

PHASE 2 INITIAL BOREHOLE DRILLING AND TESTING, SOUTH BRUCE

*Dust, Noise, and Vibration Background Study for
SB_BH01 and SB_BH02 sites, in South Bruce*

APM-REP-01332-0428

January 2021

Cambium Consulting and Engineering

nwmo

NUCLEAR WASTE
MANAGEMENT
ORGANIZATION

SOCIÉTÉ DE GESTION
DES DÉCHETS
NUCLÉAIRES

Nuclear Waste Management Organization
22 St. Clair Avenue East, 4th Floor
Toronto, Ontario
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Phase 2 Initial Borehole Drilling and Testing, South Bruce

Dust, Noise, and Vibration Background Study for SB_BH01 and SB_BH02 sites, in South Bruce

Revision: 0

NWMO Document: APM-REP-01332-0428

Prepared for:

Nuclear Waste Management Organization

22 St. Clair Avenue East, 4th Floor
Toronto, ON, M4T 2S3

Prepared by:



CAMBIUM
Consulting & Engineering

Project Number: 11714-001
January 13, 2021



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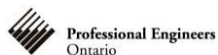
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Peterborough, ON
K9H 1G5

Locations

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Barrie
Oshawa

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January 13, 2021

Geofirma Engineering Ltd.
1 Raymond Street, Suite 200
Ottawa, Ontario
K1R 1A2

Attn: Sean N. Sterling, M.Sc., P.Eng., P.Geo
Vice President / Manager of Geoscience

**Re: Dust, Noise, and Vibration Background Study for
1021 Concession 8 and 1257 Concession 8, in South Bruce
Cambium Reference No. 11714-001**

Dear Mr. Sterling,

This letter report outlines the assessment of the baseline dust, noise and vibration levels for the two proposed borehole drilling and testing sites (the Sites) located in South Bruce, Ontario. The onsite work for the baseline data collection was conducted on October 26th, 2020.

Cambium was retained to provide onsite measurements of noise, vibration, and dust at both locations prior to the start of any construction activities. The locations are shown on the appended Figure 3 and described as follows:

- A property at 1021 Concession 8, in South Bruce (deemed Location 1 throughout this report). Testing was conducted southwest of the structures onsite at approximate UTM coordinates: 17T 473,648 m E, 4,873,270 m N.
- A property at 1257 Concession 8, in South Bruce (noted as Location 2). Testing was conducted at the south end of the west property line laneway at approximate UTM coordinates: 17T 471,242 m E, 4,872,715 m N.

WEATHER

Cambium staff were at Location 1 from 07:00 until 11:30, and at Location 2 from 12:00 until 15:30. As shown in the attached report from the nearest official Environment Canada weather station, the weather conditions during the day were mostly cloudy with a low of approximately 5°C and a high of approximately 8°C. Cambium staff used a Kestral 5500 Weather Meter to take local readings of some parameters. Wind was generally low in the morning, either with no observable direction, or from the west reading less than 1 m/s (3.6 km/hr). Wind speeds in the afternoon generally increased but was variable with short term maximums (i.e. gusts) of approximately 6 m/s (21 km/hr). The humidity was high, at greater than 80%. Very light rain occurred at approximately 09:00 to 09:30, and again at 15:15.



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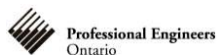
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BASELINE NOISE STUDY

We define the noise environment of the area surrounding both locations as rural, where natural noises from the wind and the wildlife are the dominant audible sounds at most times during both daytime and nighttime. The most significant audible, non-natural noise sources are:

- The road traffic on Concession 8 and the road traffic on Bruce County Road 6.
- The aggregate operations south of both the locations, on Sideroad 25 North, and near the intersection of Bruce County Road 6 and Sideroad 25 North.
- Local farming practices.

Cambium conducted noise measurement of octave band sound pressure using a Brüel and Kjær Type 2270 hand-held Sound Level Meter (SLM) with microphone. The SLM has a factory calibration certification as attached, and was field calibrated using a Larson Davis CAL200 Calibrator, which also has a factory calibration certification as attached. Each measurement reported was greater than 20 minutes long.

The results of the noise measurements are summarized below.

Table 1 Noise Results Summary Table

Measurement ID	Location	Start Time	LAeq (dBA)	LAF90 (dBA)	LAFmax (dBA)
20201026001	Location 1	07:39	35.1	28.4	59.8
20201026002	Location 1	09:01	33.5	28.0	53.8
20201026003	Location 1	09:36	29.6	25.5	56.4
20201026004	Location 1	10:31	30.9	26.7	58.6
20201026005	Location 2	12:14	32.8	25.7	56.0
20201026006	Location 2	13:10	33.7	24.0	56.8
20201026007	Location 2	14:22	34.9	24.9	55.9

Where:

- LAeq - represents the A-weighted, logarithmically averaged noise levels over the duration of the measurement.
- LAF90 - represents the A-weighted, 90th percentile noise level, or the noise level that is exceeded 90 percent of the time during the measurement.
- LAFmax - represents the A-weighted, maximum noise level reached under the 'fast-response' noise meter settings.

Some short-term interference noise from the staff operating the noise meters is likely captured in the LAFmax measurements but can be seen to not significantly affect the LAeq results.

BASELINE VIBRATION STUDY

During the site visit there were no vibrations perceived by Cambium staff.

- It was observed that there is aggregate operations to the south of the locations, on Sideroad 25 North, and near the intersection of Bruce County Road 6 and Sideroad 25 North. The nearest potential operations of the aggregate pits are approximately 780 m from the vibration monitoring location at the 1021 Concession 8 property (i.e.



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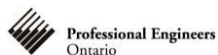
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Location 1). From satellite imagery review of the site, it does not appear to be likely that blasting occurs at this site.

- Some farming operations were observed during the site visit. A tractor was cultivating the front garden area of the house at 1273 Concession 8, directly west of the 1257 Concession 8 (Location 2) property. This activity occurred from approximately 14:45 until 15:30 and was approximately 210 m from the vibration monitoring location at Location 2.

Due to the distances described above, observations of the area surrounding both vibration monitoring locations indicate there is unlikely any significant source of vibration located nearby.

Cambium conducted vibration measurements of peak particle velocity using a PCB ICP Accelerometer. The ICP Accelerometer has a factory calibration certification as attached, and was field calibrated using an IMI handheld shaker calibrator, which also has a factory calibration certification as attached.

The results of the vibration measurements are summarized below.

Table 2 Vibration Results Summary Table

Measurement ID	Location	Start Time	Signal Average RMS (mm/s)	Maximum 1 second RMS (mm/s)
2020_10_26_Field_BKGD01	Location 1	08:45	0.0023	n/a *
2020_10_26_Field_BKGD02	Location 1	09:46	0.0023	0.0024
2020_10_26_Field_BKGD03	Location 1	09:50	0.0023	0.0029
2020_10_26_Field_BKGD04	Location 1	10:27	0.0023	0.0039
2020_10_26_Field_BKGD05	Location 1	11:20	0.0023	0.0028
2020_10_26_Field_BKGD06	Location 2	12:31	0.0023	0.0041
2020_10_26_Field_BKGD07	Location 2	13:09	0.0024	0.0062
2020_10_26_Field_BKGD08	Location 2	14:01	0.0023	0.0038
2020_10_26_Field_BKGD09	Location 2	14:44	0.0022	0.0023
2020_10_26_Field_BKGD10	Location 2	15:00	0.0022	0.0025

* This data point was deemed invalid due to a setup error in the vibration monitoring software.

Where:

- Signal Average RMS - represents the root mean squared, peak particle velocity, over the duration of the measurement.
- Maximum 1 second RMS - represents the highest root mean squared, peak particle velocity, using 1 second averaging time.

Some, minimal, short term interference vibrations from the staff operating the vibration sensor are likely captured in the maximum 1 second RMS measurements but can be seen to not significantly affect the signal average RMS results.

BASELINE AIRBORNE DUST STUDY

We define the air quality environment of the area surrounding both locations as rural, where the land surface is mostly agricultural use. There are also some wetland and forested areas nearby.



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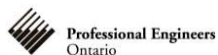
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Local sources of airborne dust potentially include: local agricultural activity, local unpaved roadways and driveways, and the nearby aggregate operations to the south of the locations.

Cambium conducted measurements of dust as total suspended particulate (TSP) using a TSI 8533 DustTrak aerosol monitor. The TSI DustTrak has a factory calibration certification as attached, and the flowrate was field calibrated using a Streamline Pro MultiCal flow meter, which also has a factory calibration certification as attached. Each measurement was 55 minutes long, with data logged every 5 minutes.

The results of the dust measurements are summarized below.

Table 3 Dust Results Summary Table

Measurement ID	Location	Start Time	Average TSP ($\mu\text{g}/\text{m}^3$)	Max TSP ($\mu\text{g}/\text{m}^3$)
Test 018	Location 1	07:51	2	7
Test 019	Location 1	08:47	2	6
Test 020	Location 1	09:43	1	3
Test 021	Location 1	10:39	3	6
Test 022	Location 2	12:13	2	7
Test 023	Location 2	13:09	3	4
Test 024	Location 2	14:05	1	4
Test 025	Location 2	15:01	2	4

Where:

- Average TSP - represents the 55 minute average of the total suspended particulate readings.
- Max TSP - represents the highest of the 5 minute averaged, total suspended particulate logged readings during the full measurement.

It is recognised that airborne dust can be significantly variable depending on weather conditions and time of year. The day that Cambium conducted dust measurements had low wind speeds and moist soil conditions, and therefore likely does not represent a worst case scenario for dust.

In order to better classify a general baseline level for typical airborne dust in the area, we reference published data from Environment and Climate Change Canada (ECCC) and the National Air Pollution Surveillance (NAPS) program.

The nearest relevant ECCC Ambient Air Quality monitoring station is at Tiverton, Ontario. This station is approximately 40 km from the study location and has full hourly datasets published as recent as 2018. There is also more recent daily data published through Ontario Air Quality, as a division of the Ontario Ministry of the Environment, Conservation, and Parks (MECP). These data sets use fine particulate matter (PM_{2.5}) concentrations to represent dust levels. PM_{2.5} represents only a fraction of the total suspended particulate concentrations in the air, but in a regional sense, the variability of PM_{2.5} is representative of the variability of TSP.



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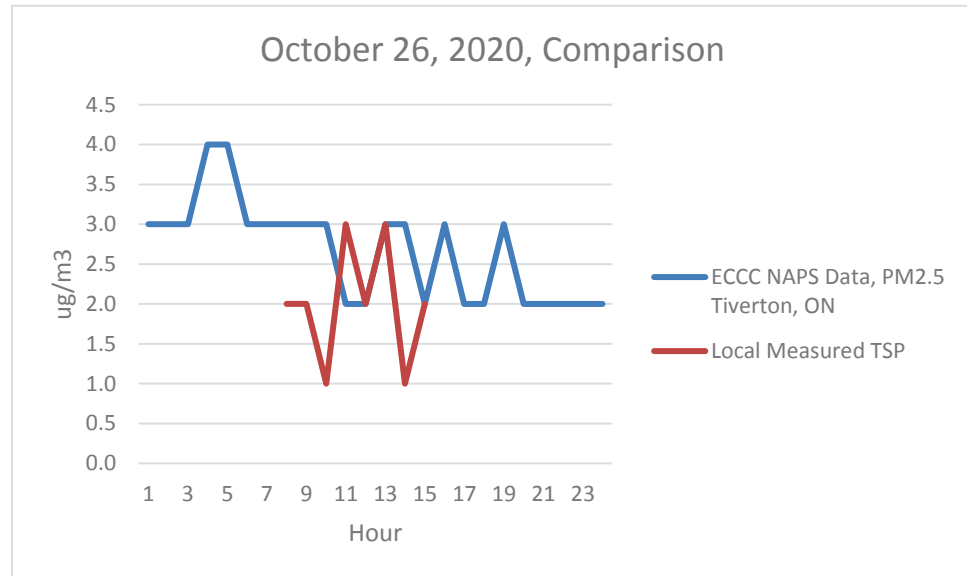
 Professional Engineers
Ontario

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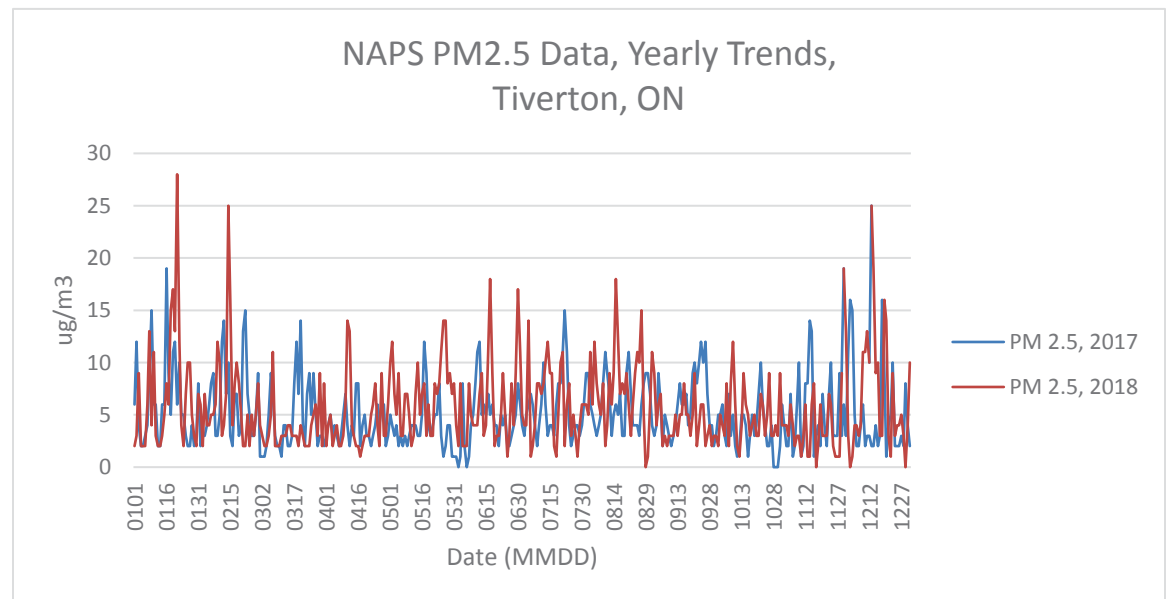
The following October 26th, daily trend graph of the Tiverton station data shows that the data aligns reasonably well with the measurements Cambium collected at the study locations.

Figure 1



The following yearly trend graph of the Tiverton station shows the range of daily averaged PM2.5 values typical for the region.

Figure 2



The graph indicates that the typical daily PM2.5 readings would expect to be in the range of 5 to 15 $\mu\text{g}/\text{m}^3$. Outliers on the graph are likely related to very dry and windy days that would result in dust readings greater than 15 $\mu\text{g}/\text{m}^3$.



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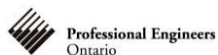
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CONCLUSION

The results of the baseline studies as described therein, provides a determination of the general background environment surrounding the two borehole drilling and testing sites located in South Bruce, Ontario, on October 26th, 2020.

Based on the described conditions of the study day, the data for noise and vibration presented for October 26th, 2020 can be considered to be generally applicable as baseline levels for any day of the year. Airborne dust is significantly more variable by weather conditions and time of year, and is also significantly affected by nearby seasonal, agricultural activities (as in: cultivating in dry conditions). Seasonal trends were discussed using published data.

Cambium followed the methods of applicable best practices when conducting the measurements and calculations contained in this assessment.

Best regards,

Cambium Inc.

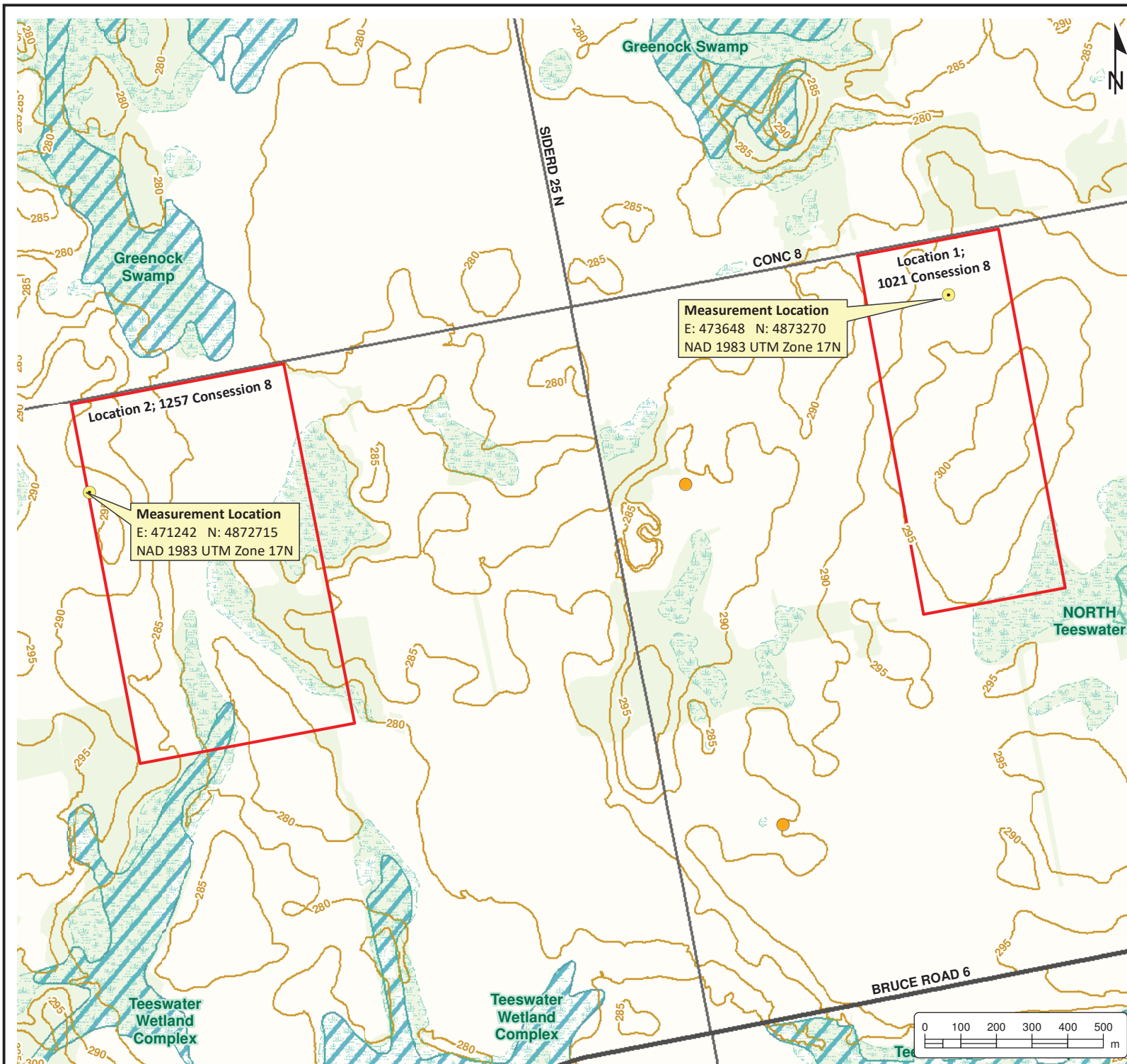
Sadie Bachynski, P. Eng.
Senior Project Manager

Trevor Ross, E.I.T.
Project Specialist

SLB/tgr

Encl. *Figure 3 – Site and Location Layout*
Attachment A – Supporting Documents

P:\11700 to 11799\11714-001 Geofirma Engineering Ltd - ECA Studies Air & Noise - South Bruce\Deliverables\Baseline Study\2021-01-13 - Baseline Study Report.docx














NOISE IMPACT STUDY

GEOFIRMA ENGINEERING LTD.

1021 Concession 8 &
1257 Concession 8,
South Bruce, Ontario

LEGEND

-  Aggregate Operations
-  Measurement Location
-  Major Road
-  Minor Road
-  Contour 5m Interval (Major)
-  Contour 5m Interval (Minor)
-  Unevaluated Wetlands
-  Locally Significant Wetlands
-  Provincially Significant Wetlands
-  Wooded Area
-  Site (approximate)

Notes:

- Base mapping features are © Queen's Printer of Ontario, 2019 (this does not constitute an endorsement by the Ministry of Natural Resources or the Ontario Government).

- Distances on this plan are in metres and can be converted to feet by dividing by 0.3048.

- Cambium Inc. makes every effort to ensure this map is free from errors but cannot be held responsible for any damages due to error or omissions. This map should not be used for navigation or legal purposes. It is intended for general reference use only.



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SITE AND LOCATION LAYOUT

Project No.: 11714-001		Date: January 2021 Rev.:	
Scale: 1:15,000		Projection: NAD 1983 UTM Zone 17N	
Created by: MAT	Checked by: SLB	Figure: 3	



January 13, 2021

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Attachment A

Supporting Documents





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of Canada

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Hourly Data Report for October 26, 2020

All times are specified in Local Standard Time (LST). Add 1 hour to adjust for Daylight Saving Time where and when it is observed.

GODERICH ONTARIO Current Station Operator: ECCC - MSC

Latitude:	43°46'00.000" N	Longitude:	81°43'00.000" W	Elevation:	213.70 m
Climate ID:	6122847	WMO ID:	71261	TC ID:	WGD

TIME	Temp °C	Dew Point °C	Rel Hum %	Wind Dir 10's deg	Wind Spd km/h	Visibility km	Stn Press kPa	Hmdx	Wind Chlll	Weather
00:00	4.9	1.3	78	4	9		99.47			NA
01:00	4.7	1.1	77	4	8		99.45			NA
02:00	4.6	0.8	76	6	9		99.40			NA
03:00	4.6	0.7	76	7	10		99.32			NA
04:00	4.5	0.2	73	4	5		99.35			NA
05:00	4.3	0.8	78	34	6		99.36			NA
06:00	4.3	0.6	77	5	4		99.37			NA
07:00	4.2	0.7	78	7	8		99.34			NA
08:00	4.1	1.3	82	4	6		99.39			NA
09:00	4.2	1.0	80	4	3		99.47			NA
10:00	5.6	1.6	76	12	3		99.39			NA
11:00	6.4	1.0	69	29	5		99.39			NA
12:00	7.2	1.6	68	29	7		99.43			NA
13:00	7.5	2.5	70	30	10		99.44			NA
14:00	7.1	3.6	78	32	21		99.42			NA
15:00	6.6	3.5	81	33	23		99.45			NA
16:00	6.4	3.1	80	30	20		99.51			NA
17:00	6.7	2.2	73	30	20		99.52			NA
18:00	6.6	2.4	74	30	19		99.57			NA
19:00	6.5	2.4	75	29	18		99.68			NA
20:00	6.4	2.3	75	29	21		99.70			NA
21:00	6.4	2.4	76	31	14		99.71			NA
22:00	5.5	2.2	79	4	6		99.73			NA
23:00	5.6	2.1	78	30	12		99.76			NA

Legend

- E = Estimated
- M = Missing
- NA = Not Available*
- [empty] = Indicates an unobserved value

Date modified:



Certificate of Conformity

This instrument was produced under rigorous factory production control and documented standard procedures. It was individually inspected and leak tested and the functioning of its display, backlight, buttons and firmware was verified. The accuracy of each of its primary measurements was individually calibrated and/or validated against standards traceable to the National Institute of Standards and Technology ("NIST") or other calibrated standards in accordance with the documented standard test methods detailed below. This instrument is warranted to perform in compliance with the published specifications for the specific measurements and features of its model number including specified typical drift since its date of manufacture. (See Kestrel Limited Warranty for full warranty terms.)

Standards Used in Testing

Wind Speed:

The Kestrel Weather & Environmental Meter impeller installed in this unit was individually tested in a subsonic wind tunnel operating at approximately 300 fpm (1.5 m/s) and 1200 fpm (6.1 m/s) monitored by a Gill Instruments Model 1350 ultrasonic time-of-flight anemometer. The Gill 1350 is calibrated regularly and is traceable to NIST with a maximum combined uncertainty of $\pm 1.04\%$ within the airspeed range 711.4 to 3930 fpm (3.59 to 19.93 m/s), and $\pm 1.66\%$ within the airspeed range 170 to 711.4 fpm (0.85 to 3.59 m/s).

Temperature:

Temperature response is verified in comparison with an Ametek DTI-050 Digital Temperature Indicator and STS Reference Sensor. The DTI-050 is calibrated annually and is traceable to NIST with a maximum relative expanded uncertainty of $\pm 0.40^\circ\text{C}$.

Direction / Heading

The sensitivity of the magnetic directional sensor is verified after assembly by orienting the unit to the cardinal directions

and confirming the magnetic field output. The compass output is accurate to within ± 5 degrees as compared to a Suunto KB-14/360R G precision compass.

Relative Humidity:

Relative humidity is verified in comparison with an Edgetech HT120 Humidity Transmitter. The HT120 is calibrated annually and is traceable to NIST with a maximum relative expanded uncertainty of $\pm 1.0\%\text{RH}$.

Barometric Pressure:

Pressure response is verified against a Vaisala PTB210A Digital Barometer. The Vaisala Barometer is calibrated annually and is traceable to NIST with a maximum relative expanded uncertainty of $\pm 0.3\text{hPa}$.

Approved By:

A handwritten signature in black ink, appearing to read "Michael Naughton", written over a horizontal dashed line.

Michael Naughton
Chief Product Officer, Nielsen-Kellerman

West Caldwell Calibration Laboratories Inc.

Certificate of Calibration

for

HANDHELD ANALYZER

Manufactured by: **BRUEL & KJAER**
Model No: **2270**
Serial No: **2679353**
Calibration Recall No: **30681**

Submitted By:

Customer: **Jade McGann**
Company: **Cambium Inc.**
Address: **52 Hunter Street East**
Peterborough, On Cana **K9H 1G5**

The subject instrument was calibrated to the indicated specification using standards traceable to the National Institute of Standards and Technology or to accepted values of natural physical constants. This document certifies that the instrument met the following specification upon its return to the submitter.

West Caldwell Calibration Laboratories Procedure No. **2270** **BRUE**

Upon receipt for Calibration, the instrument was found to be:

Within **(X)**

tolerance of the indicated specification. See attached Report of Calibration.

The information supplied relates to the calibrated item listed above.

West Caldwell Calibration Laboratories' calibration control system meets the following requirements, ISO 10012-1 MIL STD 45662A, ANSI/NC SL Z540-1, IEC Guide 25, ISO 9001:2015 and ISO 17025

Note: With this Certificate, Report of Calibration is included.

Calibration Date: **11-Feb-20**

Certificate No: **30681 - 1**

QA Doc. #1051 Rev. 2.0 10/1/01

Certificate Page 1 of 1

**West Caldwell
Calibration
Laboratories, Inc.**
uncompromised calibration
1575 State Route 96, Victor, NY 14564, U.S.A.

Approved by:

James Zhu

Quality Manager
ISO/IEC 17025:2005



Calibration Lab. Cert. # 1533.01

West Caldwell Calibration Laboratories Inc.

Certificate of Calibration

for

MICROPHONE

Manufactured by: **BRUEL & KJAER**
Model No: **4189**
Serial No: **2695416**
Calibration Recall No: **30681**

Submitted By:

Customer: **Jade McGann**
Company: **Cambium Inc.**
Address: **52 Hunter Street East**
Peterborough, On Cana **K9H 1G5**

The subject instrument was calibrated to the indicated specification using standards traceable to the National Institute of Standards and Technology or to accepted values of natural physical constants. This document certifies that the instrument met the following specification upon its return to the submitter.

West Caldwell Calibration Laboratories Procedure No. **4189** **BRUE**

Upon receipt for Calibration, the instrument was found to be:

Within **(X)**

tolerance of the indicated specification. See attached Report of Calibration.
The information supplied relates to the calibrated item listed above.

West Caldwell Calibration Laboratories' calibration control system meets the following requirements, ISO 10012-1 MIL STD 45662A, ANSI/NCSL Z540-1, IEC Guide 25, ISO 9001:2015 and ISO 17025

Note: With this Certificate, Report of Calibration is included.

Calibration Date: **13-Feb-20**

Certificate No: **30681 - 2**

QA Doc. #1051 Rev. 2.0 10/1/01

Certificate Page 1 of 1

West Caldwell Calibration Laboratories, Inc.
uncompromised calibration
1575 State Route 96, Victor, NY 14564, U.S.A.

Approved by:

James Zhu

Quality Manager
ISO/IEC 17025:2005



Calibration Lab. Cert. # 1533.01

West Caldwell Calibration Laboratories Inc.

Certificate of Calibration

for

PRECISION ACOUSTIC CALIBRATOR

Manufactured by: **LARSON DAVIS**
Model No: **CAL200**
Serial No: **15401**
Calibration Recall No: **29604**

Submitted By:

Customer:

Company: **Cambium Inc.**
Address:

The subject instrument was calibrated to the indicated specification using standards traceable to the National Institute of Standards and Technology or to accepted values of natural physical constants. This document certifies that the instrument met the following specification upon its return to the submitter.

West Caldwell Calibration Laboratories Procedure No. **CAL200 LARS**

Upon receipt for Calibration, the instrument was found to be:

Within **(X)**

tolerance of the indicated specification. See attached Report of Calibration.
The information supplied relates to the calibrated item listed above.

West Caldwell Calibration Laboratories' calibration control system meets the requirements, ISO 10012-1 MIL-STD-45662A, ANSI/NCSL Z540-1, IEC Guide 25, ISO 9001:2015 and ISO 17025.

Note: With this Certificate, Report of Calibration is included.

Approved by:

James Zhu

Calibration Date: **06-Feb-19**

Certificate No: **29604 -4**

Quality Manager
ISO/IEC 17025:2005

QA Doc. #1051 Rev. 2.0 10/1/01

Certificate Page 1 of 1

**West Caldwell
Calibration
Laboratories, Inc.**
uncompromised calibration
1575 State Route 96, Victor, NY 14564, U.S.A.



Calibration Lab. Cert. # 1533.01

Certificate of Calibration

This document certifies that the equipment referenced below meets manufacturers specifications.

Manufacturer:	IMI	Temperature:	70.7	°F
Model Number:	699B02	Humidity:	54	%
Serial Number:	2523	Pressure:	992.5	mBars
Description:	Handheld Shaker			
Calibration Tech:	BTH <i>B. M. H.</i>	Calibration Date:	21-Aug-20	
Customer:	TMS Rental	Calibration Due Date:		

Test Results

Measured Operating Frequency:	159.283	Hz
Measured Acceleration Amplitude:	1.03	gRMS

As Found: Within tolerance

As Left: Within tolerance

Reference Equipment:

Manufacturer	Description	Model Number	Serial Number	Due Date
HP	DMM	34401A	US36061937	24-Jan-21
PCB	Reference Accel	353B02	11659	23-Jun-21

The calibration was performed under operating procedures intended to implement the requirements of ISO 9001 and the former MIL-STD-45662A.

The equipment referenced above was calibrated using standards traceable to N.I.S.T. Evidence of traceability and accuracy is on file at The Modal Shop, Inc.

The results documented in this certificate relate only to the item that was verified and tested. Calibration interval assignment and adjustment are the responsibility of the end user. This certificate may not be reproduced, except in full, without the written permission of The Modal Shop, Inc.



The Modal Shop Inc.
10310 Aerohub Blvd.
Cincinnati, Ohio 45215
Phone: (513) 351-9919
Toll Free: 800-860-4TMS
FAX: (513) 458-2172

**For any questions concerning this certificate,
please call The Modal Shop and ask for an application engineer.**

~ Calibration Certificate ~

Per ISO 16063-21

Model Number: 393A03

Serial Number: 59365

Description: ICP® Accelerometer

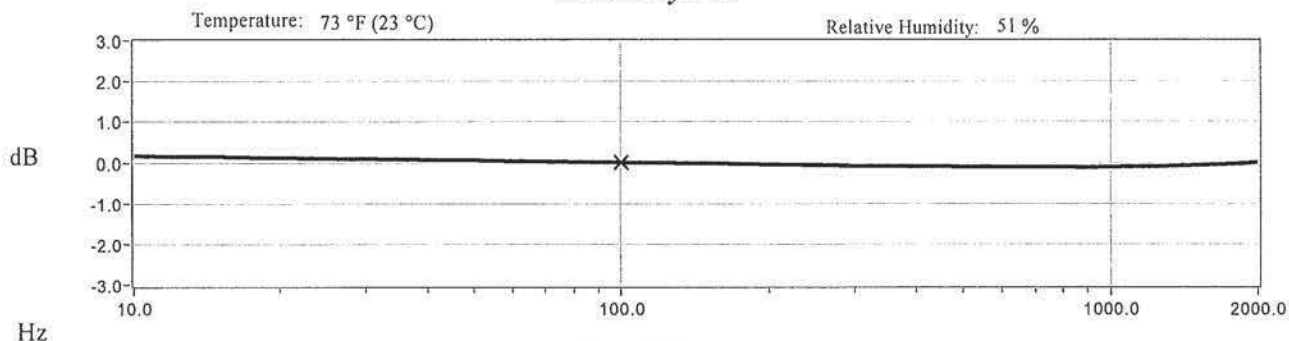
Manufacturer: PCB

Method: Back-to-Back Comparison AT401-3

Calibration Data

Sensitivity @ 100 Hz	1024 mV/g (104.4 mV/m/s ²)	Output Bias	10.9 VDC
Discharge Time Constant	1.4 seconds	Transverse Sensitivity	1.0 %
		Resonant Frequency	13.8 kHz

Sensitivity Plot



Data Points

Frequency (Hz)	Dev. (%)	Frequency (Hz)	Dev. (%)
10	1.9	300	-1.0
15	1.6	500	-1.2
30	1.0	1000	-1.3
50	0.6	2000	-0.1
REF. FREQ.	0.0		

Mounting Surface: Stainless Steel w/Silicone Grease Fastener: 1/4-28 Female Fixture Orientation: Vertical

Acceleration Level (pk): 1.00 g (9.81 m/s²)

¹The acceleration level may be limited by shaker displacement at low frequencies. If the listed level cannot be obtained, the calibration system uses the following formula to set the vibration amplitude: Acceleration Level (g) = 0.008 x (freq)². ²The gravitational constant used for calculations by the calibration system is: 1 g = 9.80665 m/s².

Condition of Unit

As Found: n/a

As Left: New Unit, In Tolerance

Notes

1. Calibration is NIST Traceable thru Project 683/287323 and PTB Traceable thru Project 17014.
2. This certificate shall not be reproduced, except in full, without written approval from PCB Piezotronics, Inc.
3. Calibration is performed in compliance with ISO 10012-1, ANSI Z540.3 and ISO 17025.
4. See Manufacturer's Specification Sheet for a detailed listing of performance specifications.
5. Measurement uncertainty (95% confidence level with coverage factor of 2) for frequency ranges tested during calibration are as follows: 5-9 Hz; +/- 2.0%, 10-99 Hz; +/- 1.5%, 100-1999 Hz; +/- 1.0%, 2-10 kHz; +/- 2.5%, 10-15 kHz; +/- 5%.

Technician: Gary Oatis

Date: 6/29/2020



HEADQUARTERS: 3425 WALDEN AVENUE - DEPEW, NY 14043
CALIBRATION PERFORMED AT: 10869 HIGHWAY 903, HALIFAX, NC 27839
TEL: 888-684-0013 - FAX: 716-685-3886 - www.pcb.com

~ Calibration Certificate ~

Per ISO 16063-21

Model Number: 393A03

Serial Number: 59365

Description: ICP® Accelerometer

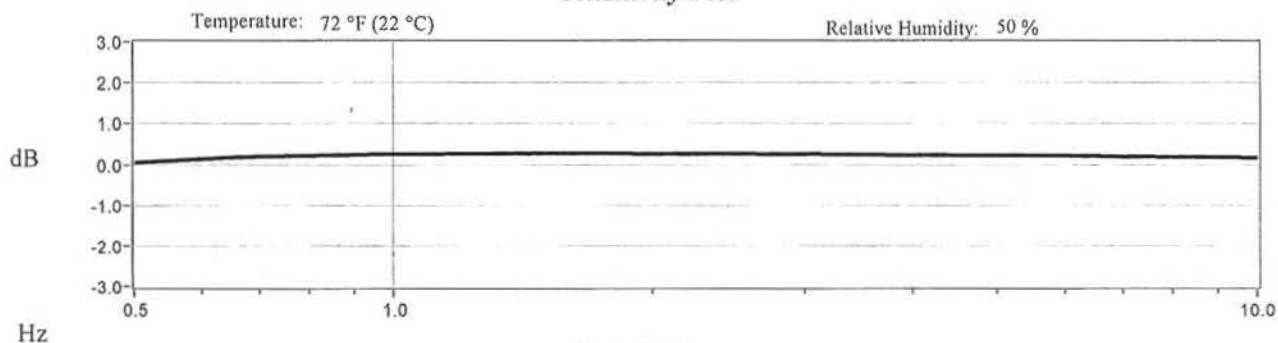
Manufacturer: PCB

Method: Back-to-Back Comparison AT401-12

Calibration Data

Sensitivity @ 100 Hz 1024 mV/g
(104.4 mV/m/s²)

Sensitivity Plot



Data Points

Frequency (Hz)	Dev. (%)	Frequency (Hz)	Dev. (%)
0.5	0.5	7	2.2
0.7	2.2	10	1.9
1	2.9		
3	2.9		
5	2.5		

Mounting Surface: Stainless Steel w/Silicone Grease Fastener: 1/4-28 Female Fixture Orientation: Vertical
Acceleration Level (pk): 1.00 g (9.81 m/s²)

*The acceleration level may be limited by shaker displacement at low frequencies. If the listed level cannot be obtained, the calibration system uses the following formula to set the vibration amplitude; Acceleration Level (g) = 0.207 x (freq)^{1.35}. *The gravitational constant used for calculations by the calibration system is: 1 g = 9.80665 m/s².

Condition of Unit

As Found: n/a

As Left: New Unit, In Tolerance

Notes

1. Calibration is traceable to one or more of the following; PTB 10065, PTB 10066 and NIST 683/283498.
2. This certificate shall not be reproduced, except in full, without written approval from PCB Piezotronics, Inc.
3. Calibration is performed in compliance with ISO 10012-1, ANSI Z540.3 and ISO 17025.
4. See Manufacturer's Specification Sheet for a detailed listing of performance specifications.
5. Due to state of art limitations, the test uncertainty ratio is 3:1. Measurement uncertainty (95% confidence level with coverage factor of 2) for frequency ranges tested during calibration are as follows: 0.5-0.99 Hz; +/- 1.8%, 1-30 Hz; +/- 1.0%, 30.01-199 Hz; +/- 1.5%, 200-1 kHz; +/- 3.0%.

Technician: _____

Gary Oatis

Date: 6/30/2020



HEADQUARTERS: 3425 WALDEN AVENUE - DEPEW, NY 14043
CALIBRATION PERFORMED AT: 10869 HIGHWAY 903, HALIFAX, NC 27839
TEL: 888-684-0013 - FAX: 716-685-3886 - www.pcb.com

CAL143-3676342614.603+0



~ Calibration Certificate ~

Per ISO 16063-21

Model Number: 393A03

Serial Number: 59365

Description: ICP® Accelerometer

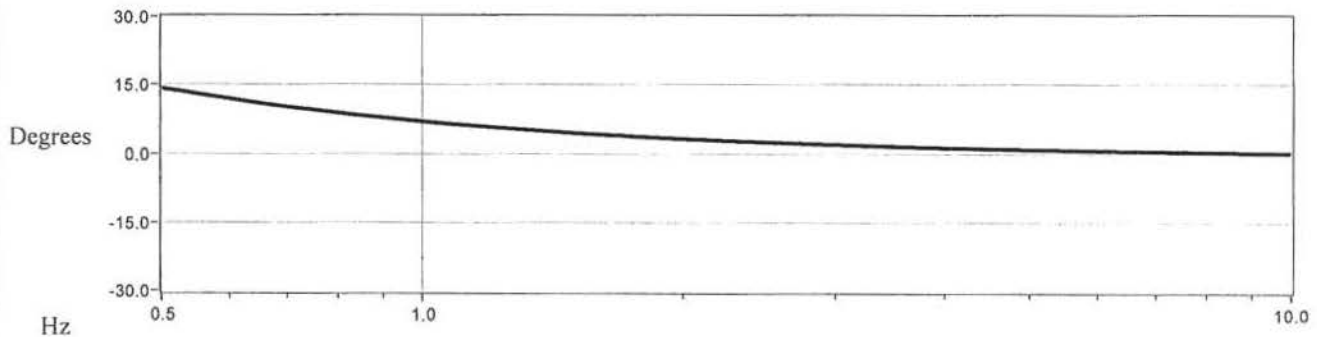
Manufacturer: PCB

Method: Back-to-Back Comparison AT401-12

Calibration Data

Sensitivity @ 100 Hz 1024 mV/g (104.4 mV/m/s²)

Phase Plot



Data Points

Frequency (Hz)	Phase (°)
0.5	14.2
0.7	10.1
1	6.9
3	1.8
5	0.8
7	0.4
10	0.1

Notes

1. Calibration is traceable to one or more of the following; PTB 10065, PTB 10066 and NIST 683/283498.
2. This certificate shall not be reproduced, except in full, without written approval from PCB Piezotronics, Inc.
3. Calibration is performed in compliance with ISO 10012-1, ANSI Z540.3 and ISO 17025.
4. See Manufacturer's Specification Sheet for a detailed listing of performance specifications.
5. Measurement uncertainty for Phase (95% confidence level with coverage factor of 2) for frequency ranges tested during calibration are as follows: = 0.5 to < 10 Hz; +/- 2.5°, = 10 to < 200 Hz; +/- 0.75°, = 200 Hz to = 1 kHz; +/- 1.5°.

Technician: Gary Oatis

Date: 6/30/2020

PCB PIEZOTRONICS INC.

HEADQUARTERS: 3425 WALDEN AVENUE - DEPEW, NY 14043
CALIBRATION PERFORMED AT: 10869 HIGHWAY 903, HALIFAX, NC 27839
TEL: 888-684-0013 - FAX: 716-685-3886 - www.pcb.com





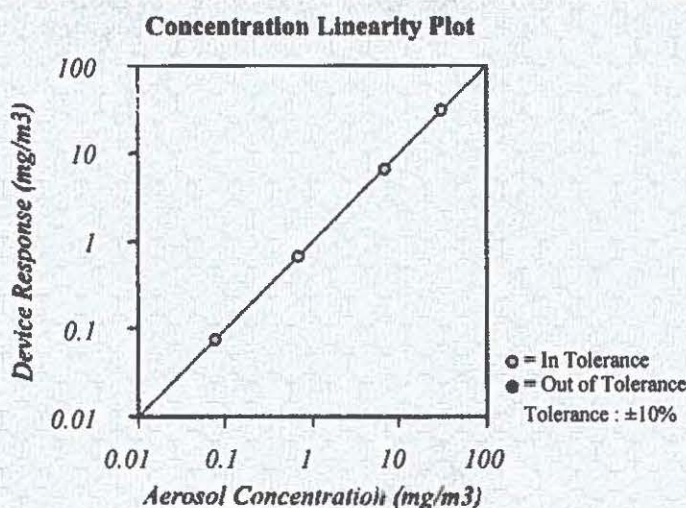
CERTIFICATE OF CALIBRATION AND TESTING

TSI Incorporated, 500 Cardigan Road, Shoreview, MN 55126 USA
Tel: 1-800-874-2811 1-651-490-2811 Fax: 1-651-490-3824 <http://www.tsi.com>

Environment Conditions			Model	8533EP
Temperature	73.39 (23.0)	°F (°C)	Serial Number	8533131504
Relative Humidity	36.7	%RH		
Barometric Pressure	28.23 (956.0)	inHg (hPa)		

☒ As Left
☐ As Found

☒ In Tolerance
☐ Out of Tolerance



System ID: DTII01-01

FLOW AND PRESSURE VERIFICATION

SYSTEM DTII01-01

Parameter	Standard	Measured	Allowable Range	Parameter	Standard	Measured	Allowable Range
Flow lpm	3.00	3.04	2.91 ~ 3.09	Pressure kPa	95.5	95.5	90.76 ~ 100.32
Full Flow lpm	N/A	6.03	>3.80				

TSI Incorporated does hereby certify that all materials, components, and workmanship used in the manufacture of this equipment are in strict accordance with the applicable specifications agreed upon by TSI and the customer and with all published specifications. All performance and acceptance tests required under this contract were successfully conducted according to required specifications. There is no NIST standard for optical mass measurements. Calibration of this instrument performed by TSI has been done using emery oil and has been nominally adjusted to respirable mass per standard ISO 12103-1, A1 test dust (Arizona dust). Our calibration ratio is greater than 1.2:1

Measurement Variable	System ID	Last Cal.	Cal. Due
Photometer	E003433	09-17-19	03-31-20
DC Voltage(Keithley)	E002859	08-15-19	08-31-20
Pressure	E005651	07-18-19	07-31-20
3 um PSL	206030	n/a	n/a

Measurement Variable	System ID	Last Cal.	Cal. Due
Flowmeter	E004570	06-13-19	06-30-20
Microbalance	M001324	10-03-18	10-31-20
1 um PSL	698880	n/a	n/a
10 um PSL	212455	n/a	n/a

C. Wong

Calibrated

October 22, 2019

Date



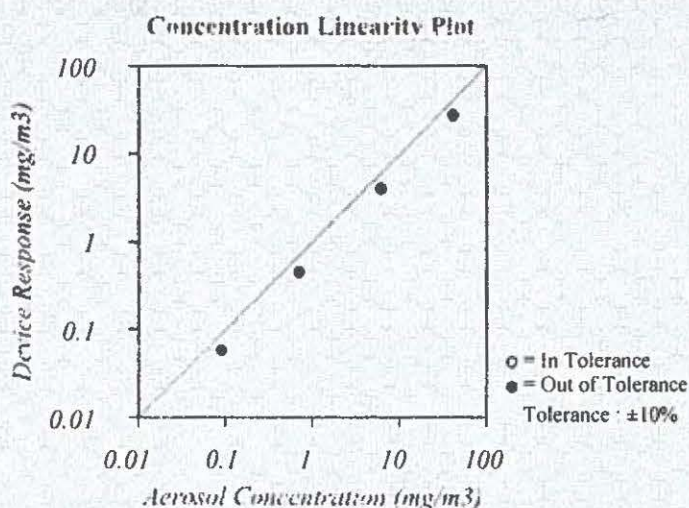
CERTIFICATE OF CALIBRATION AND TESTING

TSI Incorporated, 500 Cardigan Road, Shoreview, MN 55126 USA
Tel: 1-800-874-2811 1-651-490-2811 Fax: 1-651-490-3824 <http://www.tsi.com>

Environment Conditions			Model	8533EP
Temperature	76.31 (24.6)	°F (°C)	Serial Number	8533131504
Relative Humidity	30.7	%RH		
Barometric Pressure	28.64 (969.9)	inHg (hPa)		

☐ As Left
☒ As Found

☐ In Tolerance
☒ Out of Tolerance



System ID: DTII01-02

FLOW AND PRESSURE VERIFICATION

SYSTEM DTII01-02

Parameter	Standard	Measured	Allowable Range	Parameter	Standard	Measured	Allowable Range
Flow lpm	3.00	2.94	2.85 ~ 3.15	Pressure kPa	97.0	96.8	92.12 ~ 101.82
Full Flow lpm	N/A	5.17	>3.80				

Pump run time: 1552 Hours, Pump voltage: 1023 Bits

TSI Incorporated does hereby certify that all materials, components, and workmanship used in the manufacture of this equipment are in strict accordance with the applicable specifications agreed upon by TSI and the customer and with all published specifications. All performance and acceptance tests required under this contract were successfully conducted according to required specifications. There is no NIST standard for optical mass measurements. Calibration of this instrument performed by TSI has been done using emery oil and has been nominally adjusted to respirable mass per standard ISO 12103-1. All test dust (Arizona dust). Our calibration ratio is greater than 1.2:1

Measurement Variable	System ID	Last Cal.	Cal. Due	Measurement Variable	System ID	Last Cal.	Cal. Due
DC Voltage	E003314	02-25-19	02-29-20	DC Voltage	E003315	02-25-19	02-29-20
Photometer	E005612	08-29-19	02-29-20	Microbalance	M001324	10-03-18	10-31-20
1 um PSL	698880	n/a	n/a	3 um PSL	180387	n/a	n/a
10 um PSL	212455	n/a	n/a	Pressure	E003511	10-04-19	10-31-20
Flowmeter	E003769	04-03-19	04-30-20				

Kimberly Claus
Verified

October 18, 2019

Date

Certificate of Calibration

This Streamline Pro™ MultiCal™ System, serial number: **M130501**

was calibrated against the following NIST-traceable Reference Standards:

Flow: Critical Flow Venturi S/Ns 10962, 10963

on date: 08/26/20

Barometric Pressure: Precision Barometer S/N 913930-M1

on date: 08/24/20

Temperature: NIST Traceable Hg-in-glass thermometers,
S/Ns 2J3106, 2Y6027, 3L9452.

on date: 08/20/20

Quality Assurance:

Flow:

Reference Std. Q_{ref} (l/min)	Streamline Pro Q_{SLPro} (l/min)	Absolute difference (l/min)	% Diff. F.S.
0.90	0.89	-0.01	-0.04%
3.00	3.02	0.01	0.07%
6.67	6.67	0.00	0.00%
10.00	9.99	-0.01	-0.05%
13.66	13.66	0.00	-0.01%
16.66	16.68	0.01	0.06%
19.00	18.99	-0.01	-0.03%

BP:

Reference Std. BP_{ref} (atm)	Streamline Pro BP_{SLPro} (atm)	Absolute difference (atm)	% Diff. F.S.
0.750	0.750	0.000	-0.03%
0.900	0.900	0.000	0.01%
1.050	1.050	0.000	0.01%

Temp.:

Reference Std. T_{ref} (°C)	Streamline Pro T_{SLPro} (°C)	Absolute difference (°C)	% Diff. F.S.*
0.0	0.0	0.0	0.01%
21.0	21.0	0.0	0.00%
42.1	42.1	0.0	0.01%

* based on absolute temp. scale (K)

Lab temp: 22.8 °C

Lab pressure: 0.867 atm

Certified By: Marty Kjorstad

Date: Aug 26, 2020

Chinook Engineering
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