METRO NORTH TRANSMISSION STUDY
ELECTRIC AND MAGNETIC FIELD PROFILES
(VILLAGE OF ANMORE)

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March 2016

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METRO NORTH TRANSMISSION STUDY

ELECTRIC AND MAGNETIC FIELD PROFILE

KEY FINDINGS

As part of the Metro North Transmission Study BC Hydro is considering the option of double circuit an existing single circuit 230 kilovolt (kV) transmission line through the Community of Anmore on the north side of an existing right-of-way. An electric and magnetic field profile has been completed in response to public consultation and engagement undertaken earlier in the study.

The profile is based on a conservative minimum distance between the lowest point of the lowest wire and the ground (8 m), using the average yearly load when the line reaches its maximum rating (or the maximum amount of current the line is designed to carry). It is not expected for the line to reach the maximum rating until closer to the end of the 30 year study period, or near 2045. BC Hydro has adopted the residential magnetic field exposure limit from the International Commission of Non-Ionizing Radiation Protection (ICNIRP) of 2000 milligauss (mG) with no distinction between controlled and uncontrolled environments.

The electric and magnetic field profile for the Metro North Transmission Study through Anmore finds:

1. On the northern side of the right-of-way edge, The **magnetic field** level is reduced from 33.3 mG to 18.5 mG or 1.67% to 0.93% of ICNIRP guidelines. The **electric field** level decreases by about 25% down to less than 0.5 kV/m.

2. On the southern side of the right-of-way edge, the **magnetic field** level is increase marginally from 49.2 mG to 52.6 mG or from 2.46% to 2.63% of ICNIRP guideline. The **electric field** level does not change and remains less than 0.3 kV/m.

The reduction in magnetic field, most notably on the northern side of the right-of-way edge, is attributed to the use of transposed phasing line arrangement, allowing some of the magnetic field emission from the new line to cancel the emission from the existing line. In all cases, the magnetic field levels from the proposed double circuit line remain far below the ICNIRP guideline endorsed by the World Health Organization.

This profile is based on specific information that was current at the time of writing. If there is a change to this information, an addendum will be issued.

METRO NORTH STUDY ELECTRIC AND MAGNETIC FIELD PROFILES

1.0 INTRODUCTION

As part of the Metro North Transmission Study BC Hydro is planning to double-circuit an existing H-frame single-circuit 230 kV transmission line. The H-frame line parallels an existing double-circuit 230 kV line that passes through the community of Anmore. This report provides electric and magnetic field profiles across the Right-of-Way (RoW) for the assumed line configuration. The scope of this report is limited to the area around and through the community of Anmore shown in Figure 1.

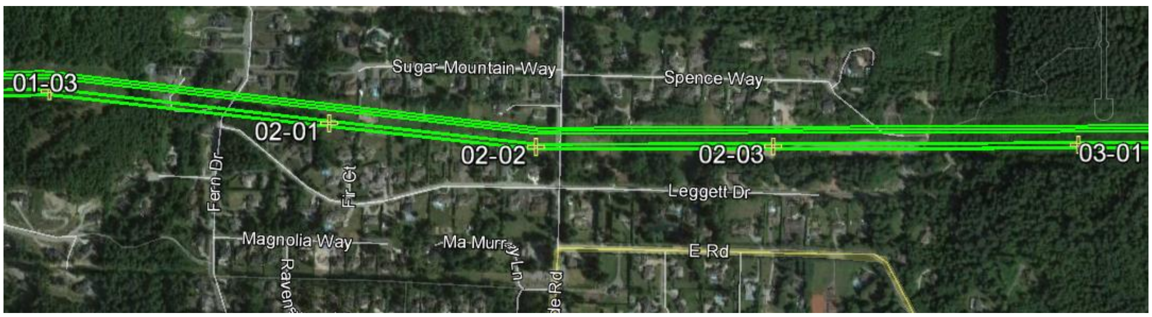

Figure 1 Area of study

2.0 SAFETY BY DESIGN

Safety by Design (SbD) is an application of engineering principles and standards for designing features into new and existing facilities to ensure that they are inherently safe.

This memo applies Safety by Design by assessing the electric and magnetic field limits needed to mitigate shock hazards and provide safe levels of human exposure to electric and magnetic fields. Other effects of electric and magnetic fields, such as the impact on pipelines and fences that parallel power lines must be evaluated separately.

3.0 DATA

The present-day cross-section of the 230 kV RoW through Anmore is shown in Figure 2. The design data was gathered from phasing diagrams, circuit details drawings, structure designs, Eline Z data, 5T-10 ratings, and profile design data [1]-[12].

Phasing of 2L054 and 2L061 is shown on [1] and [2]. Phasing of 2L049 is shown on [8], note that the area of interest of this report is between Meridian Substation and Burrard Thermal station.

The maximum rating of 2560 A on 2L054 and 2L061, and presumed for the new proposed lines, were based on the maximum winter rating [10].

The existing circuit-to-circuit separation was estimated from [12].

The conductor height used to calculate the profiles for 2L054 and 2L061 was based on an average structure attachment point height, based on profile design data, and an estimated minimum conductor height at maximum sag of 8 m. Similarly, structure attachment point heights for the proposed new circuits were based on preliminary profile designs and an estimated 8 m minimum conductor height. Average conductor height used in this report is calculated using:

$$H_{avg} \cong H_t - \frac{2}{3}S_{max} \tag{1}$$

Where, H_t is the conductor attachment height, and S_{max} is the maximum sag.

Calculation of the average conductor heights is shown in Table 1.

Table 1 Calculation of the average conductor heights [m]

Circuit	Attachment height [m]	Minimum ground clearance [m]	Max sag [m]	Average height [m]
2L049	23.6	8	15.6	13.2
2L054	23.4	8	15.4	13.13
2L061	23.4	8	15.4	13.13
2L018	23.6	8	15.6	13.2

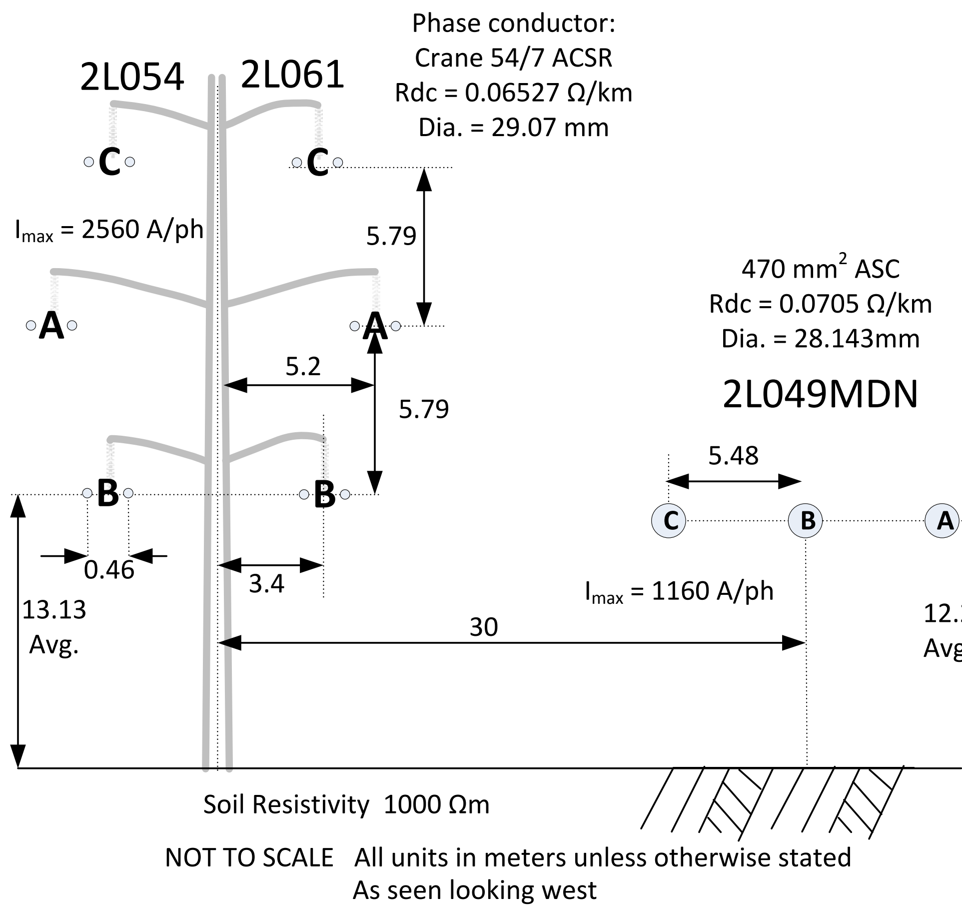

Figure 2 Right-of-Way present day cross section

The proposed future cross section shown in Figure 3 is based on preliminary design information from the Overhead Design group, and assuming similar structure cross sections as the recently completed circuit 2L329 [13]-[15].

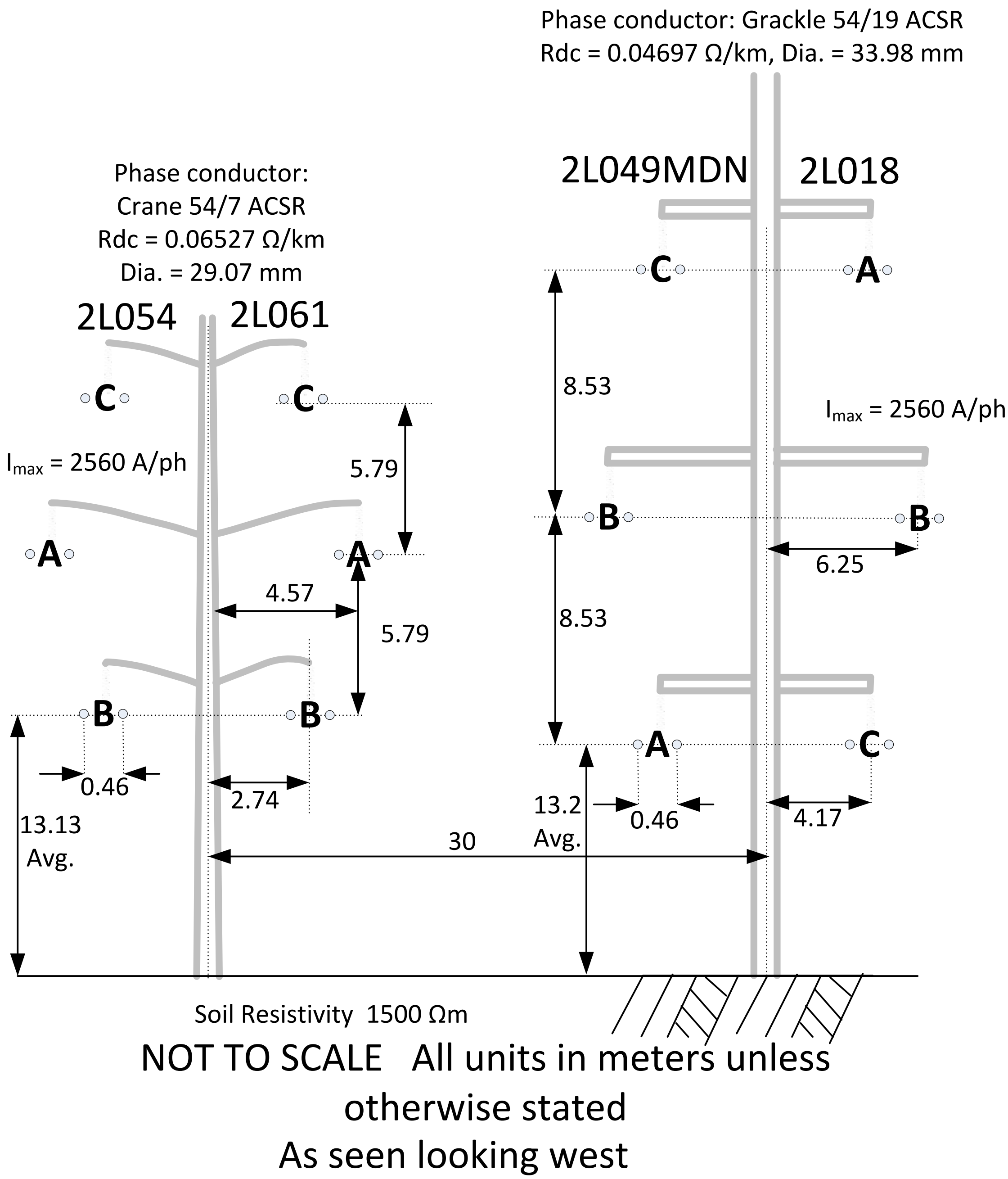

Figure 3 Right-of-Way proposed cross section

4.0 BC HYDRO EMF LIMITS

BC Hydro EMF limits for human exposure are based on the Institute of Electrical and Electronics Engineers (IEEE) standard C95.6 (2007). This standard provides a maximum permissible electric field level for public exposure of 5 kV/m for uncontrolled environments (outside of the power line RoW) and 10 kV/m for controlled environments (within the power line RoW). The maximum permissible magnetic field exposure specified for the public is 9000 mG.

For comparison, the International Commission of Non-Ionizing Radiation Protection (ICNIRP) “Guidelines for Limiting Exposure to Time-varying Electric and Magnetic Fields (1 Hz to 100 kHz)” specifies a magnetic field limit for public exposure of 2000 mG with no distinction between controlled and uncontrolled environments. Strictly for urban areas, where public exposure would be the greatest, BC Hydro has voluntarily adopted the ICNIRP value.

To evaluate a RoW based on BC Hydro’s EMF limits the maximum rating of all circuit on the RoW is considered. The maximum rating may be limited by thermal constraints of the line, station equipment, or network limitations. These constraints must be evaluated on a circuit by circuit basis. In the case of the circuits through Anmore the lines are ultimately limited by their winter thermal rating. The voltage on the transmission lines is assumed to be 1.05 per-unit. Conductor height is based on the designed maximum sag for the maximum loading scenario averaged over a typical span. It should be noted that his high loading scenario of all 4 circuits is not likely to occur in practice.

For information only BC Hydro also calculates EMF exposure levels. These exposure levels are calculated for a hypothetical future year in which the lines are briefly loaded to their maximum loading. The “ultimate average loading” is defined as the average loading over the course of a year in which the maximum line loading is briefly reached. The voltage on the transmission line is assumed to be 1.05 per-unit. To err on the side of conservativism, conductor height is based on the designed maximum sag for the maximum loading scenario averaged over a typical span.

It should be expected that at various locations on the line, the actual conductor height above ground may be less than the assumed average conductor height values as the conductor height will vary based on environmental factors, uneven terrain, span length and conductor attachment heights. Assumptions made for average values are intended to provide an approximate representation over the length of the section.

The “ultimate average loading” is the loading that a line would carry on average in the year it reaches its maximum rating. The ratio of the annual average load to the annual maximum load was calculated from 2015 historical data. This ratio was then used to estimate the “ultimate average loading”. The results are shown in Table 2. A ratio of 0.5 was assumed for the planned 2L018 based on the other circuits in the RoW.

Table 2 Calculation of “Ultimate average loading”

Circuit	Average to peak load ratio	Maximum rating [A]	“Ultimate average loading” [A]
2L049	0.45	2560	1152
2L054	0.50	2560	1280
2L061	0.43	2560	1100
2L018	0.5 (assumed)	2560	1280

Maximum rating

Table 3 Line parameter values for maximum rated operating condition

Circuit	Average height of lowest conductor [m]	Phase current [A]	Voltage [kV]
2L049	13.2	2560	242
2L054	13.13	2560	242
2L061	13.13	2560	242
2L018	13.2	2560	242

"Ultimate average loading" - Exposure of the public

To err on the side of conservativism, average conductor height based on the maximum (rather than annual average) sag was assumed. As described above the "Ultimate average loading" was based on the maximum loading and maximum-to-average loading ratio for the line in 2015.

Table 4 Line parameter values for exposure of the public

Circuit	Average height of lowest conductor [m]	Phase current [A]	Voltage [kV]
2L049	13.2	1152	242
2L054	13.13	1280	242
2L061	13.13	1100	242
2L018	13.2	1280	242

5.0 SIMULATION

For All scenarios Transmission Line Electrical Design's internal calculation tool TLEEF was used to calculate the electric and magnetic field profiles across the RoW. Fields were calculated 1 m from the ground.

Every phasing arrangement of 2L049 and 2L018 was simulated. The arrangement with the lowest magnetic field at the southern RoW edge is shown in Figure 3. This is Transmission Line Electrical Design's recommended phasing arrangement, and all further calculations made for the proposed line assume this arrangement.

Simulations showed that the electric and magnetic field levels were well within BC Hydro's standard limits for all conditions. The following figures show the magnetic and electric field profiles from the maximum rated and "ultimate average loading" conditions. The figures show a cross-section of the right of way viewed facing west and are scaled to show the maximum permissible magnetic and electric field levels.

Maximum rating

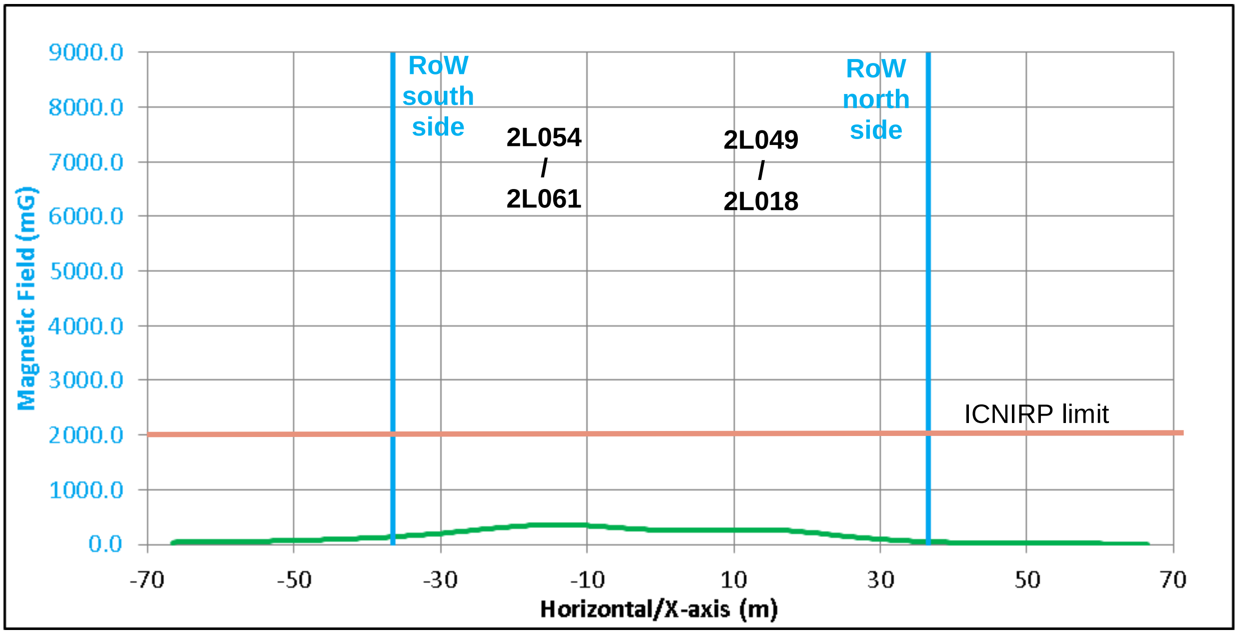

Figure 4 Magnetic field profile of proposed configuration under maximum rating conditions

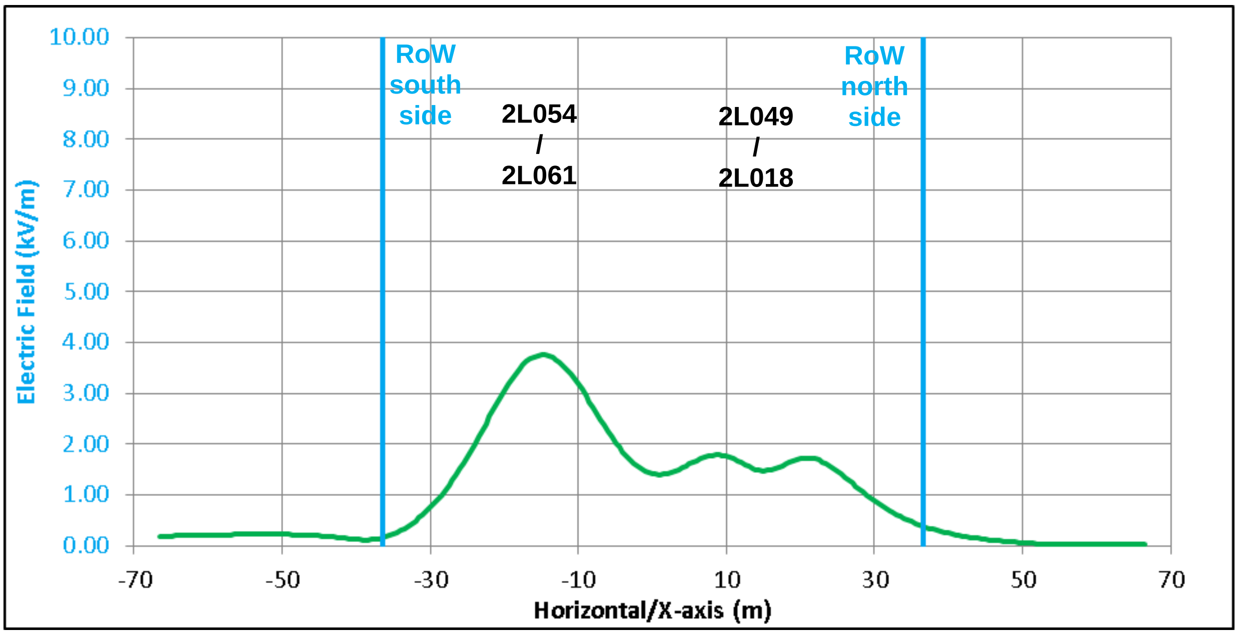

Figure 5 Electric field profile of proposed configuration under maximum rating conditions

“Ultimate average loading” - Exposure of the public

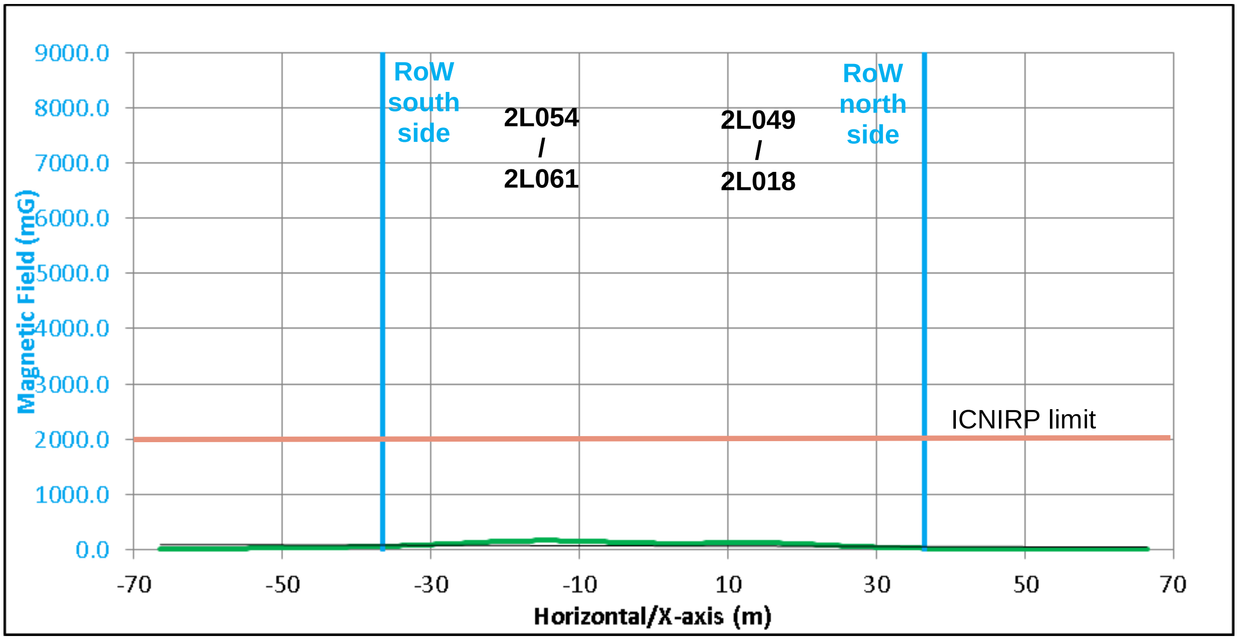

Figure 6 Magnetic field exposure of proposed configuration

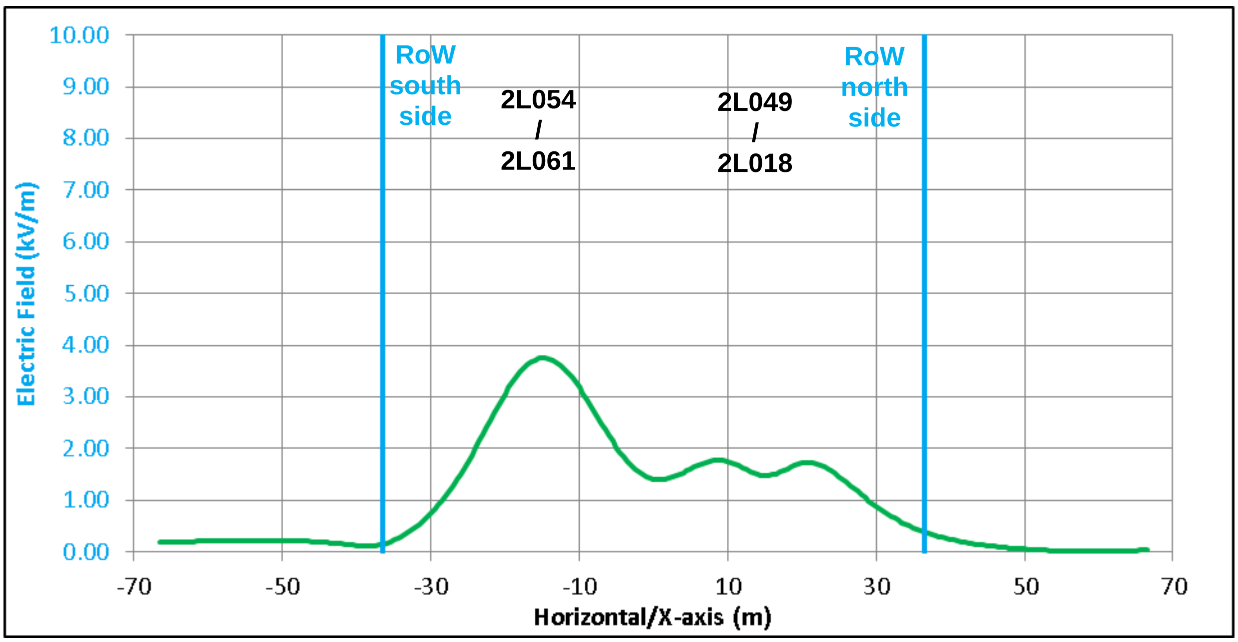

Figure 7 Electric field exposure of proposed configuration

Comparison with existing configuration

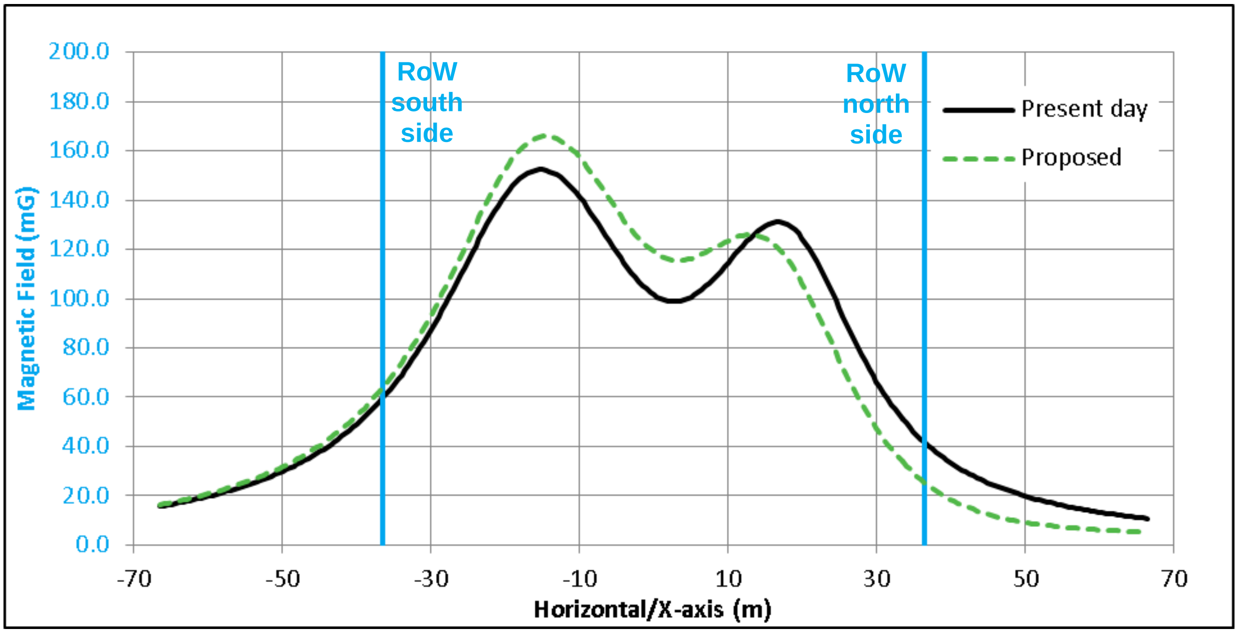

Figure 8 Magnetic field exposure of existing and proposed configurations

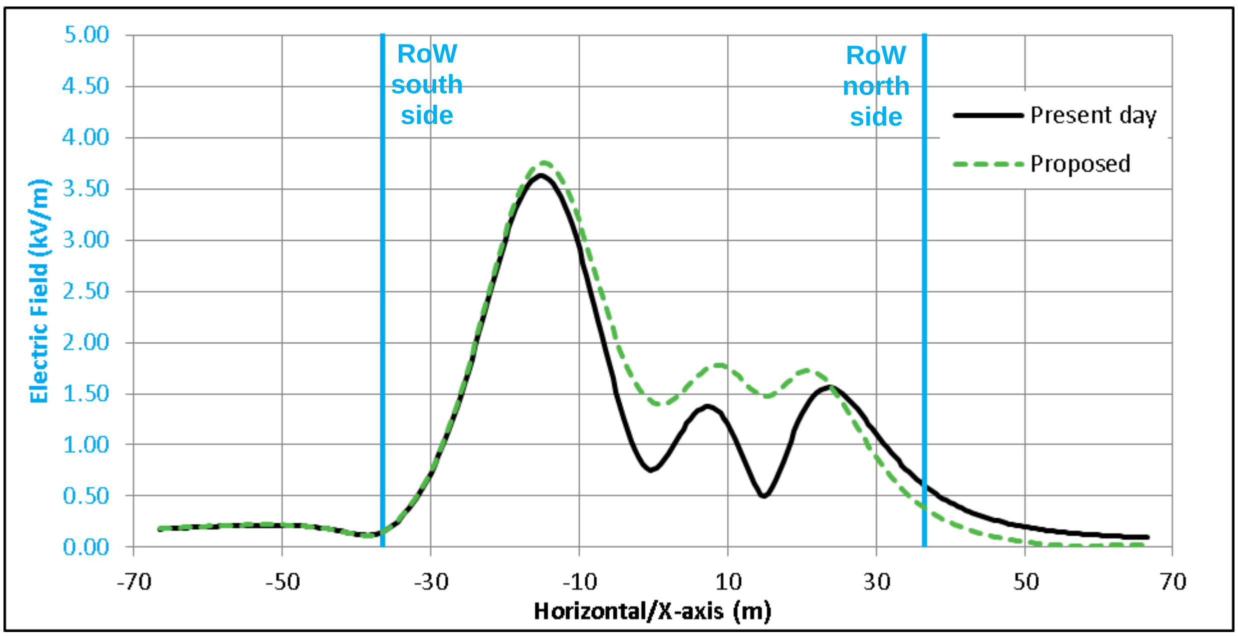

Figure 9 Electric field exposure of existing and proposed configurations

6.0 REFERENCES

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