Scottish & Southern Electricity Networks

EMF-OHL-002

Transmission - Engineering

# Electric & Magnetic Field Study Report

*for*

# Spittal – Loch Buidhe - Beauly 400kV Overhead Lines

| Revision | Overview of Amendment & Text Affected | Previous Document | Revision Author | Date |
|---|---|---|---|---|
| 1.0 | N/A | - | - | - |

| | Name | Title |
|---|---|---|
| Author | [redacted] | OHL Engineer |
| Checked by | [redacted] | Assistant Engineering Manager |
| Approved by | [redacted] | Principal Engineer |

## Summary


This report summarises the assessments of Electric and Magnetic Fields (EMF) associated with the proposed Spittal to Loch Buidhe to Beauly 400kV Overhead line project, focusing on the project's compliance with the exposure limits in the UK's Code of Practice 'Power Lines: Demonstrating compliance with EMF public exposure guidelines (DECC: 2012)', validation process and assessment of the more complex arrangements. The project uses an AAAC Araucaria conductor in triple-bundled configuration per phase supported by lattice steel AS4 tower structures. SSEN undertook a comprehensive assessment of the EMF levels using PLS CADD software for two levels of current, 3370A and 5000A, for both transposed (optimal) and untransposed phasing scenarios. PLS CADD is the industry standard for overhead line design. To validate the results, an independent consultant, WSP, was engaged, using an alternative software package for the assessment, SES CDEGS. Both analyses produced consistent results, ensuring the accuracy and reliability of the findings.

The assessed EMF levels comply fully with the exposure limits set out in the UK's Code of Practice. These guidelines are based on internationally recognised limits and form the basis of the framework for EMF safety in the UK. The results confirm that EMF levels remain within the permissible thresholds, demonstrating the projects' compliance with the Code of Practice.

# Table of Contents

# 1 Introduction

This document presents an assessment, results and compliance statement of the proposed Spittal to Loch Buidhe to Beauly 400kV overhead line in terms of Electric and Magnetic Fields (EMF). This report is applicable to the new build overhead line and the specific arrangements in section 5 only.

## 1.1 Objective of EMF Study

The goal of this study is to assess the Electric and Magnetic Field (EMF) levels generated by the new 400kV overhead line and to determine compliance with the UK's code of practice 'Power Lines: Demonstrating compliance with EMF public exposure guidelines (DECC: 2012)[1]'. This report summarises the studies carried out on EMF levels from the proposed overhead lines to demonstrate a compliant design. The in-house design calculations were done using PLS CADD software with the results being independently validated by Consultants using SES CDGES software.

## 1.2 Project Background

Scottish and Southern Electricity Networks/ SSEN Transmission plc ("SSEN") is proposing to construct and operate approximately 96 kilometres (km) of new double circuit 400 kilovolts (kV) overhead transmission line (OHL) between the proposed Banniskirk and Carnaig 400 kV Substations and 77 km of new double circuit 400 kV OHL between the proposed Carnaig and Fanellan 400 kV Substations.

In July 2022, National Grid ESO (as of 1 October 2024 now known as the National Energy System Operator (NESO)) published the Pathway to 2030 Holistic Network Design (Pathway to 2030 HND), setting out the electricity transmission network infrastructure required to enable the forecasted growth in renewable electricity across Great Britain, in light of the UK and Scottish Government's 2030 offshore wind allocations of 50 gigawatt (GW) and 11 GW (through the Crown Estate and ScotWind leasing rounds) which are the main driver for these upgrades.

The proposed 400 kV overhead line (OHL) will consist of steel lattice towers using a new tower series known as the ASTI SSE400 or AS4 for short. These towers are expected to average 57 m in height across the routes. The conductor system is proposed to be 3 x 700 $mm^2$ AAAC Araucaria with 500 mm bundle spacing. The circuit is designed to function up to 90°C while maintaining a minimum ground clearance of 9 m under normal conditions. Although it is capable of operating at to 90°C, it is not currently intended to be used at this maximum rating.

[1] Power Lines: Demonstrating compliance with EMF public exposure guidelines (DECC: 2012)





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# 2 Electric and Magnetic Field

## 2.1 Introduction to Electric and Magnetic Field Study

Overhead Lines (OHLs) are used to carry high voltage electricity across long distances and are a source of electric and magnetic fields. There are long established concerns around the potential health effects of exposure of these fields. As a result, OHL have been subject to a large body of scientific research and regulatory initiatives. A summary of the known potential impacts is provided in this section.

## 2.2 Electric Fields

Electric fields are found wherever there is electricity. Electric fields are created by the presence of electric charges and are measured in volts per meter (V/m). An electric field is associated with any device or wire that is connected to a source of electricity, even when a current is not flowing. Electric fields are easily shielded by common objects such as trees, fences, and walls. It has been determined there is no body of evidence indicating a relationship between exposure to electric fields and human disease. However, strong electric fields can lead to micro-shocks from poorly earthed objects and sensory impacts (reversible on removal from the field and temporary in duration). As such it essential the electric field strength is controlled.

## 2.3 Magnetic Fields

Magnetic fields are created by charges (electrons) moving in a conductor, such as a wire. The number of electrons moving through a conductor at any given time is called the current (measured in amperes). As the powerflow increases, so does the magnetic field. The magnetic field decreases as the distance from the source increases. Scientific studies have identified that there is a statistical association between magnetic fields and childhood leukaemia however the evidence of the association has weakened in recent years . No biological mechanism has been found for this relationship and since this potential relationship was identified in the 1960s, subsequent studies have shown a steady decline in the potentially elevated risk. This is despite powerflows, and thus the magnetic field strength from OHLs, increasing over the same period. There is insufficient evidence of magnetic fields being linked to other diseases or cancers. As the statistical association with childhood leukaemia remains it is acknowledged as a potential impact and thus it is considered necessary to control the magnetic field strength to reduce the potential risk.

## 2.4 EMF Statutory Exposure limits

To ensure the safety of the public due EMF emissions from OHLs, the UK Government issued, following consultation, a code of practice for the industry 'Power Lines: Demonstrating compliance with EMF public exposure guidelines' issued via the Department of Energy & Climate Change in 2011 and updated in 2012. This was based on levels set by 1998 guidelines published by the International Commission on Non-Ionizing Radiation Protection (ICNIRP). These levels are set to minimise any health risk posed by the OHL. Additionally, whilst being low risk, the statistical association with childhood leukaemia was recognised and UK further introduced a precautionary measure requiring optimal phasing, where reasonably possible, in the Code of Practice.

The code of practice sets the maximum levels for long term public exposure as **360 µT** for magnetic fields and **9 kV/m** for electric fields. Long term exposure relates to places of residence or similar where people regularly spend extended periods of time. The SSEN OHL design standard TG-NET-OHL-506 Rev 2.0 defines the exposure limits in accordance with the code of practice.

The following parameters are defined by TG-NET-OHL-506 Rev 2.0 for calculation of the EMF fields from overhead lines:

- Fields shall be measured directly below the line
- Fields shall be calculated with maximum continuous current and voltage
- The conductors shall be modelled at the design minimum clearance
- Double circuit vertical transmission lines shall have optimum phase arrangement to reduce imbalance EMF and induced ground currents.

The UK Government have reconfirmed the principles and limits set out in the code of practice with their latest policy on EMF. National Policy Statement EN-5[2], (NPS EN-5) which was reissued in November 2023 and came into force on 17 January 2024. This policy confirmed the current UK Government guidance, informed by relevant international guidance, is therefore still considered appropriate.

[2] National Policy Statement EN-5

# 3 EMF Calculations

This section summarises the SSEN Transmission calculations of EMF for the proposed OHLs.

## 3.1 Line Modelling Parameters

The Spittal to Loch Buidhe to Beauly overhead line is being designed with a triple bundled AAAC Araucaria conductor per phase on AS4 Towers (a modified version of the SSE400). The phase configurations are considered as optimal phasing i.e. a fully transposed phase arrangement.

The following conductor system design is proposed for this project as shown in the table 3.1 below.

**Table 3.1 – Conductor System**

| Conductor | Construction | Diameter (mm) | Resistivity (nΩm) | No. of Sub conductors | Bundle Distance (mm) | Max. Operating Temperature (°C) |
|---|---|---|---|---|---|---|
| Araucaria | AAAC 700mm$^2$ | 37.26 | 30.5 | 3 | 500 | 90 |

Two power flow scenarios were considered:

- Intended maximum power flow; 3370 Amps (winter pre-fault continuous based on a summer pre-fault continuous power flow of 2090MVA),
- Maximum possible power flow; 5000A (maximum winter pre-fault continuous considering substation limitations)

It should be noted that although analysis has been carried out up to a maximum current of 5000A the line is only intended to operate up to 3370A but the full capability has been considered to be conservative.

The proposed structure design for the Spittal Loch Buidhe Beauly scheme is the AS4 series of lattice steel towers, specifically designed for the project. Proposed tower outline drawing for the standard suspension tower (AS4-AD) is attached in Appendix-A

## 3.2 Design Calculations

The EMF calculations were performed in-house by SSEN Transmission's Onshore Capital Delivery Project Engineering team using PLS-CADD Software, an internationally recognised tool by the transmission industry. The line was modelled on the basis of the parameters defined in section 3.1 of this report. The calculations were performed for both transposed and untransposed (for reference only) phase arrangement and calculated at middle of the span where the conductor is nearest to the ground level; the worst-case scenario. These calculations were made for a range of different ground clearance options in order to determine the minimum ground clearance needed to ensure compliance with the code of practice. The smallest, minimum ground clearance which was found to be compliant is shown in green for each of the following scenarios:

- Transposed: Maximum possible power flow,

- Transposed: Required maximum power flow,
- Untransposed: Maximum possible power flow,
- Untransposed: Required maximum power flow,

The below tables summarise the EMF level for the range of heights checked. The EMF reports, generated by the PLS-CADD software, used to populate these tables are enclosed in Appendix-B.

Table 3.2 - Transposed Phase Arrangement

| Current: 5000 A | | | Current: 3370 A | | |
|---|---|---|---|---|---|
| **TRANSPOSED (RYB-BYR)** | | | | | |
| **Clearance (m)** | **Electric Field (kV/m)** | **Magnetic Field (uT)** | **Clearance (m)** | **Electric Field (kV/m)** | **Magnetic Field (uT)** |
| 7.3 | 11.20 | 111.20 | 7.3 | 11.20 | 74.90 |
| 7.6 | 10.6 | 108.30 | 7.6 | 10.60 | 72.96 |
| 8.0 | 9.86 | 104.36 | 8.0 | 9.86 | 70.34 |
| 8.5 | 9.05 | 96.47 | 8.5 | 9.05 | 65.02 |
| 8.7 | 8.63 | 93.12 | 8.7 | 8.63 | 62.76 |
| 9.0 | 8.30 | 89.36 | 9.0 | 8.30 | 60.22 |
| 9.5 | 7.54 | 83.24 | 9.5 | 7.54 | 44.65 |

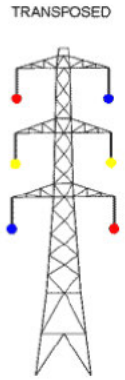
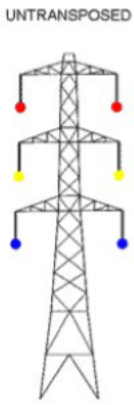


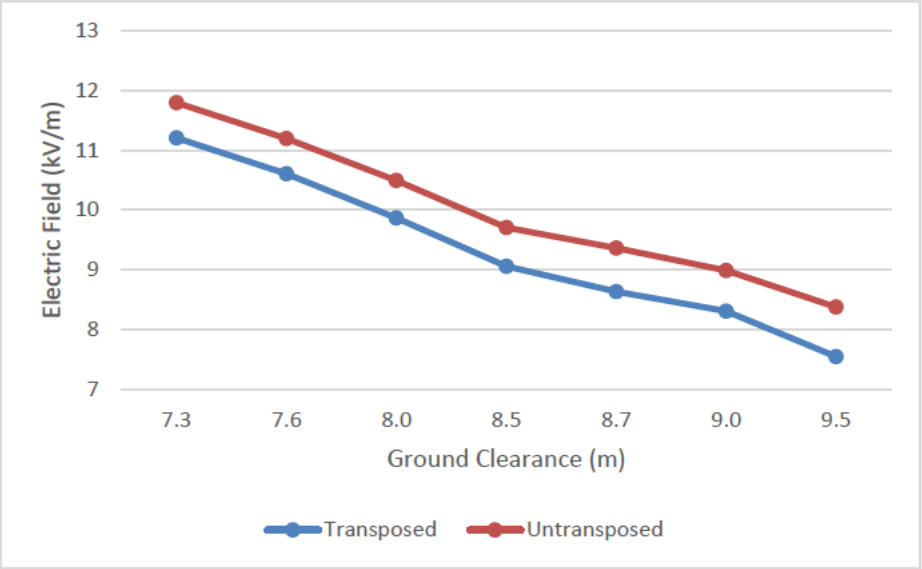

Table 3.3 - Un-Transposed Phase Arrangement

| Current: 5000 A | | | Current: 3370 A | | |
|---|---|---|---|---|---|
| **UNTRANSPOSED (RYB-RYB)** | | | | | |
| **Clearance (m)** | **Electric Field (kV/m)** | **Magnetic Field (uT)** | **Clearance (m)** | **Electric Field (kV/m)** | **Magnetic Field (uT)** |
| 7.3 | 11.79 | 92.50 | 7.3 | 11.79 | 67.80 |
| 7.6 | 11.19 | 91.66 | 7.6 | 11.19 | 64.90 |
| 8.0 | 10.49 | 90.55 | 8.0 | 10.50 | 61.03 |
| 8.5 | 9.70 | 83.91 | 8.5 | 9.70 | 56.56 |
| 8.7 | 9.36 | 81.11 | 8.7 | 9.36 | 54.67 |
| 9.0 | 8.98 | 77.90 | 9.0 | 8.98 | 52.51 |
| 9.5 | 8.37 | 72.85 | 9.5 | 8.37 | 49.10 |



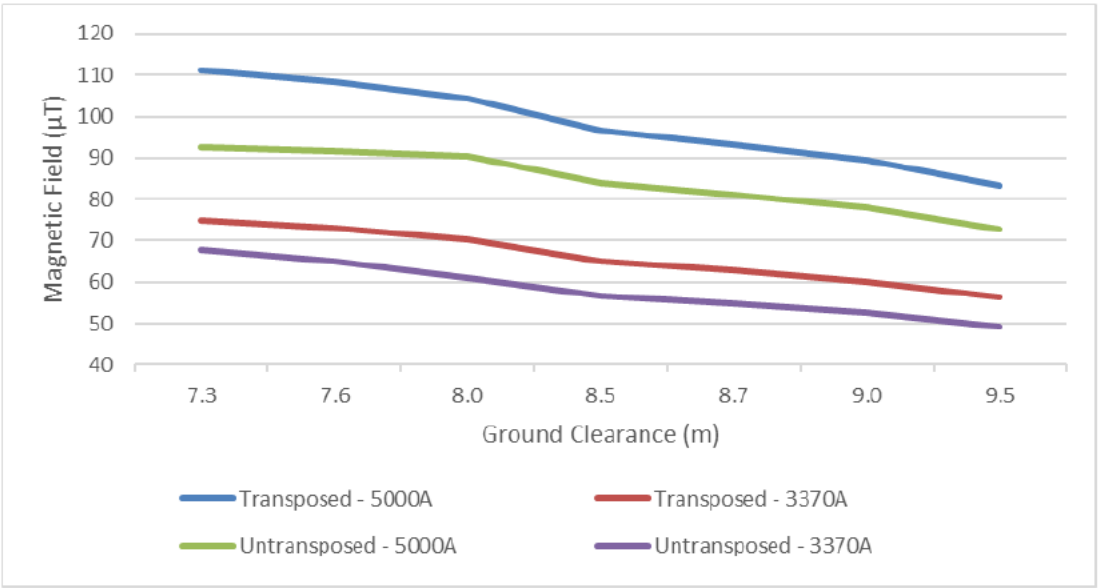

The calculated values for Electric field at the minimum statutory ground clearance (7.3m) are 11.20 kV/m and 11.79 kV/m for the transposed and untransposed scenarios respectively. These values are not within the acceptable limits (i.e. 9kV/m). The acceptable electric field exposure levels are not achieved until a ground clearance of 8.7m and 9.0m is achieved for the transposed and untransposed scenarios respectively. The following figure shows a graphical representation of the electric field in transposed and untransposed phasing scenarios.

Figure 3.1 - Electric Field Arrangement




The calculated values for the magnetic field varies with the increase in the current/load. However, the statutory limit for the magnetic field is 360 uT which is achieved at the 7.3m ground clearance for all scenarios. The following figure shows the graphical representation of the Magnetic Field at transposed and untransposed phasing scenarios and with two different power flows:

Figure 3.2 - Magnetic Field Arrangements




It was concluded from the above tables that the minimum compliant clearance to ground, 8.7m-9.0m, was relatively consistent for the four scenarios considered, including the conservative untransposed values. As such,

there is no design saving on tower height, and subsequent visual impact, in adopting the least conservative value 8.7m, and the more conservative 9.0m value was adopted.

## 3.3 Summary of Assessment and Further Precautions

The Assessment of Electric and Magnetic Field levels for the proposed overhead line project confirms that with a minimum ground clearance of 9.0m, all calculated values are within the statutory exposure limits. It should be noted that these values are for a 1m height above ground, directly beneath the line and assume long term exposure that would be typical for a residence or similar. The routeing of the Spittal Loch Buidhe Beauly project has avoided the oversail of residential (or similar) properties and looked to site the OHL away from the properties. Whilst this is not necessary under the code of practice, nor was the EMF levels the sole factor in these routeing decisions, in practice this substantially reduces the EMF exposure levels compared to the values given in this report. This is visualised in the figures 3.3 and 3.4, shared at the projects' public consultations in the Pathway to 2030 EMF leaflet.

**Figure 3.3 - Magnetic Field Strength as per Pathway to 2030 EMF leaflet**

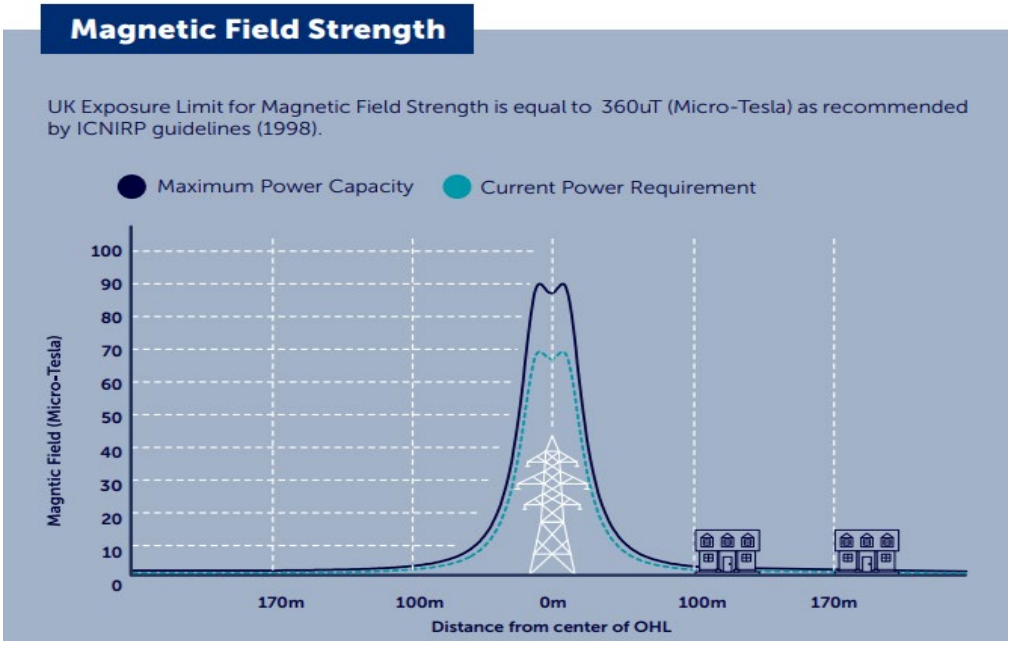
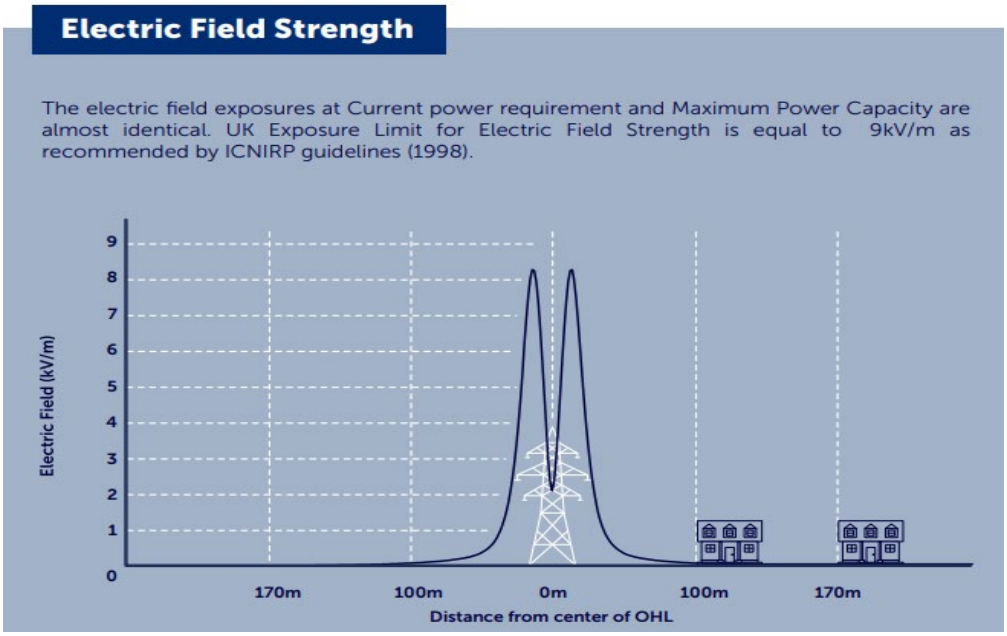


Figure 3.4 - Electric Field Strength as per Pathway to 2030 EMF leaflet



# 4 Validation of EMF Result

SSEN Transmission commissioned the consultancy group WSP to provide an independent validation of the EMF levels generated by the proposed OHL. WSP utilised another industry standard tool, SES CDEGS software, for this work. The EMF reports generated by WSP by using CDEGS software are enclosed in Appendix-C. The results from WSP's analysis were consistent with those calculated in Section 3, see table 4.1, and confirmed that the EMF levels are well within the acceptable exposure limits set by the code of practice.

Table 4.1 - Comparison of WSP and SSEN-T EMF analysis

| Power flow/ Current (3x Araucaria on AS4) | Clearance | Magnetic Field (under the line at mid span) | | Electric Field (under the line at mid span) | |
|---|---|---|---|---|---|
| | | SSEN-T (PLS-CADD) | WSP (CDEGS) | SSEN-T (PLS-CADD) | WSP (CDEGS) |
| 5000 A | 9.00 m | 89.3 µT | 92 µT | 8.3 kV/m | 7.9 kV/m |
| 3370 A | 9.00 m | 60.2 µT | 62 µT | 8.3 kV/m | 7.9 kV/m |

# 5 Complex OHL Arrangements

## 5.1 Cumulative Assessment

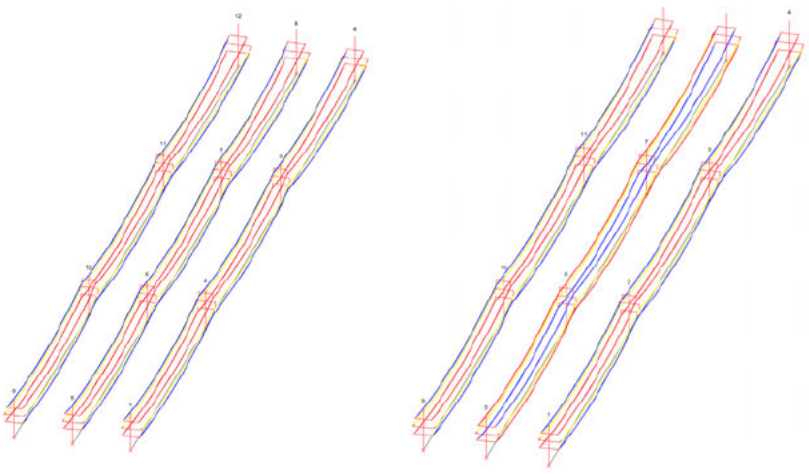
Where overhead lines come into close proximity to each other, their electric and magnetic fields can interact with one another and therefore a cumulative assessment is required to demonstrate compliance. Due to the fact that Electric and Magnetic fields are vector quantities and have both magnitude and direction, the way in which they combine is complex and the values cannot simply be added together. Although combining the EMFs from different sources is complex, generally when the field from one source is larger than the other, the larger field dominates, with the smaller field making a minor impact to the overall field. This is why at substations the largest fields typically come from the overhead lines entering the substation and the impact of the plant within the substation itself is considered to have minimal impact to the overall fields.

To demonstrate compliance a conservative assessment has been carried out within PLS-CADD considering three 400kV overhead lines, in parallel, all operating at 5000A using the parameters from section 3. The three lines have been spaced at 72m centre to centre which has been selected based off an 18m substation bay spacing and is considered to be the closest the lines will operate at this voltage on approach to a substation.

The exact field that is produced by the lines in parallel depends on specifics of relative phasing and loads however this assessment considers a number of scenarios that are considered to be representative of the cumulative effect.

Two phasing scenarios have been modelled. The first scenario (Case 1) considers all lines being optimally phased and the circuits between adjacent lines also being optimally phased. This is an ideal scenario as when circuits have optimal phasing the electric and magnetic fields can partially cancel each other out reducing the resultant fields. However, while the proposed development is to be optimally phased, as phasing of future developments is not yet confirmed a precautionary assessment was undertaken, therefore a second case (Case 2) was considered where the three individual lines were still optimally phased but the circuits between the adjacent lines were not optimally phased. This second arrangement has the potential to increase the magnitude of the resultant fields. Figure 5.1 below depicts the two cases described above

Figure 5.1 – Case 1 on left, Case 2 on right



The maximum fields for each scenario are presented in table 5.1 below. The full PLS-CADD report can be seen in Appendix-D. Figures 5.2 and 5.3 show the two cases for both the cumulative electric field and magnetic field extracted from the PLS Report.

Table 5.1 - Summary of Electric and Magnetic Field Values for Cumulative Assessment

| Cumulative Assessment Case | Maximum Magnetic Field (μT) | Maximum Electric Field (kV/m) |
|---|---|---|
| **Case 1 – Optimal phasing of adjacent circuits** | 92.71 | 8.69 |
| **Case 2 – Non-Optimal phasing of adjacent circuits** | 94.71 | 8.67 |

Figure 5.2 - Cumulative Electric Field Results

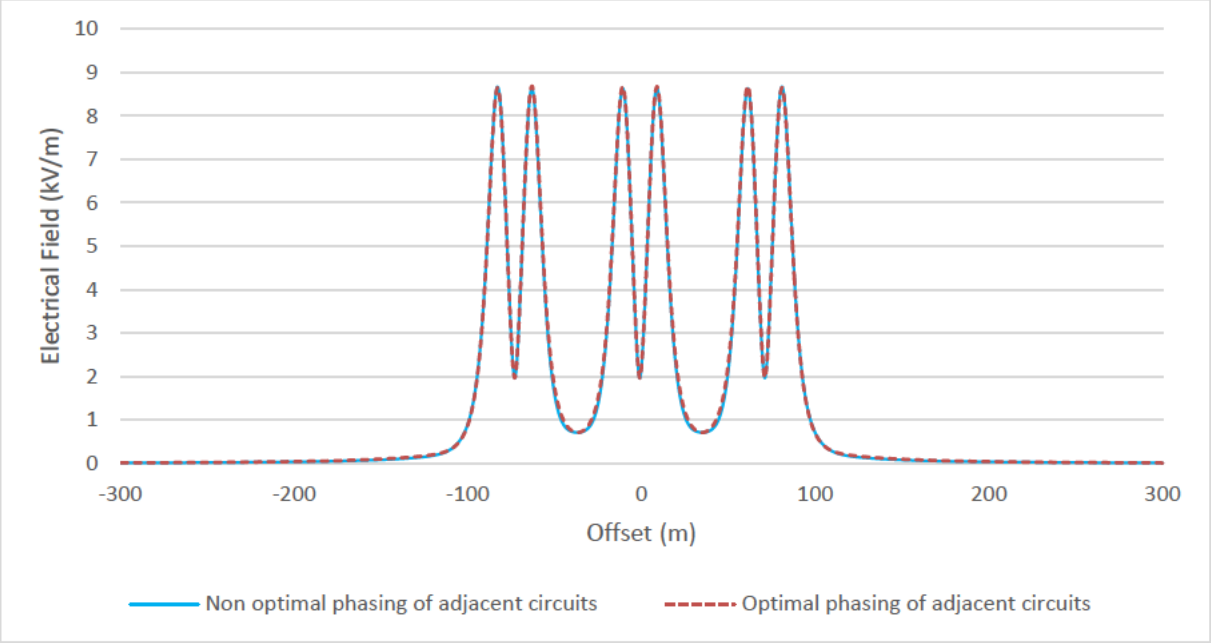
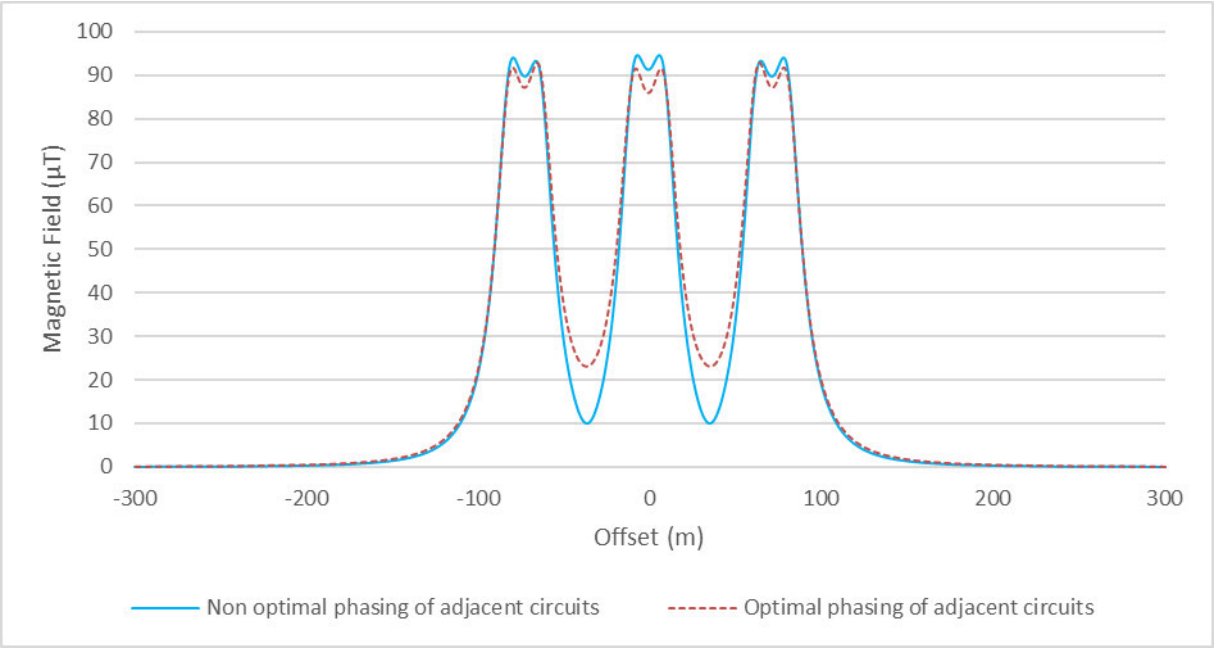


Figure 5.3 - Cumulative Magnetic Field Results




As stated above, this analysis depends on numerous factors such as phasing and load, however the cases carried out demonstrate the mechanisms in which fields combine and are considered representative for the proposed development. This assessment demonstrates that the combined impact of electric and magnetic fields from parallel overhead lines does not affect the assessment of compliance for the proposed new overhead line with the maximum fields remaining within the acceptable exposure limits set by the code of practice.

## 5.2 Complex Crossings

Across the Spittal Loch Buide Beauly 400kV OHL there are certain complex OHL arrangements that require further detailed analysis. These arrangements are a result of the proposed OHL crossing an existing OHL. Where these crossings occur, the electric and magnetic fields of the respective OHLs can interact with one another and therefore the combined effects must be considered.

This analysis cannot be carried out in the same method as discussed in the previous section and requires specialist software, SES CDEGS, due to the complexity of these crossings involving multiple circuits directly crossing each other. This type of analysis is best suited to the specialist software to accurately model the resultant electric and magnetic fields. A specialist consultant, Arcadis Consulting (UK) Limited, was commissioned to carry out this detailed analysis and the full study is appended to this report.

An overview of the results for the proposed crossing is provided within table 5.2 below.

Table 5.2 - Summary of Electric and Magnetic Field Values for Complex Arrangements

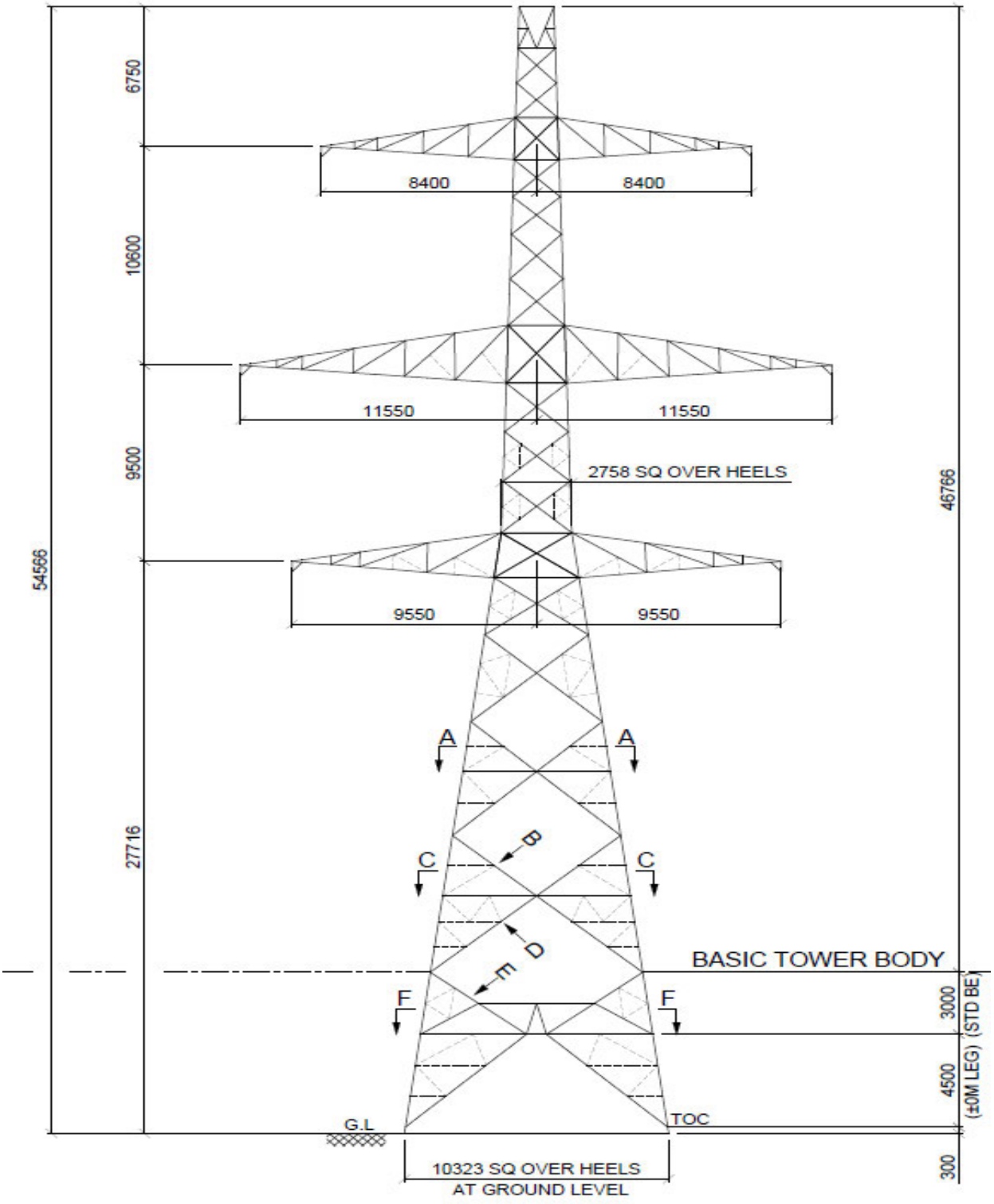
| Description of Crossing | Maximum Magnetic Field (μT) | Maximum Electric Field (kV/m) |
|---|---|---|
| **Section A – Crofts of Benachielt – 132kV Duck Under** | 78.28 | 6.83 |
| **Section B - Strath Carnaig – 132kV Diamond Duck Under** | 55.77 | 4.67 |
| **Section C - West of Loch Buidhe – 275kV Diamond Duck Under** | 65.71 | 6.42 |
| **Section C – Near Invershin – 132kV Duck Under** | 68.63 | 6.04 |
| **Section E – North-West of Fairburn – 132kV Diamond Duck Under** | 74.94 | 6.87 |
| **Section E – West of Fanellan/Aigas Gorge – 132kV Duck Under** | 55.91 | 4.59 |

Based on the results in the table above it can be observed that both the maximum magnetic and electric fields observed at the crossing remain below the acceptable exposure limits set by the code of practice. Moreover, a review will be undertaken in detail design stage to confirm the design remains complaint in accordance with these assessments. The full details of this analysis can be seen in Appendix-E.

# 6 Conclusion

In conclusion, as demonstrated by this report and it's supporting documents, the proposed OHLs are complaint with the industry's current code of practice the industry 'Power Lines: Demonstrating compliance with EMF public exposure guidelines' developed by the Department of Energy & Climate Change.

# Appendix A Tower Geometry

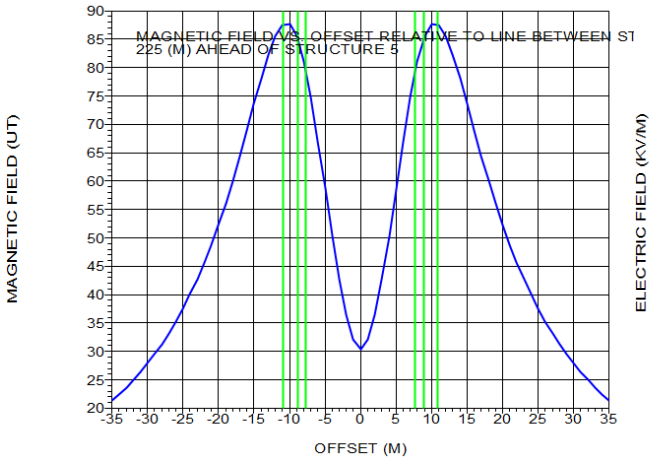


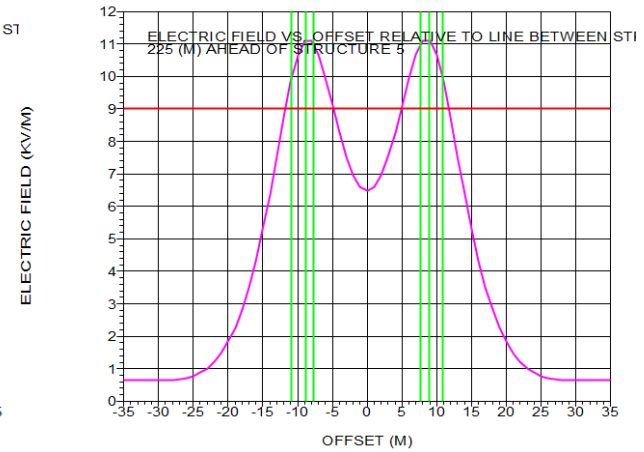
# Appendix B PLS CADD Electric and Magnetic Field Calculations

## TRIPLE Araucaria (7.6m ground clearance)

```
PLS-CADD Version 18.00x64    11:51:13 AM 06 July 2023
Scottish and Southern Energy
Project Name: 'C:\Users\AM25305\Desktop\CSR ASTI-\PLS Model ASTI\profile 637.don'

Criteria Notes:
  Design criteria developed for SSE Beauly Blackhillock Line reconductoring
  Global wind notes: wind directions are annotated NNW-330, E-90, etc as `wind from` - angles in GLB wind are `wind to` or wind azumuth
  delete - survey and maps confirm angle as per XYZ 19/08/08.Terrain 289: angle has been corrected in pfl. CHECK xyz
  delete?20/08/08.PFL 180 and 181 points edited
  tower 229 is a D10 with extended crossarms. It should be modeled???Erection loads??CHECK.


3D EMF Calculation Notes:
  1) Calculations based on the EPRI Red Book methods (3rd Edition, 2005 - 7.4 Calculation of Magnetic Fields and Appendices 7.1 Calculation
of Field Ellipse Parameters and 7.6 Electric Field Calculations for 3D Geometry).
  2) All wire positions are modeled at the specified weather case and wind direction. Height above ground determined by the modeled ground
TIN.
  3) Only the effects of wires are being analyzed. The effects of structures are not included unless enabled as noted below.
  4) Ground return is being ignored for magnetic field calculations.


Meter height above ground:                  1.00 (m)
Maximum wire distance:                    150.00 (m)
Maximum cable segment size:                 3.00 (m)
Cross section offset +/-:                  35.00 (m)
Result interval:                            1.00 (m)
Electric field limit:                       9.00 (kV/m)
Magnetic field limit:                     360.00 (uT)
Space potential limit:                      0.00 (kV)
Contour Map Spacing:                           3 (m)
Analyzing spans between these structures:  1 - 6

One or more sections have wind from both directions which is not supported. A wind direction of left is being used for those sections.

Section Data for 3D EMF Results:
```

| Section Number | Section Note | Voltage Ph-Ph (kV) | Current (Amps) | Cable Filename | Cable Description | Conductors Per Phase | Bundle Diameter (cm) | Cable Radius (cm) | Weather Case | Condition | Wind Dir. | WC Temperature (deg C) | Effective Radius (cm) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | | 400.0 | 4570.0 | araucaria lumpi - 30.5.wir 700mm² AAAC - Araucaria | | 3 | 57.735 | 1.863 | 90°C | Creep RS | Left | 90.000 | 16.700 |
| 2 | | 400.0 | 4570.0 | araucaria lumpi - 30.5.wir 700mm² AAAC - Araucaria | | 3 | 57.735 | 1.863 | 90°C | Creep RS | Left | 90.000 | 16.700 |



**TRIPLE Araucaria** (7.6m ground clearance)

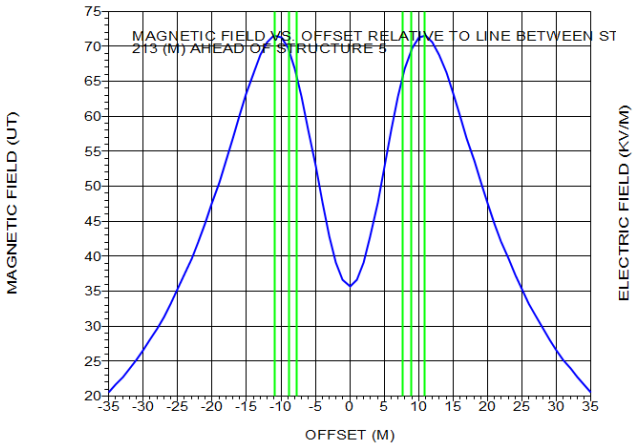
3D EMF Point Results Span from 5 to 6:

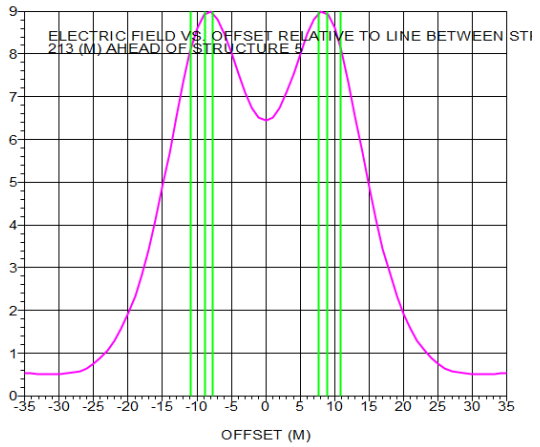
| Measurement | | | B | | | | | H | EF | | | | | Space Potential | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| X (m) | Y (m) | Z (m) | Real (uT) | Imaginary (uT) | Angle (deg) | Magnitude (uT) | Polarization Axial Ratio % | Magnitude (A/m) | Real (kV/m) | Imaginary (kV/m) | Angle (deg) | Magnitude (kV/m) | Polarization Axial Ratio % | Real (kV) | Imaginary (kV) | Angle (deg) | Magnitude (kV) |
| 275807.9 | 3098063.4 | 1.9 | 17.279 | 12.506 | 35.9 | 21.330 | 20.2 | 16.974 | 0.273 | 0.582 | 64.8 | 0.643 | 6.0 | 0.269 | 0.581 | 65.1 | 0.640 |
| 275808.2 | 3098064.4 | 1.9 | 18.101 | 13.284 | 36.3 | 22.452 | 20.4 | 17.867 | 0.238 | 0.599 | 68.3 | 0.645 | 6.9 | 0.232 | 0.599 | 68.8 | 0.642 |
| 275808.5 | 3098065.3 | 1.9 | 18.975 | 14.132 | 36.7 | 23.659 | 20.7 | 18.827 | 0.197 | 0.616 | 72.3 | 0.646 | 7.9 | 0.188 | 0.615 | 73.0 | 0.643 |
| 275808.8 | 3098066.3 | 1.9 | 19.906 | 15.057 | 37.1 | 24.960 | 21.0 | 19.862 | 0.151 | 0.629 | 76.5 | 0.647 | 9.1 | 0.136 | 0.628 | 77.8 | 0.643 |
| 275809.1 | 3098067.2 | 1.9 | 20.898 | 16.069 | 37.6 | 26.362 | 21.2 | 20.978 | 0.103 | 0.640 | 80.8 | 0.648 | 10.5 | 0.075 | 0.638 | 83.3 | 0.642 |
| 275809.4 | 3098068.2 | 1.9 | 21.955 | 17.178 | 38.0 | 27.877 | 21.4 | 22.184 | 0.079 | 0.645 | 83.0 | 0.650 | 12.2 | 0.003 | 0.642 | 89.7 | 0.642 |
| 275809.7 | 3098069.1 | 1.9 | 23.083 | 18.393 | 38.5 | 29.515 | 21.5 | 23.487 | 0.119 | 0.643 | 79.5 | 0.654 | 14.2 | -0.081 | 0.640 | -82.8 | 0.645 |
| 275810.1 | 3098070.1 | 1.9 | 24.286 | 19.729 | 39.1 | 31.290 | 21.7 | 24.899 | 0.203 | 0.633 | 72.2 | 0.665 | 16.4 | -0.178 | 0.628 | -74.2 | 0.653 |
| 275810.4 | 3098071.0 | 1.9 | 25.571 | 21.197 | 39.7 | 33.214 | 21.7 | 26.431 | 0.311 | 0.610 | 63.0 | 0.685 | 18.6 | -0.291 | 0.604 | -64.3 | 0.671 |
| 275810.7 | 3098072.0 | 1.9 | 26.943 | 22.814 | 40.3 | 35.304 | 21.7 | 28.094 | 0.440 | 0.573 | 52.5 | 0.722 | 20.5 | -0.422 | 0.564 | -53.2 | 0.704 |
| 275811.0 | 3098072.9 | 1.9 | 28.409 | 24.595 | 40.9 | 37.576 | 21.6 | 29.902 | 0.590 | 0.517 | 41.2 | 0.784 | 21.6 | -0.574 | 0.502 | -41.2 | 0.762 |
| 275811.3 | 3098073.9 | 1.9 | 29.978 | 26.557 | 41.5 | 40.049 | 21.4 | 31.870 | 0.763 | 0.438 | 29.8 | 0.880 | 21.5 | -0.748 | 0.413 | -28.9 | 0.854 |
| 275811.6 | 3098074.8 | 1.9 | 31.655 | 28.718 | 42.2 | 42.741 | 21.2 | 34.012 | 0.964 | 0.338 | 19.3 | 1.021 | 20.4 | -0.948 | 0.290 | -17.0 | 0.991 |
| 275811.9 | 3098075.8 | 1.9 | 33.450 | 31.098 | 42.9 | 45.673 | 20.8 | 36.345 | 1.193 | 0.242 | 11.4 | 1.218 | 18.5 | -1.177 | 0.122 | -5.9 | 1.183 |
| 275812.3 | 3098076.7 | 1.9 | 35.371 | 33.712 | 43.6 | 48.863 | 20.2 | 38.884 | 1.456 | 0.272 | 10.6 | 1.482 | 16.3 | -1.439 | -0.102 | 4.0 | 1.443 |
| 275812.6 | 3098077.7 | 1.9 | 37.425 | 36.574 | 44.3 | 52.329 | 19.6 | 41.642 | 1.757 | 0.500 | 15.9 | 1.827 | 14.2 | -1.739 | -0.394 | 12.8 | 1.783 |
| 275812.9 | 3098078.6 | 1.9 | 39.617 | 39.693 | 45.1 | 56.081 | 18.7 | 44.628 | 2.099 | 0.857 | 22.2 | 2.267 | 12.3 | -2.079 | -0.770 | 20.3 | 2.217 |
| 275813.2 | 3098079.6 | 1.9 | 41.947 | 43.066 | 45.8 | 60.119 | 17.7 | 47.841 | 2.486 | 1.328 | 28.1 | 2.819 | 10.6 | -2.464 | -1.246 | 26.8 | 2.761 |
| 275813.5 | 3098080.5 | 1.9 | 44.408 | 46.673 | 46.4 | 64.424 | 16.6 | 51.267 | 2.923 | 1.923 | 33.3 | 3.498 | 9.1 | -2.897 | -1.837 | 32.4 | 3.430 |
| 275813.8 | 3098081.5 | 1.9 | 46.972 | 50.461 | 47.1 | 68.940 | 15.3 | 54.861 | 3.409 | 2.650 | 37.9 | 4.318 | 7.8 | -3.378 | -2.557 | 37.1 | 4.237 |
| 275814.1 | 3098082.4 | 1.9 | 49.585 | 54.336 | 47.6 | 73.560 | 13.8 | 58.537 | 3.944 | 3.514 | 41.7 | 5.282 | 6.6 | -3.906 | -3.407 | 41.1 | 5.183 |
| 275814.5 | 3098083.4 | 1.9 | 52.147 | 58.133 | 48.1 | 78.095 | 12.2 | 62.146 | 4.516 | 4.502 | 44.9 | 6.377 | 5.5 | -4.469 | -4.377 | 44.4 | 6.256 |
| 275814.8 | 3098084.3 | 1.9 | 54.492 | 61.603 | 48.5 | 82.246 | 10.5 | 65.449 | 5.106 | 5.576 | 47.5 | 7.560 | 4.6 | -5.047 | -5.429 | 47.1 | 7.412 |
| 275815.1 | 3098085.3 | 1.9 | 56.380 | 64.393 | 48.8 | 85.587 | 8.7 | 68.108 | 5.675 | 6.664 | 49.6 | 8.753 | 3.7 | -5.602 | -6.490 | 49.2 | 8.573 |
| 275815.4 | 3098086.2 | 1.9 | 57.501 | 66.075 | 49.0 | 87.591 | 6.9 | 69.703 | 6.173 | 7.655 | 51.1 | 9.834 | 3.0 | -6.084 | -7.455 | 50.8 | 9.623 |
| 275815.7 | 3098087.2 | 1.9 | 57.534 | 66.217 | 49.0 | 87.720 | 4.9 | 69.806 | 6.537 | 8.417 | 52.2 | 10.657 | 2.4 | -6.436 | -8.199 | 51.9 | 10.424 |
| 275816.0 | 3098088.1 | 1.9 | 56.246 | 64.522 | 48.9 | 85.596 | 3.0 | 68.115 | 6.713 | 8.834 | 52.8 | 11.095 | 2.0 | -6.609 | -8.612 | 52.5 | 10.855 |
| 275816.3 | 3098089.1 | 1.9 | 53.598 | 60.960 | 48.7 | 81.172 | 1.0 | 64.594 | 6.679 | 8.848 | 53.0 | 11.086 | 1.8 | -6.582 | -8.641 | 52.7 | 10.862 |
| 275816.7 | 3098090.0 | 1.9 | 49.784 | 55.810 | 48.3 | 74.788 | 1.0 | 59.514 | 6.456 | 8.492 | 52.8 | 10.668 | 1.8 | -6.375 | -8.317 | 52.5 | 10.479 |
| 275817.0 | 3098090.9 | 1.9 | 45.180 | 49.566 | 47.7 | 67.067 | 3.0 | 53.370 | 6.098 | 7.871 | 52.2 | 9.957 | 2.0 | -6.039 | -7.738 | 52.0 | 9.816 |
| 275817.3 | 3098091.9 | 1.9 | 40.224 | 42.787 | 46.8 | 58.726 | 4.9 | 46.732 | 5.677 | 7.122 | 51.4 | 9.107 | 2.1 | -5.641 | -7.034 | 51.3 | 9.017 |
| 275817.6 | 3098092.8 | 1.9 | 35.337 | 35.982 | 45.5 | 50.432 | 6.7 | 40.133 | 5.258 | 6.370 | 50.5 | 8.260 | 2.2 | -5.244 | -6.326 | 50.3 | 8.217 |
| 275817.9 | 3098093.8 | 1.9 | 30.904 | 29.595 | 43.8 | 42.789 | 7.9 | 34.051 | 4.891 | 5.711 | 49.4 | 7.519 | 2.1 | -4.895 | -5.705 | 49.4 | 7.517 |
| 275818.2 | 3098094.7 | 1.9 | 27.294 | 24.103 | 41.4 | 36.413 | 7.9 | 28.976 | 4.610 | 5.206 | 48.5 | 6.954 | 1.8 | -4.628 | -5.230 | 48.5 | 6.983 |
| 275818.5 | 3098095.7 | 1.9 | 24.892 | 20.176 | 39.0 | 32.042 | 5.2 | 25.498 | 4.435 | 4.892 | 47.8 | 6.603 | 1.4 | -4.461 | -4.934 | 47.9 | 6.652 |
| 275818.9 | 3098096.6 | 1.9 | 24.043 | 18.702 | 37.9 | 30.460 | 0.0 | 24.240 | 4.376 | 4.785 | 47.6 | 6.484 | 1.1 | -4.405 | -4.834 | 47.7 | 6.540 |
| 275819.2 | 3098097.6 | 1.9 | 24.892 | 20.176 | 39.0 | 32.042 | 5.2 | 25.498 | 4.435 | 4.892 | 47.8 | 6.603 | 1.4 | -4.461 | -4.934 | 47.9 | 6.652 |
| 275819.5 | 3098098.5 | 1.9 | 27.294 | 24.103 | 41.4 | 36.413 | 7.9 | 28.976 | 4.610 | 5.206 | 48.5 | 6.954 | 1.8 | -4.628 | -5.230 | 48.5 | 6.983 |
| 275819.8 | 3098099.5 | 1.9 | 30.904 | 29.595 | 43.8 | 42.789 | 7.9 | 34.051 | 4.891 | 5.711 | 49.4 | 7.519 | 2.1 | -4.895 | -5.705 | 49.4 | 7.517 |
| 275820.1 | 3098100.4 | 1.9 | 35.337 | 35.982 | 45.5 | 50.432 | 6.7 | 40.133 | 5.258 | 6.370 | 50.5 | 8.260 | 2.2 | -5.244 | -6.326 | 50.3 | 8.217 |
| 275820.4 | 3098101.4 | 1.9 | 40.224 | 42.787 | 46.8 | 58.726 | 4.9 | 46.732 | 5.677 | 7.122 | 51.4 | 9.107 | 2.1 | -5.641 | -7.034 | 51.3 | 9.017 |
| 275820.8 | 3098102.3 | 1.9 | 45.180 | 49.566 | 47.7 | 67.067 | 3.0 | 53.370 | 6.098 | 7.871 | 52.2 | 9.957 | 2.0 | -6.039 | -7.738 | 52.0 | 9.816 |
| 275821.1 | 3098103.3 | 1.9 | 49.784 | 55.810 | 48.3 | 74.788 | 1.0 | 59.514 | 6.456 | 8.492 | 52.8 | 10.668 | 1.8 | -6.375 | -8.317 | 52.5 | 10.479 |
| 275821.4 | 3098104.2 | 1.9 | 53.598 | 60.960 | 48.7 | 81.172 | 1.0 | 64.594 | 6.679 | 8.848 | 53.0 | 11.086 | 1.8 | -6.582 | -8.641 | 52.7 | 10.862 |
| 275821.7 | 3098105.2 | 1.9 | 56.246 | 64.522 | 48.9 | 85.596 | 3.0 | 68.115 | 6.713 | 8.834 | 52.8 | 11.095 | 2.0 | -6.609 | -8.612 | 52.5 | 10.855 |
| 275822.0 | 3098106.1 | 1.9 | 57.534 | 66.217 | 49.0 | 87.720 | 4.9 | 69.806 | 6.537 | 8.417 | 52.2 | 10.657 | 2.4 | -6.436 | -8.199 | 51.9 | 10.424 |
| 275822.3 | 3098107.1 | 1.9 | 57.501 | 66.075 | 49.0 | 87.591 | 6.9 | 69.703 | 6.173 | 7.655 | 51.1 | 9.834 | 3.0 | -6.084 | -7.455 | 50.8 | 9.623 |
| 275822.6 | 3098108.0 | 1.9 | 56.380 | 64.393 | 48.8 | 85.587 | 8.7 | 68.108 | 5.675 | 6.664 | 49.6 | 8.753 | 3.7 | -5.602 | -6.490 | 49.2 | 8.573 |
| 275823.0 | 3098109.0 | 1.9 | 54.492 | 61.603 | 48.5 | 82.246 | 10.5 | 65.449 | 5.106 | 5.576 | 47.5 | 7.560 | 4.6 | -5.047 | -5.429 | 47.1 | 7.412 |
| 275823.3 | 3098109.9 | 1.9 | 52.147 | 58.133 | 48.1 | 78.095 | 12.2 | 62.146 | 4.516 | 4.502 | 44.9 | 6.377 | 5.5 | -4.469 | -4.377 | 44.4 | 6.256 |
| 275823.6 | 3098110.9 | 1.9 | 49.585 | 54.336 | 47.6 | 73.560 | 13.8 | 58.537 | 3.944 | 3.514 | 41.7 | 5.282 | 6.6 | -3.906 | -3.407 | 41.1 | 5.183 |
| 275823.9 | 3098111.8 | 1.9 | 46.972 | 50.461 | 47.1 | 68.940 | 15.3 | 54.861 | 3.409 | 2.650 | 37.9 | 4.318 | 7.8 | -3.378 | -2.557 | 37.1 | 4.237 |
| 275824.2 | 3098112.8 | 1.9 | 44.408 | 46.673 | 46.4 | 64.424 | 16.6 | 51.267 | 2.923 | 1.923 | 33.3 | 3.498 | 9.1 | -2.897 | -1.837 | 32.4 | 3.430 |
| 275824.5 | 3098113.7 | 1.9 | 41.947 | 43.066 | 45.8 | 60.119 | 17.7 | 47.841 | 2.486 | 1.328 | 28.1 | 2.819 | 10.6 | -2.464 | -1.246 | 26.8 | 2.761 |
| 275824.8 | 3098114.7 | 1.9 | 39.617 | 39.693 | 45.1 | 56.081 | 18.7 | 44.628 | 2.099 | 0.857 | 22.2 | 2.267 | 12.3 | -2.079 | -0.770 | 20.3 | 2.217 |
| 275825.2 | 3098115.6 | 1.9 | 37.425 | 36.574 | 44.3 | 52.329 | 19.6 | 41.642 | 1.757 | 0.500 | 15.9 | 1.827 | 14.2 | -1.739 | -0.394 | 12.8 | 1.783 |
| 275825.5 | 3098116.6 | 1.9 | 35.371 | 33.712 | 43.6 | 48.863 | 20.2 | 38.884 | 1.456 | 0.272 | 10.6 | 1.482 | 16.3 | -1.439 | -0.102 | 4.0 | 1.443 |
| 275825.8 | 3098117.5 | 1.9 | 33.450 | 31.098 | 42.9 | 45.673 | 20.8 | 36.345 | 1.193 | 0.242 | 11.4 | 1.218 | 18.5 | -1.177 | 0.122 | -5.9 | 1.183 |
| 275826.1 | 3098118.5 | 1.9 | 31.655 | 28.718 | 42.2 | 42.741 | 21.2 | 34.012 | 0.964 | 0.338 | 19.3 | 1.021 | 20.4 | -0.948 | 0.290 | -17.0 | 0.991 |
| 275826.4 | 3098119.4 | 1.9 | 29.978 | 26.557 | 41.5 | 40.049 | 21.4 | 31.870 | 0.763 | 0.438 | 29.8 | 0.880 | 21.5 | -0.748 | 0.413 | -28.9 | 0.854 |
| 275826.7 | 3098120.4 | 1.9 | 28.409 | 24.595 | 40.9 | 37.576 | 21.6 | 29.902 | 0.590 | 0.517 | 41.2 | 0.784 | 21.6 | -0.574 | 0.502 | -41.2 | 0.762 |
| 275827.0 | 3098121.3 | 1.9 | 26.943 | 22.814 | 40.3 | 35.304 | 21.7 | 28.094 | 0.440 | 0.573 | 52.5 | 0.722 | 20.5 | -0.422 | 0.564 | -53.2 | 0.704 |
| 275827.4 | 3098122.3 | 1.9 | 25.571 | 21.197 | 39.7 | 33.214 | 21.7 | 26.431 | 0.311 | 0.610 | 63.0 | 0.685 | 18.6 | -0.291 | 0.604 | -64.3 | 0.671 |
| 275827.7 | 3098123.2 | 1.9 | 24.286 | 19.729 | 39.1 | 31.290 | 21.7 | 24.899 | 0.203 | 0.633 | 72.2 | 0.665 | 16.4 | -0.178 | 0.628 | -74.2 | 0.653 |
| 275828.0 | 3098124.2 | 1.9 | 23.083 | 18.393 | 38.5 | 29.515 | 21.5 | 23.487 | 0.119 | 0.643 | 79.5 | 0.654 | 14.2 | -0.081 | 0.640 | -82.8 | 0.645 |
| 275828.3 | 3098125.1 | 1.9 | 21.955 | 17.178 | 38.0 | 27.877 | 21.4 | 22.184 | 0.079 | 0.645 | 83.0 | 0.650 | 12.2 | 0.003 | 0.642 | 89.7 | 0.642 |
| 275828.6 | 3098126.1 | 1.9 | 20.898 | 16.069 | 37.6 | 26.362 | 21.2 | 20.978 | 0.103 | 0.640 | 80.8 | 0.648 | 10.5 | 0.075 | 0.638 | 83.3 | 0.642 |
| 275828.9 | 3098127.0 | 1.9 | 19.906 | 15.057 | 37.1 | 24.960 | 21.0 | 19.862 | 0.151 | 0.629 | 76.5 | 0.647 | 9.1 | 0.136 | 0.628 | 77.8 | 0.643 |
| 275829.2 | 3098128.0 | 1.9 | 18.975 | 14.132 | 36.7 | 23.659 | 20.7 | 18.827 | 0.197 | 0.616 | 72.3 | 0.646 | 7.9 | 0.188 | 0.615 | 73.0 | 0.643 |
| 275829.6 | 3098128.9 | 1.9 | 18.101 | 13.284 | 36.3 | 22.452 | 20.4 | 17.867 | 0.238 | 0.599 | 68.3 | 0.645 | 6.9 | 0.232 | 0.599 | 68.8 | 0.642 |
| 275829.9 | 3098129.9 | 1.9 | 17.279 | 12.506 | 35.9 | 21.330 | 20.2 | 16.974 | 0.273 | 0.582 | 64.8 | 0.643 | 6.0 | 0.269 | 0.581 | 65.1 | 0.640 |

**TRIPLE Araucaria** (9.0m ground clearance to achieve 9kV/m Electric Field)

```
PLS-CADD Version 18.00x64    2:28:01 PM 06 July 2023
Scottish and Southern Energy
Project Name: 'C:\Users\AM25305\Desktop\CSR ASTI-\PLS Model ASTI\profile 637.don'

Criteria Notes:
  Design criteria developed for SSE Beauly Blackhillock Line reconductoring
  Global wind notes: wind directions are annotated NNW-330, E-90, etc as `wind from` - angles in GLB wind are `wind to` or wind azumuth
  delete - survey and maps confirm angle as per XYZ 19/08/08.Terrain 289: angle has been corrected in pfl. CHECK xyz
  delete?20/08/08.PFL 180 and 181 points edited
  tower 229 is a D10 with extended crossarms. It should be modeled???Erection loads??CHECK.


3D EMF Calculation Notes:
  1) Calculations based on the EPRI Red Book methods (3rd Edition, 2005 - 7.4 Calculation of Magnetic Fields and Appendices 7.1 Calculation
of Field Ellipse Parameters and 7.6 Electric Field Calculations for 3D Geometry).
  2) All wire positions are modeled at the specified weather case and wind direction. Height above ground determined by the modeled ground
TIN.
  3) Only the effects of wires are being analyzed. The effects of structures are not included unless enabled as noted below.
  4) Ground return is being ignored for magnetic field calculations.


Meter height above ground:                  1.00 (m)
Maximum wire distance:                    150.00 (m)
Maximum cable segment size:                 3.00 (m)
Cross section offset +/-:                  35.00 (m)
Result interval:                            1.00 (m)
Electric field limit:                       9.00 (kV/m)
Magnetic field limit:                     360.00 (uT)
Space potential limit:                      0.00 (kV)
Contour Map Spacing:                           3 (m)
Analyzing spans between these structures:  1 - 6

One or more sections have wind from both directions which is not supported. A wind direction of left is being used for those sections.

Section Data for 3D EMF Results:
```

| Section Number | Section Note | Voltage Ph-Ph (kV) | Current (Amps) | Cable Filename | Cable Description | Conductors Per Phase | Bundle Diameter (cm) | Cable Radius (cm) | Weather Case | Condition | Wind Dir. | WC Temperature (deg C) | Effective Radius (cm) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | | 400.0 | 4570.0 | araucaria lumpi - 30.5.wir 700mm² AAAC - Araucaria | | 3 | 57.735 | 1.863 | 90°C | Creep RS | Left | 90.000 | 16.700 |
| 2 | | 400.0 | 4570.0 | araucaria lumpi - 30.5.wir 700mm² AAAC - Araucaria | | 3 | 57.735 | 1.863 | 90°C | Creep RS | Left | 90.000 | 16.700 |



TRIPLE Araucaria (9.0m ground clearance to achieve 9kV/m Electric Field)

3D EMF Point Results Span from 5 to 6:

| Measurement | | | B | | | | | H | EF | | | | | Space Potential | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| X (m) | Y (m) | Z (m) | Real (uT) | Imaginary (uT) | Angle (deg) | Magnitude (uT) | Polarization Axial Ratio % | Magnitude (A/m) | Real (kV/m) | Imaginary (kV/m) | Angle (deg) | Magnitude (kV/m) | Polarization Axial Ratio % | Real (kV) | Imaginary (kV) | Angle (deg) | Magnitude (kV) |
| 275818.8 | 3098059.8 | 1.9 | 16.631 | 12.096 | 36.0 | 20.564 | 19.3 | 16.364 | 0.185 | 0.497 | 69.6 | 0.530 | 7.4 | 0.179 | 0.496 | 70.2 | 0.527 |
| 275819.1 | 3098060.8 | 1.9 | 17.391 | 12.820 | 36.4 | 21.605 | 19.6 | 17.193 | 0.147 | 0.505 | 73.8 | 0.526 | 8.6 | 0.137 | 0.504 | 74.7 | 0.522 |
| 275819.4 | 3098061.7 | 1.9 | 18.197 | 13.605 | 36.8 | 22.720 | 19.8 | 18.080 | 0.106 | 0.510 | 78.3 | 0.521 | 10.1 | 0.089 | 0.508 | 80.1 | 0.516 |
| 275819.7 | 3098062.7 | 1.9 | 19.052 | 14.457 | 37.2 | 23.916 | 19.9 | 19.032 | 0.071 | 0.511 | 82.1 | 0.516 | 11.9 | 0.033 | 0.509 | 86.3 | 0.510 |
| 275820.0 | 3098063.6 | 1.9 | 19.958 | 15.383 | 37.6 | 25.198 | 20.1 | 20.052 | 0.076 | 0.507 | 81.5 | 0.513 | 13.9 | -0.032 | 0.505 | -86.4 | 0.506 |
| 275820.3 | 3098064.5 | 1.9 | 20.919 | 16.391 | 38.1 | 26.575 | 20.2 | 21.148 | 0.131 | 0.497 | 75.2 | 0.514 | 16.3 | -0.107 | 0.494 | -77.8 | 0.505 |
| 275820.7 | 3098065.5 | 1.9 | 21.939 | 17.488 | 38.6 | 28.056 | 20.3 | 22.326 | 0.211 | 0.479 | 66.3 | 0.523 | 18.7 | -0.193 | 0.475 | -67.9 | 0.512 |
| 275821.0 | 3098066.4 | 1.9 | 23.020 | 18.683 | 39.1 | 29.648 | 20.4 | 23.593 | 0.307 | 0.450 | 55.8 | 0.545 | 20.6 | -0.292 | 0.444 | -56.7 | 0.532 |
| 275821.3 | 3098067.4 | 1.9 | 24.168 | 19.986 | 39.6 | 31.361 | 20.3 | 24.956 | 0.418 | 0.409 | 44.4 | 0.585 | 21.7 | -0.405 | 0.400 | -44.6 | 0.569 |
| 275821.6 | 3098068.3 | 1.9 | 25.385 | 21.406 | 40.1 | 33.206 | 20.3 | 26.424 | 0.547 | 0.353 | 32.9 | 0.651 | 21.4 | -0.534 | 0.338 | -32.3 | 0.633 |
| 275821.9 | 3098069.3 | 1.9 | 26.676 | 22.953 | 40.7 | 35.191 | 20.1 | 28.004 | 0.694 | 0.281 | 22.1 | 0.748 | 19.9 | -0.682 | 0.255 | -20.5 | 0.728 |
| 275822.2 | 3098070.2 | 1.9 | 28.043 | 24.637 | 41.3 | 37.328 | 19.9 | 29.705 | 0.861 | 0.201 | 13.2 | 0.884 | 17.9 | -0.848 | 0.145 | -9.7 | 0.861 |
| 275822.5 | 3098071.2 | 1.9 | 29.491 | 26.466 | 41.9 | 39.626 | 19.6 | 31.533 | 1.050 | 0.165 | 8.9 | 1.063 | 15.6 | -1.038 | 0.002 | -0.1 | 1.038 |
| 275822.9 | 3098072.1 | 1.9 | 31.021 | 28.449 | 42.5 | 42.091 | 19.1 | 33.495 | 1.264 | 0.267 | 11.9 | 1.292 | 13.5 | -1.251 | -0.181 | 8.2 | 1.264 |
| 275823.2 | 3098073.1 | 1.9 | 32.635 | 30.589 | 43.1 | 44.729 | 18.6 | 35.594 | 1.504 | 0.474 | 17.5 | 1.577 | 11.7 | -1.491 | -0.413 | 15.5 | 1.547 |
| 275823.5 | 3098074.0 | 1.9 | 34.331 | 32.885 | 43.8 | 47.540 | 17.9 | 37.831 | 1.774 | 0.755 | 23.0 | 1.928 | 10.2 | -1.759 | -0.701 | 21.7 | 1.894 |
| 275823.8 | 3098075.0 | 1.9 | 36.103 | 35.331 | 44.4 | 50.515 | 17.1 | 40.198 | 2.074 | 1.107 | 28.1 | 2.351 | 8.9 | -2.058 | -1.056 | 27.2 | 2.313 |
| 275824.1 | 3098075.9 | 1.9 | 37.941 | 37.905 | 45.0 | 53.631 | 16.2 | 42.679 | 2.406 | 1.537 | 32.6 | 2.855 | 7.7 | -2.388 | -1.484 | 31.9 | 2.811 |
| 275824.4 | 3098076.9 | 1.9 | 39.821 | 40.573 | 45.5 | 56.850 | 15.2 | 45.240 | 2.769 | 2.049 | 36.5 | 3.445 | 6.7 | -2.749 | -1.993 | 35.9 | 3.395 |
| 275824.7 | 3098077.8 | 1.9 | 41.708 | 43.275 | 46.1 | 60.102 | 14.0 | 47.828 | 3.162 | 2.645 | 39.9 | 4.122 | 5.8 | -3.138 | -2.583 | 39.5 | 4.064 |
| 275825.1 | 3098078.8 | 1.9 | 43.544 | 45.920 | 46.5 | 63.283 | 12.7 | 50.359 | 3.577 | 3.318 | 42.8 | 4.879 | 5.0 | -3.550 | -3.248 | 42.5 | 4.811 |
| 275825.4 | 3098079.7 | 1.9 | 45.244 | 48.383 | 46.9 | 66.241 | 11.3 | 52.713 | 4.005 | 4.051 | 45.3 | 5.697 | 4.3 | -3.972 | -3.971 | 45.0 | 5.617 |
| 275825.7 | 3098080.7 | 1.9 | 46.694 | 50.492 | 47.2 | 68.774 | 9.9 | 54.728 | 4.428 | 4.811 | 47.4 | 6.538 | 3.6 | -4.388 | -4.720 | 47.1 | 6.445 |
| 275826.0 | 3098081.6 | 1.9 | 47.750 | 52.046 | 47.5 | 70.632 | 8.3 | 56.207 | 4.821 | 5.548 | 49.0 | 7.350 | 2.9 | -4.774 | -5.446 | 48.8 | 7.243 |
| 275826.3 | 3098082.6 | 1.9 | 48.253 | 52.827 | 47.6 | 71.548 | 6.7 | 56.936 | 5.154 | 6.201 | 50.3 | 8.064 | 2.4 | -5.102 | -6.089 | 50.0 | 7.944 |
| 275826.6 | 3098083.5 | 1.9 | 48.062 | 52.646 | 47.6 | 71.285 | 5.0 | 56.727 | 5.399 | 6.703 | 51.1 | 8.608 | 1.9 | -5.343 | -6.586 | 50.9 | 8.481 |
| 275827.0 | 3098084.5 | 1.9 | 47.091 | 51.392 | 47.5 | 69.704 | 3.4 | 55.469 | 5.532 | 7.003 | 51.7 | 8.925 | 1.6 | -5.476 | -6.886 | 51.5 | 8.798 |
| 275827.3 | 3098085.4 | 1.9 | 45.345 | 49.078 | 47.3 | 66.819 | 1.8 | 53.173 | 5.545 | 7.076 | 51.9 | 8.990 | 1.4 | -5.493 | -6.967 | 51.7 | 8.872 |
| 275827.6 | 3098086.4 | 1.9 | 42.933 | 45.847 | 46.9 | 62.811 | 0.2 | 49.984 | 5.448 | 6.937 | 51.9 | 8.821 | 1.4 | -5.404 | -6.844 | 51.7 | 8.720 |
| 275827.9 | 3098087.3 | 1.9 | 40.052 | 41.955 | 46.3 | 58.004 | 1.3 | 46.158 | 5.268 | 6.633 | 51.5 | 8.471 | 1.4 | -5.235 | -6.561 | 51.4 | 8.394 |
| 275828.2 | 3098088.3 | 1.9 | 36.949 | 37.715 | 45.6 | 52.798 | 2.6 | 42.016 | 5.039 | 6.233 | 51.0 | 8.016 | 1.5 | -5.019 | -6.185 | 50.9 | 7.965 |
| 275828.5 | 3098089.2 | 1.9 | 33.889 | 33.461 | 44.6 | 47.624 | 3.6 | 37.898 | 4.800 | 5.807 | 50.4 | 7.534 | 1.5 | -4.792 | -5.783 | 50.4 | 7.510 |
| 275828.8 | 3098090.2 | 1.9 | 31.134 | 29.533 | 43.5 | 42.913 | 4.1 | 34.149 | 4.582 | 5.415 | 49.8 | 7.093 | 1.4 | -4.584 | -5.413 | 49.7 | 7.093 |
| 275829.2 | 3098091.1 | 1.9 | 28.930 | 26.293 | 42.3 | 39.093 | 3.7 | 31.109 | 4.409 | 5.105 | 49.2 | 6.745 | 1.2 | -4.420 | -5.119 | 49.2 | 6.763 |
| 275829.5 | 3098092.1 | 1.9 | 27.498 | 24.120 | 41.3 | 36.578 | 2.2 | 29.108 | 4.300 | 4.907 | 48.8 | 6.524 | 1.0 | -4.315 | -4.933 | 48.8 | 6.554 |
| 275829.8 | 3098093.0 | 1.9 | 27.001 | 23.348 | 40.9 | 35.696 | 0.0 | 28.406 | 4.262 | 4.839 | 48.6 | 6.448 | 0.9 | -4.280 | -4.869 | 48.7 | 6.482 |
| 275830.1 | 3098094.0 | 1.9 | 27.498 | 24.120 | 41.3 | 36.578 | 2.2 | 29.108 | 4.300 | 4.907 | 48.8 | 6.524 | 1.0 | -4.315 | -4.933 | 48.8 | 6.554 |
| 275830.4 | 3098094.9 | 1.9 | 28.930 | 26.293 | 42.3 | 39.093 | 3.7 | 31.109 | 4.409 | 5.105 | 49.2 | 6.745 | 1.2 | -4.420 | -5.119 | 49.2 | 6.763 |
| 275830.7 | 3098095.9 | 1.9 | 31.134 | 29.533 | 43.5 | 42.913 | 4.1 | 34.149 | 4.582 | 5.415 | 49.8 | 7.093 | 1.4 | -4.584 | -5.413 | 49.7 | 7.093 |
| 275831.0 | 3098096.8 | 1.9 | 33.889 | 33.461 | 44.6 | 47.624 | 3.6 | 37.898 | 4.800 | 5.807 | 50.4 | 7.534 | 1.5 | -4.792 | -5.783 | 50.4 | 7.510 |
| 275831.4 | 3098097.8 | 1.9 | 36.949 | 37.715 | 45.6 | 52.798 | 2.6 | 42.016 | 5.039 | 6.233 | 51.0 | 8.016 | 1.5 | -5.019 | -6.185 | 50.9 | 7.965 |
| 275831.7 | 3098098.7 | 1.9 | 40.052 | 41.955 | 46.3 | 58.004 | 1.3 | 46.158 | 5.268 | 6.633 | 51.5 | 8.471 | 1.4 | -5.235 | -6.561 | 51.4 | 8.394 |
| 275832.0 | 3098099.7 | 1.9 | 42.933 | 45.847 | 46.9 | 62.811 | 0.2 | 49.984 | 5.448 | 6.937 | 51.9 | 8.821 | 1.4 | -5.404 | -6.844 | 51.7 | 8.720 |
| 275832.3 | 3098100.6 | 1.9 | 45.345 | 49.078 | 47.3 | 66.819 | 1.8 | 53.173 | 5.545 | 7.076 | 51.9 | 8.990 | 1.4 | -5.493 | -6.967 | 51.7 | 8.872 |
| 275832.6 | 3098101.6 | 1.9 | 47.091 | 51.392 | 47.5 | 69.704 | 3.4 | 55.469 | 5.532 | 7.003 | 51.7 | 8.925 | 1.6 | -5.476 | -6.886 | 51.5 | 8.798 |
| 275832.9 | 3098102.5 | 1.9 | 48.062 | 52.646 | 47.6 | 71.285 | 5.0 | 56.727 | 5.399 | 6.703 | 51.1 | 8.608 | 1.9 | -5.343 | -6.586 | 50.9 | 8.481 |
| 275833.2 | 3098103.5 | 1.9 | 48.253 | 52.827 | 47.6 | 71.548 | 6.7 | 56.936 | 5.154 | 6.201 | 50.3 | 8.064 | 2.4 | -5.102 | -6.089 | 50.0 | 7.944 |
| 275833.6 | 3098104.4 | 1.9 | 47.750 | 52.046 | 47.5 | 70.632 | 8.3 | 56.207 | 4.821 | 5.548 | 49.0 | 7.350 | 2.9 | -4.774 | -5.446 | 48.8 | 7.243 |
| 275833.9 | 3098105.4 | 1.9 | 46.694 | 50.492 | 47.2 | 68.774 | 9.9 | 54.728 | 4.428 | 4.811 | 47.4 | 6.538 | 3.6 | -4.388 | -4.720 | 47.1 | 6.445 |
| 275834.2 | 3098106.3 | 1.9 | 45.244 | 48.383 | 46.9 | 66.241 | 11.3 | 52.713 | 4.005 | 4.051 | 45.3 | 5.697 | 4.3 | -3.972 | -3.971 | 45.0 | 5.617 |
| 275834.5 | 3098107.3 | 1.9 | 43.544 | 45.920 | 46.5 | 63.283 | 12.7 | 50.359 | 3.577 | 3.318 | 42.8 | 4.879 | 5.0 | -3.550 | -3.248 | 42.5 | 4.811 |
| 275834.8 | 3098108.2 | 1.9 | 41.708 | 43.275 | 46.1 | 60.102 | 14.0 | 47.828 | 3.162 | 2.645 | 39.9 | 4.122 | 5.8 | -3.138 | -2.583 | 39.5 | 4.064 |
| 275835.1 | 3098109.2 | 1.9 | 39.821 | 40.573 | 45.5 | 56.850 | 15.2 | 45.240 | 2.769 | 2.049 | 36.5 | 3.445 | 6.7 | -2.749 | -1.993 | 35.9 | 3.395 |
| 275835.4 | 3098110.1 | 1.9 | 37.941 | 37.905 | 45.0 | 53.631 | 16.2 | 42.679 | 2.406 | 1.537 | 32.6 | 2.855 | 7.7 | -2.388 | -1.484 | 31.9 | 2.811 |
| 275835.8 | 3098111.1 | 1.9 | 36.103 | 35.331 | 44.4 | 50.515 | 17.1 | 40.198 | 2.074 | 1.107 | 28.1 | 2.351 | 8.9 | -2.058 | -1.056 | 27.2 | 2.313 |
| 275836.1 | 3098112.0 | 1.9 | 34.331 | 32.885 | 43.8 | 47.540 | 17.9 | 37.831 | 1.774 | 0.755 | 23.0 | 1.928 | 10.2 | -1.759 | -0.701 | 21.7 | 1.894 |
| 275836.4 | 3098113.0 | 1.9 | 32.635 | 30.589 | 43.1 | 44.729 | 18.6 | 35.594 | 1.504 | 0.474 | 17.5 | 1.577 | 11.7 | -1.491 | -0.413 | 15.5 | 1.547 |
| 275836.7 | 3098113.9 | 1.9 | 31.021 | 28.449 | 42.5 | 42.091 | 19.1 | 33.495 | 1.264 | 0.267 | 11.9 | 1.292 | 13.5 | -1.251 | -0.181 | 8.2 | 1.264 |
| 275837.0 | 3098114.9 | 1.9 | 29.491 | 26.466 | 41.9 | 39.626 | 19.6 | 31.533 | 1.050 | 0.165 | 8.9 | 1.063 | 15.6 | -1.038 | 0.002 | -0.1 | 1.038 |
| 275837.3 | 3098115.8 | 1.9 | 28.043 | 24.637 | 41.3 | 37.328 | 19.9 | 29.705 | 0.861 | 0.201 | 13.2 | 0.884 | 17.9 | -0.848 | 0.145 | -9.7 | 0.861 |
| 275837.6 | 3098116.8 | 1.9 | 26.676 | 22.953 | 40.7 | 35.191 | 20.1 | 28.004 | 0.694 | 0.281 | 22.1 | 0.748 | 19.9 | -0.682 | 0.255 | -20.5 | 0.728 |
| 275838.0 | 3098117.7 | 1.9 | 25.385 | 21.406 | 40.1 | 33.206 | 20.3 | 26.424 | 0.547 | 0.353 | 32.9 | 0.651 | 21.4 | -0.534 | 0.338 | -32.3 | 0.633 |
| 275838.3 | 3098118.7 | 1.9 | 24.168 | 19.986 | 39.6 | 31.361 | 20.3 | 24.956 | 0.418 | 0.409 | 44.4 | 0.585 | 21.7 | -0.405 | 0.400 | -44.6 | 0.569 |
| 275838.6 | 3098119.6 | 1.9 | 23.020 | 18.683 | 39.1 | 29.648 | 20.4 | 23.593 | 0.307 | 0.450 | 55.8 | 0.545 | 20.6 | -0.292 | 0.444 | -56.7 | 0.532 |
| 275838.9 | 3098120.6 | 1.9 | 21.939 | 17.488 | 38.6 | 28.056 | 20.3 | 22.326 | 0.211 | 0.479 | 66.3 | 0.523 | 18.7 | -0.193 | 0.475 | -67.9 | 0.512 |
| 275839.2 | 3098121.5 | 1.9 | 20.919 | 16.391 | 38.1 | 26.575 | 20.2 | 21.148 | 0.131 | 0.497 | 75.2 | 0.514 | 16.3 | -0.107 | 0.494 | -77.8 | 0.505 |
| 275839.5 | 3098122.5 | 1.9 | 19.958 | 15.383 | 37.6 | 25.198 | 20.1 | 20.052 | 0.076 | 0.507 | 81.5 | 0.513 | 13.9 | -0.032 | 0.505 | -86.4 | 0.506 |
| 275839.8 | 3098123.4 | 1.9 | 19.052 | 14.457 | 37.2 | 23.916 | 19.9 | 19.032 | 0.071 | 0.511 | 82.1 | 0.516 | 11.9 | 0.033 | 0.509 | 86.3 | 0.510 |
| 275840.2 | 3098124.4 | 1.9 | 18.197 | 13.605 | 36.8 | 22.720 | 19.8 | 18.080 | 0.106 | 0.510 | 78.3 | 0.521 | 10.1 | 0.089 | 0.508 | 80.1 | 0.516 |
| 275840.5 | 3098125.3 | 1.9 | 17.391 | 12.820 | 36.4 | 21.605 | 19.6 | 17.193 | 0.147 | 0.505 | 73.8 | 0.526 | 8.6 | 0.137 | 0.504 | 74.7 | 0.522 |
| 275840.8 | 3098126.2 | 1.9 | 16.631 | 12.096 | 36.0 | 20.564 | 19.3 | 16.364 | 0.185 | 0.497 | 69.6 | 0.530 | 7.4 | 0.179 | 0.496 | 70.2 | 0.527 |

# Appendix C WSP Assessment