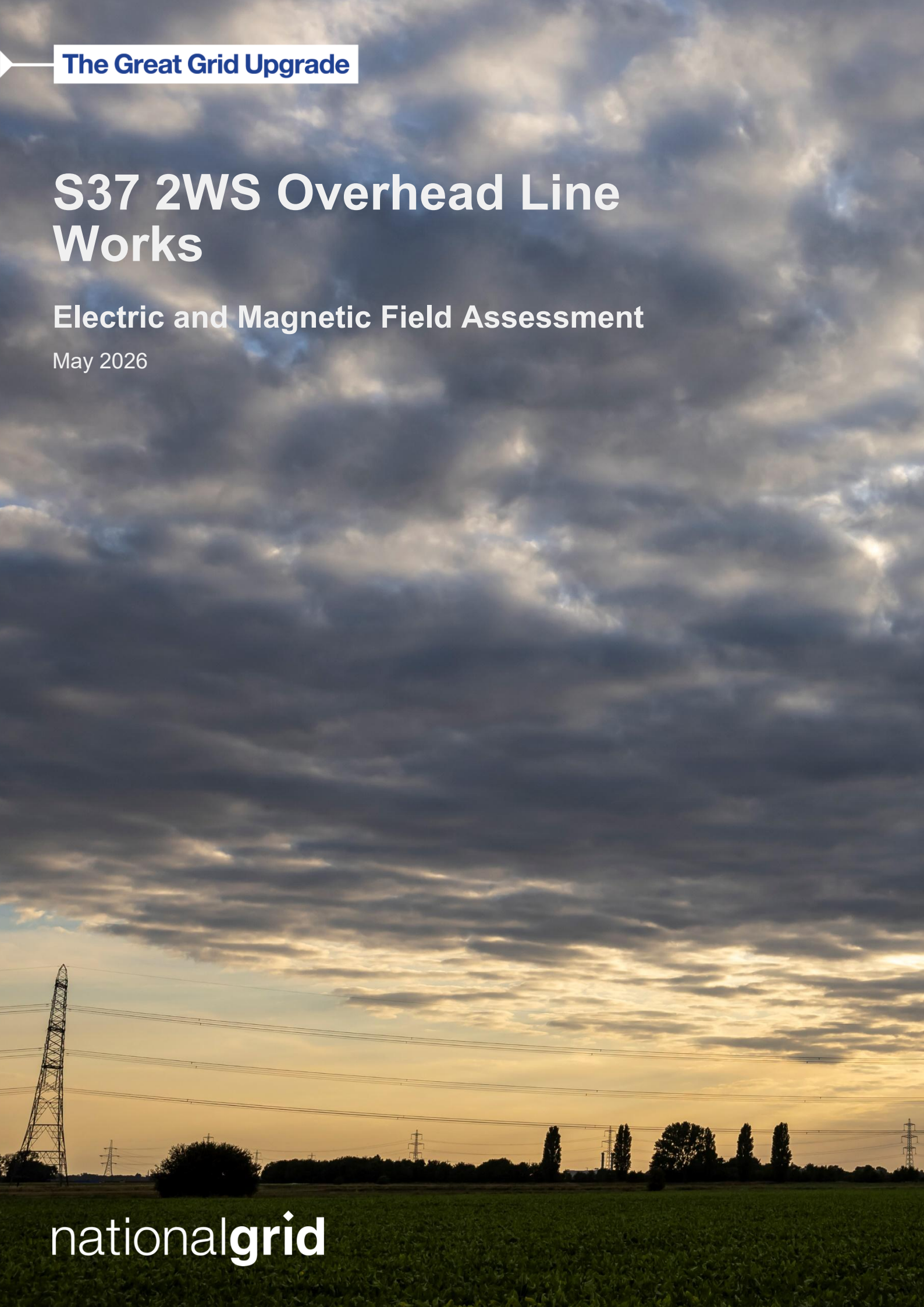
The Great Grid Upgrade

S37 2WS Overhead Line Works

Electric and Magnetic Field Assessment

May 2026



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1. Introduction

1.1.1 This report provides an assessment of the Electric and Magnetic Fields (EMFs) associated with the proposed 400 kV 2WS Overhead Line Works at Weston Marsh Substation A. This report comprises a desktop analysis undertaken in accordance with Government Policy and is based upon site specific design information.

1.1.2 National Grid has a very clear policy on EMFs, as set out in its Public Position Statement[1] which states *"…In all our operations, as a minimum we comply with EMF regulations, guidelines or practices in force in the countries and different jurisdictions in which we operate."* and this policy would be applied to this Scheme consisting of:

- Construction of the new Air Insulated Substation (AIS) - 400 kV Weston Marsh Substation A
- Construction of new sections of overhead line to connect to the existing 4ZM overhead lines into the new substations (herein referred to as '4ZM Overhead Line Works')
- Construction of new sections of new sections of overhead line to connect the existing 2WS overhead line route (herein referred to as '2WS Overhead Line Works')
- Reconductoring works required on the existing 4ZM overhead line

1.1.3 As is explained in more detail in Section 2 below, compliance with the relevant guidelines and practices in force in the UK ensures that there should be no significant health or environmental effects of EMFs.

1.1.4 This assessment covers the proposed 2WS Overhead Line Works to facilitate the connection of the new Weston Marsh Substation A. Weston Marsh Substation A and the 4ZM Overhead Line Works have been assessed for EMF compliance in separate reports.

1.1.5 All equipment that generates, distributes or uses electricity produces EMFs. The UK power frequency is 50 Hz, which is therefore the principal frequency of the EMFs produced which are also known as Extremely Low Frequency (ELF) EMFs.

Electric fields

1.1.6 Electric fields depend on the operating voltage of the equipment producing them and are measured in volts per metre, symbol V/m. The operating voltage of most equipment is a relatively constant value. Electric fields are shielded by most common building materials, trees and fences, and diminish rapidly with distance from the source.

[1] National Grid's Public Position Statement on Electric and Magnetic Fields https://www.nationalgrid.com/electricity-transmission/document/137286/download

1.1.7 As a consequence of their design, some types of equipment do not produce an external electric field. This applies to underground cables which are enclosed in a metal sheath (a protective metal layer within the cable).

Magnetic fields

1.1.8 Magnetic fields are measured in microteslas, symbol μT, and depend on the electrical currents flowing, which vary according to the electrical power requirements at any given time. They are not significantly shielded by most common building materials or trees but do diminish rapidly with distance from the source.

2. EMF policy and exposure limits

2.1 Overview of policy

2.1.1 Whilst there are no statutory regulations in the UK that limit the exposure of the general public to power-frequency EMFs, responsibility for implementing appropriate measures for the protection of the public lies with the UK Government. The Written Ministerial Statement of 16 October 2009[2] introduced a comprehensive statement of Government policy on EMFs. This policy has been reiterated in NPS EN-5[3], but follows the overarching Government policy on EMFs which applies to all electricity infrastructure, including applications made under the Town and Country Planning Act 1990. This includes a clear policy on the exposure limits and other policies that are expected to be applied. Practical details of how the policy is to be implemented are contained in a Code of Practice on Compliance[4] agreed between industry and Government.

2.1.2 The UK Government acts on the scientific advice from the UK Health Security Agency (UKHSA), which has responsibility for advising on non-ionising radiation protection, including power-frequency EMFs. UKHSA exercise radiological protection functions across the whole of the UK. The National Radiological Protection Board (NRPB) had this responsibility until becoming part of the Health Protection Agency (HPA) on 1 April 2005, which in turn was replaced by Public Health England (PHE) on 1 April 2013, which in turn was replaced by UKHSA on 1 April 2021. This report refers to UKHSA, PHE, NRPB or HPA according to the name of the organisation at the time each statement was issued.

2.1.3 In 2004, following a recommendation by the NRPB, the UK Government adopted exposure guidelines for the public published in 1998 by the International Commission on Non-Ionizing Radiation Protection (ICNIRP)[5] in line with the terms of the 1999 European Union (EU) Recommendation[6] on public exposure to EMFs.

2.1.4 In a Written Ministerial Statement in October 2009[2], (references to the Written Ministerial Statement encompass both the Statement itself and the detailed Response that the Statement introduced) the Government restated this policy of compliance with exposure limits and, acting on the recommendations of a stakeholder process, added a single precautionary measure in relation to high voltage infrastructure; a policy of “optimum phasing” of some overhead lines.

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[2] Department of Health (2009). Government response to the Stakeholder Advisory Group on extremely low frequency electric and magnetic fields (ELF EMFs) (SAGE) recommendations. https://webarchive.nationalarchives.gov.uk/ukgwa/20130104042702/http://www.dh.gov.uk/en/Publicationsandstatistics/Publications/PublicationsPolicyAndGuidance/DH_107124.

[3] Department for Energy Security & Net Zero (2025). National Policy Statement for Electricity Network Infrastructure (EN-5).

[4] Department of Energy and Climate Change (2012). Power Lines: Demonstrating compliance with EMF public exposure guidelines. A voluntary Code of Practice.

[5] International Commission on Non Ionising Radiation Protection (1998). Guidelines for Limiting Exposure to Time-Varying Electric, Magnetic and Electromagnetic Fields. Health Physics, 74 (4), p.494.

[6] European Union Council (1999). Recommendation of 12 July 1999 on the limitation of exposure of the general public to electromagnetic fields (0 Hz to 300 GHz) (1999/519/EC).

"Optimum phasing" is an engineering measure that can be incorporated in the design of some overhead lines and which reduces the EMFs they produce. The Government also made clear in the Written Ministerial Statement that no other precautionary measures are appropriate for high voltage infrastructure.

2.1.5 The 2WS overhead line is not optimally phased, as per the conditions set out in the Code of Practice on Optimum Phasing[7]. The phasing is untransposed and the currents consistently flow in the same direction. The existing 2WS overhead line directly tees into the 4ZM overhead line, meaning it is currently not optimally phased due to the physical construction of the overhead line. The proposed Scheme would remove the physical barrier to optimum phasing of the 2WS overhead line at the northern end of the route due to the introduction of the Weston Marsh Substation A. However, to allow the route to be optimally phased, line entrees at Spalding B substation would need to be altered and further system design studies would be required. Further assessment is being undertaken to ascertain if the electrical clearances are sufficient at Spalding B Substation to allow this to occur and presents no network stability issues. The overhead line route will be altered to optimum phasing if the assessment shows this is technically and physically possible.

2.1.6 The assessment has been carried out based on a worst case scenario assuming non-optimum phasing of the 2WS overhead line. This ensures that the 2WS Overhead Line Works would comply with the Government's exposure limits even if our studies indicate that it is not possible to optimally phase the 2WS overhead line.

2.2 Public exposure limits

2.2.1 The ICNIRP guidelines[5] are explained, together with details of how to apply them, in the Department of Energy and Climate Change (DECC) Code of Practice 'Power Lines: Demonstrating compliance with EMF public exposure guidelines – a voluntary Code of Practice'[4]. National Grid has ensured that it complies with Government policy on EMFs, and this Code of Practice forms an integral part of demonstrating that compliance. The assessment included in this report has been undertaken in line with the principles of this Code of Practice[4].

2.2.2 The ICNIRP public exposure limits[5] which apply in the UK are documented in Table 2.1.

Table 2.1 Recommended Public Exposure Limits Values for Power Frequencies

Public Exposure Levels	Electric Fields	Magnetic Fields
Basic restriction (induced current density in central nervous system)	2 mA/m2	
Field corresponding to the basic restriction	9000 V/m	360 µT

2.2.3 There has been extensive research in an attempt to establish whether or not long term exposure to fields at lower levels than the ICNIRP guidelines[5] might be a cause of ill health in humans; this research has been extensively reviewed by bodies such

[7] Department of Energy and Climate Change (2012). Optimum Phasing of high voltage double-circuit Power Lines. A voluntary Code of Practice.

as UKHSA[8] and the World Health Organization (WHO)[9]. There is some evidence to suggest that high magnetic fields may be associated with an increased risk of one particular disease, childhood leukaemia. However, the weight of scientific evidence is against electric and magnetic fields causing ill health in humans at levels below the ICNIRP guideline limits[5]. The Government has addressed this uncertainty by adopting precautionary measures, set out in the Code of Practice - Optimum Phasing of high voltage double-circuit Power Lines[7].

2.2.4 All relevant legislation, policies and guidance, including those contained within EN-5[3] have been reviewed and applied to the EMF assessment of the proposed substations. These policies, guidance and legislation are explained in terms of planning policy below.

2.3 Planning policy

2.3.1 The question of whether health concerns related to electricity infrastructure justifies planning constraints has been addressed at a national level. Thus, the Written Ministerial Statement of 16 October 2009[2], made by The Minister of State for the Department of Health on behalf of themself, the Minister of State for the Department of Energy and Climate Change (now Department for Energy Security and Net Zero) and the Parliamentary Under-Secretary of State for the Communities and Local Government, introduced a comprehensive statement of Government policy.

2.3.2 The policy, in essence, is that new electrical infrastructure, and new developments near existing electrical infrastructure, should comply with the relevant guidelines and policies put in place for the protection of the public, and there is one further policy relating to the design of high-voltage overhead power lines, optimum phasing. Beyond this, there are no other measures or mitigation required.

2.3.3 Details of what the policies mean in practice and what evidence is considered acceptable to demonstrate compliance is contained in two Codes of Practice[4,7]. The Code of Practice on Compliance states:

> *The Electricity Industry agrees that whenever evidence is required of compliance with EMF exposure limits, it will provide evidence according to this Code of Practice. Government agrees that such evidence will be regarded as sufficient to demonstrate compliance.*

2.3.4 Thus, the Department for Energy Security and Net Zero, faced with a section 37 Electricity Act 1989 application for overhead electricity transmission lines, would be fully entitled to ask for evidence, as specified in the Code of Practice, of compliance[4] with the relevant exposure limits. This report constitutes such evidence, ensuring that the health issues relating to those overhead lines are appropriately addressed, and further restrictions on the development on health grounds, or refusal of permission on these grounds, are not appropriate.

[8] National Radiological Protection Board (NRPB) (2004). *Review of the scientific evidence for limiting exposure to electromagnetic fields (0-300 GHz)*. Doc NRPB, 15(3), 1-215

[9] World Health Organisation (2007). *Environmental Health Criteria Monograph No 238 on Extremely Low Frequency Fields*

3. Assessment methodology

3.1 Assessment of effects

3.1.1 The 2WS Overhead Line Works would be assessed as having a significant effect if non-compliance with the EMF exposure limits was demonstrated, using the principles set out in Codes of Practice 'Power Lines: Demonstrating compliance with EMF public exposure guidelines – a voluntary Code of Practice[4].

3.1.2 The UK Government's adopted guidelines are those of ICNIRP 1998 for 50 Hz EMFs, which are produced by the electricity transmission system. These guidelines equate to a public exposure limit for uniform electric and magnetic field exposure of 9.0 kV/m and 360 µT respectively. They apply particularly to areas where people spend significant periods of time, mainly residential properties and schools. They do not apply directly to areas where people pass infrequently such as Public Rights of Way/ pathways. However, compliance with the policy has been assessed irrespective of land use and time of exposure.

3.2 Surveys undertaken

3.2.1 EMFs have been assessed as per the conditions set out in the Code of Practice and compared with UK Government exposure guideline levels. This assessment is a desk-based exercise using electric and magnetic field calculation software including industry standard modelling package EFC-400, by Narda.

3.2.2 The Code of Practice states that calculations should be performed at the maximum continuous rating of the conductors, nominal voltage, 50 Hz only and at 1 m above ground, which has been used for this assessment. Calculations were performed using worst case conditions including minimum conductor clearances and minimum burial depth. The circuits are unlikely to operate at this maximum rating routinely, therefore resulting in lower typical electric and magnetic fields on a day-to-day basis.

4. Assessment of compliance with exposure limits

4.1 400 kV overhead line

4.1.1 A proposed new section of overhead line, modified from the existing National Grid 400 kV double circuit Bicker Fen to Spalding North and Spalding North to Walpole (2WS) route is required to connect the proposed Weston Marsh Substation A to the existing electricity transmission system. Consents for Weston Marsh Substation A will be applied for in a separate application made to South Holland District Council under the Town and Country Planning Act 1990.

4.1.2 Energised high voltage overhead transmission lines are a source of both electric and magnetic fields. The electric field generated by an overhead line is mainly dependent on the voltage of the line and remains more or less constant at 400 kV once the overhead line is operational. The magnetic field will vary depending on the current flowing in the conductors. The EMFs produced by an overhead line will be highest directly under the line and will rapidly decrease at increasing distance from the line. The overhead line design will also influence the EMFs produced and a worst-case design is considered in this assessment.

4.1.3 Calculations of the EMFs are provided; these are using a worst-case situation of minimum design clearance and maximum continuous rating across the new 400 kV overhead line section.

4.1.4 With the addition of the proposed Weston Marsh Substation A, the 2WS overhead line would not tee into the 4ZM overhead line. Further assessment is therefore ongoing to examine whether it is possible to change the phasing of the 2WS overhead line to optimal phasing. The assessment is being conducted on a worst-case scenario basis that assumes optimal phasing is not possible.

2WS Overhead line Works EMF assessment

4.1.5 The new overhead line sections proposed are double circuit steel lattice designs.

4.1.6 The minimum conductor clearance to ground to meet has been used in this assessment. Calculating the EMFs at minimum design clearance would represent a worst-case assumption, as higher clearances result in lower EMFs.

4.1.7 Calculations were performed at the worst-case pre-fault continuous rating of the conductor type and nominal voltage (400 kV) for 1 m above ground. The highest calculated EMFs produced by the overhead line using the worst-case conditions and at various distances are shown in Table 4.1. All calculations were performed in accordance with the conditions set out in the codes of practice[4]. The EMFs produced by the overhead line decrease rapidly with distance as demonstrated in Image 4.1 and Image 4.2.

Table 4.1 Calculated Maximum Worst-Case EMFs from the Modified 400 kV Overhead Line

Horizontal Distance from Centre of Overhead Line	Maximum Electric Field at Nominal Voltage (V/m)	Maximum Magnetic Field at Pre-Fault Continuous Loading (μT)
Directly under overhead line circuit	8325*	56.3**
25 m	589*	25.0**
50 m	375*	8.0**
100 m	135*	2.1**
200 m	37*	0.54**

** the public exposure limit for electric fields is 9000 V/m*

***the public exposure limit for magnetic fields is 360.0 μT*

Image 4.1 Maximum Calculated Magnetic Field from the New 400 kV Overhead Line

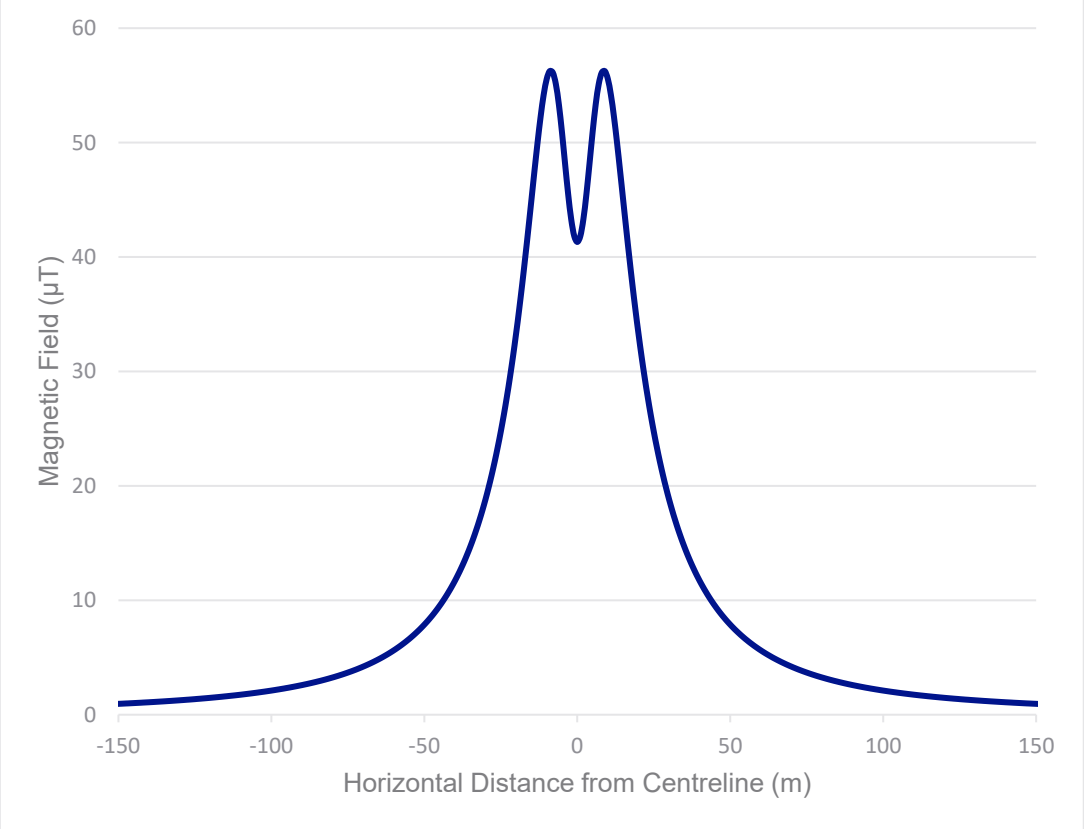
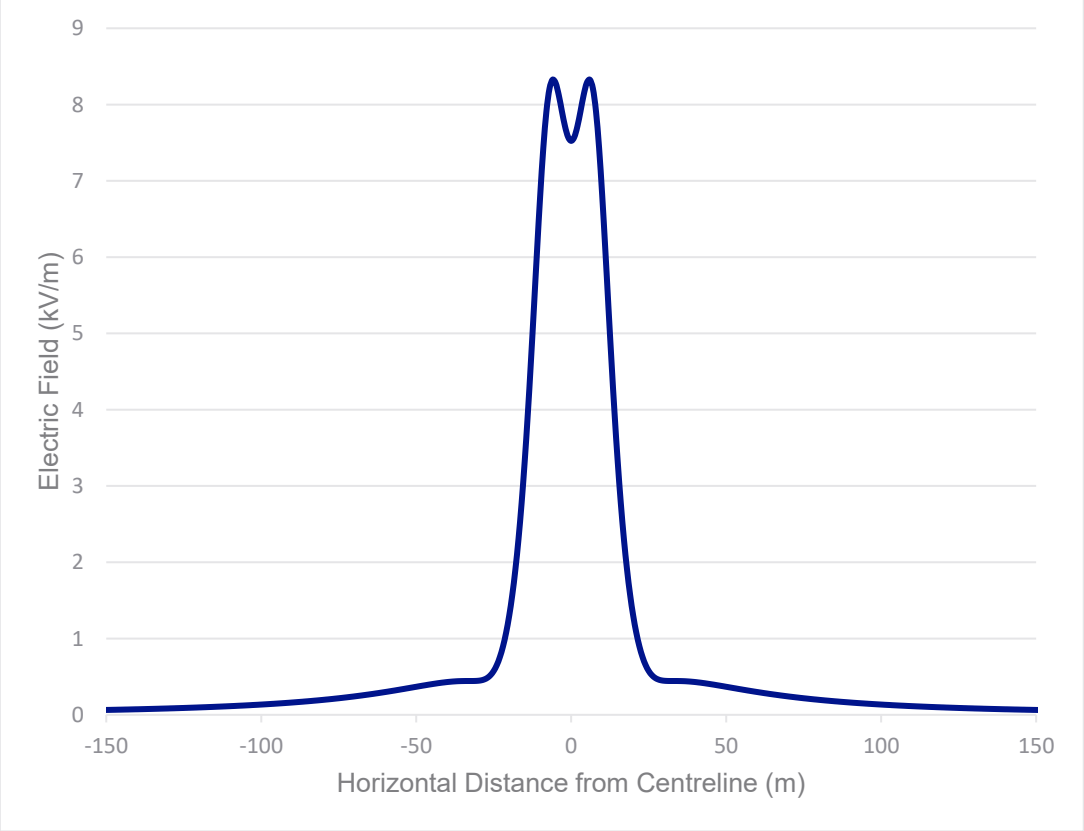


Image 4.2 Maximum Calculated Electric Field from the New 400 kV Overhead Line



4.2 Assessment summary

4.2.1 The new overhead line has been assessed and the maximum EMFs under those conditions are 8325 V/m and 56.3 μT. These are below the relevant exposure limits. The calculated EMFs are presented for compliance purposes using worst-case conditions. Typically, the overhead line would produce EMFs lower than these levels for two reasons: the circuits are unlikely to operate at the maximum rating routinely, and a typical current on a day-to-day basis would be around 50% or less of this; and for overhead lines typically the conductors would be higher than the minimum design clearance used for assessing compliance, reducing the EMFs at ground level, with the minimum clearance found only in a limited area towards the middle of certain spans.

4.2.2 The assessment presented above demonstrates that the maximum fields produced by the proposed overhead lines would be compliant with the relevant exposure limits in Table 2.1.

5. Conclusions

5.1.1 The Government, acting on the advice of authoritative scientific bodies, has put in place appropriate measures to protect the public from EMFs. These measures are set out in a Written Ministerial Statement, National Policy statement EN-5[3], and two Codes of Practice[4,7].

5.1.2 The 2WS Overhead Line Works have been assessed assuming non-optimum phasing and have demonstrated full compliance with the Government's relevant EMF exposure limits. The 2WS overhead line is not currently optimally phased and further work is being undertaken to assess if optimisation of the phases is possible. The phasing will be modified to optimal phasing if technically and physically possible.

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