8 HUMAN HEALTH ASSESSMENT

8.1 Health Background

Potential health related issues related to the Project have been based on input from First Nations and stakeholders, professional judgement, as well as the findings and outcomes of the Revelstoke 5 Environmental Assessment.

These issues include:

- The potential increase in methyl mercury accumulating in fish used for consumption;
- The potential Project-related concerns regarding public safety; and
- Effects on human health related to exposure to Electric and Magnetic Fields (EMF) at the Capacitor Station site.

8.1.1 Methyl Mercury

It is commonly recognized that impoundment dams that create flooded areas may be related to the generation of methyl-mercury through the methylation of inorganic mercury under anoxic conditions present in the substrate. The relationship between elevated mercury concentrations in fish in newly flooded reservoirs has been well documented in central Canada by Bodaly et al. (1984), Heckey et al. (1991), and Strange et al. (1991). The flooding of extensive amounts of organic materials (vegetation, muskeg, etc.) and its subsequent decomposition greatly facilitates the process of methylation of inorganic mercury by bacteria into methylmercury, which, in turn, is rapidly assimilated by the lower tropic levels and bioaccumulated up the food chain to fish.

The concern surrounding this phenomenon is typically applied to newly impounded areas, which is not consistent with the circumstances found in this Project. The typical pattern for increased methyl-mercury production would result in a maximum concentration within the first decade of operation followed by a declining production rate and lowering of the concentration through time through consumption, as the reservoir continues to operate. The factors affecting methyl-mercury generation, ingestion and bio-accumulation in fish tissue was investigated as part of the Environmental Information Review and Data Gap Analysis completed for the Upper Columbia (RL&L 2001a) that is utilized by BC Hydro in water use planning.

Samples of muscle tissue were collected from rainbow trout in Revelstoke Reservoir in 1985 (n=23) and 1986 (n=31) for analyses of total mercury (EVS 1999). Mercury content in the 1985 samples ranged from 0.07 to 0.57 part per million (ppm), with a mean of 0.20 ppm (EVS 1999). Mercury content in the 1986 samples ranged from 0.12 to 0.41 ppm, with a mean of 0.21 ppm. The relationship between mercury content of rainbow trout and size of the fish was positive in 1985 but negative in 1986, which illustrates the difficulty in interpreting poor or weakly correlated data, particularly for non-piscivorous species (EVS 1999). Mercury concentrations in two rainbow trout collected from Revelstoke Reservoir in 1995 were 0.015 and 0.038 ppm, suggesting that mercury levels in rainbow trout in the reservoir are presently well below the 0.5 ppm commercial guideline for sale of fish in Canada.

The concentration of mercury in the muscle of bull trout from Revelstoke Reservoir is presently considered to be at or near pre-flooding concentrations (EVS 1999). The total mercury concentrations of 17 bull trout collected in 1995 (Foster and Gadbois 1998) ranged from 0.12 to 0.64 ppm, with the highest level in a very large fish weighing 9100 g (EVS 1999). Based on comparisons of data collected in 1987 (where the mean mercury concentration was 0.42 ppm) and 1995 (mean concentration of 0.30 ppm), EVS (1999) concluded that mercury concentrations had declined over time, and that bull trout were accumulating mercury at a significantly slower rate than in 1987.

These historical data for key species (rainbow trout and bull trout) captured closer to the operating period of concern for methyl-mercury production and bio-accumulation strongly suggest that methyl-mercury related effects are not expected to be a concern in this Project.

One other mode of methyl-mercury production and bio-availability that relates to the Project is re-suspension of carbon-rich and labile sediments through mechanisms such as shoreline erosion or bedload transport, with subsequent deposition of sediments. Since the Revelstoke Reservoir shoreline has largely stabilized since initial impoundment and Reservoir Drawdown events are a rare occurrence, it is considered improbable that any mechanical conditions that would result in erosion that would elevate mercury levels in reservoir fish above acceptable levels for human consumption are associated with the proposed Project.

For these reasons, issues related to methyl-mercury are not considered further is this assessment.

8.1.2 Public Safety

The management of public safety during the construction and operation phases of the Project will be through the implementation of best management practices and plans as described in Section 10, Accidents and Malfunctions, and not considered further in this Section.

8.1.3 Traditional Use and Knowledge

Information regarding community wellbeing and health issues specific to First Nations is addressed in Section 6 and Part C.

8.2 Human Health

Human Health was identified as a Valued Component (VC) due to concerns raised by Project stakeholders, as well as through BC Hydro's experience related to other transmission projects, regarding the potential effects of EMF on human health.

8.2.1 Context and Boundaries

EMF are produced by electrically charged objects. EMF is a Project-related concern due to the increased load proposed to travel through existing transmission lines. Electrical power EMF has a frequency of 60 hertz (Hz), considered "extremely low frequency" EMF, which is much lower energy than other EMFs such as microwaves or visible light. Electric fields are present when there is a voltage in a transmission line and are generally blocked by trees or buildings; magnetic fields are generated when current flows through a wire but are less easily blocked than electric fields. Electric fields are measured in kilovolt per meter (kV/m) and magnetic fields are measured in Gauss (G) or milliGauss (mG) where 1000 mG = 1 G. For both electric and magnetic fields, the field's strength (or energy) decreases with distance from the source (the transmission line).

The focus for potential human health impacts is on magnetic fields, as was the case for the environmental assessment for the Mica 5/6 BC Hydro Project (Klohn, 2009).

8.2.2 Selection of Valued Component

The Human Health VC was identified in order to address concerns related to EMF. Construction of the new capacitor station will result in increased current flow through BC Hydro's transmission lines 5L96 and 5L98. This increase will result in a corresponding increase in EMF.

Linkages of the Human Health VC and the Fish VC, related to consumption of fish, are not carried forward for assessment as described in Section 4.4 Fish. No other linkages are identified with the Human Health VC.

8.2.2.1 Indicators

Indicators were selected to measure and evaluate the interaction for the Project with a particular VC. Indicators were chosen to be relevant, practical, measureable, responsive, accurate and predictable. Indicators used in the assessment of the potential effects of the Project on the Human Health VC are summarized in Table 8-1.

Table 8-1: Indicators for Human Health

Indicator	Direct or Indirect	Rationale
EMF (magnetic field measured in mG and electrical field measured in kV/m)	Direct	These indicators are common measurements of EMF exposure.

8.2.3 Regulatory Setting

The International Commission on Non-Ionizing Radiation Protection (ICNIRP) is a non-governmental research organization that has proposed EMF standards which are formally recognized by the World Health Organization (WHO). ICNIRP conducts research on the effects of external EMFs. The most recent ICNIRP guidelines (ICNIRP, 2010) present reference levels based on established health effects such as cancer, and biological responses such as direct nerve stimulation. The ICNIRP reference values for magnetic fields are summarized in Figure 8-1.

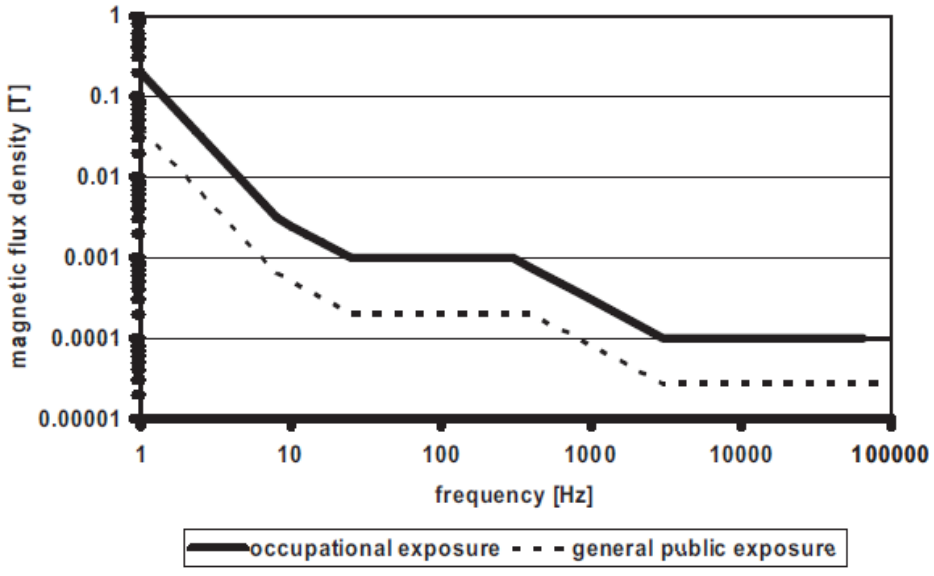


Figure 8-1: 2010 ICNIRP Guidelines where 1 tesla (T) equals 10^7 mG

The WHO and Health Canada consider EMF to be of increasing environmental interest due to a combination of increasing global technology and public awareness on the topic. Both organizations inform the public about sources that produce significant EMF, and refer ultimately to the ICNIRP guidelines (WHO, 2016) (Health Canada, 2016).

BC Hydro regularly reviews current research and regulations for very low frequency EMF. BC Hydro adopted the ICNIRP magnetic field limit of 2000 mG for urban areas. For electric fields the ICNIRP recommended a continuous exposure limit of 4.16 kV/m.

The Institute of Electrical and Electronic Engineers (IEEE) has also developed electric field exposure limits which considered the ICNIRP levels but set a higher public exposure limit of 5 kV/m. BC Hydro selected the 2007 IEEE limit of 5 kV/m for outside the ROW and 10 kV/m within the ROW since it is considered a controlled environment (BCHydro, 2013e). Table 8-2 summarizes BC Hydro's EMF exposure limits; for reference, an operating dishwasher produces a magnetic field on the order of 20 mG.

Table 8-2: BC Hydro EMF limits (BCHydro, 2013e)

EMF limit	Value
Maximum electric field on right of way under normal sag (kV/m)	10
Maximum electric field at edge of right of way under maximum sag (kV/m)	5
Maximum magnetic field in urban areas (mG)	2000

8.2.4 Assessment Boundaries

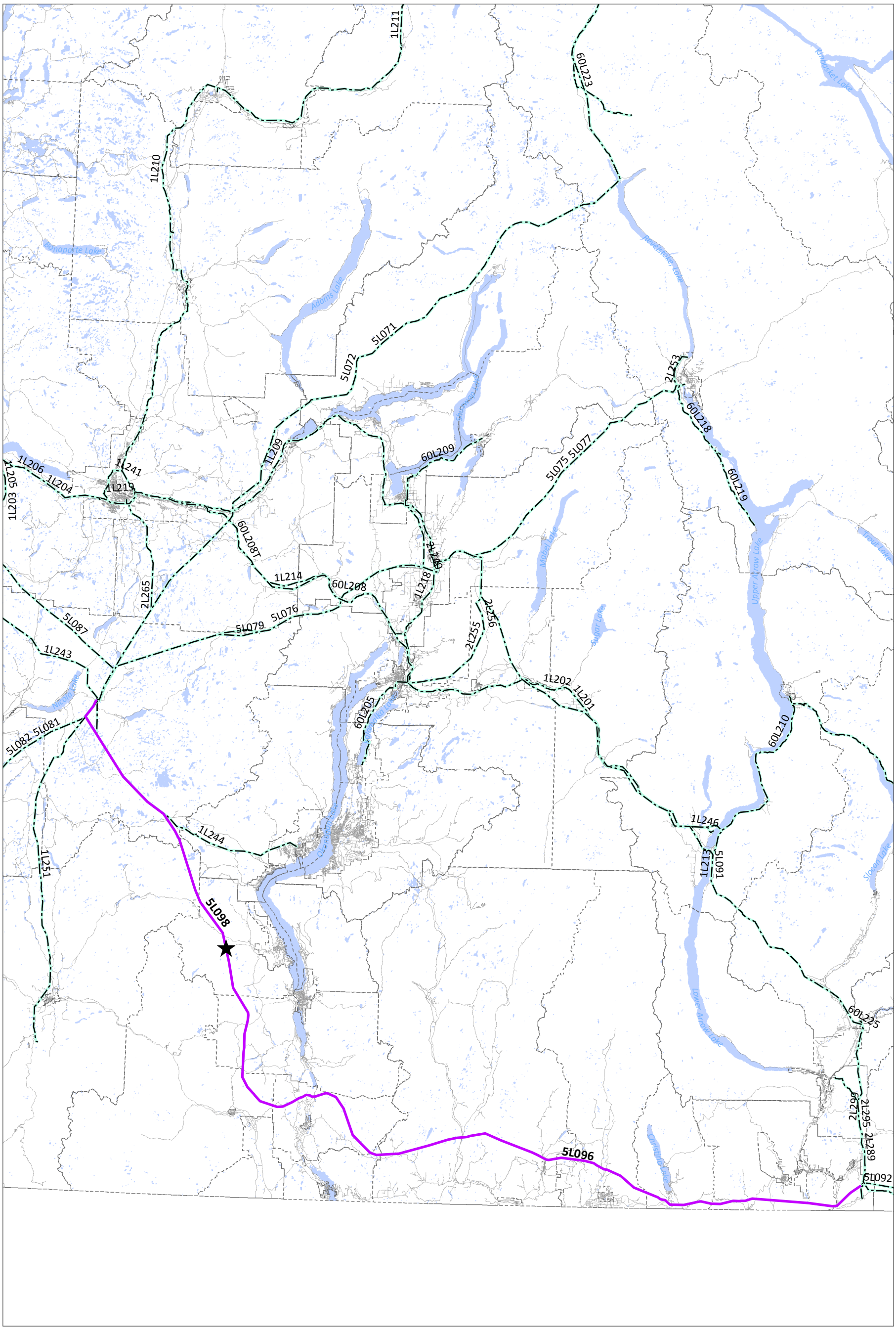
This section describes the boundaries for the assessment of Human Health. Boundaries for each VC are determined areas or time frames for which outside of the established limits no Project effects are expected to be detectable.

8.2.4.1 Spatial

The additional electricity generated by the Project will be distributed on BC Hydro's electrical grid. To avoid power overloads on transmission lines during a power outage, the Project includes construction of a capacitor station on the 500 kV transmission line between the existing BC Hydro substations Nicola and Vaseux, denoted as circuit 5L98. The changes to the grid will increase the EMF on 5L96 and 5L98. Therefore, the spatial extent of the EMF assessment is 5L96 and 5L98 and 50m on either side of BC Hydro's right of way (ROW) (Figure 8-2, Table 8-3).

Table 8-3: Spatial Boundaries for Human Health

Spatial Extent	Definition
Local Study Area (LSA)	5L96 and 5L98 plus 50m on either side
Regional Study Area (RSA)	Same as LSA



LEGEND

- Proposed Capacitor Station Location
- Human Health LSA and RSA
- Transmission Line
- Road
- Administrative Boundary
- Lake/River

0 12.5 25 50 75 100 km

NOTES

1. Original in colour.
2. Numerical scale reflects full-size print. Print scaling will distort this scale, however scale bar will remain accurate.
3. Intended for illustration purposes, accuracy has not been verified for construction or navigation purposes.

REFERENCES

DataBC, Province of British Columbia, BC Hydro, SNC-Lavalin, ESRI Base Maps

N

SNC·LAVALIN

CLIENT NAME: BC Hydro	PROJECT LOCATION: Revelstoke Dam, Revelstoke, BC

Figure 8-2 Human Health Local and Regional Study Area Boundaries

BY:	ECH	DATE:	2016/06/21	REF No: 615464-820	REV: 1
CHK'D:	MB	SCALE:	1:1,000,000		

MXD Path: \\sli2606\projects\LOB\EIAM-BC\Current Projects\BC Hydro\615864 Rev 6\4.0 Production\4.5 GIS and Drawings\GIS\MXD\EA\615464-820 Human Health LSA and RSA.mxd

8.2.4.2 Temporal

The temporal boundary for the Human Health assessment was the operational phase as no change to existing EMF will occur during Construction.

8.3 Existing Conditions

Establishing the baseline setting for the Human Health VC is a key step in the environmental assessment process. Adequate characterization of components and indicators in their existing state is the preferred basis for identifying potential project-VC interactions and predicting potential, residual, and cumulative environmental effects on Human Health. This section presents baseline data that are of adequate quality and reliability, representing the metrics, ranges and trends of observable/measurable conditions in the existing environment in sufficient detail to allow for prediction of Project-related effects.

8.3.1 Methods

A comprehensive gap analysis was conducted of the existing data and it has been concluded that the existing data is of sufficient quality and quantity to establish baseline conditions for the purpose of effects assessment for the Project. This section describes the methods and sources of information analyzed.

8.3.1.1 Data Sources

BC Hydro conducted an assessment of the potential for increased power transmission along BC Hydro transmission lines 5L96 and 5L98 due to the construction of the new capacitor station (BC Hydro, 2015h). EMF was calculated inside the ROW and at fixed distance outside the ROW using BC Hydro in-house software.

The data provided by BC Hydro were reviewed and determined to be sufficient to conduct a desktop assessment, so no field studies were conducted.

8.3.1.2 Description of Existing Conditions

Hourly measurements of current flow through 5L98 were collected by BC Hydro between November 2013 and November 2014. The current flows are summarized in Figure . The maximum recorded current flowing through the transmission lines was 950 amps (A) which occurred during less than 1% of the 12-month period.

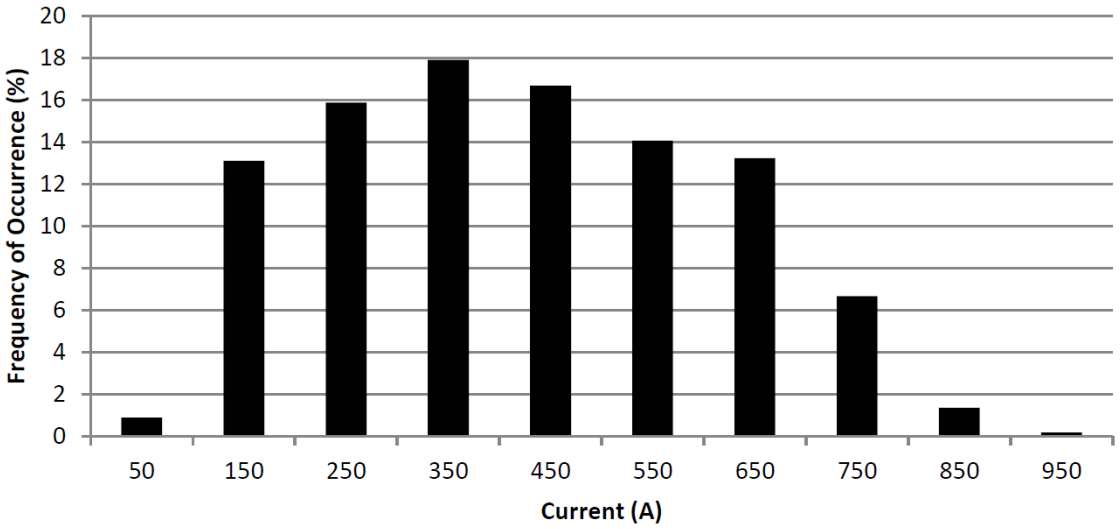


Figure 8-3: Current Measurements at 5L98 (BC Hydro, 2015h)

BC Hydro also assessed the magnetic fields generated by the current flowing through 5L98 for the same period; the calculated magnetic fields are summarized in Figure 8-4. The maximum was 166 mG which occurred during less than 1% of the 12-month period. As noted previously, electric fields were less of a concern so was assessed in less detail.

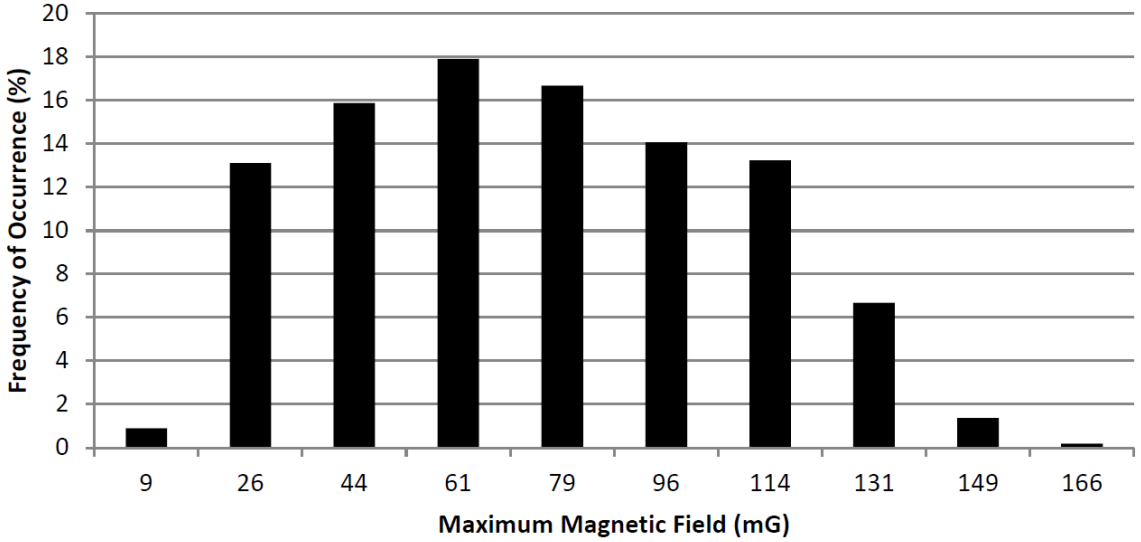


Figure 8-4: Magnetic Field Measurements at 5L98 (BC Hydro, 2015h)

8.4 Assessment of Potential Project Related Effects

This section assesses the change in EMF as a result of the Project and determines if there is any potential for adverse effects on humans.

BC Hydro calculated magnetic field distributions for the three worst case design ratings - 3506 A (30 deg C summer), 4241A (10 deg C winter), and 4475 A - as well as the planned maximum rating of 2250 A after the capacitor station is operational (BC Hydro, 2015h). The worst case design ratings are shown in Figure 8-5.

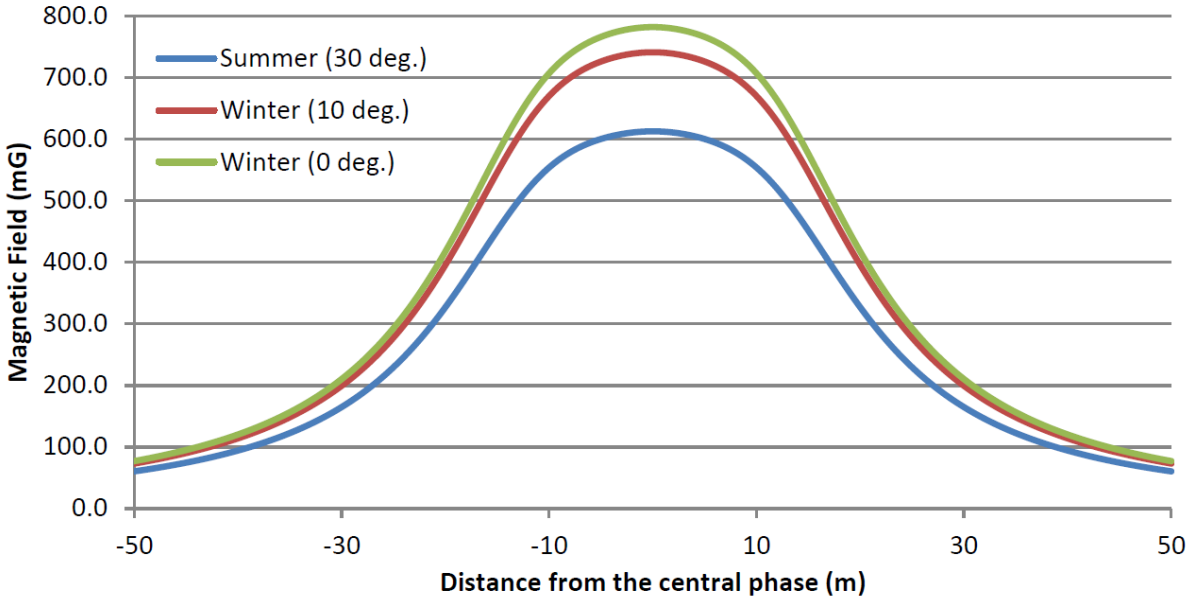


Figure 8-5: Calculated Worst Case magnetic field Values (BC Hydro, 2015h)

As can be seen, the calculated magnetic field peaks at 800 mG for the 4475 A design rating and then decreases to below 100 mG at 50 m from the center phase of the transmission line. For the planned maximum ration of 2250 A, the calculated maximum magnetic field was 400 mG which decreased to below 50 mG at 50 m from the centre phase.

Electrical fields based on 525-kV line-to-line voltage were calculated inside and at the edge of the ROW. They were below BC Hydro's standards and are shown in Figure 8-6.

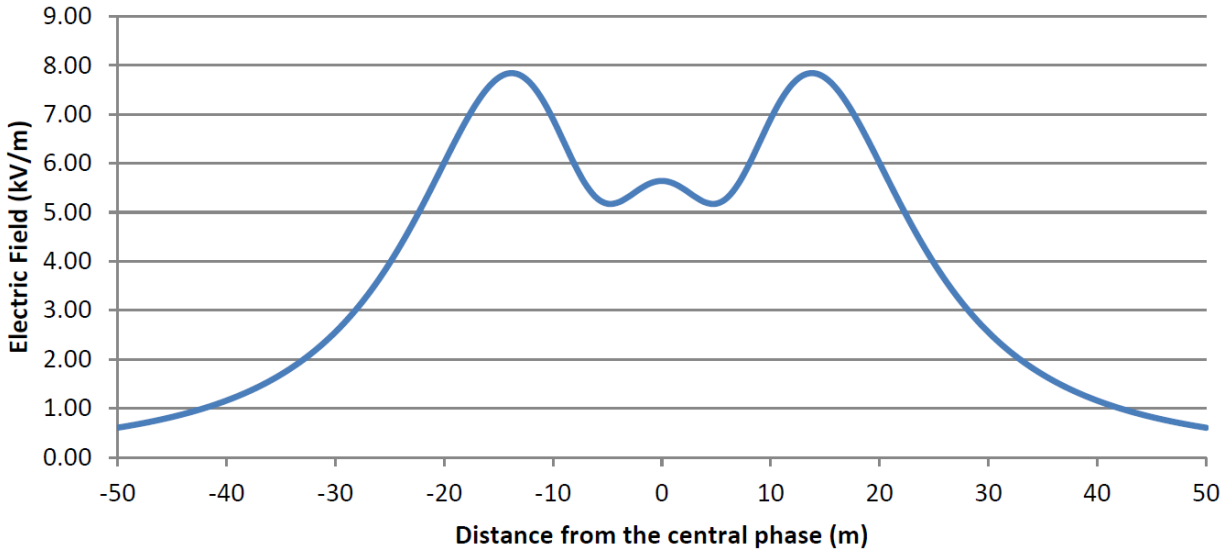


Figure 8-6: Calculated electrical fields (BC Hydro, 2015h)

The calculated worst case magnetic fields and electric fields are compared to the BC Hydro standards in Table 8-4, for the peak and at 50 m away (i.e., the edge of the BC Hydro ROW).

Table 8-4: Comparison of Calculated Magnetic Field Values for Worst Case to BC Hydro EMF Standards

Location	Calculated magnetic field value (mG)	BC Hydro magnetic field standard (mG)	Calculated electrical field values (kV/m)	BC Hydro electrical field standard	Compliance
Central phase	800	2000	8	10	Yes
50m from central phase	100	2000	1	5	Yes

Given that the calculated electrical and magnetic field values are well within the BC Hydro established EMF thresholds, it was determined that no potential adverse residual effects on Human Health due to EMF were present.

8.4.1 Mitigation Measures

No mitigation measures are proposed as there are no potential adverse effects.

8.4.1.1 Mitigation Proposed by First Nations

BC Hydro is engaging with First Nations on an ongoing basis to develop mitigation measures related to potential adverse effects on VCs and on Aboriginal Interests.

No measureable potential effects of the Project on Human Health have been identified and therefore no further mitigation is proposed.

Mitigation measures related to potential Project effects on Aboriginal Interests related to this IC are summarized in Part C in Section 11.2.3. Secwepemc mitigation measures are presented in Section 12-h and 12.2.6 of their Part C contribution. Ktunaxa mitigation measures are included in Appendix C-I and Okanagan mitigation measures are included in Appendix C-II of this Application.

8.4.2 Characterization of Residual Effects and their Significance

The significance of the residual effects were not assessed because residual effects were not identified. In the absence of residual adverse effects, there is no potential for cumulative adverse effects on Human Health.

8.4.3 Cumulative Effects and their Significance

In the absence of residual effects there are no other projects or activities that can interact cumulatively with the Project.

8.4.4 Follow-Up Strategy

No follow up programs are required.

8.5 Summary of Assessment of Human Health Effects

Table 8-5: Summary of Potential Human Health Effects

Valued Components	Potential Effects	Key Mitigation Measures	Significance of Residual Effects
Human Health	No potential effects	No mitigation measures required as no potential effects.	The significance of residual effects was not assessed because residual effects were not identified.