Appendix C17

Communications Systems Report

ADDENDUM TO

REPORT ON

ANALYSES OF

WOLFE ISLAND WIND PROJECT

POTENTIAL EFFECTS ON

COMMUNICATIONS SYSTEMS

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1.0 INTRODUCTION

"*Report on Analyses of Wolfe Island Wind Project Potential Effects on Communications Systems*" (The Report), dated 6 July 2007, was prepared in order to consider a situation where various broadcast systems were located very near to, and in fact within, the Canadian Renewable Energy Corporation (CREC) proposed wind plant on Wolfe Island, near Kingston, ON. This could be considered a fairly "unique" situation.

The purpose of this current addendum, is to consider the more general situation, where the wind plant may have potential effects on broadcast systems which are more distant from the plant, but provide programming service to the area. This addendum has been prepared at the request of the Canadian Broadcasting Corporation (CBC), who, as a result of the recent proliferation of wind farms combined with the large number of broadcast facilities operated by the CBC, have developed guidelines for wind farm coordination with broadcasters.

Specifically, this addendum considers FM and TV facilities which provide service to the Kingston area, other than the stations located on Wolfe Island itself, which have been dealt with in The Report.

Details on the Wolfe Island wind turbine plant, and a general discussion of effects on broadcast systems, etc., may be found in The Report.

2.0 FM RADIO ANALYSIS

It is well known that both static and dynamic re-radiation from wind turbine farms is not historically a problem for FM radio. As a result, the general guideline developed by RABC (in conjunction with work done by CBC and B-TAC) [1] is an exclusion zone of 1 km from any turbine.

An Industry Canada database search indicates that there are no FM stations within 1 km of any turbine, other than the stations already considered in The Report.

3.0 TELEVISION ANALYSIS

An Industry Canada database search indicates the following television stations provide service to the area:

CIII-TV-2, Midland, CH2, @ 115 km / 330 Deg
CJOH-TV-6, Desoronto, CH6, @ 50 km / 270 Deg
CBLFT-14, Kingston, CH32, @15 km / 350 Deg
CICO-TV-38, Kingston, CH38, @ 15 km / 350 Deg

These stations are considered in the following analyses.

3.1 STATIC ANALYSIS

For the purposes of analyzing the static reflections from the turbine towers, the analysis uses a proprietary simulation program based on the work of Knight [2], with impairment based on the ITU (International Telecommunication Union) 5-point rating scale as detailed by Industry Canada in [3].

For this analysis we consider a single test turbine tower, considered to be 80 metres high and 5 metres in diameter. Test viewers were located in Kingston, which can be considered representative of general viewer locations on the mainland, and in Marysville, which can be considered the worst-case location since it is the closest population center to the wind turbine plant.

Since static reflections are more severe at UHF than VHF frequencies, we consider impairments to the CBLFT-14/CICO-TV-38 signals (at approximately 600 MHz).

The results of the static analysis computer simulation are given in Table 1.

The variables in the analysis, as given in Table 1, are as follows:

$D_{tx\text{-}ps}$, $AZ_{tx\text{-}ps}$:	Distance (m) and Azimuth (deg) from the transmitter to the turbine tower
$D_{tx\text{-}rx}$, $AZ_{tx\text{-}rx}$:	Distance (m) and Azimuth (deg) from the transmitter to the receiver
U/D:	Relative amplitude of the ghost signal (dB)
Delay:	Relative delay of the ghost signal (usec)
Grade:	ITU impairment grade of the television signal

In general, a minimum impairment grade of 4.0 is the objective, which corresponds to a ghost signal which is “perceptible but not annoying” according to Industry Canada. An impairment grade of 5.0 means no impairment.

It can be seen from Table 1 that no impairment is expected on the mainland. In Marysville, and on the island in general, impairment can be expected when a wind turbine is within 2000 metres of a viewer. Such interference can, however, be mitigated with the use of a proper directional reception antenna.

3.2 DYNAMIC ANALYSIS

For the purposes of analyzing the dynamic rotor reflections, the Sengupta & Senior methodology [4] will be utilized.

For the dynamic analysis, the wind turbine population has been divided into "clusters". A cluster is considered a group of adjacent turbines which operate synchronously, and which are sufficiently close to each other that the illuminating television signal can be considered relatively uniform.

While this exercise is somewhat arbitrary, it is considered to be a compromise between the worst case where all turbines operates synchronously, and the best case where all turbines operate randomly. On inspection of the layout of the wind turbine plant, and attempting to keep the average number of turbines in a cluster at approximately 5, it was decided to base clusters on 750 metre radius circles.

In addition, there are isolated turbines where the cluster is reduced to 500 metre radius and contains 1 – 2 turbines.

The clusters are shown in Figure 1. Each of the 30 clusters has an identifier (#) and associated number of turbines (N).

Receivers (viewers) are again considered in two locations: Kingston and Marysville.

The results of the dynamic analysis are given in Tables 2 - 6.

The equation used for the analysis takes the following form:

$$\mathbf{mr = (Fe\ \eta s\ Be\ Ap) / (\lambda\ D_{ps\text{-}rx})\ \ E_{ps}/E_{rx}\ N\ \cos(k\Phi)\ SQRT(F_{AW})}$$

where the variables are as follows:

mr:	Modulation Ratio on television signal
Fe:	Empirical exceedence factor, = **2.2** for 1% probability
ηs:	Scattering efficiency of rotor blades, = **0.5** for composite material
Be:	Effective number of blades, = **MIN(2, λR/Ap)**
Ap:	Area of rotor (**R** X **W**) (m^2)
R:	Radius of rotor (m)
W:	Width of rotor, averaged to 1 metre
λ:	Television signal wavelength (m)
$\mathbf{D_{ps\text{-}rx}}$:	Distance from the centre of the turbine cluster to the receiver (m)
$\mathbf{E_{ps}/E_{rx}}$:	Field at power station relative to field at receiver, calculated using $\mathbf{D_{tx\text{-}ps}}$ and $\mathbf{D_{tx\text{-}rx}}$
N:	Number of turbines operating synchronously in a cluster
k:	forward/back scatter angular factor
Φ:	transmitter – power station – receiver angle (deg)
$\mathbf{F_{AW}}$:	Receiver antenna power discrimination factor, calculated using $\mathbf{\Phi_A}$**,** the discrimination angle at the receiver antenna

3.2 DYNAMIC ANALYSIS (CONT'D)

The value $\mathbf{F_{AW}}$ is taken from Figure 2, which shows typical television receiver antenna responses [5].

In the above equation the factor "**N**" accounts for the synchronicity of the number of wind turbines in a cluster. To add the cumulative effects of all clusters, they are added in a "power" fashion, or Root Sum Square (RSS).

The target value per Sengupta & Senior [5] is **mr** = 0.15.

The analysis for CBLFT-14/CICO-TV-38 for viewers in Kingston is given in Table 2. In this analysis we have simplified a number of factors, namely $\mathbf{D_{tx\text{-}ps}}$, $\mathbf{\Phi}$, and $\mathbf{\Phi_A}$. Furthermore, while $\mathbf{\Phi_A}$ is approximated as 180 degrees, i.e., the receiver antenna is pointed directly opposite the wind turbine farm, we have set the antenna discrimination at zero, to account for the fact that since Kingston is within the Grade A (city grade) contours of the stations, viewers may use simple indoor antennas which have no discrimination. Since the RSS **mr** is 0.032, no degradation is expected on the mainland.

The analysis for CBLFT-14/CICO-TV-38 for viewers in Marysville is given in Table 3. We have considered two scenarios: viewers using indoor antennas which have no discrimination, and viewers using typical outdoor antennas which have discrimination according to Figure 2. It is noted that in the first case degradation can be expected due to the predicted RSS **mr** of 0.186, while in the second case no degradation is expected with an RSS **mr** of 0.029.

The analysis for CJOH-TV-6 for Kingston (assuming no antenna discrimination since it is within the Grade A) and Marysville is given in Tables 4 and 5, respectively. No degradation is expected.

The analysis for CIII-TV-2 for Kingston is given in Table 6 (no analysis is provided for Marysville since the coverage contour of CIII-TV-2 only extends to Kingston). No degradation is expected.

Note that only two test receiver locations have been considered: Kingston, which is expected to be representative of the overall mainland, and Marysville, which is the population center on Wolfe Island. Obviously the analysis cannot account for every rural viewer on the Island. A general analysis shows, however, that rural viewers near to one or more turbines (i.e., within about 1 km for the UHF stations and 500 metres for the VHF stations), may experience degraded television signals, highly dependent on the specific geometry and reception antenna used.

4.0 CONCLUSIONS

The analyses indicate that no while interference is predicted to television signals on the mainland, areas of Wolfe Island may be subject to interference.

The general results of the static and dynamic analyses have been used to generate the map of Figure 3. This map shows the areas on the island where interference to television signals is possible. It also shows the areas where such interference may be mitigated with the use of a directional reception antenna.

It is somewhat difficult to determine the population in the affected area. 2006 StatsCan Census data gives the overall island population as 1306, with 529 permanent residences and 927 total residences (which would include seasonal cottages etc.). A dwelling count based on the topographic map of Figure 3 puts the number of potential residences affected in the range of 200.

5.0 SIGNATURE

J. Moltner, P.Eng.

6.0 REFERENCES

[1] RABC & CanWEA, *Technical Information and Guidelines on the Assessment of the Potential Impact of Wind Turbines on Radiocommunication, Radar and Seismoacoustic Systems*, April 2007

[2] P. Knight, *Reradiation from masts and similar obstacles at radio frequencies*, Proc. IEE, Vol. 114, No 1, January 1967

[3] Industry Canada, *Broadcast Procedures and Rules – Part 4*, Appendix 7, April 1997

[4] Sengupta and Senior, *Electromagnetic Interference from Wind Turbines*, Wind Turbine Technology, Chapter 9, 1994

[5] Industry Canada, *Broadcast Procedures and Rules – Part 7*, Appendix 7, July 2004

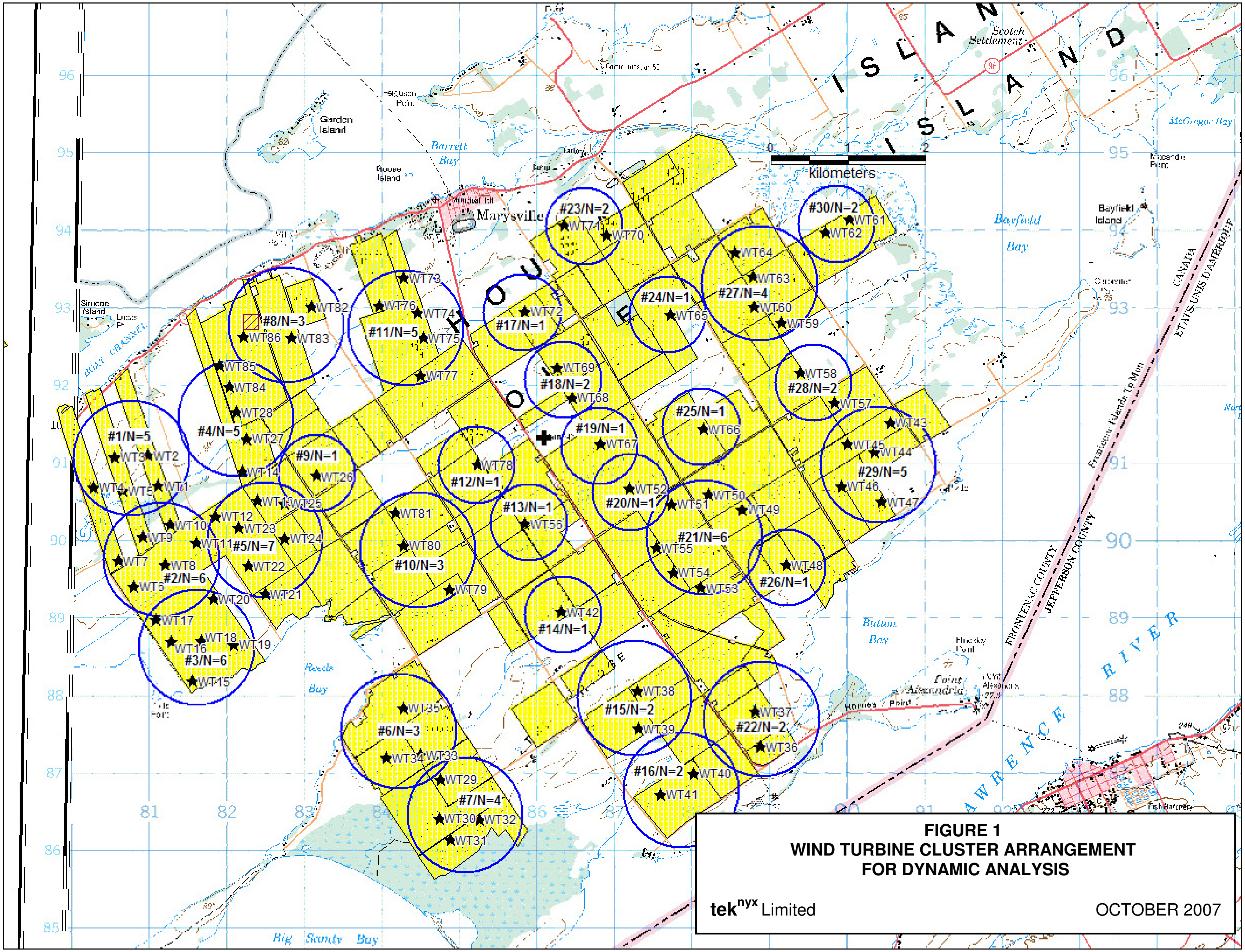

FIGURE 1
WIND TURBINE CLUSTER ARRANGEMENT
FOR DYNAMIC ANALYSIS

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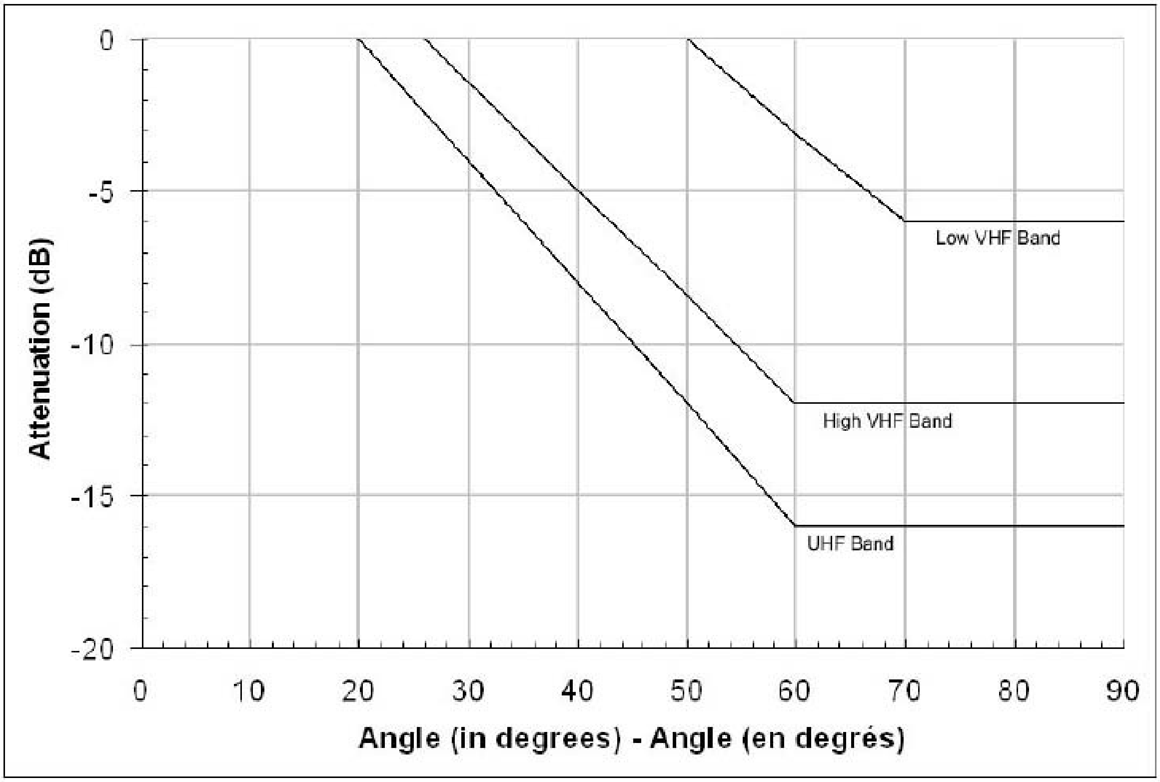

FIGURE 2
TYPICAL TELEVISION ANTENNA PATTERNS

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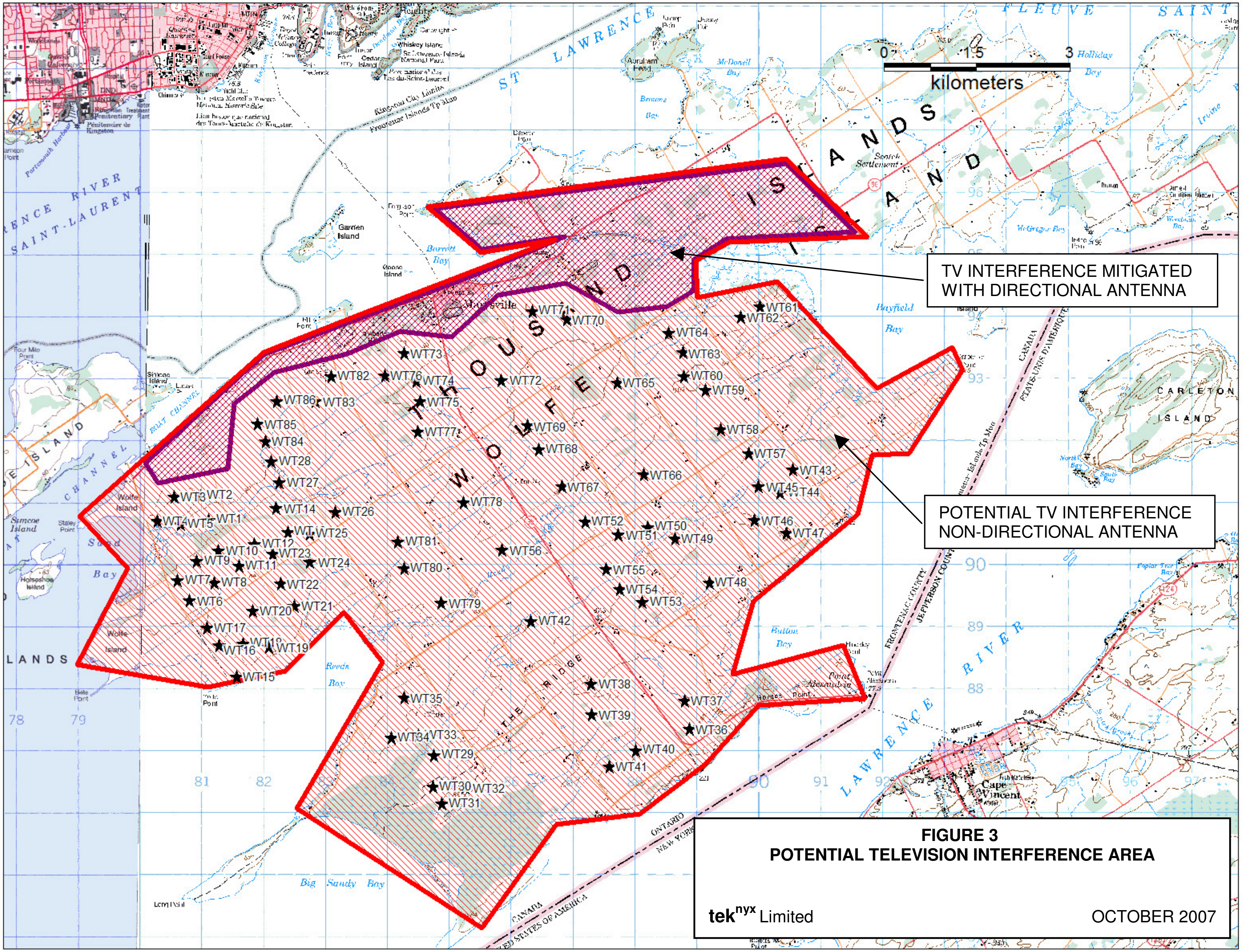

FIGURE 3
POTENTIAL TELEVISION INTERFERENCE AREA

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TABLE 1
TV STATIC ANALYSIS

LOCATION	D_{tx-ps}	Az_{tx-ps}	D_{tx-rx}	AZ_{tx-rx}	U/D	Delay	Grade
	(m)	(deg)	(m)	(deg)	(dB)	(usec)	
Kingston	15000	180	5000	180	-53.0	66.7	5.00
Marysville	12000	180	11000	180	-29.3	6.7	3.61
	12500	180	11000	180	-30.8	10.0	3.78
	13000	180	11000	180	-32.4	13.3	4.00
	13500	180	11000	180	-34.5	16.7	4.29
	14000	180	11000	180	-36.4	20.0	4.55

TABLE 2
TV DYNAMIC ANALYSIS - CBLFT-14/CICO-TV-38 IN KINGSTON

CONSTANT	VALUE
Fe	2.2
Ns	0.5
Be	0.5
R	45
W	1
Ap	45
λ	0.5

LOCATION	CLUSTER	N	D_{tx-ps}	D_{ps-rx}	D_{tx-rx}	E_{ps}/E_{rx}	Φ	k	$Φ_A$	F_{AW}	mr
			(m)	(m)	(m)		(Deg)		(Deg)	(dB)	
KINGSTON	1	5	15000	8400	5000	0.33	0	0.5	180	0	0.010
	2	6	15000	9700	5000	0.33	0	0.5	180	0	0.010
	3	6	15000	10900	5000	0.33	0	0.5	180	0	0.009
	4	5	15000	8000	5000	0.33	0	0.5	180	0	0.010
	5	7	15000	9500	5000	0.33	0	0.5	180	0	0.012
	6	3	15000	12300	5000	0.33	0	0.5	180	0	0.004
	7	4	15000	13650	5000	0.33	0	0.5	180	0	0.005
	8	3	15000	6900	5000	0.33	0	0.5	180	0	0.007
	9	1	15000	8900	5000	0.33	0	0.5	180	0	0.002
	10	3	15000	10200	5000	0.33	0	0.5	180	0	0.005
	11	5	15000	7500	5000	0.33	0	0.5	180	0	0.011
	12	1	15000	9500	5000	0.33	0	0.5	180	0	0.002
	13	1	15000	10500	5000	0.33	0	0.5	180	0	0.002
	14	1	15000	11700	5000	0.33	0	0.5	180	0	0.001
	15	2	15000	13100	5000	0.33	0	0.5	180	0	0.003
	16	2	15000	14400	5000	0.33	0	0.5	180	0	0.002
	17	1	15000	8100	5000	0.33	0	0.5	180	0	0.002
	18	2	15000	9100	5000	0.33	0	0.5	180	0	0.004
	19	1	15000	10100	5000	0.33	0	0.5	180	0	0.002
	20	1	15000	10800	5000	0.33	0	0.5	180	0	0.002
	21	6	15000	11800	5000	0.33	0	0.5	180	0	0.008
	22	2	15000	14200	5000	0.33	0	0.5	180	0	0.002
	23	2	15000	7800	5000	0.33	0	0.5	180	0	0.004
	24	1	15000	9350	5000	0.33	0	0.5	180	0	0.002
	25	1	15000	10700	5000	0.33	0	0.5	180	0	0.002
	26	1	15000	12700	5000	0.33	0	0.5	180	0	0.001
	27	4	15000	10000	5000	0.33	0	0.5	180	0	0.007
	28	2	15000	11300	5000	0.33	0	0.5	180	0	0.003
	29	5	15000	12700	5000	0.33	0	0.5	180	0	0.006
	30	2	15000	10400	5000	0.33	0	0.5	180	0	0.003
							RSS mr				**0.032**

TABLE 3
TV DYNAMIC ANALYSIS - CBLFT-14/CICO-TV-38 IN MARYSVILLE

CONSTANT	VALUE
Fe	2.2
Ns	0.5
Be	0.5
R	45
W	1
Ap	45
λ	0.5

LOCATION	CLUSTER	N	D_{tx-ps} (m)	D_{ps-rx} (m)	D_{tx-rx} (m)	E_{ps}/E_{rx}	Φ (Deg)	k	$Φ_A$ (Deg)	F_{AW} (dB)	mr
MARYSVILLE	1	5	14000	5400	11000	0.79	50	0.5	110	0	0.033
(NO RX ANT DISC)	2	6	15000	6000	11000	0.73	40	0.5	130	0	0.034
	3	6	16000	6650	11000	0.69	30	0.5	140	0	0.030
	4	5	13500	4000	11000	0.81	50	0.5	120	0	0.046
	5	7	15000	5000	11000	0.73	30	0.5	140	0	0.049
	6	3	18000	6850	11000	0.61	15	0.5	160	0	0.013
	7	4	19000	7900	11000	0.58	10	0.5	170	0	0.014
	8	3	12000	2700	11000	0.92	50	0.5	100	0	0.046
	9	1	14000	3950	11000	0.79	30	0.5	140	0	0.010
	10	3	15000	4500	11000	0.73	15	0.5	160	0	0.024
	11	5	12000	1750	11000	0.92	40	0.5	140	0	0.122
	12	1	14500	3350	11000	0.76	10	0.5	170	0	0.011
	13	1	15000	4200	11000	0.73	5	0.5	180	0	0.009
	14	1	16500	5500	11000	0.67	0	0.5	180	0	0.006
	15	2	18000	6800	11000	0.61	0	0.5	180	0	0.009
	16	2	19000	8100	11000	0.58	0	0.5	180	0	0.007
	17	1	12000	1600	11000	0.92	5	0.5	170	0	0.028
	18	2	13000	2650	11000	0.85	10	0.5	170	0	0.031
	19	1	14000	3600	11000	0.79	10	0.5	170	0	0.011
	20	1	15000	4300	11000	0.73	10	0.5	170	0	0.008
	21	6	16000	5350	11000	0.69	15	0.5	160	0	0.038
	22	2	19000	7700	11000	0.58	10	0.5	170	0	0.007
	23	2	12000	1650	11000	0.92	50	0.5	120	0	0.050
	24	1	13500	3000	11000	0.81	35	0.5	130	0	0.013
	25	1	15000	4200	11000	0.73	20	0.5	150	0	0.009
	26	1	17000	6300	11000	0.65	15	0.5	155	0	0.005
	27	4	13500	4000	11000	0.81	45	0.5	120	0	0.037
	28	2	15000	5100	11000	0.73	30	0.5	130	0	0.014
	29	5	16500	6300	11000	0.67	25	0.5	135	0	0.026
	30	2	13500	4850	11000	0.81	50	0.5	110	0	0.015
							RSS mr				**0.186**

MARYSVILLE	1	5	14000	5400	11000	0.79	50	0.5	110	-16	0.005
(WITH RX ANT DISC)	2	6	15000	6000	11000	0.73	40	0.5	130	-16	0.005
	3	6	16000	6650	11000	0.69	30	0.5	140	-16	0.005
	4	5	13500	4000	11000	0.81	50	0.5	120	-16	0.007
	5	7	15000	5000	11000	0.73	30	0.5	140	-16	0.008
	6	3	18000	6850	11000	0.61	15	0.5	160	-16	0.002
	7	4	19000	7900	11000	0.58	10	0.5	170	-16	0.002
	8	3	12000	2700	11000	0.92	50	0.5	100	-16	0.007
	9	1	14000	3950	11000	0.79	30	0.5	140	-16	0.002
	10	3	15000	4500	11000	0.73	15	0.5	160	-16	0.004
	11	5	12000	1750	11000	0.92	40	0.5	140	-16	0.019
	12	1	14500	3350	11000	0.76	10	0.5	170	-16	0.002
	13	1	15000	4200	11000	0.73	5	0.5	180	-16	0.001
	14	1	16500	5500	11000	0.67	0	0.5	180	-16	0.001
	15	2	18000	6800	11000	0.61	0	0.5	180	-16	0.001
	16	2	19000	8100	11000	0.58	0	0.5	180	-16	0.001
	17	1	12000	1600	11000	0.92	5	0.5	170	-16	0.004
	18	2	13000	2650	11000	0.85	10	0.5	170	-16	0.005
	19	1	14000	3600	11000	0.79	10	0.5	170	-16	0.002
	20	1	15000	4300	11000	0.73	10	0.5	170	-16	0.001
	21	6	16000	5350	11000	0.69	15	0.5	160	-16	0.006
	22	2	19000	7700	11000	0.58	10	0.5	170	-16	0.001
	23	2	12000	1650	11000	0.92	50	0.5	120	-16	0.008
	24	1	13500	3000	11000	0.81	35	0.5	130	-16	0.002
	25	1	15000	4200	11000	0.73	20	0.5	150	-16	0.001
	26	1	17000	6300	11000	0.65	15	0.5	155	-16	0.001
	27	4	13500	4000	11000	0.81	45	0.5	120	-16	0.006
	28	2	15000	5100	11000	0.73	30	0.5	130	-16	0.002
	29	5	16500	6300	11000	0.67	25	0.5	135	-16	0.004
	30	2	13500	4850	11000	0.81	50	0.5	110	-16	0.002
							RSS mr				**0.029**

TABLE 4
TV DYNAMIC ANALYSIS - CJOH-TV-6 IN KINGSTON

CONSTANT	VALUE
Fe	2.2
Ns	0.5
Be	2.0
R	45
W	1
Ap	45
λ	3.7

LOCATION	CLUSTER	N	D_{tx-ps}	D_{ps-rx}	D_{tx-rx}	E_{ps}/E_{rx}	Φ	k	$Φ_A$	F_{AW}	mr
			(m)	(m)	(m)		(Deg)		(Deg)	(dB)	
KINGSTON	1	5	50000	8400	50000	1.00	60	0.5	90	0	0.014
	2	6	50000	9700	50000	1.00	60	0.5	90	0	0.014
	3	6	50000	10900	50000	1.00	60	0.5	90	0	0.013
	4	5	50000	8000	50000	1.00	60	0.5	90	0	0.015
	5	7	50000	9500	50000	1.00	60	0.5	90	0	0.017
	6	3	50000	12300	50000	1.00	60	0.5	90	0	0.006
	7	4	50000	13650	50000	1.00	60	0.5	90	0	0.007
	8	3	50000	6900	50000	1.00	60	0.5	90	0	0.010
	9	1	50000	8900	50000	1.00	60	0.5	90	0	0.003
	10	3	50000	10200	50000	1.00	60	0.5	90	0	0.007
	11	5	50000	7500	50000	1.00	60	0.5	90	0	0.016
	12	1	50000	9500	50000	1.00	60	0.5	90	0	0.002
	13	1	50000	10500	50000	1.00	60	0.5	90	0	0.002
	14	1	50000	11700	50000	1.00	60	0.5	90	0	0.002
	15	2	50000	13100	50000	1.00	60	0.5	90	0	0.004
	16	2	50000	14400	50000	1.00	60	0.5	90	0	0.003
	17	1	50000	8100	50000	1.00	60	0.5	90	0	0.003
	18	2	50000	9100	50000	1.00	60	0.5	90	0	0.005
	19	1	50000	10100	50000	1.00	60	0.5	90	0	0.002
	20	1	50000	10800	50000	1.00	60	0.5	90	0	0.002
	21	6	50000	11800	50000	1.00	60	0.5	90	0	0.012
	22	2	50000	14200	50000	1.00	60	0.5	90	0	0.003
	23	2	50000	7800	50000	1.00	60	0.5	90	0	0.006
	24	1	50000	9350	50000	1.00	60	0.5	90	0	0.003
	25	1	50000	10700	50000	1.00	60	0.5	90	0	0.002
	26	1	50000	12700	50000	1.00	60	0.5	90	0	0.002
	27	4	50000	10000	50000	1.00	60	0.5	90	0	0.009
	28	2	50000	11300	50000	1.00	60	0.5	90	0	0.004
	29	5	50000	12700	50000	1.00	60	0.5	90	0	0.009
	30	2	50000	10400	50000	1.00	60	0.5	90	0	0.005
							RSS mr				**0.045**

TABLE 5
TV DYNAMIC ANALYSIS - CJOH-TV-6 IN MARYSVILLE

CONSTANT	VALUE
Fe	2.2
Ns	0.5
Be	2.0
R	45
W	1
Ap	45
λ	3.7

LOCATION	CLUSTER	N	D_{tx-ps}	D_{ps-rx}	D_{tx-rx}	E_{ps}/E_{rx}	Φ	k	$Φ_A$	F_{AW}	mr
			(m)	(m)	(m)		(Deg)		(Deg)	(dB)	
MARYSVILLE	1	5	50000	5400	50000	1.00	140	0.5	30	0	0.009
	2	6	50000	6000	50000	1.00	130	0.5	45	0	0.011
	3	6	50000	6650	50000	1.00	120	0.5	55	-2	0.010
	4	5	50000	4000	50000	1.00	140	0.5	40	0	0.012
	5	7	50000	5000	50000	1.00	120	0.5	55	-2	0.015
	6	3	50000	6850	50000	1.00	90	0.5	80	-6	0.004
	7	4	50000	7900	50000	1.00	90	0.5	85	-6	0.005
	8	3	50000	2700	50000	1.00	150	2	30	0	0.015
	9	1	50000	3950	50000	1.00	120	0.5	55	-2	0.003
	10	3	50000	4500	50000	1.00	100	0.5	80	-6	0.006
	11	5	50000	1750	50000	1.00	115	0.5	60	-3	0.029
	12	1	50000	3350	50000	1.00	90	0.5	90	-6	0.003
	13	1	50000	4200	50000	1.00	80	0.5	100	-6	0.002
	14	1	50000	5500	50000	1.00	80	0.5	100	-6	0.002
	15	2	50000	6800	50000	1.00	70	0.5	105	-6	0.003
	16	2	50000	8100	50000	1.00	70	0.5	105	-6	0.003
	17	1	50000	1600	50000	1.00	70	0.5	115	-6	0.007
	18	2	50000	2650	50000	1.00	60	0.5	115	-6	0.009
	19	1	50000	3600	50000	1.00	60	0.5	115	-6	0.003
	20	1	50000	4300	50000	1.00	60	0.5	115	-6	0.003
	21	6	50000	5350	50000	1.00	55	0.5	120	-6	0.013
	22	2	50000	7700	50000	1.00	60	0.5	115	-6	0.003
	23	2	50000	1650	50000	1.00	15	0.5	170	-6	0.016
	24	1	50000	3000	50000	1.00	30	0.5	150	-6	0.004
	25	1	50000	4200	50000	1.00	45	0.5	130	-6	0.003
	26	1	50000	6300	50000	1.00	50	0.5	125	-6	0.002
	27	4	50000	4000	50000	1.00	20	0.5	160	-6	0.013
	28	2	50000	5100	50000	1.00	30	0.5	150	-6	0.005
	29	5	50000	6300	50000	1.00	30	0.5	140	-6	0.010
	30	2	50000	4850	50000	1.00	10	0.5	170	-6	0.006
							RSS mr				**0.053**

TABLE 6
TV DYNAMIC ANALYSIS - CIII-TV-2 IN KINGSTON

CONSTANT	VALUE
Fe	2.2
Ns	0.5
Be	2.0
R	45
W	1
Ap	45
λ	5.6

LOCATION	CLUSTER	N	D_{tx-ps}	D_{ps-rx}	D_{tx-rx}	E_{ps}/E_{rx}	Φ	k	$Φ_A$	F_{AW}	mr
			(m)	(m)	(m)		(Deg)		(Deg)	(dB)	
KINGSTON	1	5	115000	8400	105000	0.91	0	0.5	180	-6	0.005
	2	6	115000	9700	105000	0.91	0	0.5	180	-6	0.005
	3	6	115000	10900	105000	0.91	0	0.5	180	-6	0.004
	4	5	115000	8000	105000	0.91	0	0.5	180	-6	0.005
	5	7	115000	9500	105000	0.91	0	0.5	180	-6	0.006
	6	3	115000	12300	105000	0.91	0	0.5	180	-6	0.002
	7	4	115000	13650	105000	0.91	0	0.5	180	-6	0.002
	8	3	115000	6900	105000	0.91	0	0.5	180	-6	0.004
	9	1	115000	8900	105000	0.91	0	0.5	180	-6	0.001
	10	3	115000	10200	105000	0.91	0	0.5	180	-6	0.002
	11	5	115000	7500	105000	0.91	0	0.5	180	-6	0.005
	12	1	115000	9500	105000	0.91	0	0.5	180	-6	0.001
	13	1	115000	10500	105000	0.91	0	0.5	180	-6	0.001
	14	1	115000	11700	105000	0.91	0	0.5	180	-6	0.001
	15	2	115000	13100	105000	0.91	0	0.5	180	-6	0.001
	16	2	115000	14400	105000	0.91	0	0.5	180	-6	0.001
	17	1	115000	8100	105000	0.91	0	0.5	180	-6	0.001
	18	2	115000	9100	105000	0.91	0	0.5	180	-6	0.002
	19	1	115000	10100	105000	0.91	0	0.5	180	-6	0.001
	20	1	115000	10800	105000	0.91	0	0.5	180	-6	0.001
	21	6	115000	11800	105000	0.91	0	0.5	180	-6	0.004
	22	2	115000	14200	105000	0.91	0	0.5	180	-6	0.001
	23	2	115000	7800	105000	0.91	0	0.5	180	-6	0.002
	24	1	115000	9350	105000	0.91	0	0.5	180	-6	0.001
	25	1	115000	10700	105000	0.91	0	0.5	180	-6	0.001
	26	1	115000	12700	105000	0.91	0	0.5	180	-6	0.001
	27	4	115000	10000	105000	0.91	0	0.5	180	-6	0.003
	28	2	115000	11300	105000	0.91	0	0.5	180	-6	0.001
	29	5	115000	12700	105000	0.91	0	0.5	180	-6	0.003
	30	2	115000	10400	105000	0.91	0	0.5	180	-6	0.002
							RSS mr				**0.016**

REPORT ON

ANALYSES OF

WOLFE ISLAND WIND PROJECT

POTENTIAL EFFECTS ON

COMMUNICATIONS SYSTEMS

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EXECUTIVE SUMMARY

Canadian Renewable Energy Corporation’s proposed wind plant on Wolfe Island will be located in proximity to various broadcast facilities, comprising various Studio-to-Transmitter Links (STLs), two AM and two FM radio transmitters, and one Television transmitter. There is a possibility of interference from the wind turbines to these communications systems.

This report provides analyses on the potential for interference to the subject communications systems, using industry-recognized modeling methodologies. It also provides general guidelines in terms interference-mitigation techniques which may be employed.

The analyses find that there is negligible predicted impact on the STLs and the FM radio. No impact on the AM radio stations is expected assuming their pending conversions from AM to FM are approved by the CRTC in the near future. There is a potential dynamic ghosting impact to the Television station (CKWS-TV) with respect to viewers on Wolfe Island.

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REPORT ON

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1.0 INTRODUCTION

Canadian Renewable Energy Corporation (CREC) is proposing a wind plant on Wolfe Island, near Kingston, ON. The plant will consist of 86 2.3 MW wind turbines located on various optioned lands on the western half of the Island.

The wind turbines will be located in proximity to various broadcast facilities. These consist of the following:

- CFFX, AM station 960 kHz, operated by Corus Entertainment Inc. (Corus)
- CKLC, AM station 1380 kHz, operated by Chum Limited (Chum)

- CKWS-TV, TV station channel 11, operated by Corus

- CFMK-FM, FM station 96.3 MHz, operated by Corus
- CIKR-FM, FM station 105.7 MHz, operated by K-Rock 1057 Inc.

- Studio-to-Transmitter-Links (STLs) from the mainland to the above broadcast stations, operating in the 450 MHz, 950 MHz, and 6 GHz bands

There is potential concern of interference from the wind turbines to the above communications systems.

The purpose of this report is to analyse the potential for interference to the subject communications systems. Where a potential for interference is identified, the specific wind turbines are identified. Interference-mitigation techniques which may be employed are also discussed.

2.0 PARAMETERS AND GENERAL CONSIDERATIONS

The wind turbines will be Siemens Mark II 2.3 MW horizontal axis units. Each of the three blades will be 45 metres in length, with a metal support tower of approximately 5 metre diameter and 80 metre height. The blades will be constructed of non-metallic composite materials, but will have some type of conductors running their length for lightning protection.

The wind farm layout, substantially finalized as of the date of this report, is shown in Figure 1. The turbines are labeled “WTx”, where “x” ranges from 1 to 86.

The locations of the two AM stations, and an existing 300 metre tower which supports the FM and TV antennas, are also shown in Figure 1.

In addition, a 34.5/230 KV substation is proposed approximately 700 metres west of the CFFX array.

Data relating to turbine dimensions, preliminary layout, and optioned lands, was obtained from CREC. Data pertaining to the broadcast facilities was obtained from the Industry Canada Broadcasting Database and from Corus.

A brief layman explanation of how the subject communications systems operate and how the wind turbines can affect them is provided below.

2.1 BROADCAST SYSTEMS

The common element among the various types of broadcast systems (AM, FM and TV) on the Island are the STLs. These are microwave systems which transmit the programming signals from the studios (in downtown Kingston in the current case) to the transmitter sites on the Island. The antennas used for STLs are typically parabolic dishes. The signal can be considered a “beam” between the transmit antenna at the studio and the receive antenna at the Island transmitter site.

Once the programming signal is received at the transmitter site, it is processed and amplified and sent to the transmit antenna to be broadcast to the public. In most cases the antenna is “directional”, which means it transmits more signal towards the audience (north to the mainland), and less signal towards unpopulated areas (south towards Lake Ontario). Another reason for using a directional antenna is to protect distant stations on the same frequency or channel from interference. While the above applies generally to AM, FM and TV antennas, the way the antennas are constructed are radically different.

For FM and TV signals, the antennas are relatively compact devices which can be mounted on a single tower. Since the signals propagate through the atmosphere, it is desirable to mount the antenna as high as possible in order to maximize the distance the signal reaches, i.e., the “coverage”.

2.1 BROADCAST SYSTEMS (CONT'D)

For AM radio signals, the antenna takes the form of a "tower array", which is a number (typically 2 – 12) of short towers arranged in some geometrical fashion on a large plot of land. Note that while FM and TV antennas are mounted on a tall tower, for AM radio the towers themselves are the antenna. Further, unlike FM and TV signals, AM signals propagate along the surface of the earth and therefore the antenna is mounted on the ground.

2.2 WIND TURBINE EFFECTS

Any large metallic structure (wind turbines, cellular towers, hydro towers, etc.) can affect communications systems. The effects can be divided into 1) blockage, and 2) reradiation (reflection).

For STLs, the predominant effect is that of blockage, i.e., the wind turbine blocks the signal from reaching the receive antenna if it is located within the microwave "beam".

For TV, the effects are predominantly due to reradiation, which can be considered as the original signal "bouncing" off of the wind turbine. The reradiated signal arrives at the viewer along with the original signal, and causes a "ghost" (a replica of the original television image displaced to the right by a small distance), and/or a pulsating image. TV interference effects are therefore "sensory" (visible).

For AM radio, the effects are again due to reradiation, however, they are not sensory (audible) but rather cause distortions in the station's directional antenna pattern which can put the station out of compliance with its Industry Canada license.

For FM radio, the signal itself is very robust against interference and FM radio is therefore considered substantially immune from wind turbine interference.

3.0 STUDIO-TO-TRANSMITTER LINK ANALYSIS

The locations of the STL antennas, the microwave paths, and the frequencies are shown in Figure 2.

It will be noted that no turbines are proposed to be sited in the paths of the two AM STLs. Although WT82 is very close to the STL receiver of CFFX, this STL will likely be moved to the TV/FM tower (See Section 6.0 for rationale).

For the FM and TV STLs, clearance criteria are more stringent for the lower frequencies, so we consider the 950 MHz systems (versus the 6 GHz system). A common industry guideline is that no wind turbine should be sited within 3 Fresnel zones of the microwave beam. For the current case, where the path length is approximately 10 km, and the distance to furthest turbine is approximately 3 km, this yields a required clearance of 75 metres from the microwave beam. Adding the blade length of 45 metres, a total clearance of 110 metres is required.

These clearance zones are shown as dashed lines in Figure 2. It is apparent that all wind turbines are outside of the recommended clearance zones.

4.0 TELEVISION ANALYSIS

CKWS-TV operates on channel 11 from the Corus Wolfe Island tower. The antenna is located at 295 metres above ground. It is a 12-bay directional system, with the horizontal and vertical radiation patterns shown in Figures 3 and 4, respectively.

Television signals can be scattered by metallic and semi-metallic structures, causing impairments in the video which may be objectionable to some viewers. In the current case there are two mechanisms to consider.

The first is traditional static scattering, which would result from the signal being reflected by the stationary turbine tower. The reflected signal causes a “ghost” in the television signal. The perceived impairment is dependent on both the magnitude and delay of the reflected signal. The higher the magnitude and delay of the reflection, the worse the impairment.

The second mechanism, which is unique to wind turbines, is the time-varying dynamic reflections from the rotating rotor blades, which cause a pulsing in the video image. The impairment is again dependent on the magnitude of the reflections, but has less dependence on the relative delay.

For the purposes of analyzing the static reflections from the turbine towers, the analysis uses a proprietary simulation program based on the work of Knight [1], with impairment based on the ITU (International Telecommunication Union) 5-point rating scale as detailed by Industry Canada in [2].

For the purposes of analyzing the dynamic rotor reflections, there are three available methodologies [3,4,5]. For this analysis the Sengupta & Senior methodology [5] will be utilized, since it is the most scientific and complete and also accounts for the effects of multiple wind turbines.

4.1 STATIC ANALYSIS

The results of the static analysis computer simulation are given in Table 1.

For this analysis we consider a single test turbine tower, considered to be 80 metres high and 5 metres in diameter. It was located in steps between 500 and 3000 metres from the TV tower, at two selected azimuths designed to maximize the magnitude and delay of the ghost signals at the test viewer locations. Test viewers were located in Kingston, which can be considered representative of general viewer locations on the mainland, and in Marysville, which can be considered the worst-case location since it is the closest population center to the wind turbine plant.

The variables in the analysis, as given in Table 1, are as follows:

$\mathbf{D_{tx\text{-}ps}}$, $\mathbf{AZ_{tx\text{-}ps}}$:	Distance (m) and Azimuth (deg) from the transmitter to the turbine tower
$\mathbf{D_{tx\text{-}rx}}$, $\mathbf{AZ_{tx\text{-}rx}}$:	Distance (m) and Azimuth (deg) from the transmitter to the receiver
$\mathbf{ANT_{ps}}$:	Relative antenna pattern towards turbine tower
$\mathbf{ANT_{rx}}$:	Relative antenna pattern towards receiver
U/D:	Relative amplitude of the ghost signal (dB)
Delay:	Relative delay of the ghost signal (usec)
Grade:	ITU impairment grade of the television signal

In general, a minimum impairment grade of 4.0 is the objective, which corresponds to a ghost signal which is “perceptible but not annoying” according to Industry Canada. An impairment grade of 5.0 means no impairment.

It can be seen from Table 1 that none of the scenarios produce any degradation, that is, the impairment grade is a perfect 5.0. This is a consequence of the fact that the TV antenna is so high above the turbine tower, there is not sufficient illumination to cause an appreciable ghost signal.

4.2 DYNAMIC ANALYSIS

For the dynamic analysis, the wind turbine population has been divided into "clusters". A cluster is considered a group of adjacent turbines which operate synchronously, and which are sufficiently close to each other that the illuminating television signal can be considered relatively uniform.

While this exercise is somewhat arbitrary, it is considered to be a compromise between the worst case where all turbines operates synchronously, and the best case where all turbines operate randomly. On inspection of the layout of the wind turbine plant, and attempting to keep the average number of turbines in a cluster at approximately 5, it was decided to base clusters on 750 metre radius circles.

In addition, there are isolated turbines where the cluster is reduced to 500 metre radius and contains 1 – 2 turbines.

The clusters are shown in Figure 5. Each of the 30 clusters has an identifier (#) and associated number of turbines (N).

Receivers (viewers) are again considered in two locations: Kingston and Marysville.

The results of the dynamic analysis are given in Table 2.

The equation used for the analysis takes the following form:

$$\mathbf{mr = (Fe\ \eta s\ Be\ Ap) / (\lambda\ D_{ps\text{-}rx})\ E_{ps}/E_{rx}\ N\ \cos(k\Phi)\ SQRT(F_{AW})}$$

where the variables are as follows:

mr:	Modulation Ratio on television signal
Fe:	Empirical exceedence factor, = **2.2** for 1% probability
ηs:	Scattering efficiency of rotor blades, = **0.5** for composite material
Be:	Effective number of blades, = **MIN(2, λR/Ap)**
Ap:	Area of rotor (**R** X **W**) (m^2)
R:	Radius of rotor (m)
W:	Width of rotor, averaged to 1 metre
λ:	Wavelength at CH11 (m)
$\mathbf{D_{ps\text{-}rx}}$:	Distance from the centre of the turbine cluster to the receiver (m)
$\mathbf{E_{ps}/E_{rx}}$:	Field at power station relative to field at receiver
N:	Number of turbines operating synchronously in a cluster
k:	forward/back scatter angular factor
Φ:	transmitter – power station – receiver angle (deg)
$\mathbf{F_{AW}}$:	Receiver antenna discrimination, = **1** for the current case where discrimination between transmitter/wind plant is negligible

Other variables which appear in Table 2 are used to calculate the factor $\mathbf{E_{ps}/E_{rx}}$, and are as follows:

$\mathbf{D/AZ/EL_{tx\text{-}ps}}$:	Distance, Azimuth, Elevation angle from the transmitter to the centre of the turbine cluster
$\mathbf{D/AZ/EL_{tx\text{-}rx}}$:	Distance, Azimuth, Elevation angle from the transmitter to the receiver (viewer)
$\mathbf{ANT_{ps}}$:	Relative antenna pattern towards power station
$\mathbf{ANT_{rx}}$:	Relative antenna pattern towards receiver

4.2 DYNAMIC ANALYSIS (CONT'D)

The last two variables are the combined horizontal and vertical transmitting antenna pattern factors, and are taken from Figures 3 and 4.

In the above equation the factor "**N**" accounts for the synchronicity of the number of wind turbines in a cluster. To add the cumulative effects of all clusters, they are added in a "power" fashion, or Root Sum Square (RSS).

The target value per Sengupta & Senior [5] is **mr** = 0.15.

As Table 2 indicates, the RSS **mr** in Kingston is 0.104, which meets the target and therefore unacceptable degradation to the CKWS-TV signal is not expected on the mainland.

In Marysville, however, the RSS **mr** is 0.309, which is well above the target. In order to reduce the degradation to the target value, wind turbines in clusters 1,2,4,5,8,11 and17 would need to be relocated.

These results are naturally sensitive to the clustering arrangement, which as noted is somewhat arbitrary. It may be generalized however, that any turbines located in the northern area shown in Figure 6 will contribute significantly to degradation in Marysville.

Note that only two test receiver locations have been considered: Kingston, which is expected to be representative of the overall mainland, and Marysville, which is the population center on Wolfe Island. Obviously the analysis cannot account for every rural viewer on the Island. A general analysis shows, however, that rural viewers near to one or more turbines (i.e., within about 1.5-2.5 km), may also have a degraded CKWS-TV signal.

5.0 FM RADIO ANALYSIS

The FM antenna shared by CFMK-FM and CIKR-FM is located at 232 metres above ground. It is an 8-bay directional system, with the horizontal and vertical radiation patterns shown in Figures 7 and 8, respectively.

It is well known that static re-radiation is much less problematic for FM signals than television signals. Furthermore, dynamic interference has only been simulated under laboratory conditions, with no known cases of wind turbine farms causing problems.

Given that the horizontal pattern is very similar to the CKWS-TV pattern, the vertical pattern is slightly less directional, and the antenna is somewhat lower on the tower, it is expected that wind turbine illumination would be slightly higher than for the television case, but certainly in the same general range.

FM radio interference is not expected to be a problem.

6.0 AM RADIO ANALYSIS

Pursuant to CRTC Broadcasting Notice of Public Hearing 2007-6, both CFFX and CKLC have applied to the CRTC to “flip” these AM stations to FM. While the outcome of these applications will not be known for some time, it is assumed for the purposes of this report, that both stations will be approved.

CFFX will combine into the antenna used by CFMK-FM and CIKR-FM, and therefore the analysis of Section 5.0 applies.

CKLC will implement a new antenna on a new tower at its existing AM site. Since this site is well north of the wind turbine farm, no degradation is expected to the FM signal.

7.0 INTERFERENCE MITIGATION CONCEPTS - TELEVISION

There are four methods to mitigate the potential interference to the television signal.

The first option is to install at the receiver a highly directional antenna which suppresses the reradiated signals from the turbine plant. In the current case, since the wind plant covers such a large area, including the area of the television transmitting site itself, this is not possible.

The second option is to provide affected viewers with an ExpressVu or StarChoice type of satellite service. StarChoice currently carries CKWS-TV.

The third option is to install a small CATV system to service the residents. The CATV system would gather off-air and satellite signals at a master “headend” location and deliver them to residents via cable. Since the interfered-with television signal is now received at only a single location, it is easier to mitigate the interference, for example, by providing a direct (cable or fibre) feed to the headend from the studio or transmitter site.

The final option is to move the transmitting antenna to a more northerly location on the Island such that the wind plant is within the antenna pattern “null”. This is obviously an expensive proposition.

8.0 CONCLUSIONS

The results of the analyses can be summarized as follows.

STLs

No impact on the STLs is predicted.

CKWS-TV

No impact to the CKWS-TV signal on the mainland is predicted. Degradation can be expected to viewers in Marysville as a result of the turbines located in the areas identified in Figure 6. Various locations in the rural parts of Wolfe Island can also expect degradation, particularly those near to a wind turbine (i.e., within 1.5-2.5 km).

CFMK-FM/CIKR-FM

No degradation to the FM radio signals is expected.

CKLC AM/CFFX AM

Assuming these services are approved by the CRTC to flip to FM, no impact on them is expected.

Other considerations should be noted.

- The current analysis has considered potential effects on the Wolfe Island broadcast facilities only. No account has been taken of other radio communications facilities, such as cellular, land mobile, utilities etc, nor on mainland facilities.
- The analysis has not accounted for electrical noise which may be generated by the wind turbines, transmission lines and substation, and which can affect AM signals in particular (although the effects are limited to the immediate vicinity of the electrical noise source).
- It must be noted that the analyses contained herein are theoretical and based on many assumptions. While the analyses have attempted to lean towards “worst-case but realistic” conditions in order to generate conservative results, actual effects can vary considerably, both on the positive and negative side. Therefore the results should be considered guidelines only.

9.0 REFERENCES

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[2] Industry Canada, *Broadcast Procedures and Rules – Part 4*, Appendix 7, April 1997

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[4] Salema, Fernandes and Fauro, *TV Interference from Wind Turbines*, Publication Unknown

[5] Sengupta and Senior, *Electromagnetic Interference from Wind Turbines*, Wind Turbine Technology, Chapter 9, 1994

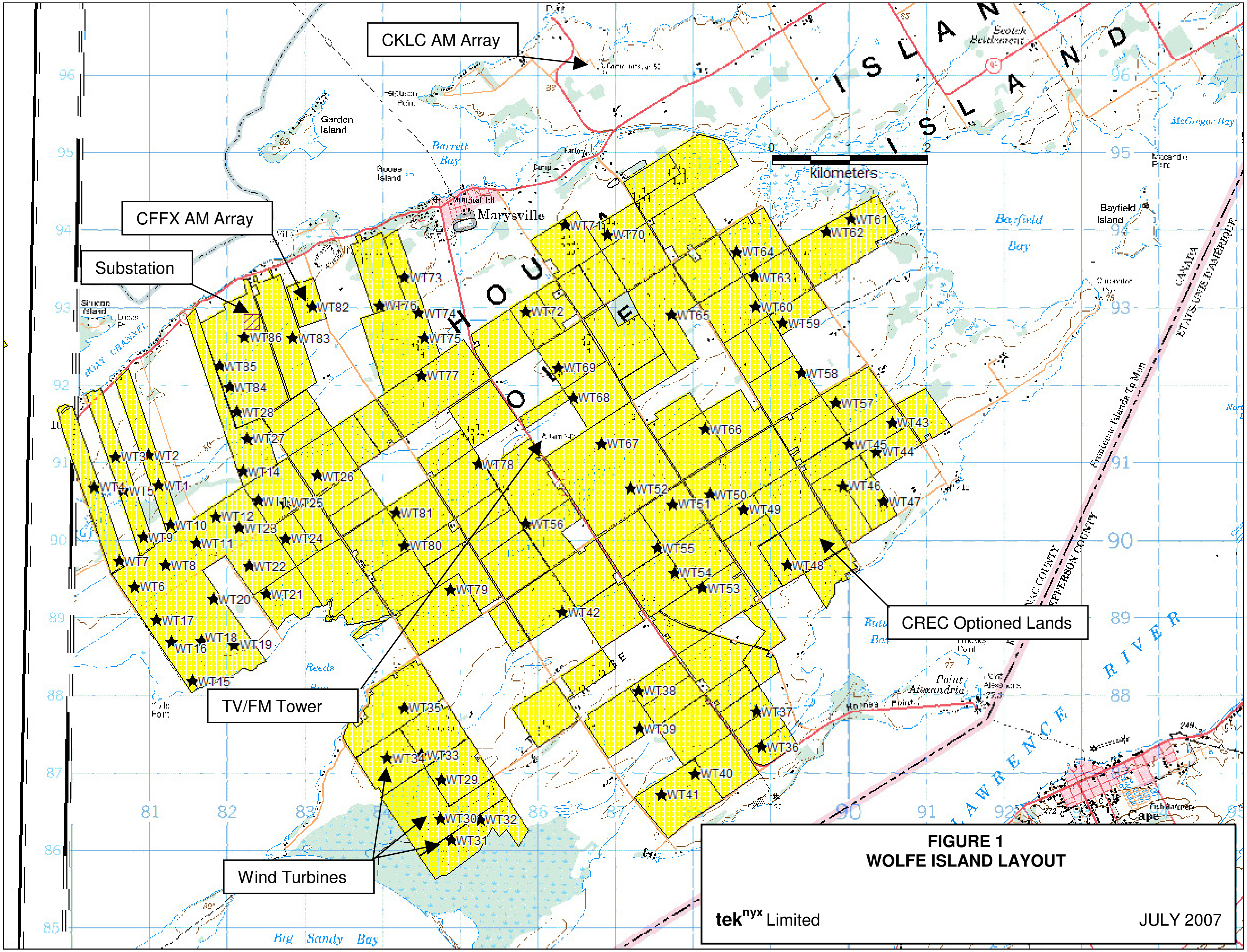

FIGURE 1
WOLFE ISLAND LAYOUT

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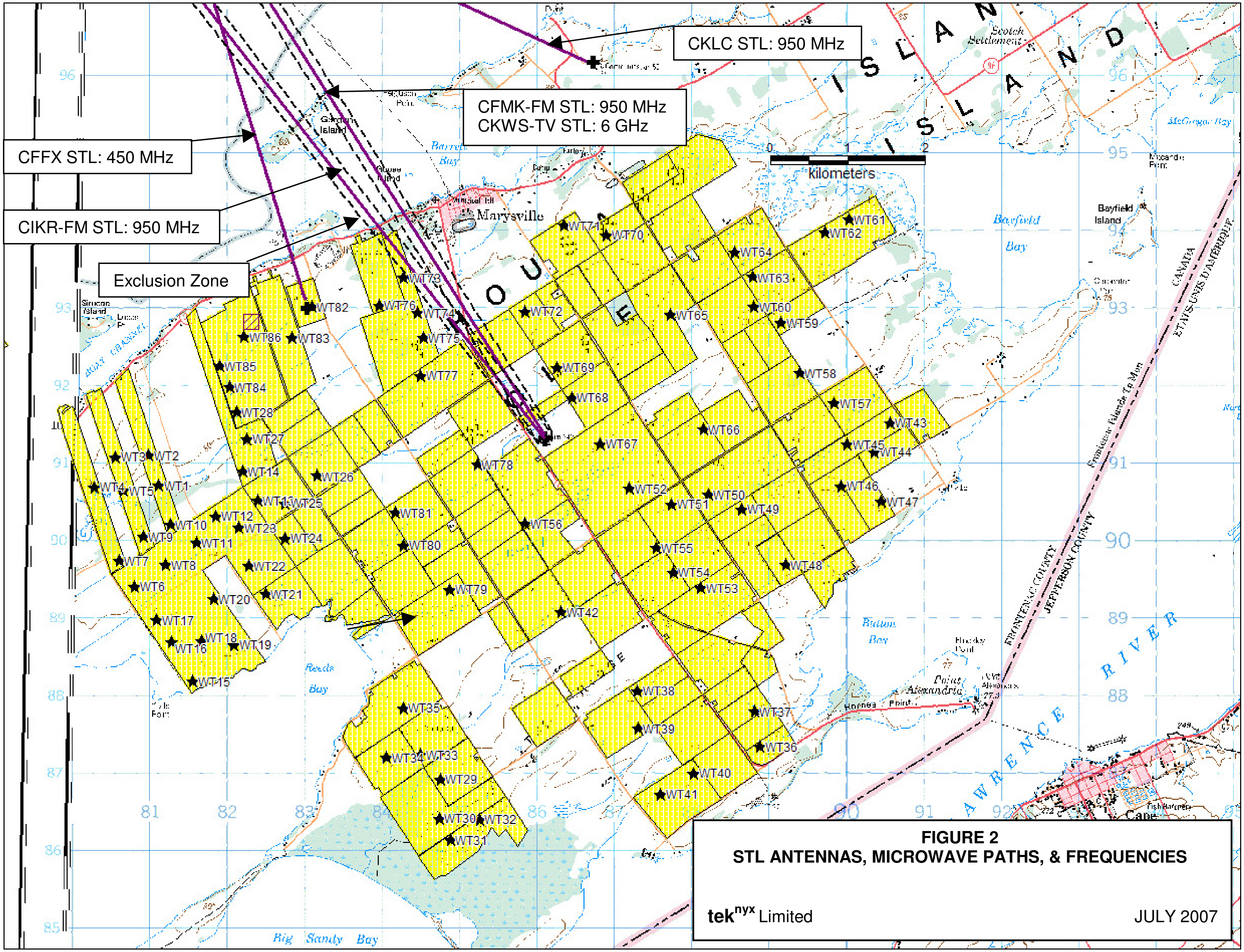

FIGURE 2
STL ANTENNAS, MICROWAVE PATHS, & FREQUENCIES

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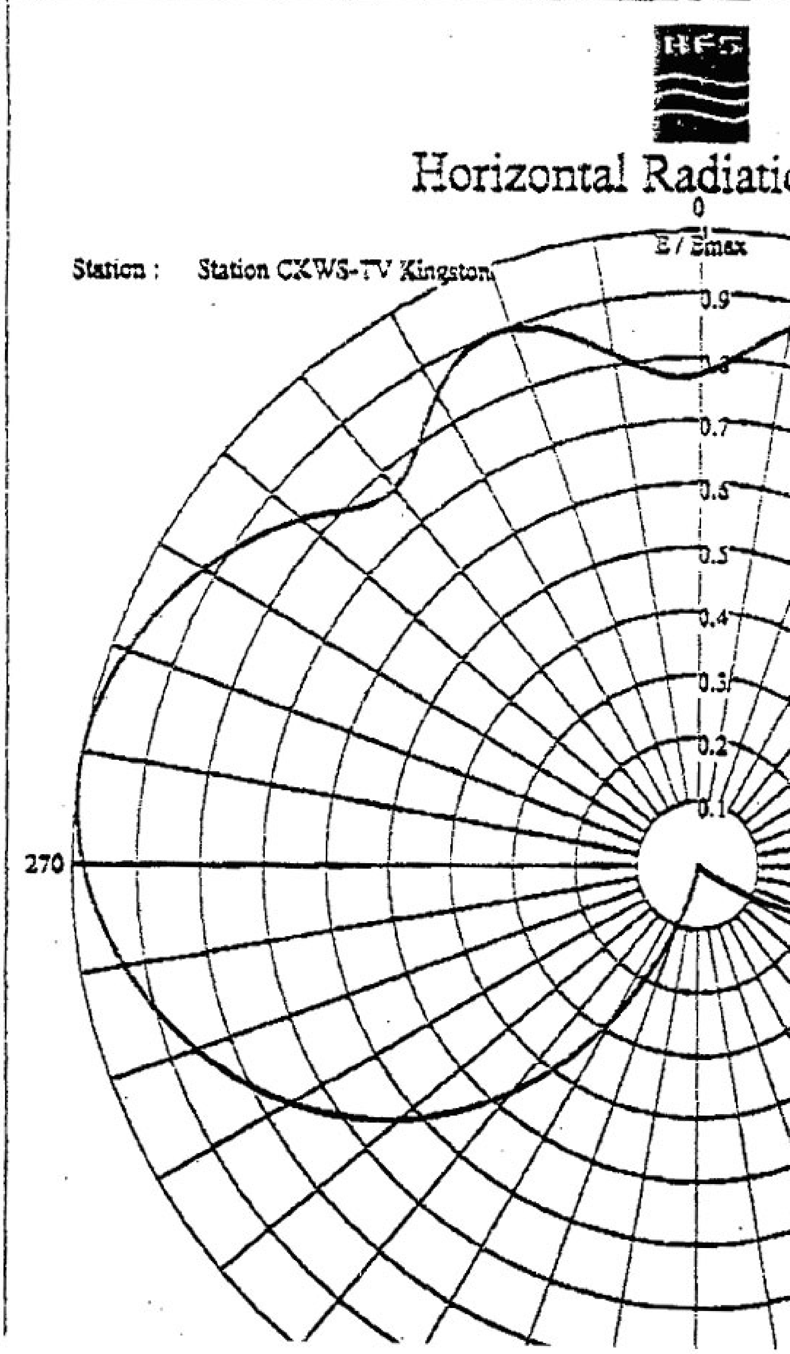

FIGURE 3B. HORIZONTAL RADIATION PATTERN

TRANSMITTING ANTENNA

Change of Facilities CKWS-TV
Kingston (Ontario)

FIGURE 3
CKWS-TV ANTENNA HORIZONTAL PATTERN

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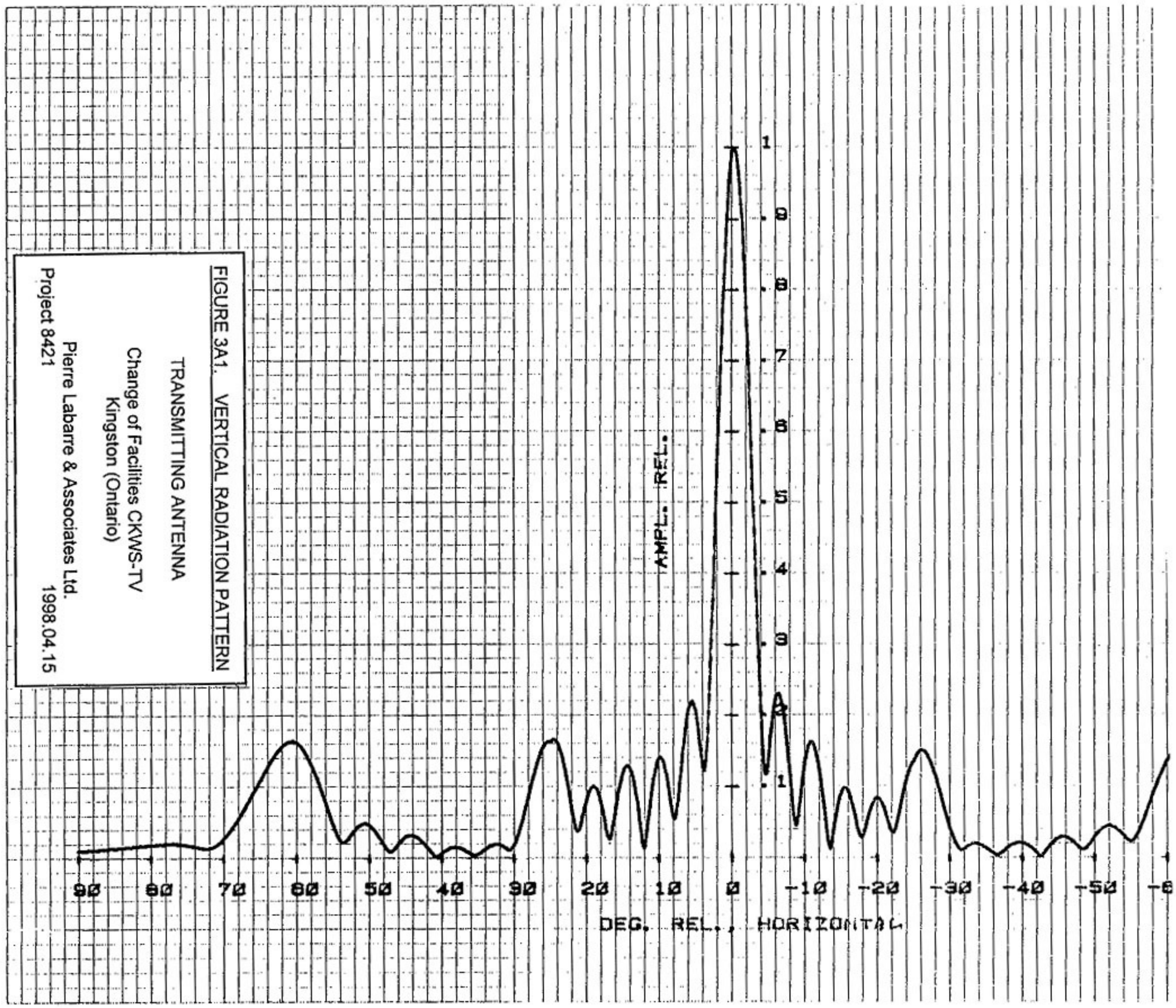

FIGURE 4
CKWS-TV ANTENNA VERTICAL PATTERN

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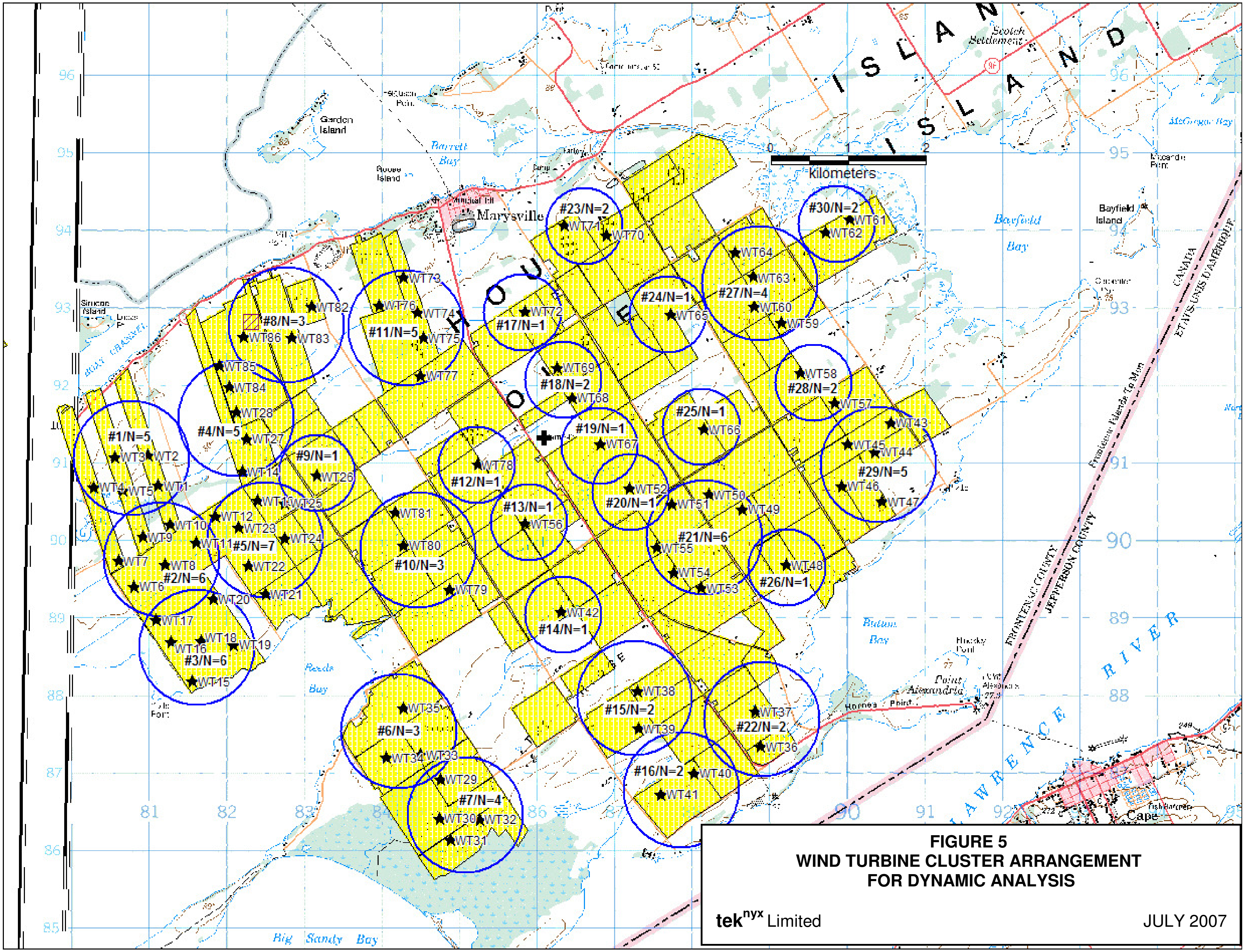

FIGURE 5
WIND TURBINE CLUSTER ARRANGEMENT
FOR DYNAMIC ANALYSIS

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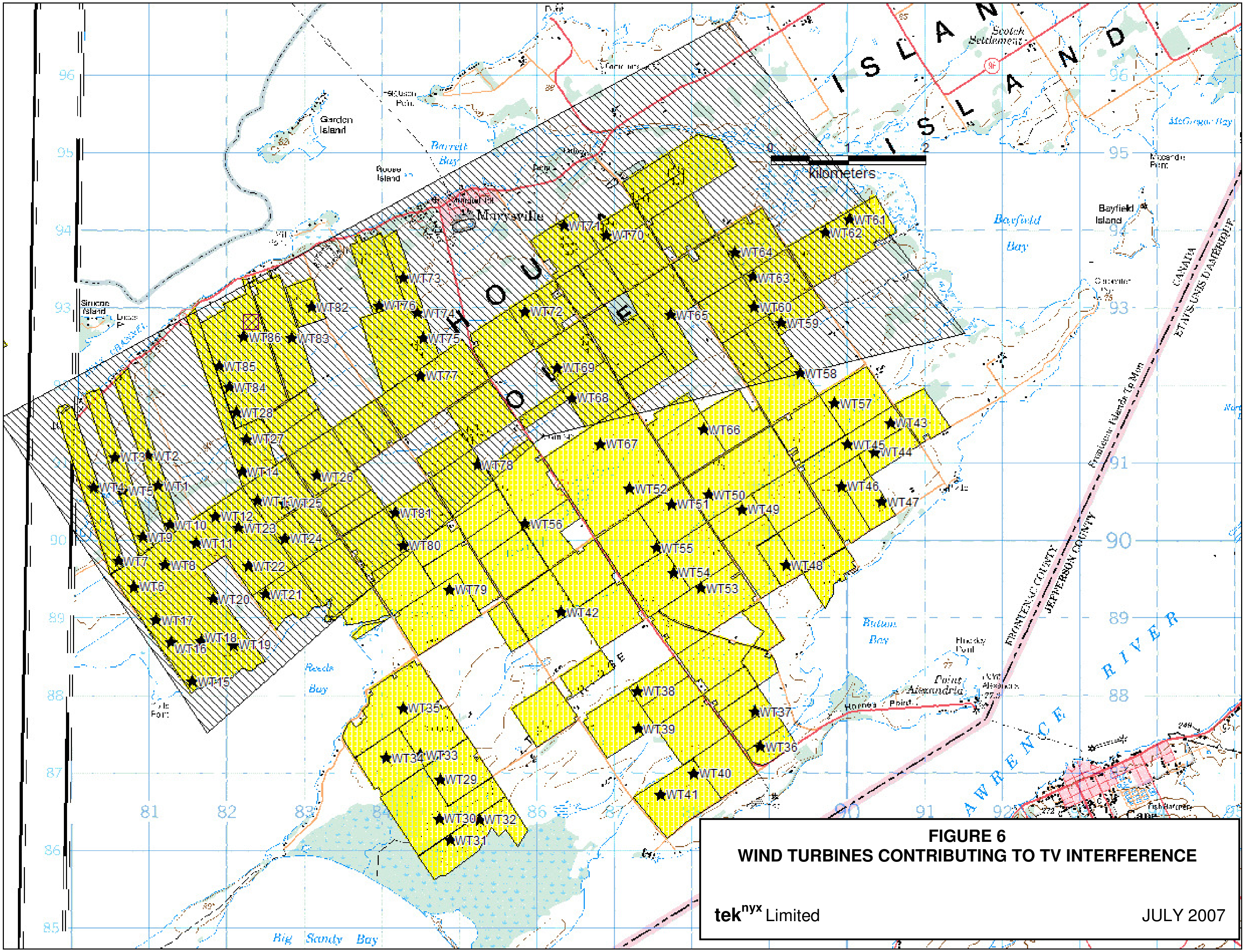

FIGURE 6
WIND TURBINES CONTRIBUTING TO TV INTERFERENCE

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JULY 2007

S I R A Sistemi Radio	ANTENNA TYPE FMC-05/16 (8x2) CIRCULAR POLARIZATION KINGSTON Station	Date : 21/12/2000 Oper.: M.I. Appr.: Graph No.:

THEORETICAL HORIZONTAL PATTERN

(Linear scale)

Frequency 96.30 MHz

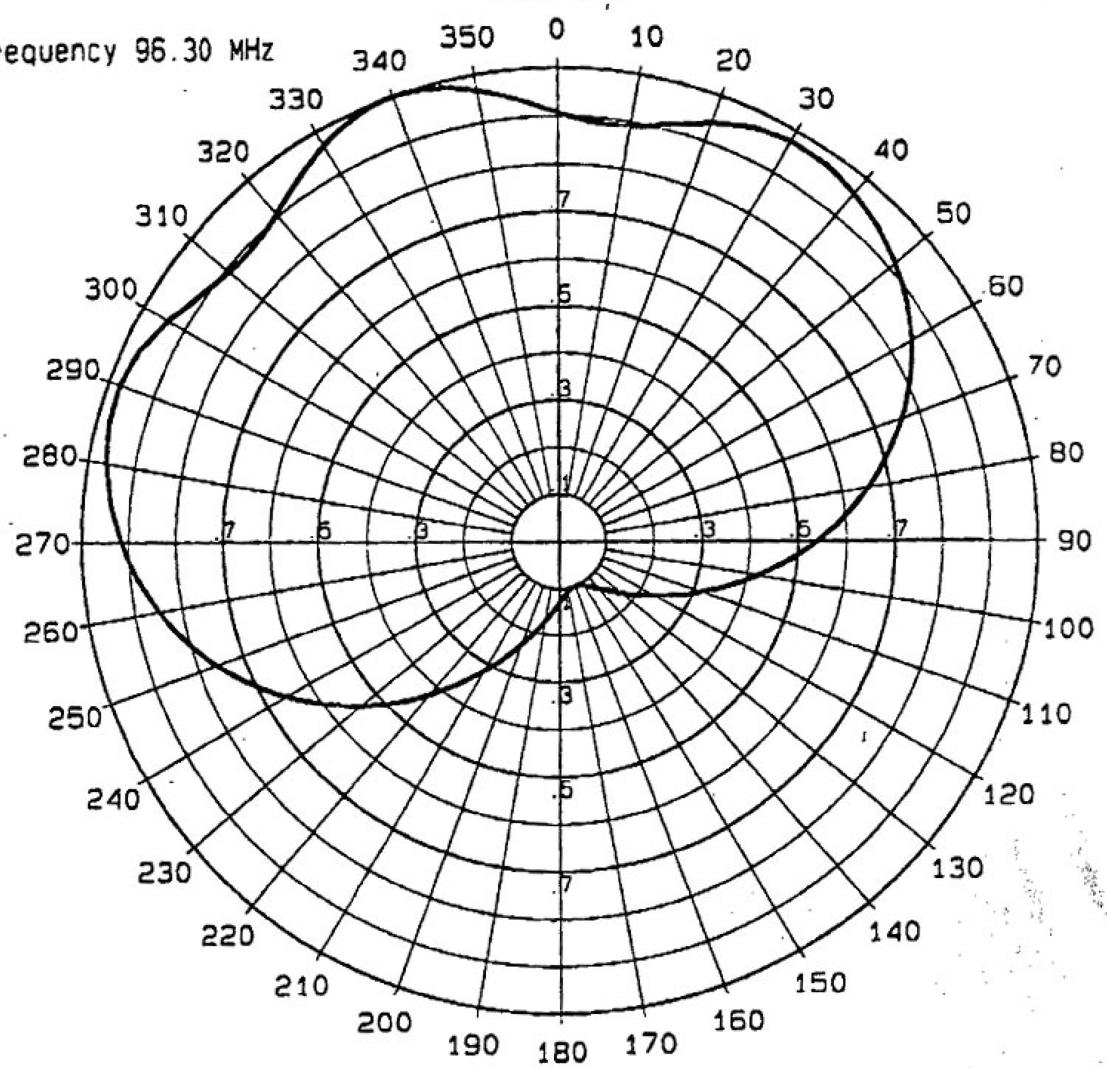

FIGURE 7
CFMK-FM/CIKR-FM ANTENNA HORIZONTAL PATTERN

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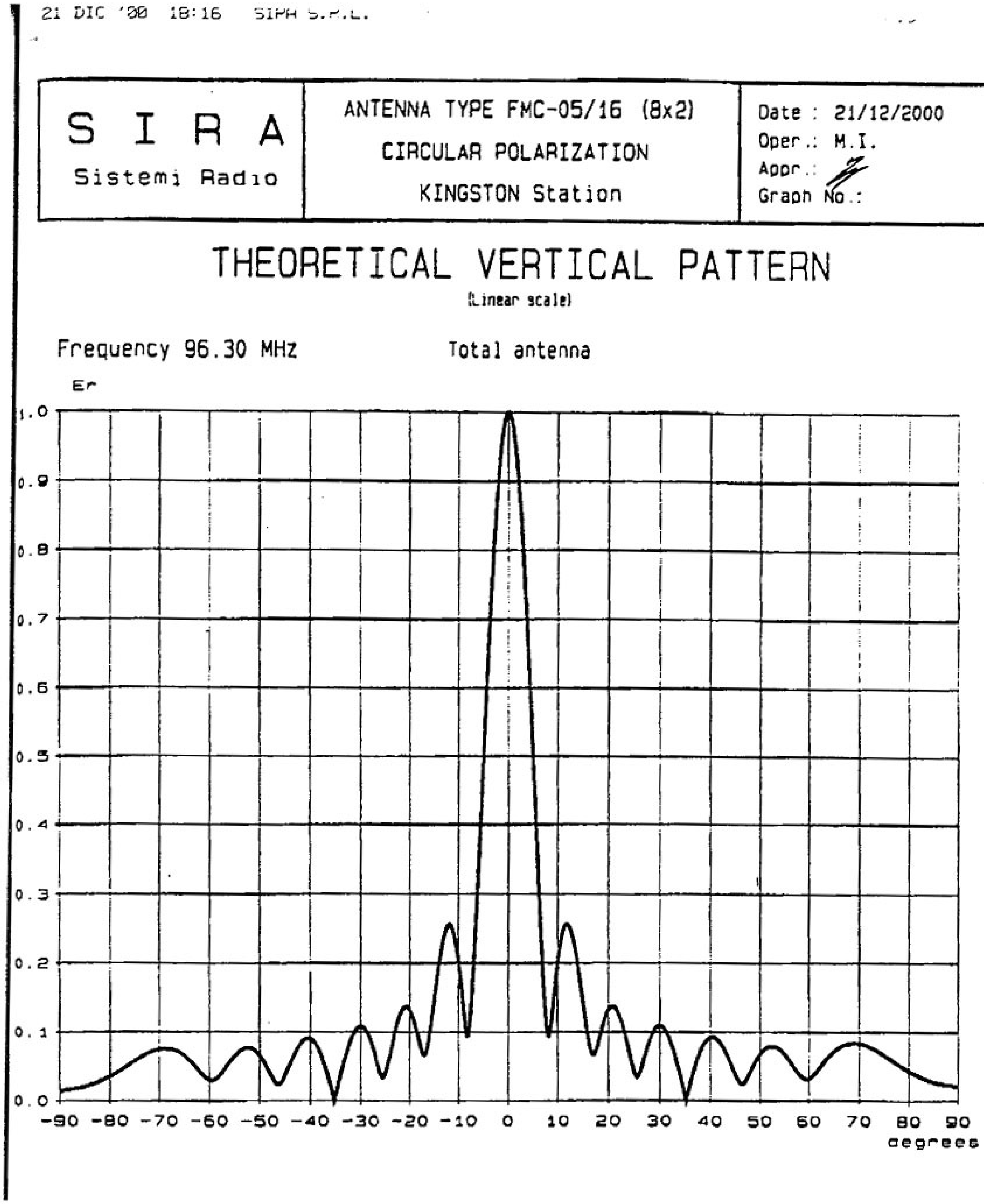

FIGURE 8
CFMK-FM/CIKR-FM ANTENNA VERTICAL PATTERN

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TABLE 1
TELEVISION STATIC ANALYSIS RESULTS

LOCATION	D_{tx-ps}	Az_{tx-ps}	D_{tx-rx}	AZ_{tx-rx}	ANT_{ps}	ANT_{rx}	U/D	Delay	Grade
	(m)	(deg)	(m)	(deg)			(dB)	(usec)	
Kingston	500	90	9500	325	1.0	1.0	-90.0	2.7	5.00
	1000	90	9500	325	1.0	1.0	-82.0	5.4	5.00
	2000	90	9500	325	1.0	1.0	-70.0	10.9	5.00
	3000	90	9500	325	1.0	1.0	-81.0	16.6	5.00
	500	145	9500	325	1.0	1.0	-90.0	3.3	5.00
	1000	145	9500	325	1.0	1.0	-82.0	6.7	5.00
	2000	145	9500	325	1.0	1.0	-71.0	13.3	5.00
	3000	145	9500	325	1.0	1.0	-82.0	20.0	5.00
Marysville	500	90	3200	340	1.0	1.0	-63.0	2.4	5.00
	1000	90	3200	340	1.0	1.0	-52.0	4.9	5.00
	2000	90	3200	340	1.0	1.0	-49.0	10.4	5.00
	3000	90	3200	340	1.0	1.0	-53.0	16.3	5.00
	500	160	3200	340	1.0	1.0	-64.0	3.3	5.00
	1000	160	3200	340	1.0	1.0	-53.0	6.7	5.00
	2000	160	3200	340	1.0	1.0	-50.0	13.3	5.00
	3000	160	3200	340	1.0	1.0	-57.0	20.0	5.00

TABLE 2
TELEVISION DYNAMIC ANALYSIS RESULTS

CONSTANT	VALUE
Fe	2.2
Ns	0.5
Be	1.5
R	45
W	1
Ap	45
λ	1.5

LOCATION	CLUSTER	N	$D_{tx\text{-}ps}$ (m)	$D_{ps\text{-}rx}$ (m)	$D_{tx\text{-}rx}$ (m)	$AZ_{tx\text{-}ps}$ (Deg)	$AZ_{ps\text{-}rx}$ (Deg)	$AZ_{tx\text{-}rx}$ (Deg)	$EL_{tx\text{-}ps}$ (Deg)	$EL_{tx\text{-}rx}$ (Deg)	ANT_{ps}	ANT_{rx}	E_{ps}/E_{rx}	Φ (Deg)	k	mr
KINGSTON	1	5	5300	8400	9500	265	0	325	2.1	1.8	0.76	0.72	1.89	85	0.5	0.041
	2	6	5100	9700	9500	255	0	325	2.2	1.8	0.72	0.72	1.86	75	0.5	0.045
	3	6	5200	10900	9500	240	355	325	2.1	1.8	0.60	0.72	1.52	65	0.5	0.035
	4	5	4000	8000	9500	275	350	325	2.8	1.8	0.55	0.72	1.81	105	0.5	0.034
	5	7	3800	9500	9500	250	350	325	2.9	1.8	0.43	0.72	1.48	80	0.5	0.041
	6	3	4250	12300	9500	210	345	325	2.6	1.8	0.17	0.72	0.51	45	0.5	0.006
	7	4	5000	13650	9500	195	340	325	2.2	1.8	0.08	0.72	0.21	35	0.5	0.003
	8	3	3600	6900	9500	295	345	325	3.1	1.8	0.48	0.72	1.74	130	0.5	0.016
	9	1	2950	8900	9500	260	345	325	3.8	1.8	0.38	0.72	1.70	95	0.5	0.006
	10	3	2200	10200	9500	230	340	325	5.1	1.8	0.13	0.72	0.78	70	0.5	0.009
	11	5	2250	7500	9500	310	330	325	5.0	1.8	0.17	0.72	1.00	160	2	0.025
	12	1	900	9500	9500	245	335	325	12.2	1.8	0.16	0.72	2.35	90	0.5	0.009
	13	1	1100	10500	9500	190	330	325	10.1	1.8	0.02	0.72	0.24	40	0.5	0.001
	14	1	2300	11700	9500	175	330	325	4.8	1.8	0.02	0.72	0.11	25	0.5	0.000
	15	2	3550	13100	9500	160	330	325	3.1	1.8	0.05	0.72	0.19	10	0.5	0.001
	16	2	4850	14400	9500	160	330	325	2.3	1.8	0.07	0.72	0.19	10	0.5	0.001
	17	1	1650	8100	9500	350	320	325	6.7	1.8	0.16	0.72	1.28	150	2	0.004
	18	2	750	9100	9500	20	320	325	14.6	1.8	0.19	0.72	3.34	120	0.5	0.018
	19	1	700	10100	9500	100	320	325	15.6	1.8	0.07	0.72	1.32	40	0.5	0.006
	20	1	1300	10800	9500	120	320	325	8.5	1.8	0.02	0.72	0.20	20	0.5	0.001
	21	6	2500	11800	9500	120	320	325	4.5	1.8	0.02	0.72	0.11	20	0.5	0.003
	22	2	4650	14200	9500	145	325	325	2.4	1.8	0.06	0.72	0.17	0	0.5	0.001
	23	2	2800	7800	9500	10	315	325	4.0	1.8	0.17	0.72	0.80	125	0.5	0.005
	24	1	2250	9350	9500	45	315	325	5.0	1.8	0.20	0.72	1.17	90	0.5	0.004
	25	1	2000	10700	9500	85	315	325	5.6	1.8	0.14	0.72	0.92	50	0.5	0.004
	26	1	3550	12700	9500	120	320	325	3.1	1.8	0.05	0.72	0.19	25	0.5	0.001
	27	4	3450	10000	9500	55	305	325	3.2	1.8	0.48	0.72	1.82	70	0.5	0.029
	28	2	3550	11300	9500	80	310	325	3.1	1.8	0.38	0.72	1.39	50	0.5	0.011
	29	5	4300	12700	9500	95	310	325	2.6	1.8	0.30	0.72	0.93	35	0.5	0.017
	30	2	4700	10400	9500	55	300	325	2.4	1.8	0.57	0.72	1.60	65	0.5	0.013
														RSS mr		0.104
MARYSVILLE	1	5	5300	5400	3200	265	50	340	2.1	5.3	0.76	0.21	2.22	35	0.5	0.097
	2	6	5100	6000	3200	255	40	340	2.2	5.3	0.72	0.21	2.18	35	0.5	0.103
	3	6	5200	6650	3200	240	30	340	2.1	5.3	0.60	0.21	1.78	30	0.5	0.077
	4	5	4000	4000	3200	275	45	340	2.8	5.3	0.55	0.21	2.13	50	0.5	0.119
	5	7	3800	5000	3200	250	30	340	2.9	5.3	0.43	0.21	1.73	40	0.5	0.113
	6	3	4250	6850	3200	210	5	340	2.6	5.3	0.17	0.21	0.60	25	0.5	0.013
	7	4	5000	7900	3200	195	0	340	2.2	5.3	0.08	0.21	0.25	15	0.5	0.006
	8	3	3600	2700	3200	295	55	340	3.1	5.3	0.48	0.21	2.04	60	0.5	0.097
	9	1	2950	3950	3200	260	30	340	3.8	5.3	0.38	0.21	1.99	50	0.5	0.023
	10	3	2200	4500	3200	230	5	340	5.1	5.3	0.13	0.21	0.91	45	0.5	0.028
	11	5	2250	1750	3200	310	25	340	5.0	5.3	0.17	0.21	1.17	105	0.5	0.101
	12	1	900	3350	3200	245	355	340	12.2	5.3	0.16	0.21	2.75	70	0.5	0.033
	13	1	1100	4200	3200	190	350	340	10.1	5.3	0.02	0.21	0.28	20	0.5	0.003
	14	1	2300	5500	3200	175	345	340	4.8	5.3	0.02	0.21	0.13	10	0.5	0.001
	15	2	3550	6800	3200	160	340	340	3.1	5.3	0.05	0.21	0.22	0	0.5	0.003
	16	2	4850	8100	3200	160	340	340	2.3	5.3	0.07	0.21	0.22	0	0.5	0.003
	17	1	1650	1600	3200	350	330	340	6.7	5.3	0.16	0.21	1.50	160	2	0.036
	18	2	750	2650	3200	20	330	340	14.6	5.3	0.19	0.21	3.92	130	0.5	0.062
	19	1	700	3600	3200	100	330	340	15.6	5.3	0.07	0.21	1.55	50	0.5	0.019
	20	1	1300	4300	3200	120	330	340	8.5	5.3	0.02	0.21	0.24	30	0.5	0.003
	21	6	2500	5350	3200	120	325	340	4.5	5.3	0.02	0.21	0.12	25	0.5	0.007
	22	2	4650	7700	3200	145	330	340	2.4	5.3	0.06	0.21	0.20	5	0.5	0.003
	23	2	2800	1650	3200	10	280	340	4.0	5.3	0.17	0.21	0.94	90	0.5	0.040
	24	1	2250	3000	3200	45	300	340	5.0	5.3	0.20	0.21	1.37	75	0.5	0.018
	25	1	2000	4200	3200	85	310	340	5.6	5.3	0.14	0.21	1.08	45	0.5	0.012
	26	1	3550	6300	3200	120	315	340	3.1	5.3	0.05	0.21	0.22	15	0.5	0.002
	27	4	3450	4000	3200	55	285	340	3.2	5.3	0.48	0.21	2.13	50	0.5	0.095
	28	2	3550	5100	3200	80	295	340	3.1	5.3	0.38	0.21	1.63	35	0.5	0.030
	29	5	4300	6300	3200	95	300	340	2.6	5.3	0.30	0.21	1.09	25	0.5	0.042
	30	2	4700	4850	3200	55	275	340	2.4	5.3	0.57	0.21	1.87	40	0.5	0.036
														RSS mr		0.309