RADIOCOMMUNICATION, RADAR AND SEISMOACOUSTIC SYSTEMS IMPACT ASSESSMENT

St. Joseph Wind Energy Project, Manitoba

Prepared for
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DEFINITIONS AND SYMBOLS

ALS	Assignment and Licensing System
AM	amplitude modulation
CanWEA	Canadian Wind Energy Association
DME	Distance Measurement Equipment
DND	Department of National Defence
FM	frequency modulation
GHz	gigahertz
GMCO	Government Mobile Communications Office
RCMP	Royal Canadian Mounted Police
kHz	kilohertz
km	kilometre
ILS	Instrument Landing System
m	metre
MHz	megahertz
MLS	Microwave Landing System
NDB	Non-directional Beacon
RABC	Radio Advisory Board of Canada
RCMP	Royal Canadian Mounted Police
TACAN	Tactical Air Navigation
VOR	VHF Omni-directional Range

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1 INTRODUCTION

It is generally recognized that wind turbine generators (WTG), like other large structures, can disrupt the propagation of electromagnetic signals and thereby interfere with the proper functioning of radiocommunication systems. In this context, BowArk Energy Ltd. (“Client”) – which is currently developing a wind farm on behalf of *St. Joseph Wind Farm Inc.*, near St. Joseph, Manitoba (the "Project") – has contracted Helimax Energy Inc. (“Helimax”) to evaluate the impact of the the Project on radiocommunication systems present in the region.

Section 2 of this report summarizes the interference mechanisms associated with the presence of wind turbines. An inventory of the radiocommunication, radar and seismoacoustic systems which could potentially be disturbed in the vicinity of the wind farm is presented in Section 3. This system inventory is consistent with the requirements of the document *‘’Technical Information and Guidelines on the Assessment of the Potential Impact of Wind Turbines on Radiocommunication, Radar and Seismoacoustic Systems’’* (Radio Advisory Board of Canada and Canadian Wind Energy Association, 2007: RABC and CanWEA) (“RABC/CanWEA Guidelines”) [1]. Though not legally binding, this publication does contain a set of guidelines to help wind energy promoters coordinate with communications system operators in Canada. Additionally, the document defines consultation zones for several systems where further investigation is recommended to ensure a trouble-free coexistence of infrastructure.

Section 4 of this report examines the presence or absence of radiocommunication systems within these proposed consultation zones. When such systems are identified, the anticipated impact of the wind project thereon is described and, if possible and appropriate, potential mitigation measures or recommendations for further investigation are proposed.

2 INTERFERENCE MECHANISMS

Wind turbines can disrupt the functioning of radiocommunication systems by interfering with the propagation of electromagnetic waves. Although a wind turbine does not itself emit electromagnetic waves, its very presence can cause interference by disrupting the waves traveling between an emitter and a receptor. The waves are modified by different physical mechanisms such as reflection, dispersion and diffraction.

Interference can manifest itself in various ways, mainly by creating a shadow zone where the signal is weak or by generating a parasite signal by reflection, thus interfering with the direct signal.

Shadow interference occurs behind an obstacle, i.e. on the side opposite that of the emitter position. By disturbing the propagation of electromagnetic signals, the wind turbine may deprive a certain zone located behind it of part or of the entire signal, thus modifying the coverage and range of the signal whose level may drop below the threshold of the receptor's sensitivity.

Reflection interference occurs when the wind turbine structure reflects towards the receptor part of the signal that it receives from the emitter, creating a parasite signal which interferes with the direct signal. At the receptor location, the parasite signal is characterized by its amplitude and delay with respect to the signal having arrived via a direct path. Having been reflected by various obstacles, the receptor can thus receive the same signal multiple times, though spread over a period of time. This type of interference, referred to as "multiple path distortion", increases the noise perceived by the receptor, and can thereby compromise its operation. Moreover, because of the constantly rotating blades, the reflected signal can be modulated in amplitude, frequency and/or phase.

Wind turbine-caused interference is difficult to predict with certainty. Generally speaking, modeling electromagnetic wave propagation and interference mechanisms is a complex task given the dimensions of the problem with respect to the wavelength in cause. The level of interference depends on several factors related to the emitter, the receptor, the wind turbine and the propagation environment, including:

- Relative positions of emitter, receptor and wind turbines;
- Transmit power (strength of emitted signal);
- Radiating patterns of the antennas used;
- Frequency and modulation of signal;
- Information transfer rate and bandwidth of the system;
- Noise sensitivity of receptor system;
- Site topography and ground cover;
- Meteorological conditions;
- Size and shape of wind turbines;
- Number and layout of wind turbines;
- Material composing the wind turbine;
- Orientation of blades and rotor;
- Rotor rotation speed.

3 INVENTORY OF RADIOCOMMUNICATION SYSTEMS

The present section describes the main types of telecommunication, radar and seismoacoustic systems, and inventories those which are present in the area under study. In Canada, Industry Canada is responsible for attributing frequencies and managing the electromagnetic spectrum. The said agency's Assignment and Licensing System (ALS) database and the Technical and Administrative Frequency List (TAFL) were consulted to identify various types of registered radiocommunication and radar systems. The Canadian National Seismograph Network (CNSN) webpage was consulted to identify the seismoacoustic systems. It should be noted that Helimax assumes no responsibility for missing or erroneous data retrieved.

Additionally, as per the recommendations of the RABC/CanWEA Guidelines, the following agencies have been contacted by memo and were sent the coordinates of the Project:

- Department of National Defence (DND);
- Royal Canadian Mounted Police (RCMP);
- Canadian Coast Guard (CCG).

A "Land Use Submission Form" should also be sent to NAV CANADA once a final project layout is prepared.

This systems inventory is consistent with the recommendations of the RABC/CanWEA Guidelines [1]. Though not legally binding, the publication does contain a set of guidelines to help wind energy developers coordinate with communications system operators in Canada. Additionally, the document defines consultation zones for several systems where further investigation is recommended to ensure a trouble-free coexistence of infrastructure.

The following types of systems are described in the subsequent sections as part of the evaluation of potential impacts:

- Point-to-Point Systems;
- Multipoint Distribution Systems;
- Over-the-Air Reception (Radio and TV Broadcasting);
- Satellite Systems;
- Land Mobile Radio Systems;
- Cellular Type Network;
- Aeronautical Radionavigational Aids;
- Air Defence, Vessel Traffic and Air Traffic Control Radar Systems;
- Weather Radar Systems;
- Seismoacoustic Systems.

The wind turbines coordinates of the Project are presented in Appendix A and the inventoried systems in the vicinity are presented in Appendix B, and illustrated in Appendix C and Appendix D.

3.1 Point-to-Point Systems

Point-to-point links are used to relay information from one tower to another without having to resort to coaxial cables, fibre optics or satellite. In TV broadcasting, point-to-point links are used to link a production studio with a local transmitter antenna. In cellular telecommunications, they serve to link the cellular base station to relay centres.

As recommended by the RABC/CanWEA Guidelines [1], a consultation zone of width L_c was established and mapped for the different links. As shown in the equation below, the size of the buffer zone is a function of the operating frequency (F) and the distance (D) covered by the link (B being the length of a blade). It is based on taking three times the maximum width of the 1st Fresnel zone.

$$L_{c(m)} = 52\left(\frac{D_{(km)}}{F_{(GHz)}}\right)^{1/2} + 2B$$

Additionally, 1-km radius consultation zones have been set (as per the RABC/CanWEA Guidelines) for each tower position.

The paths of two low capacity links and three microwave links operating at public microwave frequencies transect the planned wind farm Project area. Low capacity links are illustrated for information purposes only, but are not considered exclusion zones per se.

Appropriate authorities have been contacted to identify potential microwave links, operating at protected frequencies, which might transect the wind farm project area (see Section 4).

3.2 Multipoint Distribution Systems

The multipoint distribution system (MDS) is used for television broadcasting and Internet services. It allows companies to offer service in rural regions where it would be too onerous to install conventional cables. This system operates in the microwave frequency band. To receive these services, the user must be equipped with an outside antenna and subscribe to a service provider. For television broadcasting, the service in Canada is known by the name “multipoint distribution television” (MDS-TV). Service providers using frequency bands under licence are listed in the Industry Canada database, while those offering wireless Internet services use unlicensed frequency bands and are not listed in this public database.

The only licensed MDS provider in the area is Craig Wireless International Inc. The nearest antenna is located approximately 100 km from the wind farm. There are potential receivers in the Project area. Helimax considers each residence to be a potential subscriber to an MDS service (wireless television and Internet). In the context of this study, the MDS transmitter antennas of Craig Wireless International are far enough away such that no service is offered in the projected wind farm area. This information was confirmed via direct communication with Craig Wireless International.

3.3 Over-the-Air Reception (Radio and TV Broadcasting)

The RABC/CanWEA Guidelines recommend 1-km radius consultation zones around radio and television broadcasting antennas. In addition, for TV broadcasting, the RABC/CanWEA Guidelines establish a consultation zone around the wind farm. The document recommends further investigation when receivers are within the consultation zone defined by:

$$R = 0.051 \times B \times \sqrt{T}$$

where:

R: radius of consultation zone [km] from geographical centre of proposed wind farm
B: length of wind turbine blades [m]
T: number of turbines in wind farm

3.4 Satellite Systems

There are potential Direct Broadcast Satellite (DBS) receivers (home satellite dishes) in the Project area. This study considers each residence to be a potential subscriber to satellite TV.

Additionally, one registered earth station in the meteorological-satellite service is located in the RABC/CanWEA recommended consultation zone.

3.5 Land Mobile Radio Systems

A multitude of systems of this type are deployed to facilitate the communication of diverse parties covering vast territories. These systems operate by means of networks with fixed stations in liaison, mobile stations in liaison via a fixed repeater, or any arrangement dictated by a specific application. The RABC/CanWEA Guidelines recommend that land mobile radio towers within 1 km of a wind turbine be identified.

3.6 Cellular Type Network

Land-based cellular telephony requires the service provider to deploy a radiocommunication network wherein the entire coverage area is divided into a number of cells. In the centre of each cell is a base station which ensures communication with each mobile station (the cellular telephone of the user). Base stations are in turn linked to control stations and relay stations (switching stations) by microwave hops (or other means) in order to establish communication. The present inventory focuses on the base stations, whereas the inventory of the microwave links is discussed in Section 3.1. The RABC/CanWEA Guidelines recommend that cellular base stations within 1 km of a wind turbine be identified.

3.7 Aeronautical Radionavigational Aids

A number of systems are used in aeronautics for controlling and directing air traffic, including:

- Distance Measurement Equipment (DME);
- Instrument Landing System (ILS);
- Microwave Landing System (MLS);
- Non-directional Beacon (NDB);
- Tactical Air Navigation (TACAN);
- VHF Omni-directional Range (VOR).

The majority of these systems are located along the periphery of airports, though some may also be scattered along aviation routes. Most of these systems are registered to NAV CANADA, a private society providing air traffic control services, radio navigation information systems and airport counselling.
The RABC/CanWEA Guidelines do not stipulate any size for the consultation zone which should be used. However, these systems are protected as defined in a Transport Canada document [2]. Air Traffic Control Radar Systems are discussed in the following section. Helimax considers that a consultation zone of 25 km is necessary around VOR/DME/TACAN and 10 km around the other systems.

3.8 Air Defence, Vessel Traffic and Air Traffic Control Radar Systems

The RABC/CanWEA Guidelines require all air defence radars within 100 km and all vessel traffic radars and air traffic control radars within 60 km of a wind energy project to be identified.

No such radar system was inventoried within the RABC/CanWEA Guidelines recommended consultation zone.

3.9 Weather Radar Systems

Weather radars are used to evaluate the probability of precipitation and to detect and forecast extreme weather events. Environment Canada weather radars have a range of approximately 250 km in normal mode and 125 km in Doppler mode. The Environment Canada radar network comprises 31 radars across Canada in order to cover inhabited areas. The RABC/CanWEA Guidelines recommend a consultation zone of a radius of 80 km.

No Environment Canada weather radar has been identified within the said consultation zone.

3.10 Seismoacoustic Systems

The operation of seismological monitoring systems is not based on the use of electromagnetic waves, but rather on the measurement of seismoacoustic waves, which are mechanical waves. The RABC/CanWEA Guidelines recommend that Natural Resources Canada be consulted if a wind energy project is located within 50 km of a monitoring array or 10 km from a “single monitoring station”.

According to the Canadian National Seismograph Network (CNSN) Station Book (available online by NRCan) which provides the locations of such systems, no seismoacoutic stations are found within these consultation zones. The nearest station (code: ULM) is approximately 180 km from the Project.

4 IMPACT ASSESSMENT

Table 4-1 below summarizes the potential impact of the Project on the above-mentioned communication systems identified in the vicinity. Turbines located within the proposed consultation zones are identified. When appropriate, mitigation measures or further analysis are proposed.

As previously mentioned, a certain number of agencies must be contacted in order to verify the presence of protected systems in the vicinity of a project area. In this context, the following agencies were contacted:

- Department of National Defence (DND);
- Royal Canadian Mounted Police (RCMP);
- Canadian Coast Guard (CCG).

The RCMP and the DND have responded to Helimax's notification and do not foresee any detrimental effects to their respective radio communication systems. At the time of this report, the CCG had yet to reply to Helimax's enquiry.

Table 4-1: Radiocommunication, Radar and Seismoacoustic Systems Impact Assessment

System Type	Recommended Consultation Zone around System	Overlap with Consultation Zones	Comments	Effect Assessment
Point-to-Point Systems	1 km from towers Buffer around link	No (microwave links) Yes (low capacity links)	Microwave links and their buffers were kept free of wind turbines in order to avoid interference. These were taken into account in the Project layout. Since low capacity links often do not require a direct line of sight to operate, they would not be sensitive to the presence of wind turbines.	No effect is anticipated since microwave links and their buffers are avoided.
Multipoint Distribution Systems	1 km from towers	No	Though no turbine is located near an emitter, interference might affect signal quality at certain receptor locations, especially if the wind turbine is located between the emitter and the receiver.	No effect is anticipated on registered MDS systems
Over-the-Air Television Broadcasting Reception	1 km from towers Calculated radius around wind farm (this case: 27 km)	No turbine within 1 km of towers Approximately 2180 buildings with potential presence of TV receptors within consultation zone defined around Project area	Buildings need to be validated for potential presence of TV receptors	Though no turbine is located near an analogue or digital television emitter, interference might affect signal quality at certain receptor locations [3].
Over-the-Air AM/FM Radio Broadcasting Reception	1 km	No	-	Although no emitter is located near the site, interference might affect signal quality at certain receptor locations. The reception of AM and FM radiobroadcast would be only affected when the receiver is located in close proximity of a metallic structure, such as a turbine, i.e. a few tens of metres [3]. The anticipated effect is considered minimal.

System Type	Recommended Consultation Zone around System	Overlap with Consultation Zones	Comments	Effect Assessment
Satellite Systems	Conical shape depending on satellite and receptor antenna location	Yes	At the Project's latitude, a satellite dish should have an elevation angle of between 25° and 40° with respect to the ground, pointing to a geostationary satellite orbiting the Earth. A wind turbine – or any structure – will intercept satellite signals if it stands in the line of sight between the satellite dish and a geostationary satellite. In order to avoid interference with a satellite signal, and assuming flat terrain conditions and the lowest angle with the ground (25°), a 127.5-m high turbine (including rotor) should be at least 300 m away from dwellings. Satellite dishes installed at participant and non-participant dwellings will not be affected by the Project since all turbines are at least 500 m away from residences. One registered earth station in the meteorological-satellite service (owned by Environment Canada; call signed XN231) is located 886 m and 552 m from WTGs #144 and 145, respectively.	No effect is anticipated on satellite dish signals. Interference might affect signal quality at Environment Canada earth station in the meteorological-satellite service. The impact should be evaluated with the system owner.
Land Mobile and Fixed Radio Systems	1 km	Yes	Turbine positions overlap with the consultation zone of 6 towers. The following WTGs are located within the 1-km consultation zone: - WTGs #45 and 66: nearest turbine is 809 m away from XNT383. - WTGs #40 and 41: Associated Protein (no call sign registered for this system); nearest turbine is 765 m away. - WTG #66: 949 m from XOB223	If a wind turbine is located too close to the antenna, the metallic tower of the turbine could modify the radiation pattern and thus the quality of the service. As a rule-of-thumb, Salema and Fernandes [4] establish an exclusion zone of between 50 m and 200 m around the antenna. This information should be reviewed with the system owner. The nearest turbine being located at 305 m, no effect to these systems is anticipated.

System Type	Recommended Consultation Zone around System	Overlap with Consultation Zones	Comments	Effect Assessment
			- WTGs #98, 99 and 100: nearest turbine is 305 m away from VFP938. - WTG #148: 872 m from XKQ974 - WTG #184: 972 m from CIH762	Reception might be affected when the receiver is a few metres away from a wind turbine [3].
Cellular Type Network	1 km	Yes	4 turbine positions overlap with the consultation zone of 2 Cellular Type Network towers. The following WTGs are located within the 1-km consultation zone: WTGs #21, 22 and 23 are respectively 368 m, 362 m and 765 m away from the Cellular System tower call signed 92901402 (owned by MTS Allstream Inc.). WTG #75 is 687 m away the Cellular System tower call signed 92901349 (owned by Rogers Wireless Inc.).	Interference might affect signal quality at certain receptor locations. The impact should be evaluated with the system owners.
Aeronautical Radionavigational Aids (except radars)	25 km (TACAN, DME, VOR) 10 km (other)	No	-	No effect is anticipated.
Air Defence Radars, Vessel Traffic Radars and Air Traffic Control Radars.	100 km (air defence radars) 60 km (vessel traffic radars and air traffic control radars)	No	The distance between the radar and the nearest wind turbine is approximately 80 km.	No effect is anticipated.
Weather Radars	80 km	No	-	No effect is anticipated.
Seismoacoustic Systems	50 km (monitoring array) 10 km (single monitoring station)	No		No effect is anticipated.

5 CONCLUSION

In accordance with the RABC/CanWEA Guidelines [1] and in light of the consultation zones recommended therein, Helimax has conducted an inventory and an impact assessment of radiocommunication, radar and seismoacoustic systems present in the vicinity of the Project. Public databases were queried and notices to relevant agencies (potentially detaining information on protected systems) were sent to complete the inventory. Specifically, the impact of the wind farm on the following systems has been evaluated:

- Point-to-Point Systems;
- Multipoint Distribution Systems;
- Over-the-Air Reception (Radio and TV Broadcasting);
- Satellite Systems;
- Land Mobile Radio Systems;
- Cellular Type Network;
- Aeronautical Radionavigational Aids;
- Air Defence, Vessel Traffic and Air Traffic Control Radar Systems;
- Weather Radar Systems;
- Seismoacoustic Systems.

Protected Systems

The following three agencies were contacted in order to verify the presence of protected systems in the vicinity of the Project area:

- Department of National Defence (DND);
- Royal Canadian Mounted Police (RCMP);
- Canadian Coast Guard (CCG).

The RCMP and the DND have responded and do not foresee any detrimental effects to their respective radio communication systems. At the time of this report, the CCG had yet to reply to Helimax's enquiry.

Non-protected Systems – Publicly Available Information

For the majority of systems, no wind turbines are located within the respective consultation zones, with the following exceptions:

- Two low capacity links and three microwave links operating at public microwave frequencies transect the Project area. No effect is anticipated since microwave links and their buffers are avoided.
- Although no turbine is located near an analogue or digital television emitter, interference might affect signal quality at certain receptor locations. Approximately 2180 buildings with potential presence of TV receptors are located within the recommended consultation zone defined around the Project.
- Two turbine positions (WTGs #144 and 145) overlap with the RABC/CanWEA recommended consultation zone of one registered satellite system (earth station in the meteorological-satellite service) owned by Environment Canada. The nearest turbine is located 552 m from the system.
- WTGs #40, 41, 45, 66, 98, 99, 100, 148 and 184 are located within the 1-km radius consultation zone around land mobile and fixed stations (see Table 4-1). The nearest turbine being located 305 m from the system, no effect thereto is anticipated.

- Two cellular base stations are located within the Project area. As WTGs #21, 22, 23 and 75 overlap the consultation zone of two cellular base stations, interference might affect signal quality at certain receptor locations. The impact should be evaluated with the system owners.

As for next steps, it is recommended that the various system owners be notified of the presence of turbines located within the consultation zones recommended by the CanWEA/RABC Guidelines. The Land Use Submission Form should also be completed and sent to NAV CANADA.

6 REFERENCES

Publications

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[3] Sengupta, Ph.D. and Thomas B. A. Senior, Wind Turbine Technology – Fundamental Concepts of Wind Turbine Engineering, Chapter 9, *Interference from Wind Turbine* by Dipak L., Ph.D. (1994), edited by David A. Spera, ASME, Press, New York, G.1998.

[4] Carlos Salema and Carlos Fernandes, *Co-siting Criteria for Wind Turbine Generators and Transmitter Antennas*, 2nd Conference for Telecommunications. Sesimbra, Portugal, April 1999.

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Industry Canada Database – Technical and Administrative Frequency List, April 2008
http://spectrum.ic.gc.ca/tafl/tafindxe.html

Natural Resources Canada – Canadian National Seismograph Network (CNSN), April 2008
http://earthquakescanada.nrcan.gc.ca/stnsdata/cnsn/stn_book/index_e.php

Personal Communication

Alex Beckstead, Radio Spectrum Engineer Mobile Communication Services, RCMP. Correspondence in December 2007 and January 2008.

Jim Hawkes, Engineering/Airfield Siting/Wind Turbines/Crystals ATESS/CCISF/EES, Department of National Defence. Correspondence in December 2007.

Mario Lavoie, Spectrum Engineer, Department of National Defence. Correspondence in December 2007.

APPENDIX A WIND TURBINE COORDINATES

Coordinates of the turbines of the Project[1] are presented in the table below. Coordinates are given in UTM-14 NAD83 format.

Table A-1: Wind Turbine Coordinates – St. Joseph Wind Farm

WTG No	Easting [m]	Northing [m]	WTG No	Easting [m]	Northing [m]
1	617427	5451541	**101**	621504	5442190
2	617809	5451548	**102**	621934	5442755
3	618210	5451567	**103**	622532	5442753
4	618584	5451581	**104**	622946	5442746
5	619072	5451537	**105**	613904	5440343
6	619432	5451560	**106**	614394	5440355
7	619799	5451583	**107**	614823	5440359
8	618158	5449734	**108**	615281	5440366
9	618609	5449745	**109**	616061	5440372
10	619051	5449774	**110**	616547	5440382
11	619488	5449780	**111**	617053	5440392
12	619913	5449738	**112**	617631	5440519
13	620410	5449815	**113**	618016	5440525
14	620804	5449833	**114**	618420	5440539
15	621192	5449835	**115**	618835	5440550
16	622162	5449062	**116**	619276	5440541
17	607483	5448065	**117**	619678	5440551
18	609190	5448106	**118**	620096	5440554
19	609547	5448103	**119**	620502	5440557
20	609906	5448104	**120**	620930	5440551
21	610934	5448111	**121**	621329	5440553
22	611402	5448129	**122**	621738	5440567
23	611882	5448135	**123**	613946	5438660
24	612396	5448085	**124**	614428	5438682
25	612790	5448123	**125**	614815	5438684
26	613248	5448134	**126**	615257	5438706
27	613610	5448140	**127**	615625	5438716
28	614111	5448147	**128**	616133	5438717
29	614496	5448149	**129**	616739	5438407
30	615880	5448212	**130**	617130	5438418
31	616258	5448212	**131**	617653	5438350
32	616673	5448228	**132**	617980	5438356
33	618033	5448290	**133**	618346	5438362
34	618468	5448292	**134**	619793	5437920
35	619007	5448308	**135**	622538	5438535
36	619428	5448316	**136**	622913	5438537
37	619869	5448320	**137**	623296	5438541
38	620260	5448318	**138**	623655	5438551
39	620653	5448328	**139**	614428	5437180
40	621911	5448241	**140**	614829	5437186
41	622347	5448235	**141**	615242	5437184
42	607561	5446907	**142**	615638	5437194
43	607922	5446907	**143**	622546	5436811
44	607571	5445678	**144**	622906	5436815
45	608070	5445680	**145**	623270	5436825
46	609273	5445741	**146**	625038	5437402

[1] L20-277STJO(ALL)-20080520-SD.WLX

WTG No	Easting [m]	Northing [m]	WTG No	Easting [m]	Northing [m]
47	609577	5445742	**147**	625416	5437402
48	610054	5445904	**148**	619421	5436253
49	610411	5445905	**149**	619805	5436263
50	613303	5446516	**150**	620176	5436268
51	613701	5446520	**151**	624268	5436128
52	614183	5446525	**152**	624651	5436119
53	614552	5446528	**153**	625072	5436243
54	614975	5446533	**154**	614025	5435078
55	616152	5446015	**155**	614381	5435453
56	616582	5446023	**156**	614743	5435451
57	616938	5446026	**157**	615117	5435520
58	617808	5446111	**158**	615454	5435520
59	618524	5446150	**159**	626929	5435256
60	619034	5446474	**160**	616727	5434828
61	619422	5446482	**161**	617274	5434845
62	619881	5446398	**162**	617664	5435517
63	621215	5446149	**163**	618002	5435523
64	621633	5446146	**164**	618375	5435525
65	621992	5446149	**165**	613481	5433894
66	608370	5444074	**166**	613865	5433904
67	609331	5444094	**167**	614367	5433891
68	609700	5444095	**168**	614958	5433902
69	610123	5444102	**169**	615464	5433807
70	610533	5444254	**170**	616007	5434025
71	610961	5445170	**171**	616414	5434033
72	611367	5445176	**172**	614558	5432173
73	611760	5445201	**173**	614943	5432175
74	612118	5445188	**174**	615335	5432174
75	614585	5444904	**175**	615752	5432179
76	615011	5444910	**176**	616207	5432205
77	615418	5444906	**177**	616626	5432211
78	619089	5445022	**178**	617008	5432221
79	619500	5445029	**179**	620973	5434062
80	619950	5445041	**180**	621387	5434068
81	620375	5445053	**181**	621821	5434076
82	620803	5445066	**182**	622231	5434074
83	621200	5445073	**183**	622859	5434090
84	621597	5445083	**184**	624326	5434118
85	614515	5443129	**185**	624718	5434118
86	614960	5443123	**186**	625105	5434130
87	611474	5442487	**187**	625493	5434137
88	612182	5442210	**188**	626040	5434156
89	613026	5441941	**189**	626391	5434150
90	613413	5441948	**190**	626814	5434160
91	613770	5441952	**191**	627211	5434162
92	616144	5442027	**192**	621496	5432402
93	616605	5442033	**193**	621883	5432408
94	617841	5442083	**194**	622260	5432412
95	618236	5442089	**195**	622756	5432345
96	618655	5442089	**196**	623175	5432338
97	619259	5442096	**197**	624284	5432382
98	619613	5442113	**198**	624689	5432390
99	619990	5442126	**199**	625110	5432394
100	621131	5442170	**200**	625522	5432396

APPENDIX B SYSTEM INVENTORY

Table B-1: Low Capacity (LC) Links Transecting Project Area

Licensee Name	Frequency [MHz]	Station Calling Sign	Link Station Calling Sign
Manitoba Hydro	170	VAK385 Lettelier	XOM51 Rosenfeld
Golden West Broadcasting	451	CJY491 Morris	CJY490 Altona

Table B-2: Microwave Links Transecting Project Area

Licensee Name	Frequency [MHz]	Station Calling Sign	Link Station Calling Sign
Rogers Wireless	5.9 GHz	CFB318 Sommerfeld	VAM463 Morden
Rogers Wireless	5.9 GHz	VOO520 Morris	CFB318 Sommerfeld
Golden West Broadcasting	934.8 MHz	CJY491 Morris	CJY490 Altona

Table B-3: Satellite System (Earth Station in the Meteorological Satellite Service) with Consultation Zone Overlapping with Turbine Positions

Tx Frequency [MHz]	Latitude [ddmmss] (NAD83)	Longitude [ddmmss] (NAD83)	Station Location	Licensee Name	ITU	Call Sign	Azimut	Distance [m]
401	490428	971820	Riviere aux Marais NR Chris	Environment Canada	TM	XN231	--	--

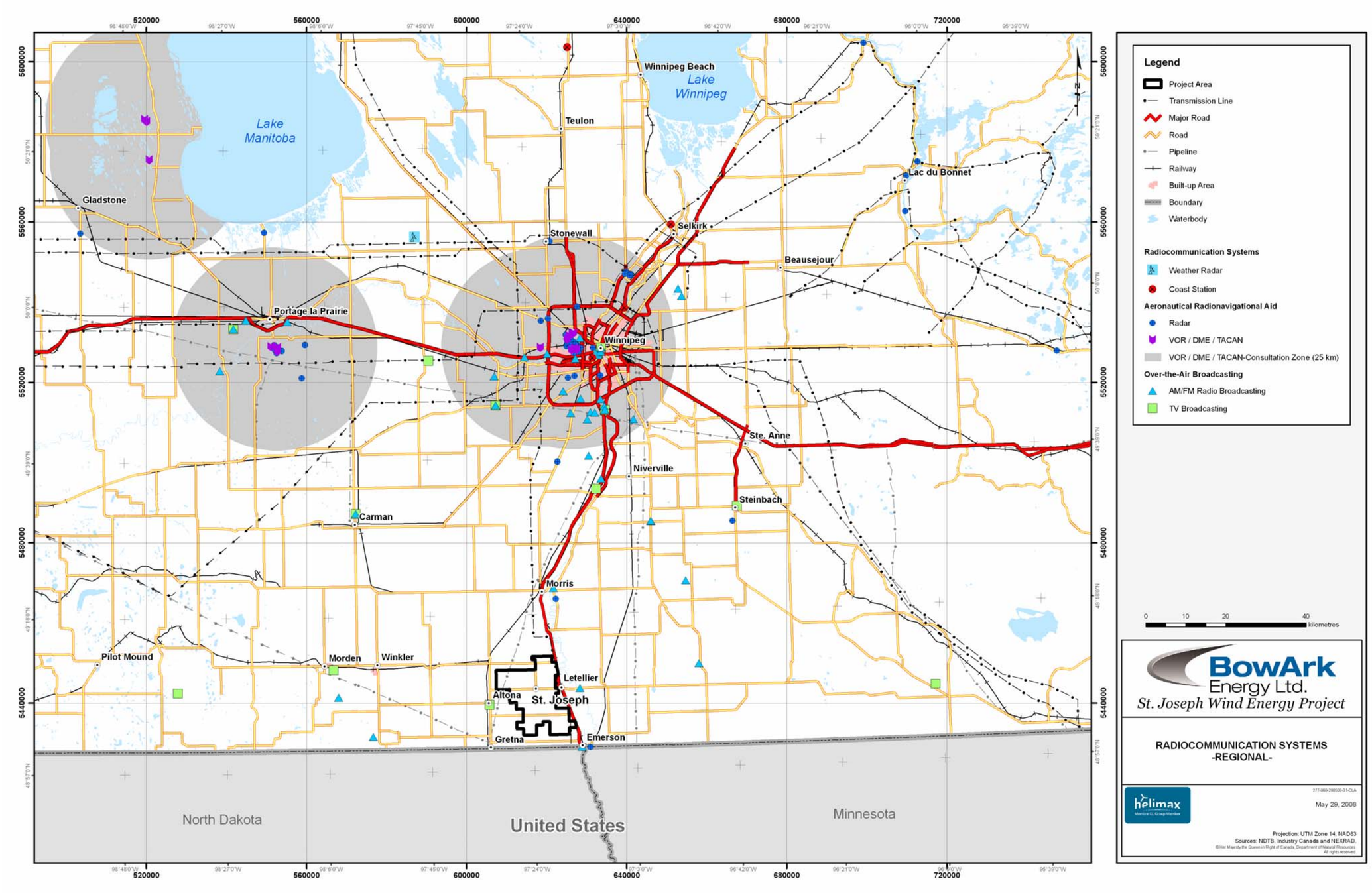
Table B-4: Land Mobile and Fixed Radio Systems with Consultation Zones Overlapping Project Layout

Tx Frequency [MHz]	Latitude [ddmmss] (NAD83)	Longitude [ddmmss] (NAD83)	Station Location	Licensee Name	ITU	Call Sign	Azimut	Distance [m]
457.0125	490851	973052	Altona, Manitoba-NE 21 2 2 W	Henry G. Stoesz	FB	XNT383	279.43	9.67
467.8375	491005	971931	Ste Agath, MB	Associated Protein	ML	--	--	--
154.445	490842	973129	Rosenfeld, Manitoba-NW	Jake Heppner	FB	XOB223	--	--
170.31	490717	972106	Lettelier, MB SE14-2-1W	Guy Damphousse	FB	VFP938	119.95	2.66
462.4125	490432	972216	Halbstadt, MB	Scott and Kim Frie	FB	XKQ974	--	--
453.025	490225	971823	Letellier, MB - NE18-1-2E	Ian Forrester OBO Forrester Farms	FB	CIH762	151.53	11.77

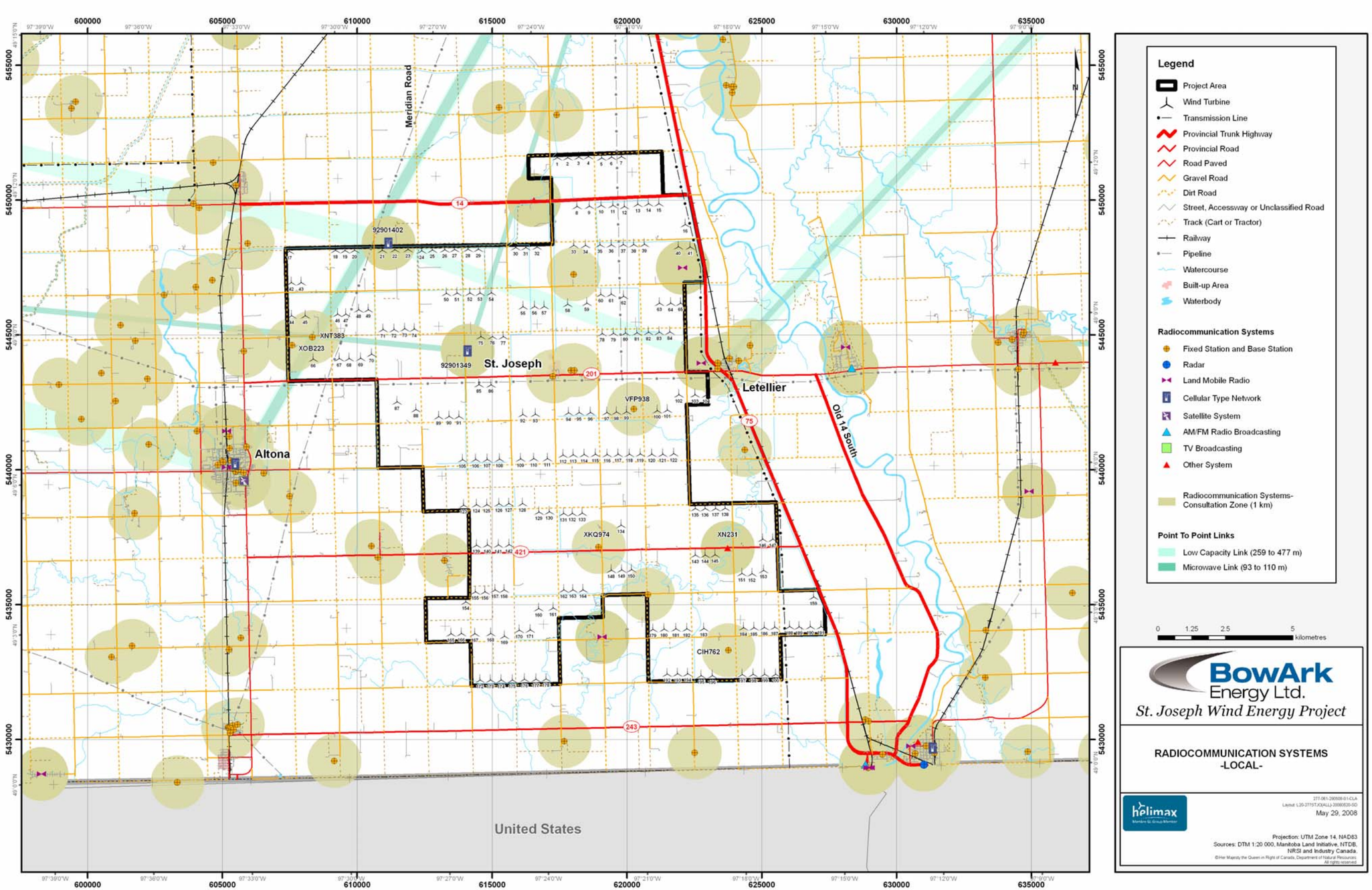
Table B-5: Cellular Type Network Systems with Consultation Zones Overlapping with Turbine Positions

Tx Frequency [MHz]	Latitude [ddmmss] (NAD83)	Longitude [ddmmss] (NAD83)	Station Location	Licensee Name	ITU	Call Sign	Azimut	Distance [m]
869	491042	972829	Rosenfeld	MTS Allstream Inc. Attn: Chief Tech. Info. Officer	FB	92901402	307.01	8.32
1930	490831	972608	W0633-RM OF Montcalm MB NW Quarter	Rogers Wireless Inc.	FB	92901349	284.17	3.92

APPENDIX C RADIOCOMMUNICATION SYSTEMS – REGIONAL MAP



APPENDIX D RADIOCOMMUNICATION SYSTEMS – PROJECT AREA MAP



APPENDIX E TV BROADCASTING CONSULTATION ZONE