosphene threshold in order to avoid these transient but potentially disturbing effects of exposure".*

2.2.2 Long-term effects

In 2002, International Agency for Research on Cancer (IARC) published a monograph[4] classifying extremely low-frequency magnetic field as Group 2B "possibly carcinogenic to humans". This classification is used to denote an agent for which there is limited evidence of carcinogenicity in humans and less than sufficient evidence for carcinogenicity in experimental animals. As started by the WHO (2007), *"this classification was based on a pooled analyses of epidemiological studies demonstrating a consistent pattern of a two-fold increase in childhood leukaemia associated with average exposure to residential power-frequency magnetic field above 0.3 to 0.4 μT*". However, WHO (2007) noted that the epidemiological evidence is weakened by:

- Potential selection bias,
- There are no accepted biophysical mechanisms that would indicate that low-level exposure leads to cancer development, and
- Animal studies, for the most part, have been negative.

Other potential health effects associated with long-term exposure to magnetic fields have been studied including other childhood cancers, cancers in adults, depression, suicide, cardiovascular disorders, reproductive dysfunction, developmental disorders, immunological modifications, neurobehavioural effects and neurodegenerative disease. WHO (2007) identified that the scientific evidence supporting these other health effects is much weaker (or not at all) than for childhood leukaemia.

In relation to other potential health effects, ICNIRP (2010) concluded:

- The available data do not indicate that low frequency magnetic fields affect the neuroendocrine system in a way that would have an adverse impact on human health.

[3] i.e. internal electric fields induced by magnetic fields.
[4] International Agency for Research on Cancer. Static and extremely low frequency electric and magnetic fields. Lyon, France: IARC; IARC Monographs on the Evaluation of Carcinogenic Risk to Humans Volume 80; 2002.

- The evidence for the association between low frequency exposure and Alzheimer's disease and amyotrophic lateral sclerosis is inconclusive.
- The evidence does not suggest an association between low frequency exposure and cardiovascular diseases.
- The evidence for an association between low frequency exposure and developmental and reproductive effects is very weak.

A recent review by the European Commission (2015)[5] similarly concluded that overall, existing studies do not provide convincing evidence for a causal relationship between Extremely Low Frequency electric field and magnetic field exposure and self-reported symptoms, and noted the following:

- *"The new epidemiological studies are consistent with earlier findings of an increased risk of childhood leukaemia with estimated daily average exposures above 0.3 to 0.4 μT. As stated in the previous Opinions, no mechanisms have been identified and no support is existing from experimental studies that could explain these findings, which, together with shortcomings of the epidemiological studies prevent a causal interpretation.*
- *Studies investigating possible effects of ELF exposure on the power spectra of the waking EEG are too heterogeneous with regard to applied fields, duration of exposure, and number of considered leads, and statistical methods to draw a sound conclusion. The same is true for behavioural outcomes and cortical excitability.*
- *Epidemiological studies do not provide convincing evidence of an increased risk of neurodegenerative diseases, including dementia, related to power frequency magnetic field (MF) exposure. Furthermore, they show no evidence for adverse pregnancy outcomes in relation to ELF MF. The studies concerning childhood health outcomes in relation to maternal residential ELF MF exposure during pregnancy involve some methodological issues that need to be addressed. They suggest implausible effects and need to be replicated independently before they can be used for risk assessment.*
- *Recent results do not show an effect of the ELF fields on the reproductive function in humans."*

WHO (2007) noted that "*there are uncertainties about the existence of chronic effects, because of the limited evidence for a link between exposure to ELF [Extremely Low Frequency] magnetic fields and childhood leukaemia. Therefore, the use of precautionary approaches is warranted. However, it is not recommended that 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*."

In consideration of the uncertainty regarding long-term effects, WHO (2007) recommended that:

> "*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*"; and
>
> "*Government and industry should monitor science and promote research programmes to further reduce the uncertainty of the scientific evidence on the health effects of ELF field exposure*".

2.3 Health Legislation and Guidelines

ARPANSA has adopted ICNIRP's 2010 'Guidelines for limiting exposure to time varying electric and magnetic fields (1Hz to 100 kHz)', which it regards as international best practice, for application in Australia. The ARPANSA website states:

> "*The ICNIRP ELF guidelines are consistent with ARPANSA's understanding of the scientific basis for the protection of the general public (including the foetus) and workers from exposure to ELF EMF."*

[5] European Commission (2015) Scientific Committee on Emerging and Newly Identified Health Risks SCENIHR Opinion on Potential health effects of exposure to electromagnetic fields

In line with ARPANSA's advice, the ICNIRP (2010) magnetic field Reference Levels have been adopted for this assessment. Within ICNIRP (2010), limitations of exposure that may lead to established health effects (as discussed in Section 2.2.1) are termed 'Basic Restrictions'. The physical quantity used to specify the 'Basic Restrictions' on EMF exposure is the internal electric field strength, as it is the internal electric field that effects nerve and other cells. However, given the difficulties in assessing internal electric field strength, 'Reference Levels' of exposure were derived from relevant Basic Restrictions using measured and/or computational techniques. Reference Levels are defined by ICNIRP (2010) as "*the electric and magnetic fields and contact currents to which a person may be exposed without an adverse health effect and with acceptable safety factors*". The Reference Levels are described by ICNIRP (2010) as "*practical or surrogate" parameters that may be used for determining compliance with the Basic Restrictions*" and "*assume an exposure by a uniform (homogenous) field with respect to the spatial extension of the human body*". However, if the Reference Levels are exceeded it does not necessarily mean that a health effect will occur if it can be demonstrated that the Basic Restrictions are not exceeded.

The recommended ICNIRP (2010) magnetic field Reference Levels are provided in Table 2-1. It should be noted that the Reference Levels (ICNIRP, 2010) were based on established short-term health effects only (as discussed in Section 2.2.1). ICNIRP (2010) concluded that "*a causal relationship between magnetic fields and childhood leukemia has not been established nor have any other long term effects been established. The absence of established causality means that this effect cannot be addressed in the basic restrictions*".

In addition to the ICNIRP guidelines, the WHO also recognises The Institute of Electrical and Electronics Engineers (IEEE) standards including IEEE Standard C95.6:2002 'Safety Levels with Respect to Human Exposure to Electromagnetic Fields, 0-3 kHz'. However, the IEEE levels are much higher than the ICNIRP Reference Levels and were specific to certain body parts, rather than to the person as a whole; therefore, the IEEE levels have not been included herein. It should be noted that ICNIRP *"consider the scientific evidence related to possible health effects from long-term, low-level exposure to ELF fields insufficient to justify lowering these quantitative exposure limits"* (WHO, 2007).

Table 2-1: 50Hz Magnetic Field Reference Levels[1]

Publication	Reference Levels[2]	
	General Public[3]	Occupational[4]
ICNIRP (2010)[3]	200μT (2,000mG)	1,000μT (10,000mG)

Table 2-1 Notes:

1. At 50Hz the most sensitive known impact is to the retinal tissue in the form of magneto-phosphenes.
2. The International System of Units (SI) for magnetic field strength is Tesla (T) and another commonly used unit is Gauss (G), where 1μT = 10mG.
3. The general public is defined as individuals of all ages and of differing health statuses, which may include particularly vulnerable groups or individuals, and who may have no knowledge of or control over their exposure to EMF. Note that a foetus is defined as a member of the general public, regardless of exposure scenario, and is subject to the general public restrictions (ICNIRP 2010).
4. Occupationally-exposed individuals are defined as healthy adults who are exposed under controlled conditions associated with their occupational duties. They are trained to be aware of potential EMF risks and to employ appropriate harm-mitigation measures, and who have the capacity for such awareness and harm-mitigation response it is not sufficient for a person to merely be a worker (ICNIRP 2010).

2.3.1 Personal Medical Devices

As stated in ICNIRP (2010), compliance with the present guidelines may not necessarily preclude interference with, or effects on, medical devices such as metallic prostheses, cardiac pacemakers and implanted defibrillators and cochlear impacts. Interference with pacemakers may occur at levels below the recommended Reference Levels.

For persons wearing Active Implanted Medical Devices (AIMDs), which include pacemakers and implantable defibrillators, the most relevant standard is considered to be European Standard EN 50527-1 (2016) titled 'Procedure for the assessment of the exposure to electromagnetic fields of workers bearing active implanted medical devices'. Clause 4.1.2 of this standard states that:

> "*AIMDs are expected to function as described in their product standards as long as the General Public Reference levels of Council Recommendation 1999/519/EC (except for static magnetic fields) are not exceeded… and where no specific warnings have been issued to the AIMD-Employee*."

In regard to AIMD manufacturers, what this means in practice is that the devices need to be designed with an immunity up to the general public reference levels. Based on the date of the referred European Council recommendation, this means that older AIMDs are considered to be immune up to 100μT (1,000mG).

For persons wearing a hearing aid or cochlear implant there is the standard risk of 50Hz magnetic field noise occurring, which will not damage the devices or the ear. Where the device has a loop system receiver, operating the device in this mode will also function correctly as the magnetic field strength of the induction loop transmissions are to be designed with a high enough signal-to-noise ratio over background magnetic fields (as per EN 60118-4).

Whilst modern AIMDs are expected to be designed with consideration of the current published Reference Levels, due to differences between manufacturers and countries of origin, we recommend any persons concerned consult with their physician.

2.4 Prudent Avoidance

The practice of Prudent Avoidance has been adopted by the Energy Networks Association and most Australian power utilities and distributors. In accordance with the latest advice from ENA EMF Handbook[6], it states:

> "*Prudent Avoidance does not mean that there is an established risk that needs to be avoided. It means that if there is uncertainty, then there are certain types of avoidance (no cost / very low-cost measures) that could be prudent*."

It also states:

> "*Both Prudent Avoidance and the precautionary approach involve implementing no cost and very low-cost measures that reduce exposure while not unduly compromising other issues*."

The application of Prudent Avoidance is addressed in Section 5.

[6] Energy Networks Association (2016), EMF Management Handbook

2.5 Typical EMF Levels

ARPANSA provides a summary of typical magnetic field levels that may be encountered in daily life:

Table 2-2: Typical Magnetic Field Levels Encountered

Location	Source	Typical Range	
		µT	mG
Home(1)	Television	0.02 - 0.2	0.2 - 2
	Pedestal fan	0.02 - 0.2	0.2 - 2
	Refrigerator	0.2 – 0.5	2 - 5
	Kettle	0.2 - 1	2 - 10
	Toaster	0.2 - 1	2 - 10
	Hairdryer	1 - 7	10 - 70
	Electric Stove	0.2 - 3	2 - 30
	Electric Blanket	0.5 - 3	5 - 30
Public Streets / Neighbourhood	Directly under LV/MV Distribution Line	0.2 - 3	2 - 30
	10 m away from LV/MV Distribution Line	0.05 – 0.1	0.5 - 10
	Directly under HV Transmission Line	1 - 20	10 - 200
	At the edge of HV Transmission Line Easement	0.2 - 5	2 - 50
	Above underground cables (voltage not defined)	0.5 - 20	5 - 200

Table 2-2 Notes:

1. The range of typical magnetic field levels associated with common household appliances are at normal user distances.

3.0 Desktop Review

3.1 Reference Documents

The assessment is based on the following documents:

Table 3 Reference Drawings and Design Packages

Drawing Number	Title
EL 0011123 (Rev C)	Mortdale Substation HV Outdoor Area Arrangement & Earthing Plan
CV 719350 (Rev B)	MTMS2 – Mortdale Maintenance Centre Bogie Exchange System – Concept Design Package

3.2 Modelling Inputs

In undertaking this EMF assessment, the following assumptions have been considered:

Existing Mortdale Maintenance Centre Substation

- 33kV busbar current flow is assumed 140A for an estimated 8MVA load
- 11kV cable current flow is assumed 210A for an estimated 4MVA load
- 33kV busbars are at 4.5m above the ground
- 33kV aerial pole attachments are at 7m above the ground
- 11kV cable trench is 1m below the ground
- Primary winding current flow is assumed 8.75A per phase for each 500kVA transformer
- 30 degrees phase shift in 33kV/415V transformer

Proposed Mortdale Maintenance Centre Substation

- 33kV aerial conductors are 7m above the ground (flat configuration) for both poles with assumed current flow of 140A for an estimated 8MVA load
- 11kV cables are located inside a conduit 1m below the ground with assumed current flow of 210A for an estimated 4MVA load
- The proposed 11kV substations are typical as per ASA Standard EP 16 00 00 02 SP
- 30 degrees phase shift in 11kV/415V transformer
- The ISMSB busbar current flow is assumed 778A for 70% loading of 800kVA per transformer
- The loading values summarised and applied in the assessment are relevant to the short-term effects. It is conservative to use these for long-term exposure considerations. However, to accurately assess this (and remove conservatism) would require knowledge of the actual load profiles over the course of one year which is not available.

3.3 Points of Interest

These places are nearby the Mortdale Maintenance Centre substation where both public or staff could be exposed to the magnetic fields:

- Georges River College Oatley Senior Campus (High School) – located 70m east of the existing Mortdale Maintenance Centre substation.
- Oatley Senior Citizen Centre (Community Centre) – located 145m south of the existing Mortdale Maintenance Centre substation.
- Mortdale Maintenance Centre Staff meal room and toilets – located inside Mortdale Maintenance Centre site and 5m north of the existing Mortdale Maintenance Centre substation.

4.0 Modelling Analysis

4.1 Approach

The magnetic field contributions of the Mortdale Maintenance Centre substation have been modelled in the HIFREQ module of the CDEGS software package. The purpose of these calculations provides an understanding of the magnetic field contribution likely to be associated with the substation modifications. In all cases, the field contributions have been calculated at a height of 1m above ground in accordance with international practice. The total field level at any point will be the vector sum of all of the field contributions of the various underground and above ground sources associated with the substation, and any other electrical infrastructure.

4.2 Magnetic Fields at the Existing 33kV/415V Substation

Figure 2 shows the existing magnetic field contribution calculated within and around the substation, due to aerial feeders and substation equipment. The sources of EMF are from the 33kV feeders, 11kV cables, 33kV busbars and the 33kV/415V transformers.

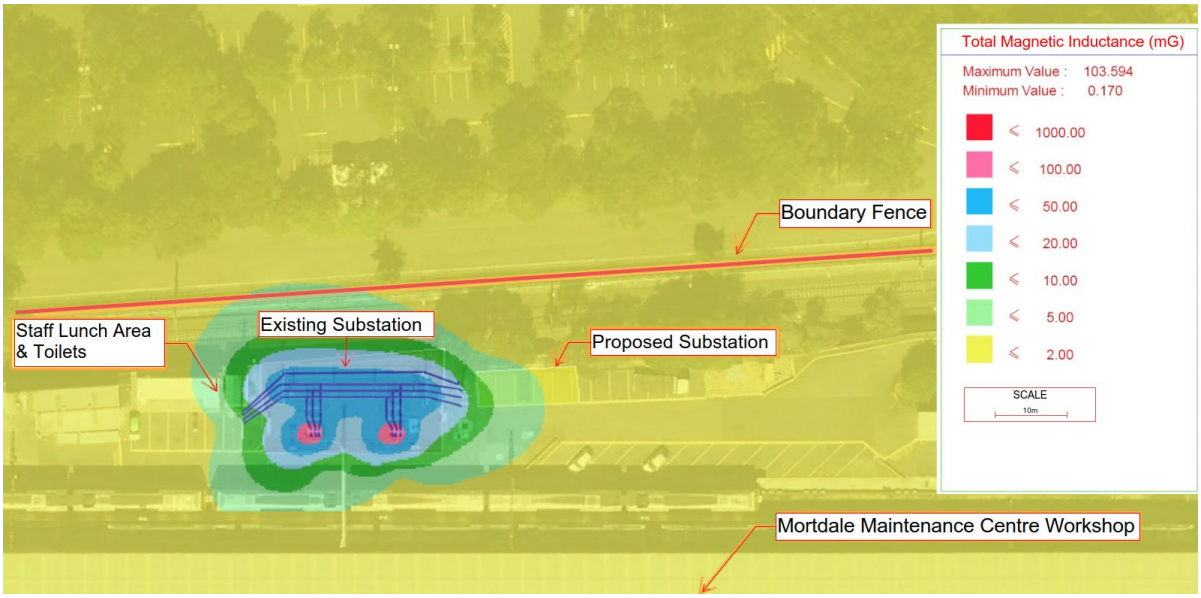

Figure 2 Existing Mortdale Maintenance Centre Substation – magnetic field contributions

The following observations are made with regard to the forecasted magnetic field contribution from the existing Mortdale Maintenance Centre substation:

- The magnetic field levels 1m above ground level within the substation are highest in the areas in the immediate vicinity of the 33kV busbars and transformers. These fields are predicted to reach approximately 104mG which is below the occupational guideline reference level of 10,000mG.
- The magnetic fields are considered negligible level (less than 2mG) at the substation eastern boundary fence. This is well below the public guideline reference level of 2,000mG.
- The highest predicted magnetic fields are up to 5mG at Staff Lunch Area & Toilets close to Pole 44. This is well below the public guideline reference level of 2,000mG. The magnetic fields drop to negligible level (less than 2mG) approximately 5m away from Pole 44.

4.3 Magnetic Fields at the Proposed 11kV/415V Mortdale Maintenance Centre Substation

The predicted EMF levels from the proposed Mortdale Maintenance Centre substation are shown in Figure 3.

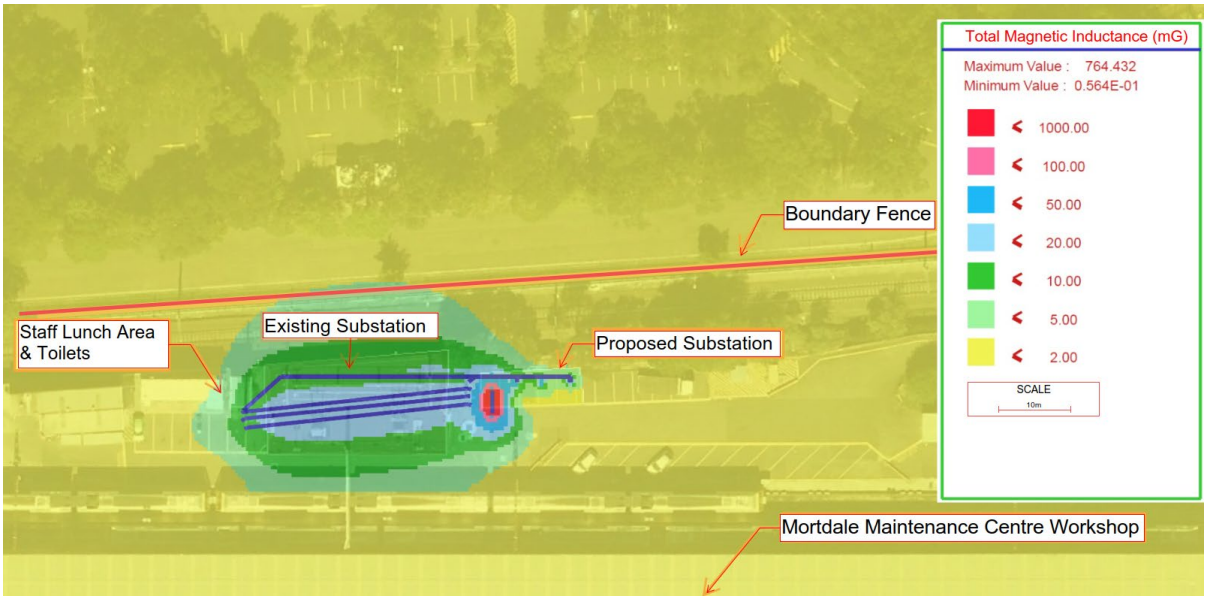

Figure 3 Proposed Mortdale Maintenance Centre Substation – magnetic field contributions

The following observations are made with regard to the forecast magnetic field contribution from the proposed Mortdale Maintenance Centre substation:

- The magnetic field levels 1m above ground level within the substation are highest in the areas in the immediate vicinity of the 11kV/415V transformers and 415V busbars inside the ISMSB. These fields are predicted to reach approximately 574mG which is below the occupational guideline reference level of 10,000mG. Note the metallic enclosures (including the ISMSB) have not been modelled and the magnetic field results presented are conservative.
- The predicted magnetic field levels 1m above ground level under the proposed 33kV aerial lines are predicted to reach up to 20mG.
- The predicted magnetic field levels 1m above ground level above the 11kV cables underground are predicted to reach up to 10mG.
- The magnetic fields are considered negligible level (less than 2mG) at the substation eastern boundary fence. This is well below the public guideline reference level of 2,000mG.
- The highest predicted magnetic fields are up to 5mG at Staff Lunch Area & Toilets close to Pole 44. The magnetic fields drop to negligible level (less than 2mG) at approximately 10m away from Pole 44.

5.0 Prudent Avoidance Measures

As noted in Section 2.4, prudent avoidance is to be applied whereby any available low-cost measures should be adopted to reduce magnetic field exposure whilst not resulting in additional constraints.

The summary of the available mitigation measures for further reducing magnetic fields in accordance with the Prudent Avoidance approach are:

- For the new 33kV aerial line section, we recommend the design apply a delta arrangement, if practical, to maximise the magnetic field cancellation.
- The new 11kV cable is understood to be a three core cable, which is preferred over single core cables to maximise the magnetic field cancellation.
- The design has located the substation within the Mortdale Maintenance Centre site, in an area where general public access is unlikely.
- Openly share to public and staff the EMF health issue and the proposed facilities.
- Ensure staff awareness of the EMF health issue and field sources within the substation.
- Staff with medical implants should consult with their physician if working in high EMF exposure areas.

Although the benefits of these measures could not be certain, they would still be aligned with the concept of prudent avoidance.

6.0 Summary

AECOM has assessed the magnetic field contributions associated with the Mortdale Maintenance Centre Upgrade as part of More Trains, More Services against the relevant health guidelines and the principles of Prudent Avoidance.

The magnetic field sources from the proposed Mortdale Maintenance Centre Upgrade are the new 33kV aerial feeders, 11kV cables, three padmount substations and the ISMSB busbars. The predicted magnetic field in all locations are confirmed to be well below the Reference Levels applied to the general public and staff. Therefore, no adverse effects are expected, as there will be minimal change to the existing arrangement.