



37 Sandiford Dr., Suite 411, Stouffville, ON L4A 7X5

P 905.766.4054 F 905.642.5999

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Electromagnetic Radiation (EMR) Testing Report Twenty-Five Schools, Peel District School Board

G2S13600

Peel District School Board
5650 Hurontario Street
Mississauga, Ontario
L5R 1C6

Executive Summary

G2S Environmental Consulting Inc. (G2S) was retained by Peel District School Board (PDSB) to complete electromagnetic radiation (EMR) testing of twenty-five school buildings within the PDSB.

PDSB recently installed Wi-Fi computer networks in all the elementary and secondary schools within the board. The installation started in July 2012 and was completed by the end of the 2012/2013 school year. Wi-Fi access points were installed at ceiling level at various locations throughout the schools. The objective of the testing was to assess the levels of radiofrequency (RF) emissions associated with the Wi-Fi equipment and compare the collected data to the exposure limits specified in Health Canada's Safety Code 6.

A total of 551 locations were measured at the twenty-five school buildings. All measurements were well below the Safety Code 6 limit of 10 W/m^2 (for frequency ranges between 1500 to 15000 MHz). On average, the RF measurements were higher when the Wi-Fi equipment was turned on compared to when it was turned off, which is expected.

Both the background RF levels (Wi-Fi network "off") and the total RF levels (Wi-Fi network "on") showed values typical for residential areas of relatively low population density. Note that higher population density usually relates to higher RF activity, especially when cell towers are present.

Based on the findings of this survey, the RF measurements in the areas tested are well within the limits set by Health Canada Safety Code 6 (2009). The need for further investigations has not been identified at this time.

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1.0 Introduction

G2S Environmental Consulting Inc. (G2S) was retained by Peel District School Board (PDSB) to complete electromagnetic radiation (EMR) surveys at the following twenty-five school buildings.

- | | | |
|-----------------------------|----------------------------|----------------------------|
| • Allan Drive M.S. | • Belfountain P.S. | • Castlebrooke S.S. |
| • Cawthra Park S.S. | • Central Peel S.S. | • Dorset Drive P.S. |
| • Fallingbrook M.S. | • Fletcher's Meadow S.S. | • Glenforest S.S. |
| • Herb Campbell P.S. | • Hillcrest M.S. | • Humberview S.S. |
| • Huttonville P.S. | • Kenollie P.S. | • Lorne Park S.S. |
| • Loughheed M.S. | • Meadowvale S.S. | • Middlebury P.S. |
| • Mineola P.S. | • Morning Star M.S. | • North Park S.S. |
| • Port Credit S.S. | • Queen Elizabeth Sr. P.S. | • SouthFields Village P.S. |
| • William G. Davis Sr. P.S. | | |

PDSB recently installed Wi-Fi computer networks in all the elementary and secondary schools within the board. The installation started in July 2012 and was completed by the end of the 2012/2013 school year. Wi-Fi access points were installed at ceiling level at various locations throughout the schools. The objective of the EMR testing was to assess the levels of radiofrequency (RF) emissions associated with the Wi-Fi equipment and compare the collected data to the exposure limits specified in Health Canada's Safety Code 6.

2.0 Background

2.1 Radio Frequency and Wi-Fi Background

Radio frequency is defined as any electromagnetic wave frequencies that range from 3 kHz to 300 GHz. RF power is often emitted from devices such as cell phones, medical devices, radar, and from radio and television broadcasting (Health Canada, 2009).

Wi-Fi is a trademark of the Wi-Fi Alliance and defines Wi-Fi as any wireless local area network (WLAN) product that is based on the Institute of Electrical and Electronics Engineers (IEEE) 802.11 standards (Industry Canada, 2012). Wi-Fi networks use radio technologies called 802.11 to provide secure, reliable, and fast wireless connectivity. A Wi-Fi network can be used to connect electronic devices to each other, to the Internet, and to wired networks which use ethernet technology. Wi-Fi networks operate in the 2.4 GHz frequency band (from 2.400 GHz to 2.484 GHz) and in the 5 GHz band (from 5.725 GHz to 5.825 GHz), with some products that can operate in both bands (dual band).

A device that can use Wi-Fi (such as a personal computer, video-game console, smartphone, digital camera, tablet, or digital audio player) can connect to a network resource such as the Internet via a wireless network access point. Such an access point (or hotspot) has a range of about 20 meters (65 feet) indoors and typically consists of one or more low power transmitters installed at the ceiling level.

2.2 PDSB Wi-Fi Equipment System

The Wi-Fi equipment (access points) installed at the twenty-five schools consisted of Cisco AP3500e and AP1260 devices. The locations of the access points for each school are shown on the corresponding drawings provided in Attachments B1 to B25. The installed Wi-Fi equipment operate in the frequency range between 2.4 GHz and 5.825 GHz.

3.0 Objective and Scope of Work

The objective of the investigation was to evaluate the RF exposure levels from the Wi-Fi computer network at each school and compare the measurements to Health Canada's Safety Code 6 exposure limits. More information regarding the Safety Code 6 limits is provided in Section 4 and a methodology of our survey is provided in Section 5.

In general, the scope of work for the survey included the following:

1. Completion of a preliminary Site visit for each location to establish sampling locations;
2. Review of all existing EMR sources within an approximate 250 m radius of each Site;
3. Conduct testing using a Narda Broadband Field Meter NBM-550 equipped with a NAR-EC5091 300 kHz - 50 GHz Shaped E-Field Probe, SC6 Canada, Isotropic;
4. Collection of RF readings from various locations throughout the schools with and without the wireless network equipment signals present;
5. Data evaluation with respect to Safety Code 6 exposure limits; and
6. Preparation of a report detailing the RF measurement results.

4.0 Health Canada's Safety Code 6 (2009)

Guidelines for acceptable levels of RF exposure for the protection of human health are outlined in the 2009 Health Canada document entitled "*Limits of Human Exposure to Radiofrequency Electromagnetic Fields in the Frequency Range from 3 kHz to 300 GHz*" (Safety Code 6). The purpose of Safety Code 6 is to establish safety limits for human exposure to RF electromagnetic energy in the frequency range from 3 kHz to 300 GHz. Limits of exposure to RF energy in the code concerning the general public were set to a minimum of fifty times lower than the levels where potential harmful effects (alterations in core-body temperature of about 1° C) could take place.

Safety Code 6 has specified two types of exposure limits: (i) exposure in a controlled environment and (ii) exposure in an uncontrolled environment. The first type of limit addresses the maximum permissible exposures (MPEs) for employees in the RF/communications industry, where exposure is a component of their job and is, therefore, predictable and carefully monitored. The second type of limit addresses the exposure of the general public, which can occur at any arbitrary location (public or private) and which, therefore, cannot be controlled or monitored on a regular basis. The applicable limit for this investigation is exposure in an uncontrolled environment.

The recommended exposure levels are regulated through: (a) the specific absorption rate (SAR) limits, and (b) the field strength or the power density limits, depending on the frequency range. SAR is a measurement of the rate at which electromagnetic energy is absorbed in the body and is measured in Watts per kilogram (W/kg). The SAR is typically determined for situations where exposures occur at a distance of 0.2 m or less from the source and is applicable for persons classified as RF and microwave workers. For conditions where SAR determination is impractical (this is usually the case of the uncontrolled environment), field strength and power density limits are applied. Section 2.2 of Safety Code 6 specifies exposure limits for persons NOT classified as RF and microwave workers (the general public) in terms of electric field strength and power density for frequencies greater than 100 MHz. Below 100 MHz, the limits are specified only in terms of electric and magnetic field strengths. The maximum allowed spatial average values in an uncontrolled environment are summarized in Table 1 in the relevant frequency bands. Note that the probe used in the current survey is specifically designed to report the RF emissions relative to Safety Code 6 in the frequency range from 300 kHz (or 0.3 MHz) to 50 GHz (or 50 000 MHz).

TABLE 1:
EXPOSURE LIMITS FOR UNCONTROLLED ENVIRONMENTS ACCORDING TO SAFETY CODE 6

Frequency f (MHz)	E -field strength, rms (V/m)	H -field strength, rms (A/m)	Power Density (W/m ²)	Averaging Time (min)
0.003 to 1	280	2.19	NA	6
1 to 10	$280/f$	$2.19/f$	NA	6
10 to 30	28	$2.19/f$	NA	6
30 to 300	28	0.073	2 (above 100 MHz)	6
300 to 1 500	$1.585f^{0.5}$	$0.0042f^{0.5}$	$f/150$	6
1 500 to 15 000	61.4	0.163	10	6
15 000 to 150 000	61.4	0.163	10	$616\,000/f^{1.2}$

5.0 Methodology

The RF survey was conducted by G2S staff between January 13 and March 24, 2014. RF measurements were taken with a Narda Broadband Field Meter NBM-550 equipped with a NAR-EC5091 300 kHz - 50 GHz Shaped E-Field Probe, SC6 Canada, Isotropic. This probe ensures that RF exposure is evaluated in the entire frequency band from 300 kHz to 50 GHz, which includes all possible emissions from radio and TV, mobile handhelds (police, emergency services, etc.), cell phone towers and handsets, Bluetooth and Wi-Fi hot spots and devices, etc.

5.1 Preliminary Site Visit

Prior to conducting the EMR survey, G2S visited the twenty-five schools to establish sample locations and identify existing EMR sources within an approximate 250 m radius of each school.

The majority of the schools are situated within a residential setting and have similar potential EMR sources including radio, TV broadcast, wireless networks, hydro corridor, cordless phones and mobile devices. Additional EMR sources that were identified during the preliminary site visits are labelled on the site location plans and summarized below.

TABLE 2:
ADDITIONAL (NOT WI-FI) ELECTROMAGNETIC SOURCES

School	EMR Source	Approximate Distance from School (m)
Belfountain P.S	Communication Tower	On Site
Cawthra S.S.	Communication Tower	On Site
Central Peel S.S.	Multiple Communication Towers	100 - 200
	Roof top Cellular Antenna	325
Lorne Park S.S	Communication Tower	On Site
Meadowvale S.S	Roof top Cellular Antenna	250 m Northeast
Port Credit S.S	Communication Tower	On Site

The additional (not Wi-Fi) Electromagnetic Sources that were identified above are shown on the site location plans provided in Attachments B2, B4, B5, B15, B17 and B22.

5.2 Measurement Equipment

The instrument measures values as percentage of the overall Safety Code 6 MPE limits for which the probe is designed. In this case, the instrument reports the overall detected RF power from 300 kHz to 50 GHz as a percentage of the limits specified by Health Canada Safety Code 6 for controlled environments. Note that this frequency range includes the 2.4 GHz and 5 GHz bands utilized by the PDSB Wi-Fi networks. As a result, a conversion of the measured values is required to assess the measurements against the RF exposure limits set out in Health Canada Safety Code 6 for uncontrolled environments.

A comparison between the MPE limits for controlled environments versus uncontrolled environments in the frequency band of the probe (300 kHz to 50 GHz) is given in Table 3. The exposure value reported by the instrument, which is relative to the limits for a controlled

environment, must be multiplied by a conversion coefficient of 5 in order to obtain the exposure value relative to the limits for an uncontrolled environment. For example, a recorded exposure value of 0.3017% relative to the limits for a controlled environment corresponds to an exposure value of 1.509% relative to the limits for an uncontrolled environment. Note (from Table 3) that the conversion coefficient is 4.6 below 100 MHz frequency, which means that applying a coefficient of 5 results in a slight overestimation of the exposure value relative to the limits for the uncontrolled environment (if radiation below 100 MHz frequency is indeed present). A slight overestimation of the emissions is in fact preferable as it provides an additional, albeit small, safety margin.

TABLE 3:
COMPARISON OF THE MPE LIMITS FOR CONTROLLED ENVIRONMENT VERSUS UNCONTROLLED ENVIRONMENT IN HEALTH CANADA SAFETY CODE 6

Frequency range	SC6 limit (controlled)	SC6 limit (uncontrolled)	Limit type	Power Ratio
0.003 MHz to 1 MHz	600	280	Electric field strength in V/m	4.6
1 MHz to 10 MHz	600/ <i>f</i>	280/ <i>f</i>	Electric field strength in V/m	4.6
10 MHz to 30 MHz	60	28	Electric field strength in V/m	4.6
30 MHz to 100 MHz	60	28	Electric field strength in V/m	4.6
100 MHz to 300 MHz	10	2	Power density in W/m ²	5.0
300 MHz to 1.5 GHz	<i>f</i> /30	<i>f</i> /150	Power density in W/m ²	5.0
1.5 GHz to 3.0 GHz	50	10	Power density in W/m ²	5.0
3.0 GHz to 50.0 GHz	50	10	Power density in W/m ²	5.0

Note: *f* denotes frequency in MHz.

At each survey location, a maximum, a minimum and a spatial average measurement was recorded. Note that the time required to survey each location is at least 6 minutes as required by the time-averaging interval of Safety Code 6 (see Table 1). Thus, the spatial average measurement is an average of all values recorded over a 6 minute period and over a volume of space of roughly 0.35 m width, 0.35 m depth, and 1.25 m height, which is at a reasonable distance (for example, 0.5 m) from the floor. This volume represents roughly the volume of a human body and it is the value that must be used to evaluate the exposure relative to the specified limits. The maximum/minimum measurements represent the highest/lowest values recorded over this 6 minute period and they serve the purpose of identifying where possible hot spots may reside. However, in an uncontrolled environment such as schools and public buildings, due to constant changes in the environment (mostly people moving around), such hot spots change constantly and are highly unpredictable. Here, the minimum and maximum values are reported to simply provide the client with an idea of how dynamic the RF environment is in the measured locations.

Two measurements were taken at each location, one with the Wi-Fi computer network “off” and one with the computer network turn “on”. In addition to Wi-Fi, the instrument has the capability of capturing other sources of EMR such as radio and TV broadcast, cellular towers (base-stations), mobile devices, etc. Thus, a measurement with the Wi-Fi network “off” provides a measure of the “background” radiation while the measurement with the Wi-Fi network “on” provides a measure of the “background” radiation plus the added RF power due to the Wi-Fi nodes. It is not uncommon in an uncontrolled environment to observe lower emission levels with

the Wi-Fi network “off” as compared to when it is “on”. This is because: (i) the environment changes and (ii) effects of destructive and constructive RF wave interference influence the measurements locally.

During this survey, the Wi-Fi computer network “on” measurements were collected with one laptop and three tablets uploading and downloading simultaneously. The four devices were uploading and downloading in the 2.4 GHz or the 5.0 GHz band. The laptop and tablets were in close proximity of the access point during the Wi-Fi computer network “on” measurements, actual distances are provided in Tables 1 to 25 in Attachments B1 to B25.

Data which included the location, time and frequency were recorded and the measurements were saved in the NBM-550 machine.

5.3 *Measurement Locations*

The survey locations for each school are shown on the site plans provided in Attachments B1 to B25. Readings were taken at various floors and rooms throughout the twenty-five school buildings to ensure proper representation of the school. The survey locations were chosen based on various factors including type of building construction, room size, room use, and potential exposure scenarios (proximity to access points).

Readings were taken at various height levels; in general, measurements were taken between approximately 0.3 m to 6.0 m from the access points.

6.0 Data Evaluation

The number of survey locations ranged from 10 to 22 in an elementary school and 25 to 37 in a secondary school.

The overall average of the spatial average readings when the Wi-Fi equipment was turned on compared to when it was turned off at each of the twenty-five schools is summarized in Table 4 below:

TABLE 4:
OVERALL AVERAGE OF THE SPATIAL AVERAGE RESULTS WITH THE WI-FI COMPUTER NETWORK “OFF”
AND “ON” BY LOCATION

School	Sample Type	Wi-Fi Computer Network				Measurement Difference
		Operating		Off		
		% of SC 6	W/m²	% of SC 6	W/m²	
Allan Drive M.S.	Overall Spatial Average	0.943 %	0.0939	1.003 %	0.0999	-0.060 %
Belfountain P.S.	Overall Spatial Average	2.211 %	0.2202	0.263 %	0.0262	1.948 %
Castlebrooke S.S.	Overall Spatial Average	1.815 %	0.1808	0.673 %	0.0670	1.142 %
Cawthra Park S.S	Overall Spatial Average	1.297 %	0.1292	0.992 %	0.0988	0.305 %
Central Peel S.S	Overall Spatial Average	1.799 %	0.1792	1.223 %	0.1218	0.576 %
Dorset Drive P.S.	Overall Spatial Average	2.579 %	0.2569	1.256 %	0.1251	1.323 %
Fallingbrook M.S	Overall Spatial Average	1.843 %	0.1836	1.235 %	0.1230	0.608 %
Fletcher's Meadow S.S	Overall Spatial Average	2.154 %	0.2145	1.777 %	0.1770	0.377 %
Glenforest S.S	Overall Spatial Average	1.052 %	0.1048	1.312 %	0.1307	-0.260 %
Herb Campbell P.S.	Overall Spatial Average	1.600 %	0.1594	1.337 %	0.1332	0.263 %
Hillcrest M.S.	Overall Spatial Average	2.655 %	0.2644	0.783 %	0.0780	1.872 %
Humberview S.S	Overall Spatial Average	1.368 %	0.1363	0.873 %	0.0870	0.495 %
Huttonville P.S.	Overall Spatial Average	2.251 %	0.2242	1.374 %	0.1369	0.877 %
Kenollie P.S.	Overall Spatial Average	1.916 %	0.1908	2.31 %	0.2301	-0.394 %
Lorne Park S.S	Overall Spatial Average	1.270 %	0.1265	0.961 %	0.0957	0.309 %
Lougheed M.S	Overall Spatial Average	1.761 %	0.1754	2.933 %	0.2921	-1.172 %
Meadowvale S.S	Overall Spatial Average	1.504 %	0.1498	1.073 %	0.1069	0.431 %
Middlebury P.S.	Overall Spatial Average	1.937 %	0.1929	1.770 %	0.1763	0.167 %
Mineola P.S.	Overall Spatial Average	1.526 %	0.1520	2.429 %	0.2419	-0.903 %
Morning Star M.S	Overall Spatial Average	1.081 %	0.1077	0.791 %	0.0788	0.290 %
North Park S.S	Overall Spatial Average	1.316 %	0.1311	1.092 %	0.1088	0.224 %
Port Credit S.S	Overall Spatial Average	1.682 %	0.1675	0.706 %	0.0703	0.976 %
Queen Elizabeth Sr. P.S.	Overall Spatial Average	1.836 %	0.1829	0.589 %	0.0587	1.247 %
Southfields Village P.S.	Overall Spatial Average	0.750 %	0.0747	0.625 %	0.0623	0.125 %
William G. Davis Sr. P.S.	Overall Spatial Average	0.984 %	0.0980	0.958 %	0.0954	0.026 %

Note: Measurements are % of Safety Code 6 limit in an uncontrolled environment
Safety Code 6 Limit = 10 W/m² (uncontrolled)

A summary of the maximum spatial average, minimum spatial average and overall spatial average at each of the twenty-five schools is presented in a summary table included in Attachment A. The complete results for each school are presented in summary tables included in Attachments B1 to B25. Spatial average, maximum and minimum measurements are presented as a percentage of the allowable limits and in W/m^2 .

The results relative to the Safety Code 6 in a controlled and uncontrolled environment are shown in the summary tables. A summary of the maximum spatial average measurements recorded at each of the twenty-five schools is summarized in Table 5 below.

TABLE 5:
MAXIMUM OF THE SPATIAL AVERAGE RESULTS BY LOCATION

School	Sample ID	Wi-Fi Computer Network	% of Safety Code 6 Limits (uncontrolled environment)	Power Density (W/m^2)
Allan Drive Middle School	AD 1	OFF	1.756 %	0.1749
Belfountain Public School	BPS 1	ON	3.260 %	0.3247
Castlebrooke Secondary School	CB 22	ON	2.742 %	0.2731
Cawthra Park Secondary School	CSS 21	OFF	4.745 %	0.4726
Central Peel Secondary School	CP 22	OFF	5.750 %	0.5727
Dorset Drive Public School	DD 7	ON	3.934 %	0.3918
Fallingbrook Middle School	FB 1	ON	5.205 %	0.5274
Fletcher's Meadow Secondary School	FM 23	OFF	3.853 %	0.3838
Glenforest Secondary School	G 23	OFF	4.815 %	0.4796
Herb Campbell Public School	HC 5	OFF	2.937 %	0.2925
Hillcrest Middle School	HMS 14	ON	3.506 %	0.3492
Humberview Secondary School	HV 19	ON	5.830 %	0.5807
Huttonville Public School	HPS 6	OFF	5.410 %	0.5388
Kenollie Public School	K7	OFF	3.369 %	0.3356
Lorne Park Secondary School	LP 14	OFF	2.972 %	0.2960
Lougheed Middle School	L 4	OFF	4.530 %	0.4512
Meadowvale Secondary School	MV 34	OFF	4.961 %	0.4941
Middlebury Public School	MPS 9	ON	3.467 %	0.3453
Mineola Public School	M 13	ON	5.265 %	0.5244
Morning Star Middle School	MS 2	ON	4.240 %	0.4223
North Park Secondary School	NP 15	OFF	2.573 %	0.2563
Port Credit Secondary School	PC 34	ON	2.780 %	0.2769
Queen Elizabeth Sr. Public School	QE 7	ON	2.508 %	0.2498
Southfields Village Public School	SFV 11	ON	1.704 %	0.1697
William G. Davis Sr. Public School	WD 12	OFF	3.010 %	0.2998

Note: Measurements are % of Safety Code 6 limit in an uncontrolled environment
Safety Code 6 Limit = $10 W/m^2$ (uncontrolled)

7.0 Conclusion and Recommendations

A total of 551 locations were measured at the twenty-five school buildings. All measurements were well below the Safety Code 6 limit of 10 W/m^2 (for frequency ranges between 1500 to 15000 MHz). On average, the RF measurements were higher when the Wi-Fi equipment was turned on compared to when it was turned off, which is expected.

Both the background RF levels (Wi-Fi network “off”) and the total RF levels (Wi-Fi network “on”) show values typical for residential areas of relatively low population density. Note that higher population density usually relates to higher RF activity, especially cell towers.

Based on the findings of this survey, the RF measurements in the areas tested are well within the limits set by Health Canada Safety Code 6. The need for further investigations has not been identified at this time.

8.0 Qualifications of the Reviewer

Dr. Natalia K. Nikolova, P.Eng. (ON), is a Professor at McMaster University, Hamilton. She has been a faculty member of the Department of Electrical and Computer Engineering in McMaster University since 1999 where she teaches courses related to electromagnetic fields and waves, antennas, and radio-frequency (RF) and microwave engineering. She supervises a large research team working on projects in microwave and antenna engineering, electromagnetic field theory and computational methods. She has consulted for more than 11 years in the areas of microwave antennas, radar imaging and detection, and electromagnetic high-frequency computer-aided design. She has been working on collaborative projects between McMaster University and industrial partners related to the RF hazard evaluation of mobile devices and radiation sources for the last seven years. Prof. Nikolova is a registered Professional Engineer in the province of Ontario and a Fellow of the Institute of Electrical and Electronic Engineers (IEEE).

9.0 References

- a) Health Canada. *Environmental Workplace and Health: Radiofrequency Fields*. Updated 2009-11-12. <<http://www.hc-sc.gc.ca/ewh-semt/radiation/cons/radiofreq/index-eng.php>>.
- b) Health Canada. *Limits of Human Exposure to Radiofrequency Electromagnetic Fields in the Frequency Range from 3 kHz to 300 GHz* (Safety Code 6). 2009.
- c) Industry Canada. *Case Study: Measurements of Radio Frequency Exposure from Wi-Fi Devices*. May 2012.
- d) Occupational Health and Safety Act - Ministry of Labour (MOL).

10.0 Limitations

This report has been prepared for the sole benefit of the Peel District School Board and is intended to provide a Radiofrequency Electromagnetic Field Survey of the twenty-five school properties. The report may not be used by any other person or entity without the expressed written consent of the Peel District School Board and G2S Environmental Consulting Inc. (G2S). Any use which a third party makes of this report, or any reliance on decisions made based on it, is the responsibility of such third parties. G2S accepts no responsibility for damages, if any suffered by any third party as a result of decisions made or actions based on this report.

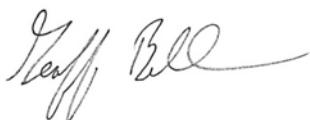
The findings in this report are limited to the conditions at the Site at the time of this investigation (January, February and March 2014) as well as information provided by the Site representatives as reported herein. Conclusions presented in this report should not be construed as legal advice.

If Site conditions or applicable standards change or if any additional information becomes available at a future date, changes to the findings, conclusions and recommendations in this report may be necessary.


11.0 Closing Remarks

We trust this report is satisfactory for your purposes. Should you have any questions, please do not hesitate to contact this office.

Yours truly,



Geoff Bell, P. Geo. (limited)
Senior Project Manager
G2S Environmental Consulting



Dr. N.K. Nikolova, Fellow IEEE, P.Eng.
Electrical Engineer
McMaster University