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# REPORT

Proposed Labrador City
Hospital Blasting
Vibration and Noise
Consultation
Labrador West Hospital

GOVERNMENT OF NEWFOUNDLAND
AND LABRADOR

**PROJECT NO. 1035792.**

Jacques Whitford

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# PROJECT NO. 1035792.

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| REPORT TO | **Government of Newfoundland and Labrador**<br>**Transportation and Works**<br>**Design and Construction Division (Works)**<br>**5th Floor, West Block**<br>**Confederation Building**<br>**St. John's, NL A1B 4J6**<br>**Attention: Clyde Clarke, P.Eng.** |
| FOR | **Proposed Labrador City Hospital and Blasting**<br>**Vibration and Noise Consultation** |
| ON | **Labrador West Hospital** |

**December 18, 2008**

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# EXECUTIVE SUMMARY

Jacques Whitford was retained to provide consultation to the Government of Newfoundland and Labrador on the potential impacts of blasting at the IOC mines on the proposed hospital/college site in Labrador West. Following a review of practices, audit of site work, and a review of consultant reports, Jacques Whitford generally agrees with the information provided in this work and concludes that, on the basis of our limited audit and review of the information, these tests were conducted in accordance with normally accepted methods and equipment.

The results indicate that the site will experience ground vibration and airborne noise as a result of the blasting activities, but the magnitude of these effects can be mitigated through design of the site, design of the hospital, and selection of the equipment to prevent damage to the equipment or undue constraints on the operations of the hospital.

It is recommended that the design and equipment selection process incorporate review stages to accommodate the special circumstances of the site, and the tendering documents include reasonable estimates of the effects that the equipment must withstand.

As a follow-up, we recommend that the permitting authorities require IOC to document and monitor blast events during and after construction, and to provide written reports of any blast event that exceeds the permissible levels.

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# 1.0 INTRODUCTION

Jacques Whitford was retained by Mr. Clyde Clarke of the Government of Newfoundland and Labrador to provide consultation regarding a proposed hospital and college on Highway 500 in Labrador City. The specific terms of the assignment included:

- Review of ATCO measurement protocols and telephone advice to Mr. Clarke on the suitability of these protocols;
- Review of specifications of equipment to be used by ATCO, and any necessary recommendations;
- Meet with ATCO, IOC, and other involved contractors at the IOC plant, visit and agree upon suitable locations to implement the monitoring program;
- Provision and operation of Jacques Whitford instruments to do a parallel monitoring test on the equipment and test protocols;
- Review of ATCO and S. S. Wilson results and conclusions;
- Participation in several teleconferences, and telephone advice to Mr. Clarke on the evolving test program;
- Preparation of this report summarizing the results, and providing recommendations for future action.

## 1.1 Background

The Project is the construction of a new hospital and community college in Labrador City. The hospital site is on Rte 500, northwest of Labrador City, and nearer to future developments by IOC, including the Wabush 3 mine. IOC and the Government of Newfoundland and Labrador have developed concerns that noise and vibration due to blasting at Wabush 3 may compromise the diagnostic equipment or operations at the new hospital, therefore a test program was developed to monitor blasting at the existing operations at a site a similar distance and orientation from the blast as the Rte 500 site will be from Wabush 3. IOC retained S. S. Wilson to conduct numerical modeling of the potential impacts, and ATCO Noise Management to conduct the field measurement program. Mr. Clyde Clarke, of the Government of Newfoundland and Labrador, contacted Mr. Lorne Boone of Jacques Whitford (JW) to retain JW on their behalf.

## 1.2 Information Base

This work is based on information gained through:

1) numerous telephone discussions with the client, including conference calls with representatives of IOC, SS Wilson and ATCO Noise;
2) site visits by Lorne Boone and John Walker at the beginning of April, 2008, during the setup by ATCO Noise of the equipment to monitor blasts at the current operating area;
3) Draft and final report from SS Wilson regarding the modeling of vibration and airborne vibration at the proposed site and other sites in Labrador City;

4) Final report by ATCO Noise documenting the vibration and sound monitoring program during 2008, with instrument traces and tabulations of vibration and sound; and

5) Document furnished by Clyde Clarke listing the responses of several medical imaging and testing equipment suppliers to questions posed by a representative of the Department of Health on vibration sensitivity of hospital equipment.

## 1.3 Definitions and Concepts

### 1.3.1 Vibration

The two main variables that effect ground vibration due to blasting are the maximum charge weight and the distance from the blast. These two variables can be combined in a mathematical relation called scale distance. Ground vibration as it relates to structural damage is measured as peak particle velocity. This is the maximum speed at which particles vibrate due to the energy from a blast.

### 1.3.2 Noise

Noise is produced by energy from a blast that is spent in compression of the atmosphere. It results from the rapid expansion of air due to the heat and chemistry of the explosive detonation. Although some noise is inevitable, well conducted blasting events produce more efficient results than poorly done events, and result in lower noise. This occurs because the energy is dissipated in fracturing rock rather than in transmitting pressure waves. A typical blast is composed of a number of strings of charges that are set off with delays between each string. The delays are designed to assist the fragmentation process, but also distribute the blast over a period of several seconds. Thus the sound of a large blast, such as those at IOC is more of a rumble than a sudden crack. Intervening terrain between the blast and the receiver will result in some attenuation. Low frequency sounds are less well attenuated than high frequency sounds. This also applies to the penetration of sounds into buildings. The low frequency is not as impeded by the structure as the high frequency.

# 2.0 BACKGROUND

The Government of Newfoundland and Labrador has been conducting initial site design work and building design for a new hospital to be constructed in Labrador City. The site is located on the north side of town. Concerns were raised because of the future expansion possibilities of IOC, including the development of the Wabush 3 mine, located immediately north of the proposed hospital site.

# 3.0 BLAST MONITORING AUDIT

As a result of concerns expressed about the effects of blasting at the proposed hospital site, a monitoring program was developed that was designed to monitor the effects of the existing mine blasting at a number of locations, including one that simulated the distance and general orientation of the trajectory from Wabush 3 to the proposed hospital site (see Figure 1). ATCO Noise Management was retained by IOC to implement the monitoring program, and provided a test plan to the Government of Newfoundland and Labrador for comment.

Jacques Whitford was provided with the plan on March 14, 2008 and provided comments with respect to the instruments and test plan proposed by ATCO Noise, and participated in a telephone conference call. The conclusion of these discussions was that the ATCO Noise plan was suitable, and the equipment acceptable and appropriate for this work. All parties agreed that site constraints, such as snow depth, safety and general logistics would result in some alterations to the plan, but that the results would be of value in addressing the concerns.

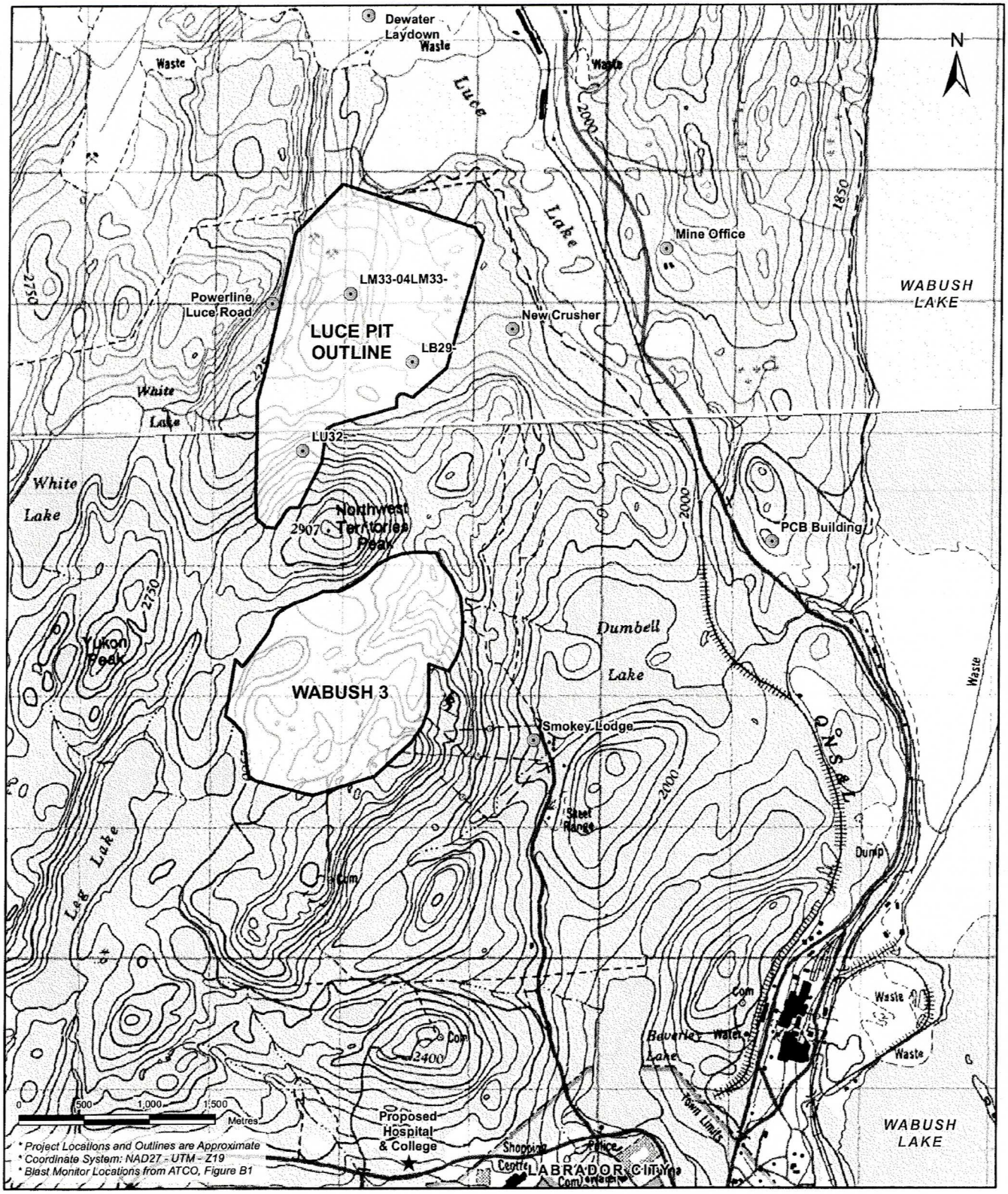
At the request of the client, Lorne Boone and John Walker travelled to the site and met with Paul Wierzba of ATCO Noise and representatives of IOC on April 1. These three were able to set up equipment to measure a blast on the first day on-site. They were only able to conduct the observations at the Smokey Ski Lodge as site safety briefings had not been conducted at that time. The team anticipated witnessing blasts in the following two days; however, IOC elected to postpone these events, so only that first event was witnessed. On the following day, upon further safety orientations, Jacques Whitford and ATCO Noise visited several candidate locations for monitoring and agreed upon suitable candidates, with the provision that safety and site logistics could alter these choices.

As a result of the observations on-site, Jacques Whitford concluded that the equipment, locations, and equipment were appropriate.

## 4.0 CONSULTANTS REPORTS AND OTHER INFORMATION

Reports were provided through Clyde Clarke of the Government of Newfoundland and Labrador, Mr. Lee Preziozi of IOC, or Mr. Paul Wierzba of ATCO Noise. The timeline for this was:

- February 15 – Test Plan
- February 25 – SS Wilson Report of November 2007
- April 1, 2, 3 – On-site meetings
- March 14 – ATCO Noise Test Plan
- March 20 – Equipment Specifications
- March 20 – Topographical Map
- April 29 – ATCO Noise Results for Four Blast Events
- May 1 – Conference Call – N&L, IOC, SS Wilson, JWA
- May 5 – SS Wilson Report of April 4
- September 23 – Final ATCO Report

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|---|---|---|
| DATE: 30/09/2008 | Proposed Labrador City West Hospital Blasting Vibration and Noise Consultation | FIGURE NO: Figure 1 |
| PREPARED BY: L. Kendell | **STUDY AREA LAYOUT** | Jacques Whitford |
| JW PROJECT NO.: 1035792 | | |

# 5.0 DISCUSSION

## 5.1 Vibration

### 5.1.1 Ground Borne Vibrations

Our assessment of the proposed Wabush 3 project included a review of the SS Wilson Associates report of April 4, 2008 and the Blast Noise and Vibration Measurement Report by ATCO Noise Management of August 13, 2008. Based on these reports and our own calculations we have made preliminary conclusions regarding ground borne vibrations and possible effects on a proposed hospital at the Highway 500 site.

The chart on Figure 2 indicates the relationship between peak particle velocity that was measured at various sites and scaled distance (defined in Section 1.3) calculated for each blast. Each point on the figure represents a seismograph reading as a function of its scaled distance. Each measurement site has a distinct symbol. For example Smokey Lodge readings are represented by solid triangles.

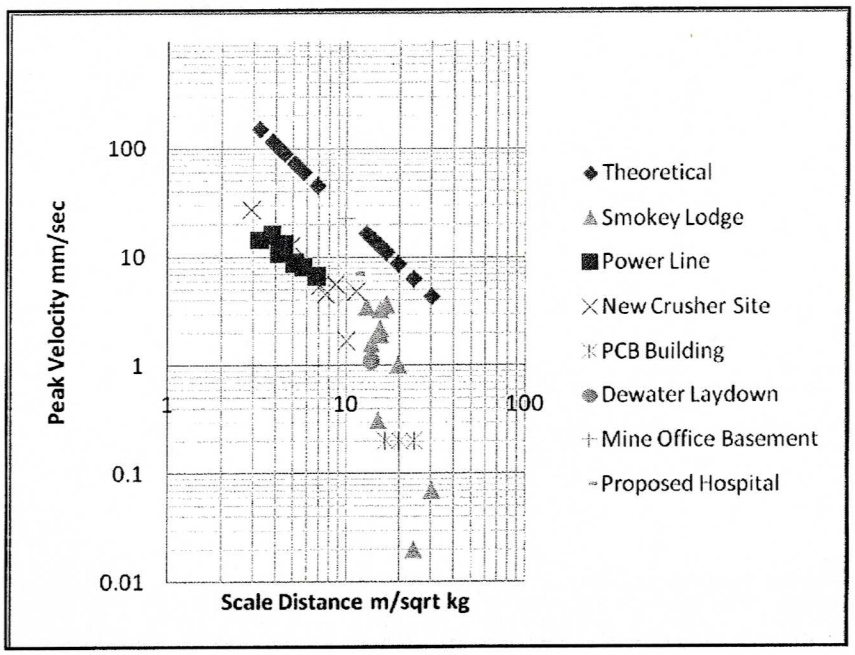


**FIGURE 2 Peak Particle Velocity**

It can be seen from the chart that there is a pattern and for each scale distance there appears to be an upper limit vibration level. The sloping line of blue diamond points above the measured points represents a theoretical maximum velocity for each scaled distance. It is unlikely that vibration measurements would be above this line of points and the vast majority would be within the measured grouping below it. Of the 30 seismograph readings measured by ATCO there is one high reading

(represented by a blue cross) measured in the basement of the mine office building that coincides with the maximum theoretical velocity.

The reason the measured results vary is that there are several variables in addition to charge weight and distance. These include variations in geology and topography, blast loading configuration, loading accuracy etc. They tend to be less important factors but can occasionally add up unfavourably to give a higher than normal reading.

### 5.1.2 Effects Geological Fault

It is understood that there exists a geological fault located between the proposed Wabush 3 mine and the proposed Hospital site. The fault is situated on a line bearing approximately north east, immediately south of the proposed mine. The question has arisen whether this fault would affect the transference of ground vibrations. The Smokey Lodge and The PCB Storage monitoring sites are south of the fault and perhaps on the fault zone, respectively. Figure 2 indicates that these two sites had the lowest ground vibration readings although the Smokey Lodge site also had some of the highest readings relative to scaled distance. Based on this we infer that the fault may at times have a buffering effect but that this effect can not be relied upon.

### 5.1.3 Predicted Maximum Ground Vibration Proposed Hospital Site

It is our understanding that the maximum instantaneous charge that would be detonated at the proposed new Wabush 3 mine would be 96,000 kg and the closest distance between the new mine and the proposed hospital site would be approximately 3,500 metres. Using these parameters with the measured data from the existing mine, it is predicted that normally the vibration level would be less than approximately 7 mm/second. The theoretical maximum would be approximately 21 mm /second. The SS Wilson report predicted average vibration levels of 11.8 mm/second and upper limits of 23.6 mm/second.

### 5.1.4 Sensitive Equipment

A questionnaire was sent to several of the present hospital equipment suppliers to determine if the predicted level of vibration would affect their equipment. The responses were widely varying from no effect to possibly some effect during operation of the equipment. Some of the suppliers recommended use of isolation kits to protect the equipment from vibration. Toshiba of Canada was the only company that quoted vibration specifications; this was in relation to their CT machines. Toshiba gave a maximum acceleration equal to 0.1 g. Acceleration is the rate of change of velocity and can be calculated approximately from the particle velocity knowing the frequency of vibration. By estimating the normal frequencies that would occur, the expected acceleration can be inferred to be in the range of 0.1 g to 0.5 g, which is higher than the specified maximum. The seismograph readings measured at the site generally support this conclusion. The following equations may be used to convert between particle velocity, V mm/sec and particle acceleration, A in terms of gravity (g).

V mm/sec= Ag/(f x 0.000641) and Ag= f x V x 0.000641 (where f is the frequency of vibration)

Based on the field monitoring data normal frequencies associated with the highest vibration levels would fall in the range of approximately 10 to 40 cycles per second. For example, a theoretical

maximum particle velocity of 21 mm/sec at a frequency of 15 cycles per second would correspond to an acceleration of 0.2 g. Higher frequency would result in higher acceleration.

### 5.2 Noise

The noise readings from the blasting events are summarized in the final ATCO Noise report. Blast noise in the information provided to date has been about 130 dBL or less. Anecdotal reports of the dataset that has not been transmitted to Jacques Whitford are of delays consisting of up to 36 charges, approaching the theoretical limits presented by IOC during teleconference.

The most significant evidence is from the blast of April 1, resulting in a peak sound pressure level of 119 dBL at Smoky Lodge from a blast using 38 charges/delay. This is most like the potential situation of Wabush 3 relative to the proposed hospital, but blast design 2.1 would have 60 holes/delay.

Results of the S.S. Wilson report are that blast 2.1 could give peak sound pressure levels of 131 to 138 dBL at the hospital site. It was not possible to verify this level, as the model, the source strength and the method of estimating source strength were not provided. The terrain and the propagation of noise are complex in this area. The proposed site is sheltered, to some extent, by the 800 m high ridge running from west to east just north of the Rte 500 site. The differences in distance and exposure between the Rte 500 site and any other feasible sites within the town are not large enough to conclude that there are significant differences among them. By adding a focus on mitigation of noise during the design and construction phases, much of the differences, if any, may be cancelled out.

## 6.0 CONCLUSIONS AND RECOMMENDATIONS

### 6.1 Vibration

Review of the results of vibration monitoring indicates that the measured results are slightly lower than predictions made in the SS Wilson report. However, considering the uncertainties of the prediction methods and the relatively low number of measurements we consider them to be fairly in agreement. In our opinion the maximum predicted vibration level of 23.8 mm/second is within a range for which a normal building can be designed to withstand significant damage especially considering that the average vibration would be well below this. We note that humans are much more sensitive to ground vibrations and vibrations caused by air-blast noise than are structures. The range of particle velocity predicted at the proposed hospital would probably be described as strong or severe in the case of the highest readings, by people who are not familiar with blast vibrations.

The predicted vibration level at the proposed hospital site may exceed accepted or specified limits for some of the sensitive electronic equipment, in particular the CT and MRI machines. This should be explored further with the manufacturers. If the limits quoted only apply while the equipment is operational it may be possible to schedule tests around the blasts which we understand are approximately once per week. Alternatively it may be possible to mechanically isolate the equipment.

## 6.2 Noise

The noise assessment showed that there may be elevated levels of noise experienced at the hospital site. These levels are sufficient to cause some level of alarm, but citizens of this town are relatively accustomed to such events. All sites within the town are at a distance that will experience elevated noise. On the other hand, there is some topographic shielding offered at the proposed Highway 500 site, and this might be exploited in the design of the site layout and building. It is considered essential that the designers employ modern noise reduction techniques in the hospital. This includes walls, windows and the roof of the building, and also the project documentation to all contractors.

An appropriate level of acoustic design input at the appropriate stage of design would include:

1) Determination of design generalized acoustic criteria for all critical spaces in the building, such as: operating rooms, patient rooms, atrium and large corridors, offices, meeting rooms, and common work areas (among others)
2) Review of the building layout and proposed space usage as an evaluation of the facility's architectural acoustics. Provide recommendations for room layout and surface treatments for key occupied spaces, in order to deliver appropriate sound quality and speech privacy performance.
3) Review vibration isolation requirements for all HVAC equipment, based on the estimated deflection of the floor(s) and ensure that the corresponding spring deflection is adequate to provide the required vibration isolation efficiency.
4) Tender documents should be reviewed and modified to include standard acoustical treatment references and appropriate targets.
5) Supplier submissions to be reviewed for compliance with tender specifications that should include anticipated rain and vibration levels.

Provided that the hospital be designed and built with appropriate levels of input to the noise and vibration protective systems, it is considered likely that the site constraints will be overcome.

# 7.0 CLOSURE

This report has been prepared for the sole benefit of the Government of Newfoundland and Labrador. This report may not be relied upon by any other person or entity without the express written consent of Jacques Whitford and the Government of Newfoundland and Labrador. Any use of this report by a third party, or any reliance on decisions made based upon this report, are the responsibility of the third party. Jacques Whitford accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this report. Jacques Whitford makes no representation or warranty with respect to this report, other than the work was undertaken by trained professional and technical staff in accordance with generally accepted engineering and scientific practices current at the time the work was performed. Any information or facts provided by others and referred to or utilized in the preparation of this report was assumed by Jacques Whitford to be accurate. This study was undertaken exclusively for the purpose outlined herein. This report cannot be used or applied under any circumstances to another location or situation or for any other purpose without further evaluation of the data and related limitations.

This report was prepared by Dan R. McQuinn, P.Eng. and John Walker, Ph.D., and reviewed by Lorne Boone, P.Eng. If you have any questions regarding the contents of this report, or require any additional information, please do not hesitate to contact the undersigned.

Yours truly,

**JACQUES WHITFORD LIMITED**

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