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Executive Summary Report

**Assessment of Radio Frequency Emissions
Against Health Canada's Emission Limit for Uncontrolled Environments**

Prepared for British Columbia Ferry Services Inc.

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1 Safety Code 6 RF Power Density Test Overview

1.1 Test Purpose

British Columbia Ferry Services Inc., BC Ferries, has Wi-Fi access points in selected vessels and terminals to enable wireless internet service to passengers while waiting for ferries. Several passengers have raised concerns about the safety to the public of the radio frequency (RF) emissions emanating from the Wi-Fi access points.

To address this passenger safety concern, BC Ferries retained Planetworks Consulting Corp., Planetworks, to conduct radio frequency (RF) field intensity testing on the Spirit of BC and Coastal Celebration vessels and at the Swartz Bay and Tsawwassen terminals. The purpose of the testing was to determine compliance of the RF emissions to Health Canada Safety Code 6.

The RF field intensity testing encompassed RF frequency bands used by Wi-Fi as well as bands where other RF signals may be present at the terminal including vessel safety systems (radar, marine radio, satellite, vessel 2-way radio), terminal 2-way radio systems, cellular communications devices, external sources (cellular sites, broadcast sites) and unintentional emitters (lighting, etc.).

1.2 Test Method

Planetworks conducted the testing using test equipment manufactured by Narda Safety Test Solutions comprising a calibrated meter, the Narda NBM-550, and a wideband RF antenna, referred to as a shaped probe, the Narda EC5091. This test set is recognized as the defacto standard for conducting RF safety testing by Innovation, Science and Economic Development Canada (formerly Industry Canada) and accurately measures RF electric fields levels over a broad frequency range of 300 kHz to 50 GHz. The Narda EC5091 probe has been shaped to conform to the latest Health Canada standard.

The primary focus of this test activity was to determine levels in passenger accessible areas which are attributable to Wi-Fi access points. However, the test results are broadband and include and assess RF energy from a wide area of other sources including cellular communications, 2-way radio communications, broadcast as well as emissions from lighting systems and other appliances.

Between 14 and 28 tests were conducted at various locations on each vessel or at each terminal. At each test location, the RF levels were measured over time, and the peak value observed over the test period was recorded.

A total of 79 sample measurements were taken on the two vessels and two terminals over a two-day period.

1.3 Health Canada RF Exposure Limits

Health Canada defines maximum permissible RF exposure levels in its Safety Code 6 (2015) document - (HC Pub. 150313) Limits of Human Exposure to Radio Frequency Electromagnetic Energy in the Frequency Range from 3 kHz to 300 GHz – Health Canada Safety Code 6 (2015).

Safety Code 6 defines the allowable limits for the public in Table 5 of the document. Based on frequency this table presents the permissible power density over an averaging period. The standard assumes that a steady-state condition is obtained after a period of 6 minutes. This means that:

1. high power densities may be permissible for shorter time periods;
2. the stated power density limit is permissible for periods longer than 6 minutes (i.e. the limits does not have to be de-rated for longer term exposure).

For convenience, this table is included below.

Table 5. Reference Levels for Electric Field Strength, Magnetic Field Strength and Power Density in Uncontrolled Environments

Frequency (MHz)	Electric Field Strength (E_{RL}), (V/m, RMS)	Magnetic Field Strength (H_{RL}), (A/m, RMS)	Power Density (S_{RL}), (W/m ²)	Reference Period (minutes)
10 - 20	27.46	0.0728	2	6
20 - 48	$58.07 / f^{0.25}$	$0.1540 / f^{0.25}$	$8.944 / f^{0.5}$	6
48 - 300	22.06	0.05852	1.291	6
300 - 6000	$3.142 / f^{0.3417}$	$0.008335 / f^{0.3417}$	$0.02619 / f^{0.6834}$	6
6000 - 15000	61.4	0.163	10	6
15000 - 150000	61.4	0.163	10	$616000 / f^{1.2}$
150000 - 300000	$0.158 / f^{0.5}$	$4.21 \times 10^{-4} / f^{0.5}$	$6.67 \times 10^{-5} / f$	$616000 / f^{1.2}$

Frequency, f , is in MHz.

At the frequencies used by the access points, the Safety Code 6 standard establishes permissible, steady-state RF power density at a level of 5.34 W/m².

2 Summary of Test Results

The following table summarizes the measured power RF power densities at the test locations, as a percentage of the Health Canada RF limit for the public.

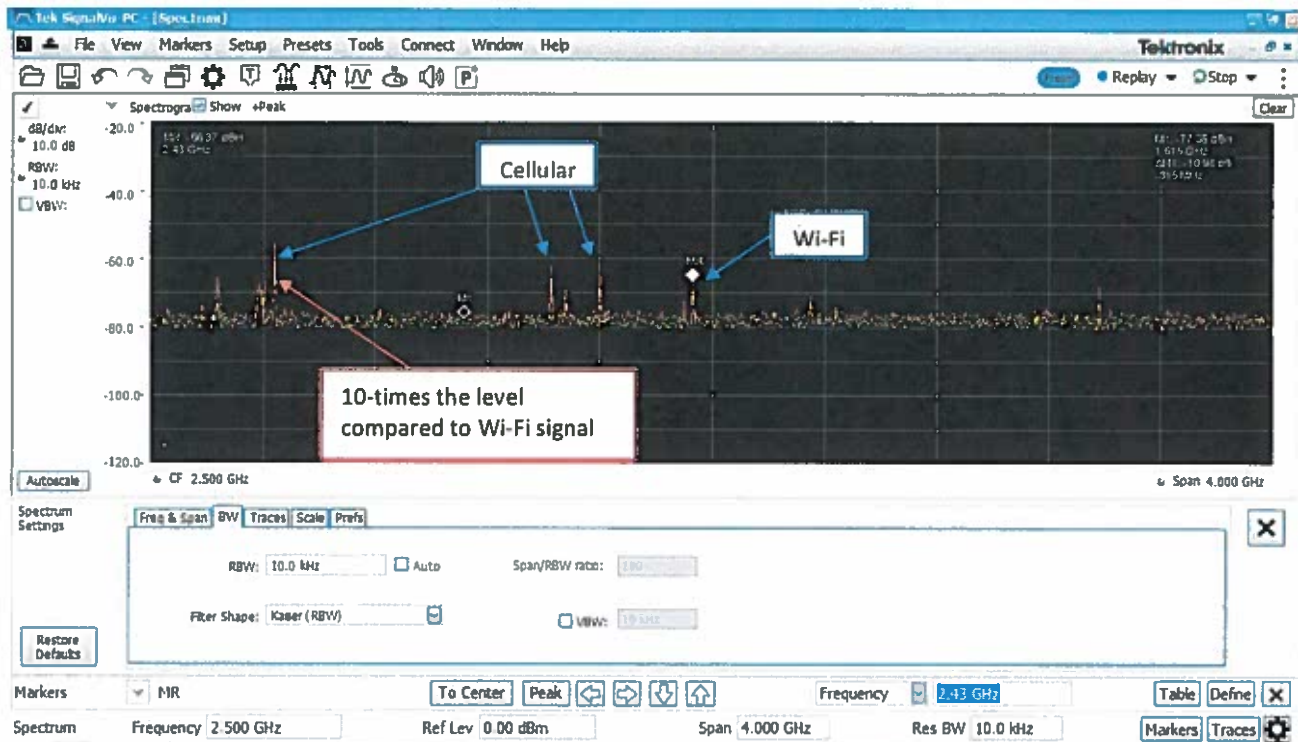
Vessel/Terminal	# of Tests Conducted	Peak Level Recorded at the Test Location with the Lowest Peak RF Level	Peak Level Recorded at the Test Location with the Highest peak RF Level	Average of the Peak Level for all Test Locations
Spirit of BC	14	1.61%	17.56%	4.61%
Coastal Celebration	17	0.94%	3.03%	1.96%
Swartz Bay Terminal	20	1.06%	20.5%	5.05%
Tsawwassen Terminal	28	1.09%	8.89%	2.62%
All Vessels/Terminals	79	0.94%	20.5%	3.45%

All test location measurements are significantly lower the Permissible Safety Code 6 limits for the public. The average peak level observed across all test locations was 3.45% of the Health Canada limit. The maximum peak level observed across all test locations was 20.5% of the Health Canada limit.

As noted above, the test approach assesses RF signals from all sources including cellular, 2-way radio and Wi-Fi. An analysis of the RF spectrum for the highest peak locations shows that the higher measurements are a result of cellular communications signals in the immediate vicinity of the test location.

As an example, the following spectrum plots shows contributing signal levels captured at the Swartz Bay terminal for the test location yielding 20.5%. This plot clearly shows three dominant cellular signals as noted on the figure. The strongest cellular signal, alone, is at least 10-times stronger than the Wi-Fi signal. As a result, the measurement at this location was heavily influenced by cellular signal strength and would have yielded similar results even if the Wi-Fi service had been disabled.

Detailed test results for each vessel or terminal can be found in the reports for the four locations tested.



3 Review of Findings, Conclusions and Remedial Actions

Planetworks was retained by BC Ferries to conduct RF power density testing in the terminal Swartz Bay Terminal. Planetworks confirmed that the aggregate of all RF emissions on the vessels or terminals including those from Wi-Fi access points do not exceed the Health Canada power density limit for the public in Uncontrolled Environments.

3.1 Findings

All areas measured complied with Health Canada RF power density requirements for Uncontrolled Environments, i.e. Safety Code 6. The results observed are consistent with other public spaces including schools, offices, urban outdoor spaces, and shopping malls.

3.2 Next Steps and Required Remedial Actions

No remedial action is required as the measured areas are well within permissible RF power density limits established by Health Canada.

APPENDICES

Appendix 1 - Comparison to other Public Areas

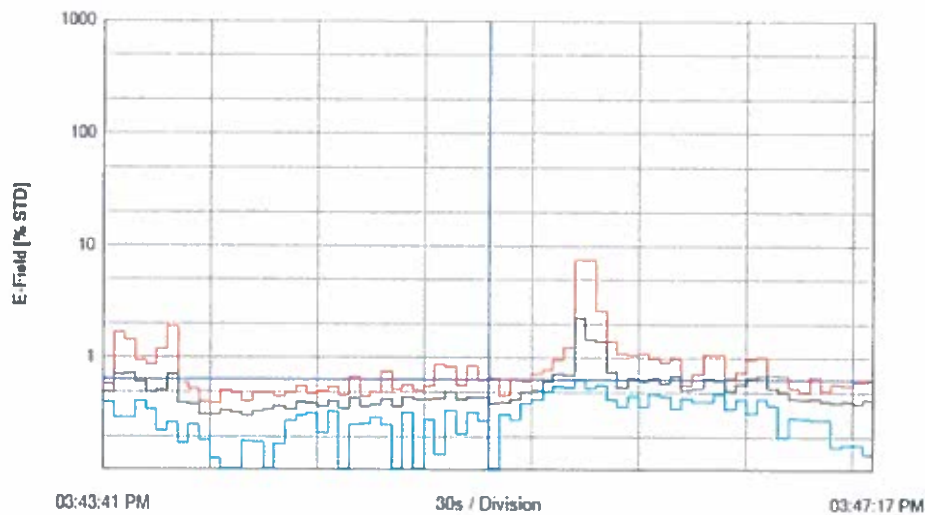
Based on Planetnetworks experience from measuring RF emissions at over 500 locations, the results obtained on this vessel are consistent with what can be found in public areas such as shopping malls, offices, outdoor areas, and schools.

The following figures show a sampling of measurements from these areas. All measurements are based on the Controlled Environment limit and therefore must be multiplied by 8.66 to arrive at the level based on Uncontrolled Environment (i.e. limit for general public). The samples were randomly selected and represent typical cases.

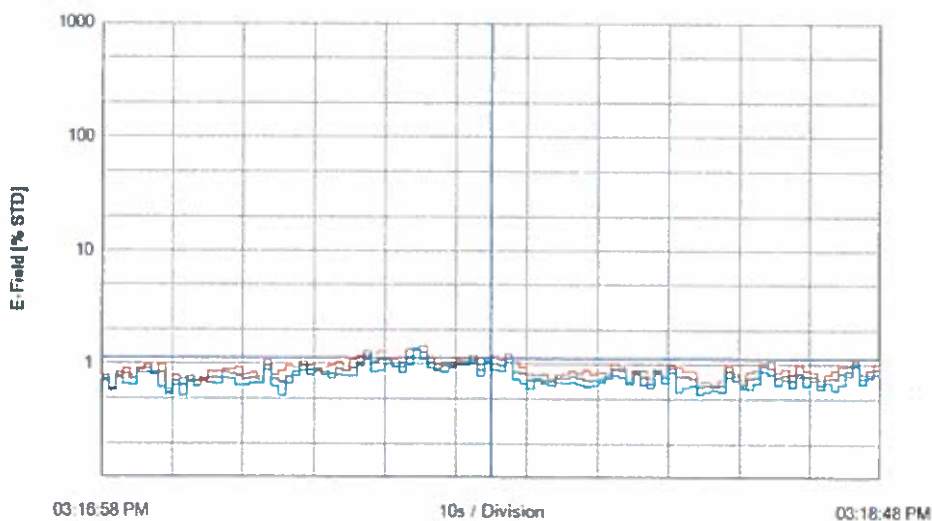
In general, the emissions in outdoor areas are bursty with periods of detectable RF and then periods of no detectable RF sources. Peaks of up to 16-20% of the Uncontrolled Limit are common on outdoor Urban streets while Indoor measurements are more constant with typical steady-state values of 6-10% of the Uncontrolled Limit. Schools, with and without Wi-Fi, follow the typical indoor results which indicate that the RF emissions are from a variety of sources and that Wi-Fi is not dominant.

The results obtained within BC Ferries' vessel and terminals are consistent with previous results obtained for indoor spaces including shopping malls, offices, and schools.

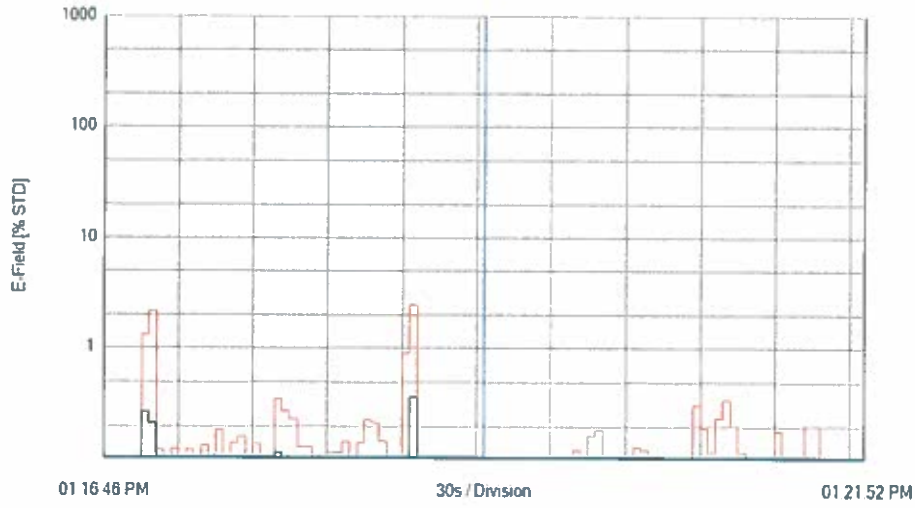
3.1 Inside Major Shopping Mall



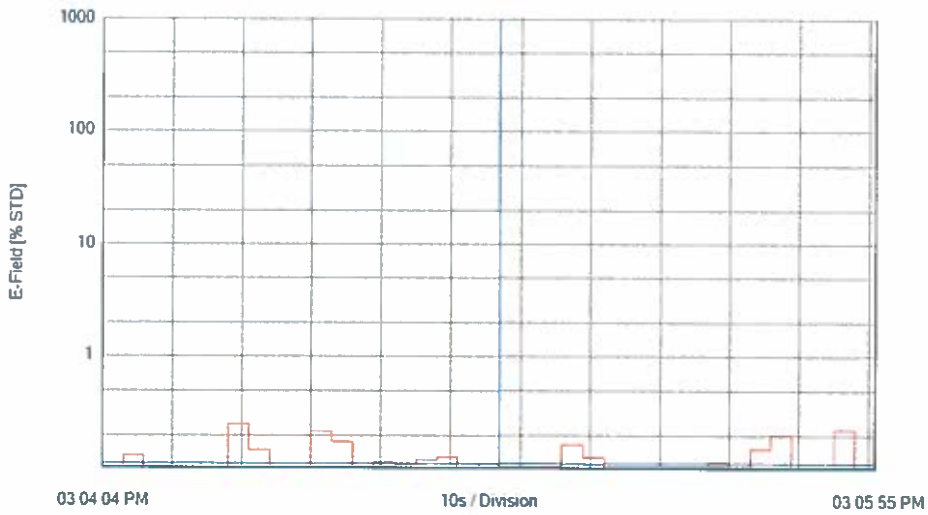
3.2 Inside Office Building



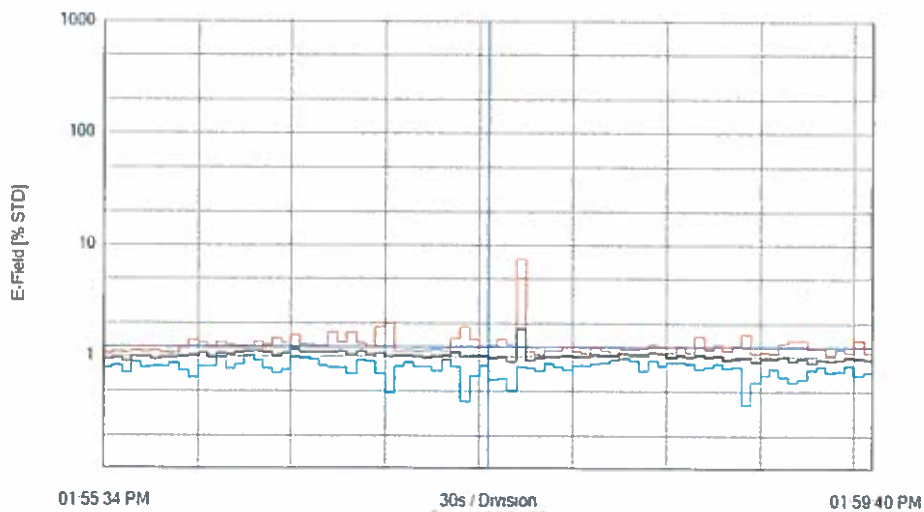
3.3 Metro Vancouver Urban Street



3.4 Metro Vancouver Semi-Urban Street



3.5 Metro Vancouver - Inside Elementary School with Wi-Fi



3.6 Metro Vancouver Elementary School without Wi-Fi

