2.4 ELECTROMAGNETIC FIELD STUDY

2.4.1 Introduction

This report summarizes the audible noise (AN), radio interference (RI), electric field and magnetic flux density calculations carried out for the Talston Hydroelectric Expansion Project 161 kV ac transmission line. These effects were calculated and compared with standards or with the regulations and limits adopted by various utilities.

The CORONA3 program was used to determine the levels of electric field, magnetic flux density, audible noise (AN) and radio interference (RI). The CORONA3 program was developed following extensive monitoring and measurements of both AC and DC lines carried out by Bonneville Power Administration (BPA) and is widely used in the industry. With the exception of static electric field and magnetic fields, which are exactly calculated based on voltage, current and line geometry, all of the calculation algorithms implemented in the CORONA3 program are empirically derived from measured data. Some care and judgement needs to be applied when using such empirical methods especially if the line configurations being studied are different from the lines originally used in the measurements.

The following are the data and configuration of lines for which the calculations of electrical effects were performed.

- Structure Type: Type 'A' 0-3 degree lattice steel structure, single circuit with horizontal configuration, presented in Figure 6-26 in the Appendix D.
- Ground Clearance: 4.3 m for energized conductors.
- Nominal voltage: 161 kV, 60 Hz
- Phase conductors: single ACSR conductors 716 Stilt, each carrying 0.194 kA.
- Rain rate: 2.54 mm/hr
- Altitude less than 1000 m a.s.l.

All the 'measuring points' are 1 m above ground level. It should be noted that selection of the lowest point of the conductor presents the worst case and for all other points the effects would be lower. Since corona is significantly affected by weather, the EMF effects are stochastic quantities. The values presented are L50, meaning the actual values are expected to exceed the calculated values 50 % of time.

2.4.2 Electric Field

There are several documents that provide guidelines on the permitted level of time-varying electric fields [1-5]. A review of available documents indicates that there are no uniform international standards for limiting maximum electric field strength due to HVAC lines. The reference electric field levels for 60 Hz for occupational and general public exposure are shown in Table 2-13.

Table 2-13
Reference Levels for Exposure to Electric Fields (kV/m) (rms values, 60 Hz)

	IEEE 2002 [2]	ICNIRP 1998 [1]	ACGIH 2000 [3]	NRPB 1993 [4]	EU 1999
Occupational	20	8.3	25	12	-
General Public	5[a]	4.2[a]	-	12	4.2[a]

[a] On the edge of right of way

In the frequency range up to 1 kHz, the general public reference levels for electric fields are one-half of the values set for occupational exposure. The value 8.3 kV/m for a 60 Hz occupational exposure includes a sufficient safety margin to prevent stimulation effects from contact currents under all possible conditions. Half of this value was chosen for the general public reference levels (4.2 kV/m), to prevent adverse indirect effects for more than 90% of exposed individuals.

Some jurisdictions have set their own limits on the magnitude of the electric field as presented in Table 2-14. Another survey [6] of different utilities in North America shows that maximum permitted value of electric field within the ROW falls between 8-20 kV/m and maximum permitted value at the edge of the ROW is 1-3 kV/m.

Table 2-14
Electric Field Limits for Overhead Power Lines

Jurisdiction	Within ROW, kV/m	Edge of ROW, kV/m
Florida	10 (500 kV) 8 (230 kV)	2
Minnesota	8	
Montana	7	1
New Jersey		3
New York	11.8	1.6
Belgium	10	

The electric field profiles for the considered tower configuration are given in the Appendix D, on Figure 6-27. The maximum calculated electric field is 5.7 kV/m and 50 m from the center of the transmission line the electric field is below 0.1 kV/m. These values are the worst case at the lowest point of the line; all other points are higher and would produce lower values of electric field. If the most stringent limit (Montana) is used, the edge of the right of way shall be no less than 14 m from the center line of the proposed transmission line (28 m ROW width) to give a maximum exposure to the general public of 0.8 kV/m. The minimum distance from center line to edge of right of way could be reduced to 7 m (14 m ROW width) if the IEEE 2002[2] level was chosen as the maximum acceptable exposure level for the general public.

2.4.3 Magnetic Field

Influence of the low-frequency magnetic field on humans and animals has been investigated for more than 25 years. The ICNIRP document [1] provides guidelines on the permitted levels of time-varying magnetic fields. In the low-frequency range, the general public reference levels for magnetic fields are set at a factor of 5 below the values set for occupational exposure. Values recommended by different organizations for long-term exposure are presented in Table 2-15. Only a very few jurisdictions have set limits of magnetic filed and they are presented in Table 2-16.

Table 2-15
Reference Levels for Exposure to Magnetic Fields (Gauss) (rms values, 60 Hz)

	IEEE 2002	ICNIRP 1998	ACGIH 2000	NRPB 1993	EU 1999
Occupational	27.1	4.167	10	13	-
General Public	9.04	0.833	-	13	0.83

Table 2-16
Magnetic Field Limits for Overhead Power Lines [1]

	Edge of ROW, Gauss
Florida	0.2 (500 kV) 0.15 (230 kV)
New York	0.2

The magnetic flux density profile is presented in Figure 6-28, in the Appendix D. The calculated maximum value of magnetic flux density is 0.1 Gauss. At a point 50 m away from the center line of the transmission line, the value is 0.004 Gauss. Therefore, at all points, the magnetic field generated by the proposed Talston transmission line is lower than the recommended maximums.

2.4.4 Audible Noise (AN)

Audible noise generated by corona on high voltage transmission lines is different from other noise sources (e.g. traffic). The human response to corona noise is subjective and depends on the background noise. For example, ac corona intensifies when it's raining but at the same time the background noise level is much higher, thus the annoyance level is lower. Therefore, the fair weather values are accepted as reference for AN. Generally it is accepted that noise between 35-45 dB A corresponds to a quiet library environment.

The audible noise profile is given in Appendix D, in Figure 6-29. Audible noise levels generated by the lines during fair weather are very low, below 30 dB, and therefore only the rainy weather profile, at no point higher than 35 dB, is presented. According to the US Environmental Protection Agency (EPA) the day-night average sound level in residential areas should be limited to 55 dB A outdoors and 45 dB A indoors. Therefore in all cases the audible noise generated by the proposed Talston transmission line are well below the recommended maximums.

Table 2-17
Audible Noise (AN)

Recommended average sound level limit (outdoors/indoors) [US EPA]	Maximum audible noise generated by the proposed Talston transmission line
55 dB A / 45 dB A	Less than 35 dB A

2.4.5 Radio Interference (RI)

Canadian Standards Association (CSA) has developed a standard [7], for interference from high voltage ac power systems. This standard applies to radio interference in the frequency range of 0.15 MHz- 30 MHz generated by ac power lines. The standard specifies that the fair weather interference field strength, measured at 15 m laterally from the outermost conductor of the power line shall not exceed 49 (dB μV/m) for 70-200 kV lines at frequency of 0.5 MHz.

The RI profile is given in Figure 6-30 in the Appendix D.

For the proposed configuration, 15 m away from the outer conductor the RI is 34 (dB μV/m). Therefore, the RI generated by the proposed Talston transmission line is well below the CSA standard maximum.

Table 2-18
Radio Interference (RI)

Maximum radio interference [CSA]	Maximum radio interference generated by the proposed Talston transmission line
49 dB μV/m	34 dB μV/m

2.4.6 Summary

A summary of EMF effects generated by the considered structure is presented in Table 2-19. All the parameters are below recognized limits and are similar compared to other ac lines with similar configuration. The values for AN and RI are L50, which means the actual AN and RI are expected to be below the calculated values 50% of the time.

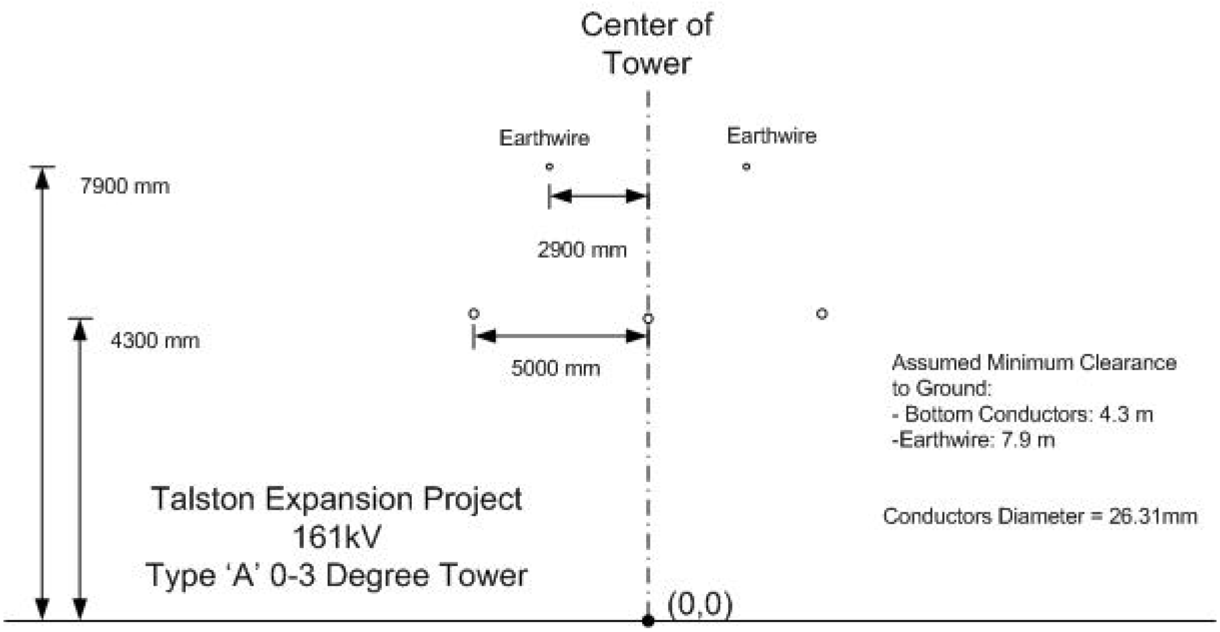
Table 2-19
Summary of Results

	Type 'A' 0-3 Degree Tower
Electric Field	
a) Maximum[1] (kV/m)	5.7
b) 7 m from Center Line (kV/m)	4.7
c) 14 m from Center Line (kV/m)	0.8
b) 50 m from Center Line (kV/m)	0.1
Magnetic Induction	
a) Maximum (Gauss)	0.1
b) 50 m from Center Line (Gauss)	0.004
AN[2] (dBA)	35
RI[3] (dB μV/m)	34

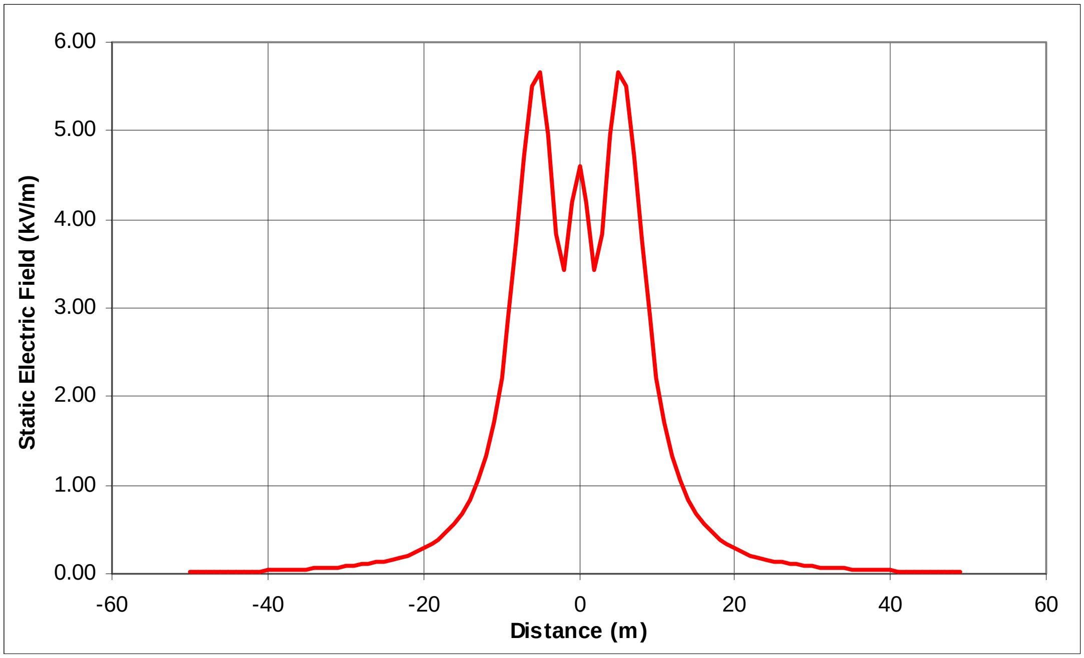
2.4.7 References

1. ICNIRP Guidelines, Guidelines for Limiting Exposure to Time-Varying Electric, Magnetic, and Electromagnetic Fields (up to 300 GHz)
2. Institute of Electrical and Electronics Engineers (IEEE). IEEE PC95.6-2002 standard for safety levels with respect to human exposure to electromagnetic fields, 0 to 3 kHz. Prepared by Subcommittee III of Standards Coordinating Committee 28, IEEE Standards Department. New York: Institute of Electrical and Electronics Engineers, Inc.; 2002.
3. American Conference of Governmental Industrial Hygienists (ACGIH): 2002 TLVs® and BEIs®: threshold limit values for chemical substances and physical agents and biological exposure indices. Cincinnati, OH: American Conference of Governmental Industrial Hygienists; 2002.
4. National Radiological Protection Board (NRPB). Restrictions on human exposure to static and time varying electromagnetic fields and radiation: scientific basis and recommendation for implementation of the Board's statement. Documents of the NRPB 1993;4:8–69.
5. B.J. Maddock, Guidelines and Standards for Exposure to Electric and Magnetic Fields at Power Frequencies (CIGRE, 1992 Session, 30 August – 5 September)
6. Teshmont Consultants LP, Factors Utilized by North American Utilities to Determine the Width of Right-of-Way
7. CSA C108.3.1-M84, Limits and Measurement Methods of Electromagnetic Noise from AC Power Systems 0.15 - 30 MHz

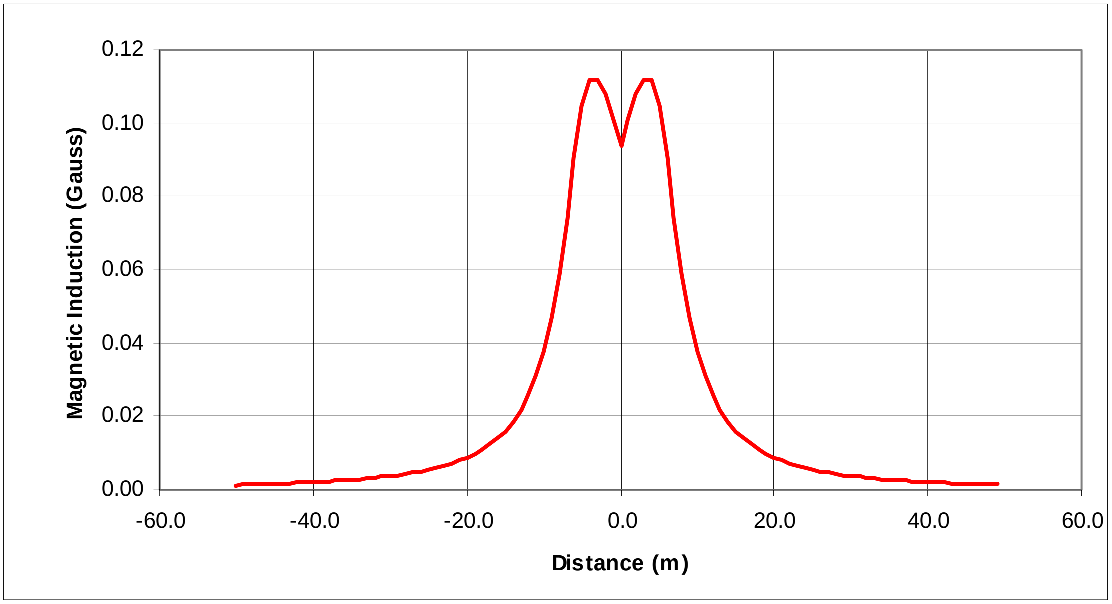
Appendix D
ELECTROMAGNETIC FIELD EFFECTS



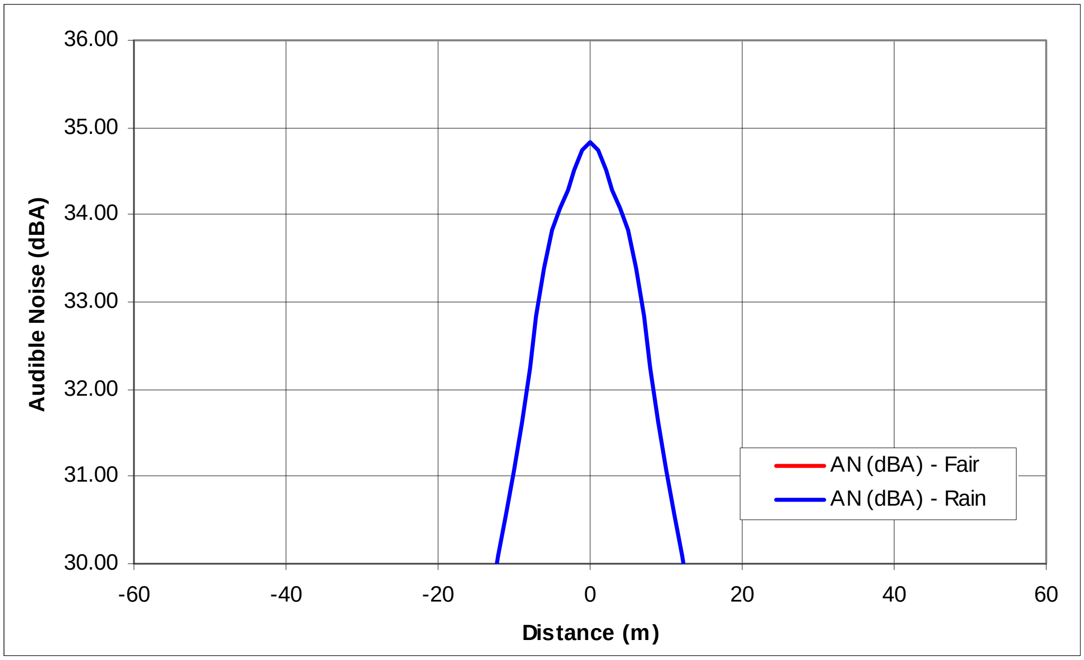
Type 'A' Conductor Configuration
Figure 6-26



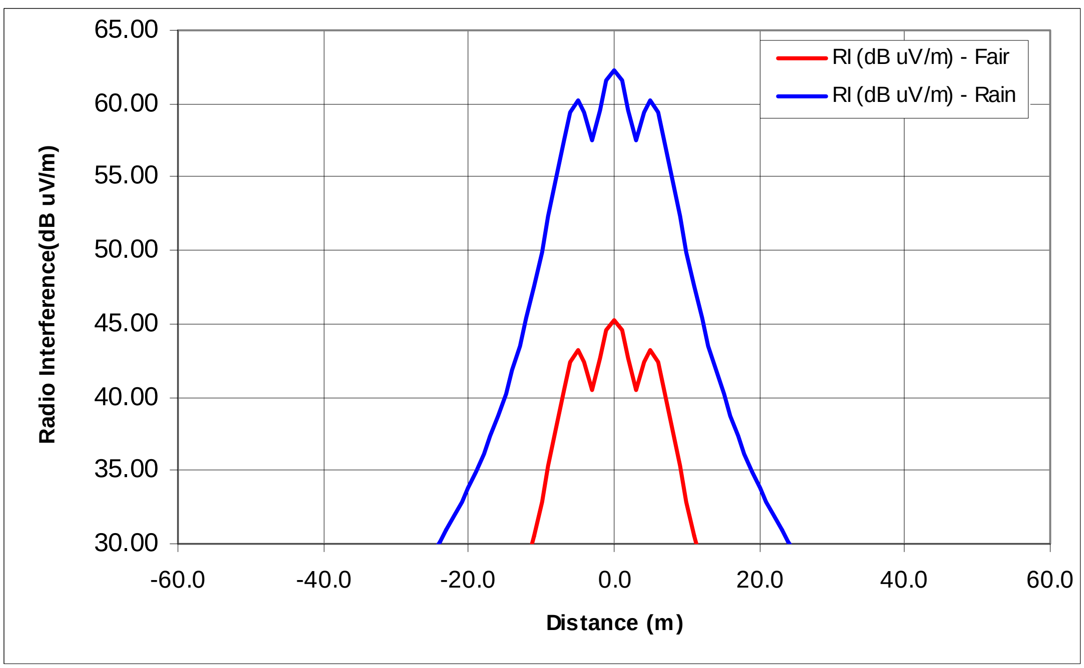
Electric Field Profile for the Type 'A' Tower
Figure 6-27



Magnetic Flux Density Profile for the Type 'A' Tower (0.194 kA)
Figure 6-28



Audible Noise Profile for the Type 'A' Tower
(Fair Weather AN Profile is below 30 dBA)
Figure 6-29



Radio Interference Profile for the Type 'A' Tower
Figure 6-30