Chapter 22
Electromagnetic Effects and Stray Current

Table of contents

22. ELECTROMAGNETIC EFFECTS AND STRAY CURRENT ... 22/2
22.1 Introduction ... 22/2
22.2 Legislation, policy and guidance ... 22/3
22.2.1 Legislation ... 22/3
22.2.2 Policy and guidance ... 22/4
22.3 Methodology ... 22/4
22.3.1 Study area ... 22/5
22.3.2 Survey methodology ... 22/6
22.3.3 Assessment methodology ... 22/7
22.3.4 Consultation ... 22/13
22.3.5 Difficulties encountered/ limitations ... 22/14
22.4 Receiving environment ... 22/14
22.4.1 Description and categorisation of the receiving environment ... 22/14
22.4.2 Baseline Survey Results ... 22/24
22.5 Description of potential impacts ... 22/27
22.5.1 Potential construction impacts ... 22/27
22.5.2 Potential operational impacts ... 22/28
22.6 Mitigation measures ... 22/40
22.6.1 Embedded mitigation specific to Intel ... 22/40
22.7 Monitoring ... 22/42
22.8 Residual Effects ... 22/42
22.9 Cumulative Effects ... 22/43
22.9.1 Cumulative Electromagnetic Fields ... 22/43
22.9.2 Cumulative Stray Current ... 22/43
22.10 References ... 22/43

22. ELECTROMAGNETIC EFFECTS AND STRAY CURRENT

22.1 Introduction

Radiation is referred to throughout this chapter by reference to a number of terms including Electromagnetic Radiation (EMR), Electromagnetic Spectrum, electric and magnetic fields (e.g. Direct Current (DC) fields, Alternating Current (AC) fields and Radiofrequency fields), Electromagnetic Compatibility (EMC) and Electromagnetic Interference (EMI). A description of stray current is also provided.

EMR is a phenomenon that takes the form of self-propagating waves in air or in water. It consists of electric and magnetic field components which oscillate in phase perpendicular to each other and perpendicular to the direction of energy propagation. E MR is classified into several types according to the frequency of its wave; these include (in order of increasing frequency and decreasing wavelength) radio waves, microwaves, terahertz radiation, infra-red radiation, visible light, ultraviolet radiation, x-ray and gamma rays. A small and somewhat variable window of frequencies is sensed by the eyes of various organisms; this is what we call the visible spectrum or light. EMR carries energy and momentum that may be imparted into matter with which it interacts.

The Electromagnetic Spectrum covers a very wide frequency range and there are many aspects of it with which we are familiar and exposed to on a daily basis.

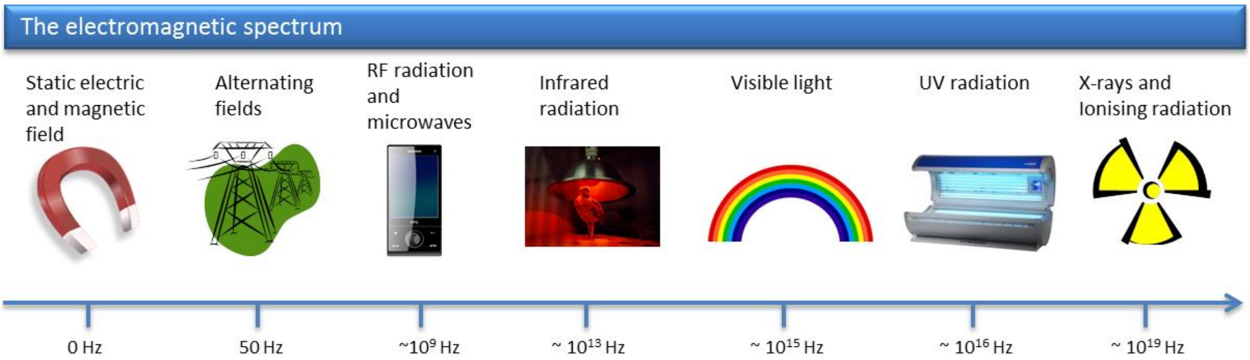

Figure 22-1 The Electromagnetic Spectrum

The electromagnetic spectrum is so called because it comprises electric and magnetic fields, hence the term "electromagnetic". At the beginning of the electromagnetic spectrum, we have static fields. The most common static field is the earth's magnetic field in which we are all immersed at all times. As we move up the electromagnetic spectrum, we reach the frequency used by electricity (50 Hz) and we are also continuously surrounded by fields at this frequency as they are a by-product of domestic appliances and wiring. At higher frequencies we enter the radiofrequency range. These are so called as they radiate and pass freely through the air. We rely on radiofrequency waves to receive TV and radio. There are also many communications systems using these frequencies for mobile phones, air traffic control, Garda radio etc.

As the electromagnetic spectrum is a scarce resource and is used for safety critical applications it is carefully protected by EU Directives and National Regulations. This means that all equipment placed on the EU market, including rail systems, must meet strict emissions limits. Sources of EMF in the existing environment includes items such as electrical equipment, power lines, telephone lines, signals from existing telecommunications masts (mobile phone and radio), underground communication cables, electrified trains, broadcast transmitters etc. The emissions from these sources combine to make up the current electromagnetic baseline environment.

The proposed project will generate electric and magnetic fields which can be categorised in three ranges:

- Direct Current (DC) fields and Quasi DC fields, generated by the traction system which powers the trams.

- Alternating Current (AC) fields, generated by the electricity drawn by the system from the ESB and used to power the equipment at all the stops.
- Radiofrequency fields, generated by the systems used for communications and, also a by-product of every electrical and electronic systems such as the train drive systems, signalling systems etc.

The construction and operation of the new system poses the potential for EMI on receptors. The following potentially sensitive receptors were considered:

- Local residents and the community.
- Domestic and industrial electrical equipment.
- Telecommunications infrastructure (including wireless radio services).
- Sensitive medical and research equipment.
- Utilities.
- Mainline rail, suburban rail, and light rail systems.

Electromagnetic compatibility (EMC) relates to the ability of different EM devices to function properly when they are situated in the same environment, i.e. it relates to the compatibility between different devices. EM devices can generate and propagate energy causing EMI. Devices can also receive and be interfered with by energy generated and propagated by other devices in the same environment. If an EM device is not compatible with other devices in the same environment, EMI can lead to the device not functioning properly. High levels of EMR can also cause adverse health effects in human beings. Electromagnetic Fields (EMF) comprise an electric field and a magnetic field and are emitted from both natural and manmade sources in the environment. All sources of EMF below 300GHz in the electromagnetic spectrum are considered Non-Ionising Radiation, which means the EMF do not carry enough energy to remove an electron from its atomic structure unlike what is classed as ionising radiation such as Gamma rays or X-rays.

EM fields are a combination of E-Fields and M-Fields which interact with each other. Both are discussed within this chapter. While both are associated with each other the simplest way to consider each is that the E-Field is related to the voltage of an EM source while the M-Field is related to the current (charges) flowing. Where the dominant or most applicable component of an EM field is the E-Field or the M-Field, they will be discussed as such. For clarification also, M-Field is used as the general term and can refer to either the Magnetic Field Strength (H-Field) or the Magnetic Flux Density (B-Field) which are two related vectors.

Stray current is a phenomenon associated with any electrified rail system and occurs when current leaks from the rails and passes through other nearby metallic structures. The current flowing into and out of the structure can result in corrosion. The structures potentially at risk are usually large electrically conductive systems such as utility pipes or cables running close to and parallel with the track.

22.2 Legislation, policy and guidance

22.2.1 Legislation

Córas Iompair Éireann is applying to An Bord Pleanála for a Railway Order for the DART+ West project under the Transport (Railway Infrastructure) Act 2001 (as amended and substituted) ("the 2001 Act") and as recently further amended by the European Union (Railway Orders) (Environmental Impact Assessment) (Amendment) Regulations 2021 in Statutory Instrument No. 743/2021 ("the 2021 Regulations"). The purpose of the 2021 Regulations was to give further effect to the transposition of the EIA Directive (EU Directive 2011/92/EU as amended by Directive 2014/52/EU) on the assessment of the effects of certain public private projects on the environment by amending the 2001 Act. The proposed project is required to comply with the requirements of the European Directive on Electromagnetic Compatibility (2014/30/EU).

The proposed project is required to comply with the requirements of the European Directive on Electromagnetic Compatibility (2014/30/EU), and European Standards EN 50121 (Parts 1-5), which address railway

Electromagnetic Compatibility (EMC). In addition, all electrical and electronic products placed on the market or taken into service in the European Union must comply with all applicable directives which include the above EMC Directive, the Low Voltage Directive (2014/35/EU) and the Radio Equipment Directive (2014/53/EU). These directives have been transposed inter alia by S.I. No. 145/2016 - European Communities (Electromagnetic Compatibility) Regulations 2016; S.I. No. 248/2017 - European Union (Radio Equipment) Regulations 2017; S.I. No. 345/2016 - European Union (Low Voltage Electrical Equipment) Regulations 2016

Further, the proposed development is assessed by reference to the guidelines on limiting exposures to electromagnetic fields as published by the International Commission on Non-Ionising Radiation Protection (ICNIRP) and the EU EMF Recommendation (1999/519/EC) when addressing human health effects.

The Electromagnetic Compatibility Directive (2014/30/EU) and the Radio Equipment Directive (2014/53/EU) do not cover emissions from DC and near DC fields (also known as quasi-DC fields) which are also an interference risk to particularly sensitive equipment such as Scanning Electron Microscopes (SEMs) and Magnetic Resonance Imaging (MRI) equipment. Nonetheless an assessment of this type of EMI will be included in the scope of the investigation.

Potential impacts from stray currents arising from the operation of the system will also be covered as per European Standard EN 50122-2.

22.2.2 Policy and guidance

The following guidelines were considered and consulted in the preparation of this chapter:

- Environmental Protection Agency (EPA) Guidelines on the Information to be contained in Environmental Impact Statements (EPA 2002).
- Advice Notes on Current Practice (in the preparation of Environmental Impact Statements) (EPA 2003).
- Draft Advice Notes for Preparing Environmental Impact Statements (EPA 2015a).
- Guidelines on the Information to be contained in Environmental Assessment Reports (hereafter referred to as the EPA Guidelines) (EPA 2022).

Additionally, the scope and methodology for the baseline assessment has been devised in consideration of the following guidelines:

- EN 50121-2:2006 Railway applications - Electromagnetic compatibility Part 2: Emission of the whole railway system to the outside world.
- International Commission on Non-Ionising Radiation Protection (ICNIRP) Guidelines for limiting exposure to time-varying electric, magnetic, and electromagnetic fields (up to 300GHz). Health Physics 74 (4): 494-522; 1998.
- EU Council Recommendation on the limitation of exposure of the general public to electromagnetic fields (0Hz to 300GHz) 1999/519/EC.

22.3 Methodology

The baseline environment is defined as the existing environment against which future changes can be measured.

This section describes the methods applied in assessing the baseline environment from an EMI and Stray Current perspective. It discusses how potentially sensitive receptors along the alignment were identified along with key stakeholders. It also details the criteria applied in assessing the significance of effects from EMI and Stray current impacts based on the predicted EMR from the system and the known sensitivities of specific receptors in the receiving environment.

The baseline radiation and stray current environment has been defined through a desktop study, consultation with relevant stakeholders and field surveys. The baseline environment is then categorised using the criteria outlined and baseline ratings are assigned. These baseline ratings are subsequently used when considering the significance of effects for each receptor.

22.3.1 Study area

In determining the size of the study area, the following key aspects of the proposed project were reviewed with the intent of identifying a corridor of influence (i.e. a specific distance) either side of the proposed alignment:

- Proposed electrification scheme.
- Design features of the traction power feed systems including:
  - Overhead line.
  - Return rails.
  - Substation locations.

Electromagnetic field strengths dissipate over distance. The precise distance at which EMI could be considered an influence will depend on the sensitivity of individual receptors. The protection distance provided in the European Directive on Electromagnetic Compatibility (2014/30/EU) is 10 m and therefore all systems located 10 m or greater from the rail system should not encounter radio frequency interference.

However, due to the potential for extremely sensitive equipment to be used in some facilities in the study area such as medical, research, industrial etc. the corridor of influence was widened to 100 m for the following receptor types:

- Research facilities (including universities and third level institutes).
- Medical centres.
- Dental facilities.
- Hospitals.
- Scientific institutions.
- Industry with potentially sensitive equipment.
- Mixed sensitive land uses.
- Veterinary clinics.
- Theatre's or recording studios.
- Utilities.

A narrower corridor of 10 m was used for the following receptor types:

- Day-care facilities.
- Elderly housing.
- Educational facilities (excluding universities and third level institutes).
- Heritage buildings.
- Churches.
- Hospitality.
- Opticians.
- Residential.
- Offices and corporate land uses.

Table 22-1 below details the study area either side of the alignment and distinguishes between the different EMI sources and the maximum distance at which they may cause an impact.

Table 22-1 Study area

Criteria	Width of study area (on both sides of the alignment) with respect to field types	
	Wide corridor receptors	Narrow Corridor receptors
Potential impacts from Direct Current (DC) fields	100 m	10 m
Potential impacts from Alternating Current (AC) fields	100 m	10 m
Potential impacts from Radiofrequency (RF) and microwave fields	100 m	10 m
Potential impacts from stray currents	100 m	10 m

22.3.2 Survey methodology

The data sources utilised to identify potentially sensitive land uses/receptors and stakeholders within the study area included the following:

- Ordnance Survey Ireland (OSI) maps.
- Google maps™.
- Land use surveys and mapping undertaken as part of proposed project.
- Utilities maps.
- Site visits of sections of the alignment to confirm that desktop data was up to date. For example, available directories for business, technology and industrial parks do not always reflect the current uses.

These sources of information were combined to create a database of stakeholders. This included medical centres (including dentists), entertainment venues, domestic and commercial premises, hospitals, schools, universities etc. Based on desktop study the EMI consultant listed stakeholders in the study area who could potentially possess equipment sensitive to EMI associated with the electrification scheme. The stakeholders were sent a questionnaire to gather information on the specific location and type of any electrical or electronic equipment that may be potential sensitive equipment to EMI from the proposed development

A subgroup of all these stakeholders were categorised as major stakeholders. These were organisations with either large campuses or networks (such as utilities, rail etc.). The likelihood of these major stakeholders having particularly sensitive equipment to EMI from DC rail systems was considered to be higher. This included hospitals, universities, rail operators etc. Due to the size and complexity of these organisations meetings and presentations were undertaken in order to present information about EMI, how it manifests itself, and to provide assistance in compiling their sensitive equipment lists.

As well as reviewing the equipment lists provided by all the stakeholders that engaged in the consultation process, some sites were chosen to perform EMI baseline surveys. It was key to establish the current EMR baseline environment within which equipment and systems were being operated and whether any known issues already existed.

A baseline survey was performed at the location where the Maynooth line meets the northern DART line. It is at this location that an electrified rail already exists in the environment. A survey was also performed at a location where there were no electrified lines and was also adjacent to one of the major identified stakeholders adjacent to the Intel campus at Leixlip.

In summary the following data sources were used in identifying and categorising the baseline environment.

Table 22-2 Baseline data sources

Information acquired	Data sources
Sensitive land uses / receptors	• Project land use mapping. • Google maps. • OSI maps. • Site visits to sections along the proposed development (for example business and industrial parks). • Stakeholder questionnaires. • Utilities maps. • Industrial Estate Directories. • Major stakeholder meetings and presentations.
Baseline EMR profile	• Monitoring conducted at selected sites using broadband radiation meters, spectrum analysers and appropriate antennas. The frequency range covered was from DC (0 Hz) to 18 GHz i.e. including DC, AC, RF and Microwave frequencies

22.3.3 Assessment methodology

22.3.3.1 Methodology for categorisation of the baseline environment

This section of the baseline report categorises the baseline radiation and stray current environment. The baseline environment is assigned a baseline rating based on importance, sensitivity and existing adverse effects of the receiving environment. Each of these three terms is explained in detail in this section. The professional opinion of the specialist also plays an important role in assigning the baseline rating. The baseline rating will subsequently be used in the impact chapter to determine the significance of effects for each.

22.3.3.1.1 Importance of the baseline environment

The importance of a receptor is determined by how serious the consequences of its failure or malfunction would be. Receptors are considered to be important if their loss causes widespread disruption or if safety issues arise if they malfunction.

EMI can potentially affect equipment in medical centres, safety signalling and navigational equipment in railways and airports and certain medical equipment in the home. Such receptors are therefore important because of the potential safety issues that could arise.

EMI can also affect wider infrastructure facilities such as telecommunications equipment and cabling, electrical substations, computer screens and sensitive instruments in industrial and educational facilities. These receptors are therefore also considered to be important.

Stray current can cause corrosion in metal structures such as utility pipes and cables, reinforcing bars in bridges and buildings and underground fuel tanks, particularly where such infrastructure runs parallel and close to the alignment. Because of the safety implications of such corrosion and because loss of the infrastructure concerned may be potentially disruptive, such receptors are also considered to be important.

22.3.3.1.2 Sensitivity of the baseline environment

The sensitivity of a receptor is determined by how readily it will fail or malfunction in the presence of external EMR. Equipment which fails when exposed to even weak fields is considered to be sensitive, while equipment which continues to operate in much stronger fields is considered to be non-sensitive.

Equipment which relies on EM fields to operate, e.g. radio receivers, TV and telecommunications receivers and many types of rail signalling systems, is most sensitive to external radiation which happens to be at the same frequency as the equipment is designed to operate. Such equipment is considered to be sensitive at that frequency.

On the other hand, non-radio equipment continues to operate in much stronger fields and so is generally considered to be non-sensitive. However, certain types of medical and high-end research equipment, such as LINACs and SEMs are known to be susceptible to strong AC and DC fields and are therefore also classed as sensitive.

Some facilities already exist and operate in an adverse EM environment. The purpose of the stakeholder consultations was to identified pre-existing interference issues due to particularly sensitive equipment being in close proximity to high EM field generating sources.

In relation to utilities and stray current the most notable utilities are those that run close and parallel to the alignment for long distances. These were identified and listed as part of the Baseline Description and Categorisation (22.4.1) while shorter cable/pipe runs and those not running parallel for large distances are not listed.

22.3.3.1.3 Baseline rating

The baseline rating of the existing radiation and stray current environment is determined by having regard to the range of criteria which reflect its importance, sensitivity and existing adverse effects of the baseline environment. The criteria that have been defined for EMR and stray current are shown in Table 22-3 and Table 22-4 respectively.

Table 22-3 Criteria for baseline categorisation with respect to EMR

Criteria	Baseline rating
Any facilities that have highly sensitive equipment on the premises on a permanent basis. Public/private health facilities. Signalling on rail networks. Highly sensitive equipment in universities, colleges and schools	Very high
Telecommunications infrastructure. Public/private scientific/research institutes. Medical Centres including dentists and vets. Universities, colleges and schools that may have potentially sensitive equipment. Emergency services mobile radio. Locations with installations of custom audio-visual equipment.	High
Any facilities that have sensitive equipment on the premises on a permanent basis Some residential areas, e.g. containing specific medical equipment. Industrial facilities with potentially sensitive equipment. Universities, colleges, and schools which do not have sensitive equipment	Medium
All other residential areas. Mixed units with a residential component. Electricity substations with earthing equipment. Educational institutions without sensitive equipment.	Low
All other areas.	Very low

Table 22-4 Criteria for baseline categorisation with respect to stray current

Criteria	Baseline rating
Any ground embedded metal shielded facility which has a high requirement for safety, e.g. high-pressure gas or water pipes. Chemical industry installations. Large ground embedded fuel tanks, e.g. fuel depot. Signalling on rail networks.	Very high
Any ground embedded metal shielded facility which has a medium requirement of safety, e.g. low-pressure gas or water pipes, heating pipes.	High

Criteria	Baseline rating
Pre-stressed reinforcement of tunnels, bridges or port structures other than the proposed Project structures. Metal shielded cables. Other rail infrastructure, e.g. track Small ground embedded fuel tanks, e.g. a petrol station.	Medium
Other metal reinforced structures parallel to the alignment with a minimum length of 100m (e.g. buildings)	Low
Industrial facilities with large metal structures. All other areas.	Very low

By way of informing the baseline assessment, and following consultations, monitoring of DC magnetic fields, AC electromagnetic fields and RF electric fields was conducted at selected sites.

For the purpose of assigning a baseline rating for stray current, the rating levels were selected based on a combination of the length of the buried structures and known sensitivities of such structures.

22.3.3.2 Methodology for predicting theoretical worst case EMR levels

Electromagnetic emissions may be generated by either the power supply system such as electrical substations, the current supply system along the alignment, or the propulsion system onboard the rolling stock. The proposed project itself could be susceptible to external electromagnetic fields that are generated by sources such as electricity cables and RF transmitters.

Stray currents could potentially occur on nearby receptors including buried tanks, water pipes and utilities running parallel to the system. The entry/exit points of these potential receptors for the stray current may experience corrosion over time without adequate mitigation measures.

Rail systems can generate transient emissions that are not controlled by EMC regulations. Such transients can pose a threat to the operation of neighbouring electrical and electronic equipment.

Large electrical installations can also cause voltage fluctuations on the public supply that can cause the phenomenon of flicker. Flicker is evident when lighting dims and can cause a nuisance to local residents and other sensitive receptors. This will be mitigated by the power profile of the current draw from the proposed project. The current will be gradual rather than a step change.

Electrical design details such as traction system voltages, load currents, distances between rails and overhead lines were all utilised and fed into models to ascertain predicted magnetic field levels (both DC and AC) at different distances from the alignment. The highest specified working currents were utilised to inform these models as these would result in the highest field levels and therefore worst case EMR levels.

Modelling was not required for RF and Microwave field levels whose magnitudes are strictly governed by European EMC and RED Directive limits.

22.3.3.3 Methodology for evaluating impacts and the significance of effects for equipment

For the purpose of this appraisal the receptor types were categorised into three groups based on their perceived sensitivity to specific levels of EMR:

Group 1:

- Day-care facilities.
- Elderly Housing.
- Educational facilities (excluding universities and third level institutes).
- Heritage buildings.
- Churches.

- Hospitality.
- Opticians.
- Residential.

Group 2:

- Offices and corporate premises (including state offices).
- Industry with potentially sensitive equipment.
- Mixed sensitive land uses.
- Theatre/Recording studios.
- Dental facilities.

Group 3:

- Research facilities (including universities and third level institutes).
- Scientific Institutions.
- Medical Centres.
- Hospitals.

A narrow corridor of 10 m is used for the following receptor types: Group 1. Table 22-5 illustrates how these receptors were scored in relation to specific EMR levels. Below is an explanation of why particular levels were chosen.

In terms of defining the significance of effects the following rationale was applied:

- Imperceptible → There is no indication of any changes to the baseline electromagnetic environment.
- Slight → A localised change to the baseline that is measurable with specialised instrumentation but with no noticeable changes to the operability of equipment.
- Moderate → Some equipment operators may notice additional noise affecting their equipment's performance at certain sensitivity settings.
- Significant → Levels significant enough to cause a nuisance for the performance of routine tasks e.g. running a standard MRI scan.
- Profound → Some equipment rendered inoperable. Potential safety limits for human exposure to EMR exceeded.

Table 22-5 Impact magnitude and significance of effects

Magnitude		Significance of effect		
Field Type	Limit	Group 1 (Residential / Schools)	Group 2 (Industrial / Commercial)	Group 3 (Sensitive Research / Hospitals)
DC Fields	> 500 µT	Profound	Profound	Profound
	> 50 µT	Moderate	Significant	Significant
	> 10 µT	Slight	Moderate	Significant
	> 1 µT	Imperceptible	Slight	Moderate
	> 0.1 µT	Imperceptible	Imperceptible	Slight
	> 0.01 µT	Imperceptible	Imperceptible	Slight
AC and 50 Hz Fields	> 38 µT	Profound	Profound	Profound
	> 3.8 µT	Moderate	Significant	Significant
	> 1.3 µT	Slight	Moderate	Moderate
	> 0.5 µT	Imperceptible	Slight	Slight
	> 0.05 µT	Imperceptible	Imperceptible	Imperceptible

Magnitude		Significance of effect		
Field Type	Limit	Group 1 (Residential / Schools)	Group 2 (Industrial / Commercial)	Group 3 (Sensitive Research / Hospitals)
RF and Microwave Fields	> 10 V/m	Profound	Profound	Profound
	> 3 V/m	Moderate	Profound	Profound
	> 1 V/m	Slight	Slight	Moderate
	> 0.1 V/m	Imperceptible	Imperceptible	Slight
	> 0.01 V/m	Imperceptible	Imperceptible	Imperceptible

The DC limit of 500 µT is based on the implantable medical devices standard EN 45502-2-1 which requires units to comply with this exposure level.

The 50 µT DC magnetic field limit is based on the typical immunity level of some sensitive hospital equipment. It should be noted that there may be particular items of equipment with lower immunity levels.

Residential and commercial locations are classified as slight and moderate for DC magnetic fields greater than 10 µT respectively, while the most sensitive of medical and scanning equipment is known to have manufacturer specified sensitivities of as low as 1 µT and 0.1 µT.

The AC and RF field limits are based on the immunity levels listed in harmonised standards under the Electromagnetic Compatibility (EMC) Directive 2014/30/EU. 38 µT is the AC magnetic field immunity test levels for industrial equipment while 3.8 µT is for residential equipment and 1.3 µT from EN 55035 for multimedia equipment. Similarly, the levels of 10 V/m, 3 V/m and 1 V/m are some of the different immunity test levels for industrial, domestic and IT equipment.

Stray current levels cannot be modelled due to the magnitude of buried structures and utilities in the urban environment that run parallel to the alignment and the existence of other stray currents already present from the likes of the DART and Luas systems. So, for the purpose of assessing the impact significance from stray currents the significance of effects was derived from the original baseline rating for such structures.

Where the significance of effects for a specific parameter are evaluated to be significant to profound, they were determined to have a quality of effect of negative and mitigation measures discussed in 22.6 can be explored. For an imperceptible to moderate significance of effects, these were determined to have a quality of effect of neutral.

22.3.3.4 Methodology for evaluating impacts and the significance of effects for the general public

The Irish Government establishes expert groups from time to time to advise on EMF or more specifically exposure to EMF. In Ireland Government policy is set by the Department of Communications, Climate Action and Environment which continues to adopt the guidelines developed by the International Commission on Non-Ionizing Radiation Protection (ICNIRP). The ICNIRP guidelines are endorsed by the World Health Organisation (WHO) and the European Union.

In 2019 the Government published a Statutory Instrument (S.I. No 190/2019) which assigns responsibility to the Environmental Protection Agency for providing advice to the Government and the public on exposure to electromagnetic fields.

The values used in Table 22-5 are mostly derived in relation to equipment. The limit levels for human exposure are many times higher again.

Internationally the allowable exposure levels for EMF are published by ICNIRP, which are frequently updated. ICNIRP has issued guidelines for limiting exposure to static and time varying electric and magnetic fields up to 300 GHz. The latest update on static fields is covered by:

- ICNIRP Guidelines on limits of exposure to Static Magnetic Fields published in Health Physics; 2009.

The latest update on time-varying fields is covered by:

- ICNIRP Guidelines for limiting exposure to time varying electric, magnetic and electromagnetic fields (up to 300 GHz) published in Health Physics; 2009.

The ICNIRP limits have been adopted by the European Commission for both public and occupational application. For occupational purposes, a directive was published:

- Directive 2013/35/EU of the European Parliament and of the Council of 26 June 2013 on the minimum health and safety requirements regarding the exposure of workers to the risks arising from physical agents (electromagnetic fields).

While for public application, the EU published a Council Recommendation:

- 1999/519/EC: Council Recommendation of 12 July 1999 on the limitation of exposure of the general public to electromagnetic fields (0 Hz to 300 GHz).

Note: For reference, that the earth's magnetic field is between 30 micro-Tesla and 70 micro-Tesla (from equator to poles) and is a static field that is present everywhere on the earth. The level in Ireland is around 49 micro-Tesla. The ICNIRP limit for static magnetic fields, included in the Council recommendation, is 40 milli Tesla (40,000 micro-Tesla). In accordance with the Council recommendation, this limit applies only where the time of exposure is significant.

In addition to the health limits outlined in the above Directives and Council recommendations, there are also limits for EMC and potentially susceptible devices such as AIMDs. These include devices such as cardiac pacemakers, implanted defibrillators, cochlear implants and similar devices. Devices such as pacemakers have particular standards that they need to adhere to with respect to electromagnetic fields. One such example is EN 50527-2-1:2016 "Procedure for the assessment of the exposure to electromagnetic fields of workers bearing active implantable medical devices. Specific assessment for workers with cardiac pacemakers", which states that pacemakers are expected to work uninfluenced as long at the General Public Reference levels of Council recommendation 1999/519/EC are not exceeded. The ICNIRP notes that these levels can be as low as 500 micro-Tesla. The occupational EMF Directive 2013/35/EU states an action level of 500micro-Tesla for static magnetic fields reasoned by interference with the operation of AIMDs.

The ICNIRP limits for occupational exposure are an order of magnitude higher than for public exposure therefore the public guideline limits are chosen here since they are the most stringent to apply. These are the same limits that are outlined in the 1999/519/EC Council Recommendation. Table 22-6 shows the reference levels for public exposure to time-varying electric and magnetic fields.

Table 22-6 ICNIRP EMF Guidelines

Frequency Range	Electric Field Strength V/m	H-Field A/m	B-Field µT	Equivalent plane wave power S Wm^2
up to 1 Hz	-	3.2×10^4	4×10^4	-
1 – 8 Hz	10,000	$3.2 \times 10^4/f^2$	$4 \times 10^4/f^2$	-
8 – 25 Hz	10,000	4,000/*f*	5000/*f*	-
0.025 – 0.8 kHz	250/*f*	4/*f*	5/*f*	-
0.8 – 3 kHz	250/*f*	5	6.25	-
3 – 150 kHz	87	5	6.25	-

Frequency Range	Electric Field Strength V/m	H-Field A/m	B-Field µT	Equivalent plane wave power S Wm^2
0.15 - 1 MHz	87	0.73/*f*	0.092/*f*	
1 – 10 MHz	$87/f^2$	0.73/*f*	0.092/*f*	-
10 – 400 MHz	28	0.16	0.092	2
400 – 2000 MHz	$1.375f^{1/2}$	$0.0037f^{1/2}$	$0.0046f^{1/2}$	*f*/200
2 – 300 GHz	61	0.16	0.20	10

To illustrate the difference between human exposure limits and that for electromechanical equipment the guideline limit for public exposure to DC magnetic fields is 40,000 µT versus the 1 µT limit used for sensitive medical equipment. This is the same for the exposure limits for humans versus equipment up through the frequency range.

Levels up to the limits contained in the ICNIRP EMF guidelines are considered safe for members of the public and, for the purpose of this assessment, are classed as having a significance of effect of imperceptible with the quality of effect being neutral. Any predicted levels in excess of the limits set out in Table 22-6 are classed as having a significant effect, with the quality of the effect being negative.

22.3.3.5 Other criteria in the assessment of impacts

The study area for the EMR aspect of the EIAR is outlined in 22.3.1 along with the justification for the distance selected per type of radiation (DC, AC etc.). Any deviations to these distances in the relation to the extent of an impact on a particular receptor will be highlighted in the predicted impacts section.

The likelihood of the occurrence of identified impacts is also discussed. Typical operational emissions that would be expected day to day and their associated impacts on the baseline would be classed as likely for example. In discussing potential impacts, worst-case conditions are also required to be considered. An example would be fault conditions that may result in higher (or lower) localised EM emissions than would persist during normal operation. A failure of an individual substation being one such scenario would be considered unlikely on a frequent basis.

When discussing the duration of effects, the following rationale is applied.

- Momentary effects → Effects lasting from seconds to minutes.
- Brief effects → Effects lasting less than a day.
- Temporary effects → Effects lasting less than a year.
- Short-term effects → Effects lasting one to seven years.
- Medium-term effects → Effects lasting seven to fifteen years.
- Long-term effects → Effects lasting fifteen to sixty years.
- Permanent effects → Effects lasting over sixty years.

Finally, when an effect is determined to be likely it's frequency of occurrence will also be outlined e.g. once, rarely, constantly, once a day etc.

22.3.4 Consultation

Relevant feedback received from statutory, non-statutory groups, the public, community groups, and private individuals during the Options Selection Processes and responses to questionnaires helped inform this assessment. Chapter 3 of this EIAR details the Alternatives Considered. The key consultation phases include:

- Non-statutory EIA Scoping Report.
- Options Selection Process:
    - Non-statutory public consultation no.1 Emerging Preferred Option (Autumn 2020).
    - Non-statutory public consultation no.2 Preferred option (Summer 2021).

- Local Ashtown public consultation on the revised preferred option (Spring, 2022).

The feedback received during public consultation as part of the options selection process is summarised in the public consultation findings reports which has informed this chapter as appropriate. In relation to EMR questionnaires were distributed, and correspondence exchanged with several stakeholders where required more detailed engagement was undertaken with some stakeholders such as Intel.

22.3.5 Difficulties encountered/ limitations

Responses were not received for all the questionnaires distributed so a data gap may exist with respect to listed equipment. The nature of land uses were scrutinized during the chapter generation process and the potential for sensitive equipment that may exist at any of these sites was considered. The chances of an item of equipment being impacted negatively from EMI from the propose project, that hasn't been identified within this chapter, are negligible.

22.4 Receiving environment

This section includes a description of the receiving environment as it relates to EMC and stray current.

It outlines the findings of desktop studies, questionnaires, field surveys and information gained through any stakeholder consultations carried out. It uses this information to provide a description of the current profile of the environment based on all information gathered.

22.4.1 Description and categorisation of the receiving environment

As outlined in the methodology, certain stakeholders (those rated High or Very High along with recording studios) were requested to complete equipment lists detailing specific equipment that they had on site which they suspected may be susceptible to EMI. Examples were provided in the questionnaires by way of assisting the compilation of these lists (such as IT equipment, medical/research equipment etc.). CEI used the information garnered from these questionnaires and consultation meetings along with maps of the proposed route to assign the baseline ratings illustrated in the tables below based on the six zones outlined in Chapter 4 in Volume 2 of this EIAR.

22.4.1.1 Zone A – Connolly Station to Glasnevin Junction on GSWR Line

Zone A comprised predominantly of an urban environment. The following land uses were noted:

Table 22-7 Zone A Land Uses

Area	Summary Description	Baseline Rating with respect to EM Fields	Baseline Rating with respect to Stray Current
Zone A	Commercial/Corporate areas: • Ossory Autoparts. • Dempsey Automotive. • Kelly's Homevalu (N Strand Road). • Foley Motors. • Phoenix Tyre Company. • D15 Barbers (Drumcondra). • Quillsen Estate Agents. • Des Kelly Interiors (Prospect Rd.).	Low	Very Low
	Utilities (pipes and cables) • ESB Low and Medium Voltage cables (up to 38 kV) notably.	Very Low	Medium

Area	Summary Description	Baseline Rating with respect to EM Fields	Baseline Rating with respect to Stray Current
	• ESB High voltage cables (buried 110 kV line crossing at Connolly station and at Drumcondra Road lower). • Medium and Low pressure Gas lines notably pipes running parallel to the line. ○ between Connolly Station and Croke Park. ○ along Clonliffe Road. ○ along Fitzroy Avenue. ○ along Russell Avenue. ○ along Whitworth Avenue. ○ along Lindsay Road and Iona Road. • Water mains notably pipes running parallel - ○ to both lines between Connolly Station and Croke Park. ○ along Clonliffe Road. ○ along Fitzroy Avenue. ○ along Russell Avenue. ○ along Whitworth Road. ○ along Lindsay Road and Iona Road. • Telecoms cables notably ○ eircom cable running parallel along Clonliffe Road. ○ eircom cable running parallel along Fitzroy Avenue.		
	Parklands and Sports Fields • Cabra Kayak Club. • Charleville Lawn Tennis Club.	Very Low	Very Low
	Croke Park	Low	Very Low
	• Luas Red Line. • Luas Green Line.	Very High	Medium
	Residential and hospitality areas • Residences on Ossory Road. • Residences on Bessborough Avenue. • Residences on Northbrook Terrace. • Residences on North Strand Road. • Residences on Northbrook Avenue Lower. • Residences on Xavier Avenue. • Spring Garden House. • Residences on St. Patrick's Avenue. • Residences in Ballybough. • Residences on Ballybough Road. • 2-11 St. James's Avenue. • 8 and 15 St. Joseph's Avenue. • 2 and 17 Jones' Road. • Residences at Fitzroy Avenue • 2-11 St. Georges Avenue • 31-35 Drumcondra Road Lower. • 21 St. Anne's Road. • Residences at David Park. • Residences at David Road. • Residences at Wigan Road. • Residences at Claude Road. • Residences at St. Brendan's Road.	Low	Very Low

Area	Summary Description	Baseline Rating with respect to EM Fields	Baseline Rating with respect to Stray Current
	• 27, 28 and 37 St. Patrick's Road. • Shrewsbury House Nursing Home. • Hedigans - Brian Boru. • Residences in Claremont Estates.		
	Medical, Dental and Veterinary Centres • The Oasis Centre (North Dock). • Murrays Medical Equipment. • Perfect Smile Dental (Railway Street). • PD Dental (N Strand Road). • North Strand Health Centre (Strand Road). • Skin Check – North Strand. • Drumcondra Clinic. • United Medical Centre (Drumcondra). • Advance Pharmacy (Drumcondra). • Park's Late-Night Pharmacy (Dorset St.). • Prospect Medical Clinic. • Stack's Pharmacy (Glasnevin). • O'Loughlin's Dental Surgery.	High	Very Low
	Fuel/Service Stations • Circle K – Glasnevin.	Low	Medium
	Theatres and recording studios • Guerrilla Sound Studios. • Gúna Nua theatre Company. • Studio 4. • Panchord Studio.	Medium	Very Low
	Schools and Educational Facilities • 4 St. Joseph's Avenue (ABCD Learning Centre).	Low	Very Low
	Ballybough Community Centre	Low	Very Low

Medical, dental and veterinary facilities were classed as a high from an EM Field perspective, while the theatres and recording studios and theatres were classed as medium. The Luas lines (Red Line and Green Line) were also classed as Very High.

Locations of note that were outside the study area but close to the alignment included – Mountjoy Prison, National Children's Hospital Temple Street, the Mater Hospital and Connolly Hospital.

A baseline survey within Zone A was performed in proximity to where the Northern line separates from the Maynooth Line. This served two purposes; first it was to give an indication of the current typical urban environment with respect to RF fields. But also, in relation to typical DC to AC frequency fields the survey indicated the kind of emissions that could be expected at the selected measurement distance from an Electrified Maynooth Line. The plots from this survey are discussed in Section 22.4.2.1.

22.4.1.2 Zone B – Spencer Dock Station to Phibsborough/Glasnevin Junction on MGWR Line

Zone B comprised predominantly of an urban environment. The land uses identified are shown in Table 22-8.

Table 22-8 Zone B Land Uses

Area	Summary Description	Baseline Rating with respect to EM Fields	Baseline Rating with respect to Stray Current
Zone B	Commercial/Corporate areas: • Ossory Autoparts. • Dempsey Automotive. • Kellihers Electrical. • Quillsen Estate Agents. • Des Kelly Interiors (Prospect Road).	Low	Very Low
	Utilities (pipes and cables) • ESB Low and Medium Voltage cables (up to 38 kV). • ESB High voltage cables (buried 110 kV line crossing at Connolly station). • Medium and Low pressure Gas lines notably pipes running parallel - ○ along the Royal Canal. ○ to both lines between Connolly Station and Croke Park. ○ along Russell Avenue. ○ along Whitworth Road. ○ along Lindsay Road and Iona Road. • Water mains notably pipes running parallel – ○ along the royal canal. ○ to both lines between Connolly Station and Croke Park. ○ along Russell Avenue. ○ along Whitworth Avenue. ○ along Lindsay Road and Iona Road. • Telecoms cables (including fibre optic) notably eircom lines along ○ Ossory Road. ○ Whitworth Road for 50 metres.	Very Low	Medium
	Parklands and Sports Fields • Cabra Kayak Club. • Charleville Lawn Tennis Club.	Very Low	Very Low
	Croke Park	Low	Very Low
	• Luas Green Line	Very High	Medium
	Residential and hospitality areas • Residences on Ossory Road. • Residences on Newcomen Avenue. • Residences on Clonmore Terrace. • Residences on North Strand Road. • Residences in Ballybough. • Residences on Ballybough Road. • 2 and 17 Jones' Road. • Croke Park Hotel. • Residences at David Park. • Residences at David Road. • Residences at Wigan Road. • Residences at Claude Road. • Residences at St. Brendan's Road. • Residences in Claremont Estates.	Low	Very Low

Area	Summary Description	Baseline Rating with respect to EM Fields	Baseline Rating with respect to Stray Current
	Medical, Dental and Veterinary Centres • East Wall Health Clinic. • The Oasis Centre (North Dock). • 24 Doc Medical Clinic (North Dock). • Denture Express Clinic (Dorset St.). • Dublin Dentist Clinic (Dorset St.). • Inter Dental (Dorset St.). • North Strand Health Centre (Strand Road). • Whitworth Medical Centre. • Skin Check – North Strand. • United Medical Centre (Drumcondra). • Allen's Pharmacy (Summerhill). • Advance Pharmacy (Drumcondra). • Park's Late-Night Pharmacy (Dorset St.). • Allcare Pharmacy (Dorset St.). • Prospect Medical Clinic. • Smiths Pharmacy (North Circular Road). • O'Loughlin's Dental Surgery.	High	Very Low
	Theatres and recording studios • Yellow Door Music Studio.	Medium	Very Low

Due to the crossover between Zone A and Zone B some stakeholders appear in both Table 22-7 and Table 22-8. Medical, dental and veterinary facilities were classed as a high from an EM Field perspective, while the Yellow Door music studio was classed as medium. The Luas Green Line was also classed as Very High.

Similar to Zone A locations of note that were outside the study area but close to the alignment included – Mountjoy Prison, National Children's Hospital Temple Street, the Mater Hospital and Connolly Hospital.

22.4.1.3 Zone C – Phibsborough/Glasnevin Junction to Clonsilla Station

Zone C comprised of urban and suburban land. The land uses identified are shown in Table 22-9.

Table 22-9 Zone C Land Uses

Area	Summary Description	Baseline Rating with respect to EM Fields	Baseline Rating with respect to Stray Current
Zone B	Commercial/Corporate areas: • Broombridge Business Centre. • Industrial Estates along Ballyboggan Road. • Commercial premises on Bannow Road. • Dublin Industrial Estate.	Low	Very Low
	Utilities (pipes and cables) • ESB HV cables (110 kV overhead crossing at Broombridge). • ESB Low and Medium Voltage cables (up to 38 kV) notably- o Running along the royal canal at Broombridge and Royal Canal Avenue. o Running parallel for 160 m at Laurel Lodge. o Running parallel through Riverwood estates (Carpenterstown).	Very Low	Medium

Area	Summary Description	Baseline Rating with respect to EM Fields	Baseline Rating with respect to Stray Current
	• ESB High voltage cables (buried 110 kV line crossing at Connolly station). • Medium and Low pressure Gas lines notably – ○ Running through Claremont estates. ○ Running parallel at St. Oliver Plunketts GAA. ○ Running in Cherry estates (Coolmine). ○ Running through Lambourn estates. • Water main notably – ○ Running along the Royal Canal and then Royal Canal Avenue. ○ Running parallel through Riverwood estates (Carpenterstown). ○ Running through Lambourn estates. • Telecoms cables (including fibre optic)		
	Parklands and Sports Fields • Ashington Park. • Martin Savage Park. • Carpenterstown Tennis Club. • St. Mochtas Football Club.	Very Low	Very Low
	• Luas Red Line. • Luas Green Line.	Very High	Medium
	Residential and hospitality areas • Residences in Ratoath Estate. • Residences in Ashington Dale, Court and Rise. • Residences in Glendhu Park. • 12th Lock. • Greenvalley House (Castleknock Road). • Residences in Castleknock Wood, View, Meadows, Rise, Close, Walk and Downs. • 16 Riverwood Dene.	Low	Very Low
	Medical, Dental and Veterinary Centres • Lloyds Pharmacy (Pelletstown).	High	Very Low

22.4.1.4 Zone D – Clonsilla Junction to M3 Parkway

Zone D comprised a combination of suburban and rural land uses. The land uses identified are shown in Table 22-10.

Table 22-10 Zone D Land Uses

Area	Summary Description	Baseline Rating with respect to EM Fields	Baseline Rating with respect to Stray Current
Zone D	Residential and hospitality areas: • Residences in Larchfield. • Residence opposite Dunboyne Train Station car park • Residences in Elton Grove, Court and Drive. • Residences in Willow Park. • Residences in Silver Birches. • Residences in The Elms.	Low	Very Low

Area	Summary Description	Baseline Rating with respect to EM Fields	Baseline Rating with respect to Stray Current
	Utilities (pipes and cables). • ESB Low and Medium Voltage cables (up to 38 kV). • ESB HV cables (220 kV overhead crossing. • South of Dunboyne station). • Water mains notably pipe running parallel ○ On access road to Elton estates, willow park and Silver Birches in Dunboyne. • Gas mains notably pipe running parallel ○ On access road to Elton estates, willow park and Silver Birches in Dunboyne. • Telecommunications cables.	Very Low	Medium
	Dunboyne Herbal Clinic	Low	Very Low
	Agricultural land	Very Low	Very Low

22.4.1.5 Zone E – Clonsilla Station to Maynooth Station

Zone E comprised of rural and suburban land. The land uses identified are shown in Table 22-11.

Table 22-11 Zone E Land Uses

Area	Summary Description	Baseline Rating with respect to EM Fields	Baseline Rating with respect to Stray Current
Zone E	Commercial/Corporate areas: • Jones Engineering Group.	Low	Very Low
	Utilities (pipes and cables) • ESB Low and Medium Voltage cables (up to 38 kV). • ESB HV cables (110 kV overhead crossing Near Louisa Bridge). • Medium and Low pressure Gas lines notably ○ Gas line running parallel from Confey Station to Intel. ○ Pipe running parallel through Silken vale. ○ line running along Clonsilla road. • Water mains notably – ○ Pipe running parallel from Westmanstown Golf club to Collins Bridge. ○ Pipe running parallel from Collins Bridge along the R149 to Confey GAA Club. ○ Two pipes running from Louisa bridge. ○ along the R148 to Pike bridge. ○ Pipe running from Pike bridge along the R148 to Maynooth town centre. ○ Pipe running parallel along Newtown Road. ○ Pipe running parallel from Leinster clinic Along R148 to proposed Depot location • Telecoms cabling including. ○ Eircom cable running from outside Intel along the R148 to pike bridge.	Very Low	Medium
	Parklands and Sports Fields • Westmanstown Sports and conference centre. • Westmanstown Golf club. • St. Catherine's Park Lucan.	Very Low	Very Low

Area	Summary Description	Baseline Rating with respect to EM Fields	Baseline Rating with respect to Stray Current
	Intel	Very High	Medium
	Residential and hospitality areas • Residence at top of Westmanstown Road. • Residences in Glendale, Lucan. • Residences in Riverforest, Lexlip. • Residences in the Way, Lexlip. • Residences in Parklands, Maynooth. • Residences in Castlebridge, Maynooth. • Residences in Silken Vale, Maynooth.	Low	Very Low
	Medical, Dental and Veterinary Centres • Park Lodge Medical Centre, Maynooth. • Boots Pharmacy, Maynooth.	High	Very Low
	Parklands and Sports Fields • Maynooth Playground.	Very Low	Very Low
	Agricultural Land	Very Low	Very Low

Intel was identified as a major stakeholder within this zone with a baseline rating of Very High. A baseline survey was performed between Louisa Bridge Station and Intel and the results of which are discussed in Section 22.4.4.2.2. Maynooth University was also classed as Very High. A baseline survey was not conducted at this site however as the nature of the campus layout should ensure any potentially sensitive receptors are located on the North campus of the university, well outside the 100 m study area. No unexpected receptors were identified in the equipment questionnaire responses received from stakeholders within the 100 m study area.

22.4.1.6 Zone F – Maynooth Station to Maynooth Depot

Zone F comprised predominantly of rural land. The suburban land uses along this stretch of line were mostly greater than 100 m from the alignment. The land uses identified are shown in Table 22-12.

Table 22-12 Zone F Land Uses

Area	Summary Description	Baseline Rating with respect to EM Fields	Baseline Rating with respect to Stray Current
Zone F	Residential and hospitality areas: • Residences in Silken Vale, Maynooth. • Residences in Woodlands, Maynooth. • Residences in Castledawson, Maynooth. • Residences in Newtown Hall, Maynooth.	Low	Very Low

	Utilities (pipes and cables)
	• ESB Low and Medium Voltage cables (up to 38 kV).
	• Medium and Low pressure Gas lines notably.
	  o Pipe running parallel through Silken vale.
	• Water mains notably –
	  o Pipe running parallel along Newtown Road.
	  o Pipe running parallel from Leinster clinic Along R148 to proposed depot location.
		Very Low	Medium

	Maynooth University	Very High	Medium

22.4.1.7 Receiving environment receptors

As discussed, information was gathered from a number of sources before arriving at the final ratings for each selected land use within the study area. Table 22-7 to Table 22-12 depict the assigned ratings for the stakeholders within each zone. This section discusses in a little more detail the receptors for these stakeholders.

In relation to most of the land uses, similar types of equipment were listed frequently. Standard equipment types that would be encountered by the majority of the population on a regular basis. The following list is a summary of the typical equipment assumed to be present at various locations along the route:

- TVs.
- IT equipment.
- Communications equipment.
- Radio systems.
- Security systems.
- Medical equipment such as ventilators, monitors etc.
- Scanning Medical equipment such as X-ray machines.
- Microscopes.
- Manufacturing equipment and machinery.
- Signalling systems.
- Audio/Visual equipment.
- Laboratory equipment.

The potential operational impacts on such equipment are discussed in Section 22.5. With regard to the significant stakeholders identified (those rated with a Baseline rating of Very high) within each zone, a summary of the discussions and consultations with respect to each follows.

The Luas lines (red and green) come within the study area of the alignment at locations within Zones, A, B and C. Transport Infrastructure Ireland (TII) listed the following equipment and systems as being potentially sensitive.

- Traction systems.
- Line signalling systems.
- Telecommunications systems.

22.4.1.7.1 Zone A – Connolly Station to Glasnevin Junction on GSWR Line Receptors

Questionnaire responses were received from Prospect Medical Clinic, Murray's Pharmacy and Panchord Music.

Equipment questionnaire sheets were examined for these stakeholders with equipment such as the following being listed –

- Computer equipment.
- Network and server equipment.
- Electrical instrumentation.
- Sound recording equipment (in the case of recording studios).
- Equipment listed by TII for the Luas (traction systems, line signalling systems, telecommunications systems).

No unexpected equipment was listed in these questionnaire responses that the consultant felt required further investigation.

Aside from the equipment specifically outlined in the questionnaire responses the following is a list of assumed additional equipment that could be present at the any of the different types stakeholders within Zone A (domestic, commercial or otherwise).

- TVs.
- IT equipment.
- Communications equipment.
- Radio systems.
- Security systems.
- Medical equipment such as ventilators, monitors etc.
- Microscopes.
- Manufacturing equipment and machinery.
- Signalling systems.
- Audio/Visual equipment.
- Laboratory equipment.

22.4.1.7.2 Zone B – Spencer Dock Station to Phibsborough/Glasnevin Junction on MGWR Line Receptors

No additional potentially sensitive receptors were identified in this zone with standard equipment as listed in Section 22.4.1.7.1 also assumed to be present in domestic and commercial premises within the study area.

Questionnaire responses were received from Whitworth Medical Centre.

The equipment questionnaire was examined with equipment such as the following being listed –

- Computer equipment.
- Network and server equipment.
- Electrical instrumentation.

The same Luas equipment from Zone A was assumed for the section of the alignment that runs close to the Luas at Spencer Dock i.e. traction systems, line signalling systems, telecommunications systems).

No unexpected equipment was listed in these questionnaire responses that the consultant felt required further investigation.

22.4.1.7.3 Zone C – Phibsborough/Glasnevin Junction to Clonsilla Station Receptors

The alignment passed the Green Luas line again at Broombridge, which is the location of a Luas Depot. In addition to the systems that would be considered for the lines (traction systems, line signalling systems, telecommunications systems) the following additional receptors were listed by TII:

- Luas servers and control systems/equipment in depot and adjacent areas.
- Luas Tetra radio base station and tower.
- Luas lineside signalling and vehicle location systems.
- Telecommunication networks and switching devices.
- Luas control centre.

No additional potentially sensitive receptors were identified in this zone with standard equipment as listed in Section 22.4.1.7.1 assumed to be present in domestic and commercial premises within the study area.

22.4.1.7.4 Zone D – Clonsilla Junction to M3 Parkway Receptors

No additional potentially sensitive receptors were identified in this zone with standard equipment as listed in Section 22.4.1.7.1 assumed to be present in domestic and commercial premises within the study area.

22.4.1.7.5 Zone E – Clonsilla Station to Maynooth Station Receptors

Questionnaire responses were received from Park Lodge Medical Centre and Maynooth University while consultations were undertaken with Intel. Park Lodge listed telecommunications equipment as a potentially sensitive EMI receptor.

Maynooth University provided details of equipment they wished to highlight including data centres, computers, microscopes, electronic instrumentation and scanning systems such as a VNA scanner. The majority of these were located outside the study area of 100 m and on the North side of the Maynooth University campus in the Science, Bioscience, Computer Science, Callan, Hume, Lyreen and Laraghbryan buildings. Particularly sensitive equipment listed included an NMR machine and electron microscopes. Again, these were located on the North campus of the university.

A portion of Intel's campus falls within the 100m study area with most of their site falling outside of it. Discussions were held surrounding equipment with potential sensitivities to EMI from an electrified rail scheme. At the request of Intel and for the purpose of protecting their Intellectual Property (IP) and data protection purposes the details of the equipment discussed is not included. However, with regards to Intel the study area was extended beyond the 100 m at their request to include the majority of their campus.

Standard equipment as listed in Section 22.4.1.7.1 were also assumed to be present in domestic and commercial premises within the study area

22.4.1.7.6 Zone F – Maynooth Station to Maynooth Depot Receptors

No additional potentially sensitive receptors were identified in this zone with standard equipment as listed in Section 22.4.1.7.1 assumed to be present in domestic and commercial premises within the study area.

22.4.2 Baseline Survey Results

EMR baseline surveys were performed at the following locations –

- Survey Site 1 - Beside the railway bridge on Ossory Road, Dublin 3.
- Survey Site 2 – Adjacent to Louisa Bridge station, Leixlip (Intel side of canal).

The plots for of these surveys are presented in Appendix A22.1 Site Survey Plots in Volume 4 of this EIAR. A summary of these surveys is presented in this section.

22.4.2.1 Survey site 1 – Ossory Road, Dublin 3

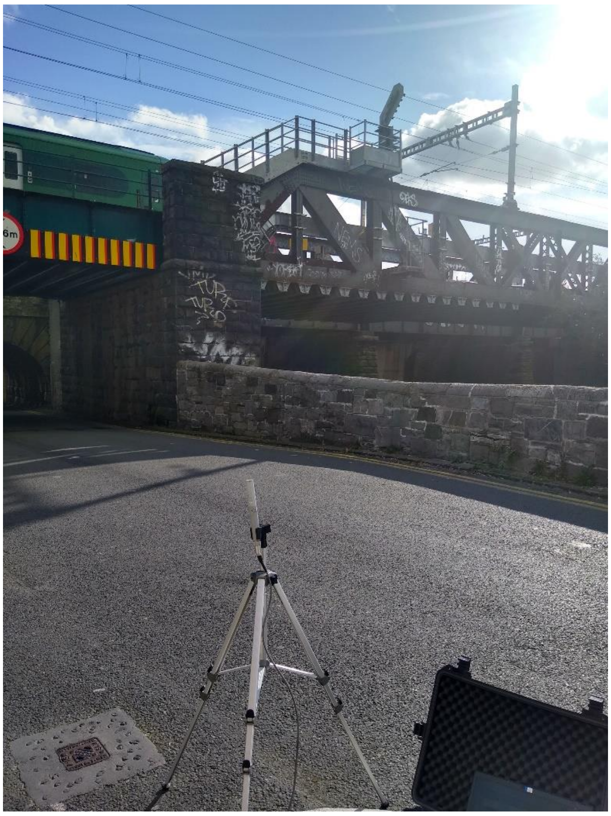

Figure 22-2 Site 1 – Baseline survey location

22.4.2.1.1 DC Magnetic Field – Ossory Road, Dublin 3

The Earth's DC magnetic flux density (B) was measured for a period of 32 minutes. The average static field was approximately 48 µT (see Figure A in Appendix A22.1 Site Survey Plots in Volume 4 of this EIAR). The measurement location was approximately 10 metres from the train line with the lines energised and trains passing the measurement location on multiple occasions. As would be expected for such a location relatively large DC magnetic field fluctuations were noted of the order of with maximum fluctuations measured during this period, attaining a maximum of 4 µT with typical fluctuations of up to 2 µT as depicted in FigureB in Appendix A22.1 in Volume 4 of this EIAR.

22.4.2.1.2 AC Electric and Magnetic Fields (1 Hz – 10 kHz) – Ossory Road, Dublin 3

Figure C in Appendix A22.1 in Volume 4 of this EIAR shows a spectral plot of the magnetic field from DC to 100 Hz. The DC component can be seen to be much higher than any other frequency at 48 µT. The near DC fields (less than 10 Hz) were typically of a magnitude of less than 0.01 µT. An elevated 50 Hz magnetic field was measured at 1 µT, understandably as the measurement location was approximately 10 m away from the electrified rail line but also there was likely a buried mains cable near the location also as would be typical for the supply of urban dwellings. From 100 Hz to 1 kHz (Figure D in Appendix A22.1 in Volume 4 of this EIAR) harmonics of the mains frequency were evident. Notably the odd numbered harmonics were of a greater magnitude than the even harmonics. This is a typical feature of a DC line supply generated from a rectified AC source as would be used with the DART traction scheme. Figure G and Figure H in Appendix A22.1 in Volume 4 of this EIAR show the equivalent E-Fields over the frequency range 10 Hz to 10 kHz with the harmonics again evident.

22.4.2.1.3 Radiofrequency Fields (10 kHz – 18 GHz) – Ossory Road, Dublin 3

At this site the strongest emissions were caused by Analog radio broadcasts (80 – 110 MHz), Digital Radio (147-223 MHz), Tetra Radio (390 MHz), Digital Television Broadcasting (470 – 790 MHz) and WiFi (2.4 GHz and 5 GHz). Aeronautical radionavigation signals are also seen in the 4.2 GHz range. In terms of mobile technology, the following signals were present, mobile broadband, LTE (791-821 MHz and 925-960 MHz), GSM 900 and 1800 (900 MHz and 1.8 GHz) and 3G (2.1 GHz). Due to the proximity of the measurement location to the airport 9 GHz radionavigation transmissions sere also detected.

22.4.2.2 Survey site 2 – Louisa Bridge, Leixlip

Figure 22-3 Site 1 – Baseline survey location

22.4.2.2.1 DC Magnetic Field – Louisa Bridge, Leixlip

The Earth's DC magnetic flux density (B) was measured for a period of 25 minutes. The average static field was approximately 42.5 µT (Figure Q in Appendix A22.1 in Volume 4 of this EIAR). The measurement location was approximately 25 metres from the train line but near an overhead electricity cable. DC magnetic field fluctuations were noted of the order of with maximum fluctuations of 1 µT were measured during this period as depicted in Figure 4 in Appendix A22.1 in Volume 4 of this EIAR. The fluctuations were quite uniform at this location suggesting a constant load on the line at the time with a switching element causing the spikes seen.

22.4.2.2.2 AC Electric and Magnetic Fields (1 Hz – 10 kHz) – Louisa Bridge, Leixlip

Figure S in Appendix A22.1 in Volume 4 of this EIAR shows a spectral plot of the magnetic field from DC to 100 Hz. The DC component can be seen to be much higher than any other frequency at 42.5 µT. The near DC fields (less than 10 Hz) were typically of a magnitude of less than 0.001 µT. The mains frequency (50 Hz) magnetic field was measured at 0.01 µT, with the main source coming from the nearby overhead line. Low level harmonics were noted from 100 Hz to 1 kHz (Figure T in Appendix A22.1 in Volume 4 of this EIAR). Figure X and Figure Y in Volume 4 of this EIAR show the equivalent E-Fields over the frequency rage 10 Hz to 10 kHz with the harmonics again evident.

22.4.2.2.3 Radiofrequency Fields (10 kHz – 18 GHz) – Louisa Bridge, Lexlip

At this site the strongest emissions were caused by Analog radio broadcasts (80 – 110 MHz), Digital Radio (147-223 MHz), Emergency Services radio (235-267 MHz), Tetra Radio (390 MHz), Digital Television Broadcasting (470 – 790 MHz) and WiFi (2.4 GHz and 5 GHz). Aeronautical radionavigation signals are also seen in the 2.5-2.8 GHz range and 4.2 GHz. In terms of mobile technology, the following signals were present, mobile broadband, LTE (791-821 MHz and 925-960 MHz), GSM 900 and 1800 (900 MHz and 1.8 GHz) and 3G (2.1 GHz).

22.5 Description of potential impacts

Within this section we outline the magnitude of the predicted impacts and the significance of the effects on the receptors identified in the baseline environment in Section 22.4, including human exposure. The metrics used for assigning the impact magnitude to a significance of effects are outlined in Table 22-5. Where other metrics or limits are used, then the rationale for their use is explained.

The tables within this section group many receptors into general categories for conciseness where the significance of effects from the predicted impacts have been rated as imperceptible to slight. Therefore, any receptors listed in Section 22.4 that are not explicitly discussed in this section fall within these general groupings. For example, a dental practice explicitly listed such as Dublin Dentist Clinic (Dorset Street) falls within the grouping Medical, Dental and Veterinary Centres.

22.5.1 Potential construction impacts

Electromagnetic emissions from the construction phase of the project will not differ from a typical large-scale construction project. The significance of effects on all identified receptors will vary between imperceptible to slight. The largest sources of elevated baseline levels in the AC range will be in the immediate vicinity (within 5 m) of onsite generators used to power electronic tools and lighting. Levels will not exceed public exposure guideline limits outside of the construction works.

Temporary onsite communications and IT infrastructure will result in emissions in the RF range of frequencies. However, any emissions from such equipment are governed by the EMC and Radio Directives such that impacts on identified receptors in the study area are unlikely.

No likely significant effects have been identified for the construction phase of the proposed project. DC field perturbations will not present an impact to any of the identified receptors. A change to the baseline EM environment due to RF emissions from on-site communications equipment and AC emissions from local power generators is likely and will be constant during the construction phase. However, the duration of these effects will be *short-term*, disappearing once the construction site ceases its activity.

Receptors that may have specialised equipment, such as spectrum analysers, that can be tuned to the detect the frequency content of these emissions (AC or RF) are classified as having a significance of effect of *slight* with a quality of effect of *neutral*. All other receptors are classified as *imperceptible* with a quality of effect of *neutral*.

Table 22-13 summarises the predicted significance of effects and quality of effects from the construction phase for electromagnetic radiation (DC, AC, RF and microwave) while Table 22-14 summarises stray current. There are no notable sources of stray current during the construction phase.

Table 22-13 Significance of effects for electromagnetic emissions during the construction phase

Receptors	Significance of effects	Quality of effects
Commercial/Corporate areas (including Croke Park)	Slight	Neutral
Utilities (pipes and cables)	Imperceptible	Neutral
Residential and hospitality areas	Imperceptible	Neutral
Medical, Dental and Veterinary Centres	Imperceptible	Neutral
Intel	Slight	Neutral
Luas Red Line, Luas Green Line	Slight	Neutral

Receptors	Significance of effects	Quality of effects
Maynooth University	Slight	Neutral
Fuel/Service stations	Imperceptible	Neutral
Community Centres, Theatres and recording studios	Imperceptible	Neutral
Schools and Educational Facilities	Slight	Neutral
Agricultural land uses	Imperceptible	Neutral
Parklands and sports fields	Imperceptible	Neutral

Table 22-14 Significance of effects for stray currents during the construction phase

Receptors	Significance of Effects	Quality of Effects
Utilities (pipes and cables)	Imperceptible	Neutral
Fuel/Service stations	Imperceptible	Neutral
Luas Red Line, Luas Green Line	Imperceptible	Neutral

22.5.2 Potential operational impacts

The potential EMI sources arising from the operation of the proposed project have been introduced in Section 22.1 – Introduction. Potential impacts include electromagnetic interference from the DC magnetic fields, AC fields and radiofrequency electric fields. Conducted interference may be caused by stray currents from the traction system. Elements of the proposed development that can potentially act as sources and propagators of EMI comprise:

- The power supply utility and distribution system.
- The traction supply system. The trains draw current from the traction power station along the Overhead Contact System (OCS) which returns via the running rails back again to the substation. This traction current has the potential to generate electromagnetic fields. Traction Power Supply (TPSS) includes substations, feeders, OCS, running rails (regarding return and stray current) and feeding/return current cables between the OCS and running rails to the substation.
- The rolling stock traction equipment, including inverters, traction motors and auxiliaries.
- Signalling systems.
- Communication systems.

Stray current is generated from the traction supply system. Current travels to the trains via the OCS, passes through the trains electric motors and returns to the substation via the rails. Due to the length of the rails, and the magnitude of the drive currents involved, small amounts of the return current may find alternative paths back to the substation via buried utilities and structures running for long distances in parallel with the alignment.

22.5.2.1 DC and near DC magnetic field impacts

The main forms of electromagnetic emissions from the proposed project are controlled by the RED and EMC Directives. Standard electrical equipment sensitivity to DC and near DC magnetic is not typically an issue and therefore there are few immunity standards for equipment such as IT or domestic equipment that covers this frequency range. Conversely there are no emissions standard limits for DC and near DC magnetic fields with respect to levels that could cause EMI which the development must meet.

However, there is the EC Recommendation of 1999 (1999/519/EC) which specifies limits for human exposure. This level is set from 40,000 µT at DC to 800 µT at 5 Hz. These levels will not be exceeded by the proposed project at any location the public has access to and therefore the significance of the effects arising from DC and near DC magnetic fields for human beings is classed as *imperceptible* with the quality of effect classed as *neutral.* Low level DC and near DC fields well below the limits set out in the EC Recommendation (i.e. << 40,000 µT) will persist permanently once the traction supply remains energised.

22.5.2.1.1 Modelling DC Magnetic Fields

The DC current flowing in the OCS to the trains causes a magnetic field. This current is returned in the rails to the substation which causes a magnetic field that is opposite in polarity and therefore acts to partly cancel the magnetic field resulting from the OCS. A planar view of a single rail line is shown in Figure 22-4 For illustrative purposes only a single line is shown with a pair of rails and the OCS.

The field intensity (strength) at a given point (receptor) depends upon the magnitude of the current running in the conductors (sources – OCS and rails) and the distance between them and that point (receptor).

There is the additional effect of two or more lines operating in close proximity (not depicted) which acts to effect the magnetic lines of flux even further and therefore the resultant intensity at the receptor.

Also, for simplicity the OCS is represented as a single vector/wire. In practice the OCS will consist of 3 wires (feeder, contactor and messenger wires).

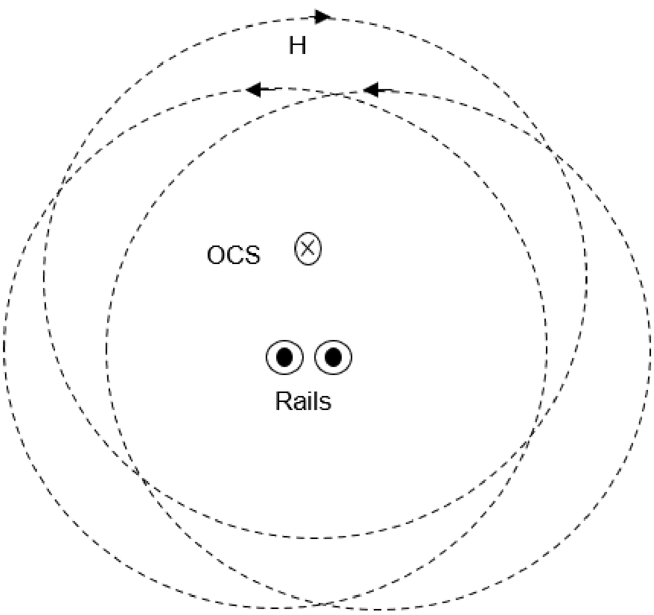

Figure 22-4 DC magnetic field around rails and OCS

The magnetic field from each conductor is defined by:

$H = I / (2 * \pi * r)$

where:

$\pi = 3.142$

H: magnetic field intensity [measured in amps per metre];

I: traction current (Amps A);

r: distance between source point and receptor

At any determined point in space, magnetic fields of various sources may interfere with each other which is what occurs with two overhead lines and 4 return rails. The resulting magnetic field may be amplified or compensated as a result of these interferences depending on the direction of current flow in each conductor.

The current flows in the overhead conductor and returns via the rails split equally between the two. Therefore, the magnetic fields partially cancel.

The magnetic flux density is related to the magnetic field strength by the relationship:

B = μ0 * μr * H

Where:

B: magnetic flux density (measured in Tesla [T]);

μ0: absolute permeability (physical constant);

μr: relative permeability (coefficient of materials).

In air B (μT) = 1.26 x H (A/m)

The DC magnetic fields have been calculated for current flowing in the power supply system. The magnetic flux density was calculated for various distances from the alignment taking account of both vertical and horizontal distances. Worst-case load currents, provided by the electrical system designers, were utilised.

To further create a worst-case calculation the following operational scenarios were assumed:

- Two trains starting and accelerating (peak current) on the two tracks at the same time.
- The traction power system is fed from only one substation (such a scenario could arise in the case of maintenance) such that the maximum current is flowing on a given section of track in the one direction.

During normal operation, the traction power supply is fed from two substations (one at each end of each section), which means that the current is split between two adjacent substations and magnetic fields strengths would be closer to half that which was modelled.

The following parameters from the proposed system design were fed into the DC magnetic field model to generate the potential DC magnetic field lines.

- Total DC current draw (per line): 2,500 A
    - Feeder wire: 1,322 A.
    - Contact wire: 658 A.
    - Messenger Wire: 520 A.
    - Return rails (x2): 1,247.5 A.
- Distance between the axis of both lines: 3.6 m.
- Contact wire height: 4.4 m.
- Messenger wire: 0.4 m above contact wire.

Feeder wire: 2 m adjacent to messenger wire. Everyday electrical and IT equipment are not susceptible to DC and quasi-DC magnetic field perturbations thereby removing the majority of stakeholders from further investigation. However, sensitive equipment does exist in the medical and advanced scientific and engineering industries such as E-beam lithography tools, MRIs, SEMs etc. The stakeholders that disclosed they possessed such equipment were Maynooth University and Intel.

A depiction of how this DC magnetic field perturbation presents itself in the time domain is depicted in Figure 22-5. T his graph shows the DC magnetic flux density for an accelerating electrified train at distances of 3 m and 10 m from the rail line. The X-axis depicts time in hours:minutes:seconds. The figure acts to demonstrate the momentary nature of the larger perturbations which occur on acceleration and the reduction of magnitude with distance from the line.

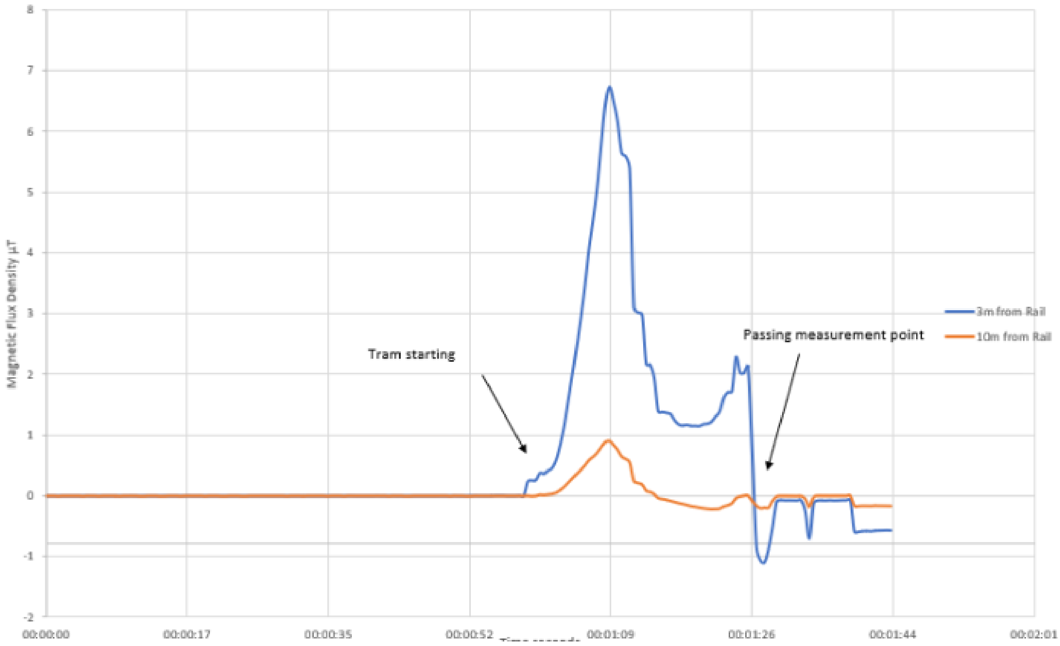

Figure 22-5 Magnetic flux density electrified train passing measuring point at 3 m and 10 m distance

As stated, the modelled worst-case levels from the proposed development involved utilising the maximum parameters provided by the design team in terms of current draw. There is also variability in the OCS height along the line with the maximum height (4.7 m) resulting in less cancellation, due to the lines being further from the rails, so again this was used. Figure 22-6 depicts the modelled worst-case magnetic flux density with distance with levels of 100 µT at 10 m distance falling to 1 µT at 100 m.

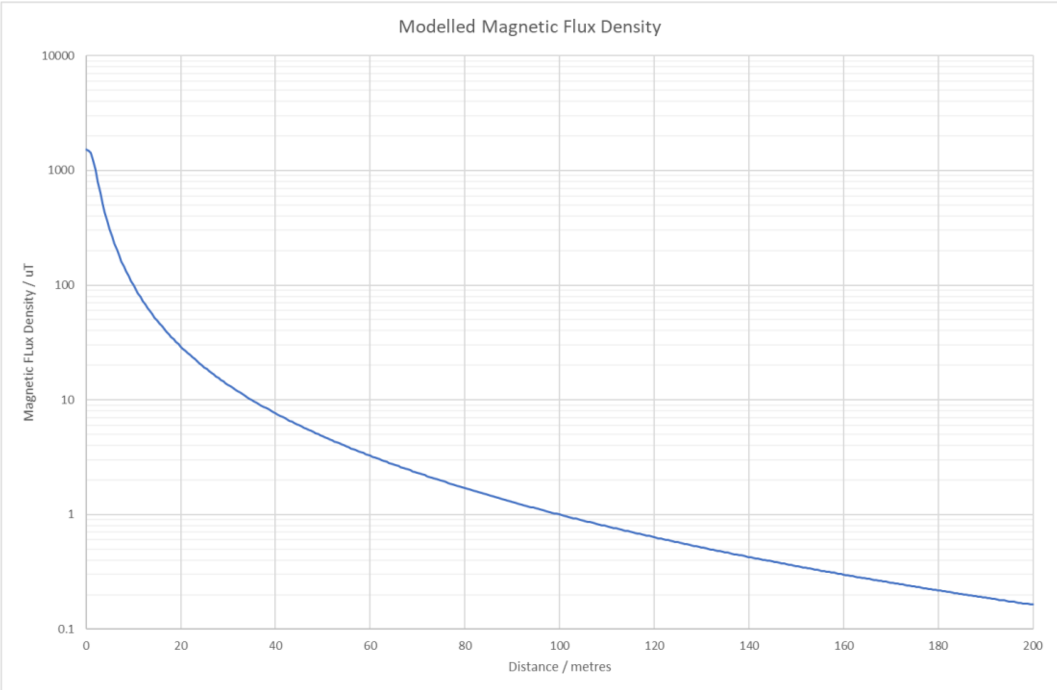

Figure 22-6 Modelled DC Magnetic flux density for worst-case conditions

22.5.2.1.2 DC and Quasi DC field impacts on Intel

The majority of Intel's campus is located beyond 100 m of the line. The modelled worst-case levels outlined in the previous section, would be an extremely rare occurrence and of a momentary duration (i.e. when two trains are at maximum acceleration). An impact on current sensitive equipment installed on the campus is unlikely.

However, consultations with Intel determined that they have a campus wide electromagnetic baseline specification for DC, Quasi DC and AC Fields. It was demonstrated through modelling that AC fields at the distances involved will not have any impact on this baseline for Intel. So, Intel's concerns focussed on the DC and near DC magnetic field perturbations throughout Intel's campus and therefore not specifically at the locations of sensitive equipment. The modelled worst-case levels for 100 m and beyond exceeded this limit for much of the campus and therefore further investigations and consultations were undertaken.

Intel was given a significance of effects rating of *moderate* with a quality of effects of *neutral* with respect to DC magnetic fields.

Resulting from further consultations during the design stages embedded mitigation measures were developed. These are discussed in Section 22.6.

DC and Quasi DC field impacts on Maynooth University

The equipment list provided by Maynooth University highlighted the following equipment which would be potentially sensitive to DC and near DC magnetic fields –

- Electron Microscopes located in the Science Building.
- NMR.

While the Electron Microscopes were listed as being in the Science building, no location was listed for the NMR. However, the typical application of an NMR would be in chemistry which would also be located in the Science building. The North Campus is the location of the main science and technology research centres in the university with the south campus, closest to the line not containing any equipment potentially sensitive to DC and near DC magnetic fields. The North Campus is further than 400 m from the line. Therefore, the significance of effects for DC magnetic fields at Maynooth University has been classed as *slight* with a quality of effects of *neutral*.

22.5.2.1.3 Predicted DC magnetic field significance of effects

The following table summarises the significance of effects for the various stakeholders with respect to DC and near DC magnetic field impacts during the operational phase of the proposed development.

Table 22-15 Significance of effects for DC and Near DC Magnetic Fields during the operational phase

Receptors	Significance of Effects	Quality of Effects
Commercial/Corporate areas (including Croke Park)	Imperceptible	Neutral
Utilities (pipes and cables)	Imperceptible	Neutral
Residential and hospitality areas	Imperceptible	Neutral
Medical, Dental and Veterinary Centres	Slight	Neutral
Intel	Moderate	Neutral
Luas Red Line, Luas Green Line	Imperceptible	Neutral
Maynooth University	Slight	Neutral
Fuel/Service stations	Imperceptible	Neutral
Community Centres, Theatres and recording studios	Imperceptible	Neutral
Schools and Educational Facilities	Slight	Neutral
Agricultural land uses	Imperceptible	Neutral
Parklands and sports fields	Imperceptible	Neutral

22.5.2.2 AC fields impacts

22.5.2.2.1 AC Fields at the power frequency

AC electromagnetic fields will occur primarily at the power frequency of 50 Hz. The main sources for these fields will be the following –

1. Traction substations.
2. Medium Voltage (MV) 10 kV, 20 kV or 38 kV lines and cables powering the proposed traction substations.
3. Low Voltage (LV) cables powering stations, signalling and communication systems.
4. AC component of DC supply in OCS.

Elevated AC field levels can be expected at the traction substations (source 1). However, these are required to be within the guideline limits for public and occupational exposure with their intensity decreasing significantly with distance due to the inverse square law.

Depending on the voltage supplied by the service provider the current loading will vary but based on the power demand of the substations the following combinations were considered.

- 38 kV – 170 Amps.
- 20 kV – 323 Amps.
- 10 kV – 646 Amps.

Basically, the higher the voltage supply the lower the current requirement and vice versa. A higher voltage supply will mean a higher electric field associated with the power line/cable and a lower magnetic field due to the current load being less.

Any runs of LV or MV cables from the service provider (sources 2 and 3) will also be significantly below the guideline limits for public exposure. EM field Levels at the power frequency of 50 Hz is also likely to be below the levels required for EMC compliance for standard electrical appliances at the final distances of these receptors from the chosen line and cable runs. The advantage of the AC feeds is that the cables can be run close together and take advantage of cancellation. This works in 3-phase feeds where each feed is out of phase with the others, such that their associated fields act to cancel (or more accurately reduce) the fields associated with the other feeds, thereby reducing the emissions for the overall line. Higher levels of AC fields in most locations would be expected to be measured from building wiring and appliances than from the proposed supply cables. The final location of these LV and MV feeds will be at the discretion of the service provider. However, noting the immunity level for domestic appliances is 3.8 µT and 3 V/m for 50 Hz magnetic and electric fields respectively, levels significantly below these would be expected at all the identified stakeholders in the receiving environment.

Due to the continued electrification required for operation of both the trains and ancillary systems, the AC fields from sources 1,2 and 3 at the power frequency will be permanent. The electric field magnitude consistent on a permanent as long as the voltage remains stable while the magnitude of magnetic fields will vary momentarily several times per hour dependent on the final train timetable. The levels from sources 1, 2 and 3 will not exceed the ICNIRP EMF guidelines nor the outlined immunity levels in the receiving environment.

Finally, in relation to source 4 listed above. The DC traction supply will have an AC component due to the rectification process involved in generating the DC. Discussions with the design team outlined that this current will not exceed 2 Amps. The magnetic fields associated with this AC component was modelled using the same methodology as was used for the DC magnetic field in Section 22.5.2.1.1. While present, the field associated with this AC component will be very difficult to measure above baseline levels at 10 m from the line in a typical urban or industrial environment due to the low levels that were modelled. 4 Amps (as opposed to 2 Amps) was modelled to simulate a substation failure and therefore the train being powered from only one substation. The resultant fields at 1 m above track level with the output illustrated in Figure 22-7 against the 3.8 µT immunity level for domestic appliances. After 4 m these worst-case levels are below this value and below 1 µT at 10 m.

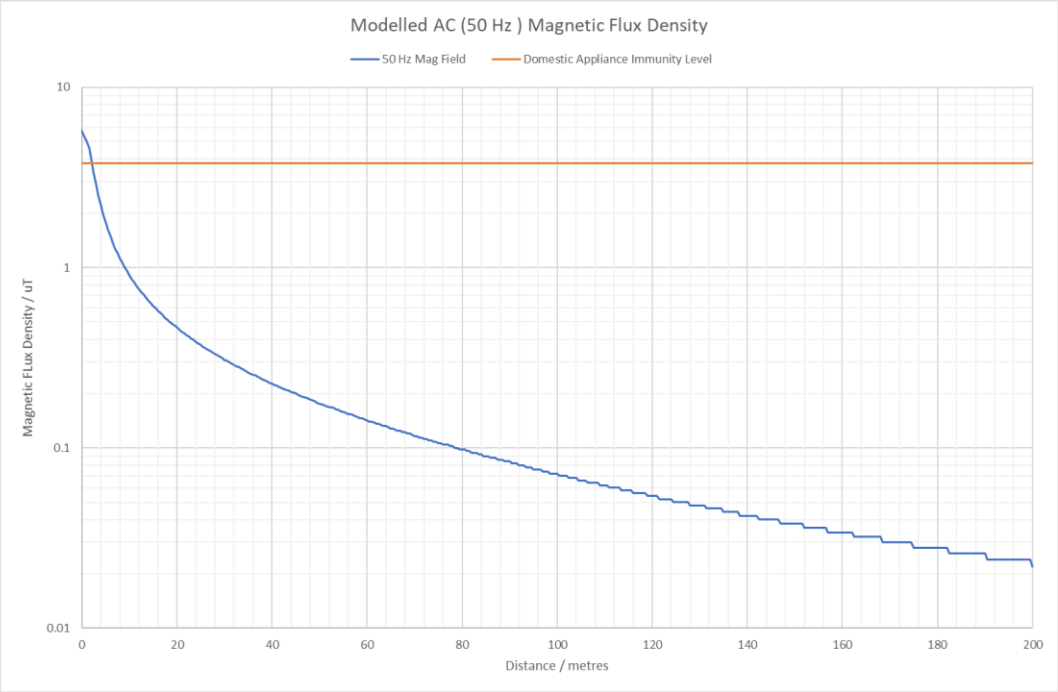

Figure 22-7 Modelled 50 Hz Magnetic flux density for worst-case conditions

AIMDs which may be worn by the general public, such as pacemakers are tested to higher EMF Immunity levels than standard electrical equipment to safeguard operation according to EU regulations. A limit of 100 µT applies to 50 Hz magnetic fields and 5,000 V/m to 50 Hz electric fields. This is the same as the public exposure limits for magnetic and electric fields also (again 100 µT and 5,000 V/m). These levels will not be exceeded by the proposed development and, accordingly, the significance of effects for public exposure to AC fields has been determined to be *imperceptible* with a quality of effects of *neutral*.

22.5.2.2.2 AC fields at harmonic frequencies

Due to the nature of the rectification of the power source, which generates the DC voltage to drive the traction system, what are known as harmonics occur at multiples of the fundamental power frequency of 50 Hz, e.g. 2 x 50 Hz, 3 x 50 Hz etc. Therefore, these harmonics will appear at 100 Hz, 150 Hz, 200 Hz, 250 Hz etc. with the magnitude of the odd harmonics larger than the even harmonics. For example, the 3rd harmonic at 150 Hz will exceed the 2nd harmonic in magnitude. Along with the modelling carried out as part of the DC and 50 Hz field modelling, these harmonic levels were modelled at different distances from the proposed alignment. Their magnitude is always below that of the 50 Hz fundamental. As these harmonics are a by-product of the DC system their duration and frequency of occurrence would be of a similar profile to that illustrated for the DC magnetic field. So, the magnitude of the harmonics will peak when the DC current peaks. Therefore, their duration would be momentary with a frequency of several times per hour dependent on the train timetable.

Typical electrical equipment such as IT, industrial, domestic etc. will not have any susceptibility to these harmonic frequencies with the exception of audio-visual equipment. The reason being that these harmonics occur within the range of human hearing (20 Hz – 20 kHz). So, while standard electrical equipment is typically only assessed for immunity to the power frequency, standard audio-visual equipment sold on the European marketplace will likely have been assessed to the standard EN 55103-2 (audio, video, audio-visual, and entertainment lighting control for professional use). This standard for professional audio equipment has immunity levels of 1 µT at 50 Hz, decreasing linearly with the logarithm of the frequency to 0.01 µT at 5 kHz.

The magnitude of harmonics can range from up to 10% of the fundamental frequency i.e. 10 % of the 50 Hz magnetic field magnitude. For higher harmonics this becomes up to 2% of the fundamental. The modelled worst-case levels (harmonics associated with a 4 A 50 Hz component at 10% equivalent magnitude) are illustrated in Figure 22-8 along with selected immunity levels taken from EN 55103-2. Immunity requirements as per EN 55103-2 are calculated to be 0.7 µT (for 150 Hz) and 0.6 µT (for 300 Hz). It can be seen that the selected limits are not exceeded for modelling at 1 m above ground level in worst-case conditions. The immunity levels are lower again for higher frequencies e.g. 0.45 µT for 600 Hz and 0.12 µT for 1,200 Hz. However, the harmonic levels associated frequencies will be lower than that what has been modelled and therefore lower than those illustrated in the figure also. Interference with approved audio-visual systems that are as close as to being physically on the lines is unlikely.

Hearing aids, as worn by members of the public, would be approved to EN 60118 under the Medical Device Directive. These would be tested to immunity levels slightly higher to those outlined above for professional audio-visual equipment.

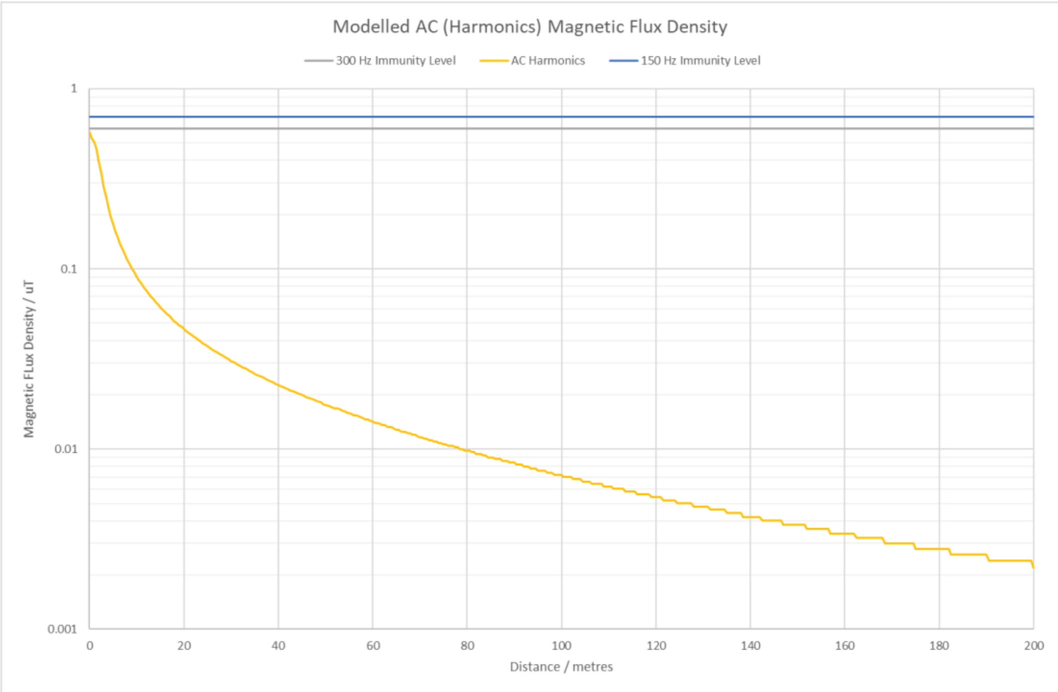

Figure 22-8 Modelled magnetic flux density of harmonics for worst-case conditions

Finally, equipment unlikely to have been assessed for immunity to magnetic field interference in the AC range are magnetic pickups, typically used on stringed instruments such as electric guitars, violins, and bespoke equipment. Lab testing of sensitivities for such an instrument suggested the following audible sensitivities:

- 300 Hz – 0.02 µT.
- 600 Hz – 0.005 µT.
- 1,200 Hz – 0.001 µT.

What is evident in the dataset above is that the higher the frequency the more sensitive the relationship. This would be what is expected due to the nonlinear sensitivity of the human ear to different frequencies. Comparing these levels to what is the worst-case modelled levels for these higher frequency harmonics:

- 10 metres (0.018 µT).
- 20 metres (0.009 µT).
- 50 metres (0.003 µT).

It can be seen that the higher frequency harmonics present more of a sensitivity issue at a greater distance than the lower harmonics. At the levels involved in normal operation (not worst-case levels that have been outlined) the impact from these harmonics beyond 10 m would be considered *imperceptible* for these equipment types. In the absence of formal standard limits however, perception based on one human observer is very much a subjective quantity.

22.5.2.2.3 Predicted AC Fields significance of effects

For recording studios, which may contain such equipment, within 20 m of the line, the significance of effects has been classed as moderate with a quality of effect of negative. For recording studios between 20 m up to 50m from the line the significance of effects is classed as slight with a quality of effect of neutral.

Twisted copper phone cables within 10 m of the alignment have the potential to experience audio frequency interference where they run parallel for large distances. The eircom cable running along Conliffe road listed in Table 22-7 for example is 35 m away and so would not experience any interference in this frequency range. Similarly, along Fitzroy Avenue at 20 m distance.

The eircom cables listed in Table 22-8 running along Whitworth Road and Ossory Road were the closet identified cable runs that could experience interference as they run for distances of greater than 50 m in parallel with the lines. The cable on Whitworth Road is approximately 10 m from the alignment while the Ossory Road cable is approximately 7 m. Assuming these cables are twisted pair copper wire (worst-case) interference levels here may be detectable using sensitive equipment and instruments. However, they would be expected of a level that would be imperceptible to any analogue telephone handset users. The significance of effects for this cable is classed as *slight* with a quality of effect of *neutral*.

All other receptors have been classed as having a significance of effects from AC fields of imperceptible with a quality of effects of neutral. There may be some domestic premises within 10 m of the line that contain effected equipment also but this was not determined during the receiving environment study.

The following table summarises the significance of effects for the various stakeholders with respect to AC field impacts during the operational phase of the proposed development.

Table 22-16 Significance of effects for AC Fields during the operational phase

Receptors	Significance of Effects	Quality of Effects
Commercial/Corporate areas	Imperceptible	Neutral
Telecom cables on Whitworth Road and Ossory Road.	Slight	Neutral
Telecom and other utilities listed as notable in the tables of 22.4.1	Imperceptible	Neutral
Utilities in proximity to the line but not listed as notable in the tables of 22.4.1	Imperceptible	Neutral
Residential and hospitality areas	Imperceptible	Neutral
Medical, Dental and Veterinary Centres	Imperceptible	Neutral
Intel	Imperceptible	Neutral
Luas Red Line, Luas Green Line	Imperceptible	Neutral
Maynooth University	Imperceptible	Neutral
Fuel/Service stations	Imperceptible	Neutral
Community Centres, Theatres and recording studios (between 20 m to 50 m) • Studio4 • Panchord Studio • Ballybough Community Centre • Croke Park	Slight	Neutral
Recording Studios within 20 m • Yellow Door Music studios • Guerrilla Sound Studios	Moderate	Neutral
Schools and Educational Facilities	Imperceptible	Neutral
Agricultural land uses	Imperceptible	Neutral

Receptors	Significance of Effects	Quality of Effects
Parklands and sports fields	Imperceptible	Neutral

22.5.2.3 RF and Microwave fields impacts

The system contractor(s) will ensure that the electrical systems, communications, and equipment associated with the proposed scheme comply with the EMC Directive 2014/30/EU and the Radio Equipment Directive 2014/53/EU. Radiofrequency fields from the proposed scheme will emanate from the following sources;

- From the traction vehicle.
- Radio communication (including GSM-R, analogue train radio).
- IT systems (WiFi, security systems etc.).
- Microwave links.
- Signalling systems.

The radiofrequency emissions from the vehicles and infrastructural equipment will be controlled by compliance with the mandatory application of the two previously mentioned directives, the EMC and RED. These are implemented in Ireland under Statutory Instruments. As such, the radiofrequency and microwave emissions levels will be controlled to levels that will ensure the absence of interference with radio, TV and telecommunications apparatus. The location of radio transmitters will be such to ensure that the levels of emissions do not cause interference with electrical and electronic equipment along the route. This will ensure that levels at possible receptors will not exceed 1 V/m. RF and microwave emissions attributed to the proposed development will be permanent in nature once the systems remain online.

All receptors in the study area along the proposed route have been given a significance of effects rating of between Imperceptible to Slight with a quality of effects of neutral.

From a human exposure perspective the levels listed in Table 22-6 are far in excess the 1 V/m discussed in the previous paragraphs. The requirement for the electrical systems installed will be required to meet the EMC directive will ensure that human exposure limits are not approached at any frequency in the RF range which starts at 87 V/m at 3 kHz reducing to 61 V/m at 300 GHz. The significance of effects for RF and microwave fields for the general public is therefore class as *imperceptible* with a quality of effects of *neutral*.

22.5.2.3.1 Predicted RF and microwave fields significance of effects

The following table summarises the significance of effects for the various stakeholders with respect to RF fields impacts during the operational phase of the proposed development.

Table 22-17 Significance of effects for RF and microwave fields during the operational phase

Receptors	Significance of Effects	Quality of Effects
Commercial/Corporate areas (including Croke Park)	Imperceptible	Neutral
All utilities	Imperceptible	Neutral
Residential and hospitality areas	Imperceptible	Neutral
Medical, Dental and Veterinary Centres	Slight	Neutral
Intel	Slight	Neutral
Luas Red Line, Luas Green Line	Slight	Neutral
Maynooth University	Slight	Neutral
Fuel/Service stations	Imperceptible	Neutral
Community Centres, Theatres and recording studios	Imperceptible	Neutral
Schools and Educational Facilities	Slight	Neutral
Agricultural land uses	Imperceptible	Neutral

Receptors	Significance of Effects	Quality of Effects
Parklands and sports fields	Imperceptible	Neutral

22.5.2.4 Stray current impacts

The current alignment intersects and runs parallel to dozens of buried pipes and cables of varying sizes and significance. These include electricity cables, sewage and water pipes, gas pipes and telecommunication cables. The more conductive the material used in the pipework, the more prone it is to stray currents. For example, cast iron pipes, the likes of which would have been installed during Victorian times. Figure 22-9 illustrates the nature of stray current with the dashed arrows indicating the stray current path through the earth and the main traction circuit depicted by the continuous line. In an ideal situation 100% of the feeding current from the OCS will pass back to the substation via the rails. However, due to the length of the circuit involved, even with the use of highly conductive rail (rails have a finite resistance of 30 mΩ per km typically), some current will pass through the earth back to the substation, but some current will inevitably find its way into the earth. The goal is to implement sufficient design measures to reduce it to as small as possible.

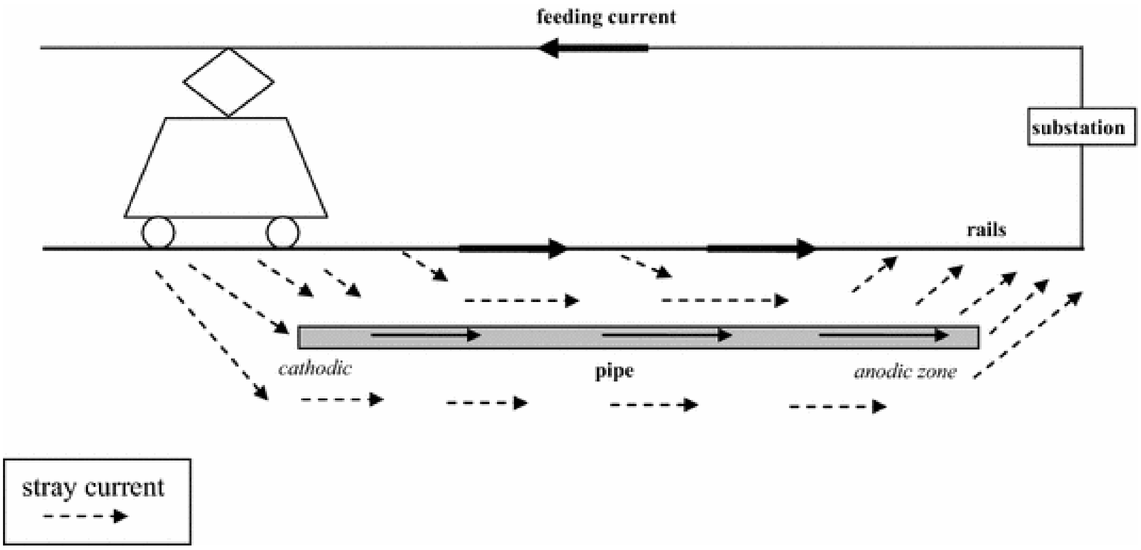

Figure 22-9 Illustration of stray currents from an electrified rail system

Corrosion is a naturally occurring feature of buried pipework also, which is not attributable to stray currents. However, not implementing good stray current practices can result in accelerated corrosion of buried pipework and structures over time at the point of discharge from the receptor. The underground environment in Dublin and its suburban environment along the route is heavily populated with various types of these buried structures and stray current is already a feature experienced by them. When the DART was installed stray current mitigation, measures were not as advanced as they are today and as a result stray currents from the DART line have been observed on various utilities around Dublin and Wicklow, often at distances of several miles away from the lines. The environment from Blanchardstown heading west to Maynooth would be considered more quiescent currently.

Mitigation measures, which are not optional, are required to be built into the design and then to be applied during the installation of the proposed development. These will significantly reduce the potential impact of stray currents on nearby buried structures.

These available measures include the following –

- Insulation of the return circuit (rails) from earth by means of insulated rail fasteners i.e. minimising its conductance to earth.
- Minimising the return circuits impedance.
- The poles carrying the OCS are required to be earthed for safety reasons. However, in order to equalise the potentials and improve the resistance to earth of the earthing system, along each track

an earth wire shall be installed joining all the poles. The earth wire will be connected to earthing facilities.

After installation and commissioning, monitoring of the efficacy of the stray current protective measures can be performed. Typically, through monitoring the return circuit to earth voltage. Once this voltage is known and historic values are also available, significant changes can indicate the presence of changes in the system. If the origin of the change is known (e.g. modifications in the installations) then there is no issue. But if the origin of the change isn't known, this indicates eventual failure or degradation of one of the measures, and prompts corrective actions to be implemented i.e. potential faults in these mitigation measures or degradation over time can adequately detected.

Additionally, if the rail-to-earth conductance is known, the stray current density can be easily evaluated. The return circuit voltage multiplied by the rail-to-earth conductance will give the stray current density. The lower the voltage and the lower the conductance then the lower the stray current density will be.

EN 50122-2 states based on operational experience, no damage within a 25-year period along structures is occurs in cases where stray currents are kept under the threshold of 2.5 A/km of track. In addition, it also states that no concern should be raised if voltage variation between metal structures and earth is lower than +200 mV.

One final mitigation measure is the possibility of installing a stray current collection system. A collector mat could be used to give another path for the remaining stray currents back to the substation. A collector mat might be installed under the rails where it is implemented by means of the installation of a metallic (steel) grid/longitudinal bars. This option hasn't been considered by the design team currently due to the fact that the tracks are pre-existing and in operation, however, if particularly problematic stretches of track are discovered later in the detailed design or installation phases of the project the use of this extra mitigation measure could be explored.

Some utilities owners themselves already apply their own mitigation measures in some instances to protect against corrosion and stray currents. Replacing old metallic pipework with non-conductive equivalents for example. But also, in some instances, using cathodic protection. This method of protection utilises a sacrificial anode to help protect the main pipework where it acts as the cathode in the electric circuit. A cathodic protection system may be passive or active. In the case of an active system an external power source is required to induce the necessary current to maintain the desired circuit polarity.

Stray currents from the proposed development will be permanent in duration once the lines are electrified. Within Dublin and its suburban environment, the magnitude of these currents may be so small as to be indistinguishable from other ambient currents even with measurement equipment. There will be momentary increases in the magnitude of the currents when trains are pulling power from the lines with the magnitude of the currents being proportional to the load current on the track. At this point the currents are likely to be detectable on structures closest to the alignment in rural locations including urban locations from Blanchardstown to Maynooth (up to 100 metres away). Within the city it should be possible to again detect the presence of these currents but much closer to the alignment, for example within 10-20 m. In this case the proposed development could be more easily identified as the likely source and not the current DART, the Luas or other another source for example. For all identified receptors that would have large, buried structures capable of conducting stray current the significance of effects has been rated as slight. For all others, they have been rated as imperceptible.

It is worth noting that the proposed development itself will also act as a sink for the stray currents already present in the subterranean environment.

The quality of effects for stray currents has been classed as *neutral*.

Table 22-18 Significance of effects for stray currents fields during the operational phase

Receptors	Significance of Effects	Quality of Effects
Commercial/Corporate areas (including Croke Park)	Imperceptible	Neutral
Utilities listed as notable in the tables of 22.4.1	Slight	Neutral
Utilities in proximity to the line but not listed as notable in the tables of 22.4.1	Imperceptible	Neutral
Residential and hospitality areas	Imperceptible	Neutral
Medical, Dental and Veterinary Centres	Imperceptible	Neutral
Intel	Imperceptible	Neutral
Luas Red Line, Luas Green Line	Slight	Neutral
Maynooth University	Slight	Neutral
Fuel/Service stations	Slight	Neutral
Community Centres, Theatres and recording studios	Imperceptible	Neutral
Schools and Educational Facilities	Imperceptible	Neutral
Agricultural land uses	Imperceptible	Neutral
Parklands and sports fields	Imperceptible	Neutral

22.6 Mitigation measures

Where the significance of effects for a stakeholder has been classed as moderate of higher mitigation measures are available for consideration. While no equipment was identified that will be impacted by DC and Quasi DC magnetic field interference from the proposed development, should any impacts manifest themselves during operation the following mitigation measures are available:

- Relocation of the affected equipment.
- Installation of an active cancellation system.
- Shielding of the labs/rooms using specialized material designed to attenuate DC magnetic field perturbations.
- The embedded mitigation measure discussed in Section 22.6.1.

Active cancellation systems operate on the basis of responding to a changing magnetic field, whereby the system generates a counter field to cancel out fluctuations as they occur.

Any impacts in relation to AC fields can be addressed in a number of ways if necessary, including –

- Relocation of the affected equipment.
- Shielding.
- Filtering.

22.6.1 Embedded mitigation specific to Intel

Figure 22-10 depicts the standard Overhead Line Equipment (OHLE) configuration with the messenger wire, contact wire and feeder wire (yellow ellipse) all running above the train line. The feed current is distributed amongst these three conductors with the return current passing through the rails. Figure 22-11 the feeder wires (yellow ellipse) for both lines have been buried as a cable beside the downline (which is the furthest line from the Intel campus in this case). The effect of running this cable closer to the rail lines is to take advantage of the natural cancellation that will occur from their closer proximity.

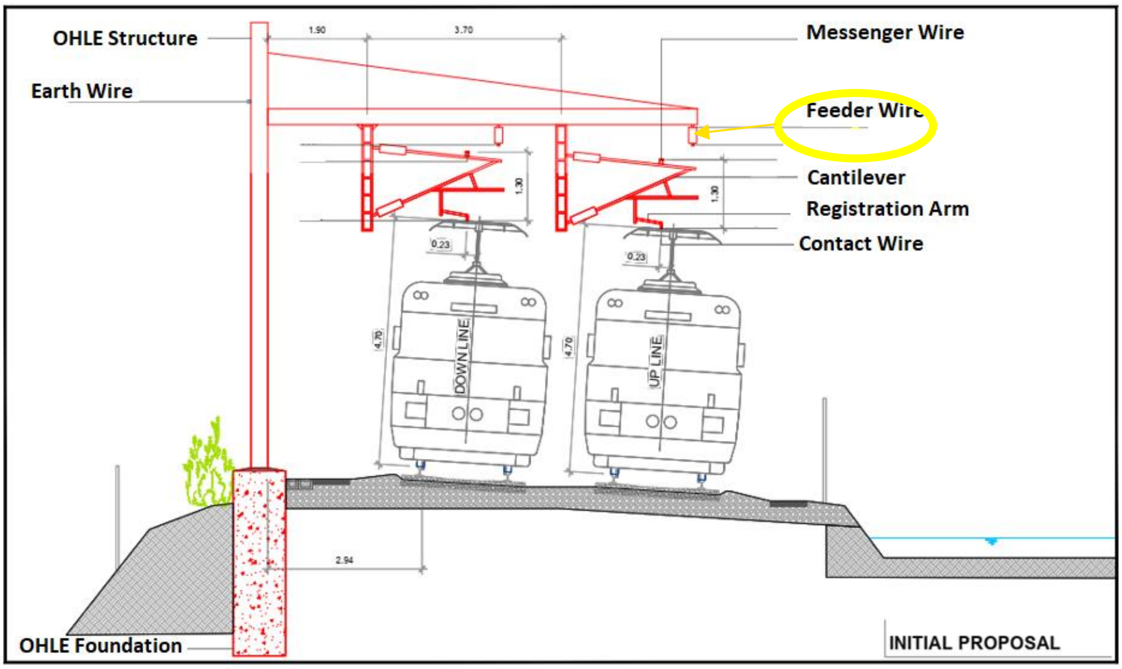

Figure 22-10 Standard OHLE layout

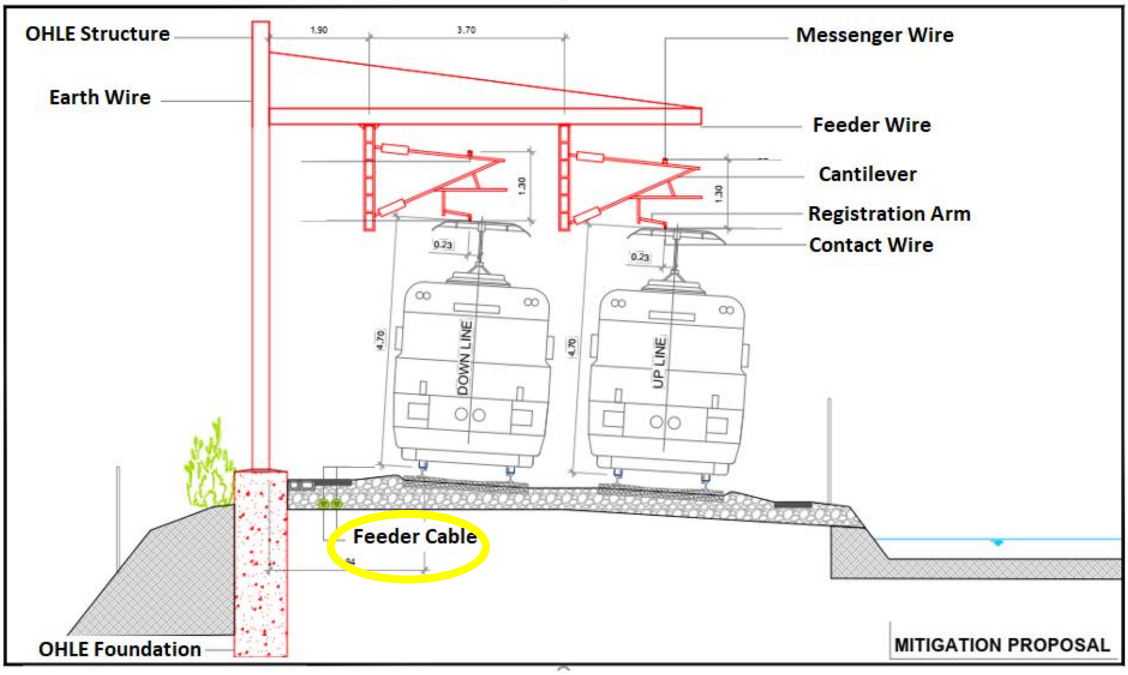

Figure 22-11 Mitigated OHLE layout

The result of this mitigation measure is depicted in Figure 22-12 where the overall effect can be seen to reduce the levels. Laterally, the distance at which the levels fall below 1 µT has been moved by 50 m closer to the line.

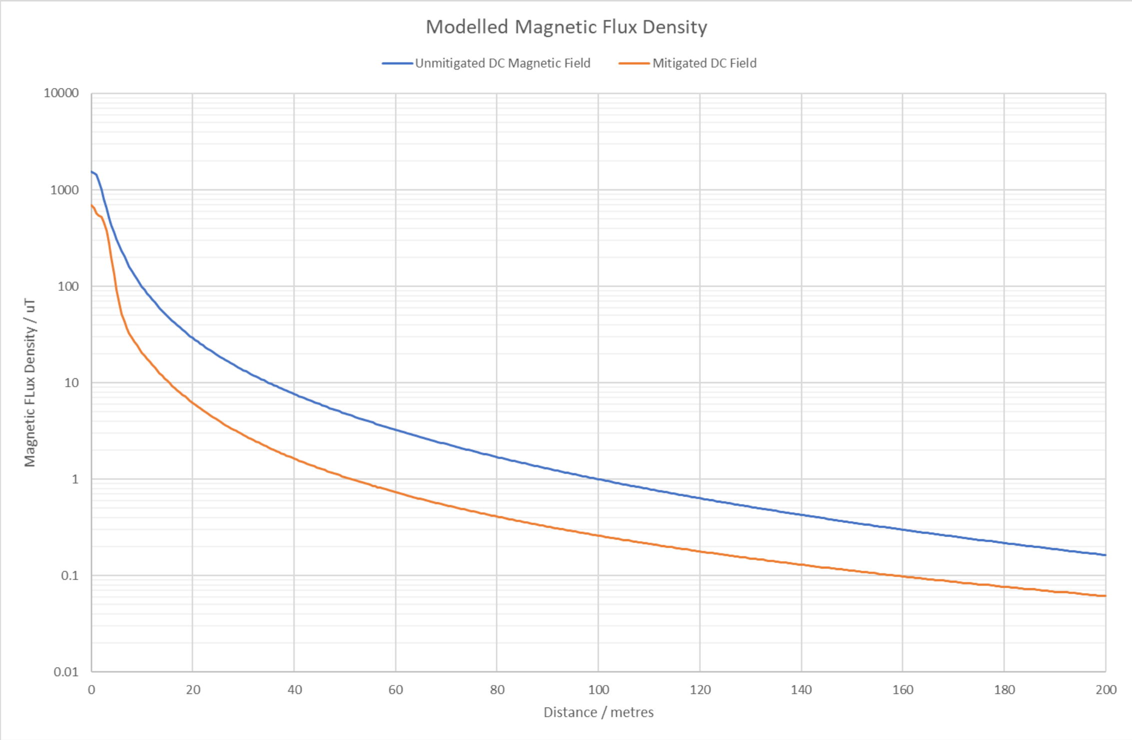

Figure 22-12 Unmitigated Vs mitigated DC Magnetic Field profile

22.7 Monitoring

Not applicable.

22.8 Residual Effects

Equipment such as MRI machines, NMRs, SEMs etc. typically have manufacturer specified operational environmental conditions which, as well as temperature, humidity etc., will state the recommended electromagnetic environment for optimum performance. End users will then survey locations within their campus and attempt to locate this equipment away from sites containing electrical transformers, high current or high voltage cabling and even traffic and ferromagnetic objects which can cause DC magnetic field perturbations. After construction and commissioning of the proposed development locations within 100 m of the line may not be suitable for the installation of equipment sensitive to DC and quasi-DC magnetic fields without the implementation of some of the mitigation measures discussed in Section 22.6.

Future developments such as extensions and new building at locations including theatres, musical venues, stadiums, domestic or commercial premises that bring unapproved audio equipment within 20 m of the lines could potentially experience interference in the audio frequency range (AC fields).

Despite applied mitigation measures to minimise the magnitude of Stray current, it is an inevitable phenomenon associated with DC rail systems. Continued monitoring of the performance of the traction circuit with respect to current returns to the substation will be required.

22.9 Cumulative Effects

The scope for cumulative impacts from the proposed project is small and predominantly relate to other electrified traction systems within the study area.

22.9.1 Cumulative Electromagnetic Fields

The cumulative effect of electric and magnetic fields in the RF and microwave frequency ranges is negligible. Likewise, there is not anticipated to be notable cumulative effects in the range of AC fields.

Where the train line runs close to Luas in Broombridge there is the potential for a small cumulative effect. At this location increased perturbations could occur in the DC and Quasi-DC range where the lines run parallel to one another. The space between the two schemes, which might only experience a low field change, may end up with a slightly higher change if trains are accelerating on both sections of the lines at the same time. Current loads would be required to be drawn in the same direction for a net gain to occur. However, it is as likely that counter fields are generated thus creating a cancelling effect also. Any potential for increased levels in this median would still be below levels that would be experienced closer to each line individually though. No potentially sensitive equipment was identified in these median locations along the proposed development during baseline examinations.

The cumulative assessment of relevant plans and projects is undertaken separately in Chapter 26 of this EIAR.

22.9.2 Cumulative Stray Current

Cumulative impacts from stray current are difficult to predict. As discussed previously, the subterranean environment within Dublin already has an ongoing impact from stray currents which can travel several kms from the source. The main contributors would be the DART, with additional smaller contributions from the various Luas lines. There could be a cumulative effect in that the incidence of the potential difference fluctuations on these buried structures may increase. Accelerated corrosion could be possible if the exit point of the stray current from the buried structure is the same as that from another source.

The cumulative assessment of relevant plans and projects is undertaken separately in Chapter 26 of this EIAR.

22.10 References

EN 50121 (Parts 1-5) – Railway Applications. Electromagnetic Compatibility

EN 50122-2:2010 – Railway applications - Fixed installations - Electrical safety, earthing and the return circuit - Part 2: Provisions against the effects of stray currents caused by d.c. traction systems

EN 45502-2-1:2004 – Active implantable medical devices Part 2-1: Particular requirements for active implantable medical devices intended to treat bradyarrhythmia (cardiac pacemakers)

EN 50527-2-1:2016 – Procedure for the assessment of the exposure to electromagnetic fields of workers bearing active implantable medical devices

EN 55103-2:2009 – Electromagnetic compatibility. Product family standard for audio, video, audio-visual and entertainment lighting control apparatus for professional use. Immunity.

EN 60118-13 – Electroacoustics - Hearing aids - Part 13: Requirements and methods of measurement for electromagnetic immunity to mobile digital wireless devices

EN 50121-2:2006 Railway applications - Electromagnetic compatibility Part 2: Emission of the whole railway system to the outside world

EU Electromagnetic Fields Directive, 2013/35/EU

EU Council Recommendation on the limitation of exposure of the general public to electromagnetic fields (0Hz to 300GHz) 1999/519/EC

EU Electromagnetic Compatibility Directive 2014/30/EU on the approximation of the laws of the Member States relating to electromagnetic compatibility

European Low Voltage Directive (2014/35/EU)

European Radio Equipment Directive (2014/53/EU)

ICNIRP Guidelines for limiting exposure to time varying electric, magnetic and electromagnetic fields (up to 300 GHz) published in Health Physics; 2009.

ICNIRP Guidelines on limits of exposure to Static Magnetic Fields published in Health Physics; 2009.

ICNIRP Guidelines for limiting exposure to time-varying electric, magnetic, and electromagnetic fields (up to 300GHz). Health Physics 74 (4): 494-522; 1998

S.I. No. 145/2016 - European Communities (Electromagnetic Compatibility) Regulations 2016

S.I. No. 248/2017 - European Union (Radio Equipment) Regulations 2017

S.I. No. 345/2016 - European Union (Low Voltage Electrical Equipment) Regulations 2016