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# Overview of Health & Safety Topics in EIS

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Bipole III Public Hearing



# Overview of Health & Safety Topics Addressed in EIS

- Components of Bipole III project
- What are EMFs?
- Bipole III EMF levels
- Agency reviews
- Human exposure guidelines
- Other environmental issues

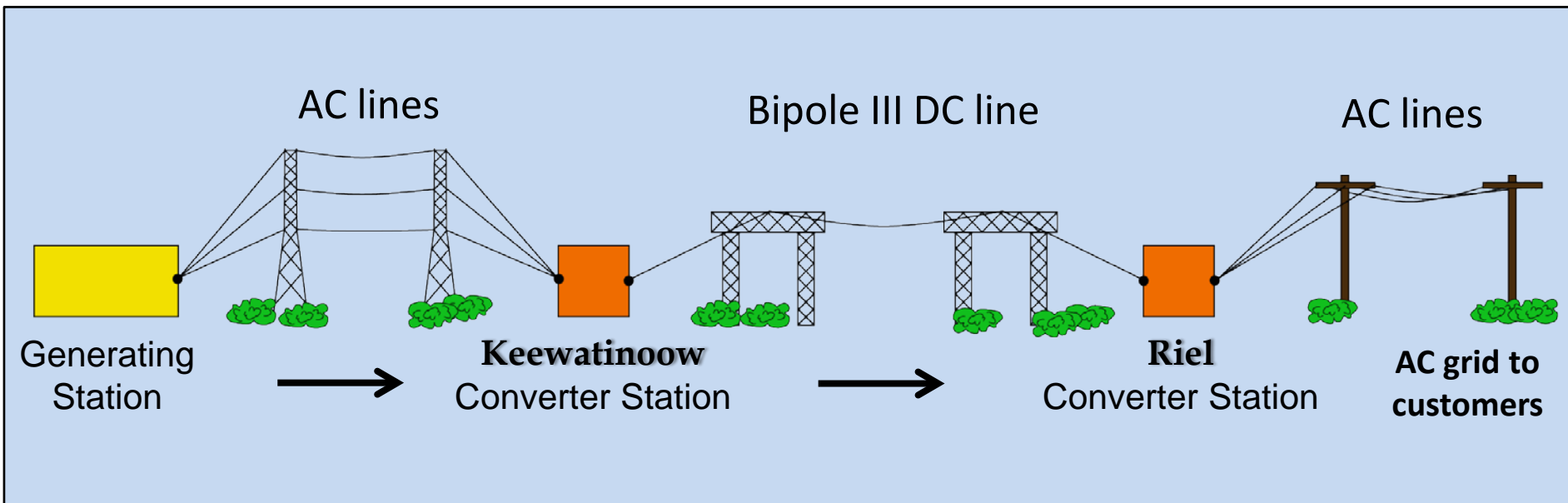
# Bipole III Project

## Proposed Transmission Components:

- $\pm 500$  kV DC Bipole III line
- Northern/southern ground electrodes
- 230 kV AC Henday-Conawapa lines

The Bipole III line and ground electrodes are very similar to the Bipole I and II facilities that have been operating in Manitoba since 1978.

# How AC Electricity Gets Converted to DC for Long-distance Transmission on Bipole III Line



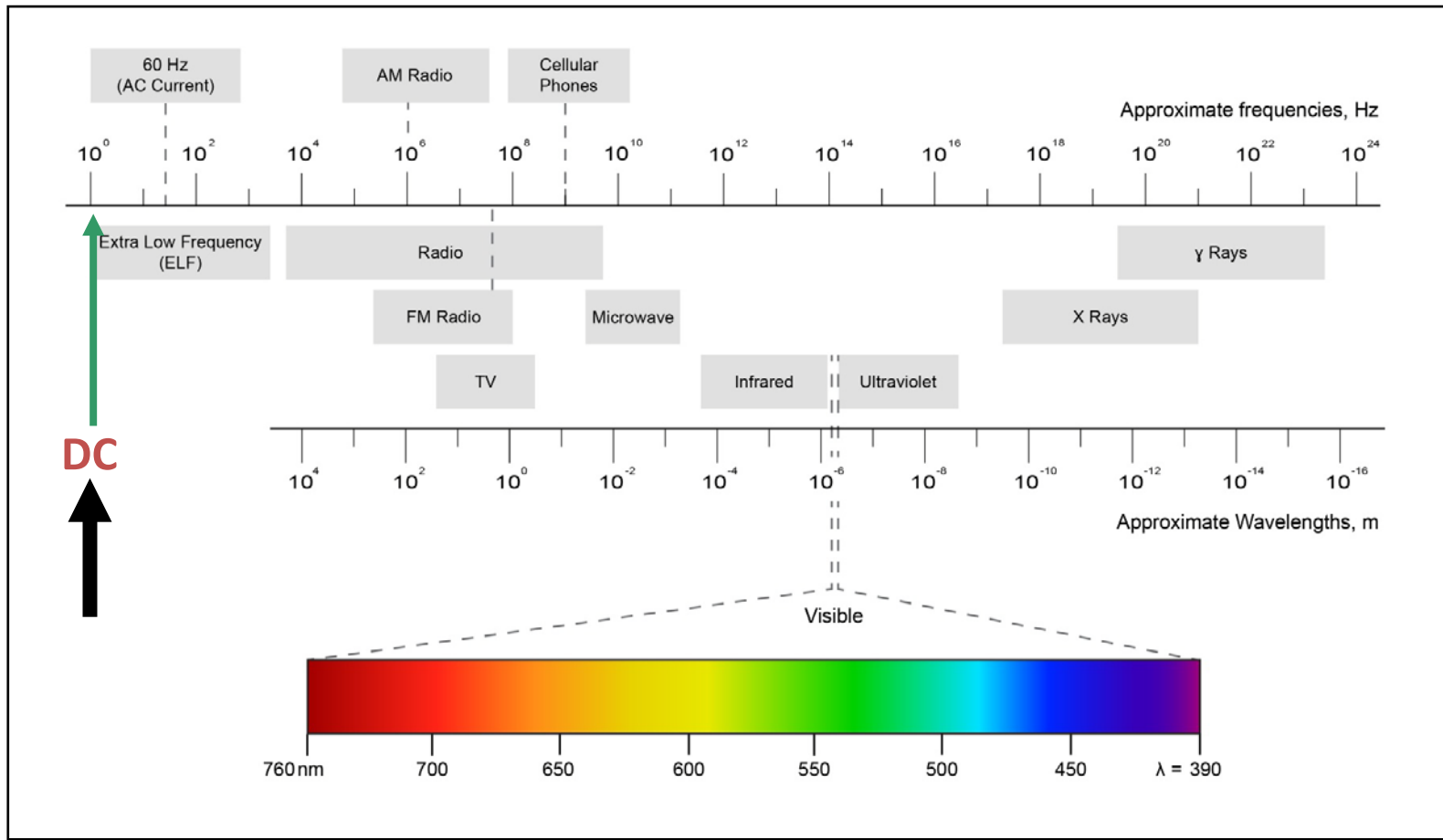
# Four Fundamental Forces of Nature

- Gravity
- Electromagnetic Fields
- Nuclear - Strong
- Nuclear - Weak

These fundamental forces explain the behavior of very tiny particles (e.g., atoms and molecules) and larger objects (e.g., planets)

# Electromagnetic Fields

## Frequency Spectrum



# Electric Fields

- Electric fields result from voltages
- Measured in units of volts per meter (V/m) or kilovolts per meter (kV/m),  
 $1,000 \text{ V/m} = 1 \text{ kV/m}$
- Strength diminishes as you move away from the source
- Shielded by objects such as trees, shrubs, or walls



# Magnetic Fields

- Magnetic fields result from current flow
- Measured in gauss (G) or milligauss (mG),  
1,000 mG = 1 G
- Strength diminishes as you move away from the source
- Not shielded by objects such as trees, shrubs, or walls

# Exposures Evaluated in Bipole III EIS

- DC line
  - DC electric field
  - DC magnetic field
  - Space charge (small air ions and charged aerosols)
  - Audible noise
  - Radio noise
- AC Lines
  - AC electric field
  - AC magnetic field
  - Audible noise
  - Radio noise

# Scientific Reviews of EMF Research by National/International Organizations

- Large panels, balanced composition
- Experts in multiple disciplines
- Defined methodology
- Conclusions represent a consensus

# Bipole III DC Transmission Line

# DC Fields $\neq$ AC Fields

- Frequency
- No direct induction of voltages and currents in conductive materials (including people and other organisms)
- Present throughout evolution of life on Earth

# DC Line 'Electrical' Issues Evaluated in EIS

- Health and safety
- Livestock, plants, wild animals
- Interference to electronic devices
  - GPS operation
  - Cell phones
  - Wireless internet
  - Cardiac pacemakers
  - Cochlear implants

# DC Transmission Electrical Environment

- DC electric field
- Air ions, charged aerosols
- DC magnetic field

# Sources of DC Electric Fields

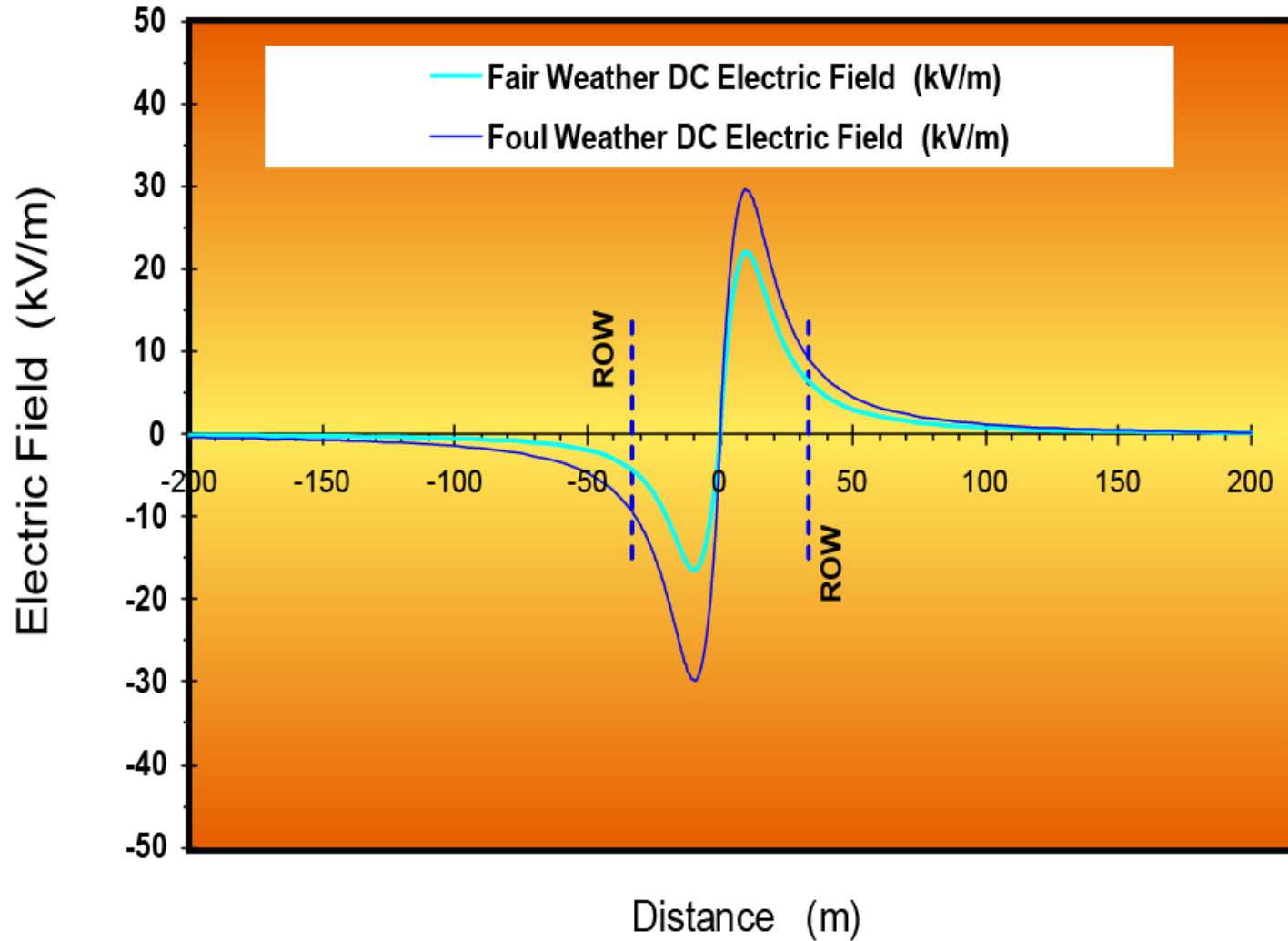
- Storm clouds, thunderstorms
- Friction
  - Carpet shocks
  - Dust swirls
- Materials – charge transfer
- DC transmission lines



# Typical Static Electric Field Levels From Common Natural and Man-made Sources

Source	Electric Field Level (kV/m)
<b>Man-made Sources</b>	
TV and CRT computer screens (at 30 centimetres)	10–20
Under Bipole III transmission line	20-30
<b>Natural Sources</b>	
Distant storm front	10-20
Storm cloud over a lake	40
Friction from walking across a carpet	Up to 100
Surface charge on the body from static cling	Up to 500

# Bipole III DC Electric Fields



# Recent Reviews of DC Electric Field Health Research

- International Agency for Research on Cancer (2002)
- National Radiation Protection Board (2004)
- World Health Organization (2006)

# Transmission Line 'Corona' Phenomena

- Corona refers to partial electrical discharge in air - *Known to sailors as St. Elmo's light*
- When corona occurs on transmission lines it is a weak source of :
  - Visible light
  - Audible noise
  - Radio noise
  - Space charge (small air ions and charged aerosols)

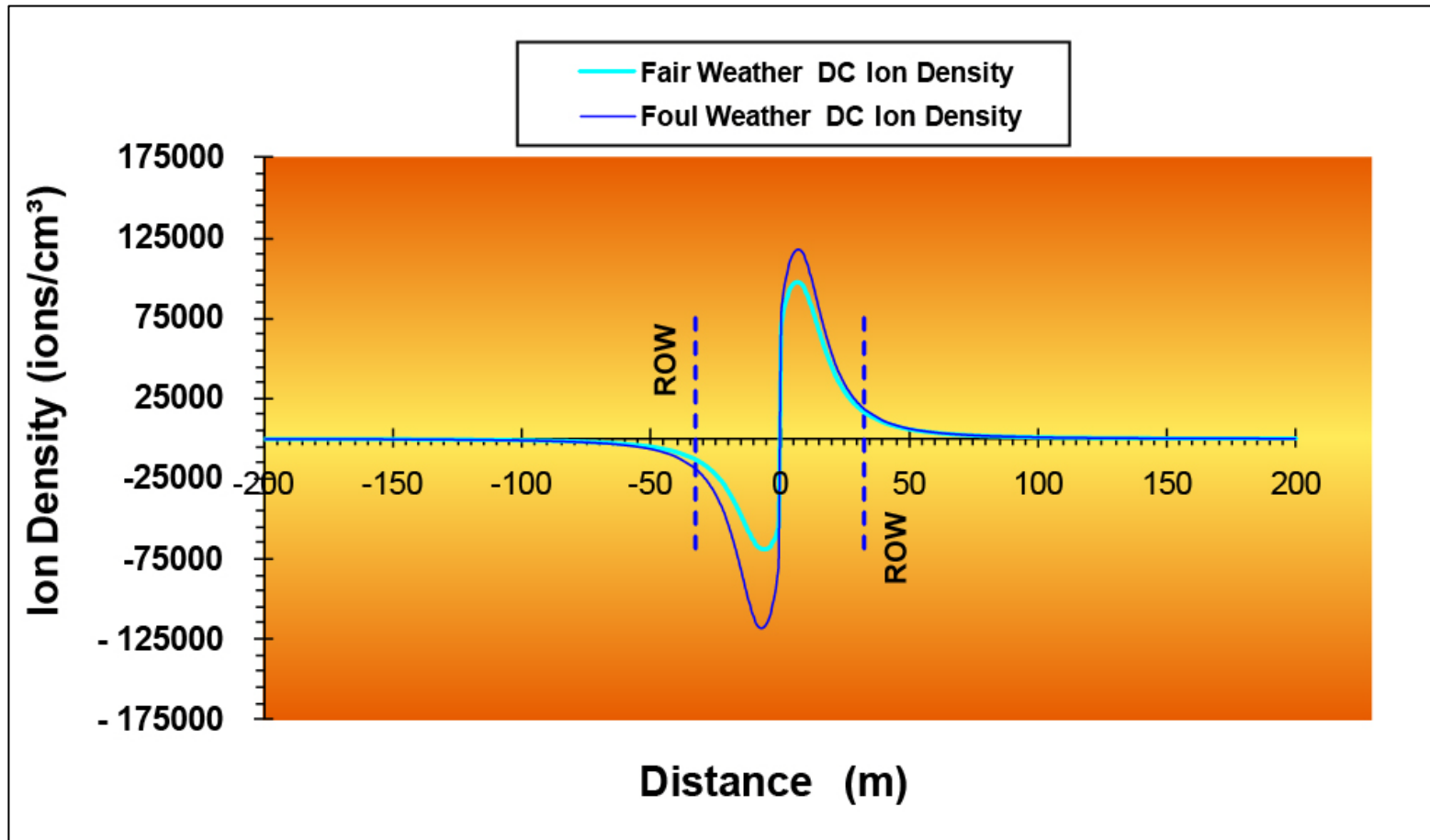
# Sources of Air Ions/Charged Aerosols

- Falling water
- Combustion sources
- Air cleaners (ionizers)
- Atmospheric discharges
- Soil
- Transmission lines

# Comparison of Air Ion Levels from the Proposed Project to Other Sources

Conditions	Ions/cm <sup>3</sup>
Air humidified by boiling water, e.g., from a tea kettle†	1,000,000 – 10,000,000
In large towns	Up to 80,000
In a candle lit room	Up to 27,600
Near an open flame	200,000 – 300,000
200 feet from a small waterfall	1,500 – 2,000
20 feet from a highway (30 vehicles/minute)	6,900 – 15,000
5 feet downwind of vehicle exhaust	34,500 – 69,000
4 feet from a negative ion generator	26,000 (-)
Peak on the ROW	97,100
At the edge of the ROW (33 m from the centerline)	12,600 – 16,300

# Bipole III Air Ion Concentrations



# Latest Review of Air Ion Research (NRPB, 2004)

“ ... it seems unlikely that corona ions would have more than a small effect on the long-term health risks associated with particulate air pollutants, even in the individuals who are most affected. In public health terms, the proportionate impact will be even lower because only a small fraction of the general population live or work close to sources of corona ions.”

“The possible implications for health of the mechanisms discussed in this report do not provide a strong case for further research in this area. It is concluded, therefore, that it is not appropriate for an epidemiological study to be carried out.”



# Characterization of Charged Aerosols Around Bipole I & II and Other Environments (Bailey et al., 2012)

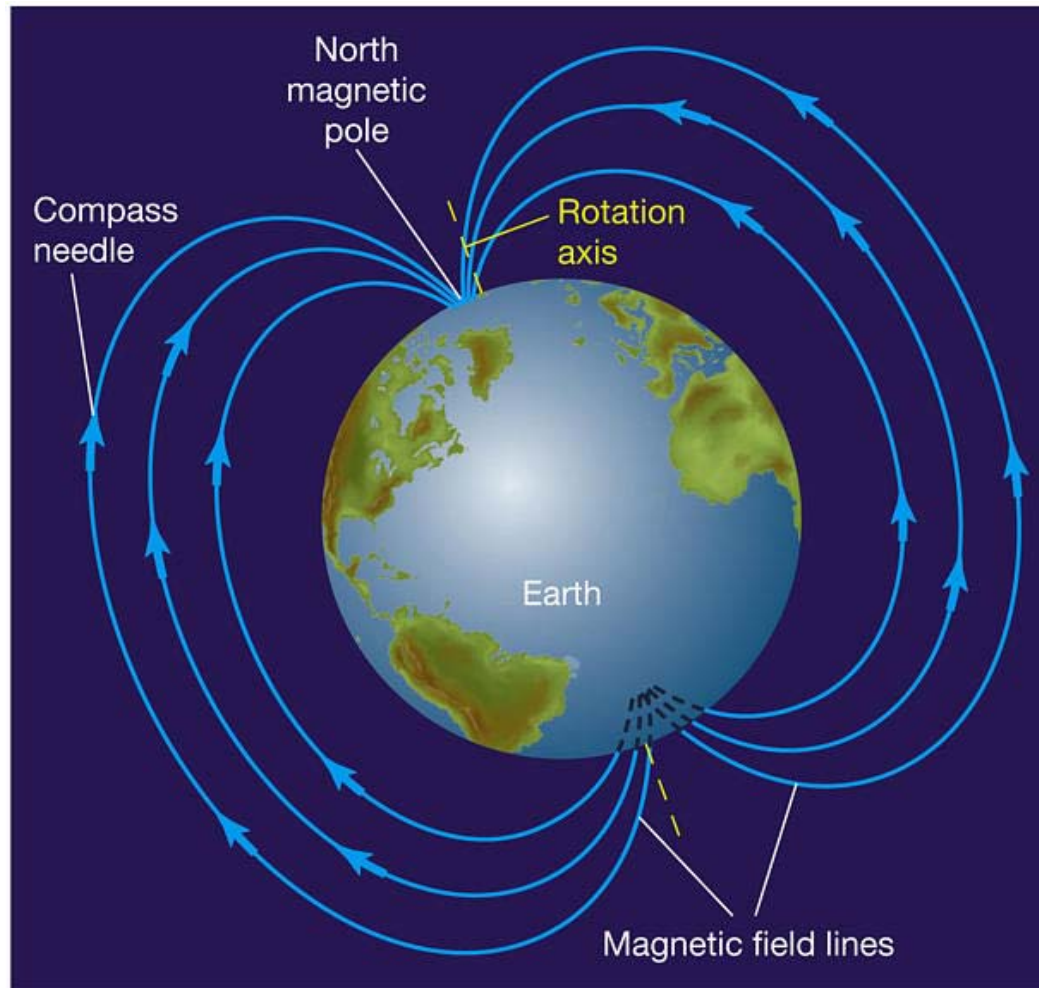
- Percent of charged aerosols is low and similar to that measured in other rural, suburban, and urban environments in Manitoba and Illinois
- No difference in prevalence of charged aerosols upwind and downwind of DC lines
- Upwind aerosols are mostly uncharged; similar low levels of aerosols with + and – charge
- Downwind aerosols are mostly uncharged; fewer aerosols with + charge than – charge
- Charge per aerosol too low to affect respiratory deposition

# Sources of DC Magnetic Fields

- Geomagnetic field
- Appliances, e.g., magnets
- Electric trains
- Magnetic resonance imaging
- Research/industry
- DC transmission lines

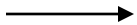
# Earth's DC Magnetic Field

~ 300-700 mG



# Appliance DC Magnetic Fields

For example



3,000-10,000 mG

# High-Speed Train DC Magnetic Fields



**< 10,000 mG**

# Magnetic Resonance Imaging (MRI) DC Magnetic Fields

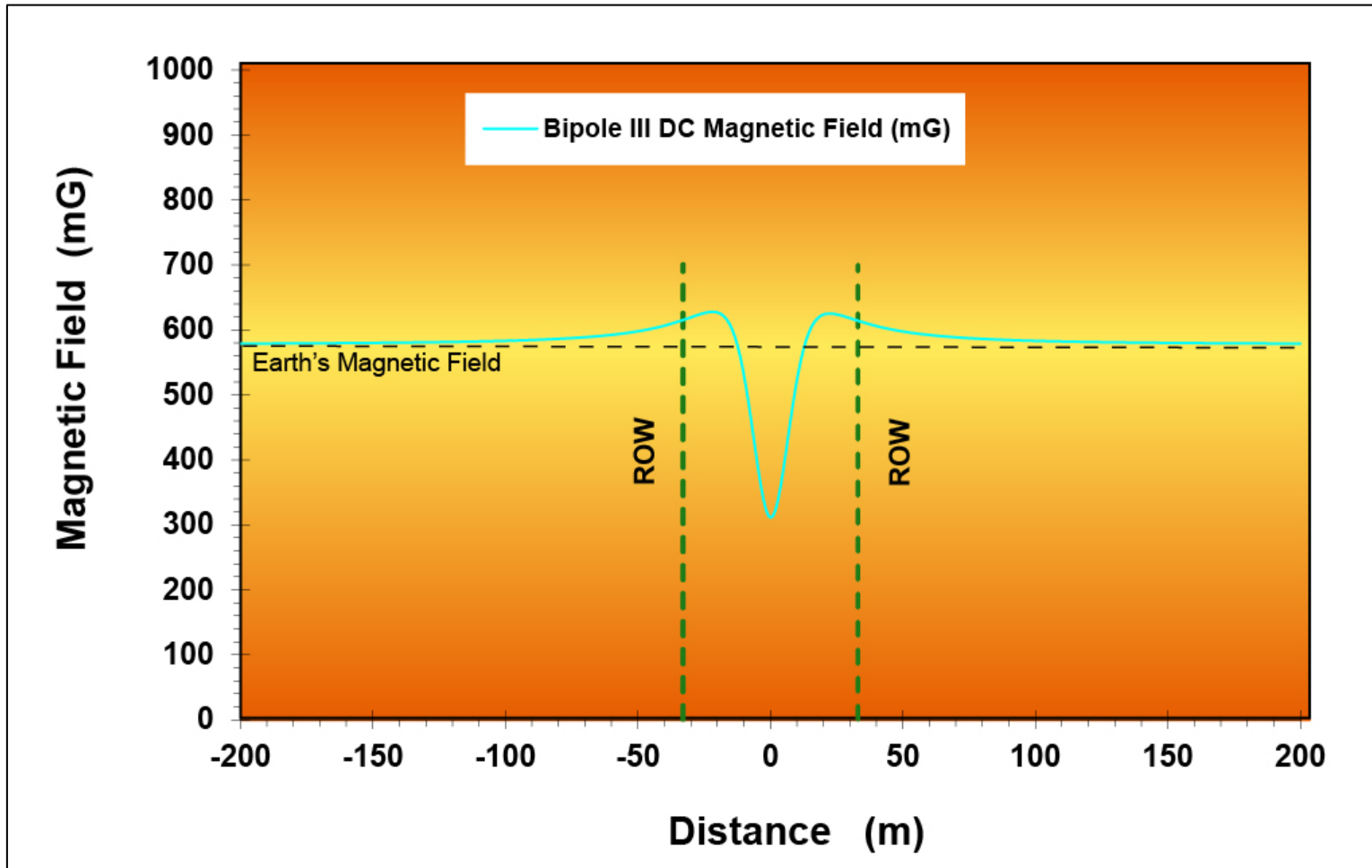


**15,000,000 - 40,000,000 mG**

# Typical Static Magnetic Field Levels from Common Natural and Man-made Sources

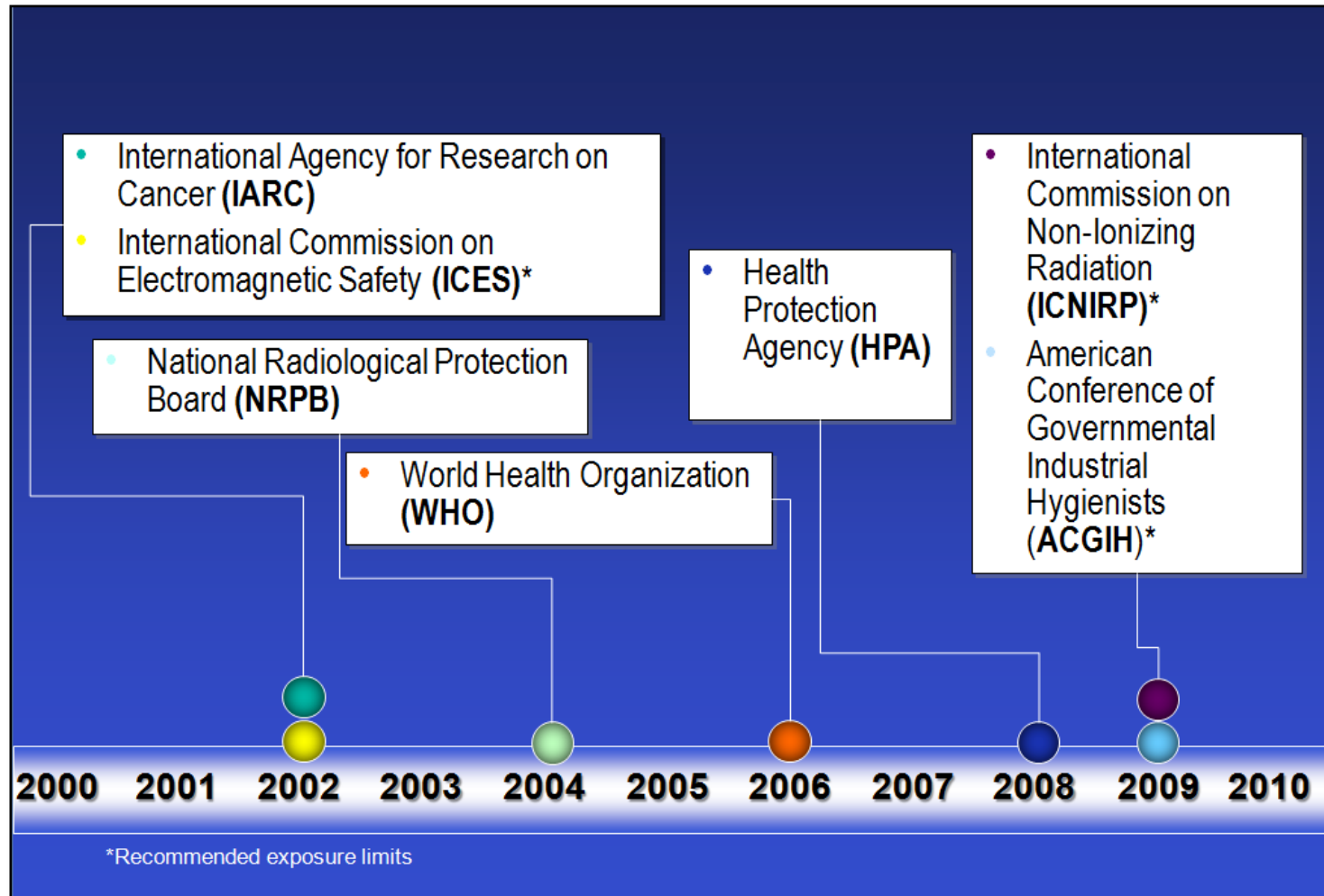
Source	Magnetic Field Level (mG)
<b>Man-made Sources</b>	
Battery operated appliances	3,000 – 10,000
Electrified railways	< 10,000
MRI machines	15 million – 40 million
Under $\pm 500$ -kV Bipole III transmission line operating at 2,000 Amperes	250-560
<b>Natural Sources</b>	
Earth's geomagnetic field in Manitoba	~ 580

# Bipole III DC Magnetic Field Added to Earth's Magnetic Field





# Reviews of Research on Static Magnetic and Electric Fields Since 2000



# Agency Reviews of DC Magnetic and Electric Field Health Research

- International Agency for Research on Cancer (2002)
- National Radiation Protection Board (2004)
- World Health Organization (2006)
- HPA (2008)
- ICNIRP (2009)

# Recommended Limits for Human Exposure to DC Magnetic Fields

	<b>ICNIRP (2009)</b>	<b>ICES (2002)</b>
	Limit (mG)	
General Public (continuous)	4,000,000	1,180,000
Workers	20,000,000 80,000,000	3,530,000

# Recommended Limits for Human Exposure to DC Electric Fields

	<b>NRPB (2004)</b>	<b>ICES (2002)</b>
	Limit (kV/m)	
General Public (continuous)	25	28

# DC Lines and Livestock, Plants, Wildlife

# MEQB Study of DC Line and Agriculture (1986)

- Field study of  $\pm 400$  kV DC transmission line
- Data analyzed on 24,000 milking cows
  - Daily milk production
  - Reproduction and mortality
  - Exposure conditions
    - Before and after line energization
    - 6 distance categories (<1/4 mi to 6-10 mi)
- No relation between exposures to the DC line and performance and reproduction in a large study with sensitive health indicators.

# Comprehensive Experimental OSU Agricultural Study (1988, 2001)

- Comparison of beef cattle and crops under  $\pm 500$  kV DC line with control site 615 m away
  - Breeding: conception, calving, weight, mortality, behaviour
  - Production: growth, quality, disease incidence among wheat and alfalfa crops
- No effect on measures that are important in commercial ranching and farming operations

# DC Transmission Lines and Wildlife

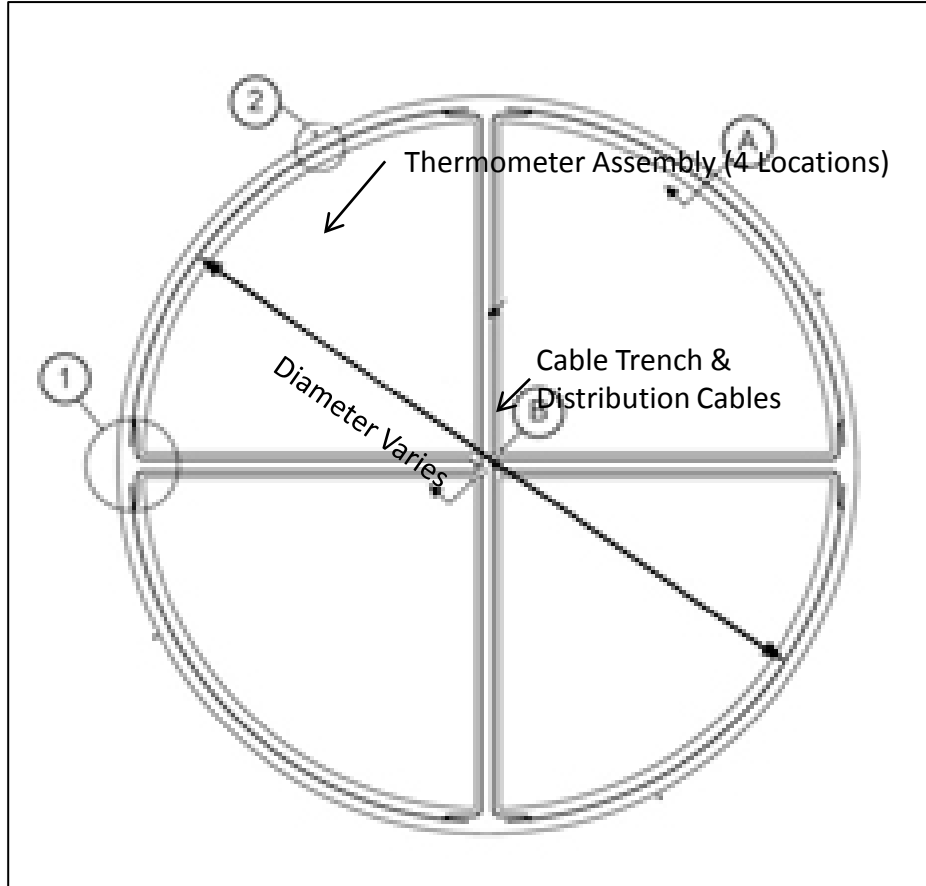
- Studies of DC lines suggest that habitat change from construction is the critical factor, not static fields
- There are reports that some varieties of birds and bees can detect and use some aspect of the Earth's magnetic field as a supplementary 'travel aid' in moving within or between habitats
- Research does not suggest that the behavior of birds or other species would be adversely affected by the relatively small change in the magnetic field from Bipole III



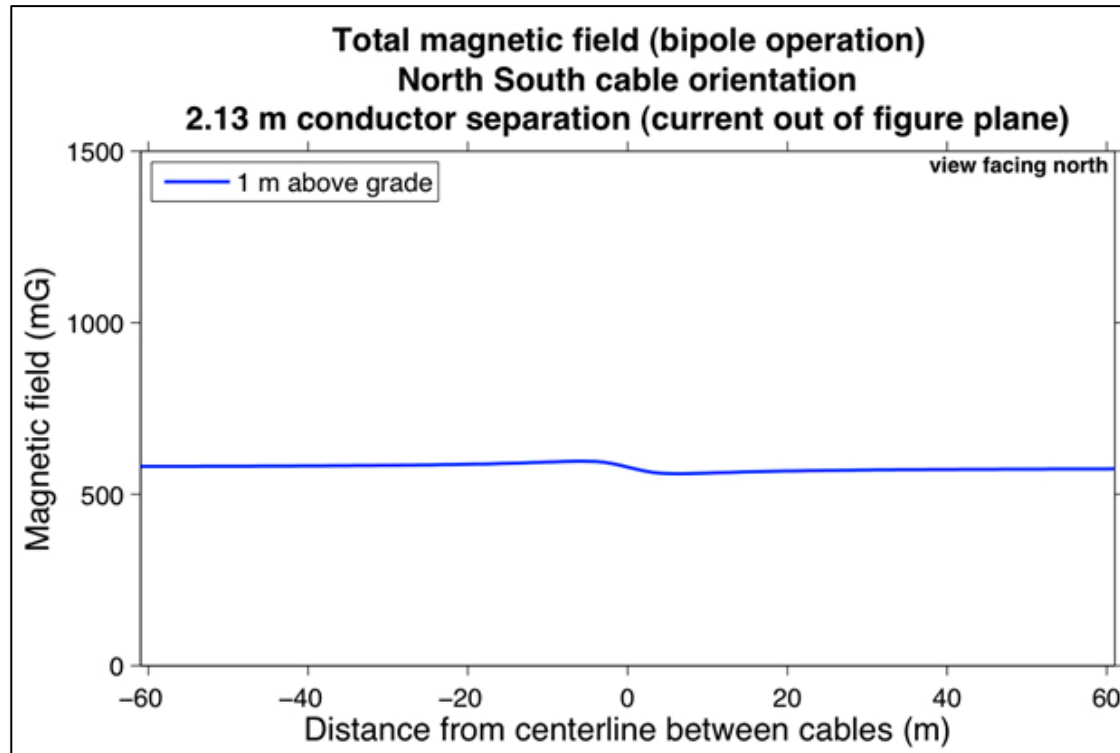
# Ground Electrode Operation

- Normally, very low current on feeder line and electrode in bipolar operation
- Maintenance and emergency monopolar operation (estimated ~8% of time) will increase current flow on feeder line to electrode
- Electric and magnetic fields below international standards
- Monopolar operation poses no threat to health and safety (Teshmont reports)

# Ground Electrode



# Overhead Electrode Line



# DC Lines and Electronic Devices

**Bipole III Transmission Project: A Major Reliability Improvement Initiative**

## DC Lines and Electronic Devices


**Radio and TV Receivers**

Manitoba Hydro is preparing to build a new direct current (DC) transmission line, known as Bipole III, to improve system reliability. The new line will link the northern power generating stations on the Long Point River with the delivery system in southern Manitoba. Current line ratings are 3,000 MW. The line will have two parallel paths, each carrying 1,500 MW. The line will be constructed in two stages, with the first stage being completed by 2015 and the second stage by 2017.

Operating stations within the same system and electronic devices including generators, transformers, and other equipment in the vicinity of DC transmission lines such as Bipole III.

DC lines and electronic devices, TV sets can pick up or produce or receive radio frequency (RF) signals. While radio and TV receivers are not sensitive to the signals, DC lines, however, can produce signals that are picked up or received by the receiver.

**Figure 1: Close up of Double Bipole Transmission Lines**



**Radio and TV Receivers**

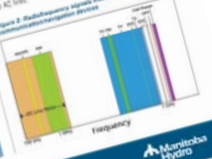
Bipole and TV interference may be noticeable, particularly when near a DC transmission line. Many people have heard interference on their radio when driving along a road with high-voltage transmission lines, particularly high-voltage AC and TV signals. It is important to understand the amount of interference from DC lines and how it can be reduced.

For radio receivers, the amount of interference from DC lines is very low. However, for TV receivers, the interference is much higher. This is because TV receivers are designed to receive signals from a single source, and the interference from DC lines is much stronger than the signal from the TV station.

Figure 2 shows the amount of interference from DC lines on radio and TV receivers. The amount of interference is measured in microvolts per meter (µV/m). The amount of interference from DC lines is much higher than the amount of interference from AC lines.

Manitoba Hydro has details of experience designing transmission lines to minimize radio noise and has worked with contractors to solve interference problems that sometimes arise near AC lines.

**Figure 2: Radio and TV Receivers**

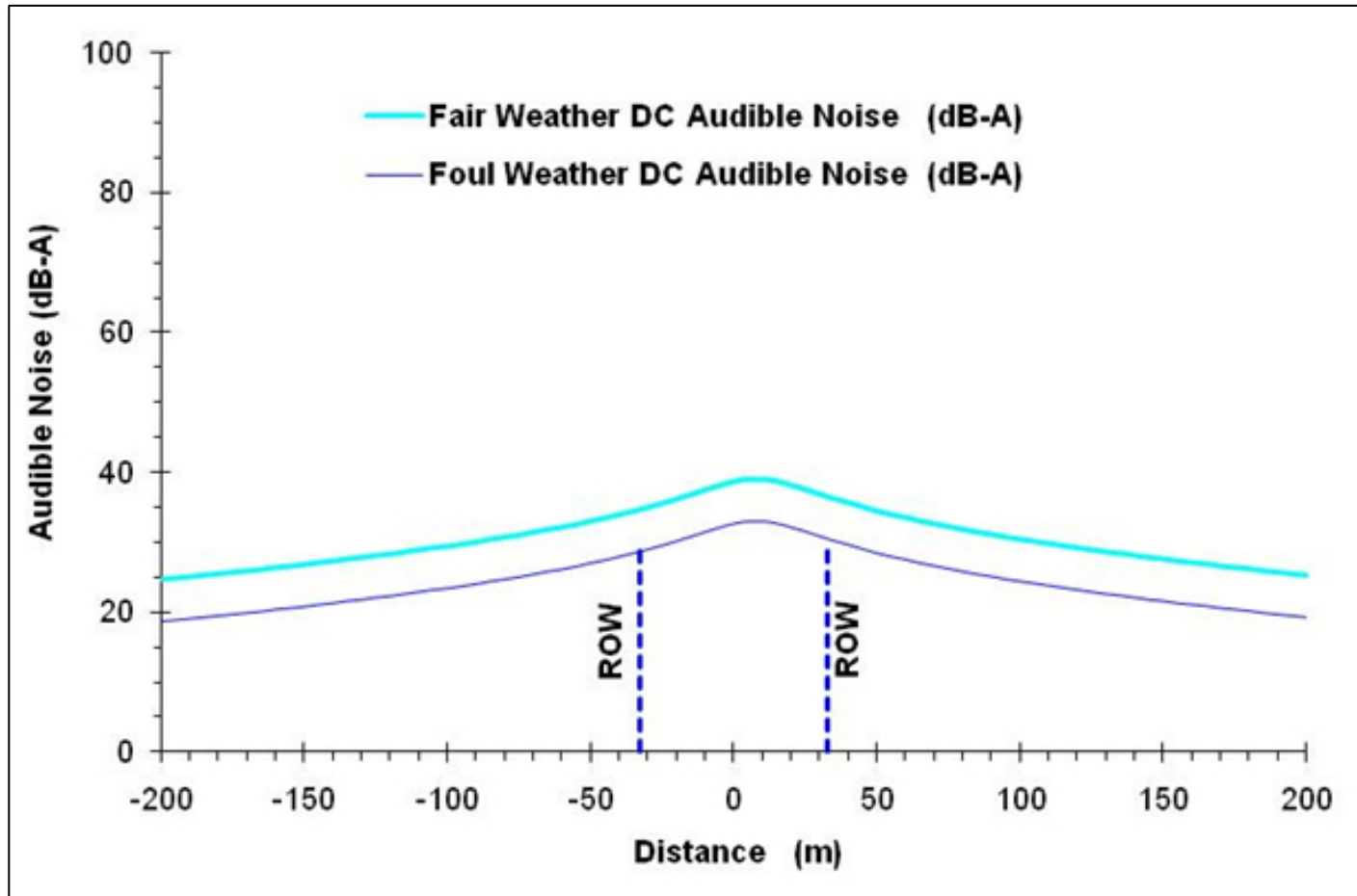


Frequency (MHz)	AC Interference (µV/m)	DC Interference (µV/m)
0.1	~0.5	~1.5
0.2	~0.5	~1.5
0.3	~0.5	~1.5
0.4	~0.5	~1.5
0.5	~0.5	~1.5
0.6	~0.5	~1.5
0.7	~0.5	~1.5
0.8	~0.5	~1.5
0.9	~0.5	~1.5
1.0	~0.5	~1.5

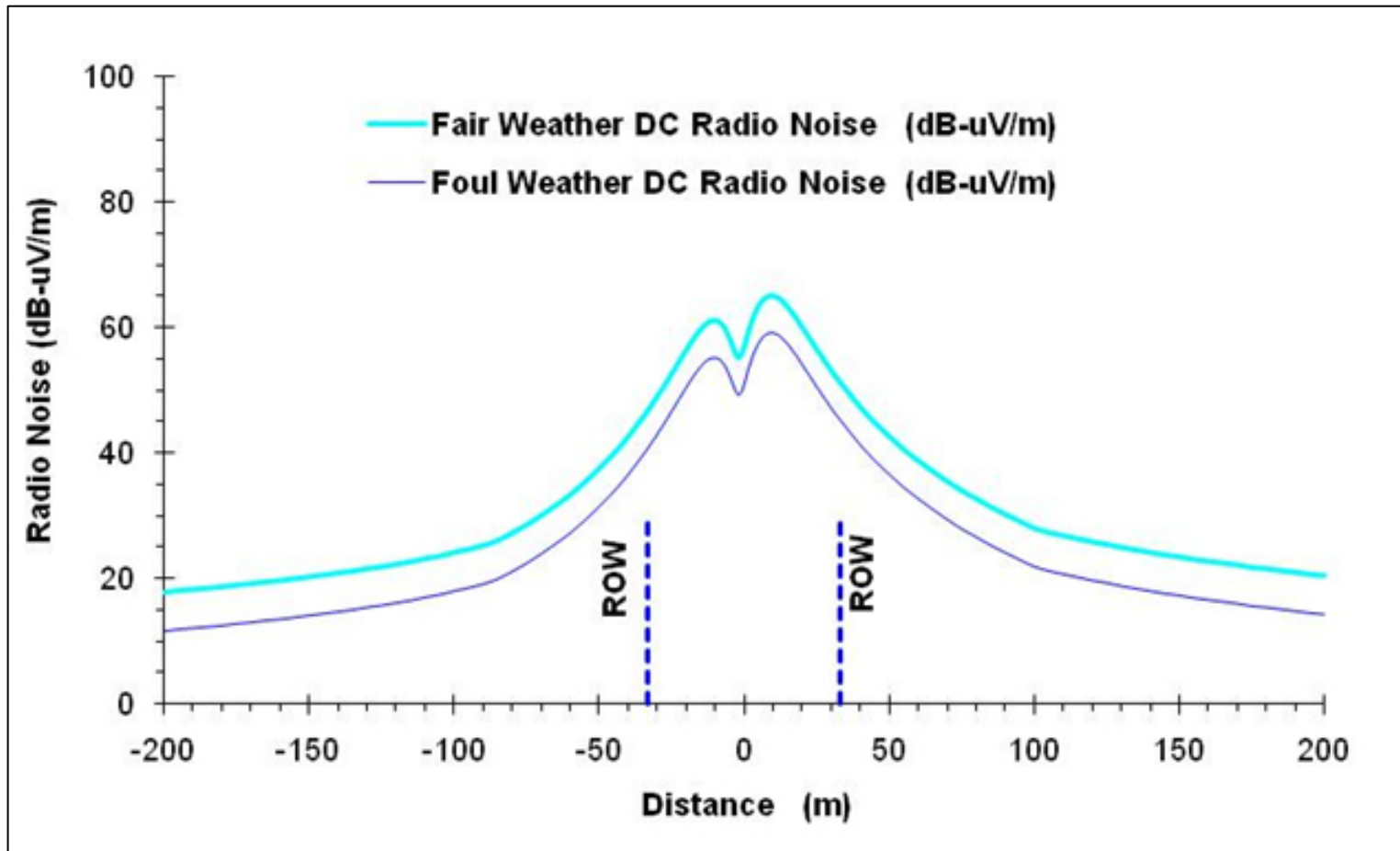
**Manitoba Hydro**

DC Lines and Electronic Devices October 2009

# Audible Noise



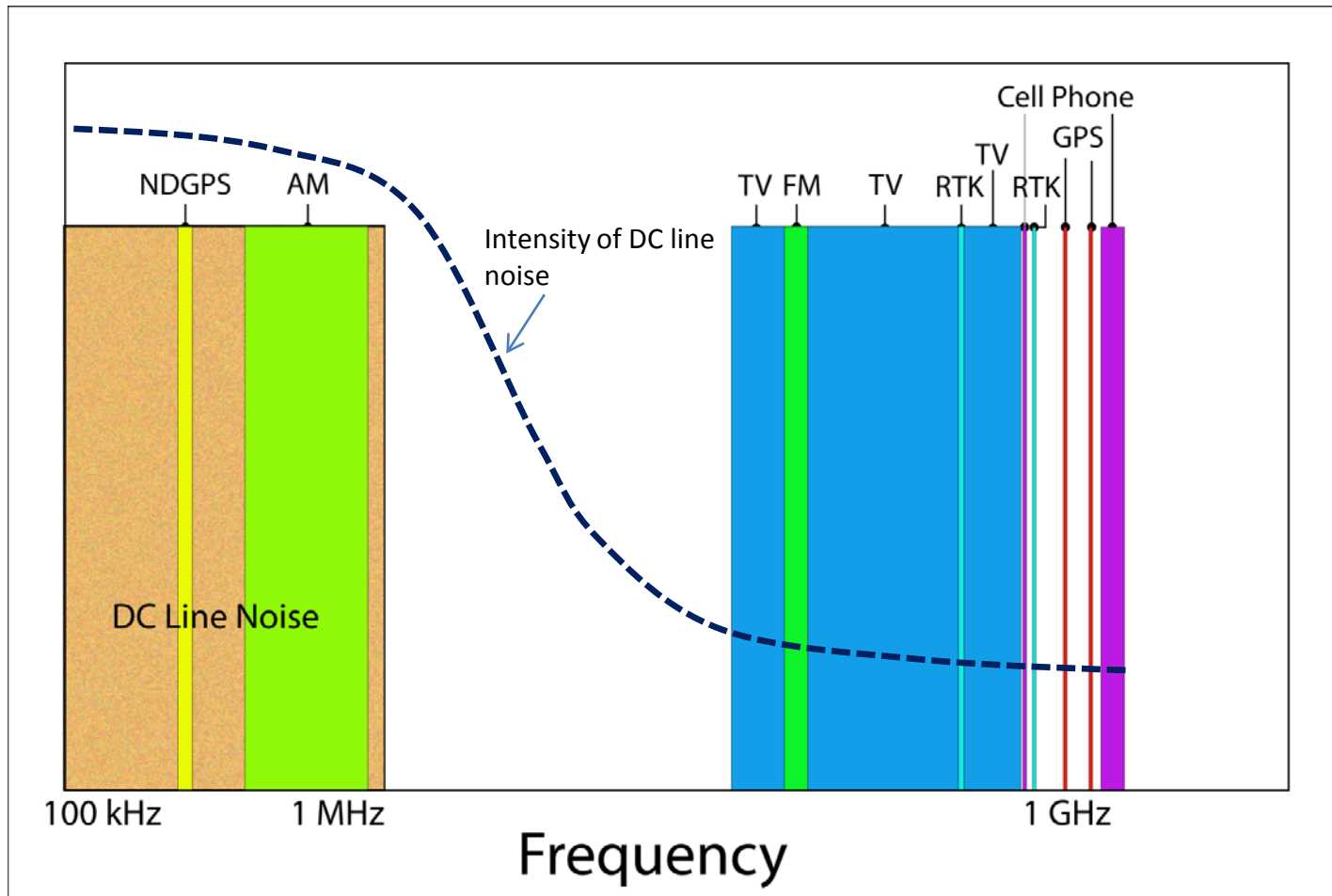
# Radio Noise



# DC Lines & Radio/TV Interference

“Radio and TV interference may be noticeable, particularly when near a DC transmission line....Digital television is not subject to this source of interference.”

# Frequencies and Intensity of DC Line Noise Compared to Other Sources, e.g., GPS





# DC Lines and GPS Receivers

Two studies of GPS receiver performance under Bipole I and II DC lines

- “No power line effect on . . . measurements was found to affect the quality of the navigation solutions “(Univ of Calgary).
- “transmission lines that supply Direct Current have no appreciable effect on either GPS measurements or ultra high frequency radios/cell phones that supply GPS correction messages. The results obtained were well within the manufacturers quoted equipment accuracies (i.e., centimeter level)” (Pollack & Wright).

# DC Lines and Cell Phones

“Cell phones receive and transmit RF signals at frequencies ranging from 850 MHz to 2150 MHz. Radio noise from a DC transmission line does not overlap with the signals from a mobile phone and, therefore, does not interfere with a phone’s functioning near a DC transmission line.”

# DC Lines and Wireless Internet

“Wireless internet operates at a frequency of 2400 MHz. Radio noise from a DC transmission line does not overlap with the signals from a mobile phone and, therefore, does not affect wireless internet function near a DC transmission line.”

# DC Lines and Medical Devices

Bipole III electric and magnetic fields are too weak to affect:

- Cardiac pacemakers
- Cochlear implants

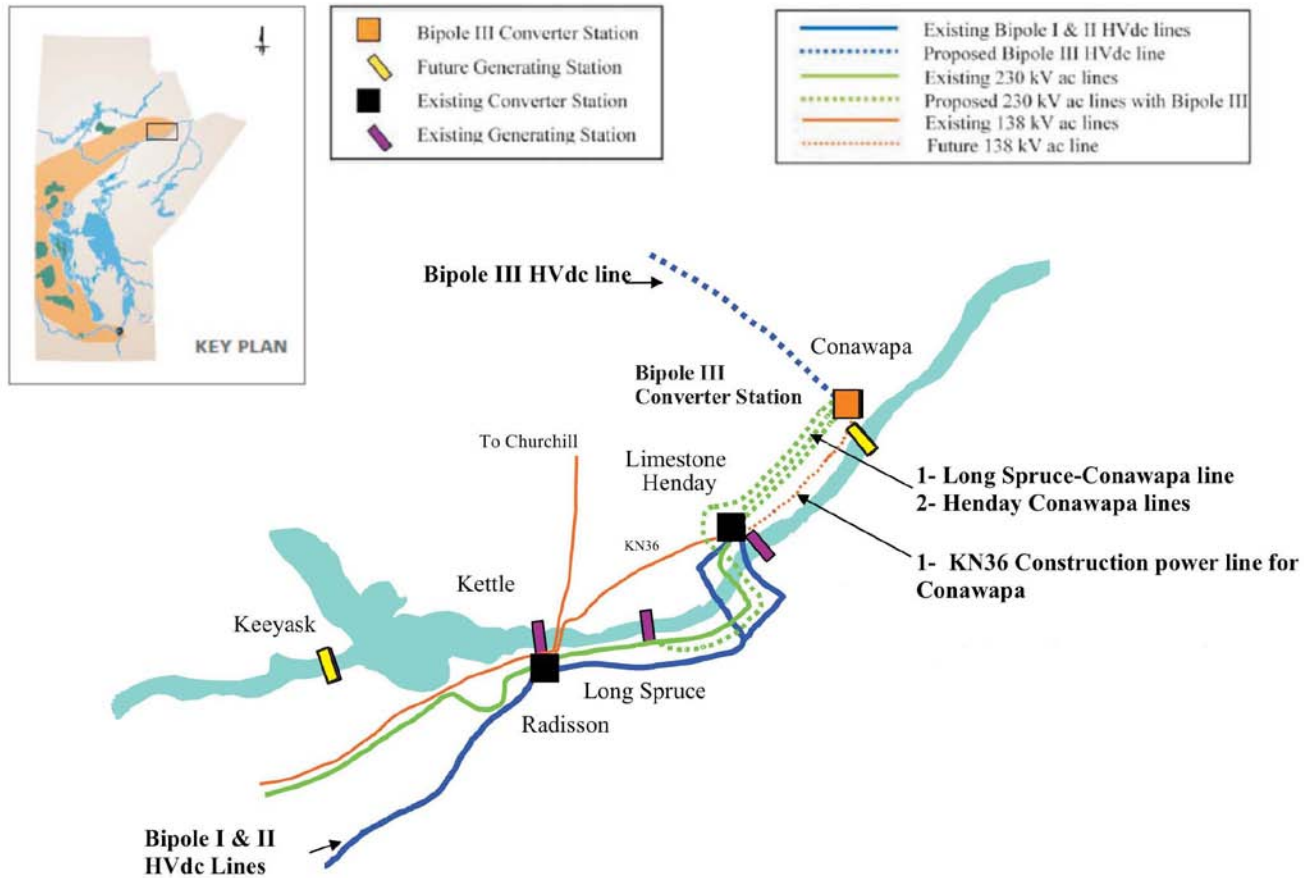
# Bipole III and Mining Surveys

- The route of the Bipole III line passes close to the Thompson Nickel Belt
- Mining companies measure variations in the earth's magnetic field down to  $\sim 0.001$  mG (less than daily variation in the field) to survey for ore deposits
  - Options to address concerns about Bipole III
    - Survey before line is constructed in 2017
    - Filter out Bipole III magnetic field
    - Use other survey methods
    - Shift route

# Bipole III

## AC Transmission Lines

# AC Lines at the Keewatinooow Converter Station



# Some Reviews of AC EMF and Health Research by Scientific Organizations

- 1998 National Institute for Environmental Health Sciences (NIEHS)
- 2002 International Agency for Research on Cancer (IARC)
- 2003 International Commission on Non-Ionizing Radiation Protection (ICNIRP)
- 2004 National Radiological Protection Board (NRPB)
- 2005 Federal-Provincial-Territorial Radiation Protection Committee (FPTRPC)
- 2007 International EMF Project, World Health Organization (WHO)



# FPTRPC - Canada (2005)

- Established to support government radiation protection agencies in Canada
- Review of epidemiology and laboratory research regarding 60-Hz EMF
- Conclusion
  - “Adverse health effects from exposure to power-frequency EMFs, at levels normally encountered in homes, schools and offices, have not been established.”
  - “Since there is no conclusive evidence that exposure to EMFs at levels normally found in Canadian living and working environments is harmful, FPTRPC is of the opinion that moderate measures and participation in the process of acquiring new knowledge are sufficient.”

# Major Reviews of EMF and Health Research by Health Agencies after WHO report

- 2008 Swedish Radiation Protection Authority (SSI)
- 2009 Scientific Committee on Emerging and Newly Identified Health Risks (SCENIHR)
- 2009 The Health Council of Netherlands
- 2010 International Commission on Non-ionizing Radiation Protection (ICNIRP)
- 2010 European Health Risk Assessment Network on Electromagnetic Fields Exposure (EFHRAN)

# FPTRPC 2008

## Response Statement to Public Concerns Regarding Electric and Magnetic Fields

“Public concerns appear to arise from periodic media reports and from dubious Internet websites which contain inaccurate, unsubstantiated, controversial or contradictory statements regarding EMF-health issues.”

# Conclusion of Exponent's Technical Report in EIS

In summary, the electrical environment of the Bipole III project is expected to conform to exposure limits recommended by provincial, national, and international agencies. The evaluation of studies of human, animals, and plants exposed to magnetic fields, electric fields, and space charge conducted in laboratories and around DC transmission lines does not show that these exposures would have an adverse impacts. Furthermore, the field levels of the proposed line were not found to pose any likely effect on electronic devices.

Q & A