APPENDIX E

Description of the Environment

E1 – Geology, Geophysical Surveys and Geotechnical Aspects

E2 – Beach/Shoreline Morphology

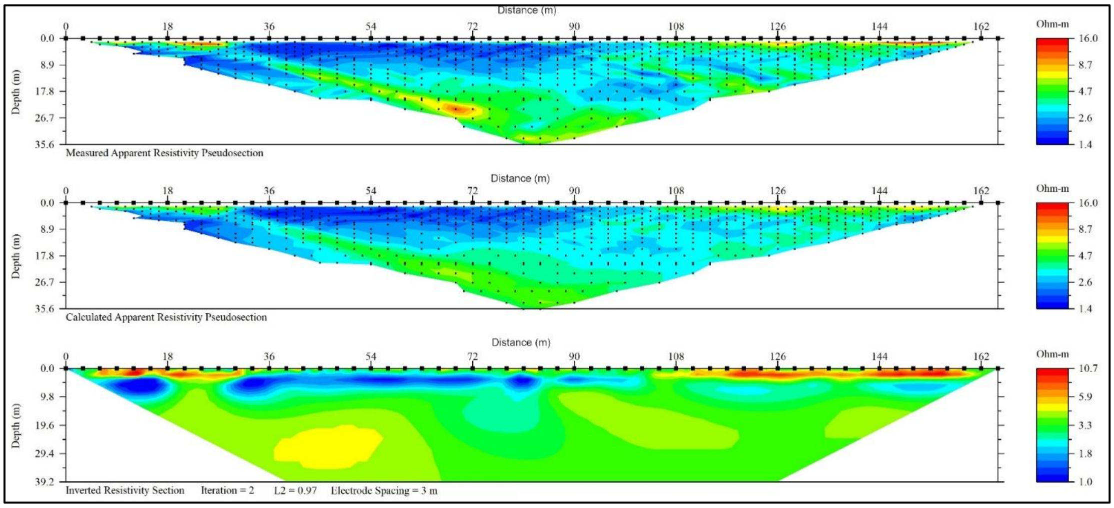
E3 – Ambient Air and Noise Quality

E4 – Biological Environment

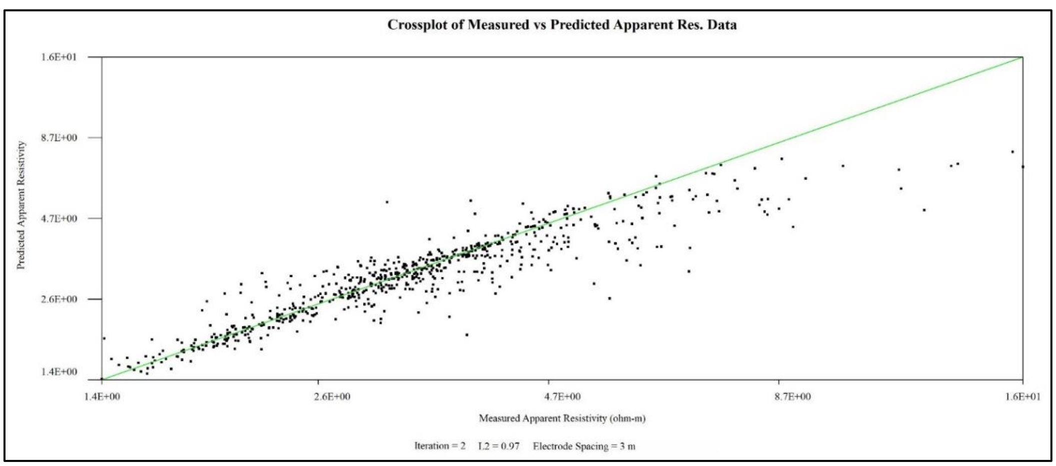
E1 – Geology, Geophysical Surveys and Geotechnical Aspects

E1.1 – Boreholes

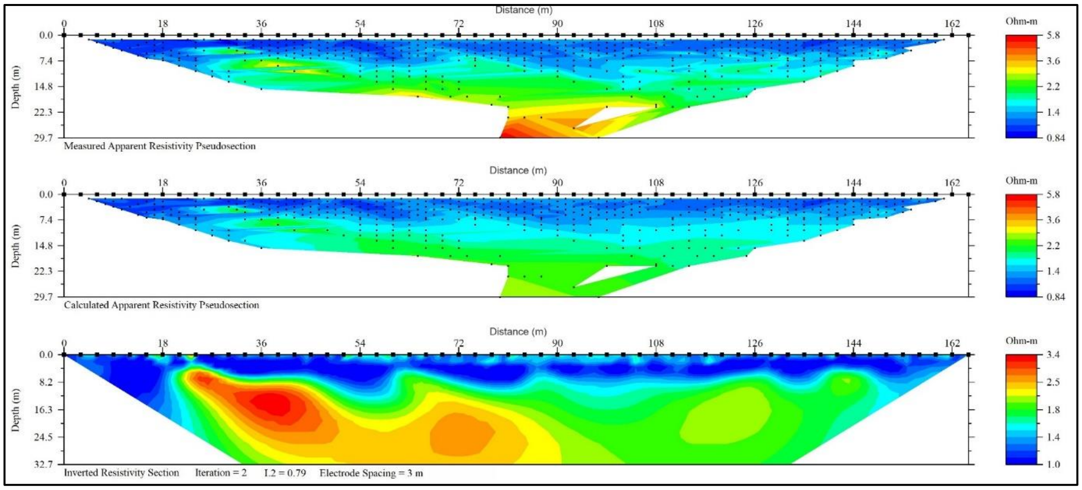
Resistivity Pseudosections and Crossplots



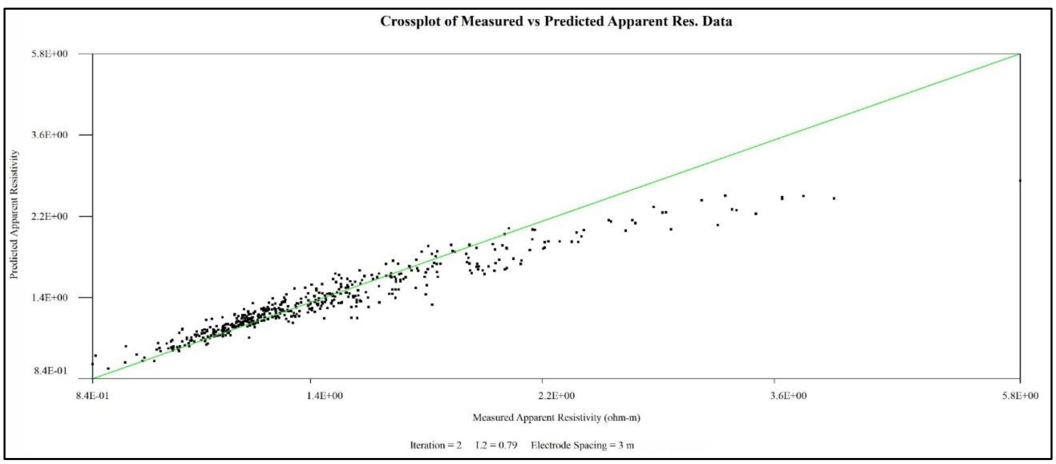
Measured apparent pseudosection (top), calculated pseudosection (middle), and inverted section (bottom), of line R1.



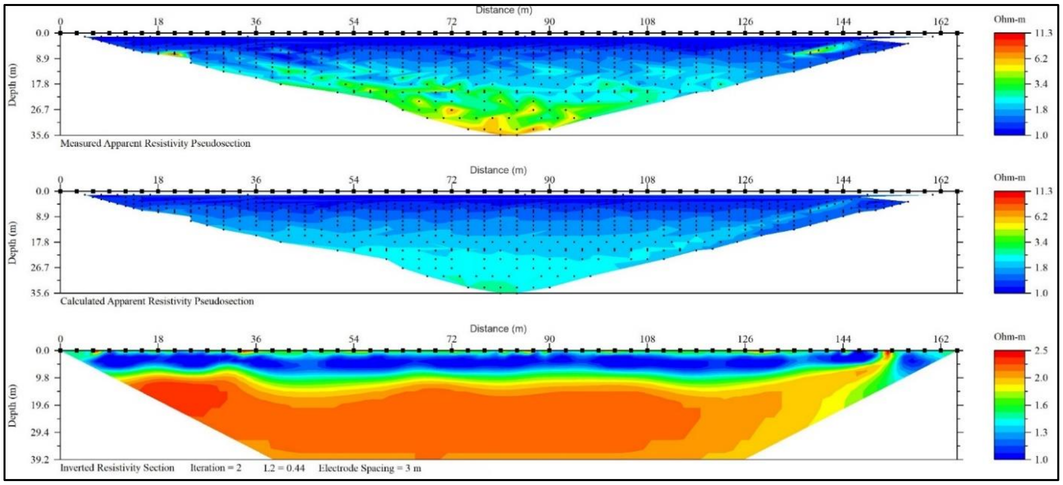
Crossplot of measured vs predicted apparent resistivity of R1.



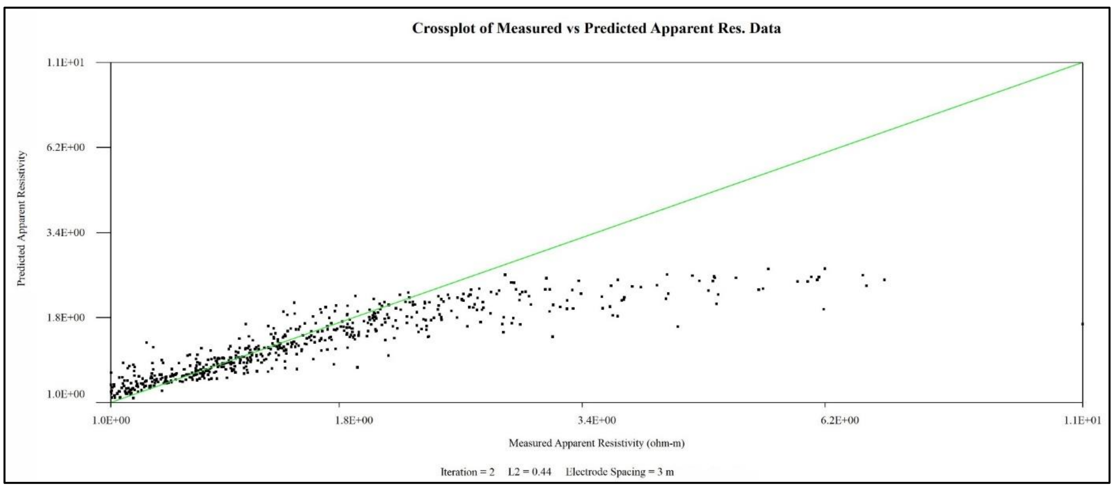
Measured apparent pseudosection (top), calculated pseudosection (middle), and inverted section (bottom), of line R2.



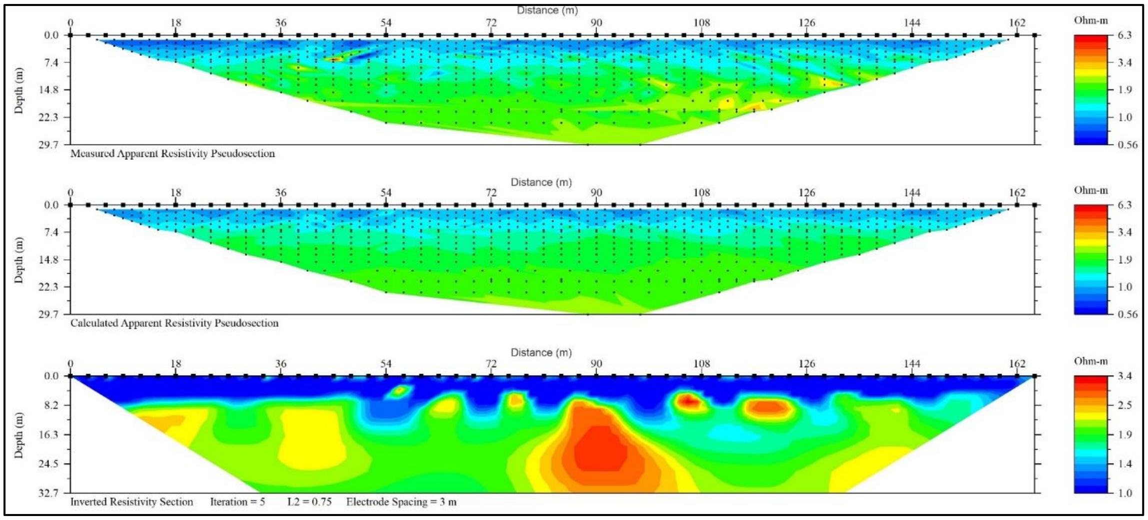
Crossplot of measured vs predicted apparent resistivity of R2.



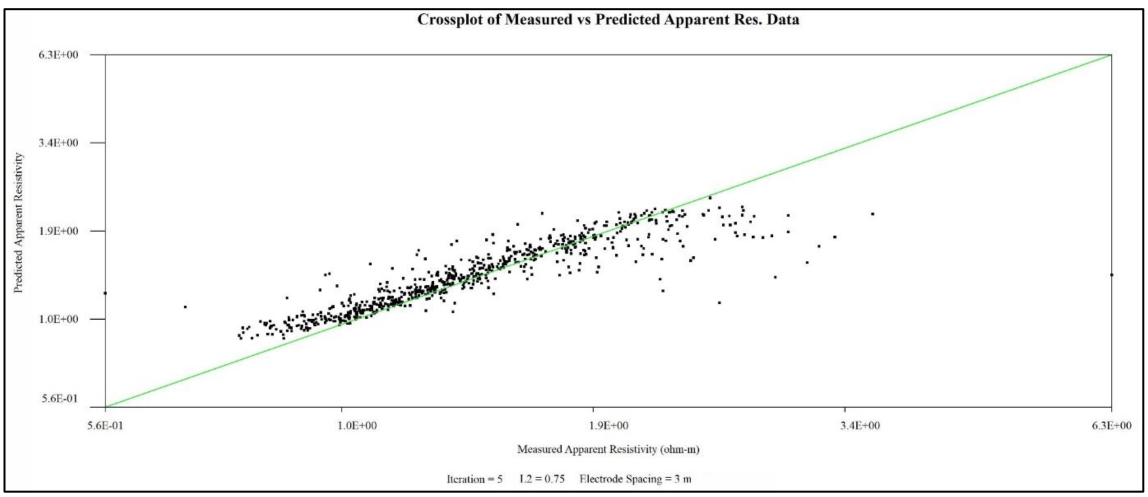
Measured apparent pseudosection (top), calculated pseudosection (middle), and inverted section (bottom), of line R3.



Crossplot of measured vs predicted apparent resistivity of R3.



Measured apparent pseudosection (top), calculated pseudosection (middle), and inverted section (bottom), of line R4.



Crossplot of measured vs predicted apparent resistivity of R4.

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Geotechnical-Bore Hole Drilling Data

Table 6-1: SPT Refusal Conditions

Item	Condition	Field SPT (N) Value	Corrected SPT (N_{60}) Value
1	No advancement in the sampler	14	10
2	Penetration for any 6" Section	70	50
3	Total number of blows for 18"	140	100

Table 6-2: Characteristics of Boring

Borehole	Date	*Location (WGS84)		Depth (ft)	+Water Level at EOB (ft)
		Latitude	Longitude		
BHKB- 1	April 26th, 2022	11° 8'54.48"N	60°48'45.72"W	34	1.0
BHKB- 2	April 26th, 2022	11° 8'49.94"N	60°48'40.98"W	22	1.1
BHKB- 3	April 26th, 2022	11° 8'59.25"N	60°48'38.52"W	32	4.0

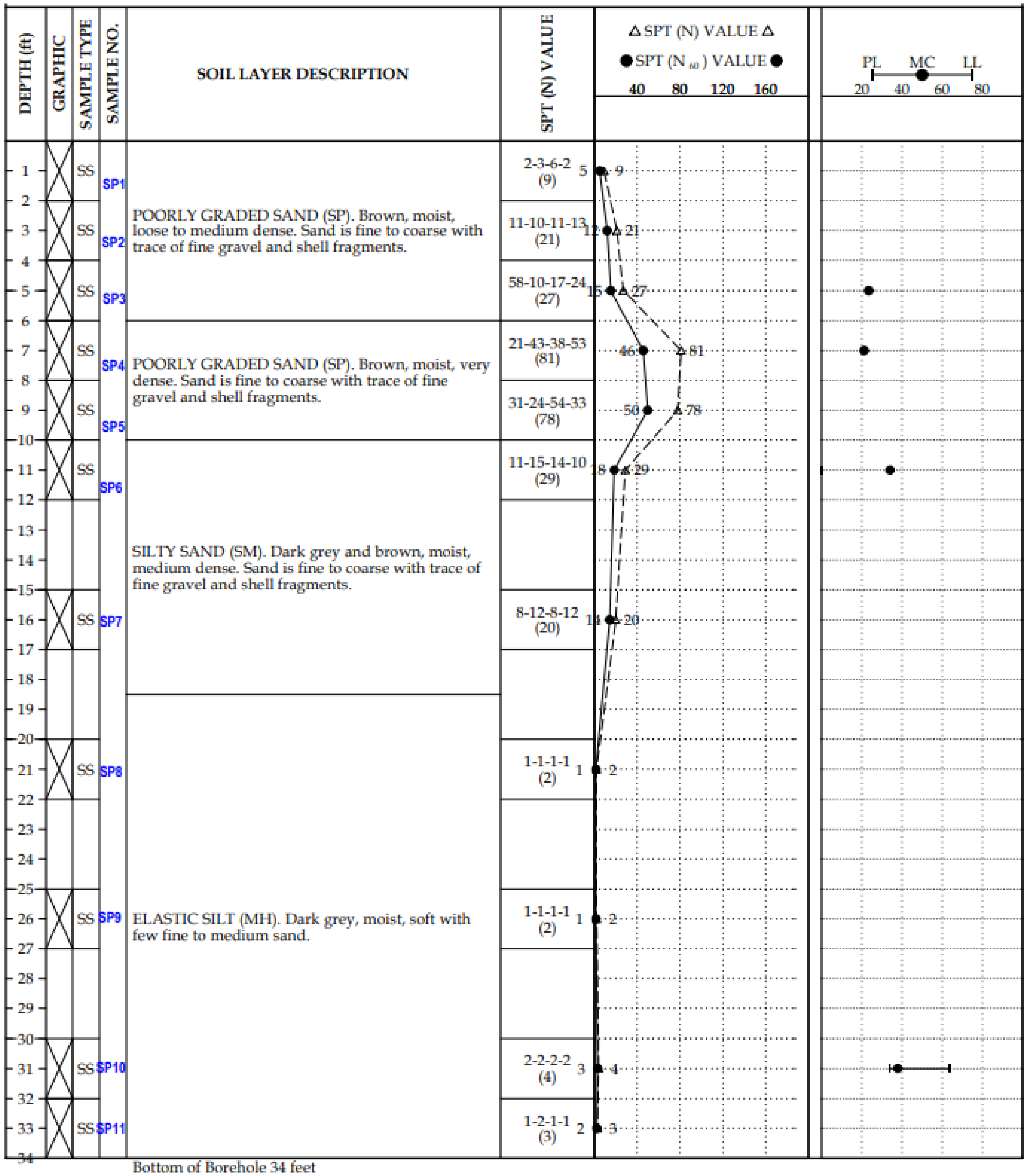
**Coordinates are based on UTM 20P WGS 84 Datum, ±5m*
+EOB-End of boring

Table 6-3: Soil Consistency Classification

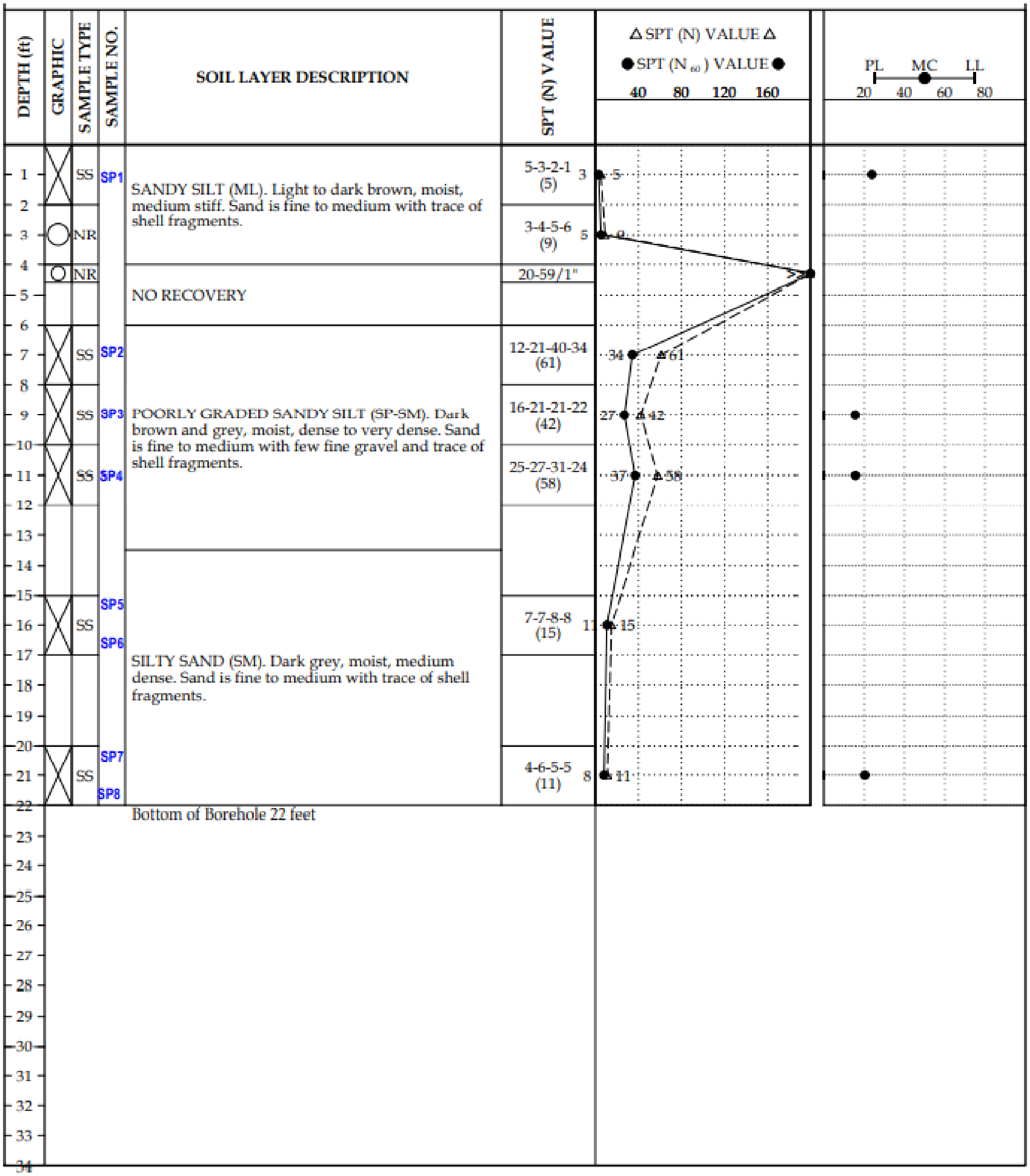
Fine Grained Soils		Coarse Grained Soils	
SPT (N-Value)	Soil Consistency	SPT (N-Value)	State of Packing
<2	Very Soft	<4	Very Loose
2 - 4	Soft	4 - 10	Loose
4 - 8	Medium	10 - 30	Medium Dense
8 - 15	Stiff	30 - 50	Dense
15 - 30	Very Stiff	>50	Very Dense
>30	Hard		

E1.2 – Field Borehole Logs

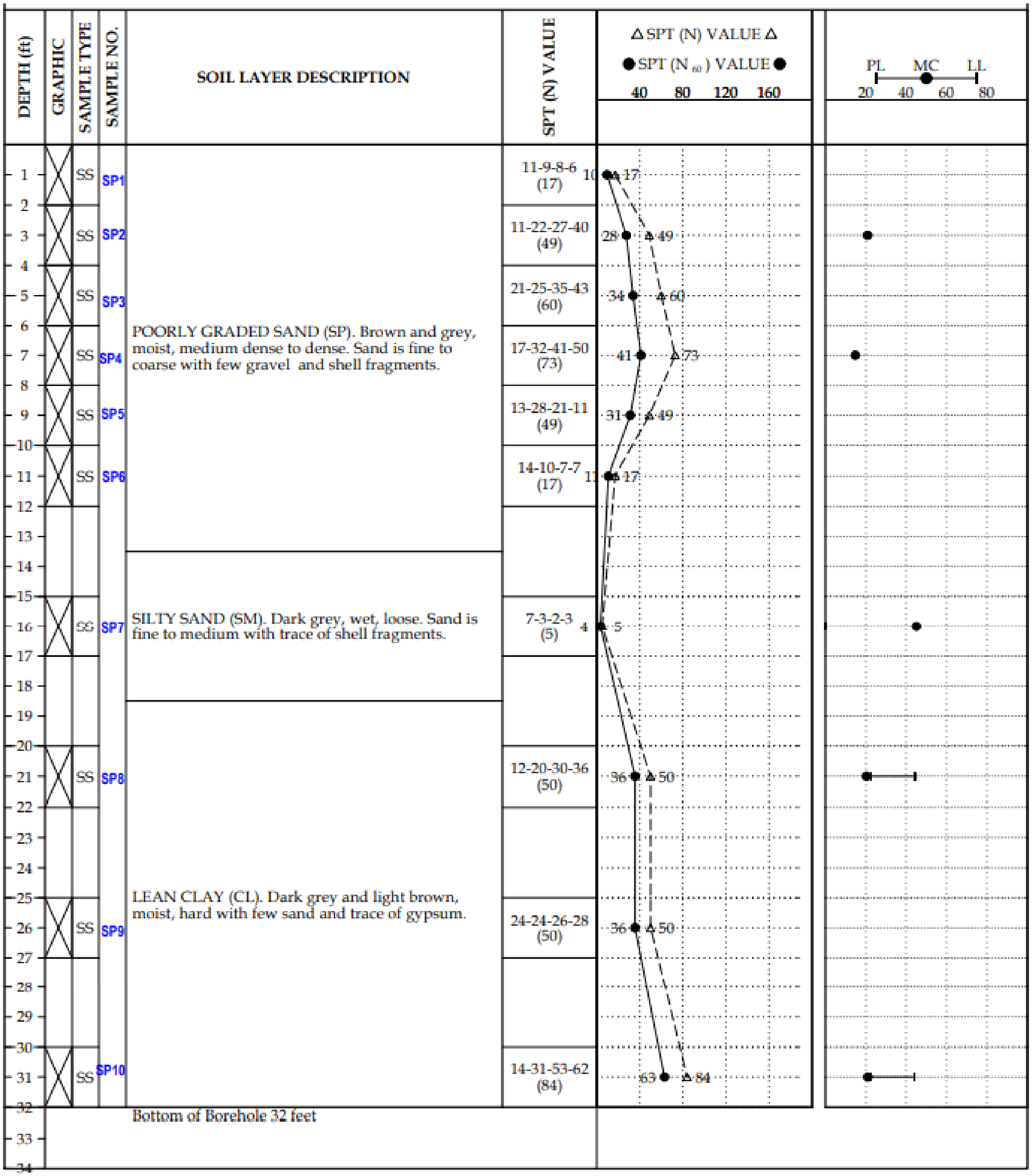
Final Borehole Drilling Log for BHKB-1



Final Borehole Drilling Log for BHKB-2



Final Borehole Drilling Log for BHKB-3



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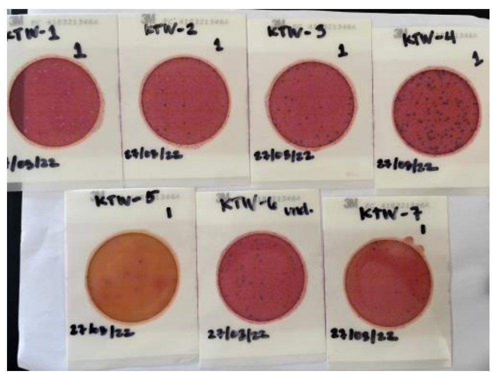
E1.3 – Laboratory Tests

Summary of Laboratory Tests

BH No.	Sample No.	Sample Depth (ft)	Liquid Limit	Plastic Limit	Plasticity Index	Max. Size (mm)	%<#200 Sieve	Water Content (%)	Wet Density (kN/m³)	Dry Density (kN/m³)	Specific Gravity	Soil Classification
1		5.0				19	3	23.3				POORLY GRADED SAND(SP)
1		7.0				9.5	4	21.1				POORLY GRADED SAND(SP)
1		11.0	NP	NP	NP	9.5	23	34.0			2.58	SILTY SAND(SM)
1		31.0	63	34	29	2	94	37.9			2.22	ELASTIC SILT(MH)
2		1.0	NP	NP	NP	2	52	23.8	23.5	19.0	2.58	SANDY SILT(ML)
2		9.0	NP	NP	NP	19	7	15.6				POORLY GRADED SAND with SILT(SP-SM
2		11.0	NP	NP	NP	19	4	15.7				POORLY GRADED SAND(SP)
2		21.0	NP	NP	NP	2	29	20.3			2.55	SILTY SAND(SM)
3		3.0				2.36	3	20.9				POORLY GRADED SAND(SP)
3		7.0				19	5	14.8				POORLY GRADED SAND(SP)
3		16.0	NP	NP	NP	2	31	45.0			2.45	SILTY SAND(SM)
3		21.0	44	23	21	2	96	20.3			2.43	LEAN CLAY(CL)
3		31.0	44	22	22	2	94	21.0	28.8	23.8	2.45	LEAN CLAY(CL)

Laboratories Analysis- Extracts form subcontracted Labs and Mobile in-house Microbiology



Mobile in-house Microbiology Laboratory for Bacteria *E. coli* Analysis- Terrestrial and Marine Water Samples

Transfers, Shipment and Laboratory Analysis

Sample Labeling Protocols

Project#: OPTIMALGESL/DSM/006	**Project#: OPTIMALGESL/DSM/006**
SUBSURFACE SOIL	**SUBSURFACE SOIL**
SAMPLE ID: KBMS- FIELD BLANK	**SAMPLE ID: KBMS-1**
PARAMETER: Bioavailable metals (As, Ba, Cd, Cr, Fe, Pb, Hg, V, Zn)	**PARAMETER: Total Metals (As, Ba, Cd, Cr, Cu, Fe, Pb, Hg, V, Zn)**

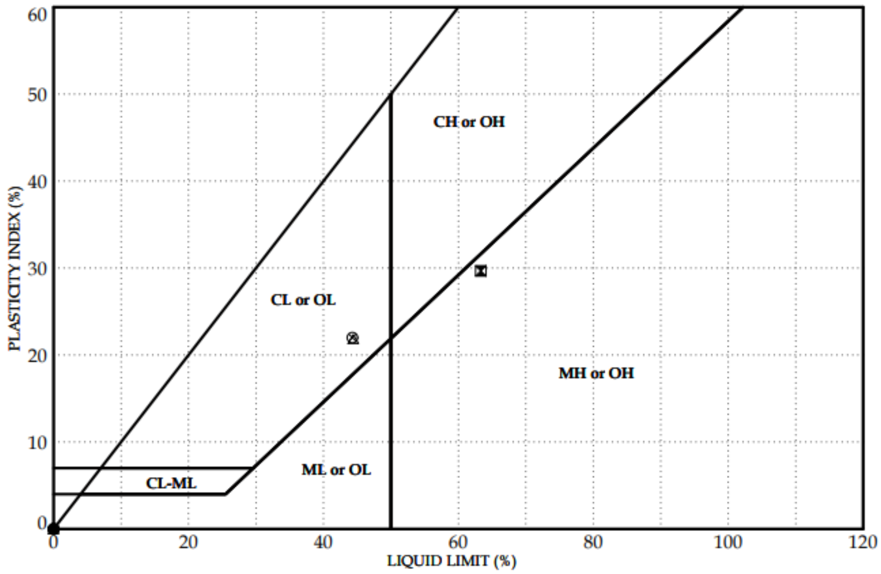
Labels Template adopted as per SOP.

Packaging for Shipment and Custody Transfer

Terrestrial Water, Soils/Sediments and Marine Water samples packaged in iceboxes being prepared for custody transfer and international shipment.

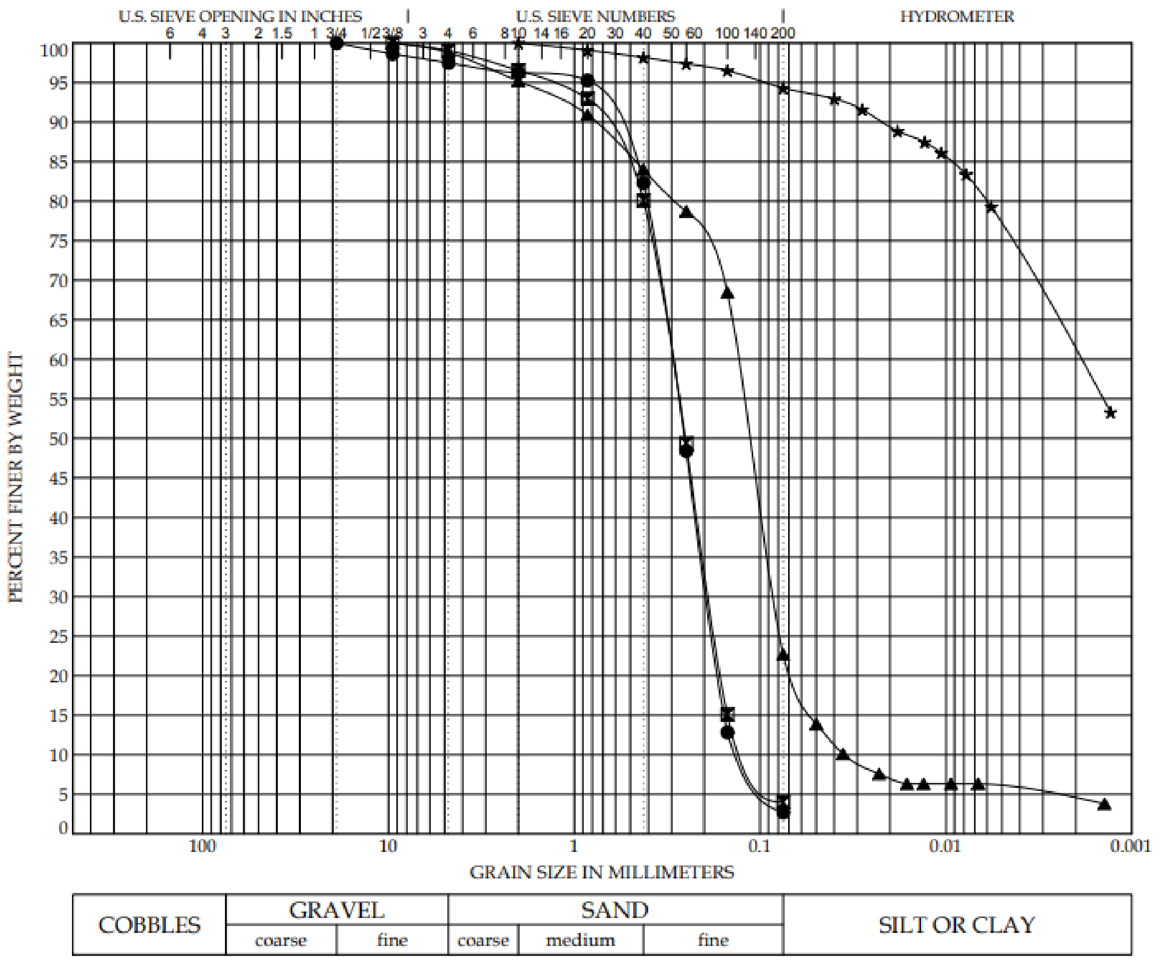
E1.4 - Laboratory Tests' Results

Atterberg Limits



Symbol	Borehole	Depth	LL (%)	PL (%)	PI (%)	Soil Classification
●	1	11 ft	NP	NP	NP	SILTY SAND(SM)
⧗	1	31 ft	63	34	29	ELASTIC SILT(MH)
▲	2	1 ft	NP	NP	NP	SANDY SILT(ML)
★	2	9 ft	NP	NP	NP	POORLY GRADED SAND with SILT(SP-SM)
⊙	2	11 ft	NP	NP	NP	POORLY GRADED SAND(SP)
✪	2	21 ft	NP	NP	NP	SILTY SAND(SM)
○	3	16 ft	NP	NP	NP	SILTY SAND(SM)
△	3	21 ft	44	23	21	LEAN CLAY(CL)
⊗	3	31 ft	44	22	22	LEAN CLAY(CL)

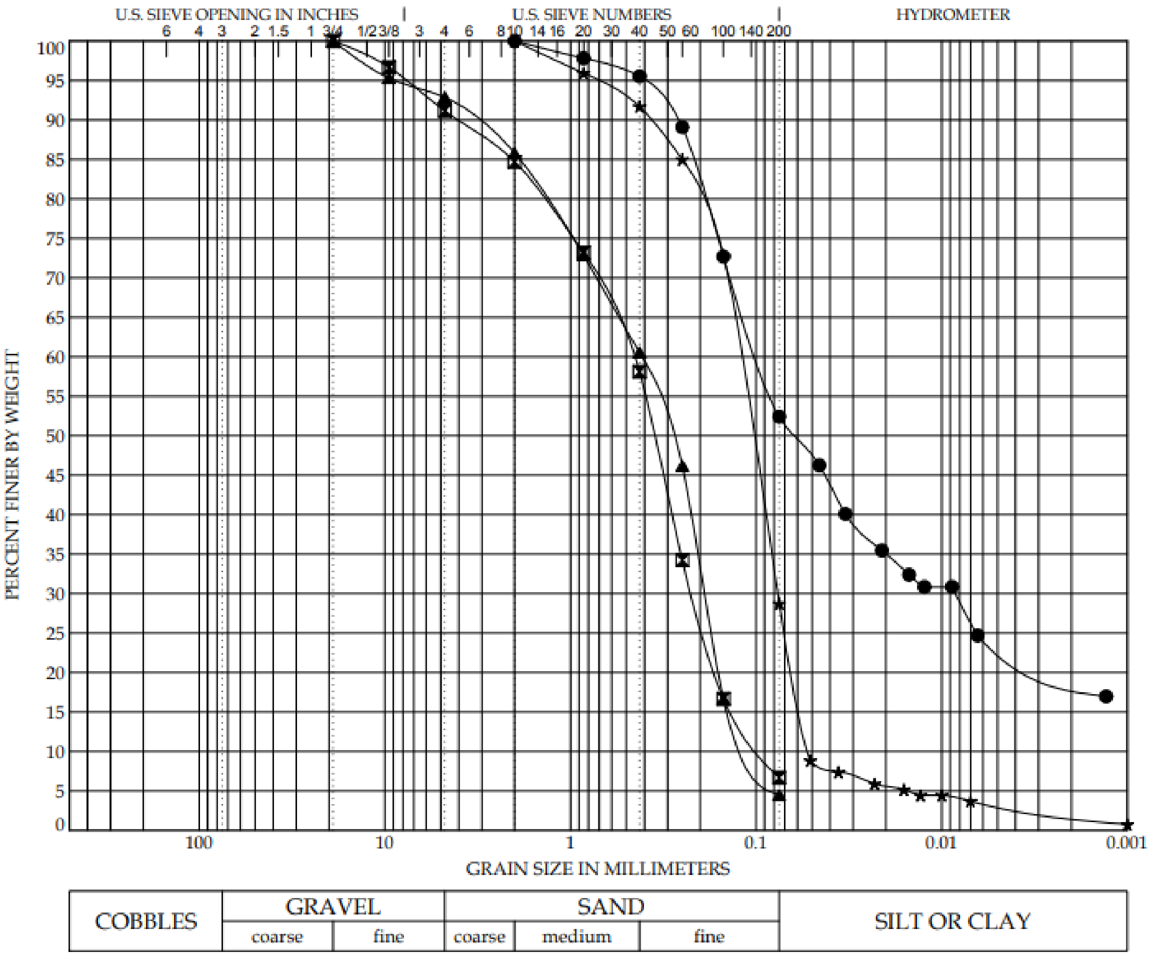
Particle Size Distribution BHKB-1



Symbol	Borehole	Depth	Soil Classification	LL	PL	PI	Cc	Cu
●	1	5 ft	POORLY GRADED SAND(SP)				1	2
⊠	1	7 ft	POORLY GRADED SAND(SP)				1	3
▲	1	11 ft	SILTY SAND(SM)	NP	NP	NP	2	4
★	1	31 ft	ELASTIC SILT(MH)	63	34	29		

Symbol	Borehole	Depth	D10	D30	D60	D100	%Gravel	%Sand	%Silt	%Clay
●	1	5 ft	0.124	0.192	0.3	19	2.5	94.8	2.7	
⊠	1	7 ft	0.109	0.187	0.3	9.5	1.0	95.0	4.0	
▲	1	11 ft	0.035	0.084	0.132	9.5	1.2	76.1	16.8	5.8
★	1	31 ft			0.002	2	0.0	5.7	17.3	77.0

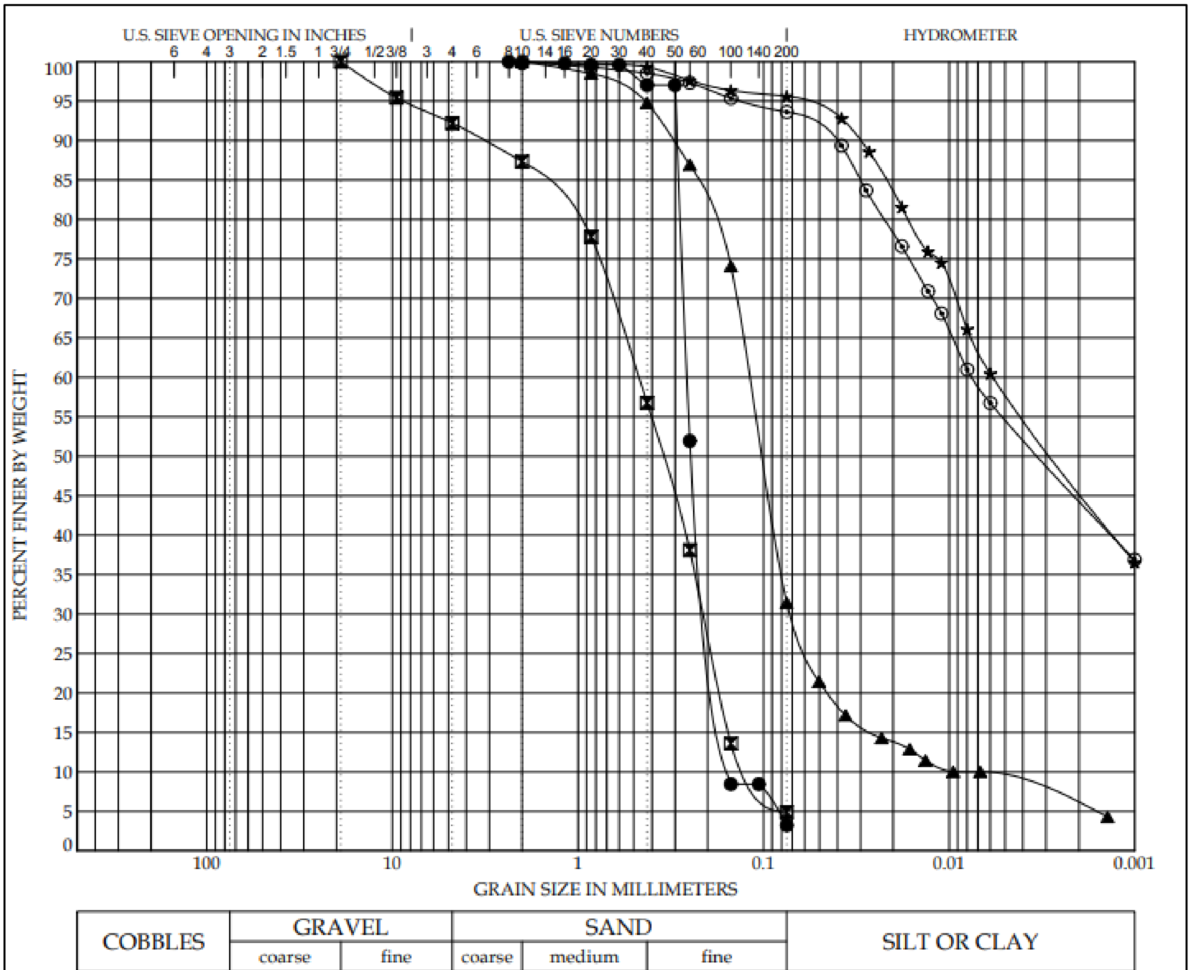
Particle Size Distribution BHKB-2



Symbol	Borehole	Depth	Soil Classification	LL	PL	PI	Cc	Cu
●	2	1 ft	SANDY SILT(ML)	NP	NP	NP		
⊠	2	9 ft	POORLY GRADED SAND with SILT(SP-SM)	NP	NP	NP	1	5
▲	2	11 ft	POORLY GRADED SAND(SP)	NP	NP	NP	1	4
★	2	21 ft	SILTY SAND(SM)	NP	NP	NP	1	2

Symbol	Borehole	Depth	D10	D30	D60	D100	%Gravel	%Sand	%Silt	%Clay
●	2	1 ft		0.008	0.097	2	0.0	47.6	28.9	23.5
⊠	2	9 ft	0.095	0.221	0.464	19	8.8	84.5	6.7	
▲	2	11 ft	0.103	0.189	0.416	19	7.1	88.4	4.5	
★	2	21 ft	0.052	0.077	0.123	2	0.0	71.3	25.6	3.2

Particle Size Distribution BHKB-3



Symbol	Borehole	Depth	Soil Classification	LL	PL	PI	Cc	Cu
●	3	3 ft	POORLY GRADED SAND(SP)				1	2
⊠	3	7 ft	POORLY GRADED SAND(SP)				1	4
▲	3	16 ft	SILTY SAND(SM)	NP	NP	NP	6	18
★	3	21 ft	LEAN CLAY(CL)	44	23	21		
⊙	3	31 ft	LEAN CLAY(CL)	44	22	22		

Symbol	Borehole	Depth	D10	D30	D60	D100	%Gravel	%Sand	%Silt	%Clay
●	3	3 ft	0.153	0.193	0.258	2.36	0.0	96.8	3.2	
⊠	3	7 ft	0.113	0.211	0.473	19	7.8	87.3	4.9	
▲	3	16 ft	0.007	0.071	0.119	2	0.0	68.6	22.5	8.9
★	3	21 ft			0.006	2	0.0	4.4	37.6	58.0
⊙	3	31 ft			0.007	2	0.0	6.4	38.9	54.7

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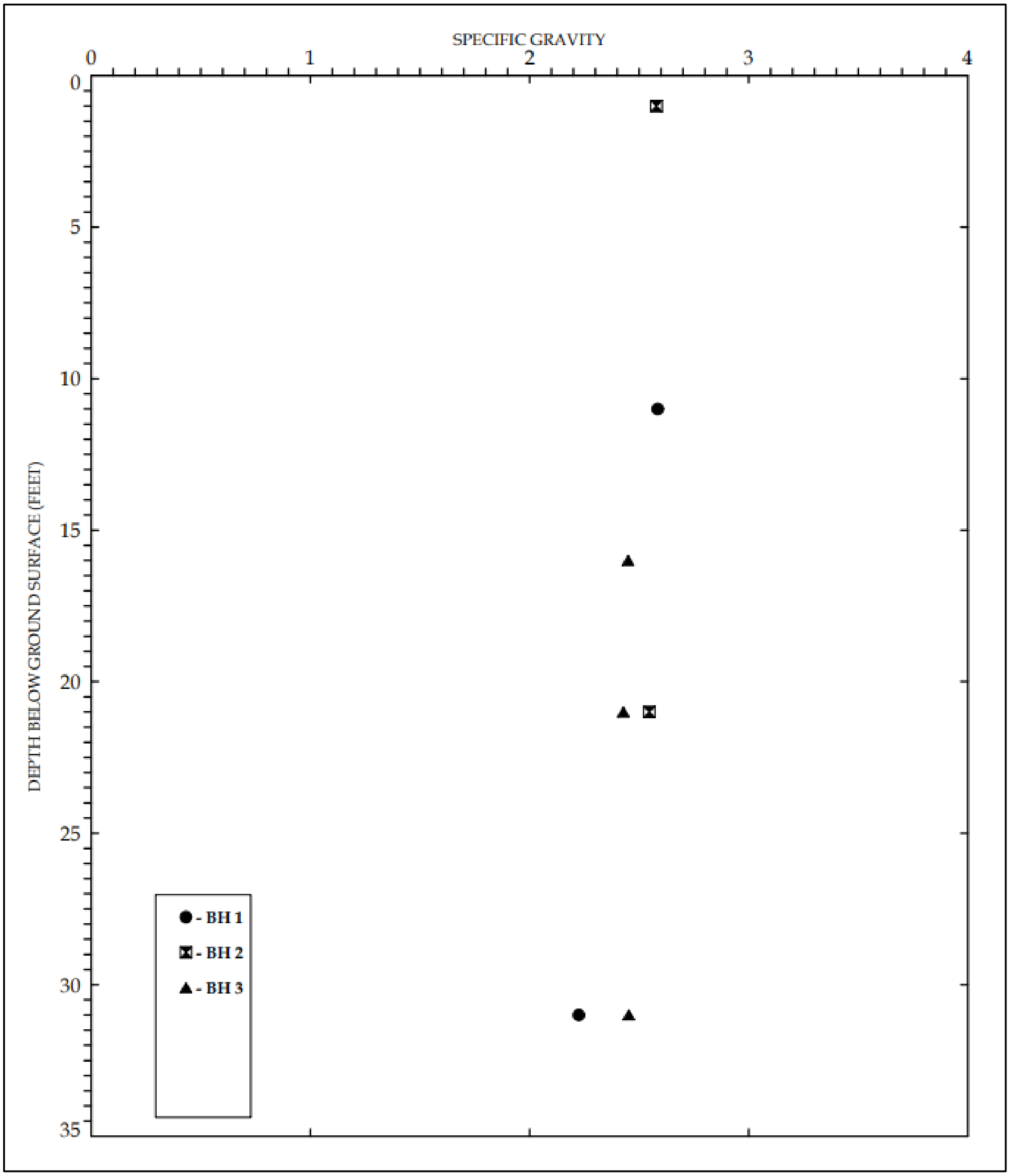
Specific Gravities – All BHKB Samples



Sample UCS Strength Tests from Geomechanics Laboratory

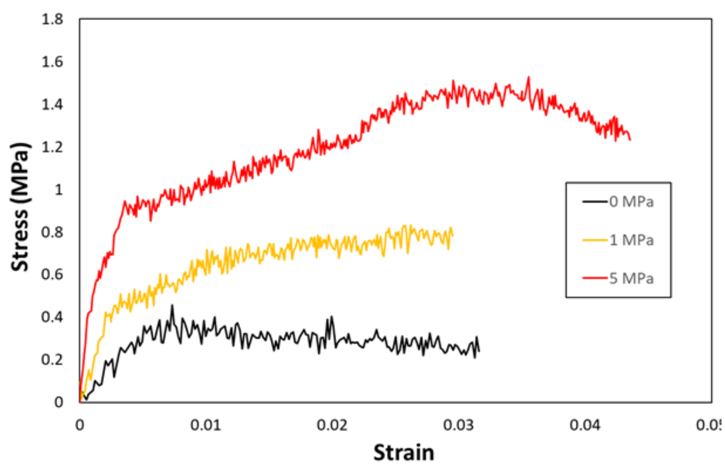
Location: BHKB-1

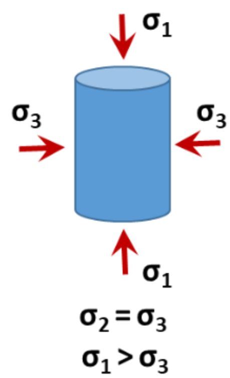
Sample: SP8

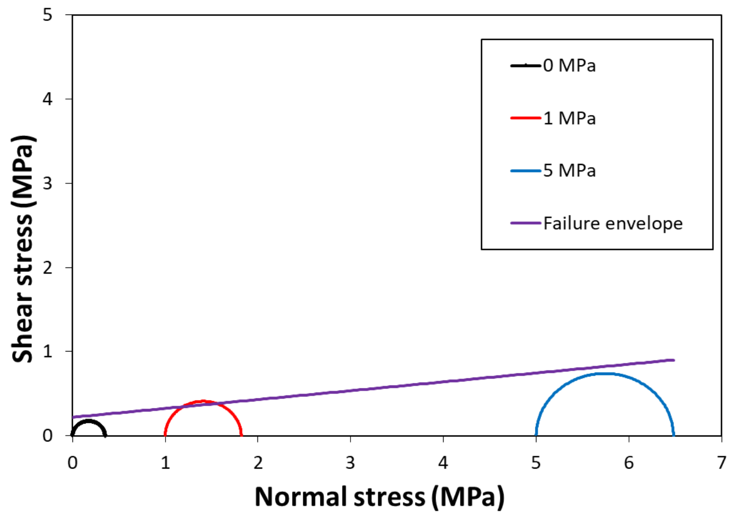
Specimens: SP8-1, SP8-2, and SP8-3

Saturated condition: Insitu

Test: Unconfined (uniaxial) and confined (triaxial) compressive strength







σ_3 (MPa)	Strength (MPa)	σ_1 (MPa)
0 (UCS)	0.35	0.35
1	0.82	1.82
5	1.48	6.48

Internal friction angle (°)	6
Cohesion (MPa)	0.22
Failure behaviour	Ductile
Failure mode	Cataclastic flow

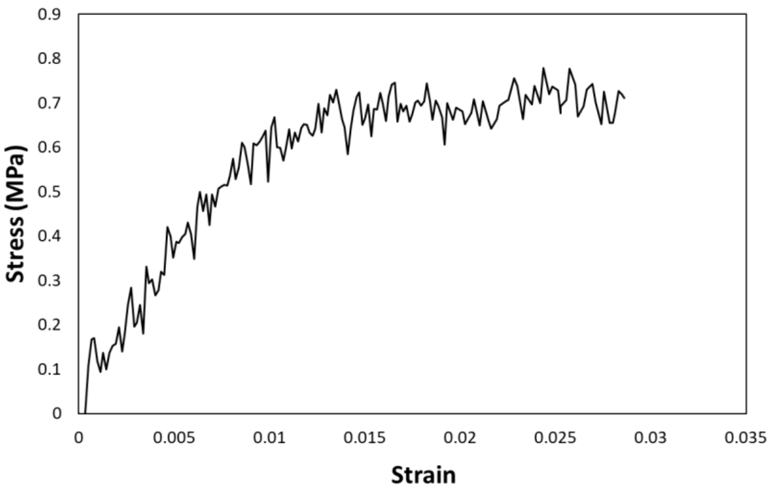
Location: BHKB-1

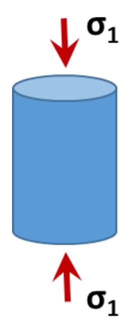
Sample: SP9

Specimen: SP9-1

Saturated condition: Insitu

Test: Unconfined (uniaxial) compressive strength





(a) Core sample. (b) Plugged specimen.

Specimen	Strength (MPa)	Failure behaviour	Failure mode
SP9-1	0.77	Ductile	Cataclastic flow

Sample Photos of Split-Spoon Sampling from Borehole Drilling


Photograph 1: BHKB- 1 - SA 4


Photograph 2: BHKB- 1 - SA 5


Photograph 3: BHKB- 1 - SA 6


Photograph 4: BHKB 1 - SA 7


Photograph 5: BHKB 1 – SA 8


Photograph 6: BHKB 1 - SA 9


Photograph 7: BHKB 1 - SA 11

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E1.4 – Fieldwork Photos

Selected Fieldwork Photos: Auger Drilling and Sampling (left image), Topographic Surveying (middle image) and GPS Line Transects (right image).

Auguring, Terrestrial and Marine Sampling and On-field Testing Photographs

Terrestrial Auguring and Soil Sampling

Soil Sample 1 (KBH3)- Auguring and Sampling

Soil Sample 6 (KBH6)- Auger Sanitization SOP and Auguring -Wash and sterilize equipment with Distilled and Deionized water after each soil sample taken.

Soil Sample 6 (KBH6)- Auguring and Sampling. - Water Table/Hydraulic head measurements

Terrestrial Water Sampling

Sluice Canal water sampling at KTW7.

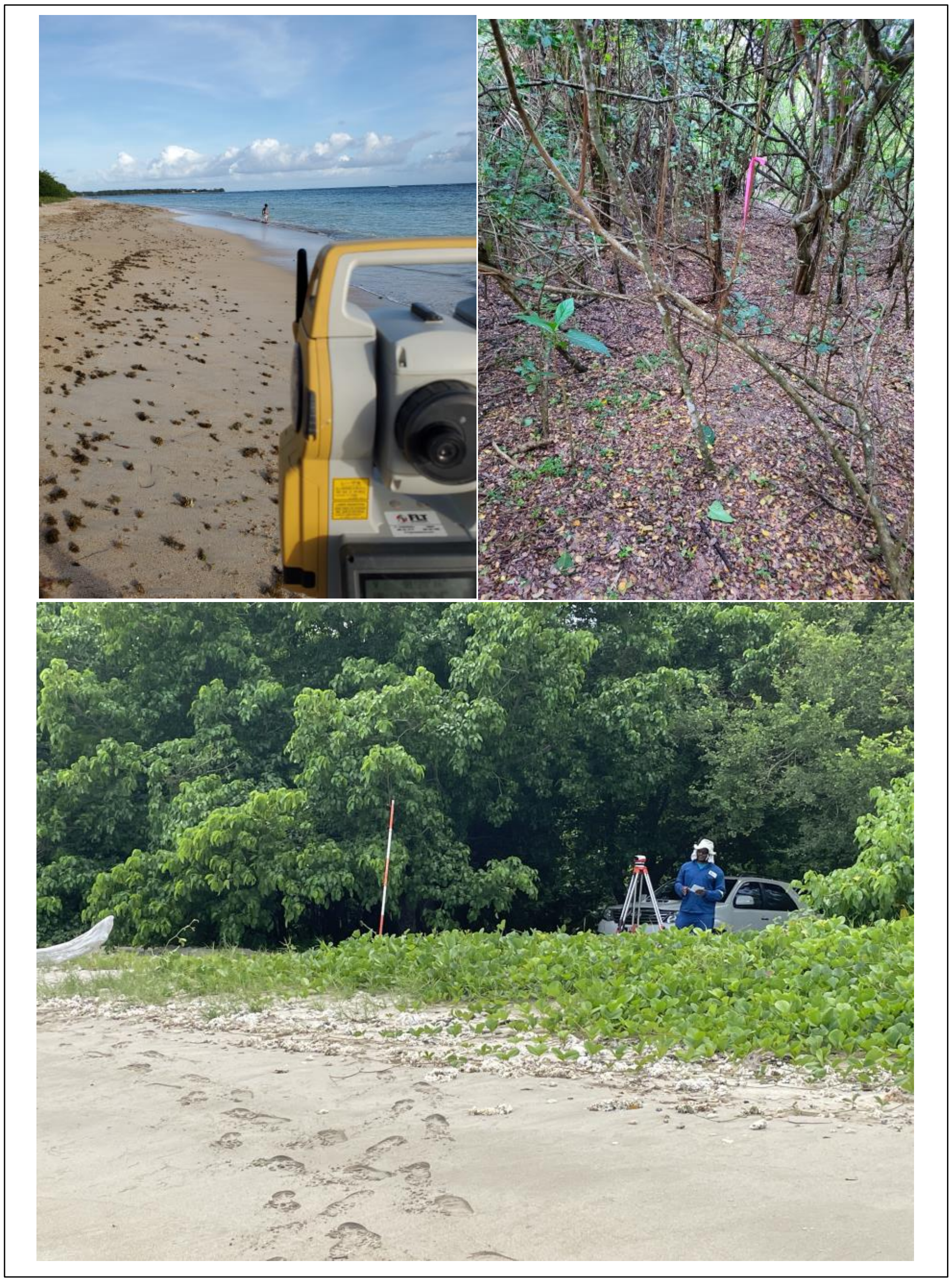
Sluice Canal water sampling at KTW5 and KTW2. Onsite data capture with YSI Multiprobe Sonde Tool for pH, Temp, Turbidity, EC, Salinity, Dissolved Oxygen and Total Suspended Solids.

Marine Sediment Sampling

Marine Sediment Sampling KBMS-1 and 3 with Ponar grab sampler.

Marine Water Sampling

Marine Water Sampling KBMS-1 and 3 using Niskin Equipment



Survey Transect Images capturing survey lines executed in the Mangrove and Beach. Pink marker ribbons in mangroves demarcate survey line paths

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E1.5 - Custody Transfer to Laboratories and Laboratory Job Confirmations

Chain of Custody Form

Biosphere Consulting Services Ltd.
Lot 25 James Lane Malabar Road Arima
Tel: (868) 778 7293
Email: info@biospherett.com

Client: Optimal GESL
Report to: Dr. RYAN RAMSOOK
Address: *127B Down Village South Oropouche, Oropouche, Trinidad and Tobago*

Invoice to: Optimal Geoscience and Engineering Solutions Limited

Sample Identification	Sample Date	BOD	COD	TSS	Total Oil and Grease	Nitrogen as Ammonia	Total Phosphorous	Total Residual Chlorine	Phenol	Trace Metals	BETX	Faecal Coliforms	Enterococci	E. Coil	Polyaromatic hydrocarbons	Total Oil and grease	TPH	Invertebrates	No. of Containers	Matrix	Comments
KBMS 1	18/09/22																	X		Sediment	Plastic Bag label
KBMS 2	18/09/22																	X		Sediment	Plastic Bag label
KBMS 3	18/09/22																	X		Sediment	Plastic Bag label
KBMS 4	18/09/22																	X		Sediment	Plastic Bag label
KBMS 5	18/09/22																	X		Sediment	Plastic Bag label coral no sand

Relinquished By: Rajeev Seecharan
Print Name: Rajeev Seecharan Signature
Firm: Optimal GESL
Date: 20/09/22 Time: 2:35pm

Received By: Erin Mangal
Print Name: Erin Mangal Signature
Firm: BCSL
Date: 20/09/22 Time:

Completed Chain of Custody Record for Marine Sediment Samples for Benthic Fauna Analysis by Biosphere

Optimal Geoscience and Engineering Solutions
27b South Oropouche
Oropouche, Trinidad
Phone: 868-499-2202
Email: optimalgesl@gmail.com

08512615

Chain of Custody Record

Company: BUREAU VERITAS LABORATORIES
Address: 4606 CANADA WAY, BURNABY, BC V5G1K5
Email Address: Kristopher.Beaudette@bvlabs.com
Phone: 1-236-464-4779 Fax:
Project: DSM EIA KILGWYN BAY TOBAGO
Project #: 2022/OPTIMALGESL/DSM-02
Project Manager: RYAN RAMSOOK
Project Location: TOBAGO
Page 1 of 1
Form Title: Chain of Custody Record
Project Name: DSM EIA KILGWYN BAY TOBAGO
Sampled by [Print Name(s)] / Affiliation: RYAN RAMSOOK / OPTIMALGESL
Sampler(s) Signature(s)
REQUESTED DUE DATE / STD /

Item No.	Field ID No.	Sampled Date	Sampled Time	Grab or Composite	Matrix (see codes)	Number of Containers	pH	Total Metals (N)	TOC (S)	PAH (S)	Total N Total P	COD (S)	Remarks	Lab. No.
1	KBMS-1	18/09/22	2:45pm	GRAB	SE	5	✓	✓	✓	✓			Sample, No Duplicate	
2	KBMS-2	"	3:15pm	"	SE	5	✓	✓	✓	✓			"	
3	KBMS-3	"	3:50pm	"	SE	5	✓	✓	✓	✓			"	
4	KBMS-4	"	4:15pm	"	SE	5	✓	✓	✓	✓			"	
5	KBMS-5	"	5:00pm	"	SE	6	✓	✓	✓	✓			" + FIELD BLANK (SO)	
1	KBMS-1	"	2:45pm	"	SW	10		✓	✓	✓	✓	✓	Sample + Duplicate (Reserved)	
2	KBMS-2	"	3:15pm	"	SW	10		✓	✓	✓	✓	✓	"	
3	KBMS-3	"	3:50pm	"	SW	10		✓	✓	✓	✓	✓	"	
4	KBMS-4	"	4:15pm	"	SW	10		✓	✓	✓	✓	✓	"	
5	KBMS-5	"	5:00pm	"	SW	10		✓	✓	✓	✓	✓	" + FIELD BLANK (W)	

77 ⇐ Total Number of Containers

Shipment Method — Out: 20/09/22 Via: AIR; Returned: / / Via:

Item No.	Relinquished by / Affiliation	Date	Time	Accepted by / Affiliation	Date	Time
	RYAN RAMSOOK / OPTIMALGESL	20/09/22	11:30	WARREN WICKHAM FEDEX	21/09/22	1:05
				Edelene Cavili Bureau Veritas	22/09/22	1454

Cooler No.(s) / Temperature(s) (C): 7 / 4° C
Sampling Kit No.
Equipment ID No.

MATRIX CODES: A = Air GW = Groundwater SE = Sediment SO = Soil SW = Surface Water W = Water (Blanks) O = Other (specify)
PRESERVATIVE CODES: H = Hydrochloric acid + ice I = Ice only N = Nitric acid + ice S = Sulfuric acid + ice O = Other (specify)

Optimal GEOSCIENCE AND ENGINEERING SOLUTIONS LTD

C278720_COC

Completed Chain of Custody Record #1 for Marine Sediment and Marine Water Samples for Geochemical Analysis – BV Labs, Canada

Optimal Geoscience and Engineering Solutions
127b South Oropouche
Oropouche, Trinidad
Phone: 868-499-2202
Email: optimalgesl@gmail.com

Optimal GEOSCIENCE AND ENGINEERING SOLUTIONS

COPY C224270.

Chain of Custody Record

Company: BUREAU VERITAS LABORATORIES
Address: 4606 CANADA WAY, BURNABY, BC V5G1K5
Email Address: Kristopher.Beaudet@bvlabs.com
Phone: 1-236-464-4774 Fax:
Project: DSM EIA KILGWYN BAY TOBAGO
Project #: 2022/OPTIMALGESL/DSM-02
Project Manager: RYAN RAMSOOK
Project Location: TOBAGO
Page 1 of 1
Form Title: Chain of Custody Record
Project Name: DSM EIA KILGWYN BAY TOBAGO
Sampled by (Print Name(s)) / Affiliation: RYAN RAMSOOK / OPTIMALGESL
Sampler(s) Signature(s): [signature]
Preservatives (see codes): N S S S
REQUESTED DUE DATE / STD /

Item No.	Field ID No.	Sampled Date	Sampled Time	Grab or Composite	Matrix (see codes)	Number of Containers	PH	TOTAL METALS	TOC	PAH	TOTAL N, TOTAL P	CO	Remarks	Lab. No.
1	KBMS-1	18/09/22	2:45pm	GRAB	SE	5	✓	✓	✓	✓			Sample, No Duplicate	
2	KBMS-2	"	3:15pm	"	SE	5	✓	✓	✓	✓			"	
3	KBMS-3	"	3:50pm	"	SE	5	✓	✓	✓	✓			"	
4	KBMS-4	"	4:15pm	"	SE	5	✓	✓	✓	✓			"	
5	KBMS-5	"	5:00pm	"	SE	6	✓	✓	✓	✓			" + FIELD BLANK (W)	
1	KBMS-1	"	2:45pm	"	SW	10		✓	✓	✓	✓	✓	Sample + Duplicate (Reserved)	
2	KBMS-2	"	3:15pm	"	SW	10		✓	✓	✓	✓	✓	"	
3	KBMS-3	"	3:50pm	"	SW	10		✓	✓	✓	✓	✓	"	
4	KBMS-4	"	4:15pm	"	SW	10		✓	✓	✓	✓	✓	"	
5	KBMS-5	"	5:00pm	"	SW	10		✓	✓	✓	✓	✓	" + FIELD BLANK (W)	

77 ⇐ Total Number of Containers

Shipment Method — Out: 20/09/22 Via: AIR; Returned: / / Via:

Item No.	Relinquished by / Affiliation	Date	Time	Accepted by / Affiliation	Date	Time
	RYAN RAMSOOK / OPTIMALGESL	20/09/22	4:30	WARREN WICKHAM FEDEX	09/20/22	1:05

Cooler No.(s) / Temperature(s) (C): 7 / 4° C
Sampling Kit No.:
Equipment ID No.:

MATRIX CODES: A = Air GW = Groundwater SE = Sediment SO = Soil SW = Surface Water W = Water (Blanks) O = Other (specify)
PRESERVATIVE CODES: H = Hydrochloric acid + ice I = Ice only N = Nitric acid + ice S = Sulfuric acid + ice O = Other (specify)

Optimal GEOSCIENCE AND ENGINEERING SOLUTIONS LTD

C278720_COC

Completed Chain of Custody Record #2 for Marine Sediment and Marine Water Samples for Chemical Analysis – BV Labs, Canada

Optimal Geoscience and Engineering Solutions
127b South Oropouche
Oropouche, Trinidad
Phone: 868-499-2202
Email: optimalgesl@gmail.com

Optimal GEOSCIENCE AND ENGINEERING SOLUTIONS

COPY C224280.

08514364

Chain of Custody Record

Company: BUREAU VERITAS LABORATORIES
Address: 4606 CANADA WAY, BURNABY, BC V5G1K5
Email Address: Kristopher.Beaudet@bvlabs.com
Phone: 1-236-464-4779 Fax:
Project: DSM EIA KILGWYN BAY, TOBAGO
Project #: 2022 OPTIMALGESL/DSM-02
Project Manager: RYAN RAMSOOK
Project Location: TOBAGO
Page 1 of 1
Form Title: Chain of Custody Record
Project Name: DSM EIA KILGWYN BAY TOBAGO
Sampled by (Print Name(s)) / Affiliation: RYAN RAMSOOK / OPTIMALGESL
Sampler(s) Signature(s): [signature]
REQUESTED DUE DATE / STD /

Item No.	Field ID No.	Sampled Date	Sampled Time	Grab or Composite	Matrix (see codes)	Number of Containers	PH	Total Metals	TOC	PAH	Remarks	Lab. No.
1	KBH-1	18/09/22	10:00am	GRAB	SO	4	✓	✓	✓	✓	SAMPLE	
2	KBH-2	"	9:30am	"	"	4	✓	✓	✓	✓	SAMPLE	
3	KBH-3	"	10:40am	"	"	4	✓	✓	✓	✓	"	
4	KBH-4	"	11:00am	"	"	4	✓	✓	✓	✓	"	
5	KBH-5	"	9:00am	"	"	4	✓	✓	✓	✓	"	
6	KBH-6	"	11:30am	"	"	4	✓	✓	✓	✓	"	
7	FIELD BLANK	"	12:00pm	W		1	✓	✓	✓	✓	W - FIELD BLANK	

25 ⇐ Total Number of Containers

Shipment Method — Out: 20/09/22 Via: AIR; Returned: / / Via:

Item No.	Relinquished by / Affiliation	Date	Time	Accepted by / Affiliation	Date	Time
	RYAN RAMSOOK / OPTIMALGESL	20/09/22	4:30	WARREN WICKHAM FEDEX	09/20/22	1:05

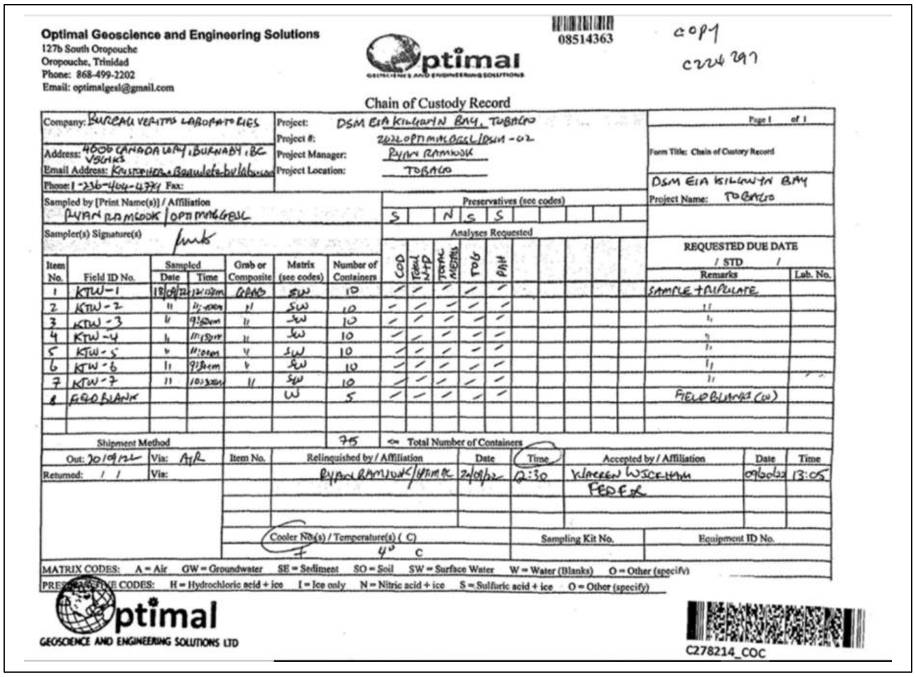
Cooler No(s) / Temperature(s) (C): 2 / 4° C
Sampling Kit No.:
Equipment ID No.:

MATRIX CODES: A = Air GW = Groundwater SE = Sediment SO = Soil SW = Surface Water W = Water (Blanks) O = Other (specify)
PRESERVATIVE CODES: H = Hydrochloric acid + ice I = Ice only N = Nitric acid + ice S = Sulfuric acid + ice O = Other (specify)

Optimal GEOSCIENCE AND ENGINEERING SOLUTIONS LTD

C278224_COC

Completed Chain of Custody Record for Terrestrial Soil Samples for Geochemical Analysis – BV Labs, Canada



Optimal Geoscience and Engineering Solutions
127b South Oropouche
Oropouche, Trinidad
Phone: 868-499-2202
Email: optimalgesl@gmail.com

08514363

copy
C224 297

Chain of Custody Record

Company: BUREAU VERITAS LABORATORIES
Address: 4606 CANADA WAY, BURNABY, BC V5G1K5
Email Address: Kristopher.Bonaulete-bvlabs.com
Phone: 1-236-404-4774 Fax:
Project: DSM EIA KILGWYN BAY, TOBAGO
Project #: 2022OPTIMALGESL/DSM-02
Project Manager: RYAN RAMSOOK
Project Location: TOBAGO
Page 1 of 1
Form Title: Chain of Custody Record
DSM EIA KILGWYN BAY
Project Name: TOBAGO
Sampled by [Print Name(s)] / Affiliation: RYAN RAMSOOK / OPTIMALGESL
Sampler(s) Signature(s):
REQUESTED DUE DATE / STD /

Item No.	Field ID No.	Sampled Date	Sampled Time	Grab or Composite	Matrix (see codes)	Number of Containers	COD	Total NH3	Total Metals	TOG	PAH	Remarks	Lab. No.
Preservatives (see codes)							S		N	S	S		
1	KTW-1	18/09/22	12:02pm	GRAB	SW	10	/	/	/	/	/	SAMPLE + TRIPLICATE	
2	KTW-2	"	11:40am	"	SW	10	/	/	/	/	/	"	
3	KTW-3	"	9:50am	"	SW	10	/	/	/	/	/	"	
4	KTW-4	"	11:15am	"	SW	10	/	/	/	/	/	"	
5	KTW-5	"	11:08am	"	SW	10	/	/	/	/	/	"	
6	KTW-6	"	9:30am	"	SW	10	/	/	/	/	/	"	
7	KTW-7	"	10:30am	"	SW	10	/	/	/	/	/	"	
8	FIELD BLANK				W	5	/	/	/	/	/	FIELD BLANKS (W)	

75 <= Total Number of Containers

Shipment Method — Out: 20/09/22 Via: AIR; Returned: / / Via:

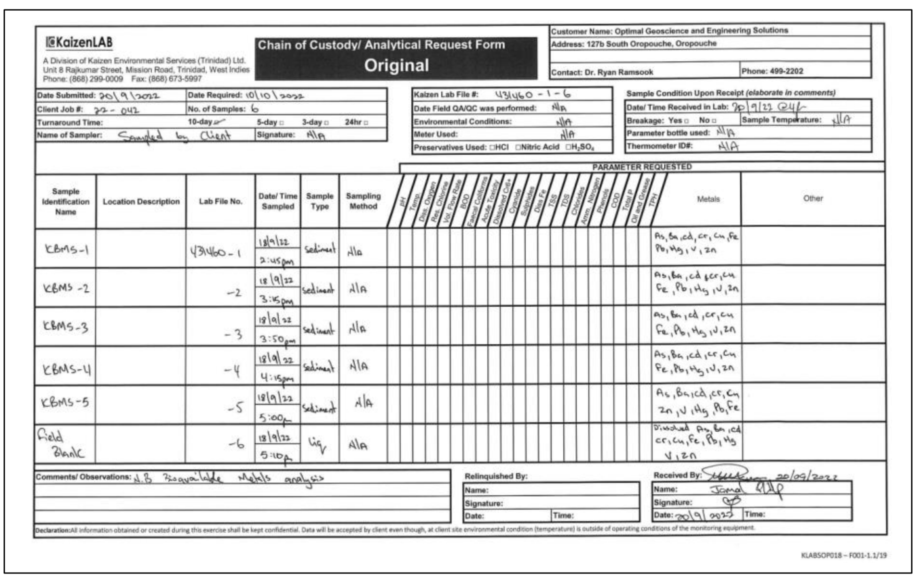
Item No.	Relinquished by / Affiliation	Date	Time	Accepted by / Affiliation	Date	Time
	RYAN RAMSOOK / OPTIMAL	20/09/22	12:30	WARREN WICKHAM FEDEX	09/20/22	13:05

Cooler No(s) / Temperature(s) (C): 7 4° C
Sampling Kit No.:
Equipment ID No.:

MATRIX CODES: A = Air GW = Groundwater SE = Sediment SO = Soil SW = Surface Water W = Water (Blanks) O = Other (specify)
PRESERVATIVE CODES: H = Hydrochloric acid + ice I = Ice only N = Nitric acid + ice S = Sulfuric acid + ice O = Other (specify)

Optimal GEOSCIENCE AND ENGINEERING SOLUTIONS LTD
C278214_COC

Completed Chain of Custody Record for Terrestrial Water Samples for Chemical Analysis – BV Labs, Canada



KaizenLAB
A Division of Kaizen Environmental Services (Trinidad) Ltd.
Unit 8 Rajkumar Street, Mission Road, Trinidad, West Indies
Phone: (868) 299-0009 Fax: (868) 673-5997

Chain of Custody/ Analytical Request Form
Original

Customer Name: Optimal Geoscience and Engineering Solutions
Address: 127b South Oropouche, Oropouche
Contact: Dr. Ryan Ramsook Phone: 499-2202

Date Submitted: 20\9\2022 Date Required: 10\10\2022
Client Job #: 22-042 No. of Samples: 6
Turnaround Time: 10-day ✓ 5-day ☐ 3-day ☐ 24hr ☐
Name of Sampler: Sampled by Client Signature: N/A

Kaizen Lab File #: 43460-1-6
Date Field QA/QC was performed: N/A
Environmental Conditions: N/A
Meter Used: N/A
Preservatives Used: ☐HCl ☐Nitric Acid ☐H_2SO_4

Sample Condition Upon Receipt *(elaborate in comments)*
Date/ Time Received in Lab: 20/9/22 @4(?)
Breakage: Yes ☐ No ☐ Sample Temperature: N/A
Parameter bottle used: N/A
Thermometer ID#: N/A

PARAMETER REQUESTED: pH, Temp., Diss. Oxygen, Res. Chlorine, Vol. Flow Rate, BOD, Faecal Coliforms, Acute Toxicity, Dissolved Cr6+, Cyanide, Sulphides, Diss Fe, TSS, TDS, Chlorides, Amm. Nitrogen, Phenols, COD, Total P, Oil and Grease, TPH, Metals, Other

Sample Identification Name	Location Description	Lab File No.	Date/ Time Sampled	Sample Type	Sampling Method	Metals	Other
KBMS-1		43460-1	18/9/22 2:45pm	Sediment	N/A	As, Ba, cd, cr, cu, Fe, Pb, Hg, V, Zn	
KBMS-2		-2	18/9/22 3:15pm	Sediment	N/A	As, Ba, cd, cr, cu, Fe, Pb, Hg, V, Zn	
KBMS-3		-3	18/9/22 3:50pm	Sediment	N/A	As, Ba, cd, cr, cu, Fe, Pb, Hg, V, Zn	
KBMS-4		-4	18/9/22 4:15pm	Sediment	N/A	As, Ba, cd, cr, cu, Fe, Pb, Hg, V, Zn	
KBMS-5		-5	18/9/22 5:00p	Sediment	N/A	As, Ba, cd, cr, cu, Zn, V, Hg, Pb, Fe	
Field Blank		-6	18/9/22 5:10p	liq	N/A	Dissolved As, Ba, cd, cr, cu, Fe, Pb, Hg, V, Zn	

Comments/ Observations: N.B Bioavailable Metals analysis

Relinquished By: Name: Signature: Date: Time:

Received By: 20/09/2022 Name: Jamal Alip(?) Signature: Date: 20/9/2022 Time:

Declaration: All information obtained or created during this exercise shall be kept confidential. Data will be accepted by client even though, at client site environmental condition (temperature) is outside of operating conditions of the monitoring equipment.

KLABSOP018 – F001-1.1/19

Completed Chain of Custody Record for Marine Sediments for Bioavailable Metals– Kaizen Labs, Canada

KaizenLAB

A Division of Kaizen Environmental Services (Trinidad) Ltd.
Unit 8 Rajkumar Street, Mission Road, Trinidad, West Indies
Phone: (868) 299-0009 Fax: (868) 673-5997

Chain of Custody/ Analytical Request Form

Original

Customer Name: Optimal Geoscience and Engineering Solutions
Address: 127b South Oropouche, Oropouche
Contact: Dr. Ryan Ramsook | Phone: 499-2202

Date Submitted: 20/9/2022	Date Required: 10/10/2022		
Client Job #: 22-042	No. of Samples: 7		
Turnaround Time:	10-day ☑	5-day ☐ 3-day ☐	24hr ☐
Name of Sampler: Sampled by Client		Signature: N/A	

Kaizen Lab File #:	431459-1-7
Date Field QA/QC was performed:	N/A
Environmental Conditions:	N/A
Meter Used:	N/A
Preservatives Used: ☐HCl ☐Nitric Acid ☐H_2SO_4	

Sample Condition Upon Receipt *(elaborate in comments)*

Date/ Time Received in Lab: 20/9/22 @ 4pm	
Breakage: Yes ☐ No ☑	Sample Temperature: N/A
Parameter bottle used: N/A	
Thermometer ID#: N/A	

PARAMETER REQUESTED

Sample Identification Name	Location Description	Lab File No.	Date/ Time Sampled	Sample Type	Sampling Method	pH	Temp.	Diss. Oxygen	Res. Chlorine	Vol. Flow Rate	BOD	Faecal Coliforms	Acute Toxicity	Dissolved Cr6+	Cyanide	Sulphides	Diss Fe	TSS	TDS	Chlorides	Amm. Nitrogen	Phenols	COD	Total P	Oil and Grease	TPH	Metals	Other
KBH-1		431459-1	18/9/22 10:00am	Soil	N/A																						As, Ba, Cd, Cr, Cu, Fe, Pb, Hg, V, Zn	
KBH-2		-2	18/9/22 9:30am	Soil	N/A																						As, Ba, Cd, Cr, Cu, Fe, Pb, Hg, V, Zn	
KBH-3		-3	18/9/22 10:40am	Soil	N/A																						As, Ba, Cd, Cr, Cu, Fe, Pb, Hg, V, Zn	
KBH-4		-4	18/9/22 11:00am	Soil	N/A																						As, Ba, Cd, Cr, Cu, Fe, Pb, Hg, V, Zn	
KBH-5		-5	18/9/22 9:00am	Soil	N/A																						As, Ba, Cd, Cr, Cu, Fe, Pb, Hg, V, Zn	
KBH-6		-6	18/9/22 11:23am	Soil	N/A																						As, Ba, Cd, Cr, Cu, Fe, Pb, Hg, V, Zn	

Comments/ Observations: N.B Bioavailable Metals analysis

Relinquished By:	
Name:	
Signature:	
Date:	Time:

Received By: [signature] 22/09/2022	
Name: Jamal [illegible]	
Signature: [signature]	
Date: 20/9/2022	Time:

Declaration: All information obtained or created during this exercise shall be kept confidential. Data will be accepted by client even though, at client site environmental condition (temperature) is outside of operating conditions of the monitoring equipment.

KLABSOP018 – F001-1.1/19

Completed Chain of Custody Record for Terrestrial Soils for Bioavailable Metals– Kaizen Labs, Canada.

BUREAU VERITAS

Confirmation of Sample Receipt

Bureau Veritas Job Number: C278214
Job Received: 2022/09/27
Final Report Due: 2022/10/21
Disposal Date: 2022/10/27

Invoice Information
Attn: Ryan Ramsook
COMMERCIAL ACCOUNTS/INTERNATIONAL – WESTERN BUREAU VERITAS CANADA (2019)
4000 – 19 Street NE
Calgary, AB, T2E 6P8
Email to:
optimalgesl@gmail.com

Report Information
Attn: Ryan Ramsook
Optimal Geosciences and Engineering Solutions
127b South Oropouche
Oropouche, --
Email to:
optimalgesl@gmail.com

Project Information
Quote #: C11345
PO/AFE#:
Project #: DSM EIA KILGWYN BAY TOBAGO
Site Location: 2022/OPTIMALGESL/DSM-02
Sampled By:

Analytical Summary

A: Due On 2022/10/14
B: Due On 2022/10/21

Lab ID	Client Sample ID	Sampling Date/Time	Matrix	# Cont.	COD in Water	PAH in Water	Total Metals (incl. Hg) in Seawater	Total Metals (incl. Hg) in Water	Total Nitrogen in Water	Total Oil and Grease in Water	Total Phosphorus in Water	Set Number
COC# 08514363												
BDT861	KTW-1	2022/09/18 12:50	SeaWater	5	A	A	A		A	B	A	1
BDT862	KTW-2	2022/09/18 11:40	SeaWater	4	A	A	A			B		2
BDT863	KTW-3	2022/09/18 09:50	SeaWater	5	A	A	A		A	B	A	1
BDT864	KTW-4	2022/09/18 11:15	SeaWater	5	A	A	A		A	B	A	1
BDT865	KTW-5	2022/09/18 11:00	SeaWater	5	A	A	A		A	B	A	1
BDT866	KTW-6	2022/09/18 09:30	SeaWater	5	A	A	A		A	B	A	1
BDT867	KTW-7	2022/09/18 10:30	SeaWater	4	A	A	A			B		2
BDT868	FIELD BLANK	2022/09/18	W	7	A	A		B	A	B	A	3
BDT869	KTW-1 DUP	2022/09/18 12:50	SeaWater	5	A	A	A		A	B	A	1
BDT870	KTW-2 DUP	2022/09/18 11:40	SeaWater	3	A	A	A					4
BDT871	KTW-3 DUP	2022/09/18 09:50	SeaWater	5	A	A	A		A	B	A	1
BDT872	KTW-4 DUP	2022/09/18 11:15	SeaWater	5	A	A	A		A	B	A	1
BDT873	KTW-5 DUP	2022/09/18 11:00	SeaWater	4	A	A	A			B		2

Confirmation Laboratory Receipt Record for Terrestrial Water Samples for Geochemical Analysis – BV Labs, Canada.

BUREAU VERITAS

Confirmation of Sample Receipt

Bureau Veritas Job Number: C278720
Job Received: 2022/09/27
Final Report Due: 2022/10/21
Disposal Date: 2022/10/27

Invoice Information

Attn: Ryan Ramsook
COMMERCIAL ACCOUNTS/INTERNATIONAL – WESTERN BUREAU VERITAS CANADA (2019)
4000 – 19 Street NE
Calgary, AB, T2E 6P8
Email to:
optimalgesl@gmail.com

Report Information

Attn: Ryan Ramsook
Optimal Geosciences and Engineering Solutions
127b South Oropouche
Oropouche, --
Email to:
optimalgesl@gmail.com

Project Information

Quote #: C11345
PO/AFE#:
Project #:
Site Location:
Sampled By:

Analytical Summary

A: Due On 2022/10/14
B: Due between 2022/10/14 and 2022/10/21
C: Due On 2022/10/21

Lab ID	Client Sample ID	Sampling Date/Time	Matrix	# Cont.	COD in Water	PAH in Sediment	PAH in Water	Total Metals (incl. Hg and pH) in Soil	Total Metals (incl. Hg) in Seawater	Total Nitrogen in Water	Total Oil and Grease in Soil and Sediment	Total Oil and Grease in Water	Total Phosphorus in Water	Index of Additive Cancer Risk Calc.	Set Number
COC# 08512615															
BDX984	KBMS-1 SOIL	2022/09/18 14:45	SEDIMENT	5		A		A			B			A	1
BDX985	KBMS-2 SOIL	2022/09/18 15:15	SEDIMENT	3		A		A			B			A	1
BDX986	KBMS-3 SOIL	2022/09/18 15:50	SEDIMENT	2		A		A			B			A	1
BDX987	KBMS-4 SOIL	2022/09/18 16:15	SEDIMENT	5		A		A			B			A	1
BDX988	KBMS-5 SOIL	2022/09/18 17:00	SEDIMENT	5		A		A			B			A	1
BDX989	KBMS-1	2022/09/18 14:45	SeaWater	2					A			C			2
BDX990	KBMS-2	2022/09/18 15:15	SeaWater	4	A		A		A	A		C	A		3
BDX991	KBMS-3	2022/09/18 15:50	SeaWater	4	A		A		A	A		C	A		3
BDX992	KBMS-4	2022/09/18 16:15	SeaWater	4	A		A		A	A		C	A		3
BDX993	KBMS-5	2022/09/18 17:00	SeaWater	4	A		A		A	A		C	A		3
BDX994	KBMS-1 DUP	2022/09/18 14:45	SeaWater	3			A		A			C			4
BDX995	KBMS-2 DUP	2022/09/18 15:15	SeaWater	5	A		A		A	A		C	A		3
BDX996	KBMS-3 DUP	2022/09/18 15:50	SeaWater	4	A		A		A	A		C	A		3

Confirmation Laboratory Receipt Record for Marine Sediment and Marine Water Samples for Chemical Analysis – BV Labs, Canada

Confirmation of Sample Receipt

Bureau Veritas Job Number: C2782
Job Received: 2022/09/
Final Report Due: 2022/10/
Disposal Date: 2022/11/

Invoice Information

Attn: Ryan Ramsook
COMMERCIAL ACCOUNTS/INTERNATIONAL – WESTERN BUREAU VERITAS CANADA (2019)
4000 – 19 Street NE
Calgary, AB, T2E 6P8
Email to:
optimalgesl@gmail.com

Report Information

Attn: Ryan Ramsook
Optimal Geosciences and Engineering Solutions
127b South Oropouche
Oropouche, --
Email to:
optimalgesl@gmail.com

Project Information

Quote #: C11345
PO/AFE#:
Project #:
Site Location:
Sampled By:

Analytical Summary

A: Due On 2022/10/14
B: Due between 2022/10/14 and 2022/10/21

Lab ID	Client Sample ID	Sampling Date/Time	Matrix	# Cont.	PAH in Soils	Total Metals (incl. Hg and pH) in Soil	Total Oil and Grease in Soil and Sediment
COC# 08514364							
BDT928	KBH-1	2022/09/18 10:00	SOIL	5	A	A	B
BDT929	KBH-2	2022/09/18 09:30	SOIL	5	A	A	B
BDT930	KBH-3	2022/09/18 10:40	SOIL	5	A	A	B
BDT931	KBH-4	2022/09/18 11:00	SOIL	5	A	A	B
BDT932	KBH-5	2022/09/18 09:00	SOIL	5	A	A	B
BDT933	KBH-6	2022/09/18 11:23	SOIL	5	A	A	B
BDT934	FIELD BLANK	2022/09/18 12:00	SOIL	6	A	A	B

Include Criteria on CofA: No

Confirmation Laboratory Receipt Record for Terrestrial Soil Samples for Geochemical Analysis – BV Labs, Canada

KaizenLAB
Analytical Division of Kaizen Environmental Services (Trinidad) Ltd.

Unit 8 Rajkumar Street,
Mission Road, Freeport.
Email: kaizenlab@kaizen-tt.com
Tel: (868) 299-0009
Fax: (868) 673-6774

ANALYSIS DATA REPORT

Customer:	Optimal Geoscience and Engineering Solutions	**Customer Contact:**	Dr. Ryan Ramsook
Customer's Address:	127b South Oropouche, Oropouche, Trinidad, W.I.		
Client Project #:	22-042	**Lab File #:**	431459
Item(s) Analyzed:	Soil & Liquid Samples		
Date of Sampling:	18-Sep-22	**Sampling Location:**	n/a
Sampling Condition:	n/a	**Sampled By:**	Customer
Sampling Plan Used:	n/a		
Date of Receipt:	20-Sep-22	**Date of Testing:**	7-Oct-22 to 12-Oct-22
Report Date:	28-Oct-22		

ANALYSIS RESULTS

Parameter Name	Method Used*	Units	Results		
			431459-1, KBH 1	431459-2, KBH 2	431459-3, KBH 3
Total Organic Carbon (TOC)	SSSA Methods of Soil Analysis Part 3, Chapter 34, 37 modified	%	1.15	2.34	2.25
Bioavailable As	DTPA extraction method, followed by SMEWW 3030 B (modified) and SMEWW 3125 B (modified)	mg/kg	0.01582	0.01794	0.02314
Bioavailable Ba		mg/kg	0.2526	0.4826	0.3252
Bioavailable Cd		mg/kg	0.00656	0.00974	<0.00300
Bioavailable Cr		mg/kg	<0.0500	<0.0500	<0.0500
Bioavailable Cu		mg/kg	7.648	1.0254	0.2316
Bioavailable Fe		mg/kg	7.20	3.68	110.80
Bioavailable Pb		mg/kg	9.4136	0.76628	0.93600
Bioavailable V		mg/kg	0.3090	0.1712	0.3490
Bioavailable Zn		mg/kg	<0.700	<0.700	<0.700
Bioavailable Hg		mg/kg	<0.500	<0.500	<0.500

Parameter Name	Method Used*	Units	Results		
			431459-4, KBH 4	431459-5, KBH 5	431459-6, KBH 6
Total Organic Carbon (TOC)	SSSA Methods of Soil Analysis Part 3, Chapter 34, 37 modified	%	<0.04	1.24	0.40
Bioavailable As	DTPA extraction method, followed by SMEWW 3030 B (modified) and SMEWW 3125 B (modified)	mg/kg	<0.00400	0.01158	0.01944
Bioavailable Ba		mg/kg	0.3358	0.3210	0.3220

Laboratory Results Record for Marine Sediment Samples for- Bio Available Metals – Kaizen Labs- Trinida

KaizenLAB

Analytical Division of Kaizen Environmental Services (Trinidad) Ltd.

Unit 8 Rajkumar Street,
Mission Road, Freeport.
Email: kaizenlab@kaizen-tt.com
Tel: (868) 299-0009
Fax: (868) 673-6774

ANALYSIS RESULTS

Parameter Name	Method Used*	Units	Results		
			431459-4, KBH 4	431459-5, KBH 5	431459-6, KBH 6
Bioavailable Cd	DTPA extraction method, followed by SMEWW 3030 B (modified) and SMEWW 3125 B (modified)B	mg/kg	<0.00300	0.01332	<0.00300
Bioavailable Cr		mg/kg	<0.0500	<0.0500	<0.0500
Bioavailable Cu		mg/kg	<0.0600	0.9538	<0.0600
Bioavailable Fe		mg/kg	<0.400	3.78	39.6
Bioavailable Pb		mg/kg	0.08428	0.35336	0.18202
Bioavailable V		mg/kg	<0.0100	0.1506	0.1540
Bioavailable Zn		mg/kg	<0.700	2.38	<0.700
Bioavailable Hg		mg/kg	<0.500	<0.500	<0.500

Parameter Name	Method Used*	Units	Results
			431459-7, Field Blank
Total Organic Carbon (TOC)	Modified from SM 5310B	mg/L	<0.50
Dissolved As	Modified from SMEWW 3030 B and SMEWW 3125 B	mg/L	<0.00400
Dissolved Ba		mg/L	0.0706
Dissolved Cd		mg/L	<0.00300
Dissolved Cr		mg/L	<0.0500
Dissolved Cu		mg/L	<0.0600
Dissolved Fe		mg/L	<0.400
Dissolved Pb		mg/L	<0.00700
Dissolved V		mg/L	0.0107
Dissolved Zn		mg/L	<0.700
Dissolved Hg		mg/L	<0.500

Laboratory Results Record for Marine Sediment Samples for- Bio Available Metals – Kaizen Labs- Trinidad.

KaizenLAB

Analytical Division of Kaizen Environmental Services (Trinidad) Ltd.

Unit 8 Rajkumar Street,
Mission Road, Freeport.
Email: kaizenlab@kaizen-tt.com
Tel: (868) 299-0009
Fax: (868) 673-6774

ANALYSIS DATA REPORT

Customer:	Optimal Geoscience and Engineering Solutions	**Customer Contact:**	Dr. Ryan Ramsook
Customer's Address:	127b South Oropouche, Oropouche, Trinidad, W.I.		
Client Project #:	22-042	**Lab File #:**	431460
Item(s) Analyzed:	Sediment & Liquid Samples		
Date of Sampling:	18-Sep-22	**Sampling Location:**	n/a
Sampling Condition:	n/a	**Sampled By:**	Customer
Sampling Plan Used:	n/a		
Date of Receipt:	20-Sep-22	**Date of Testing:**	7-Oct-22 to 12-Oct-22
Report Date:	28-Oct-22		

ANALYSIS RESULTS

Parameter Name	Method Used*	Units	Results		
			431460-1, KBMS 1	431460-2, KBMS 2	431460-3, KBMS 3
Total Organic Carbon (TOC)	SSSA Methods of Soil Analysis Part 3, Chapter 34, 37 modified	%	0.49	0.73	0.70
Bioavailable As	DTPA extraction method, followed by SMEWW 3030 B (modified) and SMEWW 3125 B (modified)	mg/kg	0.04702	0.05734	0.03742
Bioavailable Ba		mg/kg	0.4432	0.2414	0.2526
Bioavailable Cd		mg/kg	<0.00300	<0.00300	<0.00300
Bioavailable Cr		mg/kg	<0.0500	<0.0500	<0.0500
Bioavailable Cu		mg/kg	<0.0600	<0.0600	<0.0600
Bioavailable Fe		mg/kg	3.62	2.10	5.58
Bioavailable Pb		mg/kg	0.0457	0.02902	0.02510
Bioavailable V		mg/kg	0.0586	0.0312	0.0428
Bioavailable Zn		mg/kg	<0.700	<0.700	<0.700
Bioavailable Hg		mg/kg	<0.500	<0.500	<0.500

Parameter Name	Method Used*	Units	Results	
			431460-4, KBMS 4	431460-5, KBMS 5
Total Organic Carbon (TOC)	SSSA Methods of Soil Analysis Part 3, Chapter 34, 37 modified	%	0.43	0.45
Bioavailable As	DTPA extraction method, followed by SMEWW 3030 B (modified) and SMEWW 3125 B (modified)	mg/kg	0.01096	0.01444
Bioavailable Ba		mg/kg	0.1984	0.374

Laboratory Results Record for Marine Sediment Samples for- Bio Available Metals – Kaizen Labs- Trinidad.

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Tel: (868) 299-0009
Fax: (868) 673-6774

ANALYSIS RESULTS

Parameter Name	Method Used*	Units	Results	
			431460-4, KBMS 4	431460-5, KBMS 5
Bioavailable Cd	DTPA extraction method, followed by SMEWW 3030 B (modified) and SMEWW 3125 B (modified)B	mg/kg	<0.00300	<0.00300
Bioavailable Cr		mg/kg	<0.0500	<0.0500
Bioavailable Cu		mg/kg	<0.0600	<0.0600
Bioavailable Fe		mg/kg	21.0	0.806
Bioavailable Pb		mg/kg	0.06192	<0.00700
Bioavailable V		mg/kg	0.044	<0.0100
Bioavailable Zn		mg/kg	<0.700	<0.700
Bioavailable Hg		mg/kg	<0.500	<0.500

Parameter Name	Method Used*	Units	Results
			431460-6, Field Blank
Total Organic Carbon (TOC)	Modified from SM 5310B	mg/L	<0.50
Dissolved As	Modified from SMEWW 3030 B and SMEWW 3125 B	mg/L	<0.00400
Dissolved Ba		mg/L	0.1542
Dissolved Cd		mg/L	<0.00300
Dissolved Cr		mg/L	<0.0500
Dissolved Cu		mg/L	<0.0600
Dissolved Fe		mg/L	<0.400
Dissolved Pb		mg/L	<0.00700
Dissolved V		mg/L	0.0202
Dissolved Zn		mg/L	<0.700
Dissolved Hg		mg/L	<0.500

Laboratory Results Record for Marine Sediment Samples for- Bio Available Metals – Kaizen Labs- Trinidad.

KaizenLAB

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Email: kaizenlab@kaizen-tt.com
Tel: (868) 299-0009
Fax: (868) 673-6774

ANALYSIS DATA REPORT

Customer:	Optimal Geoscience and Engineering Solution	**Customer Contact:**	Dr. Ryan Ramsook
Customer's Address:	127b South Oropouche, Oropouche, Trinidad, W.I.		
Client Project #:	22-042	**Lab File #:**	431104
Item(s) Analyzed:	Soil & Liquid Samples		
Date of Sampling:	1-Apr-22	**Sampling Location:**	n/a
Sampling Condition:	n/a	**Sampled By:**	Customer
Sampling Plan Used:	n/a		
Date of Receipt:	3-Apr-22	**Date of Testing:**	13-Apr-22 to 25-Apr-22
Report Date:	25-Apr-22		

ANALYSIS RESULTS

Parameter Name	Method Used*	Units	Results			
			431104-1, KBMS 1	431104-2, KBMS 2	431104-3, KBMS 3	431104-4, KBMS 4
Total Organic Carbon (TOC)	SSSA Methods of Soil Analysis Part 3, Chapter 34, 37 modified	%	0.25	0.41	0.54	0.58
Bioavailable As	DTPA extraction method, followed by SMEWW 3030 B (modified) and SMEWW 3125 B (modified)	mg/kg	0.09374	0.09226	0.1629	0.03026
Bioavailable Ba		mg/kg	1.8492	1.7738	1.7224	1.651
Bioavailable Cd		mg/kg	<0.00300	<0.00300	<0.00300	0.00628
Bioavailable Cr		mg/kg	<0.0500	<0.0500	<0.0500	<0.0500
Bioavailable Fe		mg/kg	28.0	23.6	48.6	9.66
Bioavailable Pb		mg/kg	0.057	0.04648	0.05318	0.0511
Bioavailable V		mg/kg	0.1356	0.121	0.15	0.04
Bioavailable Zn		mg/kg	<0.700	<0.700	<0.700	<0.700
Bioavailable Hg		mg/kg	<0.000500	<0.000500	<0.000500	<0.000500

Parameter Name	Method Used*	Units	Results
			431104-5, Field Blank
Total Organic Carbon (TOC)	Modified from SM 5310 B	mg/L	28.45
Dissolved As	Modified from SMEWW 3030 B and SMEWW 3125 B	mg/L	<0.00400
Dissolved Ba		mg/L	0.5326

Laboratory Results Record for Marine Sediment Samples for- Bio Available Metals – Kaizen Labs- Trinidad.

KaizenLAB
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Tel: (868) 299-0009
Fax: (868) 673-6774

ANALYSIS DATA REPORT

Customer:	Optimal Geoscience and Engineering Solutions	**Customer Contact:**	Dr. Ryan Ramsook
Customer's Address:	127b South Oropouche, Oropouche, Trinidad, W.I.		
Client Project #:	22-042	**Lab File #:**	431105
Item(s) Analyzed:	Soil & Liquid Samples		
Date of Sampling:	1-Apr-22	**Sampling Location:**	n/a
Sampling Condition:	n/a	**Sampled By:**	Customer
Sampling Plan Used:	n/a		
Date of Receipt:	3-Apr-22	**Date of Testing:**	13-Apr-22 to 25-Apr-22
Report Date:	25-Apr-22		

ANALYSIS RESULTS

Parameter Name	Method Used*	Units	Results		
			431105-1, KBH 1	431105-2, KBH 2	431105-3, KBH 3
Total Organic Carbon (TOC)	SSSA Methods of Soil Analysis Part 3, Chapter 34, 37 modified	%	0.91	0.21	0.05
Bioavailable As	DTPA extraction method, followed by SMEWW 3030 B (modified) and SMEWW 3125 B (modified)	mg/kg	0.01502	0.01786	0.02322
Bioavailable Ba		mg/kg	1.5026	1.571	1.6312
Bioavailable Cd		mg/kg	0.00964	0.08386	<0.00300
Bioavailable Cr		mg/kg	<0.0500	<0.0500	<0.0500
Bioavailable Fe		mg/kg	12.52	5.88	9.82
Bioavailable Pb		mg/kg	9.007	0.07154	0.04916
Bioavailable V		mg/kg	<0.0100	0.0754	0.1234
Bioavailable Zn		mg/kg	<0.700	<0.700	<0.700
Bioavailable Hg		mg/kg	<0.000500	<0.000500	<0.000500

Parameter Name	Method Used*	Units	Results		
			431105-4, KBH 4	431105-5, KBH 5	431105-6, KBH 6
Total Organic Carbon (TOC)	SSSA Methods of Soil Analysis Part 3, Chapter 34, 37 modified	%	0.28	0.62	0.49
Bioavailable As	DTPA extraction method, followed by SMEWW 3030 B (modified) and SMEWW 3125 B (modified)	mg/kg	0.00866	0.01856	0.03012
Bioavailable Ba		mg/kg	1.7426	1.723	1.4344
Bioavailable Cd		mg/kg	0.55976	<0.00300	<0.00300
Bioavailable Cr		mg/kg	<0.0500	<0.0500	<0.0500

Laboratory Results Record for Terrestrial Soil Samples for- Bio Available Metals – Kaizen Labs-Trinidad

Your Project #: DSM EIA KILGWYN BAY TOBAGO
Site Location: 2022/OPTIMALGESL/DSM-02
Your C.O.C. #: 08514363

Attention: Ryan Ramsook

Optimal Geosciences and Engineering Solutions
127b South Oropouche
Oropouche, --
Republic of Trinidad and Tobago

Report Date: 2022/10/18
Report #: R3249874
Version: 1 - Final

CERTIFICATE OF ANALYSIS

BUREAU VERITAS JOB #: C278214
Received: 2022/09/27, 14:54

Sample Matrix: Sea Water
Samples Received: 14

Analyses	Quantity	Date Extracted	Date Analyzed	Laboratory Method	Analytical Method
COD by Colorimeter	13	N/A	2022/10/07	BBY6SOP-00024	SM 23 5220 D m
Mercury (Total) by CV	14	2022/10/07	2022/10/07	AB SOP-00084	BCMOE BCLM Oct2013 m
Elements by CRC ICPMS (total) - Seawater	14	N/A	2022/10/11	BBY7SOP-00003 / BBY7SOP-00002	EPA 6020b R2 m
Nitrogen (Total)	8	N/A	2022/10/12	BBY6SOP-00016	SM 23 4500-N C m
PAH in Water by GC/MS (SIM)	13	2022/10/11	2022/10/12	BBY8SOP-00021	BCMOE BCLM Jul2017m
Total LMW, HMW, Total PAH Calc (1)	13	N/A	2022/10/13	BBY WI-00033	Auto Calc
Total Oil and Grease	12	N/A	2022/10/17	BBY8SOP-00004	BCMOE BCLM Nov2015 m
Total Phosphorus	8	2022/10/12	2022/10/12	BBY6SOP-00013	SM 23 4500-P E m

Sample Matrix: Water
Samples Received: 1

Analyses	Quantity	Date Extracted	Date Analyzed	Laboratory Method	Analytical Method
COD by Colorimeter	1	N/A	2022/10/07	BBY6SOP-00024	SM 23 5220 D m
Mercury (Total) by CV	1	2022/10/11	2022/10/11	AB SOP-00084	BCMOE BCLM Oct2013 m
Elements by CRC ICPMS (total)	1	2022/10/08	2022/10/12	BBY7SOP-00003 / BBY7SOP-00002	EPA 6020b R2 m
Nitrogen (Total)	1	N/A	2022/10/14	BBY6SOP-00016	SM 23 4500-N C m
PAH in Water by GC/MS (SIM)	1	2022/10/11	2022/10/12	BBY8SOP-00021	BCMOE BCLM Jul2017m
Total LMW, HMW, Total PAH Calc (1)	1	N/A	2022/10/13	BBY WI-00033	Auto Calc
Total Oil and Grease	1	N/A	2022/10/17	BBY8SOP-00004	BCMOE BCLM Nov2015 m
Total Phosphorus	1	2022/10/12	2022/10/13	BBY6SOP-00013	SM 23 4500-P E m

Remarks:

Bureau Veritas is accredited to ISO/IEC 17025 for specific parameters on scopes of accreditation. Unless otherwise noted, procedures used by Bureau Veritas are based upon recognized Provincial, Federal or US method compendia such as CCME, MELCC, EPA, APHA.

All work recorded herein has been done in accordance with procedures and practices ordinarily exercised by professionals in Bureau Veritas' profession using accepted testing methodologies, quality assurance and quality control procedures (except where otherwise agreed by the client and Bureau Veritas in writing). All data is in statistical control and has met quality control and method performance criteria unless otherwise noted. All method blanks are reported; unless indicated otherwise, associated sample data are not blank corrected. Where applicable, unless otherwise noted, Measurement Uncertainty has not been accounted for when stating conformity to the referenced standard.

Your C.O.C. #: 08514364

Attention: Ryan Ramsook

Optimal Geosciences and Engineering Solutions
127b South Oropouche
Oropouche, --
Republic of Trinidad and Tobago

Report Date: 2022/10/24
Report #: R3252511
Version: 1 - Final

CERTIFICATE OF ANALYSIS

BUREAU VERITAS JOB #: C278224
Received: 2022/09/27, 13:05

Sample Matrix: Sediment
Samples Received: 6

Analyses	Quantity	Date Extracted	Date Analyzed	Laboratory Method	Analytical Method
Elements by ICPMS (total) (1)	6	2022/10/12	2022/10/12	BBY7SOP-00004 / BBY7SOP-00001	EPA 6020b R2 m
Moisture	5	2022/10/11	2022/10/12	BBY8SOP-00017	BCMOE BCLM Dec2000 m
Moisture	1	2022/10/12	2022/10/12	BBY8SOP-00017	BCMOE BCLM Dec2000 m
PAH in Soil by GC/MS (SIM)	1	2022/10/11	2022/10/11	BBY8SOP-00022	BCMOE BCLM Jul2017m
PAH in Soil by GC/MS (SIM)	4	2022/10/11	2022/10/12	BBY8SOP-00022	BCMOE BCLM Jul2017m
PAH in Soil by GC/MS (SIM)	1	2022/10/12	2022/10/12	BBY8SOP-00022	BCMOE BCLM Jul2017m
Total PAH and B(a)P Calculation (2)	6	N/A	2022/10/12	BBY WI-00033	Auto Calc
pH (2:1 DI Water Extract)	6	2022/10/12	2022/10/12	BBY6SOP-00028	BCMOE BCLM Mar2005 m
Total Oil and Grease	6	2022/10/12	2022/10/12	BBY8SOP-00006	BCMOE BCLM Mar 1997

Sample Matrix: Water
Samples Received: 1

Analyses	Quantity	Date Extracted	Date Analyzed	Laboratory Method	Analytical Method
Mercury (Total) by CV	1	2022/10/19	2022/10/19	AB SOP-00084	BCMOE BCLM Oct2013 m
Elements by CRC ICPMS (total)	1	2022/10/12	2022/10/12	BBY7SOP-00003 / BBY7SOP-00002	EPA 6020b R2 m
PAH in Water by GC/MS (SIM)	1	2022/10/12	2022/10/13	BBY8SOP-00021	BCMOE BCLM Jul2017m
Total LMW, HMW, Total PAH Calc (3)	1	N/A	2022/10/14	BBY WI-00033	Auto Calc
pH @25°C (4)	1	N/A	2022/10/12	BBY6SOP-00026	SM 23 4500-H+ B m
Total Oil and Grease	1	N/A	2022/10/17	BBY8SOP-00004	BCMOE BCLM Nov2015 m

Remarks:

Bureau Veritas is accredited to ISO/IEC 17025 for specific parameters on scopes of accreditation. Unless otherwise noted, procedures used by Bureau Veritas are based upon recognized Provincial, Federal or US method compendia such as CCME, MELCC, EPA, APHA.

All work recorded herein has been done in accordance with procedures and practices ordinarily exercised by professionals in Bureau Veritas' profession using accepted testing methodologies, quality assurance and quality control procedures (except where otherwise agreed by the client and Bureau Veritas in writing). All data is in statistical control and has met quality control and method performance criteria unless otherwise noted. All method blanks are reported; unless indicated otherwise, associated sample data are not blank corrected. Where applicable, unless otherwise noted, Measurement Uncertainty has not been accounted for when stating conformity to the referenced standard.

Bureau Veritas liability is limited to the actual cost of the requested analyses, unless otherwise agreed in writing. There is no other warranty expressed or

Your C.O.C. #: 08512615

Attention: Ryan Ramsook

Optimal Geosciences and Engineering Solutions
127b South Oropouche
Oropouche, --
Republic of Trinidad and Tobago

Report Date: 2022/10/18
Report #: R3249867
Version: 1 - Final

CERTIFICATE OF ANALYSIS

BUREAU VERITAS JOB #: C278720
Received: 2022/09/27, 14:54

Sample Matrix: Sea Water
Samples Received: 9

Analyses	Quantity	Date Extracted	Date Analyzed	Laboratory Method	Analytical Method
COD by Colorimeter	9	N/A	2022/10/08	BBY6SOP-00024	SM 23 5220 D m
Mercury (Total) by CV	11	2022/10/12	2022/10/12	AB SOP-00084	BCMOE BCLM Oct2013 m
Elements by CRC ICPMS (total) - Seawater	11	N/A	2022/10/13	BBY7SOP-00003 / BBY7SOP-00002	EPA 6020b R2 m
Nitrogen (Total)	8	N/A	2022/10/12	BBY6SOP-00016	SM 23 4500-N C m
Nitrogen (Total)	1	N/A	2022/10/14	BBY6SOP-00016	SM 23 4500-N C m
PAH in Water by GC/MS (SIM)	10	2022/10/12	2022/10/13	BBY8SOP-00021	BCMOE BCLM Jul2017m
Total LMW, HMW, Total PAH Calc (3)	10	N/A	2022/10/14	BBY WI-00033	Auto Calc
Total Oil and Grease	11	N/A	2022/10/18	BBY8SOP-00004	BCMOE BCLM Nov2015 m
Total Phosphorus	8	2022/10/12	2022/10/12	BBY6SOP-00013	SM 23 4500-P E m
Total Phosphorus	1	2022/10/12	2022/10/13	BBY6SOP-00013	SM 23 4500-P E m

Sample Matrix: Sediment
Samples Received: 6

Analyses	Quantity	Date Extracted	Date Analyzed	Laboratory Method	Analytical Method
Elements by ICPMS (total) (1)	6	2022/10/11	2022/10/11	BBY7SOP-00004 / BBY7SOP-00001	EPA 6020b R2 m
Moisture	6	2022/10/11	2022/10/12	BBY8SOP-00017	BCMOE BCLM Dec2000 m
Index of Additive Cancer Risk Calc.	6	N/A	2022/10/13	BBY WI-00033	Auto Calc
PAH in Soil by GC/MS Lowlevel	4	2022/10/11	2022/10/12	BBY8SOP-00022	BCMOE BCLM Jul2017m
PAH in Soil by GC/MS Lowlevel	2	2022/10/11	2022/10/13	BBY8SOP-00022	BCMOE BCLM Jul2017m
Total PAH and B(a)P Calculation (2)	6	N/A	2022/10/13	BBY WI-00033	Auto Calc
pH (2:1 DI Water Extract)	6	2022/10/11	2022/10/11	BBY6SOP-00028	BCMOE BCLM Mar2005 m
Total Oil and Grease	6	2022/10/12	2022/10/12	BBY8SOP-00006	BCMOE BCLM Mar 1997

Remarks:

Bureau Veritas is accredited to ISO/IEC 17025 for specific parameters on scopes of accreditation. Unless otherwise noted, procedures used by Bureau Veritas are based upon recognized Provincial, Federal or US method compendia such as CCME, MELCC, EPA, APHA.

All work recorded herein has been done in accordance with procedures and practices ordinarily exercised by professionals in Bureau Veritas' profession using accepted testing methodologies, quality assurance and quality control procedures (except where otherwise agreed by the client and Bureau Veritas in writing). All data is in statistical control and has met quality control and method performance criteria unless otherwise noted. All method blanks are reported; unless indicated otherwise, associated sample data are not blank corrected. Where applicable, unless otherwise noted, Measurement

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E1.6 - Survey and Topography Mapping- Raw Data collected

Survey Point no.	Reference Point name	UTM (WGS84)		Decimal Degrees		Elevation	Description
		East	North	Latitude	Longitude	MSL +/-5m	
1	DR1	739132.4	1233658	11.15189	-60.8104	8.051	drain cl.
2	DR2	739135.3	1233670	11.152	-60.8104	8.476	drain cl.
3	DR3	739130	1233652	11.15184	-60.8104	7.927	drain cl.
4	DR4	739150.8	1233272	11.1484	-60.8102	5.334	drain ed.
5	DR5	739156.3	1233276	11.14843	-60.8102	5.331	drain ed.
6	DR6	739150.4	1233265	11.14833	-60.8103	5.214	drain ed.
7	DR7	739155.4	1233262	11.14831	-60.8102	5.28	drain ed.
8	DR8	739155	1233255	11.14825	-60.8102	5.307	drain ed.
9	DR9	739150.1	1233257	11.14826	-60.8103	5.307	drain ed.
10	DR10	739148.2	1233229	11.14801	-60.8103	5.348	drain ed.
11	DR11	739153.3	1233233	11.14805	-60.8102	5.375	drain ed.
12	DR12	739152.8	1233225	11.14798	-60.8102	5.337	drain ed.
13	DR13	739147.7	1233219	11.14792	-60.8103	5.332	drain ed.
14	DR14	739152	1233213	11.14786	-60.8102	5.335	drain ed.
15	DR15	739146.1	1233201	11.14776	-60.8103	5.351	drain ed.
16	DR16	739151	1233201	11.14776	-60.8102	5.297	drain ed.
17	DR17	739150.7	1233190	11.14766	-60.8103	5.15	drain ed.
18	DR18	739145.5	1233191	11.14767	-60.8103	5.308	drain ed.
19	DR19	739150.1	1233177	11.14754	-60.8103	5.317	drain ed.
20	DR20	739143.3	1233169	11.14746	-60.8103	5.531	drain ed.
21	DR21	739149	1233163	11.14741	-60.8103	5.188	drain ed.
22	DR22	739136.5	1232994	11.14589	-60.8104	6.28	drain ed.
23	DR23	739133.2	1232995	11.1459	-60.8104	6.459	drain ed.
24	DR24	739132.2	1233003	11.14597	-60.8104	6.79	drain ed.
25	DR25	739137.1	1233005	11.14598	-60.8104	6.235	drain ed.
26	F1	739157.3	1233007	11.146	-60.8102	6.809	cell tower
27	F2	739151	1233005	11.14599	-60.8103	6.721	cell tower
28	F3	739151	1233012	11.14604	-60.8103	6.861	cell tower
34	R1	738766.8	1233674	11.15205	-60.8137	15.072	road ed.
35	R2	738766.5	1233669	11.15201	-60.8137	14.895	road ed.
36	R3	738765.6	1233667	11.15199	-60.8137	14.706	road ed.
37	R4	738764.4	1233664	11.15197	-60.8138	14.413	road ed.
38	R5	738759.8	1233662	11.15195	-60.8138	14.307	road ed.
39	R6	738758.6	1233640	11.15175	-60.8138	11.291	road ed.
40	R7	738763.6	1233639	11.15174	-60.8138	11.294	road ed.
41	R8	738758.3	1233630	11.15166	-60.8138	10.135	road ed.
42	R9	738763.3	1233630	11.15166	-60.8138	10.203	road ed.

43	R10	738763.3	1233627	11.15163	-60.8138	9.903	road ed.
44	R11	738772.1	1233625	11.15162	-60.8137	10.196	road cl.
45	R12	738778.4	1233625	11.15161	-60.8136	10.298	road cl.
46	R13	738784.7	1233625	11.15161	-60.8136	10.67	road cl.
47	R14	738791.5	1233623	11.1516	-60.8135	10.732	road cl.
48	R15	738799.2	1233621	11.15158	-60.8134	10.432	road cl.
49	R16	738763.2	1233624	11.15161	-60.8138	9.635	road cl.
50	R17	738758.1	1233625	11.15161	-60.8138	9.692	road cl.
51	R18	738756.6	1233596	11.15136	-60.8138	7.417	road ed.
52	R19	738762.3	1233597	11.15136	-60.8138	7.585	road ed.
53	R20	738756.3	1233574	11.15116	-60.8138	6.49	road ed.
54	R21	738760.7	1233574	11.15115	-60.8138	6.653	road ed.
55	R22	738755.1	1233524	11.1507	-60.8139	6.127	road ed.
56	R23	738758.2	1233524	11.1507	-60.8138	6.07	road ed.
57	R24	738751.1	1233458	11.1501	-60.8139	5.995	road ed.
58	R25	738749.8	1233458	11.15011	-60.8139	5.933	road ed.
59	R26	738754.4	1233458	11.1501	-60.8139	6.012	road ed.
60	R27	738754.6	1233457	11.1501	-60.8139	6.009	road ed.
61	R28	738749.2	1233432	11.14987	-60.8139	5.833	road ed.
62	R29	738752.6	1233432	11.14987	-60.8139	5.824	road ed.
63	R30	738751.2	1233433	11.14988	-60.8139	5.852	road cl.
64	R31	738748	1233402	11.1496	-60.8139	5.816	road cl.
65	R32	738746	1233369	11.14931	-60.8139	5.755	road cl.
66	R33	738742.2	1233347	11.1491	-60.814	5.712	road cl.
67	R34	738737.1	1233325	11.14891	-60.814	5.658	road cl.
68	R35	738732.1	1233306	11.14874	-60.8141	5.621	road cl.
69	R36	738727.1	1233275	11.14845	-60.8141	5.742	road cl.
70	R37	738719.3	1233239	11.14813	-60.8142	5.634	road cl.
71	R38	738716.4	1233224	11.148	-60.8142	5.625	road cl.
72	R39	738809.4	1233619	11.15156	-60.8133	10.103	road cl.
73	R40	738820.5	1233619	11.15156	-60.8132	10.192	road cl.
74	R41	738836.4	1233620	11.15157	-60.8131	10.459	road cl.
75	R42	738852.4	1233622	11.15158	-60.813	11.085	road cl.
76	R43	738886.3	1233618	11.15155	-60.8126	11.989	road cl.
77	R44	738908.5	1233615	11.15152	-60.8124	12.216	road cl.
78	R45	738918.2	1233614	11.1515	-60.8124	12.295	road cl.
79	R46	738946.4	1233607	11.15144	-60.8121	13.349	road cl.
80	R47	738982.2	1233598	11.15136	-60.8118	14.477	road cl.
81	R48	738981.5	1233605	11.15142	-60.8118	14.855	road cl.
82	R49	738975.4	1233616	11.15152	-60.8118	15.176	road cl.
83	R50	738967.3	1233626	11.15161	-60.8119	15.17	road cl.

84	R51	739168.9	1233552	11.15093	-60.8101	15.803	road cl.
85	R52	739163.3	1233558	11.15098	-60.8101	15.699	road cl.
86	R53	739158.1	1233562	11.15102	-60.8102	15.651	road cl.
87	R54	739153.9	1233564	11.15104	-60.8102	15.558	road cl.
88	R55	739143.1	1233566	11.15106	-60.8103	15.161	road cl.
89	R56	739131	1232998	11.14593	-60.8104	6.443	road cl.
90	R57	739112.7	1233006	11.146	-60.8106	6.396	road cl.
91	R58	739105.4	1233013	11.14606	-60.8107	6.019	road cl.
92	R59	739101.5	1233014	11.14607	-60.8107	5.842	road cl.
93	R60	739078.9	1233020	11.14613	-60.8109	6.148	road cl.
94	R61	739044.6	1233036	11.14627	-60.8112	6.134	road cl.
95	R62	739064.8	1233028	11.1462	-60.8111	6.07	road cl.
96	R63	739036.4	1233043	11.14634	-60.8113	6.184	road cl.
97	R64	739031.8	1233045	11.14635	-60.8114	6.189	road cl.
98	R65	739020.9	1233045	11.14636	-60.8115	6.174	road cl.
99	R66	739016.1	1233047	11.14637	-60.8115	6.085	road cl.
100	R67	739007.7	1233057	11.14647	-60.8116	5.954	road cl.
101	R68	738995.8	1233070	11.14658	-60.8117	5.754	road cl.
102	R69	738988.9	1233077	11.14664	-60.8117	5.719	road cl.
103	R70	738980.5	1233088	11.14675	-60.8118	5.739	road cl.
104	R71	738976.9	1233093	11.14679	-60.8119	5.682	road cl.
105	R72	738971.3	1233097	11.14683	-60.8119	5.635	road cl.
106	R73	738944.3	1233110	11.14695	-60.8121	5.585	road cl.
107	R74	738940.6	1233113	11.14697	-60.8122	5.631	road cl.
108	R75	738936.2	1233117	11.14702	-60.8122	5.699	road cl.
109	R76	738927.8	1233128	11.14712	-60.8123	5.782	road cl.
110	R77	738923.2	1233136	11.14718	-60.8123	5.785	road cl.
111	R78	738919.1	1233144	11.14726	-60.8124	5.812	road cl.
112	R79	738916.3	1233149	11.14731	-60.8124	5.784	road cl.
113	R80	738912.4	1233154	11.14735	-60.8124	5.843	road cl.
114	R81	738907.5	1233157	11.14738	-60.8125	5.77	road cl.
115	R82	738899	1233161	11.14741	-60.8126	5.803	road cl.
116	R83	738862.2	1233173	11.14752	-60.8129	5.811	road cl.
117	R84	738855.7	1233174	11.14753	-60.813	5.926	road cl.
118	R85	738814.7	1233178	11.14757	-60.8133	5.86	road cl.
119	R86	738809.5	1233179	11.14758	-60.8134	5.969	road cl.
120	R87	738786.1	1233190	11.14769	-60.8136	5.922	road cl.
121	R88	738777.6	1233193	11.14771	-60.8137	5.876	road cl.
122	R89	738758.1	1233198	11.14776	-60.8138	5.795	road cl.
123	R90	738746.4	1233202	11.14779	-60.814	5.813	road cl.
124	R91	738736.6	1233207	11.14784	-60.814	5.788	road cl.

125	R92	738728.7	1233213	11.14789	-60.8141	5.816	road cl.
126	R93	738731.3	1233211	11.14788	-60.8141	5.858	road cl.
127	R94	738725.8	1233216	11.14792	-60.8141	5.723	road cl.
128	R95	738719.8	1233224	11.14799	-60.8142	5.651	road cl.
129	R96	738728.7	1233218	11.14794	-60.8141	5.677	road ed.
130	R97	738726.1	1233221	11.14797	-60.8141	5.652	road ed.
131	R98	738724.3	1233225	11.148	-60.8142	5.648	road ed.
132	R99	738723.5	1233230	11.14805	-60.8142	5.655	road ed.
133	R100	738724.3	1233235	11.1481	-60.8142	5.677	road ed.
134	R101	738725.9	1233241	11.14815	-60.8141	5.653	road ed.
135	R102	738717.3	1233244	11.14817	-60.8142	5.619	road ed.
136	R103	738714.4	1233236	11.14811	-60.8142	5.607	road ed.
137	R104	738713.1	1233234	11.14809	-60.8143	5.556	road ed.
138	R105	738710.4	1233232	11.14807	-60.8143	5.555	road ed.
139	R106	738705.3	1233231	11.14805	-60.8143	5.612	road ed.
140	R107	738694.7	1233226	11.14802	-60.8144	5.603	road ed.
141	R108	738695.9	1233224	11.148	-60.8144	5.643	road ed.
142	R109	738705.4	1233227	11.14803	-60.8143	5.627	road ed.
143	R110	738708.3	1233227	11.14802	-60.8143	5.592	road ed.
144	R111	738712.2	1233224	11.14799	-60.8143	5.641	road ed.
145	R112	738713.1	1233222	11.14798	-60.8143	5.672	road ed.
146	R113	738717.1	1233216	11.14793	-60.8142	5.801	road ed.
147	R114	738722	1233213	11.14789	-60.8142	5.795	road ed.
148	R115	738956.7	1233632	11.15166	-60.812	15.179	road cl.
149	R116	738945.8	1233637	11.15171	-60.8121	15.212	road cl.
150	R117	738936	1233641	11.15175	-60.8122	15.292	road cl.
151	R118	739007.1	1233594	11.15132	-60.8115	13.83	road cl.
152	R119	739027.5	1233588	11.15127	-60.8114	12.096	road cl.
153	R120	739041.9	1233583	11.15122	-60.8112	11.103	road cl.
154	R121	739059.8	1233578	11.15117	-60.8111	10.366	road cl.
155	R122	739077	1233571	11.15111	-60.8109	10.794	road cl.
156	R123	739086.2	1233568	11.15108	-60.8108	11.434	road cl.
157	R124	739095.8	1233566	11.15106	-60.8107	12.038	road cl.
158	R125	739106	1233565	11.15105	-60.8106	12.768	road cl.
159	S	738764	1233625	11.15162	-60.8138	9.75	Nl.pt.
160	S1	738808.8	1233617	11.15154	-60.8134	10.083	peg put
161	S2	738749.3	1233401	11.1496	-60.8139	5.741	Nl.pt.
162	S3	738714.2	1233206	11.14783	-60.8142	6.729	peg put
163	S4	738867.7	1233622	11.15158	-60.8128	11.533	peg put
164	S5	738986.1	1233599	11.15137	-60.8117	14.737	peg put
165	S5A	738984.8	1233599	11.15136	-60.8117	14.885	peg fd.

166	S6	738840.5	1233590	11.1513	-60.8131	5.512	peg put
167	S7	739098	1233564	11.15104	-60.8107	12.241	peg put
168	S8	739155.8	1233566	11.15106	-60.8102	15.662	peg put
169	S9	739203.4	1233518	11.15062	-60.8097	13.321	peg put
170	S10	739157.9	1233448	11.14999	-60.8102	3.452	peg put
171	S10A	739157.8	1233448	11.14999	-60.8102	5.787	peg fd.
172	S11	739160.4	1233425	11.14978	-60.8101	3.496	peg put
173	S12	739160.2	1233603	11.15139	-60.8101	14.242	peg put
174	S13	739166.5	1233648	11.1518	-60.8101	15.706	peg put
175	S14	739145.9	1233506	11.15051	-60.8103	9.182	peg put
176	S15	739163.4	1233421	11.14975	-60.8101	5.408	peg put
177	S16	739155.2	1233399	11.14955	-60.8102	6.056	peg put
178	S17	739154.8	1233359	11.14918	-60.8102	5.807	peg put
179	S18	739155.5	1233335	11.14897	-60.8102	5.269	peg put
180	S19	739152.2	1233316	11.1488	-60.8102	5.854	peg put
181	S20	739148.5	1233299	11.14864	-60.8103	5.885	peg put
182	S21	739148.4	1233267	11.14835	-60.8103	5.698	peg put
183	S22	739145.5	1233231	11.14803	-60.8103	5.748	peg put
184	S23	739145.2	1233196	11.14772	-60.8103	5.416	peg put
185	S24	739140.2	1233165	11.14743	-60.8104	5.888	peg put
186	S25	739129.1	1233084	11.1467	-60.8105	6.226	peg put
187	S26	739122.6	1233048	11.14637	-60.8105	5.855	peg put
188	S27	739130.6	1233036	11.14627	-60.8104	5.851	peg put
189	S28	739130.5	1233012	11.14605	-60.8105	6.791	peg put
190	S29	739126	1233002	11.14596	-60.8105	6.387	peg put
191	S30	739033.9	1233042	11.14633	-60.8113	6.278	peg put
192	S31	739010.9	1233051	11.14641	-60.8115	6.112	Nl.pt.
193	S32	738974.1	1233093	11.1468	-60.8119	5.805	peg put
194	S33	738935.7	1233116	11.14701	-60.8122	5.705	Nl.pt.
195	S34	738909.8	1233157	11.14738	-60.8125	5.825	Nl.pt.
196	S35	738854	1233176	11.14755	-60.813	5.895	peg put
197	S36	738755.7	1233182	11.14761	-60.8139	6.199	peg put
198	S37	738712.7	1233214	11.1479	-60.8143	6.008	Ir.fd.
199	S38	738941.3	1233139	11.14721	-60.8122	5.968	peg put
200	S39	738743.6	1233144	11.14727	-60.814	5.677	peg put
201	S39A	738740.4	1233146	11.14729	-60.814	5.626	peg put
202	S40	738893.8	1233083	11.14671	-60.8126	5.704	peg put
203	S41	739081.2	1232995	11.1459	-60.8109	5.117	peg put
204	S42	738936.9	1233158	11.14738	-60.8122	5.292	peg put
205	S43	738941.5	1233183	11.14761	-60.8122	5.523	peg put
206	S44	738943.8	1233204	11.1478	-60.8121	5.644	peg put

207	S45	738942.1	1233223	11.14797	-60.8122	5.499	peg put
208	S46	738950.2	1233297	11.14864	-60.8121	5.689	peg put
209	S47	738955.6	1233341	11.14903	-60.812	5.444	peg put
210	S48	738960.1	1233371	11.14931	-60.812	5.382	peg put
211	S49	738964.8	1233405	11.14961	-60.8119	5.463	peg put
212	S50	738966.8	1233422	11.14977	-60.8119	5.477	peg put
213	S51	738974.5	1233452	11.15004	-60.8118	5.374	peg put
214	S52	738979.2	1233519	11.15064	-60.8118	5.528	peg put
215	S53	738985.9	1233549	11.15091	-60.8117	6.676	peg put
216	S54	738985.6	1233577	11.15116	-60.8117	13.675	peg put
217	S55	738967.2	1233627	11.15162	-60.8119	15.213	peg put
218	SG1	739153.8	1233326	11.14889	-60.8102	5.187	sluice gate
219	SG2	739147.3	1233326	11.14889	-60.8103	5.147	sluice gate
220	SG3	739147.7	1233331	11.14893	-60.8103	5.497	sluice gate
221	SH1	738828.7	1233621	11.15157	-60.8132	10.353	spot ht
222	SH2	738830.3	1233615	11.15152	-60.8132	10.202	spot ht
223	SH3	738831.8	1233612	11.15149	-60.8131	9.346	spot ht
224	SH4	738833.5	1233608	11.15145	-60.8131	8.096	spot ht
225	SH5	738837.2	1233599	11.15138	-60.8131	6.786	spot ht
226	SH6	738838.9	1233595	11.15134	-60.8131	5.798	spot ht
227	SH7	738843.1	1233581	11.15121	-60.813	5.024	spot ht
228	SH8	738846.2	1233570	11.15111	-60.813	4.521	spot ht
229	SH9	738846.6	1233567	11.15108	-60.813	4.774	spot ht
230	SH10	738847.3	1233562	11.15104	-60.813	4.547	spot ht
231	SH11	738848.9	1233555	11.15098	-60.813	4.321	spot ht
232	SH12	738851.2	1233546	11.1509	-60.813	4.483	spot ht
233	SH13	738852.1	1233539	11.15084	-60.813	4.681	spot ht
234	SH14	738853.1	1233535	11.1508	-60.813	4.681	spot ht
235	SH15	739155.2	1233600	11.15136	-60.8102	13.788	spot ht
236	SH16	739152.3	1233589	11.15127	-60.8102	15.14	spot ht
237	SH17	739152.4	1233579	11.15118	-60.8102	15.55	spot ht
238	SH18	739153.4	1233543	11.15085	-60.8102	15.211	spot ht
239	SH19	739152.6	1233537	11.15079	-60.8102	13.907	spot ht
240	SH20	739145.8	1233511	11.15056	-60.8103	7.328	spot ht
241	SH21	739146.6	1233503	11.15048	-60.8103	6.305	spot ht
242	SH22	739148	1233496	11.15042	-60.8103	4.878	spot ht
243	SH23	739149.4	1233489	11.15036	-60.8102	3.642	spot ht
244	SH24	739151.3	1233480	11.15027	-60.8102	3.822	spot ht
245	SH25	739153.1	1233472	11.15021	-60.8102	3.685	spot ht
246	SH26	739154.1	1233466	11.15015	-60.8102	3.135	spot ht
247	SH27	739156.2	1233453	11.15003	-60.8102	3.022	spot ht

248	SH28	739160.1	1233430	11.14983	-60.8102	5.264	spot ht
249	SH29	739160.4	1233425	11.14978	-60.8101	3.443	spot ht
250	SH30	739156.7	1233426	11.14979	-60.8102	3.663	spot ht
251	SH31	739157.1	1233415	11.14969	-60.8102	3.642	spot ht
252	SH32	739155.6	1233409	11.14964	-60.8102	3.654	spot ht
253	SH33	739154.4	1233404	11.14959	-60.8102	3.497	spot ht
254	SH34	739153.9	1233391	11.14948	-60.8102	3.533	spot ht
255	SH35	739154.4	1233628	11.15162	-60.8102	14.951	spot ht
256	SH36	739148.6	1233651	11.15182	-60.8102	11.618	spot ht
257	SH37	739158.9	1233650	11.15181	-60.8101	14.321	spot ht
258	SH38	739147.6	1233523	11.15067	-60.8103	11.878	
259	SH39	739150.6	1233311	11.14875	-60.8102	5.845	spot ht
260	SH40	739149.7	1233288	11.14854	-60.8103	5.749	spot ht
261	SH41	739136.6	1233136	11.14717	-60.8104	6.244	spot ht
262	SH42	738938.4	1233075	11.14664	-60.8122	6.579	spot ht
263	SH43	738936.7	1233072	11.14661	-60.8122	6.712	HWM
264	SH44	738934.3	1233066	11.14655	-60.8122	5.387	HWM
265	SH45	738931.1	1233056	11.14647	-60.8123	4.399	spot ht
266	SH46	738869.4	1233103	11.14689	-60.8128	6.738	spot ht
267	SH47	738868.2	1233099	11.14685	-60.8128	6.73	HWM
268	SH48	738866.6	1233093	11.1468	-60.8129	5.718	HWM
269	SH49	738927.3	1233024	11.14618	-60.8123	3.814	spot ht
270	SH50	738862.7	1233082	11.1467	-60.8129	4.323	spot ht
271	SH51	738927.9	1232991	11.14588	-60.8123	3.78	spot ht
272	SH52	738858	1233064	11.14654	-60.8129	3.969	spot ht
273	SH53	738853.6	1233047	11.14638	-60.813	3.98	spot ht
274	SH54	738929.9	1232971	11.1457	-60.8123	3.908	spot ht
275	SH55	738846.4	1233026	11.1462	-60.813	3.867	spot ht
276	SH56	738834.3	1233008	11.14604	-60.8132	3.913	spot ht
277	SH57	739134.7	1232988	11.14584	-60.8104	6.131	HWM
278	SH58	739133.5	1232982	11.14578	-60.8104	5.775	spot ht
279	SH59	739132.4	1232961	11.14559	-60.8104	4.407	spot ht
280	SH60	739038.8	1233029	11.14621	-60.8113	6.668	spot ht
281	SH61	739131.5	1232953	11.14551	-60.8104	4.306	spot ht
282	SH62	739038.2	1233027	11.14619	-60.8113	6.496	HWM
283	SH63	739130.1	1232942	11.14542	-60.8105	4.362	spot ht
284	SH64	739031.9	1233012	11.14605	-60.8114	4.346	spot ht
285	SH65	739130.4	1232934	11.14534	-60.8105	4.254	spot ht
286	SH66	739130.7	1232932	11.14532	-60.8105	3.975	spot ht
287	SH67	739029.7	1233004	11.14599	-60.8114	4.113	spot ht
288	SH68	739129.6	1232914	11.14516	-60.8105	3.965	spot ht

289	SH69	739129.9	1232910	11.14513	-60.8105	4.075	spot ht
290	SH70	739019.7	1232973	11.14571	-60.8115	3.923	spot ht
291	SH71	739128.3	1232878	11.14484	-60.8105	3.921	spot ht
292	SH72	739128.5	1232872	11.14478	-60.8105	4.091	spot ht
293	SH73	739128.1	1232837	11.14447	-60.8105	3.911	spot ht
294	SH74	738999.9	1232933	11.14534	-60.8117	3.983	spot ht
295	SH75	739128.7	1232814	11.14426	-60.8105	3.811	spot ht
296	SH76	738995.3	1232923	11.14525	-60.8117	3.914	spot ht
297	SH77	738989.3	1232909	11.14513	-60.8117	3.645	spot ht
298	SH78	738937.5	1233161	11.14741	-60.8122	6.346	spot ht
299	SH79	738939.9	1233173	11.14752	-60.8122	6.15	spot ht
300	SH80	738952.1	1233313	11.14878	-60.8121	5.347	spot ht
301	SH81	738976.5	1233539	11.15082	-60.8118	5.901	spot ht
302	SH82	738979.9	1233547	11.1509	-60.8118	6.072	spot ht
303	SH83	738982.2	1233551	11.15094	-60.8118	6.521	spot ht
304	SH84	738981.9	1233558	11.151	-60.8118	8.624	spot ht
305	SH85	738984.5	1233559	11.151	-60.8117	8.104	spot ht
306	SH86	738983.2	1233570	11.15111	-60.8118	10.5	spot ht
307	SH87	738983.7	1233574	11.15114	-60.8118	11.29	spot ht
308	SH88	738985.6	1233577	11.15116	-60.8117	13.574	spot ht
309	SH89	738966.9	1233661	11.15193	-60.8119	15.051	spot ht
310	SH90	738971.8	1233629	11.15164	-60.8119	15.184	spot ht
311	SH91	738708.8	1233192	11.1477	-60.8143	6.495	spot ht
312	SH92	738703.3	1233178	11.14758	-60.8143	6.938	HWM
313	SH93	738701.3	1233172	11.14752	-60.8144	6.144	spot ht
314	SH94	738700.5	1233169	11.1475	-60.8144	5.388	spot ht
315	SH95	738697.4	1233163	11.14744	-60.8144	4.526	spot ht
316	SH96	738696.9	1233161	11.14743	-60.8144	4.176	spot ht
317	SH97	738784.1	1233140	11.14723	-60.8136	6.457	spot ht
318	SH98	738779.1	1233133	11.14717	-60.8137	6.553	HWM
319	SH99	738695.6	1233157	11.14739	-60.8144	4.061	spot ht
320	SH100	738776.7	1233129	11.14714	-60.8137	6.084	spot ht
321	SH101	738692.6	1233140	11.14724	-60.8144	3.582	spot ht
322	SH102	738769.6	1233118	11.14703	-60.8137	4.484	spot ht
323	SH103	738763.5	1233102	11.14689	-60.8138	3.897	spot ht
324	SH104	738690.5	1233114	11.147	-60.8145	3.755	spot ht
325	SH105	738754.2	1233086	11.14674	-60.8139	3.799	spot ht
326	SH106	738752.1	1233082	11.14671	-60.8139	4.021	spot ht
327	SH107	738690.5	1233097	11.14685	-60.8145	3.654	spot ht
328	SH108	738748.2	1233066	11.14657	-60.8139	3.877	spot ht
329	SH109	738737.4	1233046	11.14638	-60.814	3.933	spot ht

330	SH110	738688.2	1233069	11.14659	-60.8145	3.697	spot ht
331	SH111	738732	1233036	11.1463	-60.8141	3.892	spot ht
332	SH112	738688.3	1233047	11.1464	-60.8145	3.628	spot ht

Survey Mapping- Raw Data collected by Registered Surveyor

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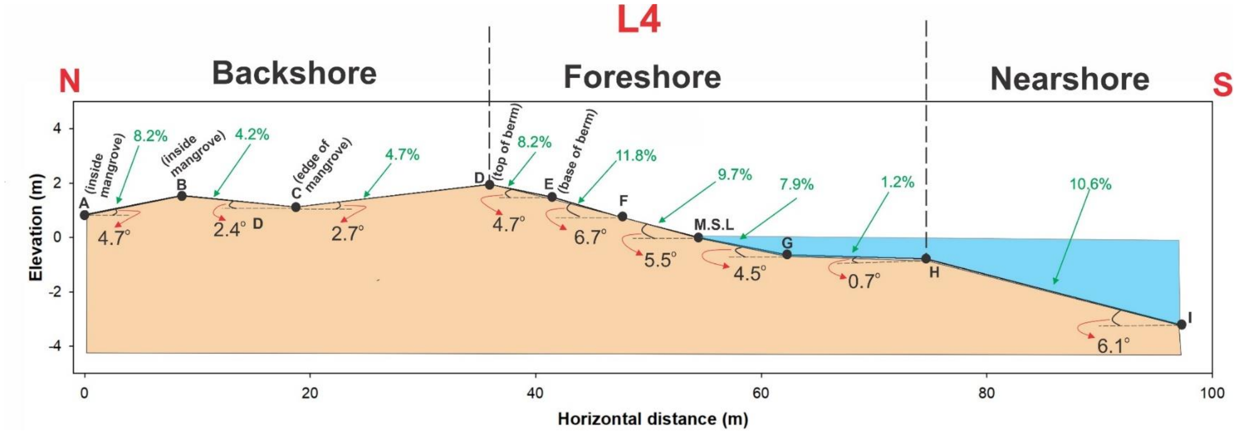
E2 – Beach/Shoreline Morphology

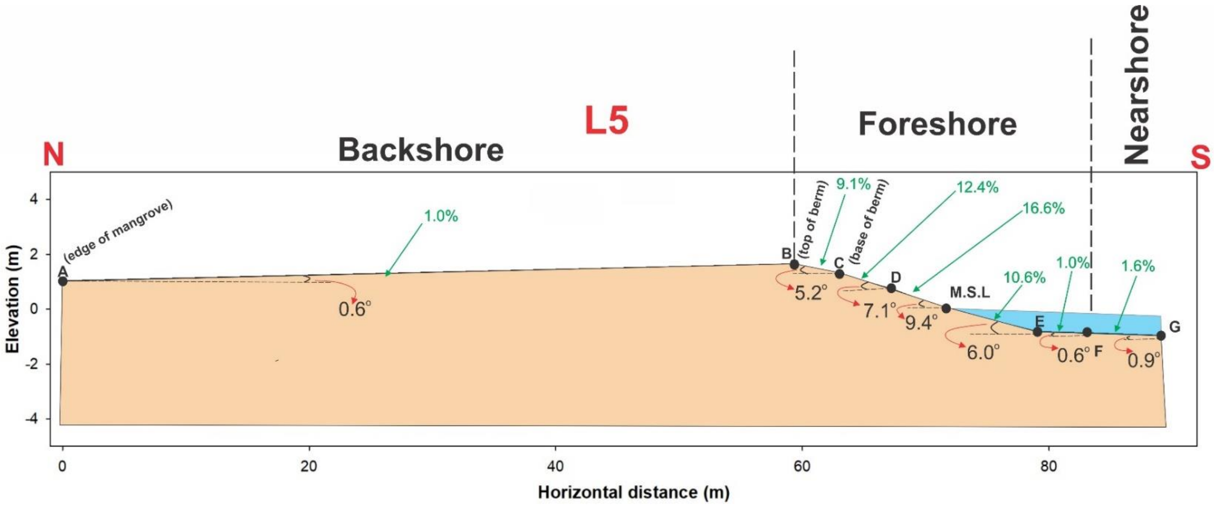
E2.1 - Dry Season – Coastline Profiles



Beach profile at location L4.

Point	Horizontal distance between points (m)	Relative height from each point (m)	Slope - rise/run (%)	Slope angle (°)
A				
	8.6	0.7	8.2	4.7
B				
	10.2	0.4	4.2	2.4
C				
	17.9	0.8	4.7	2.7
D				
	5.7	0.5	8.2	4.7
E				
	6.4	0.7	11.8	6.7
F				
	7.6	0.7	9.7	5.5
BM				
	8.1	0.6	7.9	4.5
G				
	12.6	0.1	1.2	0.7
H				
	22.9	2.4	10.6	6.1
I				

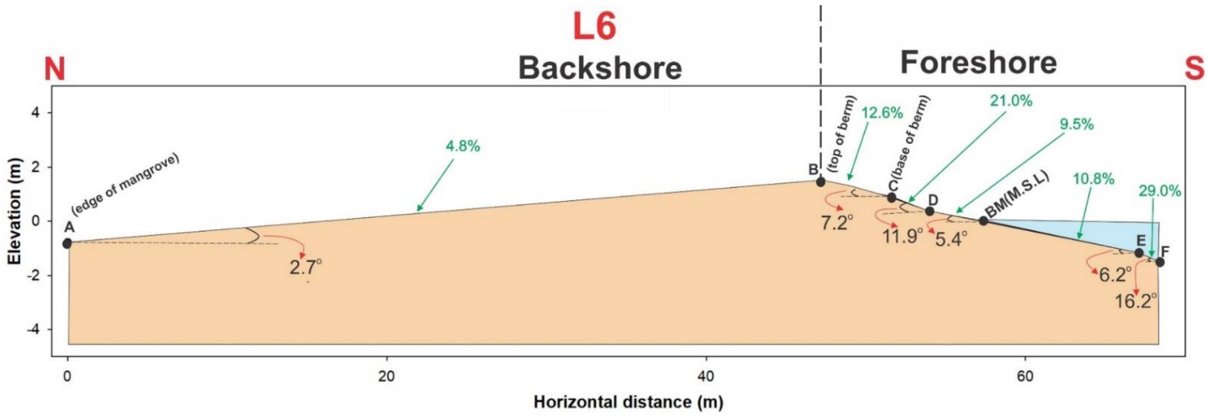
Distance, height, and slope at location L4.



Beach profile at location L5.

Point	Horizontal distance between points (m)	Relative height from each point (m)	Slope - rise/run (%)	Slope angle (°)
A				
	59.3	0.6	1.0	0.6
B				
	4.3	0.4	9.1	5.2
C				
	4.2	0.5	12.4	7.1
D				
	4.5	0.7	16.6	9.4
BM				
	7.8	0.8	10.6	6.0
E				
	4.1	0.0	1.0	0.6
F				
	6.1	0.1	1.6	0.9
G				

Distance, height, and slope at location L5.



Beach profile at location L6.

Point	Horizontal distance between points (m)	Relative height from each point (m)	Slope - rise/run (%)	Slope angle (°)
A				
	47.2	2.3	4.8	2.7
B				
	4.5	0.6	12.6	7.2
C				
	2.6	0.5	21.0	11.9
D				
	3.8	0.4	9.5	5.4
BM				
	10.7	1.2	10.8	6.2
E				
	1.3	0.4	29.0	16.2
F				

Distance, height, and slope at location L6.

Point	BS (m)	HI (m)	FS (m)	Elevation (m)	Notes
BM	0.690	9.203		8.513	At edge of dirt road
A			2.860	6.343	
B			3.760	5.443	
C			4.775	4.428	
D			5.505	3.698	Edge of swamp
BM	0.692			8.511	

Back sight (BI), fore sight (FS), and elevation at location L1.

Point	BS (m)	HI (m)	FS (m)	Elevation (m)	Notes
BM-1	0.200	10.200		10.000	At Fence - upper terrace
A			3.527	6.673	
B			4.175	6.025	
C			4.988	5.212	
D			7.295	2.905	
BM-1	0.198		7.295	10.002	At Fence - upper terrace
BM-2	1.375	9.375		8.000	At dirt road
E			6.815	2.560	
BM-2	1.375			8.000	At dirt road

Back sight (BI), fore sight (FS), and elevation at location L2.

Point	**BS (m)**	**HI (m)**	**FS (m)**	**Elevation (m)**	**Notes**
BM	3.790	3.790		0.000	MSL
A			1.767	2.023	In land
B			1.444	2.346	Top of berm
C			1.92	1.870	Base of berm
D			2.478	1.312	Between base of berm and water line
E			4.17	-0.380	Inside water
F			4.2	-0.410	Inside water
G			4.32	-0.530	Inside water
BM	3.78			0.010	MSL

Back sight (BI), fore sight (FS), and elevation at location L3.

Point	BS (m)	HI (m)	FS (m)	Elevation (m)	Notes
BM	3.245	3.245		0.000	MSL
C			2.13	1.115	Edge of mangrove
D			1.291	1.954	Top of berm
E			1.761	1.484	Base of berm
F			2.51	0.735	Between base of berm and water line
G			3.882	-0.637	Inside water
H			4.03	-0.785	Inside water
I			6.47	-3.225	Inside water
BM	3.239			0.006	MSL
B			1.7	1.545	Inside Mangrove
A			2.405	0.840	Inside Mangrove

Back sight (BI), fore sight (FS), and elevation at location L4.

Point	BS (m)	HI (m)	FS (m)	Elevation (m)	Notes
BM	3.08	3.08		0.000	MSL
B			1.43	1.650	Top of berm
C			1.82	1.260	Base of berm
D			2.34	0.740	Between base of berm and water line
E			3.9	-0.820	Inside water
F			3.94	-0.860	Inside water
G			4.035	-0.955	Inside water
BM	3.071			0.009	MSL
A			2.05	1.030	Inside Mangrove

Back sight (BI), fore sight (FS), and elevation at location L5.

Point	BS (m)	HI (m)	FS (m)	Elevation (m)	Notes
BM	2.768	2.768		0.000	MSL
B			1.303	1.465	Top of berm
C			1.87	0.898	Base of berm
D			2.41	0.358	Between base of berm and water line
E			3.925	-1.157	Inside water
F			4.298	-1.530	Inside water
BM	2.764			0.004	MSL
A			3.558	-0.790	Inside Mangrove

Back sight (BI), fore sight (FS), and elevation at location L6.

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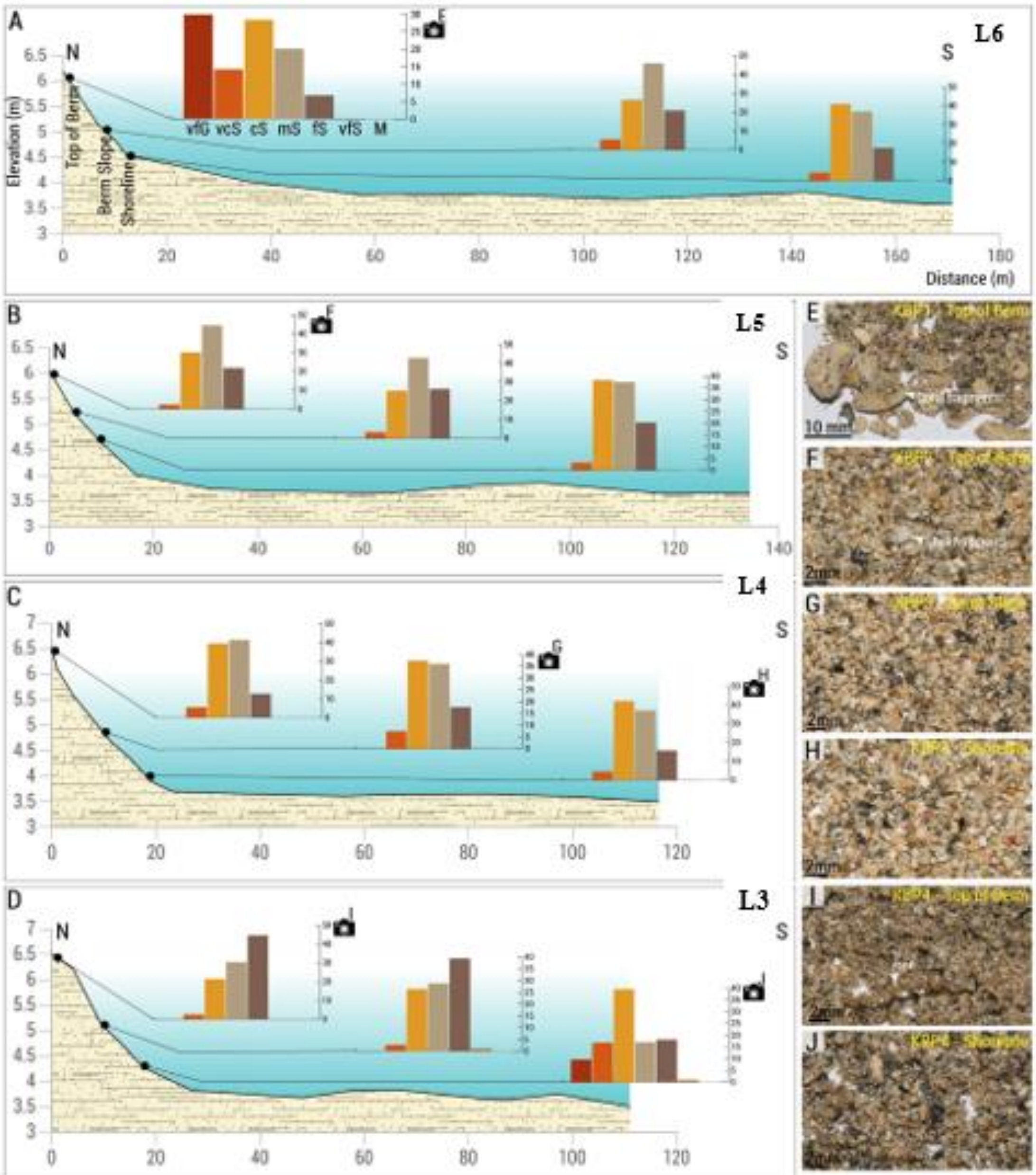
E2.2 - Wet Season - Coastline Profiles



E2.3 - Grainsize Analysis

Sample		Distribution Statistics (Logarithmic - Folk&Ward)							
		Mean ($\bar{x}$)		Sorting (σ)		Skewness (Sk)		Kurtosis (K)	
Name	**Description**	**ϕ**	**Description**	**ϕ**	**Description**	**ϕ**	**Description**	**ϕ**	**Description**
KBP1	Top of berm (wet season)	0.390	Coarse Sand	1.374	Poorly Sorted	-0.096	Symmetrical	0.635	Very Platykurtic
KBP1	Berm slope (wet season)	1.673	Medium Sand	0.929	Moderately Sorted	-0.104	Coarse Skewed	1.096	Mesokurtic
KBP1	Shoreline (wet season)	1.576	Medium Sand	0.831	Moderately Sorted	0.065	Symmetrical	0.839	Platykurtic
KBP2	Top of berm (wet season)	1.986	Medium Sand	0.841	Moderately Sorted	0.009	Symmetrical	0.881	Platykurtic
KBP2	Berm slope (wet season)	1.743	Medium Sand	0.862	Moderately Sorted	-0.008	Symmetrical	0.613	Very Platykurtic
KBP2	Shoreline (wet season)	1.629	Medium Sand	0.847	Moderately Sorted	0.054	Symmetrical	0.835	Platykurtic
KBP3	Top of berm (wet season)	1.388	Medium Sand	0.773	Moderately Sorted	-0.242	Coarse Skewed	1.055	Mesokurtic
KBP3	Berm slope (wet season)	1.583	Medium Sand	0.953	Moderately Sorted	-0.053	Symmetrical	1.056	Mesokurtic
KBP3	Shoreline (wet season)	1.554	Medium Sand	0.821	Moderately Sorted	0.068	Symmetrical	0.845	Platykurtic
KBP4	Top of berm (wet season)	1.857	Medium Sand	0.867	Moderately Sorted	-0.127	Coarse Skewed	0.816	Platykurtic
KBP4	Berm slope (wet season)	1.810	Medium Sand	0.887	Moderately Sorted	-0.080	Symmetrical	0.56	Very Platykurtic
KBP4	Shoreline (wet season)	1.065	Medium Sand	1.313	Poorly Sorted	0.138	Fine Skewed	1.24	Leptokurtic

Sample		Grainsize Distribution (%)							Description	
		Gravel	**Sand**					**Mud**		
Name	Description	vfG	vcS	cS	mS	fS	vfS	M		
KBP1	Top of berm (wet season)	29.8	14.2	28.3	20.0	6.7	0.0	0.2	Polymodal, Poorly sorted	Very fine gravelly coarse sand
KBP1	Berm slope (wet season)	0.0	5.4	26.5	45.9	20.9	0.1	0.2	Trimodal, Moderately sorted	Moderately sorted medium sand
KBP1	Shoreline (wet season)	0.0	4.4	40.8	36.9	17.5	0.0	0.1	Trimodal, Moderately sorted	Moderately sorted coarse sand
KBP2	Top of berm (wet season)	0.0	2.4	30.1	44.3	21.8	0.0	0.2	Trimodal, Moderately sorted	Moderately sorted medium sand
KBP2	Berm slope (wet season)	0.0	3.3	25.2	42.7	26.2	0.2	0.4	Trimodal, Moderately sorted	Moderately sorted medium sand
KBP2	Shoreline (wet season)	0.0	3.2	38.2	37.4	20.3	0.1	0.2	Trimodal, Moderately sorted	Moderately sorted coarse sand
KBP3	Top of berm (wet season)	0.0	5.4	39.4	41.2	12.7	0.1	0.2	Trimodal, Moderately sorted	Moderately sorted medium sand
KBP3	Berm slope (wet season)	0.0	7.4	37.4	36.0	17.6	0.1	0.3	Polymodal, Moderately sorted	Moderately sorted coarse sand
KBP3	Shoreline (wet season)	0.0	4.6	41.9	37.0	15.8	0.1	0.1	Trimodal, Moderately sorted	Moderately sorted coarse sand
KBP4	Top of berm (wet season)	0.0	2.5	21.4	30.3	44.5	0.1	0.2	Trimodal, Moderately sorted	Moderately sorted fine sand
KBP4	Berm slope (wet season)	0.0	2.7	26.4	28.8	39.3	1.1	0.3	Trimodal, Moderately sorted	Moderately sorted fine sand
KBP4	Shoreline (wet season)	9.6	16.8	39.5	17.0	18.1	1.0	0.1	Polymodal, Poorly sorted	Very fine gravelly coarse sand

Dry Season Field Sampling and Laboratory Analysis

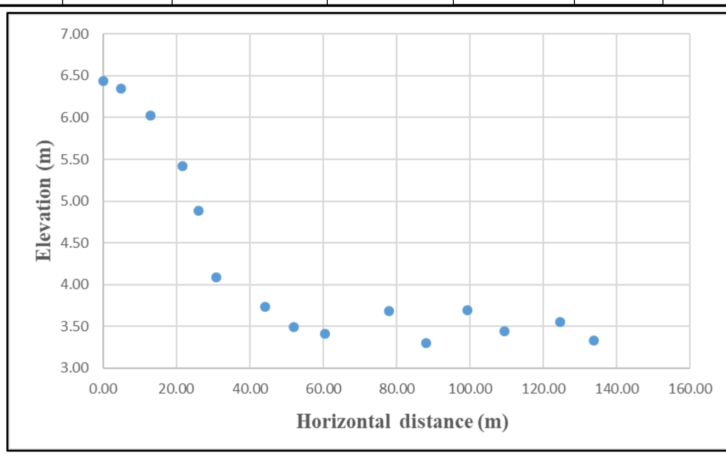
Description	Number of Locations (each)	# of Samples per location	Quantity of Samples	QC (10% of all samples)	QC (Field Blank)	Total # of Samples	Total # of Samples Being Anlysed	Parameters	Environmental Standards
Marine Sediments	5	1	5	1	1	6	6	pH,Total Metals (As, Ba, Cd, Cr, Cu, Fe, Pb, Hg, V, Zn) and Bioavailable Metals, Total Oil and Grease (TOG), PAH, TOC	EMA Requirements
Marine Water	5	2	10	1	1	22	22	pH, Temp, EC, Salinity, Dissolved Oxygen, COD, Total Suspended Solids, Turbidity, Nutrients (Nitrate and Phosphate), Total Nitrogen and Total Phosphorus, Entercocci, Total Metals (As, Ba, Cd, Cr, Cu, Fe, Pb, Hg, V, Zn), Total Oil and Grease (TOG), PAH	EMA Requirements, WPR 2019
Terrestrial Water	7	2	14	1	1	16	16	pH, Temp,Turbidity, EC, Salinity, Dissolved Oxygen, COD, Total Suspended Solids, Nutrients (Nitrate and Phosphate), EColi, Total Nitrogen and Total Phosphorus, Total Metals (As, Ba, Cd, Cr, Cu, Fe, Pb, Hg, V, Zn), Total Oil and Grease	EMA Requirements, WPR 2019
Terrestrial Soil Samples	6	1	6	1	1	8	8	pH,Total Metals (As, Ba, Cd, Cr, Cu, Fe, Pb, Hg, V, Zn) and Bioavailable Metals Total Oil and Grease (TOG), PAH, TOC	EMA Requirements

Sample Plans, sampling protocols and analysis parameters for borehole soils, terrestrial water, marine water and marine sediment sample stations.

E2.4 -
Beach Survey and Topography Mapping- Data collected Wet Season

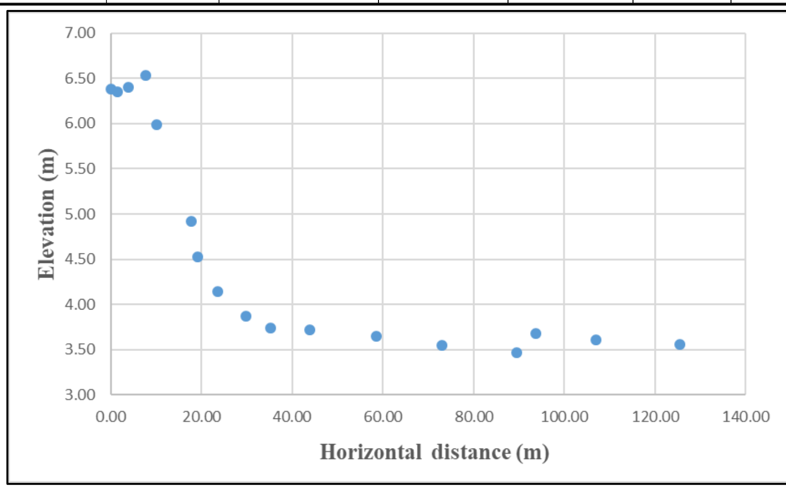
Beach Survey Line section 1

Point	Elevation (m)	Notes	Easting	Northing	Horizontal distance from SE1(m)	Horizontal distance between points (m)	Relative height from each point (m)	Slope % (rise/run)	Slope angle
SE1	6.43	Backshore	738708.72	1233191.86	0.00				
						4.84	0.09	1.9	1.1
SE2	6.34	High Water Mark	738707.26	1233187.24	4.84				
						8.11	0.32	4.0	2.3
SE3	6.02	Shoreface	738704.62	1233179.57	12.95				
						8.67	0.61	7.0	4.0
SE5	5.42	Shoreface	738701.00	1233171.69	21.60				
						4.33	0.54	12.4	7.1
SE6	4.88	Shoreface	738699.64	1233167.58	25.92				
						4.83	0.79	16.4	9.3
SE8	4.09	Shoreface	738697.73	1233163.15	30.74				
						13.37	0.36	2.7	1.5
SE14	3.74	Shoreface	738693.84	1233150.36	44.08				
						7.91	0.24	3.1	1.8
SE17	3.49	Shoreface	738691.75	1233142.73	51.97				
						8.67	0.08	0.9	0.5
SE50	3.41	Shoreface	738687.80	1233135.02	60.56				
						17.38	-0.28	-1.6	-0.9
SE52	3.69	Shoreface	738683.71	1233118.13	77.86				
						10.22	0.39	3.8	2.2
SE54	3.30	Shoreface	738682.35	1233107.99	87.91				
						11.46	-0.40	-3.5	-2.0
SE56	3.69	Shoreface	738679.50	1233096.90	99.35				
						9.96	0.25	2.5	1.4
SE58	3.45	Shoreface	738677.20	1233087.20	109.30				
						15.43	-0.11	-0.7	-0.4
SE60	3.55	Shoreface	738675.97	1233071.83	124.42				
						9.30	0.22	2.4	1.4
SE62	3.33	Shoreface	738674.68	1233062.62	133.65				



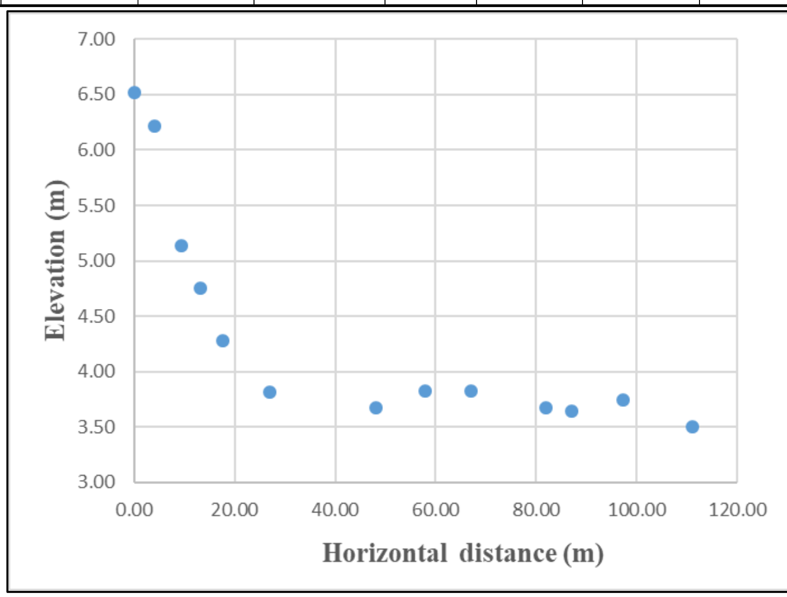
Beach Survey Line section 2

Point	Elevation (m)	Notes	Easting	Northing	Horizontal distance from SE7(m)	Horizontal distance between points (m)	Relative height from each point (m)	Slope % (rise/run)	Slope angle
SE7	6.38	High Water Mark	738782.60	1233139.56	0.00				
						1.55	0.03	1.7	1.0
SE9	6.35	Shoreface	738783.15	1233138.11	1.55				
						2.83	-0.05	-1.7	-1.0
SE10	6.40	Shoreface	738781.35	1233135.93	3.84				
						3.79	-0.13	-3.4	-1.9
SE11	6.53	Shoreface	738779.95	1233132.41	7.63				
						2.57	0.54	21.0	11.9
SE12	5.99	Shoreface	738778.85	1233130.09	10.19				
						7.56	1.07	14.2	8.1
SE13	4.92	Shoreface	738775.14	1233123.49	17.72				
						1.42	0.39	27.5	15.4
SE15	4.52	Shoreface	738774.61	1233122.17	19.14				
						4.42	0.38	8.7	5.0
SE16	4.14	Shoreface	738772.98	1233118.07	23.55				
						6.28	0.27	4.3	2.5
SE18	3.87	Shoreface	738770.78	1233112.19	29.82				
						5.45	0.12	2.3	1.3
SE19	3.75	Shoreface	738768.38	1233107.30	35.26				
						9.98	0.03	0.3	0.1
SE49	3.72	Shoreface	738760.02	1233101.85	43.96				
						14.61	0.07	0.5	0.3
SE51	3.65	Shoreface	738752.88	1233089.10	58.57				
						14.65	0.10	0.7	0.4
SE53	3.55	Shoreface	738743.63	1233077.73	73.09				
						16.38	0.09		0.3
SE55	3.46	Shoreface	738734.73	1233063.97	89.47				
						4.26	-0.22	-5.0	-2.9
SE57	3.68	Shoreface	738732.27	1233060.50	93.72				
						13.28	0.07	0.5	0.3
SE59	3.61	Shoreface	738726.32	1233048.63	106.94				
						18.75	0.05	0.3	0.1
SE61	3.56	Shoreface	738718.73	1233031.49	125.54				



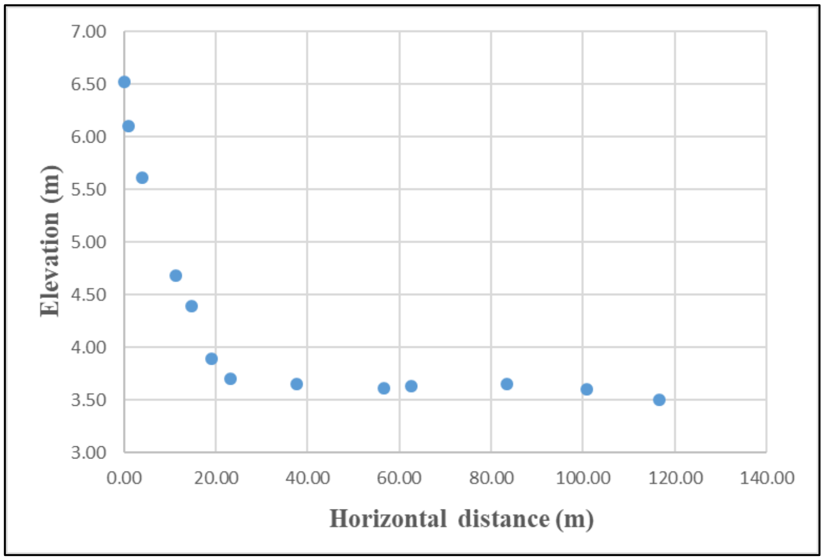
Beach Survey Line section 3

Point	Elevation (m)	Notes	Easting	Northing	Horizontal distance from SE20(m)	Horizontal distance between points (m)	Relative height from each point (m)	Slope % (rise/run)	Slope angle
SE20	6.52	Backshore	738868.32	1233101.55	0.00				
						4.10	0.31	7.4	4.3
SE21	6.22	High Water Mark	738867.40	1233097.56	4.10				
						5.36	1.08	20.1	11.3
SE22	5.14	Shoreface	738865.68	1233092.48	9.45				
						3.86	0.39	10.0	5.7
SE23	4.75	Shoreface	738864.84	1233088.72	13.30				
						4.29	0.48	11.1	6.3
SE24	4.28	Shoreface	738863.79	1233084.56	17.58				
						9.49	0.46	4.8	2.8
SE25	3.82	Shoreface	738862.61	1233075.14	27.02				
						21.20	0.14	0.7	0.4
SE27	3.68	Shoreface	738855.13	1233055.31	48.08				
						10.22	-0.15	-1.4	-0.8
SE65	3.83	Shoreface	738849.54	1233046.76	57.92				
						9.06	0.00	0.0	0.0
SE66	3.83	Shoreface	738846.72	1233038.15	66.98				
						14.89	0.16	1.1	0.6
SE67	3.67	Shoreface	738841.59	1233024.17	81.86				
						5.21	0.03	0.5	0.3
SE68	3.64	Shoreface	738840.06	1233019.20	87.07				
						10.29	-0.10	-1.0	-0.6
SE69	3.75	Shoreface	738836.80	1233009.44	97.35				
						13.72	0.24	1.8	1.0
SE71	3.50	Shoreface	738832.92	1232996.27	111.07				



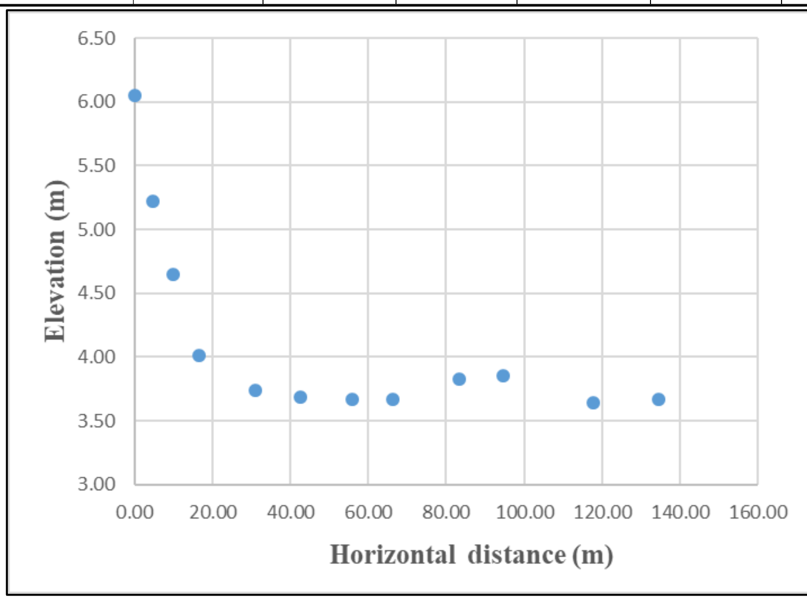
Beach Survey Line section 4

Point	Elevation (m)	Notes	Easting	Northing	Horizontal distance from SE29(m)	Horizontal distance between points (m)	Relative height from each point (m)	Slope % (rise/run)	Slope angle
SE29	6.52	Backshore	738937.26	1233072.64	0.00				
						1.05	0.41	39.3	21.5
SE26	6.11	High Water Mark	738936.94	1233071.65	1.05				
						2.91	0.50	17.1	9.7
SE30	5.61	Shoreface	738935.49	1233069.12	3.94				
						7.47	0.93	12.5	7.1
SE31	4.68	Shoreface	738932.32	1233062.36	11.41				
						3.25	0.28	8.7	5.0
SE32	4.39	Shoreface	738930.93	1233059.42	14.65				
						4.49	0.50	11.0	6.3
SE33	3.90	Shoreface	738929.32	1233055.23	19.13				
						4.27	0.20	4.6	2.6
SE34	3.70	Shoreface	738928.96	1233050.98	23.20				
						14.50	0.05	0.3	0.2
SE35	3.65	Shoreface	738925.17	1233036.98	37.65				
						19.00	0.04	0.2	0.1
SE36	3.61	Shoreface	738921.59	1233018.32	56.54				
						6.68	-0.02	-0.3	-0.2
SE70	3.63	Shoreface	738916.94	1233013.51	62.52				
						20.84	-0.02	-0.1	-0.1
SE72	3.65	Shoreface	738911.41	1232993.42	83.33				
						17.68	0.05	0.3	0.2
SE73	3.60	Shoreface	738908.03	1232976.06	100.90				
						15.87	0.10	0.7	0.4
SE74	3.50	Shoreface	738905.68	1232960.37	116.63				



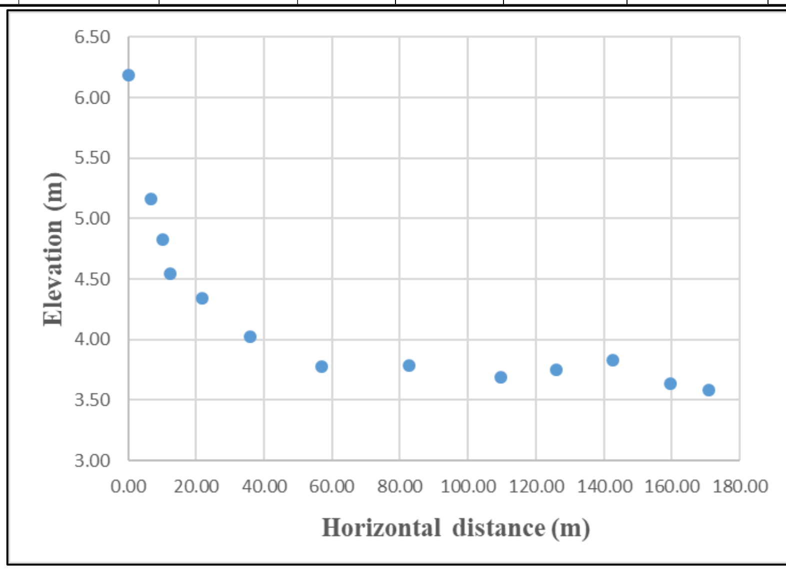
Beach Survey Line section 5

Point	Elevation (m)	Notes	Easting	Northing	Horizontal distance from SE37(m)	Horizontal distance between points (m)	Relative height from each point (m)	Slope % (rise/run)	Slope angle
SE37	6.05	High Water Mark	739037.52	1233025.65	0.00				
						4.62	0.83	17.9	10.2
SE38	5.22	Shoreface	739035.91	1233021.32	4.62				
						5.22	0.57	10.9	6.2
SE39	4.65	Shoreface	739034.04	1233016.44	9.84				
						6.77	0.64	9.5	5.4
SE40	4.01	Shoreface	739031.89	1233010.02	16.61				
						14.32	0.27	1.9	1.1
SE41	3.74	Shoreface	739028.13	1232996.20	30.91				
						11.68	0.05	0.4	0.2
SE42	3.69	Shoreface	739024.62	1232985.06	42.59				
						13.17	0.02	0.1	0.1
SE43	3.67	Shoreface	739020.14	1232972.67	55.75				
						10.51	0.01	0.1	0.0
SE44	3.67	Shoreface	739017.01	1232962.64	66.26				
						17.19	-0.16	-0.9	-0.5
SE45	3.82	Shoreface	739009.94	1232946.98	83.37				
						11.54	-0.03	-0.2	-0.1
SE46	3.85	Shoreface	739003.93	1232937.12	94.68				
						23.62	0.21	0.9	0.5
SE77	3.65	Shoreface	738990.59	1232917.63	117.78				
						16.67	-0.02	-0.1	-0.1
SE78	3.67	Shoreface	738985.25	1232901.84	134.39				



Beach Survey Line section 6

Point	Elevation (m)	Notes	Easting	Northing	Horizontal distance from SE47(m)	Horizontal distance between points (m)	Relative height from each point (m)	Slope % (rise/run)	Slope angle
SE47	6.19	High Water Mark	739134.59	1232987.84	0.00				
						6.67	1.03	15.4	8.8
SE80	5.16	Shoreface	739134.19	1232981.19	6.67				
						3.38	0.33	9.7	5.5
SE81	4.83	Shoreface	739133.55	1232977.86	10.03				
						2.21	0.29	12.9	7.3
SE82	4.55	Shoreface	739133.19	1232975.68	12.24				
						9.55	0.20	2.1	1.2
SE76	4.34	Shoreface	739132.13	1232966.19	21.79				
						14.10	0.32	2.2	1.3
SE79	4.03	Shoreface	739131.21	1232952.12	35.88				
						21.12	0.25	1.2	0.7
SE83	3.78	Shoreface	739129.56	1232931.07	56.99				
						25.97	0.00	0.0	0.0
SE84	3.78	Shoreface	739130.52	1232905.12	82.82				
						26.88	0.10	0.4	0.2
SE85	3.69	Shoreface	739129.88	1232878.24	109.70				
						16.25	-0.07	-0.4	-0.2
SE86	3.76	Shoreface	739128.53	1232862.05	125.93				
						16.83	-0.07	-0.4	-0.2
SE87	3.83	Shoreface	739129.05	1232845.23	142.72				
						16.86	0.19	1.2	0.7
SE88	3.63	Shoreface	739129.26	1232828.37	159.56				
						11.34	0.05	0.4	0.3
SE89	3.58	Shoreface	739129.98	1232817.05	170.85				



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E3 – Ambient Air and Noise Quality (5.1.9)

Item		Qty	
			Tobago - Kilgwyn Hotel Development
			Ambient Air & Noise
1		2	*Ambient Air Sampling, Analysis, Reporting x 3 locations (per event) - TSP,PM10,PM2.5, CO, O3*
2		2	*Noise Sampling, Analysis, Reporting x 3 locations (48hrs: 1 weekday + 1 weekend) - LEQ, LPEAK, Lmin, Lmax*
			Notes
		a	*Assumes both Noise and Ambient Air Sampling will be conducted simultaneously*
			All Noise Sampling will be in accordance with Noise Pollution Control Rules, 2001
			All Ambient Air Methods in accordance with EMA Testing Methods Guide EMA-QMS-AIR-08-GUI & USEPA to meet Air Pollution Rules or approved equivalent, 2014 averaging times:
		b	*(1) ASTM 1946/US EPA Method 3c - Carbon Monoxide*
			(2) UV Absorption EQOA–0815–227 - Ozone or PTC SOP - 00197 alternate
			(3) Manual Gravimetric Method - TSP,PM10,PM2.5

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E3.1 – Ambient Air Quality

CEC6143/2020

THE ESTABLISHMENT OF A 500 ROOM RESORT ON 18.7258 HECTARES OF LAND AT TYSON HALL BETWEEN KILGWIN BAY ROAD AND STORE BAY LOCAL ROAD, TOBAGO

AMBIENT AIR MONITORING REPORT

Prepared by:

EQUILIBRIUM ENVIRONMENTAL SERVICES LIMITED (EES)

For:

Optimal GESL

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1.0 INTRODUCTION

FCL financial Limited proposed to build a 500-room resort on 18.7258 hectares of land at Tyson Hall, Tobago (Figure 1.0). Due to likely environmental impacts The Environmental Management Authority has mandated that an Environmental Impact Assessment (EIA) be undertaken to allow for Certificate of Environmental Clearance (CEC) determination.

This report documents the results of the ambient air monitoring to adequately characterize the proposed development area and environs, likely to be impacted by any future resort development activity. The Dry Season study took place from 16^{th} to 17^{th} May 2022, while the Wet Season study took place from 6^{th} to 7^{th} October 2022.

1.1 Project Scope

1. To perform baseline ambient air monitoring in the vicinity of the proposed study area, in accordance with the Environmental Management Act (EMA) Ambient Air Pollution Rules, 2014 (APR 2014)
2. Frequency: Wet Season Study; Dry Season Study
3. Parameters: Total Suspended Particulate (TSP; Particulate Matter of diameters ≤ 10 µm and 2.5 µm (PM_{10} and $PM_{2.5}$); Carbon Dioxide (CO) and Ozone (O_3)
4. Utilize United States Environmental Protection Agency (USEPA), other internationally recognized and/or justifiable surrogate methodologies in sampling and analysis techniques to meet APR 2014 Schedule 1 Maximum Permissible Levels for Ambient Air averaging times

5. Measurement Interval – as defined in APR 2014 per parameter

6. Prepare a Report to satisfy the EIA Terms of Reference that contains, but is not limited to, the following specifics:

   i. A summary description of the ambient air survey program and results
   ii. Summary data and results table

iii. Diagrams/ maps reflecting ambient air results/ contours
iv. QA/QC analyses and data
v. Raw data collected
vi. Evidence of all Calibrations performed
vii. Personnel

Meteorological measurements were recorded by HOBO U30/NRC Remote Monitoring System, located in the immediate vicinity.

All points were marked via GPS and illustrated on a map of the area.

1.2 Sample Locations

Refer to Table 1 and Figure 1 below.

Table 1 Ambient Air Monitoring Locations

Sample Location	UTM Coordinates	
1	739299	Upwind – Tyson Hall
	1233460	
2	738063	Downwind – Old Store Road
	1233750	
3	737359	Downwind – Crown Point
	1233514	

CEC6143/2020 Establishment of A Resort at Tyson Hall

FCL Financial Limited Ambient Air Monitoring Report

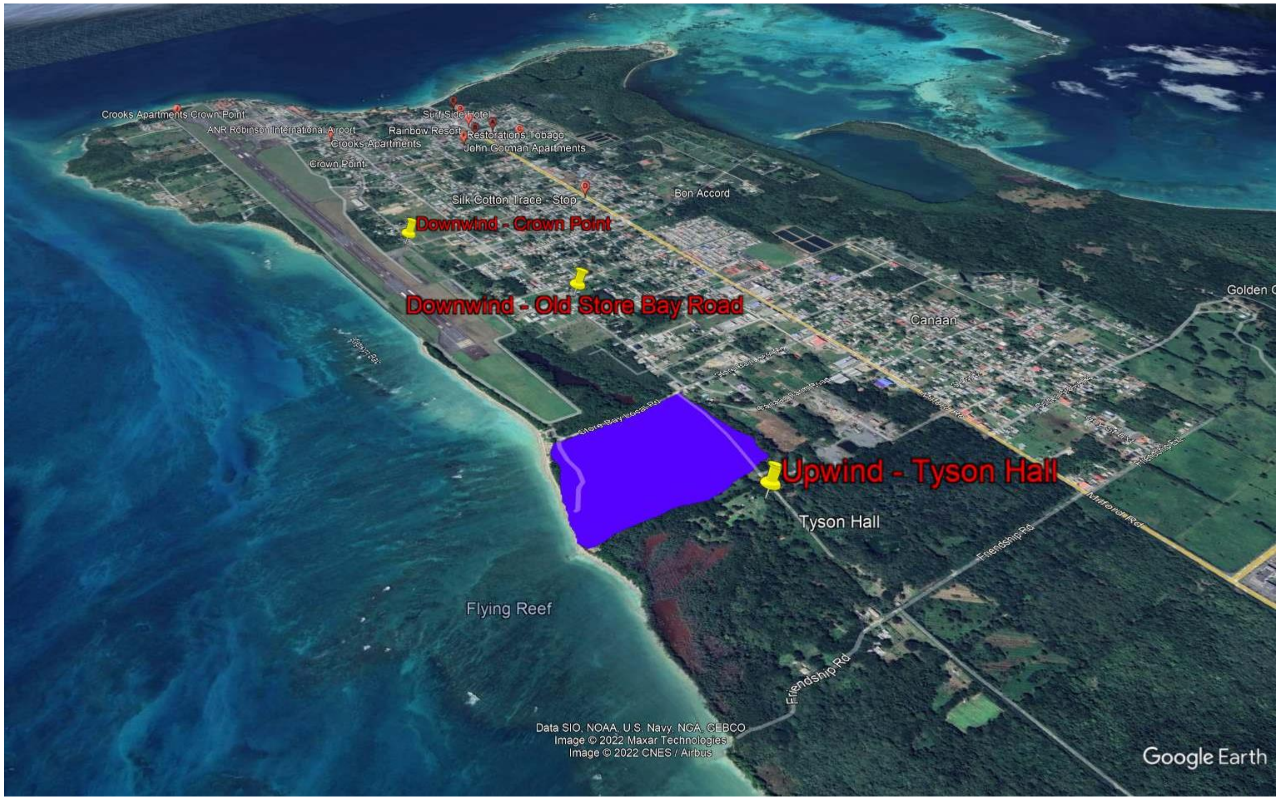

Figure 1 Southwest Tobago depicting study area (blue) in relation to sample location

1.3 Key Personnel

Table 2 Key Project Personnel

Person	Organization	Responsibility
Mr. Neil Harper	EES	Senior Technical Lead
Mr. Kieron Vincent	EES	Technical Support
Mr. Eddie Greene	EES	Technical Support

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2.0 METHODOLOGY

2.1 Summary of Technical Approach

Table 3 Summary of Proposed Methodology

Ozone	PTC SOP - 00197 Monitoring O_3 in the Atmosphere by using BV Labs All-Season Passive Samplers [H. Tang and T. Lau "A New All-Season Passive Sampling System for Monitoring Ozone in Air". Environmental
Carbon Monoxide	Thermo Electron Model 48, Non-Dispersive Infra-Red Analyzer; US EPA Designation RFCA-0981-054

Particulate Matter of diameters ≤10µm & ≤2.5µm	Near Federal Reference Low Volume Air Sample Pump capable of achieving 16.7 litres per minute (lpm) flow rate with subsequent gravimetric analysis; Saturation Monitoring as per US EPA 40 CFR part 58; ARA Instruments N-FRM
Meteorological	Onset HOBO U30 Remote Monitoring Station: Relative Humidity, Temperature, Wind Speed, Wind Direction,

2.2 Data Quality Objectives (DQO) and Measurement Performance Criteria

The primary goal of sampling and analysis was to establish baseline conditions of the study area to predict future impacts by planned works. For proper decisions to be made, the data for this project plan must be of known quality. To ensure that the quality can be assessed, the sampling team and the laboratory conducting the analyses must retain sufficient documentation to enable the project team to recreate the sampling activities and analytical results for review.

Specific Quality Assurance (QA) objectives included collecting enough transport (trip) blanks and duplicate samples to evaluate the potential for contamination from sampling equipment and sampling technique. (Note: Blanks may be collected and held for analysis until it is determined contamination may be a concern).

A valid measurement hour for continuous ambient air sampling was defined as having at least 45 minutes (75% of the minutes of an hour) of valid data. The ex-situ analyzer for CO analysis runtime will be the duration of sample extraction from Tedlar Bags. For a filter-based measurement of particulate matter, a valid measurement day is filter exposure for 24 hours. A valid measurement obtained using passive sampling methods was defined as having met MDLs with required exposure time and proper siting criteria (8-hours).

Additionally, DQO’s were modelled from the results of analytical accuracy from published papers (Appendices) attesting to the viability of collocated studies of passive sampling systems supplied by Bureau Veritas Labs of North America (BV Labs Labs) as well as laboratory data.

Integrated sampling provides a time-weighted average measurement of a gas, a vapour, or particulate matter over a set period. The integrated sample was analyzed in a laboratory to determine the ambient concentration or mass loading per sample. Passive samplers are a form of integrated sampler.

Passive sampling was the diffusive sampling method used to determine the concentration of a gas or vapour in ambient air. Passive samplers have no moving parts and do not require electricity to operate and were therefore suitable for remote locations. Passive sampling was used to monitor pollutants such as ozone. These samplers determined spatial and temporal trends of time-weighted average pollutant concentrations.

EES employed passive sampling devices (PSDs) supplied and subsequently analyzed by Bureau

Veritas Canada.

Federal Reference Method (FRM) CO analyzer was used ex-situ to analyze Tedlar bags containing air samples collected via an air pump to achieve APR 2014 averaging times. Near FRM TSP, PM_{10} and $PM_{2.5}$ instruments were installed at each of the three ambient monitoring locations in the study area so described in Figure 1.0.

The sampling technique used by the particulate sampler was a modification of the reference method described in the U. S. Code of Federal Regulations (40 CFR part 50, Appendix J). Under this criteria, a particulate sampler must have: 1) a sample air inlet system to provide particle size discrimination, 2) a flow control device capable of maintaining a flow rate within specified limits, 3) means to measure the flow rate during the sampling period, and 4) a timing control device capable of starting and stopping the sampler.

All portable samplers used in this program met all of these specifications. They will be equipped with

1) an inlet impactor capable of separating particulate matter to #10 μm, 2) a flow control device which will maintain a specified flow rate, 3) a flowmeter to measure the flow rate during the

sampling period, 4) an elapsed time meter, and 5) a programmable timer that starts and stops the sampler unattended. The sampler's flow rate was 5 – 16.7 litres per minute (lpm), where applicable. USEPA guidance also provided for its use under 40CFR Par 58 in saturation sampling programs.

Table 4 Ambient Air Monitoring Measurement Quality Objectives

Parameter	Comparability			Data Completeness		Representativeness		
	Method Type	Equipment	Reference/Method	Hourly	Daily	Bias	Sampling Frequency	Siting
CO	Gas Filter Correlation	Thermo Scientific Model 48i or equivalent	U.S. EPA Automated Reference Method: RFCA-0981-054	45, 1-minute values	75%	One Point QC Check Concentration: ≤ ±10.1%	Ex-Situ Continuous, till Tedlar Bag depletion	40 CFR 58 Appendix E
O_3	Passive Sampler	Bureau Veritas Passive Sampler	PTC SOP - 00197 Monitoring Ozone in the Atmosphere by using Maxxam All-Season Passive Samplers [H. Tang and T. Lau "A New All-Season Passive Sampling System for Monitoring Ozone in Air", Environmental Monitoring and Assessment, 65 (1-2) 129-137, 2000.] Ozone	8 hours	100%	Collocation	Wet Season/Dry Season; APR 2014 averaging time, short term	40 CFR 58 Appendix E
$PM_{2.5}$	Filter Sampler	ARA Instruments N-FRM Sampler	US EPA Reference Method 40 CFR Part 50 Appendix J	N/A	24 hours	Design Flow: ≤±5% Δ transfer standard	Wet Season/Dry Season; APR 2014 averaging time, short term	40 CFR 58 Appendix E
PM_{10}	Filter Sampler	ARA Instruments N-FRM Sampler	US EPA Reference Method 40 CFR Part 50 Appendix J	N/A	24 hours			
TSP	Filter Sampler	ARA Instruments N-FRM Sampler	US EPA Reference Method 40 CFR Part 50 Appendix J	N/A	24 hours			

2.2 Sampling Equipment, Siting Criteria and Collection Methods

Sampling Methods - Ambient Air

The ambient air monitoring study began with the deployment of the monitoring equipment at all three sample locations (Figure 1.0). CO analyzer was warmed up and calibrated. The analyzer is off site and was used in the analysis of CO.

For the filter-based TSP, PM_{10} and $PM_{2.5}$ samplers, the samplers are calibrated and set for a 24-hour measurement cycle.

O_3 sampling began with the installation of PASS shelter and removal of PSDs from storage containers. After assembly and calibration, a timer is set to collect samples for the parameter-specific amount of time (8 hours).

The parameters monitored and sampling methods applied are:

CO – CO is measured by a Thermo Environmental Model 48i analyzer or equivalent– a US EPA designated automated reference method: RFCA-0981-054 (or equivalent). The ex-situ analyzer is mounted inside a climate-controlled shelter. Field filled Tedlar Bags are used to collect and transport air samples containing CO, a stable permanent gas, off-site for analysis. Concentration averages are stored for the duration of the evacuation of each bag.

Sample air drawn from each bag via though a valve, via ¼ inch Teflon tubing. The flow rate through the sample tubing is such that the residence time of the sample is less than 20 seconds.

Ozone – PTC SOP - 00197 Monitoring Ozone in the Atmosphere by using Maxxam All-Season Passive Samplers [H. Tang and T. Lau "A New All-Season Passive Sampling System for Monitoring Ozone in Air", Environmental Monitoring and Assessment, 65 (1-2) 129-137, 2000.]   Ozone

A PSD will be housed in a Passive Air Sampling Shelter

PM_{10} – PM_{10} was sampled using an ARA Instruments sampler: a near reference US EPA equivalent method. Sample air is drawn in through a size-selective inlet and through a pre-weighed quartz-fiber sample filter at a volumetric flow rate of 16.7 l/min for 24 hours. Exposed filters are returned to the laboratory for re-weighing of the accumulated mass.

$PM_{2.5}$ – $PM_{2.5}$ was sampled using an ARA Instruments sampler: a near reference US EPA equivalent method. Sample air is drawn in through a size-selective inlet and through a pre-weighed quartz-fiber sample filter at a volumetric flow rate of 16.7 l/min for 24 hours. Exposed filters are returned to the laboratory for re-weighing of the accumulated mass.

TSP – TSP was sampled using an ARA Instruments sampler: a near reference US EPA equivalent method. Sample air is drawn in through a size-selective inlet and through a pre-weighed quartz-fiber sample filter at a volumetric flow rate of 16.7 l/min for 24 hours. Exposed filters are returned to the laboratory for re-weighing of the accumulated mass.

Routine tasks performed by EES follow ambient air monitoring standard operating procedures. These SOPs are included in appendices and are maintained with the monitoring equipment during sampling events.

Analytical Methods – Ambient Air

PSDs allowed air samples to diffuse through filters that were coated with an absorbing reagent solution, which is applied by the manufacturer (Bureau Veritas Labs). The absorbance value of this reagent was proportional to the pollutant concentration in ambient air. Field samples, field blanks, trip blanks, and laboratory blanks were extracted using deionized water and analyzed by ion chromatography.

Analysts derived concentrations using conversion equations. Sample storage conditions, conversion equations, and acceptable lifetimes were provided in SOPs and per reviewed articles (Appendix).

Note that Ion chromatography was the preferred methodology due to lower detection limit and less interferences.

Ambient air concentration measurements were performed using FRM, FEM, or internationally recognized methods.

EES performed analysis of the AAQM filters. TSP, PM_{10} and $PM_{2.5}$ samples were analyzed in general accordance with the method described in US 40 CFR 50 Appendix J.

The laboratories will adhere to their established SOPs for analysis of the sample media.

The BV Labs performed ion chromatography analysis of the exposed PSDs. The samples were analyzed in accordance with the parameter-specific methods described in PTC SOP – 00197 (Ozone analysis).

Specific Sampling & Analysis Strategies - Carbon Monoxide (CO)

The science of ex situ collection of carbon monoxide relied on its stability as a permanent gas in the atmosphere. This allowed for collection as a whole air sample via Tedlar bags, with acceptable retention times due to stability. As such the active sampling technique of whole air sample collection employed in this project was in alignment with ASTM 1946/US EPA Method 3c (sample collection portions only), as typical sample collection strategies.

Apparatus

Tedlar bags consisted of two layers of Tedlar film sealed together at the edges and a sampling valve. Since Tedlar is inert to most substances, it was used to collect reactive and more stable compounds as long as all sampling components (including the valve) were non-metallic

Tedlar bag samples were filled using active sampling, in which the sample is discharged into the Tedlar bag by a pump. All fittings and tubing were non-reactive PTFE.

Hold Time

ASTM D1946: CO - Up to 3 days

Sampling

The most common method for filling a bag is to use a calibrated small pump (active sampling) with low flow rates (50 - 500 mL/min) and tubing to fill the bag.

Sample Handling

- The Tedlar bag was filled no more than 2/3 full:
- The Tedlar bag was kept out of sunlight to avoid any photochemical reactions
- The Tedlar bag was stored and shipped in a protective box at room temperature.
- The sample information was recorded on the label before inflation
- Duplicate bags were filled per location in the rare occasion that a defective bag deflates before analysis.
- This "hold" sample did not need to be documented on the Chain-of-Custody and had an identical sample ID to the original sample indicating that it is the "hold" sample
- No preservation is required.

Quality Control

The results of the duplicate sample were compared with the primary sample to provide information on consistency and reproducibility of field sampling procedures.

Analysis

Sample collection was independent of analysis. The ex-situ analyzer for CO analysis runtime wase the duration of sample extraction from Tedlar Bags. Analyzer run time (in the lab) was independent of APR 2014 averaging times and cannot be referenced as such. It is the grab or whole air sample as collected which will meet the stated APR2014 limits. Note that the grab sample averaging time met the following APR 2014 limits:

15mins – 100,000ug/m3

Subsequent analytical quantification of carbon monoxide for ambient air via non-dispersive infrared red (NDIR) photometry was the measurement technique of choice for carbon monoxide as approved by the US EPA.

The Lower Detectable Limit was 0.04ppm via this analysis; APR 2014 limit in 15 minutes = 87ppm (100,000ug/m3). This proposed approach therefore adequately analyzed for CO.

Similarly, sample collection in ambient air has also been evaluated in the following reference and known to be valid ***(Ref: John C. Polasek and Jerry A. Bullin; Evaluation of bag sequential sampling technique for ambient air analysis; Environmental Science & Technology 1978 12 (6), 708-712; DOI: 10.1021/es60142a009)***

As such ex situ whole air ambient sampling employed by Equilibrium Environmental Services (EES) follows from the study published in the ***Journal of the A&WMA***, and validates the concept for use i.e. both sample collection and analysis (***Ref: Steven N. Rogak , Ute Pott , Tom Dann & Daniel Wang (1998) Gaseous; Emissions from Vehicles in a Traffic Tunnel in Vancouver, British Columbia, Journal of the Air & Waste Management Association, 48:7, 604-615, DOI: 10.1080/10473289.1998.10463713).***

Specific Sampling & Analysis Strategies Ozone Measurement

Proposed passive sampling devices have been confirmed to have sensitivity and adequate detection limit to satisfy the 8-hour/ 120ug/m^3 APR 2014 requirement.

Attachment 2 includes the peer-reviewed study where this which is highlighted and Attachment 3 includes feedback from Bureau Veritas, the lab undergoing the analysis.

As such we are confirming that the all-season (passive) sampler for ozone can indeed meet method detection limits in sub-24-hour studies.

Attachment 4 shows typical Method Detection Limits. In 24-hours MDL for ozone is 3 ppb and the lab has confirmed a 9ppb MDL for 8-hours.

Typical background levels are between 20-30 ppb ozone (EES experience with passives)

The APR 2014 limit for 8 hours is 120 ug/m3 = 60ppb. Thus, at an MDL at 9ppb there is sufficient resolution.

2.3 Site Selection Justification

2.3.1 Upwind – Tyson Hall

As per Figure 1.0, this location was in the immediate vicinity of the project site (150m) on the eastern boundary of the proposed development. Baseline measurements captured here represented ambient air levels mangrove in the undeveloped space currently dominated by secondary scrub vegetation and mangrove. The actual sample point was a low vehicular traffic and pedestrian traffic, “rural” farm at Tyson Hall and West Friendship communities.

2.3.2 Downwind – Store Bay Local Road

As per Figure 1.0, this location was along a main arterial east – west roadway from Crown Point airport. Land use along this roadway was predominantly small hotels, bars, small groceries and residential properties. This location was in the car park of small grocery and roadside grill 680m from the western boundary of the proposed development. Baseline ambient air monitoring at this location characterized typical vehicular and pedestrian traffic and general activity set of the South Canaan community along the Old Store Bay Road.

2.3.3 Downwind – Crown Point

As per Figure 1.0, this location was off the main arterial east – west roadway (Old Store Bay Road) from the Crown Point airport. Land use in this general area was small hotels, residential properties and the Crown Point Airport Runway. This location was north of the runway and behind a few small residential properties some 1416m from the western boundary of the proposed development. Baseline ambient air monitoring at this location characterizes low vehicular and pedestrian traffic and general activity set of the Crown Point community along Crompson Trace.


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Figure 3 Old Store Bay Road Sample Point

Figure 4 Crown Point Sample Point

3.0 QUALITY ASSURANCE/QUALITY (QA/QC) CONTROL PROGRAM

A vital part of any sampling and analysis program is the provision for procedures which maintain the quality of data throughout the sampling and analysis exercise. These procedures, termed quality assurance and quality control (QA/QC) serve to:

- Document the quality (i.e., accuracy, precision, completeness, representativeness and comparability) of generated data.
- Maintain the quality of data within predetermined control limits for specific sampling and analysis procedures.
- Provide guidelines for corrective actions if QC data indicate that a particular procedure is out of control.

To meet this goal, a rigorous and comprehensive QA/QC program was implemented from the outset of the study program to ensure that the data reported and analyzed in the study is complete, that measures of their accuracy and precision are documented and the data will stand up to public and scientific scrutiny.

QA/QC for this study include such activities:

- Duplicate sampling
- Use of field and trip blanks
- Laboratory method blanks and spike
- Use of NIST (National Institute of Standards and Technology) traceable calibration standards for flow and analyzer calibration
- CO/NO_2 analyzer calibration
- Chain of Custody documentation for sample handling
- Field logs to track sample deployment and related issues
- (Laboratory) bracketing data by QC checks, blanks, duplicates and spikes. These were

internal activities and documents to the lab.

As reference material, EES retains both digital and physical copies of instrument manuals which can be readily accessed to support both troubleshooting and maintenance.

Laboratory accreditation and statement of QA/QC activities are attached.

4.0 RESULTS

Table 5 Summary of Dry Season Ambient Air Monitoring Data

	Upwind Tyson Hall	Downwind Old Store Bay Road	Downwind Crown Point	APR 2014 Short-Term Maximum Permissible	
	$\mu g/m^3$	$\mu g/m^3$	$\mu g/m^3$	$\mu g/m^3$	averaging time
TSP	20.63	20.74	20.94	150	24 hours
PM_{10}	12.31	12.27	15.43	75	24 hours
$PM_{2.5}$	4.05	4.10	4.01	65	24 hours
Carbon Monoxide (CO)	1718	1718	1718	100,000	15 minutes
Ozone (O_3)	20	24	26	120	8 hours

Table 6 Summary of Wet Season Ambient Air Monitoring Data

	Upwind Tyson Hall	Downwind Old Store Bay Road	Downwind Crown Point	APR 2014 Short-Term Maximum Permissible	
	µg/m^3	µg/m^3	µg/m^3	µg/m^3	averaging time
TSP	12.38	16.59	16.76	150	24 hours
PM_{10}	12.31	12.27	11.57	75	24 hours
$PM_{2.5}$	4.10	3.94	3.86	65	24 hours
Carbon Monoxide (CO)	1718	1718	1718	100,000	15 minutes
Ozone (O_3)	19	24	22	120	8 hours

5.0 FINDINGS

MeteorologicalSummary

General wind direction from the dry season to the wet season was east to east-south-east. Predominant trade winds move across the island from a generally easterly direction and the data is in accordance with the general pattern of wind distribution.

Sample collection was not impaired by significant adverse weather patterns or large-scale cyclonic events.

AtmosphericParticulates

Across all size fractions (total, ≤10 μm, ≤2.5 μm) particulate contributions to the atmosphere from fugitive and point source releases are comparatively appreciably low across wet and dry seasons.

GaseousParameters

Carbon monoxide, primarily emitted as a component of fossil fuel engines (road and non-road) had comparatively low concentrations for the sample period across dry and wet seasons. Low level ozone concentrations, the result of atmospheric interactions of VOCs, with oxides of nitrogen and sunlight, also had comparatively low concentrations for the sample period across dry and wet seasons.

6.0 DISCUSSION

The sample sites selected upwind and downwind of the proposed project sites current usage/utilization serve to define baseline conditions pre-construction and pre-operation.

Proposed activities throughout the construction and operational phases of the proposed development should be assessed against the Air Pollution Rules, 2014 to determine impact to community receptors.

APPENDICES

- Summary of Meteorological Data
- Calculations

Literature Review

- Attachment 1: BV Labs Canada QA/QC Lab Program
- BV Labs Canada Lab Accreditation
- Standard Operating Procedures – Passive Sampling Devices
- Passive Sampling Devices Correlation Study
- Attachment 2: Peer Reviewed Study - 8-hour PSD Justification
- Attachment 3: Ozone PSD Method Detection Limit confirmation
- Attachment 4: Passive Sampling Device Loading Chart
- Equipment Specification Sheets
- Standard Operating Procedures Particulate Sampling

Sample Records

- Gravimetric Analysis Particulate Filters
- Flow Calibration Sheets
- Field Logs
- CO Analyzer Results
- CO Analyzer Calibration Sheets
- Passive Sampling Device Lab Reports
- Chain of Custody Sheets

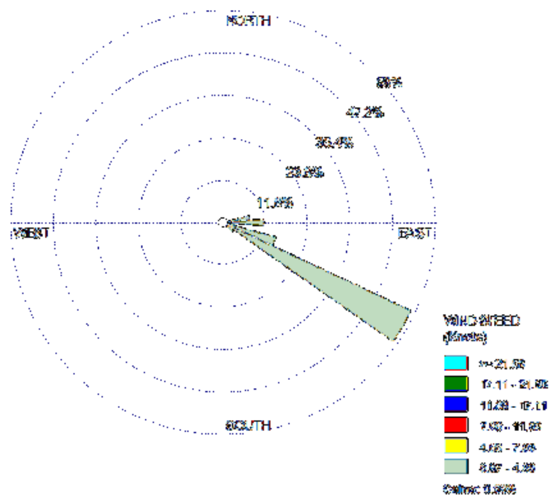

Figure 5 Dry Season (May 2022) Wind Rose

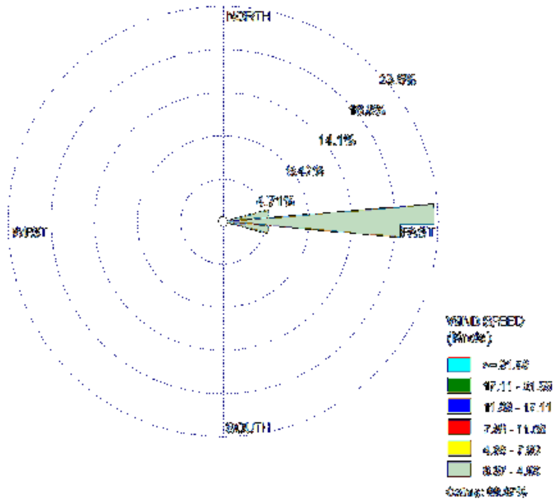

Figure 6 Wet Season (October 2022) Wind Rose

Table 7 Summary of Meteorological Data – Dry Season

Avg. Temperature/°C	27.9
Avg. Humidity/%	82.8
Avg. Wind Direction/ degrees	111.6
Avg. Wind Speed/ ms^{-1}	1.7
Total Rainfall/mm	4.2
Atmospheric Pressure/ mm Hg	760

Table 8 Summary of Meteorological Data - Wet Season

Avg. Temperature/°C	26.7
Avg. Humidity/%	89.8
Avg. Wind Direction/ degrees	85.4
Avg. Wind Speed/ ms^{-1}	1.6
Total Rainfall/mm	0.4
Atmospheric Pressure/ mm Hg	757

Calculations

Calculations

Sampling rate calculations used by Bureau Veritas Labs were mentioned in the *Scientific World* article previously cited and include detailed references:

Tang, H. and Lau, T. (2000) A new all-season passive sampling system for monitoring ozone in air. Environ. Monit. Assess. 65(1-2), 129–137.

Tang, H. (1998) Development of all-season passive sampling systems — a summary. Research Report for Research Canada Council", Contract No. 027240U-PH8.

Tang, H., Brassard, B., Brassard, R, and Peake, E. (1997) A new passive sampling system for monitoring SO in the atmosphere. FACT 1(5), 307–315.

Tang, H., Lau, T., Brassard, B., and Cool, W. (1999) A new all-season passive sampling system for monitoring NO in air. FACT 6, 338–345.

Centre for Passive Sampling Technology, Bureau Veritas Labs Inc. (2000) Newsletter for H2S All-season Passive Sampling System.

The calculation used is as follows:

Sampling rates of the Maxxam passive samplers are determined using manufacturer-specified Equations (1)–(3) for each pollutant to account for the effects of temperature, wind speed (face velocity), and relative humidity (Tang et al., 1997, 1999; Tang and Lau, 2000; Tang, 2001).

$$SO_2:\ R_S = 12.769T^{1/2} - 0.540RH + 0.276WSP - 135 \quad (1)$$

$$NO_2:\ R_S = 25.960T^{1/2} - 0.175RH + 0.180WSP - 388 \quad (2)$$

$$O_3:\ R_S = 14.8T^{1/2} - 0.259RH + 0.275WSP - 197 \quad (3)$$

where R_S = sampling rate in mL/min, T = temperature in K, RH = relative humidity in % (for SO_2 if $RH > 80$, then set $RH = 80$, for NO_2, RH = 20–100%), and WSP = wind speed in cm/sec (if $WSP > 130$, then set $WSP = 130$). The time-weighted average concentration (C_e) of each pollutant was calculated using Equation (4) based on the sampling period (t) and the collected cumulative total mass (Q) determined from the laboratory analysis post-exposure.

$$C_e = \frac{Q}{R_S t} \quad (4)$$

Data on temperature, relative humidity and wind speed is collected by meteorological sensors on site. Thus local weather conditions are in fact used, allowing for more accurate sampling data.

ConvertingAtmosphericPollutantConcentrationsfromppmvtomg/m^3

The conversion factor depends on the temperature at which the conversion (usually about 20 to 25 degrees Centigrade) is done. At an ambient pressure of 1 atmosphere, the general equation is:

mg/m^3 = (ppmv)(12.187)(MW) / (273.15 + °C)

where:

mg/m^3	=	milligrams of gaseous pollutant per cubic meter of ambient air
ppmv	=	ppm by volume (i.e., volume of gaseous pollutant per 10^6 volumes of ambient air)
MW	=	molecular weight of the gaseous pollutant
°C	=	ambient air temperature in degrees Centigrade

The CO ppm is converted to CO ppb (*1000) initially before converting to µg/m^3 using 25 deg °C as seen below:

The general equation is

µg/m^3=(ppb)*(12.187)*(M)/(273.15+ °C)

Where M is the molecular weight of the gaseous pollutant. An atmospheric pressure of1 atmosphere is assumed.

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Bureau Veritas Laboratories

Quality Assurance & Quality Control Program

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Table of Contents

1.0 Laboratory Company Profile

For over 50 years, Bureau Veritas Laboratories (formerly Maxxam) has been a leader in analytical services and solutions to the energy, environmental, industrial hygiene, food and DNA industries. Our 2,200 dedicated employees proudly lead the industry in depth of technical and scientific expertise and serve customers through our national network of laboratories. In processing over 2.4 million samples and generating in excess of 43 million results annually, we skilfully combine efficiency and customer service with rigorous science and uncompromising quality management. We are committed to success with responsibility – to our stakeholders, to our communities, and to the environment.

Our mission is to improve our customers' performance, help reduce their risks and enable our custumers to meet or exceed challenges of quality, health and safety, environmental and social responsibility. We want to be the clear choice in testing, inspection and certification services.

A major focus is analytical services for an exhaustive list of environmental contaminants. Solid wastes, effluents, potable water, receiving waters, ground waters, soils, sediments, stack emissions, ambient air, plant, animal and fish tissues are analysed for everything from pH to Dioxins.

We provide these services to a wide range of customers in North America and over 20 foreign countries. Our clients include consulting engineers, industry, businesses, all levels of government as well as private individuals.

Our laboratories function as a tight network operating under a single Quality Management System, utilizing the strengths of each and working together to ensure customer requirements are met. All major laboratories provide the full range of environmental testing services using a uniform Quality System and IT infrastructure to deliver a standardized high quality service across the country. In addition, certain locations have special areas of expertise, such as seawater analysis at our Burnaby and Bedford facilities and High Resolution Dioxin analysis in our Mississauga and Ville St-Laurent facilities.

Operating within one Laboratory Information and Quality System across Canada provides uniform report formats, management performance measurements, turnaround time measurements, corrective action management, and a number of other key performance indicators making us a reliable partner.

1.0 Laboratory Company Profile

Bureau Veritas is a world leader in laboratory testing, inspection and certification services. Established in 1828, the Group has more than 75,000 employees located in over 1,500 offices and laboratories around the globe. Since our founding our name has been synonymous with integrity - all the more crucial in an industry built on trust. As a business to business company that has a profound impact our world (or community) we are dedicated to building trust between client companies, public authorities and consumers.

2.0 Quality Program

Bureau Veritas Laboratories currently employs 35 full-time Quality Assurance (QA) staff. This group reports to the Senior Quality Assurance Manager, whose responsibility it is to ensure consistency of approach and program independence from operations. The QA team is strengthened through a web-based document control and management system that ensures consistent formats while minimizing routine administrative tasks. Authorized staff have immediate secure access to all corporate and individual laboratory SOPs and support documentation.

The Quality Program is designed to comply with or exceed the data quality objectives of Industry, Canadian Regulators, United States EPA and the International Standards Organization (ISO). The QA team is assisted in performing audits with the help of many trained internal auditors that are composed of operations and support services personnel. This brings many benefits to the customer and to our company. These benefits include improved client and accreditation audits, increased communication between groups within our company, greater variety of work for staff and increased understanding of ISO/IEC 17025, our customer requirements and our own quality requirements.

The keys to the Quality Program are Prevention and Verification.

2.1 Prevention through Quality Assurance

Extensive control charting practices ensure that analyses with biases or which are potentially out of control are recognized early so that potential problems can be rectified before exceedences occur. Comprehensive internal audits of methods, Quality Control (QC) practices, sample analyses, and quality system elements confirm adherence to Standard Operating Procedures. Regular system reviews and a structured Continuous Improvement Program combine to provide the strongest possible Quality System.

Evaluated monthly, score carding of key performance indicators such as Proficiency Testing Performance drives the Program, defining successes and highlighting areas for improvement. We also have a corporate Management of Change procedure whereby substantive changes in the laboratory are adequately reviewed, communicated and documented.

2.0 Quality Program

2.2 Training

Upon hire, personnel are required to participate in the Corporate New Employee Orientation Program (NEOP) where they are trained on the quality management system, Ethics & Integrity, and the Environment, Health and Safety program. In addition to their initial training, they are provided technical training, delivered by designated individuals (supervisor or senior analyst level) with comprehensive working knowledge and experience in the area they are training. To ensure full traceability and auditability, training records for all employees are maintained in our online document control system and in the employee's personal training file, which is maintained by his/her supervisor.

Analyst competence is essential to the production of accurate data. Prior to beginning work in the laboratory, technicians and analysts are required to thoroughly understand the QA objectives and the relevant SOP. This, in conjunction with hands-on training from a senior analyst, ensures successful transfer of information is effective. Demonstration of acceptable performance on laboratory control samples or reference materials by the analyst is required for final certification to perform the method. Ongoing demonstration of capability is provided through blind performance evaluation samples, audits and annual recertification.

2.3 Customer Complaints

Formal responses are required to any customer complaints, discrepancies, deficiencies or quality issues. The deficiencies are recorded in an electronic database and cascade to the supervisor and the analyst for immediate attention. An acknowledgment of the deficiency is required within a specified timeframe accompanied by an action plan, which must include any corrective measures taken along with results of these actions. A follow-up report on the same form must be completed and returned documenting the effectiveness of the improvements implemented. If closure of the issue is not done in the required timeframe the issue is escalated to the next management level promoting prompt resolution of the issue.

2.4 Ethics and Data Integrity

All employees are required to undergo annual ethics training and to read and sign an Ethics and Data Integrity Agreement annually, promising to not knowingly commit an unethical act or through inaction, allow a coworker to do so. Senior management reinforces the program through presentations, discussion and written tests.

2.5 Verification through Quality Control

Public safety, environmental impact and major financial decisions are routinely based on our analytical data. Legal data defensibility is essential to these activities and is verified through a comprehensive quality control program. The protocols and procedures described below are routinely employed and are described in detail in our Standard Operating Procedures (SOPs) for analysis, laboratory practice and staff training. The quality assurance objectives are translated into specific requirements that are written into all standard operating procedures.

2.6 Quality Control Protocols

Each project is conducted under a defined quality control program. Our standard quality control protocols meet or exceed the requirements of Canadian and United States regulators. In addition to this, most large projects have a defined Quality Assurance Project Plan (QAPP) that includes all required data quality objectives. The following table outlines the quality control practices routinely employed in all laboratories. Additional elements or different limits may be used on a project specific basis.

Elements of Quality			*
Eleme	**Frequen**	**Limit**	
Field QC			
Sample Containers	Precleaned to EPA Specs	Non Detect	
Traveling Blanks	Project Specific	<RDL	
Field Duplicates	Project Specific	Project Specific	
Run QC, All Methods			
Method Blanks	1 in 20 or 1/batch	<RDL	
Blank Spikes	1 in 20 or 1/batch	CCME or Provincial limits	
Matrix Spikes	1 in 20 or 1/batch	CCME or Provincial limits	
Duplicates Analysis	1 in 20 or 1/batch	± 20%-50%	
Real Time Control Charts	Key parameters, all tests	± 3 SD, trend analysis	
Inorganic QC			
Instrument Calibration	Multipoint	>0.995 correlation	
Calibration Verification	Daily (second source)	± 10% of initial	
Continuing Cal. Verification	Every 20 samples & at end	± 10% of initial	
Standard Reference Material	Daily – As Required (if available)	SRM limits	
Organic QC			
Instrument Calibration	Multipoint	RSD ± 20%	
Calibration Verification	Daily (second source)	± 20% of initial	
Continuing Cal. Verification	Every 20 samples & at end	RF or RRF ± 30% of initial	
Surrogate Standards	All samples, all organic analyses	CCME or Provincial limits	
Internal Standards (IS)	All Samples (method specific)	-50% to +100% of IS in Cal'n	
Standard Reference Material	As required (if available)	SRM limits	
External QC			
Interlaboratory Comparisons	>50/year	Top 10% overall, >95% acceptable	
Double Blind Program	Annually (Inorganic and [illegible]	Statistical Limits	
Internal QC Checks	As required	In house limits	

Typical QC acceptance criteria. Values may vary for specific tests.

2.7 Accreditation

Bureau Veritas Laboratories hold several accreditations granted by Canadian and United States regulatory organizations. The intent of accreditation is to document through laboratory audit, check samples, and round robin studies, each laboratory's conformance to ISO/IEC 17025, an internationally accepted quality system. The accreditation process is also an integral part of our philosophy of Continuous Improvement. The following organizations have endorsed our quality system. These endorsements are granted on a facility specific basis. In addition, many tier one industries have audited and approved our laboratories.

- Canadian Association for Laboratory Accreditation (CALA)
- Standards Council of Canada (SCC)
- Ministère de l'Environnement et de la Lutte contre les changements climatiques (MELCC)
- National Environmental Laboratory Accreditation (NELAC)
- National Voluntary Laboratory Accreditation Program (NVLAP)
- U.S. Environmental Protection Agency Contract Laboratory
- American Industrial Hygiene Association (AIHA)
- Various US States

2.8 Proficiency Testing

Our laboratories participate in many national and international proficiency testing and double blind check sample programs. As per ISO 17025 requirements, we are required to successfully participate in proficiency testing programs for tests included on our scope of accreditation. We go above and beyond these minimum requirements. Some of the programs in which we are currently participating include:

- Corporate Double Blind Program
- Proficiency Testing Canada (PT Canada) (formerly CALA)
- Phenova
- Environment and Climate Change Canada
- Collaborative Testing Services
- State of New York – Environmental Laboratory Approval Program

2.9 Double Blind Program

The Double Blind Program was implemented to measure the quality of data and service provided to customers. Proficiency testing samples are required as part of standard accreditation programs (ISO/IEC 17025), however they do not adequately simulate lab performance for client samples since the lab knows it is being tested. The double blind program involves using a sample from an accredited proficiency testing provider and having the sample "disguised" as a client sample so the lab is completely unaware their performance is being evaluated. The sample is sent to our laboratories as a regular sample, which upon completion is assessed by the Quality Assurance Department for turnaround time (TAT), data accuracy and traceability. This program best simulates lab performance for real client samples.

2.10 Customer Service / Project Management

The quality process extends beyond accreditations, methods and staff expertise. It includes the management system for all activities from project awards to follow-up customer satisfaction surveys. The heart of the process is the Project Management (PM) team, the largest laboratory customer service team in Canada. This team consists of dedicated professionals whose responsibility it is to ensure the customer gets the tests meeting their requirements, when promised. Project managers are also aware of current and emerging regulations and thus are able to assist customers in choosing the correct testing protocol.

Supporting the PM team is our unique Laboratory Information Management System (MaxxLIMS). MaxxLIMS tracks and monitors all project information and provides a direct link between analysis and reporting. Employing barcodes, MaxxLIMS monitors each sample's progress through the lab as it is received and logged, extracted, analyzed and the resulting data is approved, validated and reported. Comprehensive sample tracking, combined with instrument capacity and staff commitment to customer service, allows clients to be confident in our ability to deliver quality data on time. Customer feedback and PM process insight has driven a number of innovations, mostly made possible through MaxxLIMS.

- Client website access to approved data
- Client website access to project status
- On line bottle orders
- Sample integrity forms
- Custom electronic and hard copy deliverables packages.
- Regulatory reports
- Consolidated invoicing
- Project summary performance reports
- Real time, automated sample log-in and data checks

2.11 The Quality Promise

The Quality Pyramid summarizes our quality promise to our customers. Each component of the pyramid strengthens the overall customer experience and ultimately converges at a single point, the promise to deliver accurate, defensible data to our clients.


Accurate,
Defensible Results
Blind Proficiency Testing
Internal Auditing Program &
Continuous Improvement
Customer Feedback Tools
(CAR, NCR, MOC)
Unbiased Customer Protection
QA Independent of Operations
Comprehensive Employee
Education & Training Program
Experienced, Ethusiastic,
Passionate Staff
Strong Core Values,
Data Integrity & Ethics
Quality Promise = ∑
(Ethics, Experience, Training,
Corporate Committment
Accreditation, Internal Audits,
Continuous Improvement,
Blind PTs)

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SCOPE OF ACCREDITATION

Bureau Veritas Canada (2019) Inc., formerly known as Maxxam Analytics

Petroleum Technology Center

6744 - 50 Street NW
Edmonton, AB T6B
3M9

Accredited Laboratory No. 160

(Conforms with requirements of ISO/IEC 17025:2017)

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URL:	http://www.bvlabs.com
CLIENTS SERVED:	All interested parties
FIELDS OF TESTING:	Biological, Chemical/Physical
PROGRAM SPECIALTY AREA:	Environmental
INITIAL ACCREDITATION DATE:	1995-03-06

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SCOPE ISSUED ON: 2019-07-22

ACCREDITATION VALID TO: 2023-03-06

Note: Environmental testings except for Adsorbable Organic Halides, Total Sulfide by Titration, and Air matrices are performed at:

Bureau Veritas

Edmonton Environmental

9331 48 Street NW
Edmonton, AB

T6B 2R4

ENVIRONMENTAL AND OCCUPATIONAL HEALTH AND SAFETY

Environmental

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Air

PTC SOP - 00128	VOCs by Thermal Desorption Diffusive Tube [EPA 325B] 1, 3-Butadiene Benzene Ethylbenzene m,p-Xylenes o-Xylene Toluene
PTC SOP - 00148	Monitoring NO2 in the Atmosphere by using All-Season Passive Samplers [SM4500-NO2-B/AWMA 91st PAPER 98-TP44.03] Nitrite
PTC SOP - 00149	Monitoring SO2 in the Atmosphere by using All-Season Passive Samplers [H. Tang, B. Brassard, R. Brassard and E. Peake, "A New Passive Sampling System for Monitoring SO2 in the Atmosphere" Proceedings, Clean Air '96: Second North American Conference and Exhibition, Nov. 19-22, 1996 Orlando USA] Sulfite
PTC SOP - 00150	Monitoring H2S in the Atmosphere by using All-Season Passive Samplers [Hongmao Tang "A New All-Season Passive Sampling System for Monitoring H2S in Air" The Scientific World, (2002)2, 155-168] Hydrogen Sulfide
PTC SOP - 00156	Volatile Organic Compounds on Passive Samplers using GC/MS [Modified from BP 36-126-NIOSH Method 1500, Issue 2 (Aug. 15,1994) and Aromatic-NIOSH Method 1501, Issue 2 (Aug 15, 1994)] 1,1,1-Trichloroethane 1,1,2-Trichloroethane 1,2,4-Trimethylbenzene 1,2-Dichlorobenzene 1,3,5-Trimethylbenzene

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1,4-Dichlorobenzene

2-Hexanone

2-methyl-4-Pentanone (MIBK)

3-Ethyltoluene
Benzene
Chlorobenzene
Chloroform
Decane

d-Limonene
Dodecane
Ethylbenzene
Heptane
Isopropylbenzene

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	Methylcyclohexane Naphthalene Nonane
	Octane Styrene Tetrachloroethylene Toluene Trichloroethylene Undecane
	Xylene, Total
PTC SOP - 00157	Monitoring NH_3 in the Atm by using the Ogawa Passive Samplers
	[ASTM D6919]
	Ammonia
PTC SOP - 00197	Monitoring Ozone in the Atmosphere by using Maxxam All-Season Passive Samplers [H. Tang and T. Lau "A New All-Season Passive Sampling System for Monitoring Ozone in Air", Environmental Monitoring and Assessment, 65 (1-2) 129-137, 2000.]
	Ozone

Air Filter

PTC SOP - 00151	Mass Determination of Particulate Matter (PM 2.5 and 10) Gravimetric [Modified from US EPA, Quality Assurance Guidance Document, 2.12: Monitoring PM2.5 in Ambient Air Using Designated Reference or Class I Equivalent Method, Nov. 1998.]
	PM10
	PM2.5
PTC SOP - 00180	Dustfall, Total and Fixed, Gravimetric [Modified from AMD, Appendix 4-6]
	Dustfall, Fixed
	Dustfall, Total

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Soil/Solid

AB SOP-00002	Moisture Content in Soil [modified from CCME Petroleum Hydrocarbons In Soil - Tier 1 Method, Gravimetric] % Moisture
AB SOP-00003	Analysis of PAH in Water, Soil, Oil and Leachates by GC/MS [Modified from EPA 8270, GC/MS] Also includes Water (Organic) 1-Methylnaphthalene 2-Methylnaphthalene Acenaphthene Acenaphthylene

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	Acridine
	Anthracene
	Benzo (a) anthracene
	Benzo (a) pyrene
	Benzo (b, j) fluoranthene Benzo (g,h,i) perylene Benzo (k) fluoranthene Benzo(c)phenanthrene Benzo(e)pyrene Chrysene
	Dibenzo (a,e) pyrene Dibenzo (a,h) anthracene Dibenzo(a,h)pyrene Dibenzo(a,i)pyrene Dibenzo(a,l)pyrene Fluoranthene
	Fluorene
	Indeno (1,2,3 - cd) pyrene
	Naphthalene Perylene Phenanthrene Pyrene Quinoline
AB SOP-00004	Determination of Electrical Conductivity by Manual Meter [Modified From SM 2510 B, Conductivity Meter (Manual)] . Also includes Water - Inorganic
	Conductivity (25°C)
AB SOP-00005	Alkalinity Conductivity Fluoride and pH by PC-Titrate
	[Modified From SM 2320 B, Titrimetric/PC Titrate, Modified from SM
	4500-F C, Ion Selective Electrode/PC Titrate, Modified From SM
	2510 B, Conductivity Meter/PC Titrate and Modified From SM 4500-H+ B, pH Meter/PC Titrate] Also includes Water- Inorganic

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	Alkalinity Conductivity (25ºC) Fluoride
	pH
AB SOP-00006	pH by Manual Meter
	[Modified From SM 4500-H+ B, pH Meter] Also includes Water - Inorganic
	pH
AB SOP-00007	Ammonia-Nitrogen by Konelab - phenate colorimetric method [Modified From SM 4500-NH3 A,G] Also includes Water - Inorganic Ammonia

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AB SOP-00008	TKN by Konelab
	[Modified From EPA 351.1 Colorimetric] Also includes Water - Inorganic
	Dissolved Kjeldahl Nitrogen
	Total Kjeldahl Nitrogen
AB SOP-00012	Total Organic Carbon and Organic Matter in Soil [Modified From Methods Manual For Forest and Plant Analyses, Pages 27-30, Reflux - Titrimetric]
	Organic Matter
	Total Organic Carbon
AB SOP-00019	Calcium Carbonate Equivalence by pH [Modified From SSMA 20.2, pH Meter]
	Calcium Carbonate Equivalence (CCE)
AB SOP-00020	Chloride by Konelab - Automated Ferric Thiocyanate Method [Modified From SM 4500-Cl E, Colorimetric] Also includes Water - Inorganic
	Chloride
AB SOP-00022	Particle Size Distribution by Sieve Analysis [Modified from ASTM D6913, Gravimetric]
	% grain size > 75 um
	% grain size < 75 um Particle Size by sieve (Dry) Particle size by sieve (Special)
AB SOP-00023	Nitrite and Nitrate by Ion Chromatography [Modified from SM
	4110B, Ion Chromatography] Also includes Water - Inorganic
	Nitrate
	Nitrite
AB SOP-00025	Ortho-phosphate (Dissolved) by Konelab - Ascorbic Acid Reduction Method [Modified from SM 4500-P A, F Colorimetric] Also includes Water - Inorganic
	Ortho-phosphate

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AB SOP-00026	Chloride, Sulphate and Bromide by Ion Chromatography [Modified from SM 4110B, Ion Chromatography] Also includes Water-Inorganic Bromide Chloride Sulfate
AB SOP-00030	PSA by Hydrometer - Texture (Sand, Silt, Clay and Gravel) Analysis [Modified from SSMA 55.3, Hydrometer] % clay % gravel % sand % silt

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AB SOP-00033	Preparation of Saturation and Water-Soil Ratio Samples [Modified from SSMA Method 15.2, Gravimetric]
	% Saturation
AB SOP-00039	Extraction and Analysis of BTEX/F1 by HS/GC/MS/FID Water, Soil and Oil [BTEX: Modified from EPA 8260 and EPA 5021, GC/MS – Headspace and F1: Modified from CCME Petroleum Hydrocarbons In Soil - Tier 1 Method, GC/FID - Headspace] [Also includes Water - Organic, BTEX: Modified from EPA 8260 and EPA 5021, GC/MS - Headspace and F1: Modified from CCME Petroleum Hydrocarbons
	- Tier 1 Method and EPA 5021, GC/FID - Headspace. [Also includes Leachates - EPA SW-846 1311 and In-House Modified Method, GC/MS - Headspace]
	1,2,4-Trimethyl Benzene
	Benzene Ethylbenzene F1: C6-C10
	Hexane m/p-xylene
	Methyl tert-butyl ether (MTBE)
	o-xylene Styrene Toluene
AB SOP-00040	Analysis of Extractable Hydrocarbons in Water and Soils by GCFID [Modified from CCME Petroleum Hydrocarbons In Soil - Tier 1
	Method, GC/FID, Gravimetric [Also includes Water – Organic, Modified from CCME Petroleum Hydrocarbons In Soil - Tier 1
	Method, GC/FID, and Modified from Static Sheen Test (EPA Method 1617), Visual
	F2: C10-C16
	F3: C16-C34
	F4: C34-C50
	F4: Gravimetric
	Sheen

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	Total Extractable Hydrocarbons (TEH) (C11-C30)
AB SOP-00042	Metals on Liquids and Solids by ICPOES
	[Modified from EPA SW-846 6010, ICP/OES]
	Also includes Water - Inorganic
	Aluminum Barium Boron Calcium Chromium Iron Lithium
	Magnesium

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Manganese
Phosphorus
Potassium
Silicon
Sodium
Strontium
Sulfur

AB SOP-00043	Metals Analysis on Soils and Waters Using ICPMS

[Modified from EPA SW-846 6020, ICP/MS] Also includes Water - Inorganic and Paint. Also includes Leachates - EPA SW-846 1311 and In-House Modified Method.

Aluminum
Antimony
Arsenic
Barium
Beryllium
Boron
Cadmium
Chromium
Cobalt
Copper
Iron

Lead
Magnesium
Manganese
Mercury
Molybdenum
Nickel
Selenium
Silver
Thallium

Tin
Titanium
Uranium
Vanadium
Zinc
Zirconium

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AB SOP-00049	Particle Size Distribution by Hydrometer [Modified from ASTM D7928, Hydrometer]
	Particle Size Distribution
AB SOP-00050	Dry Bulk Density and Wet Bulk Density [Modified from MSSMA Section 2.21, Gravimetric]
	Dry Bulk Density

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AB SOP-00056	Preparation and Analysis VOC/F1 Water and Soil by HS/GC/MS/FID [Modified from EPA SW-846 8260 and EPA SW-846 5021, GC/MS - Headspace] Also includes Water - Organic
	1,1,1,2-Tetrachloroethane
	1,1,1-Trichloroethane
	1,1,2,2-Tetrachloroethane
	1,1,2-Trichloroethane
	1,1-Dichloroethane
	1,1-dichloroethylene
	1,2,3-Trichlorobenzene
	1,2,4-Trichlorobenzene
	1,2,4-Trimethylbenzene
	1,2-dichlorobenzene
	1,2-dichloroethane
	1,2-Dichloropropane
	1,3,5 Trichlorobenzene
	1,3,5-Trimethylbenzene
	1,3-Dichlorobenzene
	1,4-dichlorobenzene Benzene Bromodichloromethane Bromoform Bromomethane
	Carbon Tetrachloride Chlorobenzene Chlorodibromomethane Chloroethane Chloroform Chloromethane

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cis-1,2-Dichloroethylene
cis-1,3-Dichloropropene
Dichloromethane
Ethylbenzene

Ethylene Dibromide
m/p-xylene

Methyl methacrylate

Methyl t-butyl ether
o-xylene

Styrene
Tetrachloroethylene
Toluene

trans-1,2-Dichloroethylene
trans-1,3-Dichloropropene

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	Trichloroethylene Trichlorofluoromethane Vinyl Chloride
AB SOP-00062	Flashpoint by Small Scale Closed Cup Tester (Setaflash) [Modified from ASTM D3828 Method A, Seta Flash Closed Cup] Also includes Water – Inorganic Flashpoint Temperature
AB SOP-00063	Hexavalent Chromium by Konelab [Modified from SM 3500-Cr B, Colorimetric] Also includes Water - Inorganic Hexavalent Chromium
AB SOP-00067	Elemental Sulphur [Modified from Canadian Journal Of Soil Science, 65, Pp 811-813, Colorimetric] (Only for Soils) Elemental Sulphur
AB SOP-00082	Nitrite and Nitrate by Technicon [Modified from Atlas Chemical Industries Industrial Method No. 857-871, Colorimetric] Also includes Waters - Inorganic Nitrate Nitrite
EENVSOP-00061	Phenols Technicon [Modified from Methods Manual for Chemical Analysis of Water and Wastes, Updated, Alberta Enviro. Centre, Phenolics, Method Code 154 EPA 9066, SSMA 40, Colorimetric] Also includes Waters - Inorganic Phenols
EENVSOP-00062	The Determination of Cyanide by Technicon [Modified from SM 4500-CN, Colorimetric] Also includes Water - Inorganic Cyanide (SAD) Cyanide (WAD) Total Cyanide Water soluble Cyanide

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Soil/Solid Industrial Waste

AB SOP-00045	Specific Gravity [Modified from SM 2701 F, Petroleum and Natural Gas Industries- Field Testing of Drilling Fluids, Specific Gravity] Also includes Water - Inorganic Specific Gravity
AB SOP-00047	Free Liquid (Paint Filter Test) [Modified from EPA 9095, Volumetric]
	Free Liquid in Waste Samples

Water (Inorganic)

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AB SOP-00011	Silica (Reactive) by Konelab - Molybdate/ANSA Reduction Method [Modified From EPA 370.1, Colorimetric] Reactive Silica
AB SOP-00016	Chemical Oxygen Demand (Total and Dissolved) [Modified From SM 5220 D, Colorimetric] COD
AB SOP-00017	Biochemical Oxygen Demand [Modified From SM 5210 B, D.O. Meter] BOD (5 day) CBOD (5 day)
AB SOP-00018	Sulfate by Konelab - Automated Turbidimetry Method [Modified From SM 4500-SO4 E, Turbidimetric] Sulfate
AB SOP-00024	Total Phosphorus by Konelab - Ascorbic Acid Reduction Method [Modified from SM 4500-P A, B, F, Colorimetric] Total Phosphorus
AB SOP-00032	The Determination of Residual Chlorine in Waters [Modified from SM 4500-Cl G, Colorimetric] Free Chlorine Total Chlorine
AB SOP-00041	Ferrous and Ferric Iron in Water-Colorimetric Determination [Modified from SM 3500-Fe A, B, Colorimetric] Ferrous Iron
AB SOP-00058	Dissolved Oxygen- Modified Winkler Method [Modified from SM 4500-O C, Titrimetric] Dissolved Oxygen
AB SOP-00061	Total Suspended Solids, Total Fixed Solids, and Total Volatile Solids [Modified from SM 2540 C, D, E, Gravimetric] Fixed Solids

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	Total Suspended Solids
	Volatile Suspended Solids
AB SOP-00065	Total Dissolved Solids (TDS) [Modified from SM 2540 C, D, E, Gravimetric]
	Total Dissolved Solids
AB SOP-00080	Low Level Sulfide [Modified from SM 4500-S2 D, Colorimetric] Sulfide
AB SOP-00087	Organic Carbon by Technicon - Persulfate UV Oxidation [Modified from Methods Manual For Chemical Analysis Of Water and Wastes, Updated, Alberta Enviro. Centre, Method Code 119, Colorimetric]
	Organic Carbon
EENVSOP-00031	Mercury in Water Samples by Cold Vapour Atomic Absorption
	Spectrometry [Modified from EPA 245.7, Cold Vapour AA] Mercury

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EENVSOP-00065	True Colour [Modified from SM 2120 C, Colorimetric] True Colour
EENVSOP-00066	Turbidity - Nephelometric Method [Modified from SM 2130 B, Nephelometric] Turbidity
EENVSOP-00093	Oil and Grease Water Analysis by Gravimetric Hexane Extraction Method [Modified from SM 5520 B, Gravimetric] Total Oil and Grease Total Petroleum Hydrocarbons (TPH)
EENVSOP-00146	Manganese Divalent Species in Water and Wastewaters [Modified from Hach Method 8149, Colorimetric] Divalent Manganese
EENVSOP-00159	pH Analysis in Bioassay Lab [Modified From SM 4500-H+ B, pH Meter] pH
PTC SOP -00173	Sulphide - Total, Titration Method [SM 4500-S2 F]

Water (Microbiology)

AB SOP-00085	Determination of Iron Related and Sulfate Reducing Bacteria [DBI Biological Activity Reaction Test BART User Manual and modified from DBI Lab-BART Test for IRB and SRB instructions leaflet, BART] Iron Related Bacteria (IRB) Sulfate Reducing Bacteria (SRB)
AB SOP-00089	Total and Fecal Coliforms and E.Coli by Defined Substrate Technique [Modified from SM 9223 A, B, Most Probable Number (Colilert)] Escherichia coli (E. coli) Total Coliforms

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EENVSOP-00157	Fecal Coliforms by Membrane Filtration [Modified from SM 9222, D, Membrane Filtration] Fecal (Thermotolerant) Coliforms
EENVSOP-00163	Heterotrophic Plate Count [Modified from SM 9215 A, B, Pour Plate] Heterotrophic Plate Count (HPC)

Water (Organic)

(Adsorbable Organic Halides - Water [028])

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PTC SOP - 00056	Adsorbable Organic Halides [AE128.1 March 1992/ ASTM D4744] Colormetric Titration

Water (Toxicology)

AB SOP-00083	15 min. Microtox BioAssay using Vibrio fischeri [EPS 1/RM/24, Bioluminescence]
	Microtox IC50 (15 min)
EENVSOP-00154	48-Hr Acute Static Bioassay using Daphnia magna [EPS 1/Rm/11 and EPS 1/RM/14, Acute Lethality (Survival)]
	Daphnia LC50 (48 h)
	Daphnia Single Concentration (48h)
EENVSOP-00155	Ceriodaphnia dubia Reproduction Inhibition and 7-Day Survival Chronic [EPS 1/RM/21, Survival and Reproduction Inhibition] Ceriodaphnia dubia (7d)
EENVSOP-00156	Fathead Minnow Larval Growth and Survival 7 Day Chronic Test
	[EPS 1/RM/22, Survival and Growth Inhibition] Fathead Minnow (7d)
EENVSOP-00160	96-Hour Acute Static Bioassay using Rainbow Trout [EPS 1/RM/9 and EPS 1/RM/13, Acute Lethality (Survival)]
	Trout LC50 (96 h)
	Trout Single Concentration (96h)

NON METALLIC MINERALS AND PRODUCTS

Petroleum Refinery Products: (Including asphalt materials; petrochemicals; fuels and lubricants)

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Fuels and Lubricants

PTC SOP-00010	Determination of Water in Lubricating Oil by the Visual Crackle Test [Fitch, J. C., The Lubrication Field Test and Inspection Guide, Noria Publishing, Booklet, 2000]
PTC SOP-00011	Additives, Wear Metals and Contaminants in Lubricating Oils by ICPOES [ASTM D5185]
PTC SOP-00012	Kinematic Viscosity of Lubricating Oils [ASTM D7279]
PTC SOP-00013	Oxidation, Nitration, Sulphation and Soot of Engine oils by FTIR [ASTM D7418]
PTC SOP-00014	Determination of Fuel Dilution for In-Service Engine Oils by GC [ASTM D7593]

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PTC SOP-00015	Determination of Glycol Contamination for In-Service Engine Oils by GC [ASTM D7922]
PTC SOP-00017	Base Number of Lubricating Oils by Potentiometric Titration [D4739]
PTC SOP-00018	Water Content in Lubricating Oils by Coulometric KF Titration [ASTM D6304]
PTC SOP-00020	ISO Particle Count of Lubricating Oils Using an Optical Particle Counter [ISO 11500:2008]
PTC SOP-00027	Soot Percentage of Diesel Engine Oil by Wilks Soot Meter
PTC SOP-00028	PQ Index of Lubricating Oil
PTC SOP-00029	Analysis of Hydrocarbon Condensates by Heated Flash [GPA 2177, 2186, 2103, 2261]
PTC SOP-00030	Analysis of C4 Components in Condensate [GPA 2177]
PTC SOP-00031	Calibration and Analysis of Trace Sulfur Compounds in Petroleum Products [ASTM D-5504 Modified]
PTC SOP-00033	Calibration and Analysis of Trace Sulfur Compounds in Petroleum Products [ASTM D5623]
PTC SOP-00035	Analysis of Elemental and Polysulphide Sulphur ["Quantitative Determination of Elemental Sulphur in Hydrocarbons, Soils, and Other Materials", Journal of Chromatographic Science, Vol. 27, May 1989 by P.D. Clarke & K.L. Lesage]
PTC SOP-00036	Hydrocarbon C30 Analysis by Gas Chromatography

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	[ASTM D2887/CAN/CGSB 3.0, No.14.3]
PTC SOP-00037	Density of Light Hydrocarbons (condensate) by Digital Densitometer [ASTM D4052/ ASTM D5002]
PTC SOP-00038	Trace Methanol by Gas Chromatography [UOP 569 (modified)]
PTC SOP-00039	Boiling Range Distribution by ASTM D7900
PTC SOP-00044	Analysis of LPG/NGL to C15+ (Extended) [GPA 2186]
PTC SOP-00045	Ponau Analysis [CAN/CGSB 3.0 No. 14.3]
PTC SOP-00048	Hydrocarbon C100 Analysis by Gas Chromatography [ASTM D6352]
PTC SOP-00049	Component Analysis of Glycols, Amines, and Sulfinols by GC [UOP 523 modified]

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PTC SOP-00050	Total Organic Halogens and Organic Chlorides [modified ASTM D4929]
PTC SOP-00051	Boiling Range Distribution of Petroleum Fractions by Gas Chromatography [ASTM D2887]
PTC SOP-00052	High Pressure Density [ASTM D4052/5002]
PTC SOP-00054	Extractable Organic Halogens [U.S EPA 9023]
PTC SOP-00055	Boiling Range Distribution by ASTM D6352
PTC SOP-00057	Total Base Number of Lubricating Oils by Potentiometric Titration [ASTM D2896]
PTC SOP-00058	Molecular Weight by Freezing Point Depression [Cryette Instrument Manual]
PTC SOP-00062	Analysis of Hydrocarbon Gas [GPA 2286]
PTC SOP-00067	Measurement of Viscosity by Cannon - Fenske Opaque Viscometer [ASTM D445;D446]
PTC SOP-00068	Pour Point Analysis of Petroleum Products [ASTM D97; D5853]
PTC SOP-00071	Distillation of Petroleum Products at Atmospheric Pressure [ASTM D86]
PTC SOP-00072	Reid Vapour Pressure of Petroleum Products [ASTM D323A]
PTC SOP-00082	Flash-Point by Pensky-Martens Closed Cup Tester [ASTM D93]
PTC SOP-00083	Detection of Copper Corrosion from Petroleum Products by the Copper Strip

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	[ASTM D130]
PTC SOP-00084	Water and Sediment in Crude by the Centrifuge Method (Laboratory Procedure) [ASTM D4007; ASTM D1796; ASTM D2709]
PTC SOP-00089	Aniline Point of Petroleum Products [ASTM D611]
PTC SOP-00091	Electrical Conductivity of Aviation and Distillate Fuels [ASTM D2624]
PTC SOP-00092	Free Water and Particulate Contamination in Distillate Fuels (Visual Inspection Procedures) [ASTM D4176]
PTC SOP-00093	Filterability of Diesel Fuels by Low Temperature Flow Test (LTFT) [ASTM D4539]
PTC SOP-00097	Determination of Bitumen, Water, Solids by Dean Stark Method [Alberta Research Council Oil Sands Analytical Method Manual, Chapter 1, Method 1.00]
PTC SOP-00099	Density and Relative Density of Liquids by Digital Density Meter [ASTM D4052]

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PTC SOP-00100	Density and Relative Density of Crude Oils by Digital Density Analyzer [ASTM D5002]
PTC SOP-00103	Total Acid Number of Petroleum Products by Potentiometric Titration [ASTM D664]
PTC SOP-00105	Water in Petroleum Products by Coulometric Karl Fischer Titration [ASTM D4928]
PTC SOP-00107	Standard Test Method for Determination of Carbon Residue (Micro Method) [ASTM D4530]
PTC SOP-00111	Total Nitrogen Sulphur in Hydrocarbons by boat-inlet Antek [ASTM D5453-S, ASTM D5762 – N_2, ASTM D4629 – Trace Nitrogen]
PTC SOP-00115	Sediment in Oil by Membrane Filtration [ASTM D4807]
PTC SOP-00116	Sulfur in Petroleum Products by Energy-Dispersive X-Ray Fluorescence Spectroscopy [ASTM D4294]
PTC SOP-00120	Cetane Number of Diesel Fuel Oil [ASTM D613]
PTC SOP-00121	Heat of Combustion of Liquid Hydrocarbon Fuels by Bomb Calorimeter [ASTM D240]
PTC SOP-00122	Lubricity of Diesel Fuels by High Frequency Reciprocating Rig [ASTM D6079]
PTC SOP-00126	Acid Number by Color-Indicator Titration [ASTM D974]
PTC SOP-00175	Ash Content [ASTM D482]
PTC SOP-00204	High Temperature Stability of Distillate Fuels [ASTM D6468]
PTC SOP-00206	Metals Analysis in Organics by ICPOES [ASTM D5708]
PTC SOP-00209	Trace Hydrocarbon Analysis by GC
PTC SOP-00211	Light End Analysis in Stabilized Hydrocarbon Liquids
PTC SOP-00218	Boiling Range distribution by ASTM D7169
PTC SOP-00241	Ultimate Analysis of Coal and Coke (including Sulfur) [ASTM D3176

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	/ ASTM D4239]
PTC SOP-00242	Proximate Analysis of Coal and Coke and Loss on Ignition Determination [ASTM D7582 / ASTM D7348]
PTC SOP-00250	Preparation of Coal Samples and Determination of Moisture in Coal [ASTM D2013 / ASTM D3302]
PTC SOP-00254	Heating Value of Coal and Coke by Bomb Calorimeter [ASTM D5865]
PTC SOP-00267	Viscosity by Stabinger [ASTM D7042]
PTC SOP-00275	Particle Size Distribution by Beckman Coulter Laser Analyzer
PTC SOP-00279	Total Mercury in Coal and Coal Combustion Residues [ASTM D6722]

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Notes:

ASTM: American Society for Testing and Materials

ISO/IEC 17025: 2017: General Requirements for the Competence of Testing and Calibration Laboratories

MSSMA: McKeague, Manual on Soil Sampling and Methods of Analysis

SSMA: Carter, Soil Sampling and Methods of Analysis

Elias Rafoul, Vice President

Accreditation Services

Date: 2019-07-23

Number of Scope Listings: 138

SCC 1003-15/229

Partner File #0

Partner: SCC

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Passive Sample Loading and Storage

Sample Handling

Duplicate or triplicate passive samplers are recommended for each parameter used in the study. Travel blanks are also required to ensure sample integrity.

A quantity equivalent to 10% of the study size is recommended for both duplicate and blank samples. For example, a site with 20 passive air monitoring stations should have 2 blanks and 2 duplicate samples per parameter.

Please observe the following recommendations when handling passive air monitoring samples:

- Wear rubber gloves when handling passive air samples.
- The plastic cover on each passive air sample is in place for sample integrity during transportation only. Please remove this cover prior to installation and replace when removing the sample from the sampling station.
- Install samples into the sampling station with the coloured rings facing downward.
- Care should be taken to avoid damage to the filter barrier inside the coloured ring.
- Please affix sample labels to the passive sampler body.

  Please avoid writing on the samples or sample containers.
- Samples should sealed in bags and sample containers following exposure to preserve sample integrity.
- The Travel Blank must not be opened. Travel Blanks are to remain sealed in their respective containers and returned along with the corresponding sample set.
- Complete the Chain of Custody in full. Record any notes that may affect sample integrity on the chain of custody form. (ie: damaged, missing, etc)

Following the recommended sample exposure period, the samples are to be returned to Bureau Veritas' Edmonton laboratory for analysis. A new set of samples can be installed in the stations immediately or as is appropriate for your sampling project.

Chain of Custody

A Chain of Custody form must be completed for each sample set and included when the samples are returned for analysis.

It is essential that the following information is recorded:

- Sample ID and/or location.
- Sample start date and time
- Sample end date and time
- Analysis required
- Requested turn-around time (regular or rush)
- Complete contact details for invoice and reporting

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Passive Sample Loading and Storage

Parameter	Detection Limit 30 Day Exposure (ppb)	Detection Limit 7 Day Exposure (ppb)	Detection Limit 1 Day Exposure (ppb)	Maximum Sample Load[1] (Summer) (ppb)	Maximum Sample Load[1] (Winter) (ppb)	Storage Life Pre Exposure[2] (days)	Storage Life Post Exposure[2] (days)
SO_2	0.1	0.4	3	75	100	90	90
H_2S	0.02	0.09	0.6	20	30	30	30
NO_2	0.1	0.4	3	55	110	30	30
O_3	0.1	0.4	3	70	100	90	90
NH_3	0.1	0.4	3	3600	3600	90	15

[1] Values are approximate due to variability of meteorological data involved in calculation of final results

[2] Values based on storage at 4 °C

[3] Requires ambient temperature remain > 15 °C

PASSIVE AIR MONITORING OVERVIEW

Success Through Science

TECHNICAL BULLETIN

Site Locations

Installation

Sample Handling

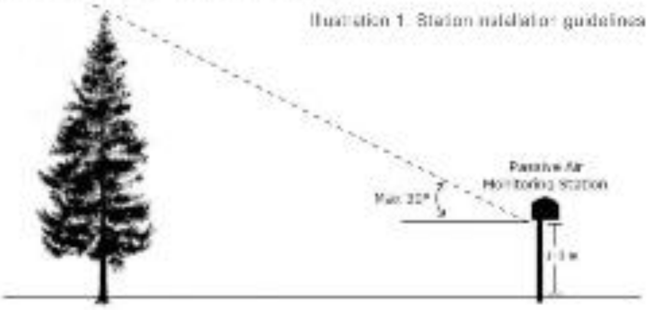
Chain of Custody

Maxxam Analytics
6716 – 50 Street NW
Edmonton, AB T6B 3M9
CANADA

Site Locations

Passive Air Monitoring station locations should be selected based on an objective representation for the geographical area of interest. The most representative monitoring location is typically achieved through the use of an appropriate air dispersion model, which is dependant on the purpose for monitoring. Most environmental guidelines suggest that stations be installed from 1 to 3 metres in height with samples installed at angles of less than 30° to the top of any obstacle.

Illustration 1. Station installation guidelines



Installation

After the optimal site locations have been determined, follow these steps to install Maxxam passive air sampling system shelters and samples:

1. Pound post into ground, leaving at least one metre above ground. NOTE: existing apparatus (such as fence posts, etc.) can be used for affixing monitoring stations.
2. Attach the passive shelter by affixing a hose clamp or other fastening method to the post.

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PASSIVE AIR MONITORING OVERVIEW

Success Through Science®

Fig. 1

Fig. 2

Fig. 3

Fig. 4

Sample Handling

Duplicate or triplicate passive samplers are recommended for each parameter used in the study. Travel blanks are also required to ensure sample integrity. A quantity equivalent to 10% of the study size is recommended for both duplicate and blank samples. For example, a site with 20 passive air monitoring stations should have 2 blanks and 2 duplicate samples per parameter.

Please observe the following recommendations when handling Maxxam passive air monitoring samples:

- Wear rubber gloves when handling passive air sample 'pucks' (Fig. 1).
- The plastic cover on each 'puck' is for sample integrity during transportation only. Please remove this cover prior to installation (Fig. 1) and replace when removing from the sampling station.
- Install sample 'pucks' into the sampling station with the coloured rings facing downward. (Fig. 2)
- Care should be taken to avoid damage to the filter barrier inside the coloured ring.
- Please affix sample labels to the bottom of the passive sampler body. Please avoid affixing sample labels to the sample tins or lids.
- Samples should be returned sealed in bags and tins to preserve sample integrity. (Fig. 3)
- The Travel Blank must not be opened. Travel Blanks are to remain sealed in their respective containers and returned to Maxxam along with the corresponding sample set. (Fig. 4)

Following the recommended sample exposure period, the 'pucks' are returned to Maxxam's Edmonton laboratory for analysis. A new set of sample pucks can be installed in the same sampling station immediately, as appropriate for your sampling project.

Chain of Custody

A Passive Air "Chain of Custody" form must be completed for each project and must be included when the pucks are returned to Maxxam. It is essential that clients provide for each sample ID or location:

- sample start date and time
- sample end date and time
- analysis required
- requested turn-around time (regular or rush)
- complete contact details for invoice and reporting

For more information, please contact:
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or call **1 780 378 8500**

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Research Article

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Introduction to Maxxam All-Season Passive Sampling System and Principles of Proper Use of Passive Samplers in the Field Study

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Maxxam all-season passive sampling system (PASS) is introduced in this paper. The PASS can be used to quantitatively and accurately monitor SO_2, NO_2, O_3, and H_2S in air in all weather conditions with flexible exposure times from several hours to several months. The air pollution detection limits of PASS are very low. They can be from sub ppb to ppt levels. The principles of proper use of passive samplers in the field study are discussed by using the PASS as an example.

KEY WORDS: passive sampling technology, air pollution, sulfur dioxide, nitrogen dioxide, ozone, hydrogen disulfide

DOMAINS: environmental sciences, atmospheric systems; environmental technology, environmental monitoring

INTRODUCTION

Scientific and social interest in monitoring air pollutants indoors and outdoors is manifest in the world. Many monitoring technologies for SO_2, NO_2, O_3, and H_2S in air have been developed and subsequently improved in the past few decades. Generally speaking, these technologies can be classified as integrative collection and real-time analytical technologies. Both technologies can be further divided into two categories: active and passive methods.

Active methods directly pump air through collection or analytical devices to collect or analyze air pollutants. Therefore, electrical power, roads or shelters are required. A passive (or diffusive) sampler is a device which is capable of taking samples of gas or vapor pollutants from air at a rate controlled by a physical process such as diffusion through a static air layer or permeation through a membrane. However, it does not involve the active movement of the air through the sampler. Passive samplers are generally simple in structure and do not require electricity and thus are cost effective and convenient to use.

The key parameter related to the correct measurement of air pollutants by using passive samplers is the sampling rate. Active samplers have a known sampling rate, which is the pump's flow rate. The passive sampler's sampling rates depend on many factors such as temperature, relative humidity (RH), wind direction, wind speed, sampler's structure, and collection media. If a passive sampler can be used in all climate conditions, a fixed passive sampling rate obtained from laboratories cannot be used for ambient studies anywhere and anytime in the world. It would be highly unreasonable to expect that a passive sampler's sampling rate would be the same when temperatures change from -30^{o} to $+30^{o}C$ and relative humidities change from 90 to 15%. Therefore, the key factor for using passive samplers is how to determine their sampling rates.

Commonly used passive sampling devices for SO_2 include a lead dioxide candle (Pb-CAD), Huey plate (H-plate), and K_2CO_3 plate (K-plate). It has been determined that there are deficien- cies with these existing SO_2 passive samplers[1]. Several groups also reported different SO_2 passive samplers[2,3]. Unfortunately, fixed sampling rates obtained by laboratory are used by the authors.

Different NO_2 passive samplers have been developed. Typically, triethanolamine (TEA) is used as a collection medium in the passive samplers since it captures these pollutants very efficiently, and ion chromatography (IC) can be used to conduct analysis with a low detection limit. Scientists in the U.S. have investigated the performance of nitration plates using controlled test atmospheres[4]. Their studies found that temperature, relative humidity and NO_2 concentration strongly affected the nitration plate sampling rates. Scientists from Europe found that TEA could not be used for long-time sampling, e.g., several weeks[5]. Their studies revealed that passive samplers covering the whole period always gave lower results than the summary of the successive samplers.

Ozone (O_3) passive samples have also been troublesome until recently. One reason is that the collection media used to sample ozone also reacts with other oxidants in the atmosphere such as peroxy acyl nitrates and oxides of nitrogen and sulfur. Another reason is the design of the passive samplers using an air gap as a diffusion barrier. For outdoor use, these kinds of passive samplers will be affected by wind direction, wind speed, and dust[6].

An H_2S passive sampler, in common use for many years utilizes a paper impregnated with zinc acetate[7]. The detection limit of H_2S using this method is quite high (2 mg/l in the test solution), and interference from SO_2 in the atmosphere is inevitable. Therefore, the accuracy for this method is questionable. Like other inadequate passive methods, the zinc acetate paper is directly exposed to the atmosphere without any protection such as a diffusion barrier. The diffusion barrier serves to eliminate the effects of particulate contamination and also makes it possible to account for the variables of wind speeds which affect the sampling rate of the device.

It is clear that although passive sampling technology is simple and cost effective compared to active methods, it might be difficult to obtain accurate results if the passive sampler is not designed and used properly. A new Maxxam all-season passive sampling system (PASS) is introduced in this paper. Principles of proper use of passive samplers in the field study are discussed by using the PASS as an example.

MAXXAM ALL-SEASON PASSIVE SAMPLING SYSTEM

The Centre for Passive Sampling Technology of Maxxam Analytics Inc. (CPST) has successfully developed an all-season Passive Air Sampling System (PASS) for sampling SO_2, NO_2, O_3, and H_2S in the atmosphere (see Fig. 1)[6,8,9,10,11] with the support of Alberta Environmental Protection (AEP), Alberta Research Council (ARC), Clean Air Strategic Alliance of Alberta (CASA) and the National Research Council of Canada (NRC). The PASS has passed several independent validations from different government organizations in Canada. The special features of the PASS are as follows.

FIGURE 1. Passive samplers of Maxxam all-season passive sampling system.

* The PASS includes four elements:

2. A newly designed rain shelter (Fig. 2). This rain shelter allows the passive sampler be installed face downwards outdoors.
3. Specially selected and developed collection media.
4. Equations to calculate sampling rates for different air pollutants. The equations account for variations in temperature, relative humidity, and wind speed.

The downward facing installation of the passive samplers can prevent the precipitation of suspended particles in the atmosphere on the surface of the diffusion barriers. This prevents the air pollutants from being absorbed by the particles and avoids the pore-size change of the diffusion barrier, which will eventually change the sampling rate. Face downward installation also helps to obtain air movement across the diffusion barrier surface of a passive sampler, which is the most sufficient way to reduce the air pollution concentration boundary layer generated during sampling.

* The PASS is very sensitive. It can be used to collect ppt levels of H_2S and sub ppb levels of SO_2, NO_2, and O_3 in air.

- The collection time is very flexible. It can be exposed from several hours to several months depending on the monitored pollutant and its average concentration in air.

- A new collection medium for sampling NO_2 — CHEMIX™ — has been developed. CHEMIX™ has been shown to be a highly efficient collection medium for NO_2 in air. Compared to TEA, it is less affected by temperature and relative humidity, and has a higher sampling rate[10].

- By attaching a clip to the sampler body, the PASS sampler can be used as a personal monitor (Fig. 3).

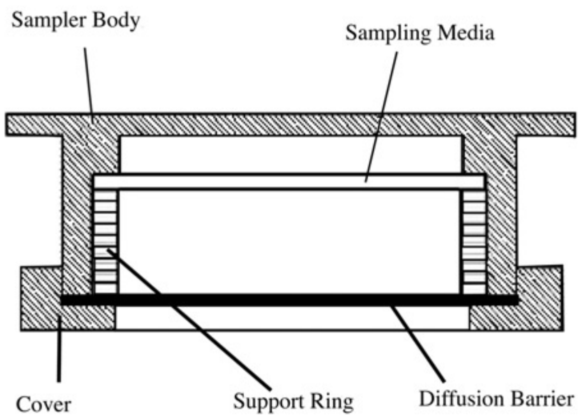

FIGURE 2. Rain shelter of Maxxam all-season passive sampling system with three passive samplers.

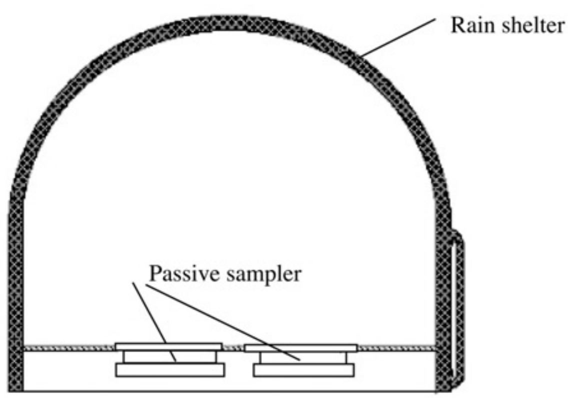

FIGURE 3. Personal monitor of the PASS H_2S.

Laboratory Study

The PASS was developed in a laboratory passive study system in the CPST. The study temperatures ranged from –37° to 32°C, relative humidities from 4 to 95%, and wind speed from 0.5 to 150 cm/s. Sampling rate equations were first derived from the laboratory studies, then validated in field studies. Different air pollutants have different equations[6,8,9,10,11]. The following is an example for calculating PASS SO_2 sampling rate[9].

$$R_S = 12.769T^{1/2} - 0.540RH + 0.276WSP - 135 \qquad (1)$$

where T = average temperature, K, RH = average relative humidity[5] (if RH > 80, then RH = 80), and WSP = average wind speed, cm/sec (if WSP > 130, then WSP = 130). The average temperature, relative humidity, and wind speed can be obtained from local weather stations if the monitoring station cannot provide the information. From Equation 1, it can be seen that the PASS passive sampler performance is proportional to 12.726 $T^{1/2}$, –0.540RH, and 0.276 WSP. Decreases of ambient temperature and wind speed (when WSP < 130) will decrease R_S, but increases of relative humidity (up to 80%) will result in the decrease of the R_S.

After collection, the exposed passive samplers will be analyzed in the laboratory. The instruments and chemicals used for the analyses are basically simple and inexpensive. Ion chromatographs are for SO_2 and ozone passive samplers; the spectrophotometric and continuous flow analysis methods are used for NO_2 passive samplers; fluorometers are used for H_2S passive samplers.

Field Validation

The PASS for SO_2, NO_2, O_3, and H_2S has been validated in many air monitoring stations in Alberta Canada for a long period of time (all seasons)[6,8,9,10,11]. The rain shelters were fastened using an outside bracket in the stations so that the passive samplers were at the same elevation as the inlet for the continuous analyzers. During validation, the temperature ranged from –40° to 35^{o}C, the average wind speed from 20 to over 130 cm/s, and the relative humidity from 30 to 100%. The exposure times ranged from 2 days to 3 months. The correlation between the PASS and an SO_2, NO_2, O_3, or H_2S continuous analyzer is very good.

Fig. 4 is an example of field validation. It shows a whole year comparison results of PASS SO_2 and an SO_2 continuous analyzer in Edmonton Industrial Monitoring Unit (EIMU) in Canada from June 1996 to June 1997. It can be observed that the correlation between the PASS SO_2 and the SO_2 continuous analyzers is excellent in all seasons.

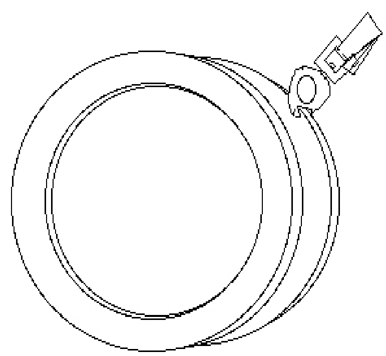

FIGURE 4. All season comparison results between PASS SO_2 and a continuously SO_2 analyzer in EIMU Canada from June 1996 to June 1997.

Independent Validation

The PASS has been independently validated by many Canadian government organizations. ARC supported by NRC conducted an independent validation of the PASS SO_2 in 1997[12]. Two different locations at different seasons were chosen to conduct the independent validation in Alberta, Canada. Table 1 lists the locations, validation periods, SO_2 concentrations measured by the passive samplers and monitored by the continuous analyzers, and the relative errors in each study conducted. AEP conducted

13 months' field validation of the PASS SO_2, NO_2, and O_3 at several stations in Alberta, Canada from December 1998 to December 1999[13]. Those stations are located across Alberta from north to south. The AEP studies included monthly and 3-month exposures in order to compare successive monthly exposure results with 3-month exposure results at the same stations. Excellent results were obtained. Fig.

5 shows an example of the PASS O_3 validation results in Beaver Lodge, Canada from December 1998 to December 1999; and Fig. 6 shows the PASS NO_2 validation results in EIMU and Calgary residential area (CRMU). Table 2 lists comparison results between successive samplers and samplers covered the whole exposure period for PASS SO_2 in three locations in Alberta, Canada. It can be seen that all the comparison results are within 15% relative deviation, which indicates that PASS is a reliable system and can be used to accurately measure SO_2, NO_2, O_3, and H_2S in air.

TABLE 1

Independent Validation Results of PASS SO_2 by ARC

Location*	Exposure date	Passive ppb	Analyzer ppb	Error%
TMK	July 31–Aug. 28	1.3	1.4	7
TMK	Nov. 1–Dec. 3	1.6	1.6	0
EIMU	July 31–Aug. 28	1.8	2.0	10
EIMU	Nov. 1–Dec. 3	3.0	3.2	6

*TMK and EIMU are locations in Alberta, Canada.

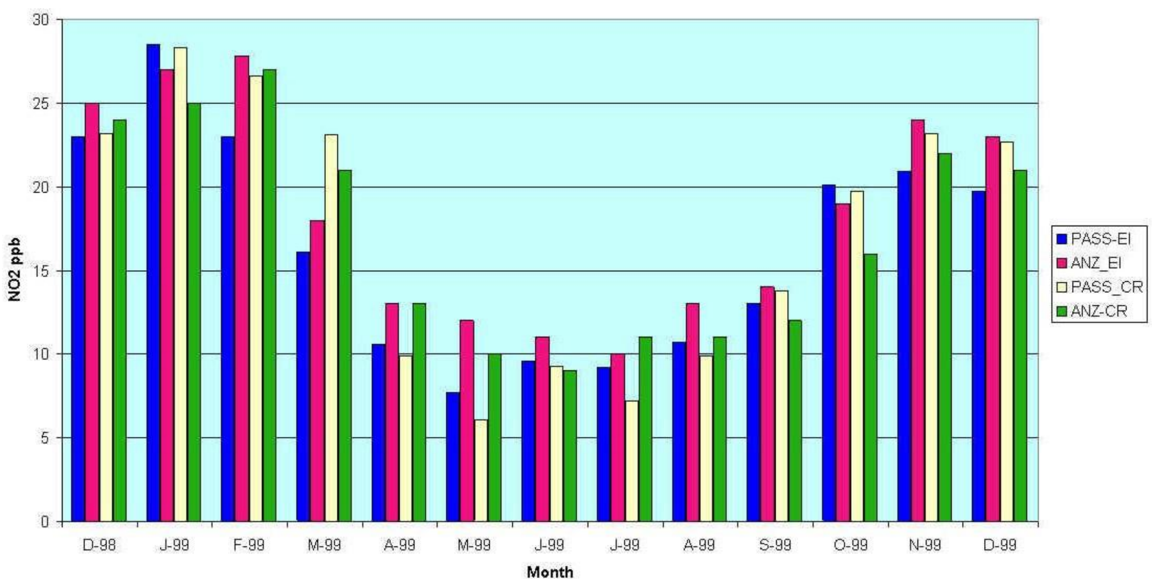

FIGURE 5. Validation results of PASS O_3 by AEP in Beaver Lodge Canada from December 1998 to December 1999 (courtesy from AEP).

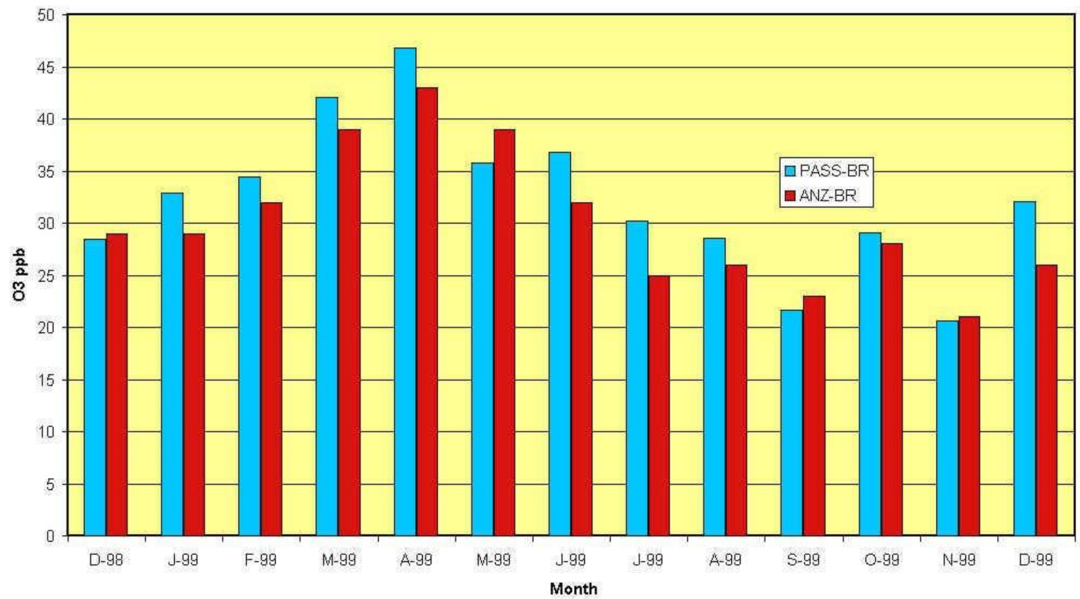

FIGURE 6. Validation results of PASS NO_2 by AEP in Edmonton and Calgary Canada from December 1998 to December 1999 (courtesy from AEP).

TABLE 2

PASS SO_2 Results Comparison of Three Successive Monthly Exposures and Exposures Covered the Whole Three Months in Different Alberta Locations

Location*	Monthly SO_2, pp			Average SO_2, ppb	3-month SO_2, ppb	Error %
	June 1999	July 1999	August 1999			
BR	0.9	1.2	1.0	1.0	1.1	10
CIMU	2.7	2.0	2.2	2.3	2.5	8

*EIMU – Edmonton industrial monitoring unite, Canada; BR – Beaver Lodge, Canada; CIMU – Calgary industrial monitoring unite, Canada

Application

The PASS has been used in many national and international projects. Those projects include indoor air quality studies, industrial hygiene assessments, ambient air pollution monitoring programs, bio-monitoring programs, and model developments of dry deposition. The following is an application example.

Parkland air monitoring zone (PAMZ) is one of the largest airsheds in Canada. It covers hundreds of thousands square kilometers of lands. There are more than 30 passive stations and several continuous air monitoring stations in the airshed. Fig. 7 shows SO_2 concentration distribution of February 2000 in PAMZ. The right side of the map is Canada national park area. There is almost no manmade SO_2 pollution there. Therefore, the SO_2 concentrations in this area were much lower than in other areas where there were a lot of industrial activities.

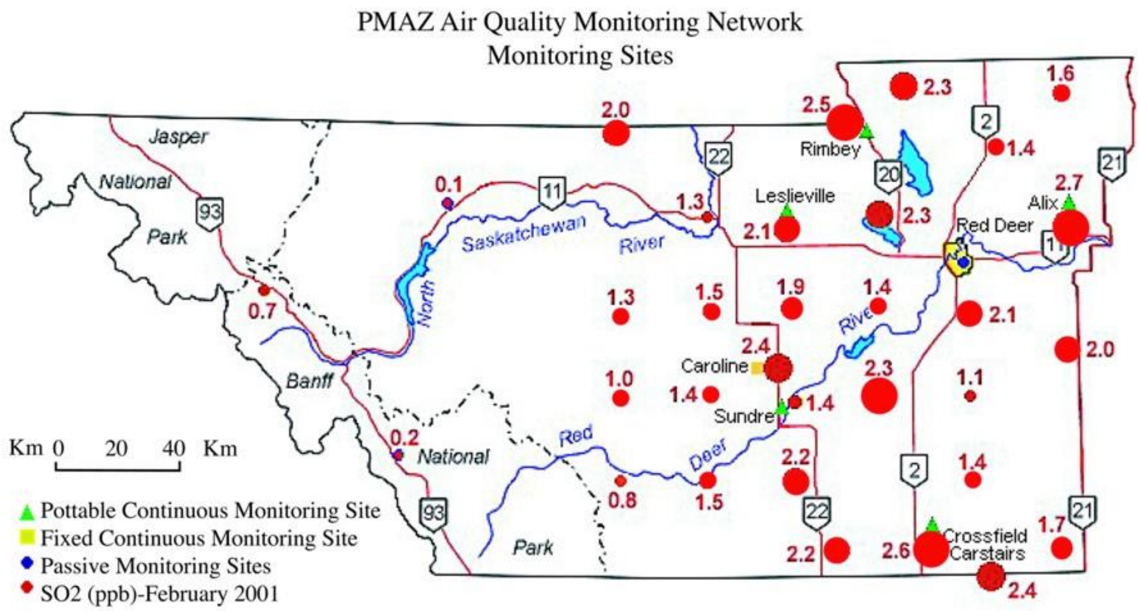

FIGURE 7. February 2000 SO_2 distribution in Parkland Air Monitoring Zone Canada (courtesy from PAMZ)

PROPER USE OF PASSIVE SAMPLERS IN THE FIELD STUDY

Through many years of experience, we have found that the proper use of the PASS has played a very important role for correct assessment of air pollution concentrations in air. The principles of proper use of passive samplers in the field study mainly include four parts:

- How to design a study program;
- How to properly install passive samplers;
- How to determine passive air sampling rates;
- How to establish a relationship between air pollution concentrations obtained by passive samplers and air quality standards. For other special studies, such as health and vegetation studies, the problem is how to establish a relationship between air pollution concentrations and health or vegetation effects.

Program Design and Site Selection

Passive sampling technology can be generally used for two purposes: indoor and outdoor air pollution studies. Indoor studies are basically for indoor air quality, personal exposure, and industrial hygiene purposes. Since indoor environments are relatively simpler than outdoor environments, program designs for indoor studies are easier than those for outdoor studies.

There are generally three applications for using passive sampling technology outdoors. The most common application is use as a compliance tool. In this case, the passive samplers are installed upwind and downwind of a facility to demonstrate the impact that facility has on the local environment (health issues or vegetation issues). The second application is use as additional references or supplementary parameters at a continuous or intermittent monitoring site. The final application is use in large network studies where the aim is to determine average level of pollutants impacting the area or pollutant distributions in the area. The last application has become more and more popular. There have been three air monitoring zones in Alberta, Canada. More zones are under development now. The air monitoring zone normally covers hundreds of thousands square kilometers. Many organizations from government, industry, agriculture, private sector, etc. are involved in the network operation and management.

Site selections are based on a study's need. There are differences for individual studies and network air quality studies. For individual studies, the study site should be close to the study subject.

But for network air quality studies, uniform-siting criteria are necessary to ensure the collection of compatible and comparable data. The following criteria should be considered for network studies.

1. Monitoring sites should not be located near pollution sources that can cause inappropriately high measurement. For example, in farm areas, typical sources will include farm machine emission, fuel and farm equipment storage, etc. A distance of at least 100 m between the site and the source is recommended.
2. Monitoring sites should not be close to roadways. The distance between the site and the roadway should be more than 10 m.
3. In industrial areas, the site should be selected to represent a typical, not a worst case, air pollution concentration level.
4. The preferred site is flat, nonrepresentative valley locations and siting at the top or base of a hill unless special studies are needed for these locations and weather information can be obtained.
5. Monitoring site should be located away from nearby obstructions such as buildings, trees, etc. The ideal monitoring site should be more than 20 m from the nearest tree canopy defined by the drip line.

For network studies, combining passive sampling technology and real-time analytical technology is necessary. Air monitoring stations equipped with air pollution continuous analyzers and climate parameter measurement devices can provide not only weather information for the need of regional passive sampler stations but also comparison results between analyzers and passive samplers. The comparison results are necessary for the network's QA/QC program.

Installation of Passive Samplers

For credible results, it is recommended that triplicate or at least duplicate passive samplers be used for each monitoring location. To validate results, travel blanks must be included. The installation height of the rain shelter should follow the standard site criteria or legal requirement in the study area. For example, the requirements of Alberta Environmental Protection Services[14] are as follows (Fig. 8):

- the rain shelter should be above ground 1–3 m;
- election angle should be $<30^{o}$ from the diffusion barrier surface of the passive sampler to the top of any obstacle; or
- the distance from the obstacle to the rain shelter should be >10 times the obstacle height.

In general, the rain shelter must be installed properly to prevent passive samplers from interference from animals, humans, or surroundings. If there are several rain shelters in one location, they can be installed together (Fig. 9). Passive samplers' exposure start and end times and dates should be recorded on a field-sampling sheet.

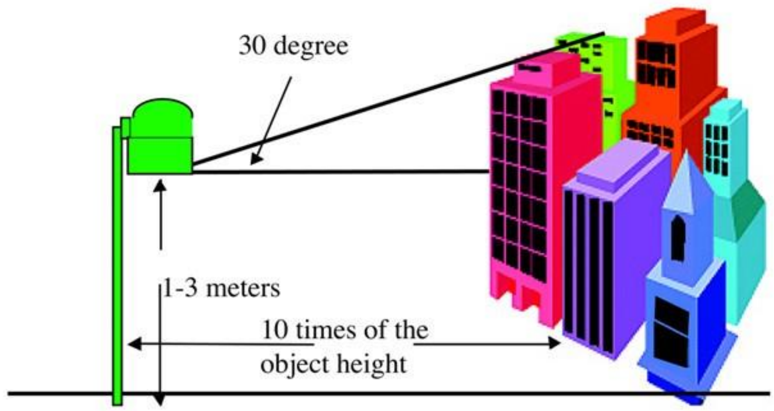

FIGURE 8. Illustration of passive installation criteria.

Passive Sampling Rate Calculation

As discussed before, the passive sampler's sampling rate cannot be a fixed value. It depends on many factors such as temperature, relative humidity (RH), wind direction, wind speed, sampler's structure, and collection media. In PASS, an equation, which accounts for variations in temperature, relative humidity, and wind speed, is used to calculate sampling rates[6,8,9,10,11].

The meteorological parameters used in the sampling rate equations can be obtained from local weather forecast stations or climate normals, such as Canadian Climate Normals (CCN)[12]. CCN is a publication of the Canadian climate program average over a 30-years period of weather parameters for different locations. It is found that the parameters listed in CCN were close to the parameters

FIGURE 9. PASS multi-rain shelter installation (courtesy from PAMZ).

TABLE 3

Comparison of Monthly Temperature and Relative Humidity in Fort. St. John Canada between Year 2000 and CCN 30 Years' Average

Month	Temperature C		Relative Humidity %	
	2000	**CCN**	**2000**	**CCN**
January	-15	-15	70	73
February	10	-11	77	70
March	-7	-6	77	77
April	5	4	60	58
May	8	10	58	55
June	13	14	65	61
July	14	17	67	65
August	16	15	67	70
September	11	10	70	70

October	3	4	64	67
November	-3	-7	80	76
December	-14	-13	78	75

monitored by the local weather station. Table 3 lists meteorological parameter comparison in Fort St. John of British Columbia, Canada between 2000 and the CCN. It can be seen that the values are very close.

Actually, even a 5°C decrease of temperature can only reduce the PASS SO_2 sampling rate around 4%. But during different seasons (such as summer and winter in Alberta) or at different locations in the world (such as Florida, U.S. and Alberta, Canada in winter), the temperature difference might be as high as 50°C. This change is very significant. Assuming RH = 60%, WSP =

12 kmph, the high temperature is 30°C, and the low temperature is –10°C, the SO_2 sampling rates will change from 91 to 76 ml/min. The difference is 15 ml/min. The relative deviation is about 20% to each individual sampling rate. That change is significant.

The change of RH at 5% will also not seriously affect the sampling rate. If RH changes from 60 to 65%, the SO_2 R_S change is about 3%. If the RH change is large, such as from 57 to 78%, combined with the temperature change from 10° to –9°C, the SO_2 sampling rate changes from 85 to 66 ml/min. This change is very significant (>20%).

Our studies show that when meteorological conditions are averaged over a long period such as one month in the same season, they do not vary greatly within a special geographical area (Table 3). For short period studies such as 8 or 24 h, the meteorological parameters might vary from location to location. Real measurements of meteorological parameters are needed.

Relationship between Air Pollution Concentrations Obtained by Passive Samplers and Air Quality Standards

CONCLUSIONS

The new Maxxam all-season passive sampling system described in this paper is suitable for monitoring SO_2, NO_2, O_3, and H_2S concentrations in air, especially for networks. The unique design of PASS can avoid the effects of suspended particles in air and wind direction on sampling rates. The equations associated with meteorological parameters determined from the lab and field studies can provide reasonable sampling rates for field measurement. Passive sampling technology can provide accurate measurement for air pollution only when it is used properly. The proper uses of passive samplers include study program design, site selection, passive sampler installation, correct sampling rate determination, and interpretation of study results.

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A NEW ALL SEASON PASSIVE SAMPLING SYSTEM FOR MONITORING OZONE IN AIR

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Abstract. A new all season passive sampling system for monitoring O_3 in the atmosphere has been developed in the laboratory and validated in the field. The unique features for this system include a newly designed passive sampler and a rain shelter, which allow the passive sampler to be installed in the field facing downwards. An equation associated with meteorological parameters is used to calculate the passive sampling rates. This system has been extensively tested in the lab (temperature from -18 to 20°C, relative humidity from 13 to 81%, and wind speed from 0.5 to 150 emfs) and validated in the field in climates of all seasons. The accuracy of the ozone concentrations in the atmosphere obtained with the use of the new passive sampling system was higher than 85% compared to those obtained with continuous ozone analyzers. The new ozone passive sampling system can be used to measure ambient 0, concentrations ranging from 3 ppb to 1000 ppb based on one-day exposure and 0.1 ppb to 140 ppb for a monthly exposure period. It is also reasonable to conclude that the new passive sampling system can be used for eight-hour exposure study because of the low field blanks and high sampling rates.

Key words: ozone, passive sampler, air pollutant, atmosphere

1. Introduction

Ozone is the most insidious and ubiquitous air pollutant affecting ecological systems and causing health problems for humans and animals in the world. Therefore it is required by regulation to be monitored in many countries. In the assessment of research needs, USEPA has recently identified that rural ozone monitoring network and test value in ecosystem studies of passive monitors should be conducted (Heck et al. 1998).

Over the past few decades, many passive-sampling methods for monitoring 0, in air have been developed (Monn and Hangartner 1990, Grosjean and Hisham 1992, Kanno and Yanagisawa 1992, Koutrakis et al. 1993). Compared to active samplers, passive samplers do not request electricity; therefore, they are cost-effective. The existing passive samplers developed by different groups are using a fixed sampling rate, and there are no systematic studies for being used outdoors at all seasons.

A key parameter related to correct measurement of O_3 in air using a passive sampler is it's sampling rate. The sampling rate is affected by many factors such as temperature, relative humidity (RH), wind direction, wind speed (WSP), sampler's structure, collection media, etc. It would be highly unreasonable to expect that the sampling rate of a passive sampler would not

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vary from -30 to 30°C and from 90% to 15% RH. Further studies are needed to find the relation between a sampling rate and atmospheric conditions.

It is more difficult to use passive samplers outdoors than indoors Because of highly variable temperatures, relative humidity, wind direction, wind speed, rain, snow, dust, etc. Therefore, special designs of passive sampling systems for outdoor use are needed. Some passive samplers are using an open-face cap to allow ozone to diffuse into the sampler and the ozone is then collected by a collection medium (Ogawa & Company 1994). There are two potential problems for using this type of ozone sampler: dust interference and effect of wind speed.

Although many chemicals can be used to collect ozone, studies have shown that sodium nitrite is a better one (Zhou and Smith 1997). Nitrate, a product from the reaction of ozone and nitrite, is used to assess the concentration of ozone.

With the support of National Research Council of Canada (NRC) and Alberta Environmental Protection (AEP), a new Maxxam all-season passive sampling system (MAPSS) for monitoring SO, and NO, have been developed (Tang et al. 1997, 1998). The MAPSS for SO_2 has passed an independent validation conducted by Alberta Research Council (ARC 1998). Excellent results have been obtained (Table 1). The unique features for the MAPSS include:

- A newly designed passive sampler (Figure 1) and a rain shelter (Figure 2), which allow the passive sampler to be installed in the field face downwards. Thus, dust and wind problems can be minimized.
- An equation associated with meteorological parameters which is used to calculate the passive sampling rate.

Table 1

Independent MAPSS SO, Passive Sampler Validation Results

Site	Exposure Date*	Passive ppb	Analyzer ppb	Error%
TMK	Jul 31 -Aug 28	1.3	1.4	7
TMK	Nov 1-Dec 3	1.6	1.6	0
EIMU	Apr 30- May 30	1.8	2.0	10
EIMU	Nov 1 –Dec 3	3.0	3.2	6

*All the studies were conducted in 1997

In this paper, a new Maxxam O, passive sampling system (MOPSS) is reported. The MOPSS employs the same approach as the Maxxam SO, passive sampling system (Tang et al. 1997). Sodium nitrate was used as a collection medium. The MOPSS was first studied in a chamber at different climates. An equation associated with temperature, RH, and WSP was derived from chamber studies.

The MOPSS has been validated for several months in many Canadian locations since 1998. The study period covered summer, fall, and winter. The equation from laboratory studies was used to calculate sampling rates in each location. The passive sampler results were compared to a co- located continuous O_3 analyzer. Very encouraging results have been obtained. Based on one-month exposure, the MOPSS can be used to measure ambient O_3 concentrations ranging from 0.1 ppb to 140 ppb. Compared to continuous O_3 analyzers, the accuracy is 85% higher.

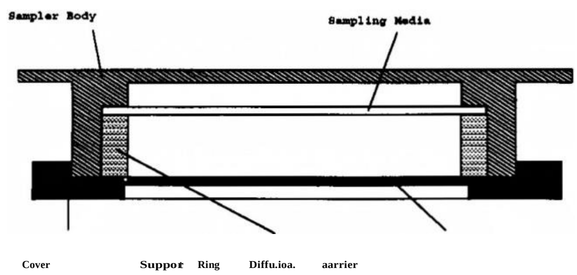

Figure 1. Schematic of the MOPSS Passive Sampler

2. Experimental

2.1 MOPSS PASSIVE SAMPLER

A schematic of the MOPSS passive sampler is shown in Figure 1. It contains a Teflon film as a diffusion barrier and a filter coated with sodium nitrate as a collection medium. An air gap between the diffusion barrier and the collection medium serves as a diffusion zone. The sampler body, support ring, and cover were made from polycarbonate. An edge at the bottom of the passive sampler allows it to be easily installed facing downwards and removed from the MOPSS rain shelter.

2.2 MOPSS RAIN SHELTER

A schematic of the MOPSS rain shelter is shown in Figure 2. It was made from a PVC end-cap for a 6-inch diameter pipe. A slotted plate with three holes was fixed inside the PVC cap. Triplicate passive samplers could be installed in the plate facing downwards. An outside bracket was used to fasten the shelter to fittings.

2.3 CHEMICAL

Chemicals involved in the studies included de-ionized (DI) water, Na_2CO_3, $NaHCO_3$, $NaNO_3$, $NaNO_2$, glycerol, and LiOH (Fisher Scientific, Nepean, CA purified grade).

2.4 TEST PROCEDURE

The MOPSS was first tested in the laboratory using a system previously reported (Tang et al. 1997). An O, analyzer (Model 8002, The Bendix

Corporation, Leursburg) was used to continuously monitor O_3 concentrations during the course of the experiment.

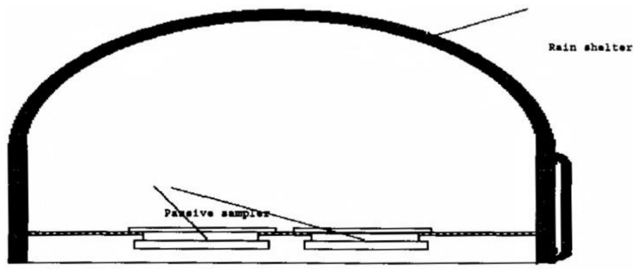

Figure 2. Schematic of MOPSS rain shelter

The MOPSS O_3 passive samplers were exposed in the Maxxam Chamber (Tang et al. 1997) at different conditions. The O_3 concentrations ranged from 20 ppb to 200 ppb, temperatures from -18 to 20°C, RH from 13 to 81%, and face velocities from 0.5 to 170 cm / sec. Triplicate passive samplers and duplicate blanks were studied. The exposure period was approximately 24 hours. After exposure, the medium in the exposed and blank samplers were extracted with DI water and analyzed by ion chromatography.

2.5 FIELD STUDY

The MOPSS passive samplers were installed in six locations in Alberta, Canada. Triplicate passive samplers and duplicate field blanks were used. These stations are equipped with O_3 continuous analyzers (TECO 49, Thermo Environmental Instruments Inc. Franklin, MA), wind speed• monitoring devices (Wind Flo 540, Athabasca Research Ltd. AB), temperature measurement devices (Fluke Model 80TK and 80T-150U, John Fluke MFG CO. INC., Everett, WA), and humidity devices (Vaisula Probe CS500, Vaisula Inc., Woburn, MA).

3. Results and Discussion

3.1 LABORATORY STUDY

A number of studies were conducted in the Maxxam chamber. The test conditions, measured sampling rates, etc., for several studies, are listed in Table 2. The lab triplicate results are very close; average relative standard deviation was 6%. The measured sampling rates range from 43 to 115 ml/min, which reveals the effects of varying temperature, RH, and face velocity on the sampling rate.

3.1.1 *Practical Quantitative Detection Limit*

From laboratory filter blank results, it is found that the pooled standard deviation was 0.6 µg of nitrate per filter based on a 24-hour exposure. The practical quantitative detection limit, thus, can be taken as 6 µg per filter (10 times the standard deviation). This is equivalent to exposure of the passive sampler to 3 ppb O_3 in the atmosphere for 24 hours. If the exposure period were increased to one month (30 days), the method practical quantitative detection limit for O_3 in the atmosphere would be about 0.1 ppb. During the summer, the O_3 concentrations are normally above 30 ppb throughout the day. It is reasonable to conclude that the MOPSS could be used for eight• hour daytime exposure studies.

Table 2

Calculated and Measured R_S Values from Experiments using the Chemex Chamber

Test No.	Temp (°C)	RH (%)	FV (emfs)	R_S Value (ml/min) Calculated	Measured	Error %
1	-1	13	130	86	85	
2	-18	19	130	80	81	1
3	19	45	130	103	105	2
4	19	81	130	113	115	2
5	21	19	130	97	100	3
6	19	21	100	89	101	12
7	18	21	40	72	73	1
8	18	20	150	97	103	6
9	20	20	0.5	62	43	44

RH= relative humidity, FV = face velocity, R_S = sampling rate

The MOPSS passive samplers were also exposed for 21 days in the Maxxam chamber at 200 ppb, 130 cm/sec of face velocity, 20°C, and 40% of RH. It was observed that the passive samplers were still not saturated. Therefore, based on a one-month exposure period, it is estimated that the passive sampler can be used to monitor 140 ppb O_3 in the atmosphere.

3.1.2 *Effect of Temperature, Face Velocity, and Relative Humidity*

As shown in Table 2, sampling rates increase with the increase of temperature, wind speed, and relative humidity. For example, at a temperature of –18°C, 19% RH, and 130 cm/sec of face velocity, the measured R_S was 81 ml/min, but at 31°C and 19% RH, the measured R_S was 100 ml/min. The overall Rs increase from -18°C to 21°C was 19 ml/min, which is about a 23% increase. This change is very significant.

Many authors have reported the effect of face velocity on sampling rates (Harper and Purnell 1987). Our studies confirmed findings by these authors. However, we also noticed that even if the face velocity was higher than 100 cm/sec for the MOPSS passive sampler, the sampling rate continuously increased. The threshold face velocity was determined from laboratory studies to be about 130 cm/sec or 4.7 kilometres per hour (km/h).

3.2 EQUATION FOR CALCULATION OF SAMPLING RATE

From the laboratory chamber studies, an equation for calculating the MOPSS passive sampler rates associated with temperature, RH, and face velocity (wind speed) was determined as follows:

$$R_5 = 14.8T^{1/2} + 0.259\ RH + 0.275\ WSP - 197 \quad (1)$$

Where R_5 = sampling rate, ml/min; T = temperature, K; RH = humidity (%);

WSP = windspeed, cm/sec; if WSP> 130, then WSP = 130.

The calculated R_5s are shown in Table 2. Compared to measured R_5s, it is seen that the largest percent error is in test 9, in which the face velocity was only 0.5 cm/sec. This test further proved findings by other scientists that a minimum 10 cm/sec face velocity is required for properly operating a passive sampler. Fortunately there are very few cases of such low wind speeds occurring outdoors, and it is therefore unnecessary to worry about such low wind speeds using the MOPSS passive samplers outdoors. The other test errors ranged from Oto 12%.

3.3 FIELD STUDY

Field study results are listed in Table 3. Table 3 shows the locations, study periods, meteorological conditions, calculated sampling rates, and O_3 concentrations measured by the passive samplers and monitored by the O_3 continuous analyzers and the relative errors in each study. Table 3 clearly shows that the study accuracy is excellent. Field study results indicate that the relative error using the MOPSS passive sampler is within 15% compared to the continuous O_3 analyzer. Figure 3 is a map of Alberta, Canada. All study locations are shown in this map

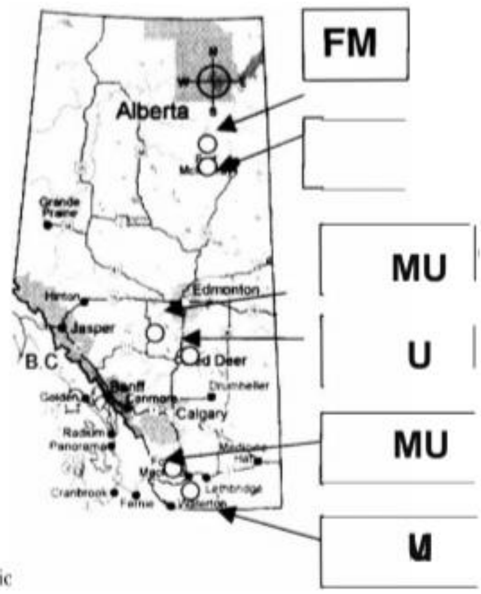

Figure 3. Study locatic

Table 3
Field Study Results

#	Location	Day	Date	RH %	T OC	WSP Km/h	R, cm/min	Ozone J212m Passive	Ozone J212m Anal~zer	Error %
	EIMU	14	10-24 Jun	63	17	11	108	22	24	8
2	EIMU	57	lOJun - 5 Aug	69	17	11	109	25	26	4
3	ERMU	2	23–25 Jun	60	16	10	107	33	33	0
4	ERMU	23	14-30 Dec	70	-20	10	92	19	20	6
5	CIMU	27	4-31 Aug	70	20	11	112	24	21	14
6	CIMU	27	4-31 Aug	70	20	11	112	28	29	3
7	PM	28	31 Jul - 28Aug	59	18	10	108	23	24	4
8	FM	31	300ct-30Nov	86	-8	9	103	15	15	0

- EIMU, Edmonton industrial monitoring unit; ERMU, Edmonton residential monitoring unit; CIMU, Calgary industrial monitoring unit; CRMU, Calgary residential monitoring unit; PM, Patricia McLnniss; FM, Ft McKay.

The field study results further prove the importance of Equation 1. Using a fixed sampling rate to conduct calculations in different seasons will cause errors. Study #4, ERMU, is a typical example. Studies #3 and #4 were conducted at the same location but in different seasons. If using Study #3 sampling rates to calculate Study #4 ozone concentrations, the result is 16 ppb. Thus, the relative error compared to the continuous analyzer is 20%, not 6%. When considering the operation of MOPSS at different seasons and different geographical areas in the world, the difference of the sampling rate might be larger.

3.4 SENSITIVITY OF SAMPLING RATE TO METEOROLOGICAL CONDITIONS

The average monthly meteorological parameters used in Equation 1 can be obtained from local weather forecast stations or ECN (1993). It is found that parameters listed in ECN (1993) were close to parameter values monitored by the local weather station based on monthly averages. For example, the temperature for EIMU in Field Study #2 was 17°C obtained from the local weather station; and the temperature listed in ECN was 17.5°C. Even a 5°C decrease in temperature would only reduce the sampling rate from 109 to 107 ml/min (Field Study #2). At different seasons (such as summer and winter in Alberta), or at different locations in the world (such as Florida and Alberta in winter), the temperature difference might be as high as 50°C. This change is very significant. Assuming RH = 60%, WSP = 12 km/h, high temperature is 30°C, and love temperature is -10°C, the sampling rates will change from 111 to 94 ml/min. The difference is 17 ml/min. The change of RH at 5% will not seriously affect the sampling rate either. Let us still using Field Study #1 as an example. If RH changes from 63% to 68%, the Rs changes from 108 to 109 ml/min. The change is only 1 ml/min. If the RH change is large, such as from 63% to 10%, the sampling rate will change from 107 to 95 ml/min. This change is very significant (>12%).

3.5 ACCURACY

Tables 2 and 3 compare the accuracy of the MOPSS with the O_3 continuous analyzer. In both field and laboratory studies, the relative error between the calculated and measured R_S ranged from 1% to 14%.

4. Conclusion

The new Maxxam all season O_3 passive sampling system described in this report is suitable for monitoring O_3 concentrations in the atmosphere for field studies and networks. The unique design of MOPSS minimizes interference of suspended particles on sampling rates. The equation determined from lab and field studies can provide reasonable sampling rates for field measurement. Based on laboratory studies, the MOPSS can be used to measure ambient O_3 concentrations ranging from 3 ppb to 1000 ppb based on one-day exposure and 0.1 ppb to 140 ppb for a monthly exposure period. It is also reasonable to conclude that the MOPSS can be used for eight-hour exposure studies because of the low field blanks and high sampling rate.

Acknowledgements

This study was supported by National Research Council of Canada. Many thanks to Mr. Ray Brassard of Alberta Environmental Protection for technical help. The authors also want to express their appreciation to Dr. Warren B. Kindzierski of the University of Alberta for constructive review.

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E-mail Correspondences between Levi Manchak (Bureau Veritas Canada) and Neil Harper (Equilibrium Envionmental Services Limited)

From: Levi Manchak <levi.manchak@bureauveritas.com>

Sent: Wednesday, April 28, 2021 8:00 AM

To: Neil Harper <nharper@ees.co.tt>

Subject: BV Labs QA/QC Documentation & Supplementary Materials

Hi Neil,

With those levels, theoretically, yes you should have resolution at 8 hrs exposure.

Thanks,

Levi Manchak

Sr. Project Manager

Bureau Veritas Canada

6744 50 Street NW, Edmonton, AB, T6B 3M9

Phone: 780 378 8542
www,bvna.com
Shaping a world of trust

From: Neil Harper <nharper@ees.co.tt>

Sent: Wednesday, April 28, 2021 8:53 AM

To: Levi Manchak <levi.manchak@bureauveritas.com>

Subject: RE: BV Labs QA/QC Documentation & Supplementary Materials

Noted on the table, but I just wanted to be sure that it can be done.

Our typical background levels are between 20-30 ppb.

Our limit for 8 hours is 120 ug/m3 = 60ppb.

So I could still achieve resolution, yes?

Regards,

ees EQUILIBRIUM ENVIRONMENTAL SERVICES LIMITED

Neil Harper

Managing Director

Equilibrium Environmental Services Limited

M: 868-341-6541

E: nharper@ees.co.tt

W: www.ees.co.tt

Safe TO Work

EES is a STOW-TT certified company

From: Levi Manchak <levi.manchak@bureauveritas.com>

Sent: Wednesday, 28 April 2021 10:01 AM

To: nharper@ees.co.tt

Subject: Re: BV Labs QA/QC Documentation & Supplementary Materials

Hi Neil,

It's a logarithmic scale so exposure for 8 hr would raise the detection limit to 9 ppb.

Please don't hesitate with any further questions or comments.

Thanks,

Levi Manchak

Sr. Project Manager

Bureau Veritas Canada

6744 50 Street NW, Edmonton, AB, T6B 3M9

Phone: 780 378 8542
www,bvna.com

Shaping a world of trust

From: nharper@ees.co.tt <nharper@ees.co.tt>

Sent: Tuesday, April 27, 2021 4:53 PM

To: Levi Manchak <levi.manchak@bureauveritas.com>

Subject: RE: BV Labs QA/QC Documentation & Supplementary Materials

That's what I thought. However the document refers to the Ozone 1-day limit as 3 ppb already??

Do you have a table showing sub-1-day limits?

Regards,

Neil Harper

Managing Director

Equilibrium Environmental Servies Ltd

M   868-341-6541

E   nharper@ees.co.tt

From: Levi Manchak <levi.manchak@bureauveritas.com>

Sent: Tuesday, April 27, 2021 6:39 PM

To: nharper@ees.co.tt

Subject: Re: BV Labs QA/QC Documentation & Supplementary Materials

Hi Neil,

Yes, O3 can be used for 8 hr exposure periods, but it raises the detection limit to 9 ppb.
I've attached the document as requested.

Kind regards,

Levi Manchak

Sr. Project Manager

Bureau Veritas Canada

6744 50 Street NW, Edmonton, AB, T6B 3M9

Phone: 780 378 8542
www,bvna.com

Shaping a world of trust

From: nharper@ees.co.tt <nharper@ees.co.tt>

Sent: Tuesday, April 27, 2021 4:27 PM

To: Levi Manchak <levi.manchak@bureauveritas.com>

Subject: RE: BV Labs QA/QC Documentation & Supplementary Materials

Levi,

I trust all is well.

Can you confirm if the Ozone badge can deployed for 8hr sampling? I seem to recall that the old correlation study spoke to the ozone being able to be used for sub 24 hour studies.

Can you send a table with what the method detection would be compared to 24hr sampling?

Thanks,

Neil Harper

Managing Director

Equilibrium Environmental Servies Ltd.

M 868-341-6541

E nharper@ees.co.tt

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Passive Sample Loading and Storage

Parameter	Detection Limit 30 Day Exposure (ppb)	Detection Limit 7 Day Exposure (ppb)	Detection Limit 1 Day Exposure (ppb)	Maximum Sample Load[1] (Summer) (ppb)	Maximum Sample Load[1] (Winter) (ppb)	Storage Life Pre Exposure[2] (days)	Storage Life Post Exposure[2] (days)
SO_2	0.1	0.4	3	75	100	90	90
H_2S	0.02	0.09	0.6	20	30	30	30
NO_2	0.1	0.4	3	55	110	30	30
O_3	0.1	0.4	3	70	100	90	90
NH_3	0.1	0.4	3	3600	3600	90	15

[1] Values are approximate due to variability of meteorological data involved in calculation of final results

[2] Values based on storage at 4 °C

[3] Requires ambient temperature remain > 15 °C

Passive Sample Loading and Stora

Shaping a world of trust

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ARA N-FRM Sampler

The ARA N-FRM ("Near" FRM) is a portable, rapidly deployable, battery-powered particulate sampling and monitoring device. It delivers Federal Reference Method (FRM) level of performance and integrates many additional functions for unmatched versatility. The compact-sized sampler collects 24-hour TSP, PM10, or PM2.5 filter samples and can simultaneously measure local meteorological parameters. It can also be equipped with a light scattering particle sensor to log temporal particulate variations. For added versatility, the N-FRM can be operated in directional sampling mode and also has the capability of remote turn on. For more utility, the N-FRM can be operated in sensor only mode for long term collection of meteorological and particulate data.

PN 101-000 N-FRM PM2.5 Sampler
PN 102-000 N-FRM PM10 Sampler
PN 103-000 N-FRM TSP Sampler

Specifications

Flow Range: 10-20 LPM

Nominal Flow: 16.7 LPM

Flow Accuracy: +/-2% Flow

Precision: +/-2%

Li-Ion Batteries: 18V /5Ah

Recharge Time: 1-Hour

Battery Operation: 30+ hrs

Data Output: USB Flash

Dimensions: 10” x 12” x 7”

Sampler Weight: 15 LBS

Shipping Weight: 25 LBS

ARA Instruments

ARA N-FRM Sampler

Features

- Versatile inlet configurations for PM2.5, PM10, or TSP sampling
- FRM quality 24-hour samples at 16.7 LPM
- Cost effective at only a fraction of traditional site-based FRM samplers
- Defensible data logging capabilities for all sampling parameters
- Deployable compact size and battery power allows remote use
- Flexible mounting options for rapid deployment
- Real-time particle sensor option for PM10 and PM2.5
- Directional sampling capability with optional meteorological sensor
- Sensor only mode for long term meteorological and dust surveys
- Easy data retrieval via USB flash drive
- Programmable with intuitive user interface
- Low maintenance particulate separators require no grease or oil
- Rechargeable batteries complete full charge in 1 hour
- Standard FRM 47mm filter media and cassettes

Applications

Urban Air Monitoring Networks
National Air Monitoring Networks
Roadside Air Monitoring

Industrial Perimeter Monitoring
Environmental Impact Assessments
Research Projects

Short-Term Hot Spot & Emergency Monitoring

Industrial Hygiene

ARA Instruments

HOBO Data Loggers

Barometric Pressure Smart Sensor (S-BPA-CM10) Manual

The barometric pressure smart sensor is designed to work with HOBO® stations. The smart sensor has a plug-in modular connector that allows it to be added easily to a HOBO station. All calibration parameters are stored inside the smart sensor, which automatically communicates configuration information to the logger without any programming or extensive user setup.

Barometric Pressure Smart Sensor

S-BPA-CM10

Items Included:

- Hook and loop tape

Accessories:

- Smart sensor extension cables (S-EXT-M-0xx)
- Weatherproof connection housing (S-EXT-CASE)
- Cable caddy (M-CDY)

Specifications

Measurement Range	660 to 1070 mbar (19.47 to 31.55 in. Hg)
Accuracy	±3.0 mbar (0.088 in. Hg) over full pressure range at 25°C (77°F); maximum error of ±5.0 mbar (0.148 in. Hg) over -40° to 70°C (-40° to 158°F)
Resolution	0.1 mbar (.003 in. Hg)
Drift	1.0 mbar (0.03 in. Hg) per year
Operating Temperature Range	-40° to 70°C (-40° to 158°F)
Environmental Rating	Weatherproof when used inside logger enclosure
Dimensions	4.5 x 4.8 x 1.6 cm (1.75 x 1.88 x 0.63 in.)
Weight	30 g (1 oz)
Bits per Sample	12
Number of Data Channels*	1
Measurement Averaging Option	Yes
Cable Length Available	10 cm (4 in.)
Length of Smart Sensor Network Cable*	0.1 m (0.3 ft)
CE	The CE Marking identifies this product as complying with all relevant directives in the European Union (EU).

* A single HOBO station can accommodate 15 data channels and up to 100 m (328 ft) of smart sensor cable (the digital communications portion of the sensor cables).

Mounting

- The barometric pressure smart sensor must be used inside the logger housing. Use the hook and loop tape to affix it to the inside the logger enclosure.

- The barometric pressure smart sensor measures the air pressure inside the enclosure.

  Therefore, the vent at the bottom of the enclosure must be free from obstructions for the sensor to function correctly.

- Refer to the logger manual for more information regarding setting up station loggers.

Connecting the Sensor to a Station

To connect the sensor to a station, stop the station from logging and insert the smart sensor's modular jack into an available smart sensor port on the station. See the station manual for details on operating stations with smart sensors.

Operation

The barometric pressure smart sensor supports measurement averaging. When measurement averaging is enabled, data is sampled more frequently than it is logged. The multiple samples are then averaged together and the average value is stored as the data for the interval. For example, if the logging interval is set at 10 minutes and the sampling interval is set at 1 minute, each data point in the data file will be the average of 10 measurements. Measurement averaging is useful for reducing noise in the data. It is recommended that measurement averaging be used when the barometric pressure smart sensor is used in a windy location. Note that fast sampling intervals (less than 1 minute) may significantly reduce battery life. Refer to the logger manual for more details about smart sensor operation and battery life.

Maintenance

Use a damp sponge or rag to clean the barometric pressure smart sensor housing if it gets dirty or needs to be cleaned. Under no circumstances should the unit be immersed in water or any other cleaning solvent. Do not open the sensor as there are no user serviceable parts inside. The electronics are sensitive to light. Do not remove the black label over the sensor. The sensor will give inaccurate measurements if exposed to light.

Verifying Sensor Accuracy

It is recommended that you check the accuracy of the barometric pressure smart sensor annually. The barometric pressure smart sensor cannot be re-calibrated. Onset uses precision components to obtain accurate measurements. If the smart sensor is not providing accurate data, then it may be damaged and should be replaced.

ONSET
1-800-LOGGERS (564-4377) • 508-759-9500
www.onsetcomp.com/support/contact

6122-E MAN-S-BPA

Standard Operating Procedures Particulate Sampling

1 INTRODUCTION

ARA Instruments Mission

Our mission at ARA Instruments is to help environmental professionals make important air quality decisions by providing them with cost effective, accurate, and reliable instrumentation. Our air samplers and calibration instruments are used in outdoor ambient air quality applications as well as indoor and industrial uses.

Overview

In response to the need for a low cost alternative to traditional site-based particulate monitors, ARA Instruments introduced a sampler that establishes a new class of air sampler we call "Near FRM" (N•FRM). The ARA N-FRM Sampler is a portable, rapidly deployable, battery powered particulate sampling and monitoring device that delivers Federal Reference Method (FRM) level of performance. It integrates with many additional components for unmatched versatility. The compact sampler collects 24-hour TSP, PM10, or PM2.5 filter samples and can simultaneously measure local meteorological parameters. It can also be equipped with a Real-Time Particulate (RTP) Profiler to log temporal particulate variations. For added versatility, the N-FRM Sampler can be operated in directional wind sampling mode or collect only sensor data in meteorological mode.

The N-FRM Sampler offers near FRM performance, while costing a fraction of traditional site-based air samplers. Its compact size and battery-powered function, gives the N-FRM Sampler many advantages over traditional air samplers. Deployment and relocation is quick and easy, and allows monitoring in locations that are inaccessible with traditional air samplers. Flexible mounting options allow for stand•alone support or the use of existing poles and structures. The ability of the N-FRM to operate on rechargeable batteries also significantly reduces the cost of establishing a monitoring site.

The N-FRM is designed for easy operation and maintenance. The intuitive user interface makes programming and calibrating the sampler simple. PM10 and PM2.5 inlets are field serviceable and require only monthly cleanings. Filter holders accept standard 47mm FRM cassettes for easy handling of various filter media. Batteries can be recharged in approximately 1-hour. Data log files with 5-min averages for all sensors can easily be downloaded to a USB Flash drive.

Cities and governments are deploying networks of N-FRM Samplers to survey unmonitored areas and validate permanent Reference Method equipment. Researchers and consultants use the N-FRM in air quality studies and environmental impact assessments. They are also utilized in industrial pollution applications, such as mines and quarries, and in large construction projects for fence line and roadside monitoring. The small and quiet N-FRM air sampler is also a great tool for indoor and industrial workplace sampling that requires high accuracy.

Better than FRM

The N-FRM sampler was designed to be the most versatile and cost-effective solution for air pollution research applications. Traditional filter based sampling methods provide an accurate measurement of particulate matter at a fixed location over a 24-hour period, and are used to determine compliance with national air quality standards. However, adding real-time meteorological and PM data gives air quality professionals a higher understanding of the data, which is crucial to designing effective control strategies. The N-FRM has the capability of directional air sampling for fence line, roadside, or single source impact air quality investigations. Additionally, the N-FRM can be used to "saturate" a study area with multiple samplers to obtain an accurate picture of spatial particulate distribution.

1.1 Principles of Operation

The N-FRM Sampler is specifically designed to meet the US-EPA operational specifications for PMIO and PM2.5 air sampling. To meet the EPA specifications, the N-FRM Sampler is designed to operate at 16.7 LPM and collect 24-hour samples to compare to EPA National Ambient Air Quality Standards. The ARA N-FRM Sampler is a microprocessor-controlled portable air sampler, which can be operated manually or programmed to collect scheduled samples. As specified by the EPA, all critical air sampling parameters are continuously monitored and logged as time indexed 5-min averages to validate the sample. These parameters include: flow rate, temperature, barometric pressure, and accumulated volume. Other sampler related performance parameters are also logged. If the N-FRM Sampler is equipped with the Real-Time Particulate {RTP) Profiler and meteorological sensors, then PMlO, PM2.5, wind speed, and wind direction are also included in the data record.

The N-FRM sampler can be easily deployed. It can be mounted on a variety of structures using our universal mounting bracket that can be screwed, clamped, or attached to utility poles, trees, fence posts, etc. Another option is to use a freestanding tripod.

The N-FRM Sampler is equipped to operate from either AC or DC power sources. In the DC mode, the sampler operates from an internal battery pack. A charged battery pack is capable of operating the sampler for about 30-40 hours. This robust capacity allows the sampler to be used in cold weather and high altitude applications. A charger is supplied so the batteries can be re-charged in approximately one hour.

1.2 Particulate Matter Sampling

The N-FRM Sampler can be set up for TSP, PMlO, or PM2.5 particulate sampling by configuring the sampling inlet components prior to the filter medium. To measure TSP, the omnidirectional Louvered Inlet is all that is required. For PMIO sampling, an FRM style inertial separator {PMlO Impactor) is added. To collect PM2.5, the sharp-cut ARAVIS-A Cyclone is attached, which physically selects particles 2.5 microns and below. Common N-FRM inlet configurations are shown in FIG. 1.

The N-FRM inertial separators {PMlO Impactor) are designed to operate at a nominal sampling rate of 1 cubic meter per hour {16.7 liters per minute). The N-FRM Sampler incorporates a microprocessor-based active flow control to maintain the sampling rate as ambient conditions and filter loading changes. The sampling rate is monitored and adjusted several times a second and logged at 5-min intervals along with all other important sampling parameters.

To allow for unattended operation, the N-FRM Sampler is easily programmed to initiate and stop sampling. For each sampling event, the N-FRM Sampler generates a summary of important sampling parameters such as start and stop times, total sampling volume, and average ambient temperature and pressure as well as 5-min averages of all ambient and sampler operational parameters. The logged data file can be easily downloaded to a USB flash drive by the operator. The "csv" {comma separated value) file can easily be imported into a spreadsheet.

2 Hardware Description

2.1 PM10 Inlet

The ARA omnidirectional PM10 Inlet is a compact version of the EPA prescribed Reference Method Inlet. It features a screened inlet, wind deflector, and precision PM10 inertial separator (impactor) with moisture trap. The PM10 Inlet is designed to operate at 1 cubic meter per hour (16.67 LPM). The inlet can be used alone for PM10 sampling or in combination with the ARA VIS-A sharp-cut vortex inversion separator for PM2.5.

2.2 PM2.5 Cyclone

The ARA VIS-A (Vortex Inversion Separator) is a precision engineered and compact sharp-cut cyclone fitted to the N-FRM inlet that physically selects particles 2.5 microns and below. This ensures precise measurement of only the PM2.5 size fraction. The PM2.5 separator is designed to operate at 1 cubic meter per hour (16.67 LPM) and requires the ARA PM10 omnidirectional inlet to collect accurate PM2.5 samples.

2.3 Filter Holder

The aluminum filter holder is precisely manufactured for a tight seal and no contamination of the filter media. The filter holder is designed to use common EPA specified 47mm cassettes for PM2.5 sampling.

2.4 Flow Control System

The N-FRM Sampler incorporates a microprocessor-based active flow control to maintain the sampling rate as ambient conditions and filter loading changes. The sampling rate is monitored and adjusted several times a second and logged at 5-min intervals along with all other important sampling parameters. Under normal conditions the active flow control will maintain the sampling well within +/- 2%. If the sampling rate cannot be maintained within +/- 5% a flow error is generated and logged, and if the error continues for 5-minutes the sampler will shut down.

3 Initial Setup

3.1. Basic Assembly

When the N-FRM Sampler arrives, please check to ensure all parts are accounted for and that no items were damaged during shipping. Please contact ARA Instruments immediately to report any damaged or missing parts.

Assemble the inlet for the desired sampling particle size. The configurations for TSP, PM10, and PM2.5 are shown in Figure 1.

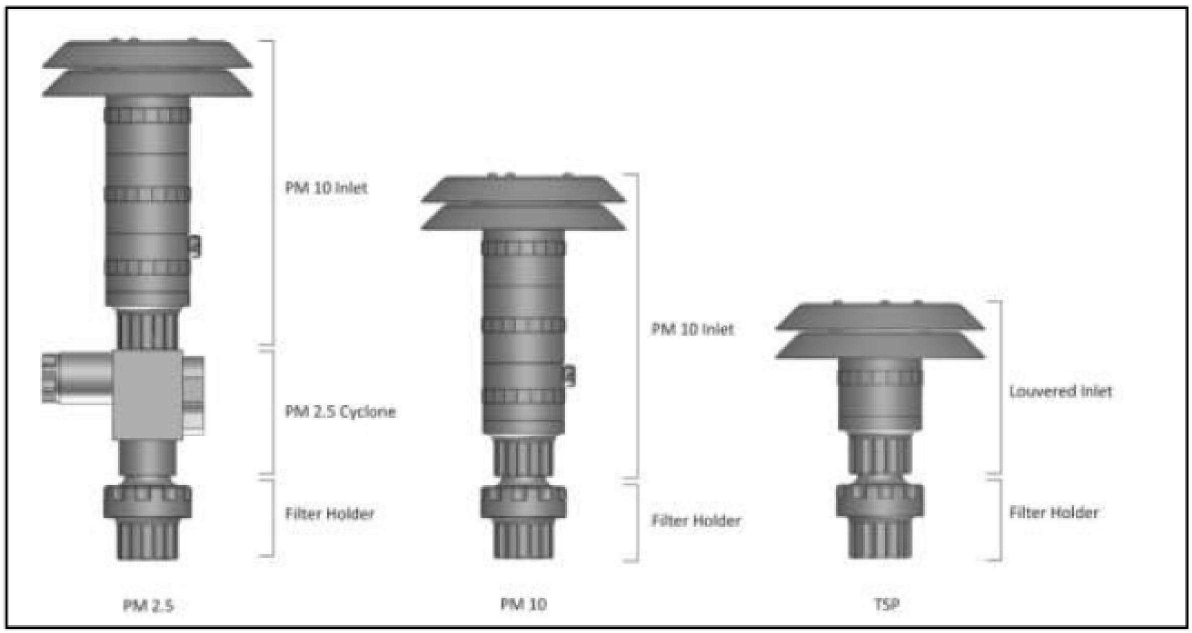

Figure 1. PM 2.5, PM 10, and TSP Configurations

3.2 Deployment

The N-FRM Sampler is designed for easy deployment. Most air sampling siting guidelines recommend samples be taken in the normal breathing zone 3-5 meters above ground. To meet these requirements, the N-FRM can be mounted on a Tripod or affixed to a stationary object like a fence post or utility pole using the Universal Mount Bracket. Both accessories are available form ARA. The Universal Mount (Figure 2) and Tripod (Figure 3) are shown to the right.

Figure 2

Figure 3

The N-FRM is designed for secure mounting on any vertical round tubing support of 1.25 – 1.375 inches in diameter (30-35mm). A clamp screw located inside the sampler secures the N-FRM to the support (Figure 4). Using the 3/16" Hex L-Wrench located on the battery holder, tighten the clamp screw to secure (Figure 5).

Figure 4

Figure 5

3.3 Power Source

3.3.1 Batteries

Each N-FRM Sampler is equipped with two 18V/5Ah DeWalt lithium-ion batteries.

Check Battery Charge

Each battery has a Charge Gauge on the front, consisting of three green LED lights and a button. Press and hold the Charge Gauge button. The LED lights will illuminate designating the level of charge left. See Figure 4 to determine if your batteries need to be charged.

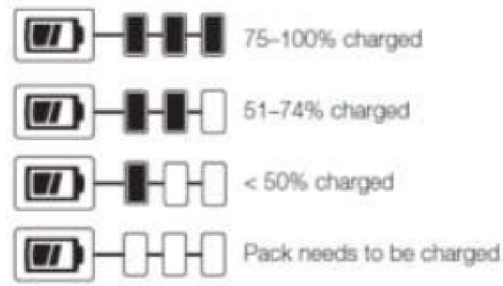

Figure 4. Battery Charge Levels

Charge Batteries

Plug the charger into an appropriate AC outlet. The charger provided by ARA Instruments is rated for 220VAC. If you prefer a 110VAC charger, we recommended DeWalt DCB105.

Insert the battery into the charger as shown in Figure 5. The red charging light will blink continuously, indicating the charging process has started. Batteries should be fully charged within 1 hour. Completion of the charging cycle is indicated by the red light remaining ON continuously. The battery is fully charged and may be used at this time or left in the charger.

The charger is designed to detect certain problems that can arise. Problems are indicated by the red charging light flashing at a fast rate. Try a different battery to determine if the charger is working properly. If the new battery charges correctly, then the original battery is defective and cannot be used.

Figure 5. Battery Charger

Please read all of the DeWalt instructions for the batteries and charger included with your sampler for more details about charging and storing batteries.

Install Batteries

Insert two charged batteries into the ARA N-FRM Battery Holder as shown in Figure 6. Make sure the batteries are fully seated and latched to the Battery Holder.

Insert the Battery Holder into the ARA N-FRM.

Figure 6. Battery Inserted Into Holder

3.3.2 AC Power Supply

Each N-FRM Sampler is also equipped with a 120/240V AC Power Supply to be used when an outlet is available.

3.3.3 Using Batteries and AC Power Supply

The AC Power Supply **does not** charge the batteries. The batteries can only be charged with the included Dewalt Battery Charger.

When both the AC Power Supply and Batteries are connected, the N-FRM Sampler will run off the AC Power Supply. If the AC Power Supply is interrupted, the Batteries will take over until AC Power Supply is restored. For protection from transient voltage spikes, we recommend plugging into a surge protector.

3.3.4 Solar Panel System

The ARA N-FRM Sampler utilizes a Zamp 24V Solar Panel System.

3.4 Powering N-FRM Sampler On/Off

Place the Power ON/OFF Rocker switch at the lower right of the front panel of the air sampler in the **ON** position. The Sampler will boot up into the Home Screen. The default operational mode is **MODE:OFF**.

3.5 Navigation

Navigate through the menus by rotating the selector knob to highlight a desired selection. Press the knob to select. The menu system is intuitive, especially to those with air sampling experience. To exit any menu, rotate the selector knob to highlight the top item of all menus and select **EXIT**. **MODE: OFF** takes you back to the Home Screen.

3.6 Sleep Mode

The N-FRM Sampler enters power saving "sleep mode" after a few minutes of no input from the selector knob. In this mode, the LCD screen is blank. To wake up the N-FRM Sampler, press and hold the selector knob for 3-seconds.

3.7 Setting Time and Date

On the Home Screen, confirm that the date and time are accurate. If necessary, follow these steps to set the correct Time and Date:

- Select **SETUP** from the Home Screen
- Scroll down, highlight **SYSTEM SETUP** and select
- Scroll down, highlight **DATE/TIME** and select
- Scroll down until the Day is highlighted and select
- Rotate the selector knob until the correct date is highlighted and select
- Repeat for Month, Year, Hour, Minute, and Second
- Select **DATE/TIME:EXIT**
- Select **YES** to save Date/Time
- Select **SYSTEM:EXIT** and then **SETUP:EXIT** to return to Home Screen

3.8 Filter Media

3.8.1 Choosing Filter Media

The ARA N-FRM Sampler is designed to use the filters specified by the US-EPA Federal Reference Method for PM2.5 Sampling. These types of filters work best for sampling…

- 2 um PTFE Teflon Filter w/support ring – Recommended if chemical analysis for non-carbon based compounds will follow gravimetric analysis**. Several manufacturers produce Teflon filters that meet the US-EPA specifications, and work well in the N-FRM Sampler. The key specification to meet for operation on battery power for is: Filter Resistance of < 30 cm-H2O @ 16.7 LPM. If you will be running samplers on battery power, we recommend the PALL Teflo Filters (#R2PJ047) as they have a very low resistance and will maintain battery charge beyond 24 hours.**
- Teflon-Coated Glass Filter – Ideal for gravimetric analysis.
- Pure Quartz Filter – Recommended if chemical analysis for carbon based compounds will follow gravimetric analysis.

For the sampler to maintain flow and run efficiently, use filters with a maximum pressure drop (with a clean filter) of 30 cm H2O column @ 16.67 LPM clean air flow. If filter media is too restrictive, the sampler will not be able to complete a 24-hour run and will automatically shut-off if batteries are depleted.

3.8.2 Installing a Filter

Note: This procedure should take place in a laboratory or clean area. Contact and handling of all filter media should be limited to the non-exposed outer edge with smooth tipped forceps (non-serrated) or plastic tipped forceps. Filter media should never be handled with fingers.

- Unscrew the Filter Holder Top from the Filter Holder Bottom
- Remove Filter Cassette
- Use ARA Cassette Separator to open the cassette. The top and bottom of the Filter Cassette are machined for a press fit. The Filter Cassette Top has a large beveled interior edge. See Figure 7 for appropriate use of Cassette Separator.

Warning: Manually prying the cassette apart with fingers can result in the cassette violently opening, causing damage to filter media or support screen.

Figure 7. Open 47mm Cassette

- With forceps, place a pre-weighed, clean filter media onto the Support Screen in the Filter Cassette Bottom. Install the Filter Cassette Top, firmly and evenly pressing down to complete the assembly.
- Place the Filter Cassette into the Filter Holder and reassemble by firmly screwing together the Filter Holder Top and Filter Holder Bottom. *Note: Cassettes can be handled with fingers. But make sure not to touch filter media.*

4 Operational Overview

4.1 Home Screen

Once the N-FRM Sampler is powered ON, the Home Screen appears. The Home Screen displays the Time, Temperature, Barometric Pressure, Wind Speed, Battery Voltage, and Hour Meter (Total Pump Operating Hours).

There are three menu selections across the top of the Home Screen: OFF, DATA, SETUP. These are the Administrative Modes.

4.2 Operational Modes

4.2.1 Mode: OFF

When the N-FRM Sampler is powered on, Mode: OFF is the default setting.

Select this administrative mode to move between the Operational Modes: OFF, ON, MET, PROGRAM, SECTOR and REMOTE.

4.2.2 Mode: ON

Select to manually turn the N-FRM pump ON.

4.2.3 Mode: MET

Select to view and log current meteorological parameters and particle sensor data if the Wind Sensor and RTP Profiler are installed. In this mode, data logging begins after 5 minutes. The pump will not run in **MET MODE**.

4.2.4 Mode: PROGRAM

Select to set the sampler to run at user-defined parameters: time, date, duration, interval, and flow rate. This mode logs all standard parameters, in addition to real-time particle data and meteorological data (if installed). This mode also allows the user to set parameters for conditional sampling. Options include: minimum wind speed, wind direction (defined sector), and minimum PM2.5 and PM10 concentrations (if Real Time Profiler is installed).

4.3 Data

The **DATA** administrative mode allows the user to view or erase summaries of the last few sampling events.

VIEW SUMMARIES – In this selection, the last 10 sampling events are stored and organized by Start Time. The summary data for each event is viewed by scrolling down the LCD screen. To change and view other events, scroll and select **ST** (start time and date). Each press of the selector knob changes the event data to view.

EXPORT LOG – Scrolling to the bottom of the **VIEW SUMMARIES** screen and selecting **EXPORT LOG** allows the user to export a summary, including 5-minute averages of sensor data and sampling parameters of the selected event to a USB flash drive.

ERASE ALL SUMMARIES – Selecting this option allows the user to erase all sampling event data. Note: It is not necessary to erase summaries. The newest sampling event will overwrite the oldest summary data once the maximum has been reached.

4.4 Setup

The **SETUP** administrative mode has various options relating to the sampler program and system setup.

SET PROGRAM: Allows the user to set the program for the next sampler run. Instructions that are more specific can be found in Section 5.1.1.

CLEAR ALL DATA: Will delete all sampler runtime data.

EXPORT SETUP: Using USB drive, the user can download sampler settings.

IMPORT PROGAM: A program may be imported from the USB drive.

SYSTEM INFO: Lists sampler information, including the Serial Number and latest Firmware version.

UPDATE FIRMWARE: With the correct file on a USB drive the user can update the firmware of the sampler. The latest firmware is available on the ARA Instruments website – www.arainstruments.com

SYSTEM SETUP: This menu allows the user to set the date and time and other sampler parameters.

DATE/TIME: User can set the current date and time. ***Note: When the sampler battery is removed, the sampler will hold the current date and time for approximately two weeks.***

FLOW RATE: User can turn the pump on and off and set the flow rate. This mode is useful for flow audits and calibration. There is a user adjustable SLOPE and INT (Intercept) if flow calibration is needed.

AMBIENT TEMPERATURE: This mode allows the user to turn ON or OFF the ambient temperature sensor if desired. If turned OFF the sampler defaults to a user adjustable, standard temperature of 25° C. The user can also enter an offset for calibration purposes.

BAROMETRIC PRESSURE: This mode allows the user to turn ON or OFF the ambient pressure sensor. If turned OFF the sampler defaults to a user adjustable, standard pressure of 760 mmHg. The user can also enter an offset for calibration purposes.

STANDARD TEMP PRESS: This mode allows the user to adjust the standard temperature and pressure used to calculate "standard" flow and volume, and also the default conditions if the temperature and/or ambient pressure sensors are turned off. Also, in this screen the user can select to sample at standard conditions or local conditions. The default for the sampler is sample at actual conditions of local temperature and pressure (LTP).

LCD BRIGHTNESS: Allows adjustment of the LCD backlight.

RESTORE DEFAULTS: Will set sampler back to factory defaults *(**be cautious in using this option since it will erase all user input calibration data**)*.

BLUETOOTH CONTROL: For future use.

PARTICLE COUNTER: The N-FRM Sampler comes with default mass values for PM2.5 and PM10 particulates. Users can adjust these values proportionally to match their local aerosol characteristics.

BOOT HISTORY: This mode is for troubleshooting firmware issues.

REBOOT: Will reboot the sampler.

5 Operating the N-FRM Sampler

5.1 User-Defined Programming

5.1.1 Creating a Program to Operate at a Specific Time Interval

There are two methods to view the **SET PROGRAM** screen.

Method 1: On the Home Screen, highlight **SETUP** and select by pushing the selector knob. Scroll down to **SET PROGRAM** and select.

Method 2: On the Home Screen, highlight **MODE: OFF** and select. Rotate the knob until **MODE: PROGRAM** is highlighted and select. Scroll down to **ST** (start date and time) and select to open the **SET PROGRAM** page.

You can now select the fields you desire to edit as you setup the sampler to run:

CLEAR PROGRAM: Select this option if you want to clear the current program. This is not necessary but can be helpful if you plan to change most of the parameters.

SAMPLE ID: A unique 4-digit ID can be entered but is not necessary. Sometimes used to identify site or filter media.

START: Select this option to enter the Start Date and Time. Scroll to the field that you would like to edit and push to edit. Turn the selector knob to choose the desired date or time variable, then select and continue to scroll through the fields until the START Date and Time are set as desired.

DURATION: Select this option to enter the duration of the sample event. Enter hours and minutes by turning the selector knob and pushing to edit the desired field.

INTERVAL: This option is used to setup a repeating sample event. Enter the hours and minutes from the end of the programmed run that you would like the event to repeat. An entry of 72:00 would repeat the sample every 72 hours. For a single non-repeating event set the INTERVAL to 00:00.

SET FLOW: Use this field to set the desired flow for the programmed event. The nominal flow rate for ARA PM10 and PM2.5 inertial separators is 16.7 LPM.

CONDITIONS: Select this field to open a sub-menu for conditional sampling. When conditions are set the sample pump will run after the condition has been met for 5-min, and will turn off when condition has not been met for 5-min. If multiple conditions are set all conditions must be met for the sample pump to run.

MINIMUM WIND: Set a minimum wind speed threshold. The default is 0.0 meters/sec.

SECTOR AZIMUTH: Works with Central Angle for Directional Sampling. Set a centerline azimuth wind direction (direction wind is from) . The default is 0 degrees.

SECTOR CENTRAL ANGLE: Set the size of the central angle (bisected by Sector Aziumth). The default is 0 degrees. *For example, if the Sector Azimuth was set to 90 degrees, and the Central Angle was set to 40 degrees, the sampler pump would only turn on when the wind direction was between 70 and 110 degrees.*

PM2.5: Set a minimum PM2.5 Concentration threshold. The default is 0 micrograms/cubic meter.

PM10: : Set a minimum PM10 Concentration threshold. The default is 0 micrograms/cubic meter.

REMOTE TRIGGER: Allows user to turn on the sampling pump with a external relay. (requires factory modification). The default is NO.

CLEAR CONDITIONS: Select this option to reset all conditions to default.

NOTE ON SAMPLING AT STANDARD CONDITIONS: If the method requires sampling at standard conditions, this can be changed in **SETUP** -> **SYSTEM SETUP** -> **STANDARD TEMP PRESS**. (See Section 4.4)

5.1.2 Running a Program

To activate the sampler at the programmed time and interval the sampler must be set to the Program Operational Mode.

On the Home Screen, select **MODE: OFF**. Rotate the knob until **MODE: PROGRAM** is highlighted and select.

The LCD screen displays **TM** (current date and time) and **ST** (start date and time) of the programmed event. Confirm that these parameters are correct and leave the sampler in Program Mode.

5.1.3 Ending a Program

After a programmed sampling event, the sampler remains in **MODE: PROGRAM** unless manually changed.

Highlight **MODE: PROGRAM** at the top of the LCD screen and select. Rotate the selector knob until **MODE: OFF** is highlighted and select. The Home Screen will appear.

5.2 Meteorological Functions

If the Wind Sensor is installed, the N-FRM Sampler will log 5-minute averages of wind speed and wind direction throughout any run in any Operational Mode (MODE:ON, MODE:MET, MODE:PROGRAM). The wind sensor can also be used to conditionally start the sampling pump.

Note: In order for a valid wind direction to be recorded in the data file or used conditionally, the wind speed must be greater than 0.5 m/s.

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Particulate Weight Log

Job #	Particulate Weight on Filter	Metals Yes	No	supplier	Sterlitech
Client	Optimal GESL (Kilgwin EIA)	Filter Blank Submitted	NA	p/n	E4700
Analysis	EES	Date of Dessication	10.05.2022	lot #	511247
Balance ID	Scientech S/N12903	Time of Dessication		type	GMF/ ambient

DE Edges of filter frayed
LPC Loose particulate material in filter container
FT Filter torn
FCL Filter contains liquid after dessication
LFT Loose filter material

Analyst	C.Homer	C.Homer	C.Homer	C.Homer	
Weighing Date	11.05.2022	12.05.2022	23.05.2022	24.05.2022	
Weighing Time	9:00	9:15	10:20	10:30	
Temperature (ºC)	24	24	24	24	
Humidity (%)	45	45	45	45	

Analyst	C.Homer	C.Homer	C.Homer	C.Homer	
Weighing Date	04.10.2022	05.10.2022	14.10.2022	15.10.2022	
Weighing Time					
Temperature (ºC)	24	24	24	24	
Humidity (%)	45	45	45	45	

#	Filter ID #	Filter Condition	Location		Pre-Weight 1 (g)	Pre-Weight 2 (g)	Post-Weight 1 (g)	Post-Weight 2 (g)	Weight 4 (g)	Net Weigt (g)	Particulate (mg)	RDL (mg)
1	20220516-1	NORMAL	Tyson Hall - PM10		0.1159	0.1159	0.1162	0.1162		0.0003	0.3	
2	20220516-2	NORMAL	Tyson Hall - PM2.5		0.1155	0.1155	0.1156	0.1156		0.0001	0.1	
3	20220516-3	NORMAL	Store Bay Rd - PM2.5		0.1138	0.1138	0.1139	0.1139		0.0001	0.1	
4	20220516-4	NORMAL	Store Bay Rd - PM10		0.1133	0.1133	0.1136	0.1136		0.0003	0.3	
5	20220516-5	NORMAL	Crown Point - PM2.5		0.1121	0.1121	0.1122	0.1122		0.0001	0.1	
6	20220516-6	NORMAL	Crown Point - PM10		0.1093	0.1093	0.1097	0.1097		0.0004	0.4	
7	20220516-7	NORMAL	Crown Point - TSP		0.1160	0.1160	0.1165	0.1165		0.0005	0.5	
8	20220516-8	NORMAL	Store Bay Rd - TSP		0.1091	0.1091	0.1096	0.1096		0.0005	0.5	
9	20220516-9	NORMAL	Tyson Hall - TSP		0.1143	0.1143	0.1148	0.1148		0.0005	0.5	
10	20221007-1	NORMAL	Tyson Hall - PM10		0.1139	0.1139	0.1142	0.1142		0.0003	0.3	
11	20221007-2	NORMAL	Store Bay Rd - PM10		0.1106	0.1106	0.1109	0.1109		0.0003	0.3	
12	20221007-3	NORMAL	Crown Point - PM10		0.1092	0.1092	0.1095	0.1095		0.0003	0.3	

13	20221007-4	NORMAL	Tyson Hall - PM2.5		0.1051	0.1051	0.1052	0.1052		0.0001	0.1	
14	20221007-5	NORMAL	Store Bay Rd - PM2.5		0.1134	0.1134	0.1135	0.1135		0.0001	0.1	
15	20221007-6	NORMAL	Crown Point - PM2.5		0.1120	0.1120	0.1121	0.1121		0.0001	0.1	
16	20221007-7	NORMAL	Tyson Hall - TSP		0.1137	0.1137	0.114	0.114		0.0003	0.3	
17	20221007-8	NORMAL	Store Bay Rd - TSP		0.1108	0.1108	0.1112	0.1112		0.0004	0.4	
18	20221007-9	NORMAL	Crown Point - TSP		0.1130	0.1130	0.1134	0.1134		0.0004	0.4	
				ZERO								
				0.3000g								

Filters are placed in a dessicator for 24 hours minimum prior to beginning weighing cycle.
Filters are not to be exposed to lab atmosphere for > 2 minutes at a relative humidity of >50 %.

ARA N-FRM FLOW CALIBRATION

Traceable Standard: CME-LFE 17242

Sampler : 16298 Client: EES

Date: 06-Oct-22

P_bar: 751.8 mm_Hg

Rel.Hum: 47 % Pump Hrs: 2.7

Calibration Equation:

Qa = (Kcal * (Del_P * (T + 273)/P_bar)^.5) + Bcal

Calculated Results:

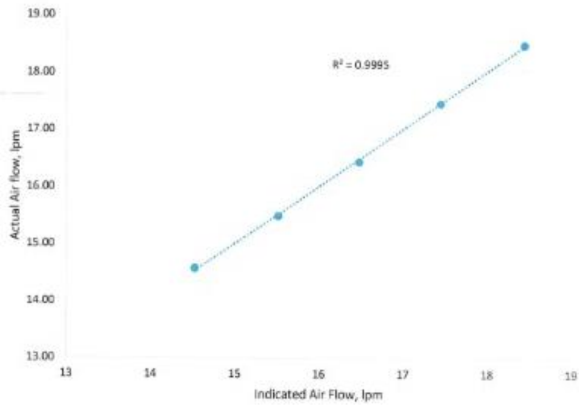
Kcal = 13.9199

Bcal = 0.30693

Flow Set lpm	Del_P mm_Hg	Temp Deg_C	"Y" Qa alpm	"X" Flow Factor	Calc Flow	% Diff	ABS % Diff
OFF	0.00	<<< ZERO Del_P SENSOR>>>					
14.5	4.95	22.9	14.56	1.021258	14.52274	-0.276438	0.276438
15.5	5.66	23.0	15.49	1.092231	15.51068	0.159359	0.159359
16.5	6.40	23.0	16.43	1.161439	16.47404	0.261955	0.261955
17.5	7.19	23.0	17.44	1.231036	17.44283	0.004755	0.004755
18.5	8.05	23.0	18.47	1.302579	18.43871	-0.153202	0.153202
OFF	0.00	<<< FINAL ZERO CHECK>>>					

Notes: w/ RTP
FW_2MAR20

Efficiency: 3.69 Watts @ 16.7 LPM &30 cm.H2O



The calibration of this air sampler is in accordance with procedures outlined by US-EPA in published guidance documents 40 CFR Part 50, Appendix L, and EPA 454/B-16-001
The traceability of flow, pressure, and temperature of the reference standards used is achieved through calibrations performed by approved and accredited calibration facilities that maintain traceability to the National Institute of Standards and Technology (NIST).
Temperature and pressure sensors are confirmed to be within the US-EPA PM2.5 FRM specifications.

The uncertainty of the flow rate is +/- 2% of reading or better with 95% confidence.

16298_ _EES

ARA N-FRM FLOW CALIBRATION

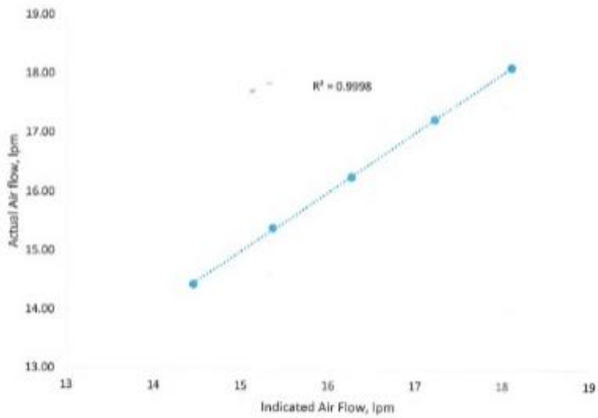
Traceable Standard: CME-LFE 17242
Sampler : 16299 Client: EES
Date: 06-Oct-22
P_bar: 751.8 mm_Hg
Rel.Hum: 46 % Pump Hrs: 3.4

Calibration Equation:
Qa = (Kcal * (Del_P * (T + 273)/P_bar)^.5) + Bcal
Calculated Results:
Kcal = 12.83388
Bcal = 1.148509

Flow Set lpm	Del_P mm_Hg	Temp Deg_C	"Y" Qa alpm	"X" Flow Factor	Calc Flow	% Diff	ABS % Diff
OFF	0.00	<<< ZERO Del_P SENSOR>>>					
14.5	5.10	23.0	14.43	1.036791	14.45457	0.163314	0.163314
15.5	5.82	23.0	15.40	1.107561	15.36282	-0.241422	0.241422
16.5	6.58	23.0	16.26	1.177658	16.26244	0.045741	0.045741
17.5	7.44	23.1	17.22	1.252466	17.22252	0.014614	0.014614
18.5	8.28	23.1	18.10	1.32128	18.10566	0.020215	0.020215
OFF	0.00	<<< FINAL ZERO CHECK>>>					

Notes: w/ RTP
FW_2MAR20

Efficiency: 3.636 Watts @ 16.7 LPM &30 cm.H2O



The calibration of this air sampler is in accordance with procedures outlined by US-EPA in published guidance documents 40 CFR Part 50, Appendix L, and EPA 454/B-16-001
The traceability of flow, pressure, and temperature of the reference standards used is achieved through calibrations performed by approved and accredited calibration facilities that maintain traceability to the National Institute of Standards and Technology (NIST).
Temperature and pressure sensors are confirmed to be within the US-EPA PM2.5 FRM specifications.

The uncertainty of the flow rate is +/- 2% of reading or better with 95% confidence.

16299_ _EES

ARA N-FRM FLOW CALIBRATION

Traceable Standard: CME-LFE 17242

Sampler : 16300 Client: EES

Date: 06-Oct-22

P_bar: 751.8 mm_Hg

Rel.Hum: 45 % Pump Hrs: 2.1

Calibration Equation:

Qa = (Kcal * (Del_P * (T + 273)/P_bar)^.5) + Bcal

Calculated Results:

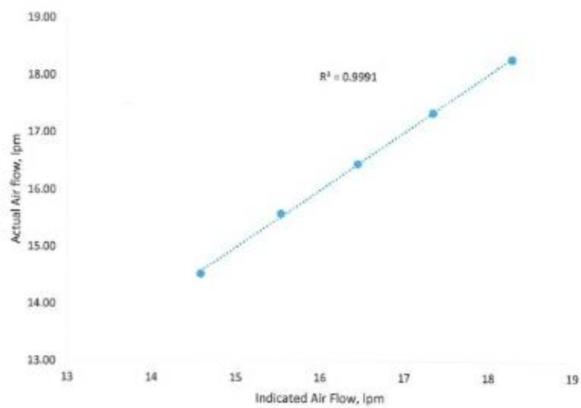
Kcal = 13.00943

Bcal = 1.319232

Flow Set lpm	Del_P mm_Hg	Temp Deg_C	"Y" Qa alpm	"X" Flow Factor	Calc Flow	% Diff	ABS % Diff
OFF	0.00	<<< ZERO Del_P SENSOR>>>					
14.5	4.93	23.1	14.53	1.019537	14.58283	0.356663	0.356663
15.5	5.66	23.1	15.59	1.092415	15.53093	-0.404445	0.404445
16.5	6.41	23.1	16.45	1.162542	16.44324	-0.059342	0.059342
17.5	7.19	23.2	17.34	1.231452	17.33971	-0.001656	0.001656
18.5	8.06	23.2	18.26	1.303828	18.28129	0.116611	0.116611
OFF	0.00	<<< FINAL ZERO CHECK>>>					

Notes: w/ RTP
FW_2MAR20

Efficiency: 3.636 Watts @ 16.7 LPM &30 cm.H2O



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The traceability of flow, pressure, and temperature of the reference standards used is achieved through calibrations performed by approved and accredited calibration facilities that maintain traceability to the National Institute of Standards and Technology (NIST).
Temperature and pressure sensors are confirmed to be within the US-EPA PM2.5 FRM specifications.

The uncertainty of the flow rate is +/- 2% of reading or better with 95% confidence.

16300_ _EES

ARA N-FRM **FLOW CALIBRATION**

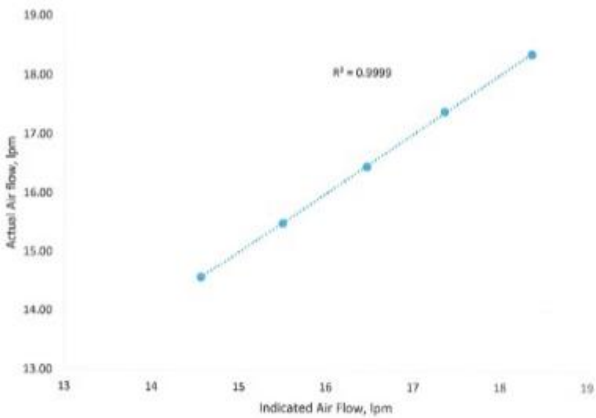
Traceable Standard: CME-LFE 17242
Sampler : 16301 Client: EES
Date: 06-Oct-22
P_bar: 751.9 mm_Hg
Rel.Hum: 46 % Pump Hrs: 4.9

Calibration Equation:
Qa = (Kcal * (Del_P * (T + 273)/P_bar)^.5) + Bcal
Calculated Results:
Kcal = 13.64437
Bcal = 0.922744

Flow Set lpm	Del_P mm_Hg	Temp Deg_C	"Y" Qa alpm	"X" Flow Factor	Calc Flow	% Diff	ABS % Diff
OFF	0.00	<<< ZERO Del_P SENSOR>>>					
14.5	4.74	23.3	14.57	0.999969	14.56669	-0.008989	0.008989
15.5	5.41	23.4	15.50	1.068487	15.50158	0.016623	0.016623
16.5	6.15	23.4	16.46	1.139222	16.4667	0.071126	0.071126
17.5	6.88	23.4	17.39	1.204938	17.36337	-0.141654	0.141654
18.5	7.74	23.4	18.35	1.27803	18.36066	0.063547	0.063547
OFF	0.00	<<< FINAL ZERO CHECK>>>					

Notes: w/ RTP
FW_2MAR20

Efficiency: 3.474 Watts @ 16.7 LPM &30 cm.H2O



The calibration of this air sampler is in accordance with procedures outlined by US-EPA in published guidance documents 40 CFR Part 50, Appendix L, and EPA 454/B-16-001
The traceability of flow, pressure, and temperature of the reference standards used is achieved through calibrations performed by approved and accredited calibration facilities that maintain traceability to the National Institute of Standards and Technology (NIST).
Temperature and pressure sensors are confirmed to be within the US-EPA PM2.5 FRM specifications.

The uncertainty of the flow rate is +/- 2% of reading or better with 95% confidence.

16301_ _EES

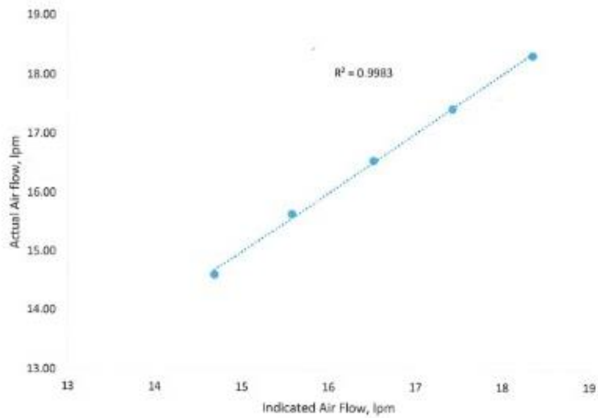
ARA N-FRM FLOW CALIBRATION

Traceable Standard:	CME-LFE 17242			Calibration Equation:			
Sampler :	16302 Client:	EES		Qa = (Kcal * (Del_P * (T + 273)/P_bar)^.5) + Bcal			
Date:	06-Oct-22			Calculated Results:			
P_bar:	751.8 mm_Hg					Kcal =	13.13637
Rel.Hum:	45 %	Pump Hrs:	1.2			Bcal =	1.336443

Flow Set lpm	Del_P mm_Hg	Temp Deg_C	"Y" Qa alpm	"X" Flow Factor	Calc Flow	% Diff	ABS % Diff
OFF	0.00	<<< ZERO Del_P SENSOR>>>					
14.5	4.89	23.4	14.61	1.015907	14.68177	0.525664	0.525664
15.5	5.56	23.5	15.65	1.083453	15.56909	-0.517025	0.517025
16.5	6.32	23.5	16.55	1.155131	16.51067	-0.213503	0.213503
17.5	7.10	23.5	17.41	1.22434	17.41982	0.050674	0.050674
18.5	7.94	23.5	18.31	1.294741	18.34464	0.167329	0.167329
OFF	0.00	<<< FINAL ZERO CHECK>>>					

Notes: w/ RTP
FW_2MAR20

Efficiency: 3.78 Watts @ 16.7 LPM &30 cm.H2O



The calibration of this air sampler is in accordance with procedures outlined by US-EPA in published guidance documents 40 CFR Part 50, Appendix L, and EPA 454/B-16-001
The traceability of flow, pressure, and temperature of the reference standards used is achieved through calibrations performed by approved and accredited calibration facilities that maintain traceability to the National Institute of Standards and Technology (NIST).
Temperature and pressure sensors are confirmed to be within the US-EPA PM2.5 FRM specifications.

The uncertainty of the flow rate is +/- 2% of reading or better with 95% confidence.

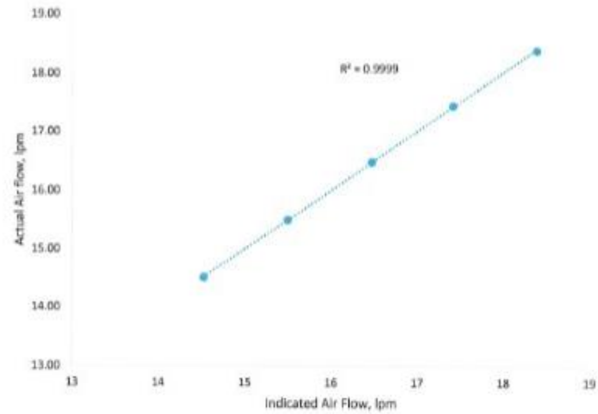
16302_ _EES

ARA N-FRM FLOW CALIBRATION

Traceable Standard:		CME-LFE 17242			Calibration Equation:			
Sampler :	16303	Client:	EES		Qa = (Kcal * (Del_P * (T + 273)/P_bar)^.5) + Bcal			
Date:	06-Oct-22				Calculated Results:			
P_bar:	751.6	mm_Hg					Kcal =	13.80472
Rel.Hum:	45	%	Pump Hrs:	2.1			Bcal =	0.304049
Flow			"Y"		"X"			
Set	Del_P	Temp	Qa		Flow	Calc	%	ABS
lpm	mm_Hg	Deg_C	alpm		Factor	Flow	Diff	% Diff
OFF	0.00	<<< ZERO Del_P SENSOR>>>						
14.5	5.02	23.7	14.51		1.02998	14.52264	0.080198	0.080198
15.5	5.73	23.7	15.50		1.100409	15.49489	-0.052286	0.052286
16.5	6.49	23.7	16.47		1.171114	16.47096	-0.01847	0.01847
17.5	7.27	23.7	17.43		1.239493	17.41491	-0.092314	0.092314
18.5	8.12	23.8	18.38		1.310171	18.3906	0.084911	0.084911
OFF	0.00	<<< FINAL ZERO CHECK>>>						

Notes: w/ RTP
FW_2MAR20

Efficiency: 3.708 Watts @ 16.7 LPM &30 cm.H2O



The calibration of this air sampler is in accordance with procedures outlined by US-EPA in published guidance documents 40 CFR Part 50, Appendix L, and EPA 454/B-16-001
The traceability of flow, pressure, and temperature of the reference standards used is achieved through calibrations performed by approved and accredited calibration facilities that maintain traceability to the National Institute of Standards and Technology (NIST).
Temperature and pressure sensors are confirmed to be within the US-EPA PM2.5 FRM specifications.

The uncertainty of the flow rate is +/- 2% of reading or better with 95% confidence.

16303_ _EES

ARA N-FRM FLOW CALIBRATION

Traceable Standard: CME-LFE 17242

Sampler : 16304 Client: EES

Date: 6-Oct-22

P_bar: 751.9 mm_Hg

Rel.Hum: 46 % Pump Hrs: 4.9

Calibration Equation:

Qa = (Kcal * (Del_P * (T + 273)/P_bar)^.5) + Bcal

Calculated Results:

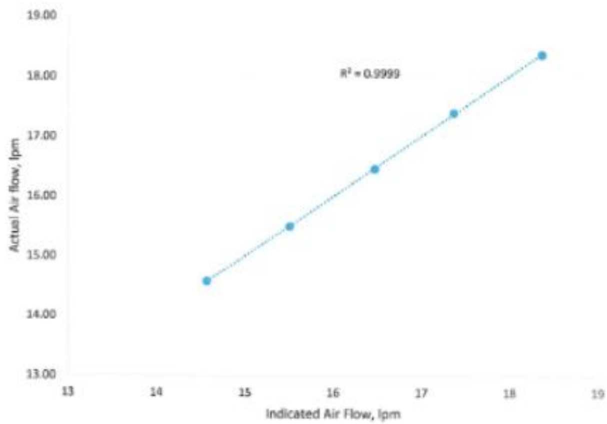
Kcal = 13.64437

Bcal = 0.922744

Flow Set lpm	Del_P mm_Hg	Temp Deg_C	"Y" Qa alpm	"X" Flow Factor	Calc Flow	% Diff	ABS % Diff
OFF	0.00 <<< ZERO Del_P SENSOR>>>						
14.5	4.74	23.3	14.57	0.999969	14.56669	-0.008989	0.008989
15.5	5.41	23.4	15.50	1.068487	15.50158	0.016623	0.016623
16.5	6.15	23.4	16.46	1.139222	16.4667	0.071126	0.071126
17.5	6.88	23.4	17.39	1.204938	17.36337	-0.141654	0.141654
18.5	7.74	23.4	18.35	1.27803	18.36066	0.063547	0.063547
OFF	0.00 <<< FINAL ZERO CHECK>>>						

Notes: w/ RTP
FW_2MAR20

Efficiency: 3.474 Watts @ 16.7 LPM &30 cm.H2O



The calibration of this air sampler is in accordance with procedures outlined by US-EPA in published guidance documents 40 CFR Part 50, Appendix L, and EPA 454/B-16-001
The traceability of flow, pressure, and temperature of the reference standards used is achieved through calibrations performed by approved and accredited calibration facilities that maintain traceability to the National Institute of Standards and Technology (NIST).
Temperature and pressure sensors are confirmed to be within the US-EPA PM2.5 FRM specifications.

The uncertainty of the flow rate is +/- 2% of reading or better with 95% confidence.

16304 _ _ EES

ARA N-FRM FLOW CALIBRATION

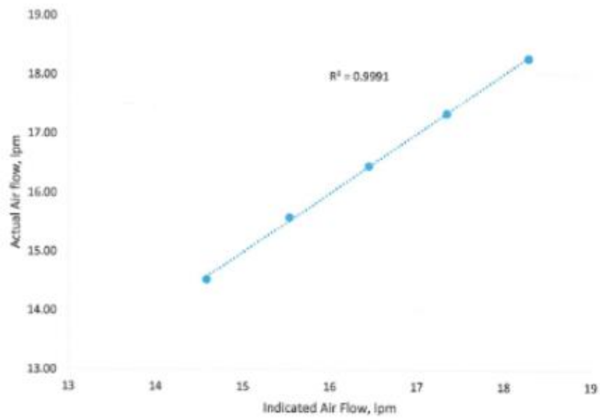
Traceable Standard: CME-LFE 17242
Sampler: 16305 Client: EES
Date: 6-Oct-22
P_bar: 751.8 mm_Hg
Rel.Hum: 45 % Pump Hrs: 2.1

Calibration Equation:
Qa = (Kcal * (Del_P * (T + 273)/P_bar)^.5) + Bcal
Calculated Results:
Kcal = 13.00943
Bcal = 1.319232

Flow Set lpm	Del_P mm_Hg	Temp Deg_C	"Y" Qa alpm	"X" Flow Factor	Calc Flow	% Diff	ABS % Diff
OFF	0.00	<<< ZERO Del_P SENSOR>>>					
14.5	4.93	23.1	14.53	1.019537	14.58283	0.356663	0.356663
15.5	5.66	23.1	15.59	1.092415	15.53093	-0.404445	0.404445
16.5	6.41	23.1	16.45	1.162542	16.44324	-0.059342	0.059342
17.5	7.19	23.2	17.34	1.231452	17.33971	-0.001656	0.001656
18.5	8.06	23.2	18.26	1.303828	18.28129	0.116611	0.116611
OFF	0.00	<<< FINAL ZERO CHECK>>>					

Notes: w/ RTP
FW_2MAR20

Efficiency: 3.636 Watts @ 16.7 LPM &30 cm.H2O



The calibration of this air sampler is in accordance with procedures outlined by US-EPA in published guidance documents 40 CFR Part 50, Appendix L, and EPA 454/B-16-001
The traceability of flow, pressure, and temperature of the reference standards used is achieved through calibrations performed by approved and accredited calibration facilities that maintain traceability to the National Institute of Standards and Technology (NIST).
Temperature and pressure sensors are confirmed to be within the US-EPA PM2.5 FRM specifications.

The uncertainty of the flow rate is +/- 2% of reading or better with 95% confidence.

16305 _ _EES

ARA N-FRM **FLOW CALIBRATION**

Traceable Standard: CME-LFE 17242

Sampler: 16306 Client: EES

Date: 6-Oct-22

P_bar: 751.8 mm_Hg

Rel.Hum: 45 % Pump Hrs: 2.1

Calibration Equation:

Qa = (Kcal * (Del_P * (T + 273)/P_bar)^.5) + Bcal

Calculated Results:

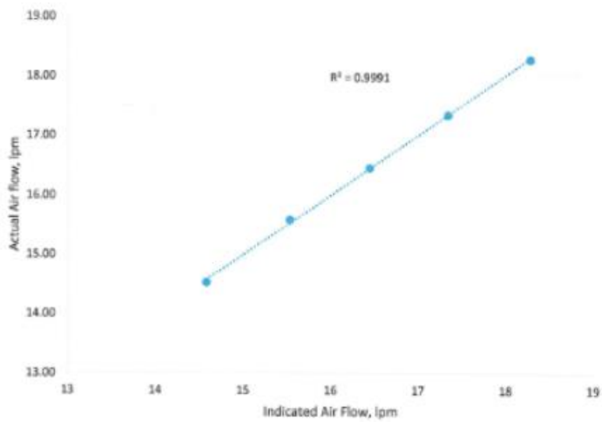
Kcal = 13.00943

Bcal = 1.319232

Flow Set lpm	Del_P mm_Hg	Temp Deg_C	"Y" Qa alpm	"X" Flow Factor	Calc Flow	% Diff	ABS % Diff
OFF	0.00	<<< ZERO Del_P SENSOR>>>					
14.5	4.93	23.1	14.53	1.019537	14.58283	0.356663	0.356663
15.5	5.66	23.1	15.59	1.092415	15.53093	-0.404445	0.404445
16.5	6.41	23.1	16.45	1.162542	16.44324	-0.059342	0.059342
17.5	7.19	23.2	17.34	1.231452	17.33971	-0.001656	0.001656
18.5	8.06	23.2	18.26	1.303828	18.28129	0.116611	0.116611
OFF	0.00	<<< FINAL ZERO CHECK>>>					

Notes: w/ RTP
FW_2MAR20

Efficiency: 3.636 Watts @ 16.7 LPM &30 cm.H2O



The calibration of this air sampler is in accordance with procedures outlined by US-EPA in published guidance documents 40 CFR Part 50, Appendix L, and EPA 454/B-16-001
The traceability of flow, pressure, and temperature of the reference standards used is achieved through calibrations performed by approved and accredited calibration facilities that maintain traceability to the National Institute of Standards and Technology (NIST).
Temperature and pressure sensors are confirmed to be within the US-EPA PM2.5 FRM specifications.

The uncertainty of the flow rate is +/- 2% of reading or better with 95% confidence.

16306 _ _EES

ARA N-FRM FLOW CALIBRATION

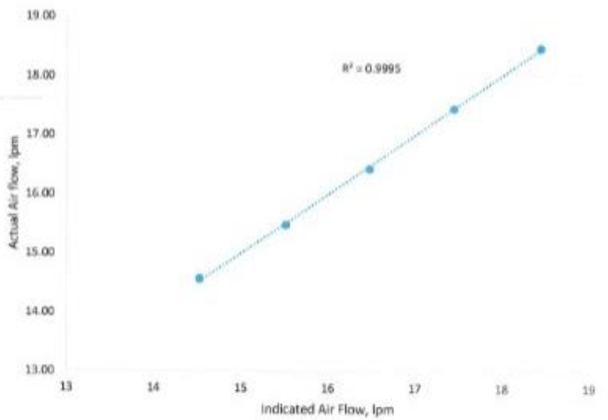
Traceable Standard: CME-LFE 17242
Sampler : 16298 Client: EES
Date: 16-May-22
P_bar: 751.8 mm_Hg
Rel.Hum: 47 % Pump Hrs: 2.7

Calibration Equation:
Qa = (Kcal * (Del_P * (T + 273)/P_bar)^.5) + Bcal
Calculated Results:
Kcal = 13.9199
Bcal = 0.30693

Flow Set lpm	Del_P mm_Hg	Temp Deg_C	"Y" Qa alpm	"X" Flow Factor	Calc Flow	% Diff	ABS % Diff
OFF	0.00	<<< ZERO Del_P SENSOR>>>					
14.5	4.95	22.9	14.56	1.021258	14.52274	-0.276438	0.276438
15.5	5.66	23.0	15.49	1.092231	15.51068	0.159359	0.159359
16.5	6.40	23.0	16.43	1.161439	16.47404	0.261955	0.261955
17.5	7.19	23.0	17.44	1.231036	17.44283	0.004755	0.004755
18.5	8.05	23.0	18.47	1.302579	18.43871	-0.153202	0.153202
OFF	0.00	<<< FINAL ZERO CHECK>>>					

Notes: w/ RTP
FW_2MAR20

Efficiency: 3.69 Watts @ 16.7 LPM &30 cm.H2O



The calibration of this air sampler is in accordance with procedures outlined by US-EPA in published guidance documents 40 CFR Part 50, Appendix L, and EPA 454/B-16-001
The traceability of flow, pressure, and temperature of the reference standards used is achieved through calibrations performed by approved and accredited calibration facilities that maintain traceability to the National Institute of Standards and Technology (NIST).
Temperature and pressure sensors are confirmed to be within the US-EPA PM2.5 FRM specifications.

The uncertainty of the flow rate is +/- 2% of reading or better with 95% confidence.

16298_ _EES

ARA N-FRM FLOW CALIBRATION

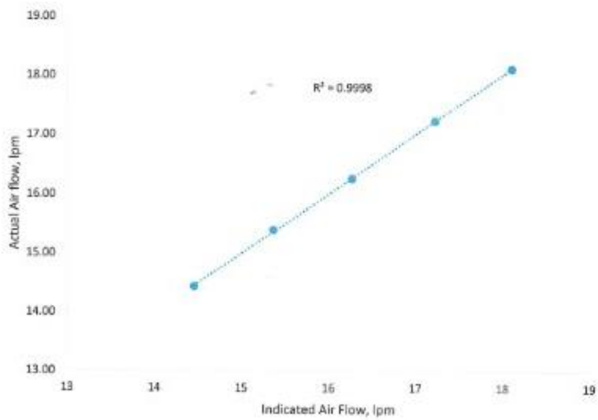
Traceable Standard: CME-LFE 17242
Sampler : 16299 Client: EES
Date: 16-May-22
P_bar: 751.8 mm_Hg
Rel.Hum: 46 % Pump Hrs: 3.4

Calibration Equation:
Qa = (Kcal * (Del_P * (T + 273)/P_bar)^.5) + Bcal
Calculated Results:
Kcal = 12.83388
Bcal = 1.148509

Flow Set lpm	Del_P mm_Hg	Temp Deg_C	"Y" Qa alpm	"X" Flow Factor	Calc Flow	% Diff	ABS % Diff
OFF	0.00	<<< ZERO Del_P SENSOR>>>					
14.5	5.10	23.0	14.43	1.036791	14.45457	0.163314	0.163314
15.5	5.82	23.0	15.40	1.107561	15.36282	-0.241422	0.241422
16.5	6.58	23.0	16.26	1.177658	16.26244	0.045741	0.045741
17.5	7.44	23.1	17.22	1.252466	17.22252	0.014614	0.014614
18.5	8.28	23.1	18.10	1.32128	18.10566	0.020215	0.020215
OFF	0.00	<<< FINAL ZERO CHECK>>>					

Notes: w/ RTP
FW_2MAR20

Efficiency: 3.636 Watts @ 16.7 LPM &30 cm.H2O



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The traceability of flow, pressure, and temperature of the reference standards used is achieved through calibrations performed by approved and accredited calibration facilities that maintain traceability to the National Institute of Standards and Technology (NIST).
Temperature and pressure sensors are confirmed to be within the US-EPA PM2.5 FRM specifications.

The uncertainty of the flow rate is +/- 2% of reading or better with 95% confidence.

16299_ _EES

ARA N-FRM FLOW CALIBRATION

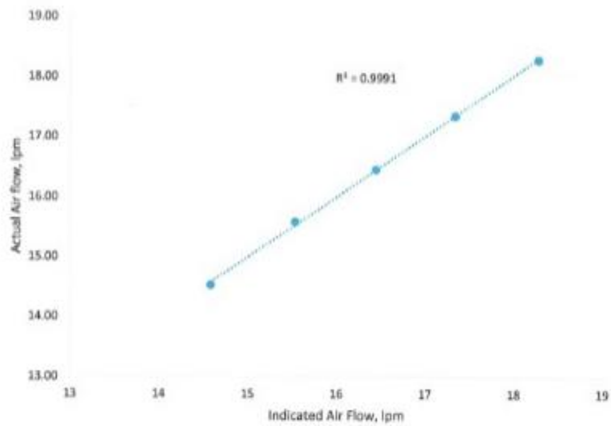
Traceable Standard: CME-LFE 17242
Sampler : 16300 Client: EES
Date: 16-May-22
P_bar: 751.8 mm_Hg
Rel.Hum: 45 %
Pump Hrs: 2.1

Calibration Equation:
Qa = (Kcal * (Del_P * (T + 273)/P_bar)^.5) + Bcal
Calculated Results:
Kcal = 13.00943
Bcal = 1.319232

Flow Set lpm	Del_P mm_Hg	Temp Deg_C	"Y" Qa alpm	"X" Flow Factor	Calc Flow	% Diff	ABS % Diff
OFF	0.00	<<< ZERO Del_P SENSOR>>>					
14.5	4.93	23.1	14.53	1.019537	14.58283	0.356663	0.356663
15.5	5.66	23.1	15.59	1.092415	15.53093	-0.404445	0.404445
16.5	6.41	23.1	16.45	1.162542	16.44324	-0.059342	0.059342
17.5	7.19	23.2	17.34	1.231452	17.33971	-0.001656	0.001656
18.5	8.06	23.2	18.26	1.303828	18.28129	0.116611	0.116611
OFF	0.00	<<< FINAL ZERO CHECK>>>					

Notes: w/ RTP
FW_2MAR20

Efficiency: 3.636 Watts @ 16.7 LPM &30 cm.H2O



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Temperature and pressure sensors are confirmed to be within the US-EPA PM2.5 FRM specifications.

The uncertainty of the flow rate is +/- 2% of reading or better with 95% confidence.

16300_ _EES

ARA N-FRM FLOW CALIBRATION

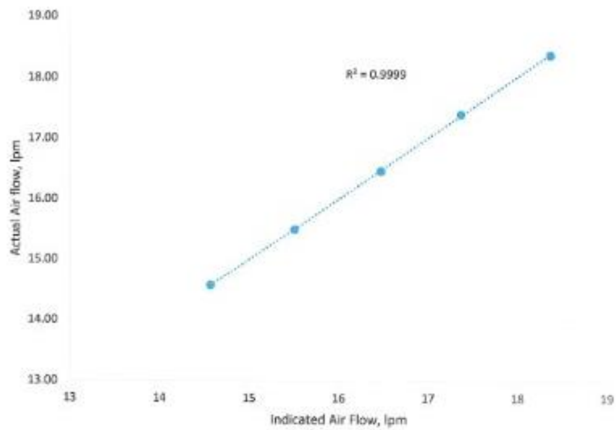
Traceable Standard: CME-LFE 17242
Sampler: 16301 Client: EES
Date: 16-May-22
P_bar: 751.9 mm_Hg
Rel.Hum: 46 % Pump Hrs: 4.9

Calibration Equation:
Qa = (Kcal * (Del_P * (T + 273)/P_bar)^.5) + Bcal
Calculated Results:
Kcal = 13.64437
Bcal = 0.922744

Flow Set lpm	Del_P mm_Hg	Temp Deg_C	"Y" Qa alpm	"X" Flow Factor	Calc Flow	% Diff	ABS % Diff
OFF	0.00	<<< ZERO Del_P SENSOR>>>					
14.5	4.74	23.3	14.57	0.999969	14.56669	-0.008989	0.008989
15.5	5.41	23.4	15.50	1.068487	15.50158	0.016623	0.016623
16.5	6.15	23.4	16.46	1.139222	16.4667	0.071126	0.071126
17.5	6.88	23.4	17.39	1.204938	17.36337	-0.141654	0.141654
18.5	7.74	23.4	18.35	1.27803	18.36066	0.063547	0.063547
OFF	0.00	<<< FINAL ZERO CHECK>>>					

Notes: w/ RTP
FW_2MAR20

Efficiency: 3.474 Watts @ 16.7 LPM &30 cm.H2O



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Temperature and pressure sensors are confirmed to be within the US-EPA PM2.5 FRM specifications.

The uncertainty of the flow rate is +/- 2% of reading or better with 95% confidence.

16301_ _EES

ARA N-FRM FLOW CALIBRATION

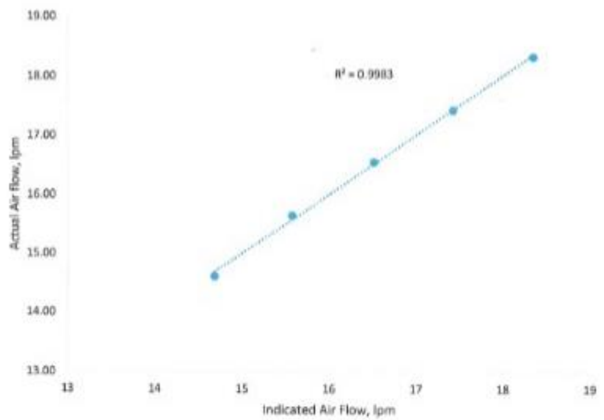
Traceable Standard: CME-LFE 17242
Sampler : 16302 Client: EES
Date: 16-May-22
P_bar: 751.8 mm_Hg
Rel.Hum: 45 % Pump Hrs: 1.2

Calibration Equation:
Qa = (Kcal * (Del_P * (T + 273)/P_bar)^.5) + Bcal
Calculated Results:
Kcal = 13.13637
Bcal = 1.336443

Flow Set lpm	Del_P mm_Hg	Temp Deg_C	"Y" Qa alpm	"X" Flow Factor	Calc Flow	% Diff	ABS % Diff
OFF	0.00	<<< ZERO Del_P SENSOR>>>					
14.5	4.89	23.4	14.61	1.015907	14.68177	0.525664	0.525664
15.5	5.56	23.5	15.65	1.083453	15.56909	-0.517025	0.517025
16.5	6.32	23.5	16.55	1.155131	16.51067	-0.213503	0.213503
17.5	7.10	23.5	17.41	1.22434	17.41982	0.050674	0.050674
18.5	7.94	23.5	18.31	1.294741	18.34464	0.167329	0.167329
OFF	0.00	<<< FINAL ZERO CHECK>>>					

Notes: w/ RTP
FW_2MAR20

Efficiency: 3.78 Watts @ 16.7 LPM &30 cm.H2O



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Temperature and pressure sensors are confirmed to be within the US-EPA PM2.5 FRM specifications.

The uncertainty of the flow rate is +/- 2% of reading or better with 95% confidence.

16302_ _EES

ARA N-FRM FLOW CALIBRATION

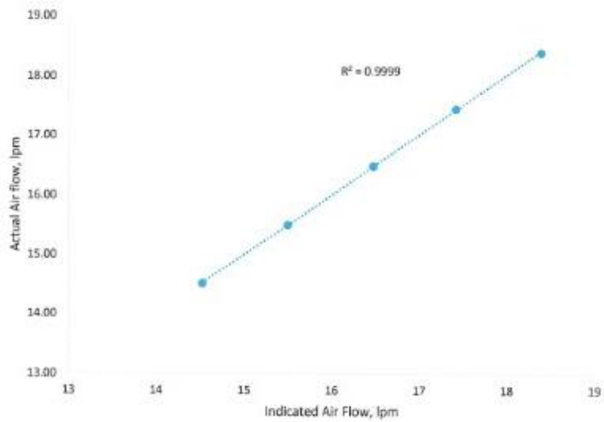
Traceable Standard: CME-LFE 17242
Sampler : 16303 Client: EES
Date: 16-May-22
P_bar: 751.6 mm_Hg
Rel.Hum: 45 % Pump Hrs: 2.1

Calibration Equation:
Qa = (Kcal * (Del_P * (T + 273)/P_bar)^.5) + Bcal
Calculated Results:
Kcal = 13.80472
Bcal = 0.304049

Flow Set lpm	Del_P mm_Hg	Temp Deg_C	"Y" Qa alpm	"X" Flow Factor	Calc Flow	% Diff	ABS % Diff
OFF	0.00	<<< ZERO Del_P SENSOR>>>					
14.5	5.02	23.7	14.51	1.02998	14.52264	0.080198	0.080198
15.5	5.73	23.7	15.50	1.100409	15.49489	-0.052286	0.052286
16.5	6.49	23.7	16.47	1.171114	16.47096	-0.01847	0.01847
17.5	7.27	23.7	17.43	1.239493	17.41491	-0.092314	0.092314
18.5	8.12	23.8	18.38	1.310171	18.3906	0.084911	0.084911
OFF	0.00	<<< FINAL ZERO CHECK>>>					

Notes: w/ RTP
FW_2MAR20

Efficiency: 3.708 Watts @ 16.7 LPM &30 cm.H2O



The calibration of this air sampler is in accordance with procedures outlined by US-EPA in published guidance documents 40 CFR Part 50, Appendix L, and EPA 454/B-16-001
The traceability of flow, pressure, and temperature of the reference standards used is achieved through calibrations performed by approved and accredited calibration facilities that maintain traceability to the National Institute of Standards and Technology (NIST).
Temperature and pressure sensors are confirmed to be within the US-EPA PM2.5 FRM specifications.

The uncertainty of the flow rate is +/- 2% of reading or better with 95% confidence.

16303_ _EES

ARA N-FRM FLOW CALIBRATION

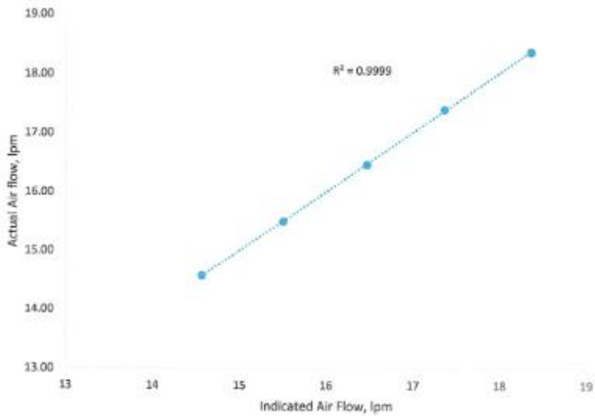
Traceable Standard: CME-LFE 17242
Sampler : 16304 Client: EES
Date: 16-May-22
P_bar: 751.9 mm_Hg
Rel.Hum: 46 % Pump Hrs: 4.9

Calibration Equation:
Qa = (Kcal * (Del_P * (T + 273)/P_bar)^.5) + Bcal
Calculated Results:
Kcal = 13.64437
Bcal = 0.922744

Flow Set lpm	Del_P mm_Hg	Temp Deg_C	"Y" Qa alpm	"X" Flow Factor	Calc Flow	% Diff	ABS % Diff
OFF	0.00	<<< ZERO Del_P SENSOR>>>					
14.5	4.74	23.3	14.57	0.999969	14.56669	-0.008989	0.008989
15.5	5.41	23.4	15.50	1.068487	15.50158	0.016623	0.016623
16.5	6.15	23.4	16.46	1.139222	16.4667	0.071126	0.071126
17.5	6.88	23.4	17.39	1.204938	17.36337	-0.141654	0.141654
18.5	7.74	23.4	18.35	1.27803	18.36066	0.063547	0.063547
OFF	0.00	<<< FINAL ZERO CHECK>>>					

Notes: w/ RTP
FW_2MAR20

Efficiency: 3.474 Watts @ 16.7 LPM &30 cm.H2O



The calibration of this air sampler is in accordance with procedures outlined by US-EPA in published guidance documents 40 CFR Part 50, Appendix L, and EPA 454/B-16-001
The traceability of flow, pressure, and temperature of the reference standards used is achieved through calibrations performed by approved and accredited calibration facilities that maintain traceability to the National Institute of Standards and Technology (NIST).
Temperature and pressure sensors are confirmed to be within the US-EPA PM2.5 FRM specifications.

The uncertainty of the flow rate is +/- 2% of reading or better with 95% confidence.

16304 _ _EES

ARA N-FRM FLOW CALIBRATION

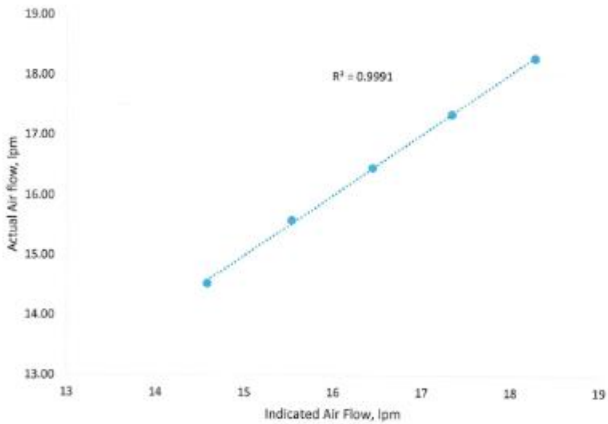
Traceable Standard: CME-LFE 17242
Sampler : 16305 Client: EES
Date: 16-May-22
P_bar: 751.8 mm_Hg
Rel.Hum: 45 % Pump Hrs: 2.1

Calibration Equation:
Qa = (Kcal * (Del_P * (T + 273)/P_bar)^.5) + Bcal
Calculated Results:
Kcal = 13.00943
Bcal = 1.319232

Flow Set lpm	Del_P mm_Hg	Temp Deg_C	"Y" Qa alpm	"X" Flow Factor	Calc Flow	% Diff	ABS % Diff
OFF	0.00	<<< ZERO Del_P SENSOR>>>					
14.5	4.93	23.1	14.53	1.019537	14.58283	0.356663	0.356663
15.5	5.66	23.1	15.59	1.092415	15.53093	-0.404445	0.404445
16.5	6.41	23.1	16.45	1.162542	16.44324	-0.059342	0.059342
17.5	7.19	23.2	17.34	1.231452	17.33971	-0.001656	0.001656
18.5	8.06	23.2	18.26	1.303828	18.28129	0.116611	0.116611
OFF	0.00	<<< FINAL ZERO CHECK>>>					

Notes: w/ RTP
FW_2MAR20

Efficiency: 3.636 Watts @ 16.7 LPM &30 cm.H2O



The calibration of this air sampler is in accordance with procedures outlined by US-EPA in published guidance documents 40 CFR Part 50, Appendix L, and EPA 454/B-16-001
The traceability of flow, pressure, and temperature of the reference standards used is achieved through calibrations performed by approved and accredited calibration facilities that maintain traceability to the National Institute of Standards and Technology (NIST).
Temperature and pressure sensors are confirmed to be within the US-EPA PM2.5 FRM specifications.

The uncertainty of the flow rate is +/- 2% of reading or better with 95% confidence.

16305 _ _EES

ARA N-FRM FLOW CALIBRATION

Traceable Standard: CME-LFE 17242

Sampler : 16306 Client: EES

Date: 16-May-22

P_bar: 751.8 mm_Hg

Rel.Hum: 45 % Pump Hrs: 2.1

Calibration Equation:

Qa = (Kcal * (Del_P * (T + 273)/P_bar)^.5) + Bcal

Calculated Results:

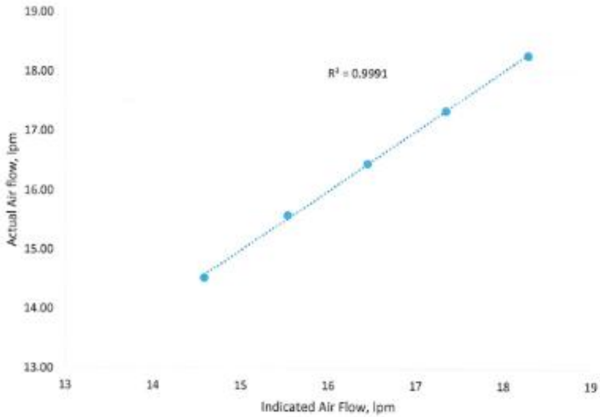
Kcal = 13.00943

Bcal = 1.319232

Flow Set lpm	Del_P mm_Hg	Temp Deg_C	"Y" Qa alpm	"X" Flow Factor	Calc Flow	% Diff	ABS % Diff
OFF	0.00	<<< ZERO Del_P SENSOR>>>					
14.5	4.93	23.1	14.53	1.019537	14.58283	0.356663	0.356663
15.5	5.66	23.1	15.59	1.092415	15.53093	-0.404445	0.404445
16.5	6.41	23.1	16.45	1.162542	16.44324	-0.059342	0.059342
17.5	7.19	23.2	17.34	1.231452	17.33971	-0.001656	0.001656
18.5	8.06	23.2	18.26	1.303828	18.28129	0.116611	0.116611
OFF	0.00	<<< FINAL ZERO CHECK>>>					

Notes: w/ RTP
FW_2MAR20

Efficiency: 3.636 Watts @ 16.7 LPM &30 cm.H2O



The calibration of this air sampler is in accordance with procedures outlined by US-EPA in published guidance documents 40 CFR Part 50, Appendix L, and EPA 454/B-16-001
The traceability of flow, pressure, and temperature of the reference standards used is achieved through calibrations performed by approved and accredited calibration facilities that maintain traceability to the National Institute of Standards and Technology (NIST).
Temperature and pressure sensors are confirmed to be within the US-EPA PM2.5 FRM specifications.

The uncertainty of the flow rate is +/- 2% of reading or better with 95% confidence.

16306 _ _EES

PM Sampling - Field Data Log

Project: Kilgwyn Ambient Air Monitoring - Dry Season

Sampling Date: 16.05.2022 **Page** 1 **of**

Start - AtmPres[mmHg]: 758 **End - AtmPres[mmHg]:** 756

Start - AmbTemp[°C]: 27.0 **End - AmbTemp[°C]:** 26.0

For Data Entry Use:	
Project ID	
Filter ID	
Logged	
File Name	
Verified	

Site ID	Sampler Serial #	Filter No	Start RotoFlow	Start ElapTime	End RotoFlow	End ElapTime	Your Notes
1	16298	20220510-1	16.7				
	Filter Cmt: PM10						
	Site Cmt: Tyson Hall					Std Vol	24.369 m3
1	16299	20220510-2	16.7				
	Filter Cmt: PM2.5						
	Site Cmt: Tyson Hall					Std. Vol	24.712 m3
1	16304	20220510-3	16.7				
	Filter Cmt: PM2.5						
	Site Cmt: Stone Bay Road					Std. Vol	24.404 m3
2	16300	20220510-4	16.7				
	Filter Cmt: PM2.5						
	Site Cmt: Stone Bay Road					Std. Vol	24.459
2	16301	20220510-5	16.7				
	Filter Cmt: PM2.5						
	Site Cmt: Crown Point					Std. Vol	24.914 m3
2	16302	20220510-6	16.7				
	Filter Cmt: PM10						
	Site Cmt: Crown Point					Std. Vol.	25.918 m3
3	16303	20220510-7	16.7				
	Filter Cmt: TSP						
	Site Cmt: Crown Point					Std. Vol	23.873 m3
3	16306	20220510-8	16.7				
	Filter Cmt: TSP						
	Site Cmt: Stone Bay Rd.					Std. Vol.	24.11 m3
3	16305	20220510-9	16.7				
	Filter Cmt: TSP						
	Site Cmt: Tyson Hall					Std. Vol.	24.233 m3
	Filter Cmt:						
	Site Cmt:						

PM Sampling - Field Data Log

Project: Kilgwyn Ambient Air Monitoring - Wet Season

Sampling Date: 06.10.2022 Page 1 of 1

Start - AtmPres[mmHg]: 75 End - AtmPres[mmHg]: 757

Start - AmbTemp[°C]: 25.7 End - AmbTemp[°C]: 29.0

For Data Entry Use:	
Project ID	
Filter ID	
Logged	
File Name	
Verified	

Site ID	Sampler Serial #	Filter No.	Start		End		Your - Notes
			RotoFlow	ElapTime	RotoFlow	ElapTime	
1	16298	20220905-2	16.7				
	Filter Cmt: PM10						Sample Duration: 24:37:24
	Site Cmt: Tyson Hall						Std Vol 24.369 m3
1	16299	20220905-4	16.7				
	Filter Cmt: PM2.5						Sample Duration 24:36:33
	Site Cmt: Tyson Hall						Std Vol: 24.362 m3
1	16304	20220905-7	16.7				
	Filter Cmt: TSP						Sample Duration. 24.233
	Site Cmt: Tyson Hall						Std Vol: 24.237 m3
2	16300	20220905-2	16.7				
	Filter Cmt: PM10						Sample Duration: 25.41.15
	Site Cmt: Old Store Bay Road						Std. Vol: 25.487 m3
2	16301	20220905-5	16.7				
	Filter Cmt: PM2.5						Sample Duration: 25:36:14
	Site Cmt: Old Store Bay Road.						Std Vol: 25.378 m3
2	16305	20220905-8	16.7				
	Filter Cmt: TSP						Sample Duration: 24.18.50
	Site Cmt: Old Store Bay Road						Std. Vol: 24.140 m3
3	16302	20220905-3	16.7				
	Filter Cmt: PM10						Sample Duration: 26.09.33
	Site Cmt: Crown Point						Std. Vol: 25.918 m3
3	16303	20220905-6	16.7				
	Filter Cmt: PM2.5						Sample Duration 26:07:33
	Site Cmt: Crown Point						Std Vol. 25.964 m3
3	16306	20220905-9	16.7				
	Filter Cmt: TSP						Sample Duration: 24.03.00
	Site Cmt: Crown Point						Std. Vol: 23.873 m3
	Filter Cmt:						
	Site Cmt:						

TEST	1	2	3	AVG	
DATE	16.05.2022	16.05.2022	16.05.2022		
START	15:00:00	15:35:00	16:16:00		
FINISH	15:30:00	16:05:00	16:46:00		
LOAD %	100	100	100		
PARAMETER					
CO	1.5	1.5	1.5	1.5	ppm
	1718.4	1718.4	1718.4	1718.4	ug/m3

SYSTEM CALIBRATION AND DRIFT CALCULATIONS

CLIENT	KILGWIN EIA-DRY SEAOSN	DATE	16.05.2022
PROJECT NUMBER	EES20220516	TIME START	15:00
SAMPLE LOCATION	Upwind Tyson Hall	TIME FINISH	15:30

TEST NUMBER 100% Test 1

INSTRUMENT RANGES

CARBON MONOXIDE 100 PPM

			INITIAL VALUES		FINAL VALUES		
ITEM	CAL.GAS VALUE	ANAL. CAL.	SYSTEM CAL.	SYSTEM CAL. BIAS (% SPAN)	SYSTEM CAL.	SYSTEM CAL. BIAS (% SPAN)	DRIFT (% SPAN)
CO ZERO	0.0	0.0	0.0	0.0	0.0	0.1	0.1
CO SPAN	45.0	45.0	45.0	0.0	45.0	0.0	0.0

Averages

Gas	Units	
CO	PPM	1.5

		SUMMARY RAW DATA				
CLIENT		KILGWIN EIA-DRY SEAOSN		DATE		16.05.2022
PROJECT NUMBER		EES20220516		TIME START		15:35
SAMPLE LOCATION		2.00		TIME FINISH		16:05
TIME			CO			
			PPM			
15:35:00			1.5			
15:36:00			1.5			
15:37:00			1.5			
15:38:00			1.5			
15:39:00			1.5			
15:40:00			1.5			
15:41:00			1.5			
15:42:00			1.5			
15:43:00			1.5			
15:44:00			1.5			
15:45:00			1.5			
15:46:00			1.5			
15:47:00			1.5			
15:48:00			1.5			
15:49:00			1.5			
15:50:00			1.5			
15:51:00			1.5			
15:52:00			1.5			
15:53:00			1.5			
15:54:00			1.5			
15:55:00			1.5			
15:56:00			1.5			
15:57:00			1.5			
15:58:00			1.5			
15:59:00			1.5			
16:00:00			1.5			
16:01:00			1.5			
16:02:00			1.5			
16:03:00			1.5			
16:04:00			1.5			
16:05:00			1.5			

SYSTEM CALIBRATION AND DRIFT CALCULATIONS

CLIENT	KILGWIN EIA-DRY SEAOSN	DATE	16.05.2022
PROJECT NUMBER	EES20220516	TIME START	15:35
SAMPLE LOCATION	Downwind Store Bay Road	TIME FINISH	16:05

TEST NUMBER 100% Test 2

INSTRUMENT RANGES

CARBON MONOXIDE 100 PPM

			INITIAL VALUES		FINAL VALUES		
ITEM	CAL.GAS VALUE	ANAL. CAL.	SYSTEM CAL.	SYSTEM CAL. BIAS (% SPAN)	SYSTEM CAL.	SYSTEM CAL. BIAS (% SPAN)	DRIFT (% SPAN)
CO ZERO	0.0	0.0	0.0	0.0	0.0	0.1	0.1
CO SPAN	45.0	45.0	45.0	0.0	45.0	0.0	0.0

Averages

Gas	Units	
CO	PPM	1.5

		SUMMARY RAW DATA				
CLIENT		KILGWIN EIA-DRY SEAOSN		DATE		16.05.2022
PROJECT NUMBER		EES20220516		TIME START		15:35
SAMPLE LOCATION		2.00		TIME FINISH		16:05
TIME			CO			
			PPM			
15:35:00			1.5			
15:36:00			1.5			
15:37:00			1.5			
15:38:00			1.5			
15:39:00			1.5			
15:40:00			1.5			
15:41:00			1.5			
15:42:00			1.5			
15:43:00			1.5			
15:44:00			1.5			
15:45:00			1.5			
15:46:00			1.5			
15:47:00			1.5			
15:48:00			1.5			
15:49:00			1.5			
15:50:00			1.5			
15:51:00			1.5			
15:52:00			1.5			
15:53:00			1.5			
15:54:00			1.5			
15:55:00			1.5			
15:56:00			1.5			
15:57:00			1.5			
15:58:00			1.5			
15:59:00			1.5			
16:00:00			1.5			
16:01:00			1.5			
16:02:00			1.5			
16:03:00			1.5			
16:04:00			1.5			
16:05:00			1.5			

SYSTEM CALIBRATION AND DRIFT CALCULATIONS

CLIENT	KILGWIN EIA-DRY SEAOSN	DATE	16.05.2022
PROJECT NUMBER	EES20220516	TIME START	16:16
SAMPLE LOCATION	Downwind Crown Point	TIME FINISH	16:46

TEST NUMBER 100% Test 3

INSTRUMENT RANGES

CARBON MONOXIDE 100 PPM

ITEM	CAL.GAS VALUE	ANAL. CAL.	INITIAL VALUES SYSTEM CAL.	SYSTEM CAL. BIAS (% SPAN)	FINAL VALUES SYSTEM CAL.	SYSTEM CAL. BIAS (% SPAN)	DRIFT (% SPAN)
CO ZERO	0.0	0.0	0.0	0.0	0.0	0.1	0.1
CO SPAN	45.0	45.0	45.0	0.0	45.0	0.0	0.0

Averages

Gas	Units	
CO	PPM	1.5

		SUMMARY RAW DATA				
CLIENT		KILGWIN EIA-DRY SEAOSN		DATE		16.05.2022
PROJECT NUMBER		EES20220516		TIME START		16:16
SAMPLE LOCATION		3.00		TIME FINISH		16:46
TIME			CO			
			PPM			
16:16:00			1.5			
16:17:00			1.5			
16:18:00			1.5			
16:19:00			1.5			
16:20:00			1.5			
16:21:00			1.5			
16:22:00			1.5			
16:23:00			1.5			
16:24:00			1.5			
16:25:00			1.5			
16:26:00			1.5			
16:27:00			1.5			
16:28:00			1.5			
16:29:00			1.5			
16:30:00			1.5			
16:31:00			1.5			
16:32:00			1.5			
16:33:00			1.5			
16:34:00			1.5			
16:35:00			1.5			
16:36:00			1.5			
16:37:00			1.5			
16:38:00			1.5			
16:39:00			1.5			
16:40:00			1.5			
16:41:00			1.5			
16:42:00			1.5			
16:43:00			1.5			
16:44:00			1.5			
16:45:00			1.5			
16:46:00			1.5			

TEST	**1**	**2**	**3**	**AVG**	
DATE	**06.10.2022**	**06.10.2022**	**06.10.2022**		
START	**17:22:30**	**18:00:12**	**18:40:25**		
FINISH	**17:52:30**	**18:30:12**	**19:10:25**		
LOAD %	**100**	**100**	**100**		
PARAMETER					
CO	1.5	1.5	1.5	1.5	ppm
	1718.4	1718.4	1718.4	1718.4	ug/m3

SYSTEM CALIBRATION AND DRIFT CALCULATIONS

CLIENT	KILGWIN EIA-DRY SEAOSN	DATE	06.10.2022
PROJECT NUMBER	EES20221006	TIME START	17:22
SAMPLE LOCATION	Upwind Tyson Hall	TIME FINISH	17:52

TEST NUMBER 100% Test 1

INSTRUMENT RANGES

CARBON MONOXIDE 100 PPM

ITEM	CAL.GAS VALUE	ANAL. CAL.	INITIAL VALUES SYSTEM CAL.	INITIAL VALUES SYSTEM CAL. BIAS (% SPAN)	FINAL VALUES SYSTEM CAL.	FINAL VALUES SYSTEM CAL. BIAS (% SPAN)	DRIFT (% SPAN)
CO ZERO	0.0	0.0	0.0	0.0	0.0	0.1	0.1
CO SPAN	45.0	45.0	45.0	0.0	45.0	0.0	0.0

Averages

Gas	Units	
CO	PPM	1.5

		SUMMARY RAW DATA				
CLIENT		KILGWIN EIA-DRY SEAOSN		DATE		06.10.2022
PROJECT NUMBER		EES20221006		TIME START		17:22
SAMPLE LOCATION		Upwind Tyson Hall		TIME FINISH		17:52
TIME			CO			
			PPM			
17:22:30			1.5			
17:23:30			1.5			
17:24:30			1.5			
17:25:30			1.5			
17:26:30			1.5			
17:27:30			1.5			
17:28:30			1.5			
17:29:30			1.5			
17:30:30			1.5			
17:31:30			1.5			
17:32:30			1.5			
17:33:30			1.5			
17:34:30			1.5			
17:35:30			1.5			
17:36:30			1.5			
17:37:30			1.5			
17:38:30			1.5			
17:39:30			1.5			
17:40:30			1.5			
17:41:30			1.5			
17:42:30			1.5			
17:43:30			1.5			
17:44:30			1.5			
17:45:30			1.5			
17:46:30			1.5			
17:47:30			1.5			
17:48:30			1.5			
17:49:30			1.5			
17:50:30			1.5			
17:51:30			1.5			
17:52:30			1.5			

SYSTEM CALIBRATION AND DRIFT CALCULATIONS

CLIENT	KILGWIN EIA-DRY SEAOSN	DATE	06.10.2022
PROJECT NUMBER	EES20221006	TIME START	18:00
SAMPLE LOCATION	Downwind Store Bay Road	TIME FINISH	18:30

TEST NUMBER 100% Test 2

INSTRUMENT RANGES

CARBON MONOXIDE 100 PPM

			INITIAL VALUES		FINAL VALUES		
ITEM	CAL.GAS VALUE	ANAL. CAL.	SYSTEM CAL.	SYSTEM CAL. BIAS (% SPAN)	SYSTEM CAL.	SYSTEM CAL. BIAS (% SPAN)	DRIFT (% SPAN)
CO ZERO	0.0	0.0	0.0	0.0	0.0	0.1	0.1
CO SPAN	45.0	45.0	45.0	0.0	45.0	0.0	0.0

Averages

Gas	Units	
CO	PPM	1.5

		SUMMARY RAW DATA				
CLIENT		KILGWIN EIA-DRY SEAOSN		DATE		06.10.2022
PROJECT NUMBER		EES20221006		TIME START		18:00
SAMPLE LOCATION		2.00		TIME FINISH		18:30
TIME			CO			
			PPM			
18:00:12			1.5			
18:01:12			1.5			
18:02:12			1.5			
18:03:12			1.5			
18:04:12			1.5			
18:05:12			1.5			
18:06:12			1.5			
18:07:12			1.5			
18:08:12			1.5			
18:09:12			1.5			
18:10:12			1.5			
18:11:12			1.5			
18:12:12			1.5			
18:13:12			1.5			
18:14:12			1.5			
18:15:12			1.5			
18:16:12			1.5			
18:17:12			1.5			
18:18:12			1.5			
18:19:12			1.5			
18:20:12			1.5			
18:21:12			1.5			
18:22:12			1.5			
18:23:12			1.5			
18:24:12			1.5			
18:25:12			1.5			
18:26:12			1.5			
18:27:12			1.5			
18:28:12			1.5			
18:29:12			1.5			
18:30:12			1.5			

SYSTEM CALIBRATION AND DRIFT CALCULATIONS

CLIENT	KILGWIN EIA-DRY SEAOSN	DATE	06.10.2022
PROJECT NUMBER	EES20221006	TIME START	18:40
SAMPLE LOCATION	Downwind Crown Point	TIME FINISH	19:10

TEST NUMBER 100% Test 3

INSTRUMENT RANGES

CARBON MONOXIDE 100 PPM

			INITIAL VALUES		FINAL VALUES		
ITEM	CAL.GAS VALUE	ANAL. CAL.	SYSTEM CAL.	SYSTEM CAL. BIAS (% SPAN)	SYSTEM CAL.	SYSTEM CAL. BIAS (% SPAN)	DRIFT (% SPAN)
CO ZERO	0.0	0.0	0.0	0.0	0.0	0.1	0.1
CO SPAN	45.0	45.0	45.0	0.0	45.0	0.0	0.0

Averages

Gas	Units	
CO	PPM	1.5

		SUMMARY RAW DATA				
CLIENT		KILGWIN EIA-DRY SEAOSN		DATE		06.10.2022
PROJECT NUMBER		EES20221006		TIME START		18:40
SAMPLE LOCATION		3.00		TIME FINISH		19:10
TIME			CO			
			PPM			
18:40:25			1.5			
18:41:25			1.5			
18:42:25			1.5			
18:43:25			1.5			
18:44:25			1.5			
18:45:25			1.5			
18:46:25			1.5			
18:47:25			1.5			
18:48:25			1.5			
18:49:25			1.5			
18:50:25			1.5			
18:51:25			1.5			
18:52:25			1.5			
18:53:25			1.5			
18:54:25			1.5			
18:55:25			1.5			
18:56:25			1.5			
18:57:25			1.5			
18:58:25			1.5			
18:59:25			1.5			
19:00:25			1.5			
19:01:25			1.5			
19:02:25			1.5			
19:03:25			1.5			
19:04:25			1.5			
19:05:25			1.5			
19:06:25			1.5			
19:07:25			1.5			
19:08:25			1.5			
19:09:25			1.5			
19:10:25			1.5			

Analyzer Performance Test

Client: Katalyst Solutions Group
79C Tunapuna Road, 00000
Tunapuna, TRINIDAD, W.I.

Instrument Details:
Type: Gas Filter Correlation Gas Analyzer
Manufacturer: Thermo Electron
Model: Model 48
Serial Number:

Calibration Setup:
Type: Multi-Gas Calibrator
Manufacturer: Environics
Model: 6103
Serial Number: 5115

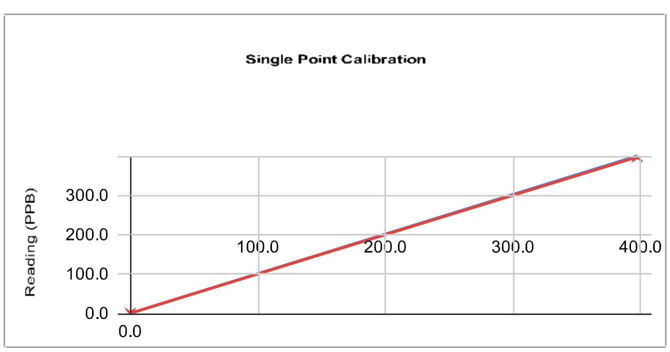
Ambient Condition(s): 24.9 °C ±0.7 °C
55.1 %RH ±4.8 %RH
1006.3 hPa ±3.1 hPa

References Used: Calibration Gas
CO Conc: 45ppm
Expiration: March 25th, 2024

Measurement results before adjustment:						
	Zero			Span		
Gas	Value (ppb)	Expected (ppb)	Drift (ppb)	Value (ppb)	Expected (ppb)	Drift (%)
CO	0.1	0.0	0.1	398.0	400.0	0.0

Measurement results after adjustment:						
	Zero			Span		
Gas	Value (ppb)	Expected (ppb)	Drift (ppb)	Value (ppb)	Expected (ppb)	Drift (%)
CO	0.0	0.0	0.0	400.0	400.0	0.0%

400.0



Analyzer Performance Test

Date: October 4th, 2022

Signature:

Calibration

It is certified that this instrument has been accurately performance tested by accepted calibration techniques, utilizing test equipment of sufficient accuracy to assure that the instrument meets all published specifications under laboratory conditions. Measurement data pertinent to this certified calibration are available from ER Equipment upon written request. Standards used to obtain and certify measurement data are periodically calibrated. Provided this instrument is used under normal laboratory environmental conditions and the operating instructions given in the Instruction Manual are followed, we recommend the calibration be checked every two years, beginning from the date of the original Certificate of Calibration (unless otherwise stated in Instruction Manual). Since frequency of use, among other factors, may affect calibration, it is suggested that the user determine the optimum calibration period.

Analyzer Performance Test

Client:	Katalyst Solutions Group 79C Tunapuna Road, 00000 Tunapuna, TRINIDAD, W.I.	**Instrument Details:**	Type: Manufacturer: Model: Serial Number:	Gas Filter Correlation Gas Analyzer Thermo Electron Model 48	

Calibration Setup:

Type: Multi-Gas Calibrator

Manufacturer: Environics

Model: 6103

Serial Number: 5115

Ambient Condition(s): 24.9 °C ±0.7 °C

55.1 %RH ±4.8 %RH

1006.3 hPa ±3.1 hPa

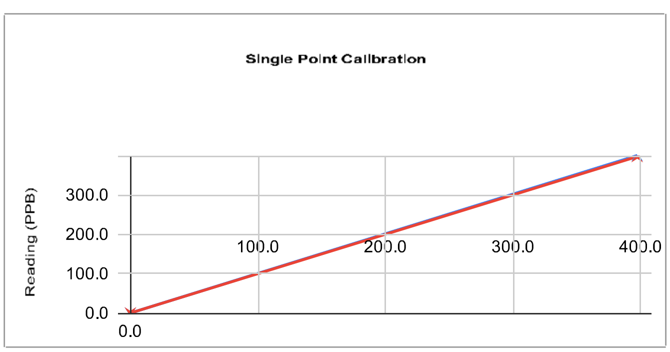
References Used: Calibration Gas

CO Conc: 45ppm

Expiration: March 25th, 2024

Measurement results before adjustment:						
Gas	Zero			Span		
	Value (ppb)	Expected (ppb)	Drift (ppb)	Value (ppb)	Expected (ppb)	Drift (%)
CO	0.1	0.0	0.1	388.0	400.0	0.0

Measurement results after adjustment:						
Gas	Zero			Span		
	Value (ppb)	Expected (ppb)	Drift (ppb)	Value (ppb)	Expected (ppb)	Drift (%)
CO	0.0	0.0 400.0	0.0	400.0	400.0	0.0%



Analyzer Performance Test

Date: May 14th, 2022

Signature:

Calibration

It is certified that this instrument has been accurately performance tested by accepted calibration techniques, utilizing test equipment of sufficient accuracy to assure that the instrument meets all published specifications under laboratory conditions. Measurement data pertinent to this certified calibration are available from ER Equipment upon written request. Standards used to obtain and certify measurement data are periodically calibrated. Provided this instrument is used under normal laboratory environmental conditions and the operating instructions given in the Instruction Manual are followed, we recommend the calibration be checked every two years, beginning from the date of the original Certificate of Calibration (unless otherwise stated in Instruction Manual). Since frequency of use, among other factors, may affect calibration, it is suggested that the user determine the optimum calibration period.

Your Project #: 2022/10/06 – 2022/10/07
Site Location: KILGWIN EIA

Attention: NEIL HARPER

EQUILIBRIUM ENVIRONMENTAL SERVICES LTD
TRINIDAD
LP#16 Bahadoor St.
California
Couva, CTT
Trinidad --

Report Date: 2022/10/26
Report #: R4999213
Version: 1 - Final

CERTIFICATE OF ANALYSIS

BV LABS JOB #: C280021
Received: 2022/10/14, 10:30

Sample Matrix: Air
Samples Received: 7

Analyses	Quantity	Date Extracted	Date Analyzed	Laboratory Method	Analytical Method
O3 Passive Analysis	7	2022/10/17	2022/10/18	PTC SOP-00197	EPA 300 R2.1

This report shall not be reproduced except in full, without the written approval of the laboratory.
Results relate only to the items tested.
* RPDs calculated using raw data. The rounding of final results may result in the apparent difference.

Encryption Key

Kristen Sywolos

Customer Service Supervisor,Oil & Gas

Division

26 Oct 2022 10:16:31

Please direct all questions regarding this Certificate of Analysis to your Project Manager.
Customer Service Passives,

Email: PassiveAir@bureauveritas.com

Phone# (780) 378-8500

==

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Total Cover Pages : 1

RESULTS OF CHEMICAL ANALYSES OF AIR

BVLabsID		ZL 8200	ZL 8201	ZL 8202		
Sampling Date		2022/10/06 16:40	2021/09/25 15:02	2021/09/25 15:48		
	UNITS	SITE 1	SITE 2	SITE 3	RDL	QC Batch

Passive Monitoring						
Calculated O3	ppb	9.5	12	11	9	A193879
RDL = Reportable Detection Limit						

GENERAL COMMENTS

Results relate only to the items tested.

QUALITY ASSURANCE REPORT

QA/ QC Batch	Init	QC Type	Parameter	Date Analyzed	Value	Recovery	UNITS	QC Limits
A193879	OZ	Spiked Blank	Calculated O3			101	%	90-110
A193879	OZ	Method Blank	Calculated O3		<0.1		ppb	

Spiked Blank: A blank matrix sample to which a known amount of the analyte, usually from a second source, has been added. Used to evaluate method accuracy.

Method Blank: A blank matrix containing all reagents used in the analytical procedure. Used to identify laboratory contamination.

VALIDATION SIGNATURE PAGE

The analytical data and all QC contained in this report were reviewed and validated by the following individual(s).

Yang Liu

Yang Liu, Analyst II

BV Labs has procedures in place to guard against improper use of the electronic signature and have the required signatories", as per ISO/IEC 17025, signing the reports. For Service Group specific validation please refer to the Validation Signature Page.

Your Project #: 2022/05/16 – 2022/05/17

Site Location: KILGWIN EIA

Attention:NEILHARPER

EQUILIBRIUM ENVIRONMENTAL SERVICES LTD
TRINIDAD

LP#16 Bahadoor St.

California

Couva, CTT
Trinidad --

Report Date: 2022/06/01

Report #: R4915411

Version: 1 - Final

CERTIFICATEOFANALYSIS

BVLABSJOB#:C278534

Received: 2022/05/23, 09:30

Sample Matrix: Air

Samples Received: 7

Analyses	Quantity	Date Extracted	Date Analyzed	Laboratory Method	Analytical Method
O3 Passive Analysis	7	2022/05/25	2022/05/26	PTC SOP-00197	EPA 300 R2.1

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Results relate only to the items tested.

* RPDs calculated using raw data. The rounding of final results may result in the apparent difference.

Encryption Key

Kristen Sywolos

C
u
s
t
o

mer Service Supervisor,Oil & Gas

Division

01 June 2022 09:46:18

Please direct all questions regarding this Certificate of Analysis to your Project Manager.
Customer Service Passives,

Email: PassiveAir@bureauveritas.com

Phone# (780) 378-8500

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Total Cover Pages : 1

RESULTS OF CHEMICAL ANALYSES OF AIR

BVLabsID		ZL 7000	ZL 7001	ZL 7002		
Sampling Date		2021/09/25 10:30	2021/09/25 11:15	2021/09/25 11:45		
	UNITS	SITE 1	SITE 2	SITE 3	RDL	QC Batch

Passive Monitoring						
Calculated O3	ppb	10	12	13	9	A193879
RDL = Reportable Detection Limit						

GENERAL COMMENTS

Results relate only to the items tested.

QUALITY ASSURANCE REPORT

QA/ QC Batch	Init	QC Type	Parameter	Date Analyzed	Value	Recovery	UNITS	QC Limits
A193879	OZ	Spiked Blank	Calculated O3			101	%	90-110
A193879	OZ	Method Blank	Calculated O3		<0.1		ppb	

Spiked Blank: A blank matrix sample to which a known amount of the analyte, usually from a second source, has been added. Used to evaluate method accuracy.

Method Blank: A blank matrix containing all reagents used in the analytical procedure. Used to identify laboratory contamination.

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Yang Liu

Yang Liu, Analyst II

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Bureau Veritas Laboratories Edmonton: 6744 - 50th Street T6B 3M9 Telephone (780) 378-8500 Fax (780) 378-8699

BUREAU VERITAS

6716-50 St. Edmonton AB Canada T6B 3M9

Ph: 780-378-8500; Toll free 800-386-7247; Fax 780-378-8699

BV Job Number:

PASSIVE AIR CHAIN OF CUSTODY

Page 1 of 1

Invoice To:	
Company Name	Eq ili i mE io n tal S ie s Ltd
Cont ct N me	N a H
A dress	Ch Ti ld d
Postal Code	
Phone	Fax

Report To:	
Name:	NEIL HARPER
Email:	[illegible]

Service Requested

☐ RUSH (Please contact us for TAT)

■ REGULAR

Company Name: EES

Project Name/LSD: Kilgwin EIA Wet Season

ANALYTICAL INFORMATION

Sample ID or Location (LSD)	Sample Start Date (DD/MM/YY)	Time (HH:MM)	Sample End Date (DD/MM/YY)	Time (HH:MM)	Volume (m^3) PM/TSP Only	SO2	H2S	NO2	O3	NOx	NH3	HNO3	VOC	PM2.5	PM10	TSP	Dustfall
St i Ty H ll(2)	0 /10/2022	1 0	07/10/2022	00 0	NA												
St Sto y oad (2)	0 /10/2022	1502	0 /10/2022	2002	NA												
Site 3 C ow Poi t (2)	6/1 /2 22	15	6/1 /2 22	20 0	NA												
Fi ld l k																	

Notes/Comments:

Sampled By: Christian Homer Phone: 8683416541 Received By: [signature] Project #

Date shipped: 11.10.2022 Date: 14.10.2022 Time: 10:30am

Signature: [signature] Signature PO#

PTCFCD-0045 Unless otherwise agreed to in writing, work submitted on this Chain of Custody is subject to Bureau Veritas' standard Terms and Conditions. Signing of this Chain of Custody document is acknowledgement and acceptance of our terms available at https://www.bvna.com/coc-terms-and-conditions

6716-50 St. Edmonton AB Canada T6B 3M9

Ph 780-378-8500; Toll free 800-386-7247; Fax 780-378-8699

BV Job Number:

PASSIVE AIR CHAIN OF CUSTODY

Page 1 of 1

Invoice To:	
Company Name	Eq ili i n E io m tal S ic s Ltd
Cont ct N me	N ai H
A dress	Ch T i Id d
Postal Code	
Phone	Fax

Report To:
Name: NEIL HARPER
Email:

Service Requested
☐ RUSH (Please contact us for TAT)
■ REGULAR

Company Name: EES
Project Name/LSD: Kilgwin EIA Dry Season

ANALYTICAL INFORMATION

Sample ID or Location (LSD)	Sample Start Date (DD/MM/YY)	Time (HH:MM)	Sample End Date (DD/MM/YY)	Time (HH:MM)	Volume (m^3) PM/TSP Only
Sit 1 Ty H I (2)	1 /05/2022	1730	17/05/2022	0130	NA
Sit Sto y ead (2)	1 /05/2022	1823	17/05/2022	0023	NA
Site 3 C ow Poi t (2)	16/ 5/2 22	175	17/ 5/2 22	128	NA
Fi ld l k					

Analysis Required: SO2, H2S, NO2, O3, NOx, NH3, HNO3, VOC, PM2.5, PM10, TSP, Dustfall

[redacted]

Notes/Comments:

Sampled By: Christian Homer Phone: 8683416541 Received By: Project #

Date shipped: 20.05.2022 Date: 23.05.2022 Time: 9:30am

Signature Signature PO#

FTCFCO-0045 Unless otherwise agreed to in writing, work submitted on this Chain of Custody is subject to Bureau Veritas' standard Terms and Conditions. Signing of this Chain of Custody document is acknowledgment and acceptance of our terms available at https://www.bvna.com/coc-terms-and-conditions.

E3.2 – Ambient Noise Quality

CEC6143/2020

THE ESTABLISHMENT OF A 500 ROOM RESORT ON 18.7258 HECTARES OF LAND AT TYSON HALL BETWEEN KILGWIN BAY ROAD AND STORE BAY LOCAL ROAD, TOBAGO

NOISE MONITORING REPORT

Prepared by:

EQUILIBRIUM ENVIRONMENTAL SERVICES LIMITED (EES)

For:

Optimal GESL

TABLE OF CONTENTS

List of Tables

List of Figures

1.0 INTRODUCTION

FCL financial Limited proposed to build a 500-room resort on 18.7258 hectares of land at Tyson Hall, Tobago (Figure 1.0). Due to likely environmental impacts The Environmental Management Authority has mandated that an Environmental Impact Assessment (EIA) be undertaken to allow for Certificate of Environmental Clearance (CEC) determination.

This report documents the results of the base line noise monitoring to adequately characterize the proposed development area and environs, likely to be impacted by any future resort development activity.

1.1 Project Scope

1. To perform baseline noise monitoring in the vicinity of the proposed study area, in accordance with the Environmental Management Act (EMA) Noise Pollution Control Rules (NPCR), 2001
2. Frequency: Wet Season (weekday + weekend sampling); Dry Season (weekday + weekend sampling)

3. Parameters: Equivalent Continuous Sound Pressure Level (Leq); Instantaneous Unweighted, Peak Sound Pressure Level (Lpeak); Minimum Sound Pressure Level (Lmin); Maximum Sound Pressure Level (Lmax)

4. Follow all measurement protocols stipulated in the Second Schedule of the EMA NPCR,

   2001

5. Measurement Interval – 24 hours per sample location

6. Prepare a Report in accordance with the Third Schedule of the EMA NPR 2001 that contains, but is not limited to, the following specifics:

   i. A summary description of the noise survey program and results
   ii. Summary data and results table
   iii. Diagrams/ maps reflecting noise results/ contours

iv. QA/QC analyses and data
v. Raw data collected
vi. Evidence of all Calibrations performed
vii. Personnel

Meteorological measurements were recorded by HOBO U30/NRC Remote Monitoring System, located in the immediate vicinity.

All points were marked via GPS and illustrated on a map of the area.

1.2 Sample Locations

Refer to Table 1 and Figure 1 below.

Table 1 Noise Monitoring Locations

Sample Location	UTM Coordinates	
1	739299	Upwind – Tyson Hall
	1233460	
2	738063	Downwind – Old Store Road
	1233750	
3	737359	Downwind – Crown Point
	1233514	

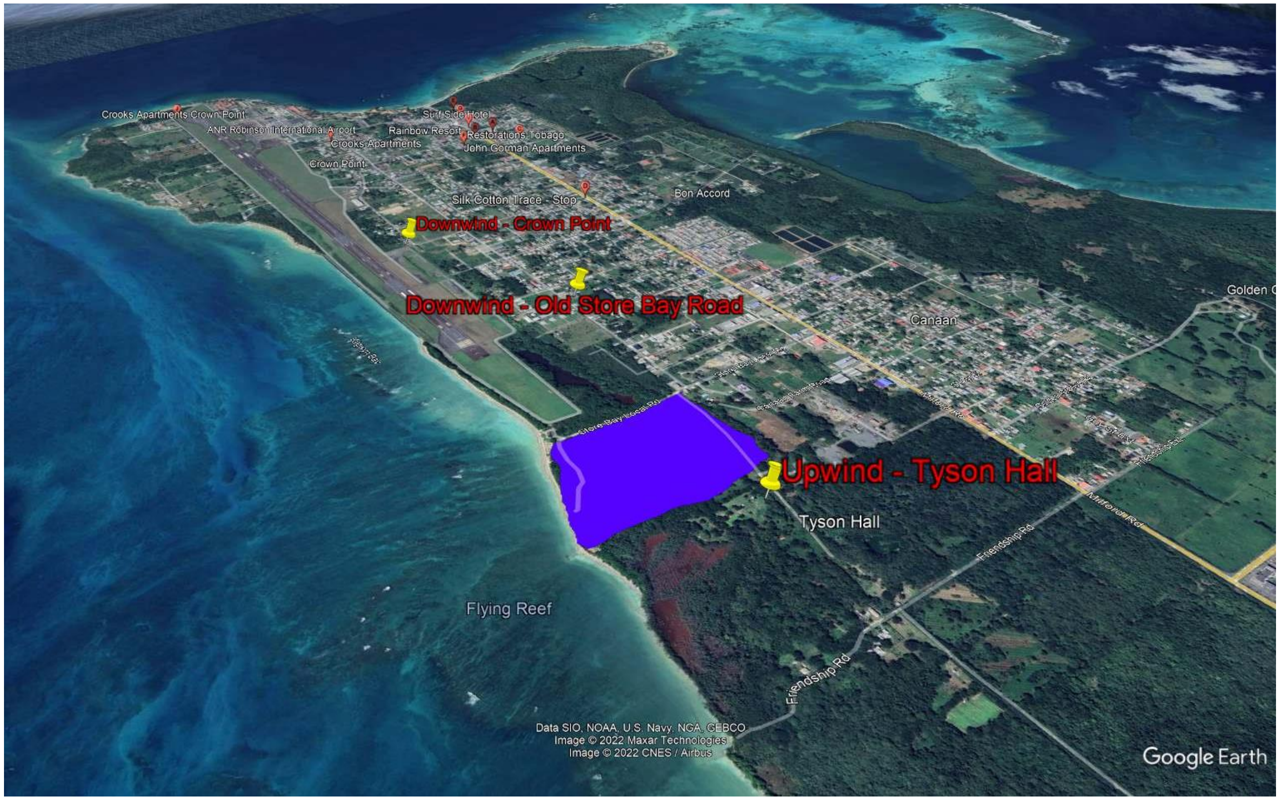

Figure 1 Southwest Tobago depicting study area (blue) in relation to sample locations

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1.3 Key Personnel

Table 2 Key Project Personnel

Person	**Organization**	**Responsibility**
Mr. Neil Harper	EES	Senior Technical Lead
Mr. Kieron Vincent	EES	Technical Support
Mr. Eddie Greene	EES	Technical Support

2.0 METHODOLOGY

2.1 Technical Approach

A Quest Technologies Model Sound Pro DL: Type 1/2 integrating – averaging sound level meter was deployed. Its measurement range (20 – 140 dB) was adjusted after powering on to suit ambient noise conditions. This instrument conforms to the requirements as stipulated in the ANSI S1.4-1983, IEC 651-1979, IEC 804-1985 standards. It can determine unweighted sound pressure levels (linear response) or "LEQs" as well as peak time weighted characteristic or "LPEAK" as specified in IEC 651-1979.

Field calibration took place prior to measurement via the use of a Quest Technologies AC-300 single frequency acoustic calibrator, specifically designed for the calibration of type 2 meters.

The instrument was set at an exchange rate of 3 dB; on a "Fast" response and "A-weighted" frequency response for measuring the equivalent sound level; on the "PEAK" response and "Linear" frequency (unweighted) characteristic to determine the peak sound pressure level.

The instrument was shielded from rain within the confines of a specifically designed environmental enclosure and fitted with a manufacturer-supplied windscreen. The microphone was oriented towards the noise source at a height of 1.5 m above the ground away from any building or facade.

The period of measurement will be 24 hours per location.

2.2 Data Processing and Analysis

The TSI Quest noise meter logged all acoustic data in its memory for the duration of the measurement period. At the end of each monitoring event, all data was processed using 3M Detection Management software. This yielded the following values:

1. LEQ - The average integrated sound level accumulated for the measurement period at a 3 dB exchange rate.

2. PEAK - The peak time unweighted sound pressure level.

3. LMAX – The maximum weighted sound pressure level

4. LMIN – The minimum weighted sound pressure level

Analysis included a comparison of results obtained versus the existing maximum permissible limits for equivalent sound pressure level and instantaneous unweighted peak sound pressure level as stated in the NPCR, First Schedule.

2.3 Site Selection Justification

2.3.1 Upwind – Tyson Hall

As per Figure 1.0, this location was in the immediate vicinity of the project site (150m) on the eastern boundary of the proposed development. Baseline measurements captured here represented ambient noise levels mangrove in the undeveloped space currently dominated by secondary scrub vegetation and mangrove. The actual sample point was a low vehicular traffic and pedestrian traffic, “rural” farm at Tyson Hall and West Friendship communities.

2.3.2 Downwind – Store Bay Local Road

As per Figure 1.0, this location was along a main arterial east – west roadway from Crown Point airport. Land use along this roadway was predominantly small hotels, bars, small groceries and residential properties. This location was in the car park of small grocery and roadside grill 680m from the western boundary of the proposed development. Baseline noise monitoring at this location characterized typical vehicular and pedestrian traffic and general activity set of the South Canaan community along the Old Store Bay Road.

2.3.3 Downwind – Crown Point

As per Figure 1.0, this location was off the main arterial east – west roadway (Old Store Bay Road) from the Crown Point airport. Land use in this general area was small hotels, residential properties and the Crown Point Airport Runway. This location was north of the runway and behind a few small residential properties some 1416m from the western boundary of the proposed development. Baseline noise monitoring at this location characterizes low vehicular and pedestrian traffic and general activity set of the Crown Point community along Crompson Trace.

Figure 2 Tyson Hall Noise Monitoring

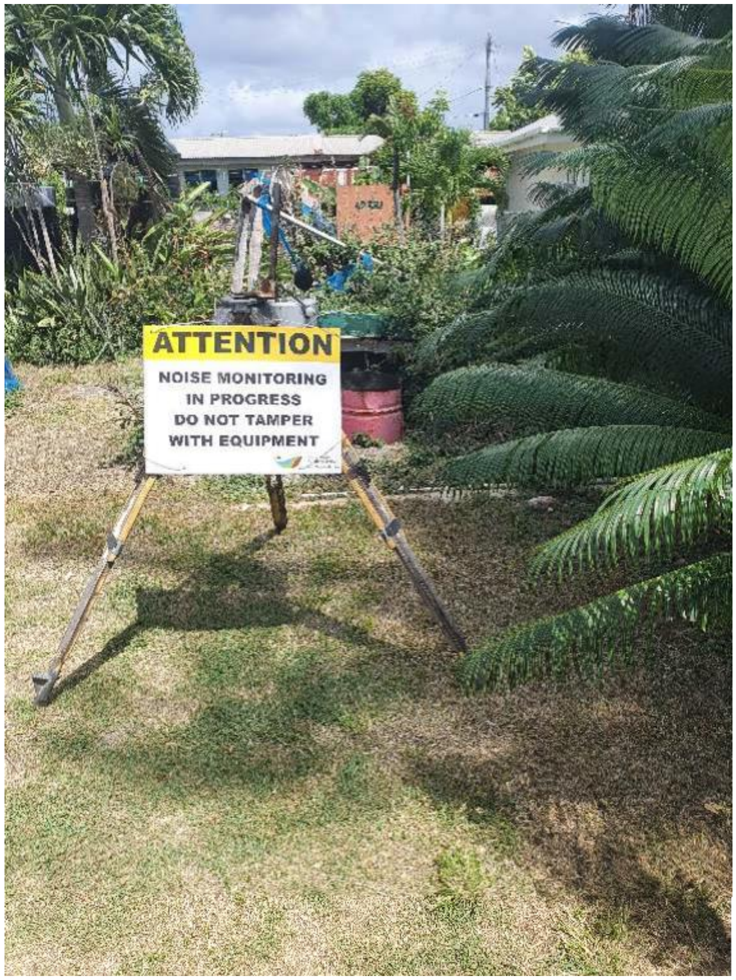


Figure 3 Old Store Bay Road Sample Point

Figure 4 Crown Point Sample Point

3.0 QUALITY ASSURANCE/QUALITY (QA/QC) CONTROL PROGRAM

- Calibrations for noise meters in use is found in the Appendices QA/QC documentation.

- The same information as above is provided for any field calibrators in use.

- Field calibration was performed before and after the test run and recorded on the meters in use. This calibration will be presented in the data report as evidence.

- Pre-use inspection of battery-life, microphone assembly, preamplifier and meter functionality were conducted.

- Background noise – a log of significant interfering noise events was recorded for the period of measurement as a means of corroborating any unusual results.

- Weather effects – wind over the microphone can spike readings and were minimized via the use of a wind screen; no noise measurements were taken during periods of heavy rainfall and thunder activity as these occurrences can skew measurements.

- The data was collected for 24 hrs. per location.

4.0 RESULTS

Table 3 Summary of Dry Season Noise Monitoring Data – Weekday Study

LOCATION	LEQ dB(A)	LPEAK dB	LMAX dB(A)	LMIN dB(A)	METER	DATE	NPCR
1 (East) Upwind Farm, Tyson Hall	53.0	95.6	95.6	44.7	BGV 120001	16.05.2022	**Zone 3 – General Areas** LEQ (daytime) 8:00am to 8:00pm + 5dBA background **80dBA max** LPEAK (daytime) 8:00Am to 8:00pm **120dB** LEQ (night-time) 8:00pm to 8:00am + 5dBA background **65dBA max** LPEAK (night-time) 8:00pm to 8:00am **115dB**
2 (West) Downwind Mini-Mart, Old Store Bay Road	58.5	112.3	96.9	44.7	BGV 120003	16.05.2022	
3 (South-West) Crown Point Airport, Crompson Trace	53.9	103.6	90.4	41.3	BGV 080001	16.05.2022	

Table 4 Summary of Dry Season Noise Monitoring Data – Weekend Study

LOCATION	LEQ dB(A)	LPEAK dB	LMAX dB(A)	LMIN dB(A)	**METER**	**DATE**	NPCR
1 (East) Upwind Farm, Tyson Hall	44.4	103.7	96.4	44.4	BGV 120001	28.05.2022	**Zone 3 – General Areas** LEQ (daytime) 8:00am to 8:00pm + 5dBA background **80dBA max** LPEAK (daytime) 8:00Am to 8:00pm **120dB** LEQ (night-time) 8:00pm to 8:00am + 5dBA background **65dBA max** LPEAK (night-time) 8:00pm to 8:00am **115dB**
2 (West) Downwind Mini-Mart, Old Store Bay Road	56.8	99.6	90.5	45.0	BGV 120002	28.05.2022	
3 (South-West) Crown Point Airport, Crompson Trace	51.5	96.9	89.3	44.7	BGV 120003	28.05.2022	

Table 5 Summary of Wet Season Noise Monitoring Data – Weekday Study

LOCATION	LEQ dB(A)	LPEAK dB	LMAX dB(A)	LMIN dB(A)	**METER**	**DATE**	NPCR
1 (East) Upwind Farm, Tyson Hall	54.8	102.2	72.8	33.9	BGV 080001	06.10.2022	**Zone 3 – General Areas** LEQ (daytime) 8:00am to 8:00pm + 5dBA background **80dBA max** LPEAK (daytime) 8:00Am to 8:00pm **120dB** LEQ (night-time) 8:00pm to 8:00am + 5dBA background **65dBA max** LPEAK (night-time) 8:00pm to 8:00am **115dB**
2 (West) Downwind Mini-Mart, Old Store Bay Road	58.3	102.0	77.7	45.1	BGV 120003	06.10.2022	
3 (South-West) Crown Point Airport, Crompson Trace	49.6	111.6	93.7	43.9	BGV 120001	06.10.2022	

Table 6 Summary of Wet Season Noise Monitoring Data – Weekend Study

LOCATION	LEQ dB(A)	LPEAK dB	LMAX dB(A)	LMIN dB(A)	**METER**	**DATE**	NPCR
1 (East) Upwind Farm, Tyson Hall	51.7	109.6	99.4	35.7	BGV 080001	07.10.2022	**Zone 3 – General Areas** LEQ (daytime) 8:00am to 8:00pm + 5dBA background **80dBA max** LPEAK (daytime) 8:00Am to 8:00pm **120dB** LEQ (night-time) 8:00pm to 8:00am + 5dBA background **65dBA max** LPEAK (night-time) 8:00pm to 8:00am **115dB**
2 (West) Downwind Mini-Mart, Old Store Bay Road	60.6	118.9	106	45.2	BGV 120003	07.10.2022	
3 (South-West) Crown Point Airport, Crompson Trace	44.9	94.8	72.7	43.6	BGV 120001	07.10.2022	

5.0 FINDINGS

Baseline LEQ ranges were as follows:

- Tyson Hall – 44.0db(A) to 54.8dB(A)
- Old Store Bay Road – 56.8 dB(A) to 60.6 dB(A)
- Crown Point – 44.9 dB(A) to 53.9 dB(A)

Baseline LPEAK ranges were as follows:

- Tyson Hall – 95.6 dB to 109.6 dB
- Old Store Bay Road – 99.6 dB to 118.9 dB
- Crown Point – 94.8 dB to 111.6 dB

Baseline LMAX ranges were as follows:

- Tyson Hall – 72.8 db(A) to 99.4 dB(A)
- Old Store Bay Road – 77.7 dB(A) to 106.0 dB(A)
- Crown Point – 72.7 dB(A) to 93.7 dB(A)

Baseline LMIN ranges were as follows:

- Tyson Hall – 33.9 db(A) to 44.7 dB(A)
- Old Store Bay Road – 44.7 dB(A) to 45.2 dB(A)
- Crown Point – 41.3 dB(A) to 44.7 dB(A)

6.0 DISCUSSION

Proposed activities throughout the construction and operational phases of the proposed development should be assessed against the Noise Pollution Control Rules, 2001 Zone 3 General Areas limits (Tables 3 to 5) for disturbance to community receptors.

APPENDICES

I. Summary of Meteorological Data
II. 3M Session Reports
III. Calibration Certificates
IV. Field Log

Table 7 Summary of Meteorological Data – Dry Season

Avg. Temperature/°C	27.9
Avg. Humidity/%	82.8
Avg. Wind Direction/ degrees	111.6
Avg. Wind Speed/ ms^{-1}	1.7
Total Rainfall/mm	4.2

Table 8 Summary of Meteorological Data - Wet Season

Avg. Temperature/°C	26.7
Avg. Humidity/%	89.8
Avg. Wind Direction/ degrees	85.4
Avg. Wind Speed/ ms^{-1}	1.6
Total Rainfall/mm	0.4

Session Report

12/1/2022

General Information

Name	S008_BGV120001_08062022_144109
Comments	
Start Time	16/05/2022 5:18:35 pm
Stop Time	17/05/2022 5:18:51 pm
Run Time	1.00:00:15
Model Type	SoundPro DL
Serial Number	BGV120001
Device Firmware Rev	R.13H
Company Name	
DescripΘon	
LocaΘon	
User Name	

Summary Data

Descri pti on	Meter	Value	Descri pti on	Meter	Value
Dose	1	0.1 %	Pdose (1:00)	1	0 %
Lavg	1	--	Lpk	1	119.1 dB
Leq	1	53 dB	TWA	1	57.8 dB
UL Time	1	00:00:00	SEL	1	102.3 dB
ProjectedTWA (1:00)	1	44 dB	MnΘme	1	16/05/2022 5:22:33 pm

MxƟme	1	16/05/2022 5:19:34 pm	PKƟme	1	16/05/2022 5:19:34 pm
WeighƟng	1	--	Range Ceiling	1	--
Criterion Level	1	--	ULL	1	--
Dynamic Range	1	--	Exchange Rate	1	--
Response	1	--	Int Threshold	1	--
Alarm Level 1	1	--	AlarmLevel2	1	--
Dosimeter Name	1	--			
Dose	2	0.2 %	Pdose (1:00)	2	0 %
Lavg	2	--	Lpk	2	119.1 dB
Leq	2	53 dB	TWA	2	57.7 dB
UL Time	2	00:00:00	SEL	2	102.3 dB

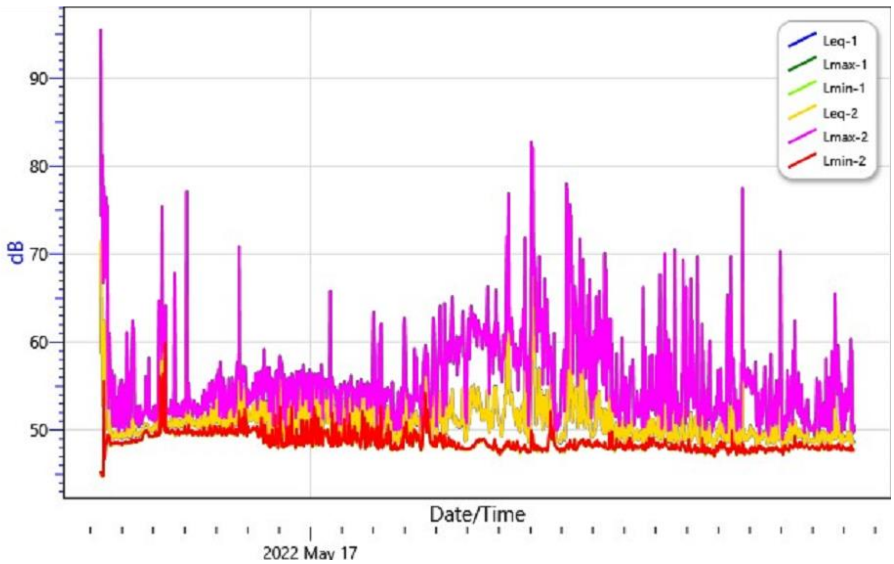
ProjectedTWA (1:00)	2	43.9 dB	MnΘme	2	16/05/2022 5:21:32 pm
MxΘme	2	16/05/2022 5:19:34 pm	PKΘme	2	16/05/2022 5:19:34 pm
WeighΘng	2	A	Range Ceiling	2	--
Criterion Level	2	85 dB	ULL	2	115 dB
Dynamic Range	2	--	Exchange Rate	2	3 dB
Response	2	FAST	IntegraΘng Threshold	2	80 dB
Alarm Level 1	2	--	AlarmLevel2	2	--
Dosimeter Name	2	--			

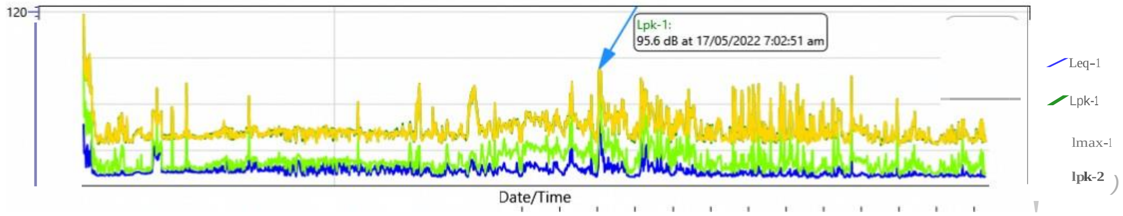
Calibration History

Date Date	Cali b rati on Acti on	Level	Cal. Model Type	S er i al Number	Cert . Due
16/05/2022 2:28:22 pm	CalibraΘon	114.0			

Logged Data Chart

S008_BGV120001_08062022_144109: Logged Data Chart - Read Only





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2022 May 17

Session Report

12/1/2022

General Information

Name	S006_BGV120003_08062022_143553
Comments	
Start Time	16/05/2022 4:38:26 pm
Stop Time	17/05/2022 4:38:26 pm
Run Time	1.00:00:00
Model Type	SoundPro DL
Serial Number	BGV120003
Device Firmware Rev	R.13H
Company Name	
DescripƟon	
LocaƟon	
User Name	

Summary Data

Descri pti on	Meter	Value	Descri pti on	Meter	Value
Dose	1	0.2 %	Pdose (1:00)	1	0 %
Lavg	1	--	Lpk	1	116.4 dB
Leq	1	58.5 dB	TWA	1	63.3 dB
UL Time	1	00:00:00	SEL	1	107.9 dB
ProjectedTWA (1:00)	1	49.5 dB	MnƟme	1	17/05/2022 2:48:07 am

MxƟme	1	16/05/2022 4:38:36 pm	PKƟme	1	16/05/2022 4:38:47 pm
WeighƟng	1	--	Range Ceiling	1	--
Criterion Level	1	--	ULL	1	--
Dynamic Range	1	--	Exchange Rate	1	--
Response	1	--	Int Threshold	1	--
Alarm Level 1	1	--	AlarmLevel2	1	--
Dosimeter Name	1	--			
Dose	2	0.7 %	Pdose (1:00)	2	0 %
Lavg	2	--	Lpk	2	116.4 dB
Leq	2	58.6 dB	TWA	2	63.3 dB
UL Time	2	00:00:00	SEL	2	107.9 dB

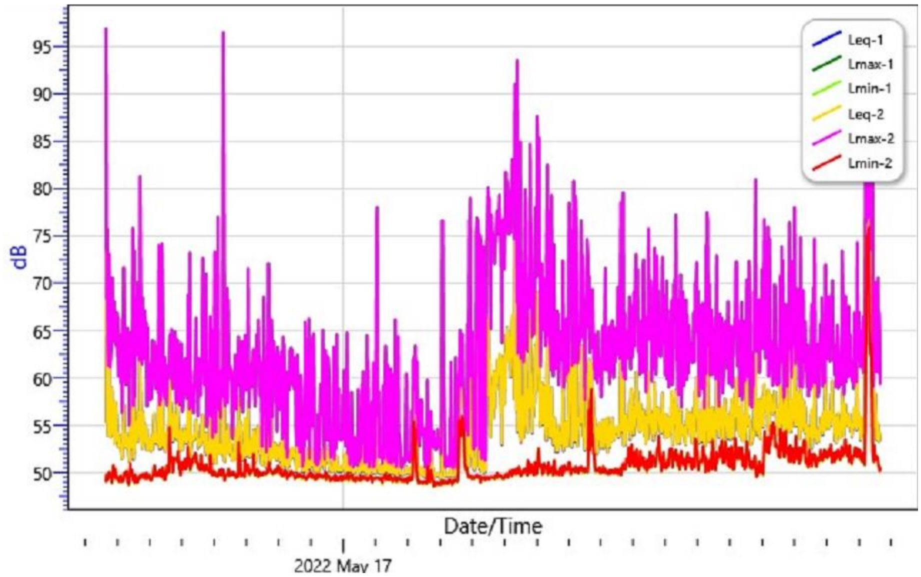
ProjectedTWA (1:00)	2	49.5 dB	MnƟme	2	17/05/2022 2:48:08 am
MxƟme	2	16/05/2022 4:38:36 pm	PKƟme	2	16/05/2022 8:17:25 pm
WeighƟng	2	A	Range Ceiling	2	--
Criterion Level	2	85 dB	ULL	2	115 dB
Dynamic Range	2	--	Exchange Rate	2	3 dB
Response	2	FAST	IntegraƟng Threshold	2	80 dB
Alarm Level 1	2	--	AlarmLevel2	2	--
Dosimeter Name	2	--			

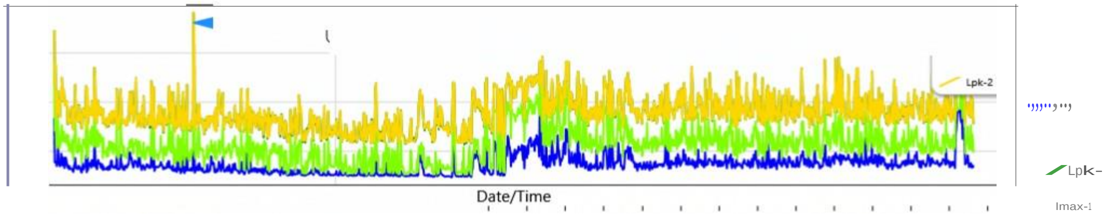
Calibration History

Date	Cali b rati on Acti on	Level	Cal. Model Type	S er i al Number	Cert . Due Date
16/05/2022 2:27:47 pm	CalibraƟon	114.0			

Logged Data Chart

S006_BGV120003_08062022_143553: Logged Data Chart - Read Only





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Session Report

12/2/2022

General Information

Name	S021_BGV080001_01122022_201406
Comments	
Start Time	16/05/2022 6:11:10 pm
Stop Time	17/05/2022 6:11:10 pm
Run Time	1.00:00:00
Model Type	SoundPro DL
Serial Number	BGV080001
Device Firmware Rev	R.13H
Company Name	
DescripӨon	
LocaӨon	
User Name	

Summary Data

Descri pti on	Meter	V alue	Descri pti on	Meter	V alue
Dose	1	0.2 %	Pdose (1:00)	1	0 %
Lavg	1	--	Lpk	1	103.6 dB
Leq	1	54 dB	TWA	1	58.7 dB
UL Time	1	00:00:00	SEL	1	103.3 dB
ProjectedTWA (1:00)	1	44.9 dB	MnӨme	1	17/05/2022 6:00:09 pm

MxƟme	1	17/05/2022 6:05:55 pm	PKƟme	1	17/05/2022 11:05:44 am
WeighƟng	1	--	Range Ceiling	1	--
Criterion Level	1	--	ULL	1	--
Dynamic Range	1	--	Exchange Rate	1	--
Response	1	--	Int Threshold	1	--
Alarm Level 1	1	--	AlarmLevel2	1	--
Dosimeter Name	1	--			
Dose	2	0.2 %	Pdose (1:00)	2	0 %
Lavg	2	--	Lpk	2	103.5 dB
Leq	2	53.9 dB	TWA	2	58.7 dB
UL Time	2	00:00:00	SEL	2	103.3 dB

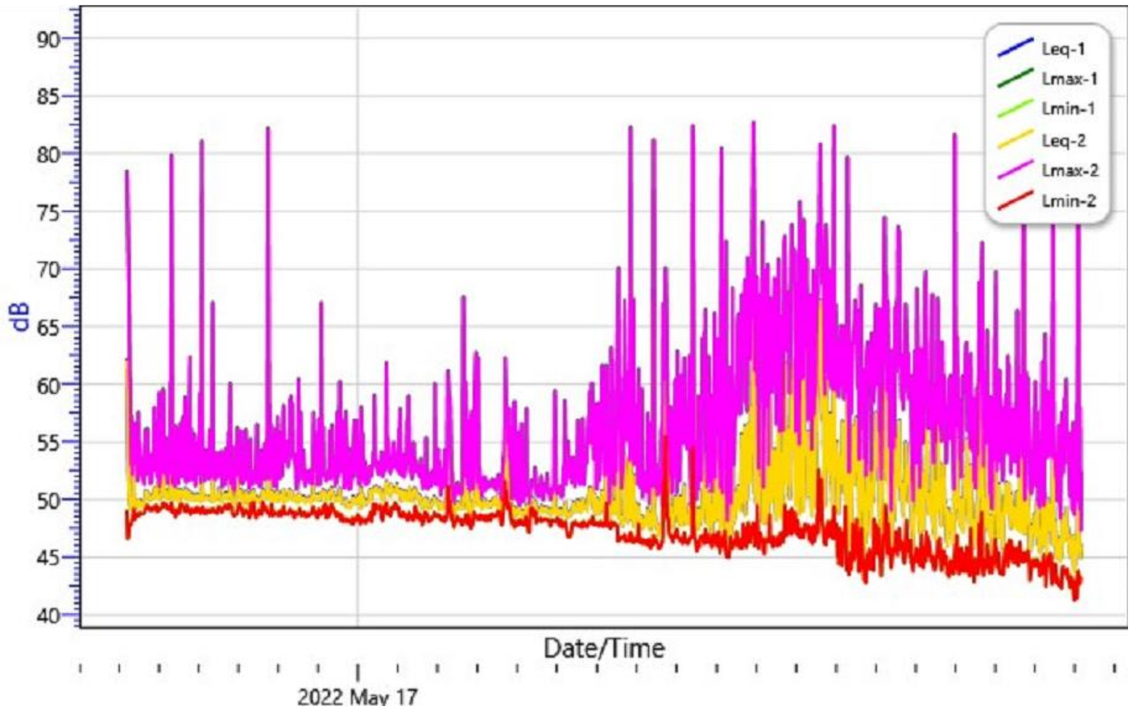
ProjectedTWA (1:00)	2	44.9 dB	MnΘme	2	17/05/2022 6:00:12 pm
MxΘme	2	17/05/2022 6:05:55 pm	PKΘme	2	17/05/2022 11:05:44 am
WeighΘng	2	A	Range Ceiling	2	--
Criterion Level	2	85 dB	ULL	2	115 dB
Dynamic Range	2	--	Exchange Rate	2	3 dB
Response	2	FAST	IntegraΘng Threshold	2	80 dB
Alarm Level 1	2	--	AlarmLevel2	2	--
Dosimeter Name	2	--			

Calibration History

Date	Cali b rati on Acti on	Level	Cal. Model Type	S er i al Number	Cert . Due Date
16/05/2022 2:30:54 pm	CalibraΘon	114.0			

Logged Data Chart

S021_BGV080001_01122022_201406: Logged Data Chart - Read Only



Session Report

12/1/2022

General Information

Name	S009_BGV120001_08062022_144110
Comments	
Start Time	28/05/2022 10:03:54 am
Stop Time	29/05/2022 10:03:54 am
Run Time	1.00:00:00
Model Type	SoundPro DL
Serial Number	BGV120001
Device Firmware Rev	R.13H
Company Name	
DescripƟon	
LocaƟon	
User Name	

Summary Data

Descri pti on	Meter	Value	Descri pti on	Meter	Value
Dose	1	0.1 %	Pdose (1:00)	1	0 %
Lavg	1	--	Lpk	1	118.3 dB
Leq	1	53.4 dB	TWA	1	58.2 dB
UL Time	1	00:00:00	SEL	1	102.8 dB
ProjectedTWA (1:00)	1	44.4 dB	MnƟme	1	28/05/2022 4:23:02 pm

MxѲme	1	29/05/2022 5:35:30 am	PKѲme	1	28/05/2022 10:04:53 am
WeighѲng	1	--	Range Ceiling	1	--
Criterion Level	1	--	ULL	1	--
Dynamic Range	1	--	Exchange Rate	1	--
Response	1	--	Int Threshold	1	--
Alarm Level 1	1	--	AlarmLevel2	1	--
Dosimeter Name	1	--			
Dose	2	0.2 %	Pdose (1:00)	2	0 %
Lavg	2	--	Lpk	2	118.3 dB
Leq	2	53.4 dB	TWA	2	58.2 dB
UL Time	2	00:00:00	SEL	2	102.8 dB

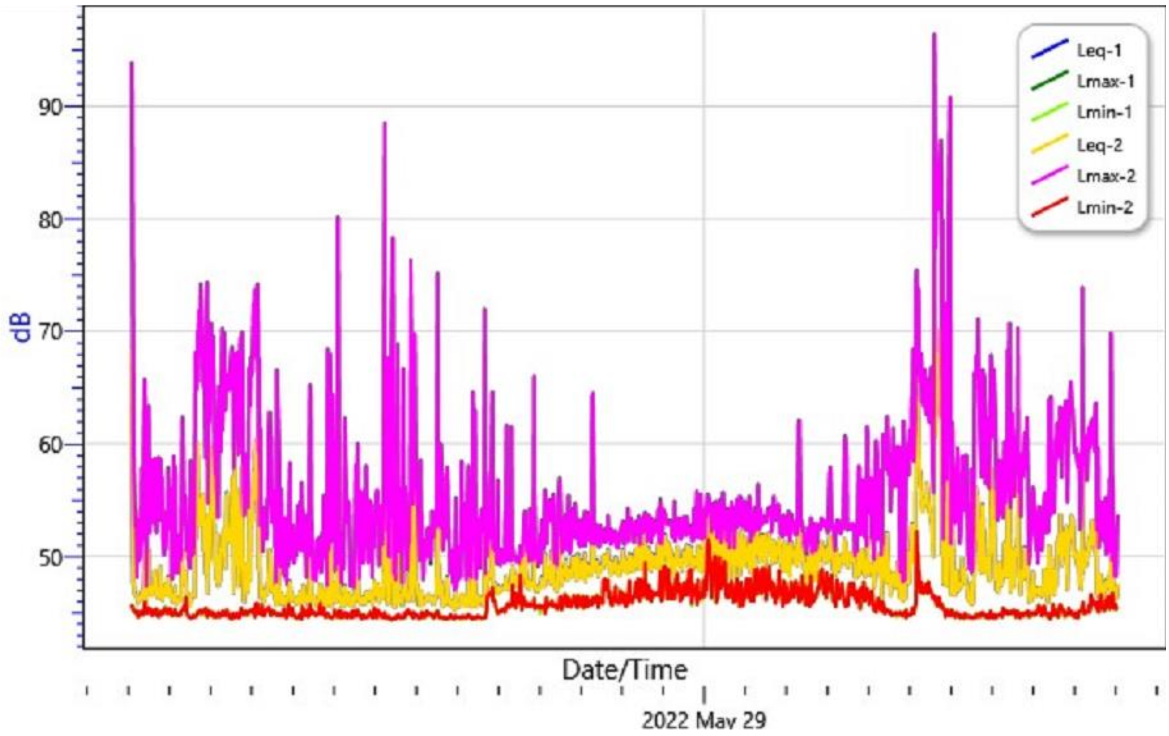
ProjectedTWA (1:00)	2	44.4 dB	MnΘme	2	28/05/2022 12:29:30 pm
MxΘme	2	29/05/2022 5:35:30 am	PKΘme	2	28/05/2022 10:04:53 am
WeighΘng	2	A	Range Ceiling	2	--
Criterion Level	2	85 dB	ULL	2	115 dB
Dynamic Range	2	--	Exchange Rate	2	3 dB
Response	2	FAST	IntegraΘng Threshold	2	80 dB
Alarm Level 1	2	--	AlarmLevel2	2	--
Dosimeter Name	2	--			

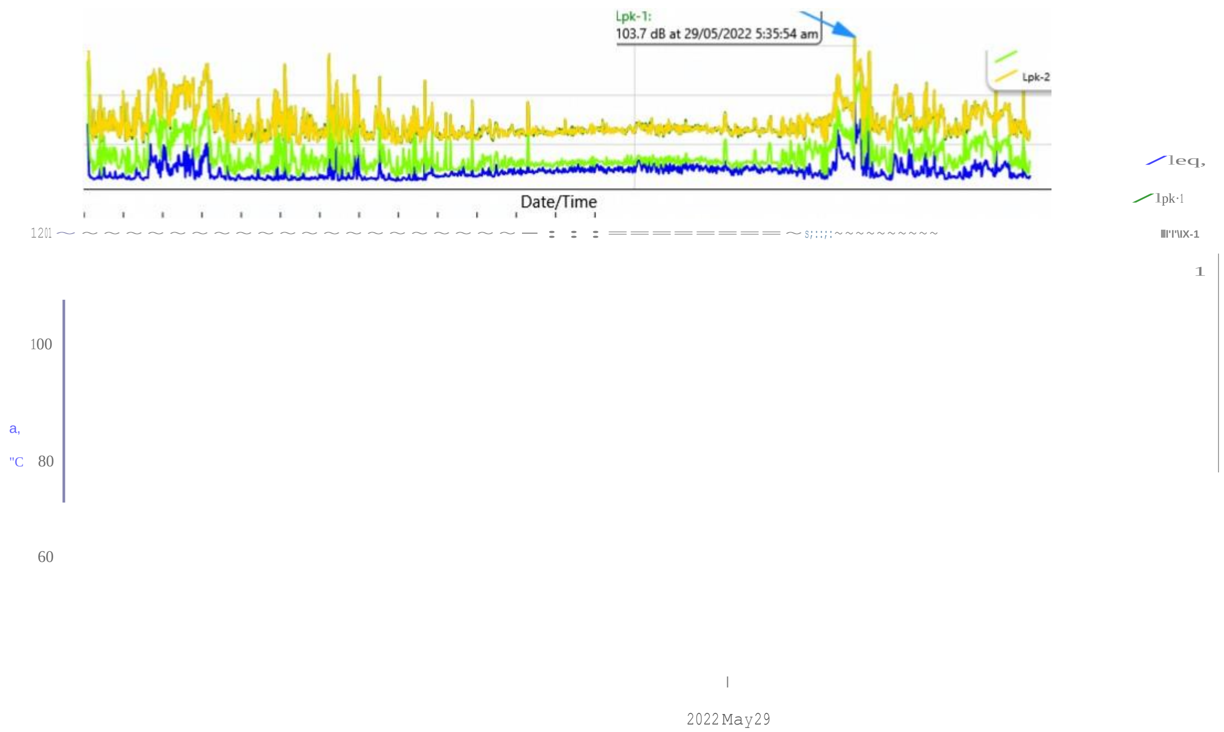
Calibration History

Date	Cali b rati on Acti on	Level	Cal. Model Type	S er i al Number	Cert . Due Date
28/05/2022 9:46:35 am	CalibraΘon	114.0			

Logged Data Chart

S009_BGV120001_08062022_144110: Logged Data Chart - Read Only




Lpk-1:
103.7 dB at 29/05/2022 5:35:54 am
Lpk-2
Date/Time
leq,
lpk-1
120
100
80
60
2022 May 29

Session Report

12/1/2022

General Information

Name	S008_BGV120002_03072022_163314
Comments	
Start Time	28/05/2022 10:20:23 am
Stop Time	29/05/2022 10:20:23 am
Run Time	1.00:00:00
Model Type	SoundPro DL
Serial Number	BGV120002
Device Firmware Rev	R.13H
Company Name	
DescripΘon	
LocaΘon	
User Name	

Summary Data

Descri pti on	Meter	Value	Descri pti on	Meter	Value
Dose	1	0.1 %	Pdose (1:00)	1	0 %
Lavg	1	--	Lpk	1	109.2 dB
Leq	1	56.8 dB	TWA	1	61.6 dB
UL Time	1	00:00:00	SEL	1	106.2 dB
ProjectedTWA (1:00)	1	47.8 dB	MnΘme	1	29/05/2022 3:31:36 am

MxӨme	1	28/05/2022 10:21:11 am	PKӨme	1	28/05/2022 10:20:58 am
WeighӨng	1	--	Range Ceiling	1	--
Criterion Level	1	--	ULL	1	--
Dynamic Range	1	--	Exchange Rate	1	--
Response	1	--	Int Threshold	1	--
Alarm Level 1	1	--	AlarmLevel2	1	--
Dosimeter Name	1	--			
Dose	2	0.5 %	Pdose (1:00)	2	0 %
Lavg	2	--	Lpk	2	109.2 dB
Leq	2	56.8 dB	TWA	2	61.6 dB
UL Time	2	00:00:00	SEL	2	106.2 dB

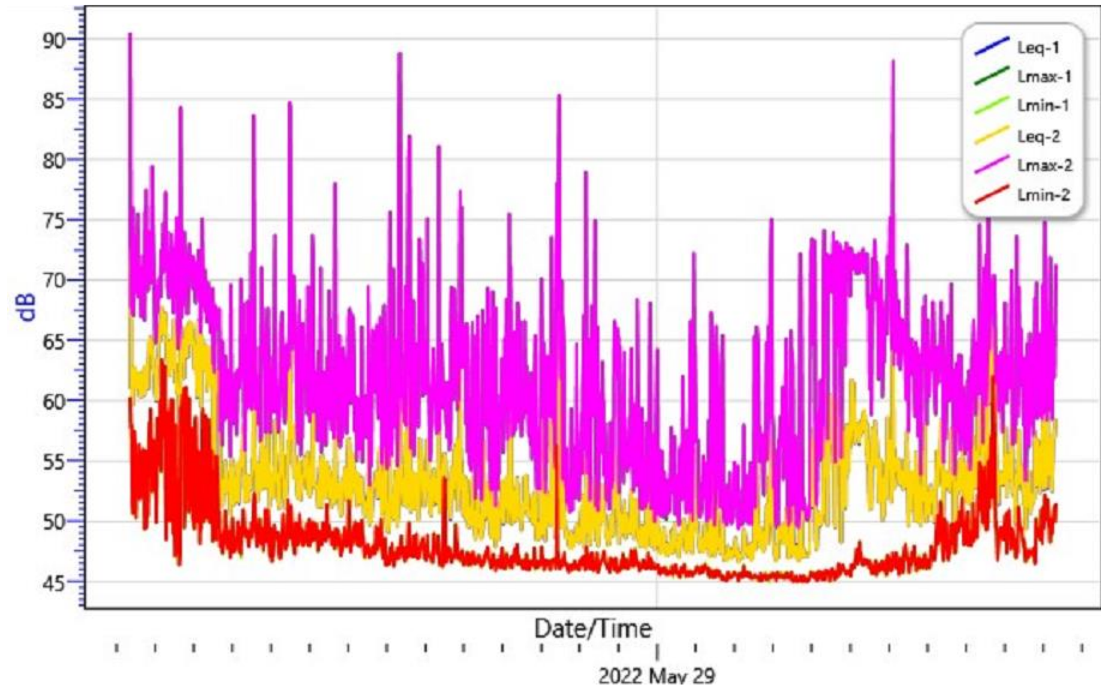
ProjectedTWA (1:00)	2	47.8 dB	MnΘme	2	29/05/2022 2:54:52 am
MxΘme	2	28/05/2022 10:21:11 am	PKΘme	2	28/05/2022 10:20:58 am
WeighΘng	2	A	Range Ceiling	2	--
Criterion Level	2	85 dB	ULL	2	115 dB
Dynamic Range	2	--	Exchange Rate	2	3 dB
Response	2	FAST	IntegraΘng Threshold	2	80 dB
Alarm Level 1	2	--	AlarmLevel2	2	--
Dosimeter Name	2	--			

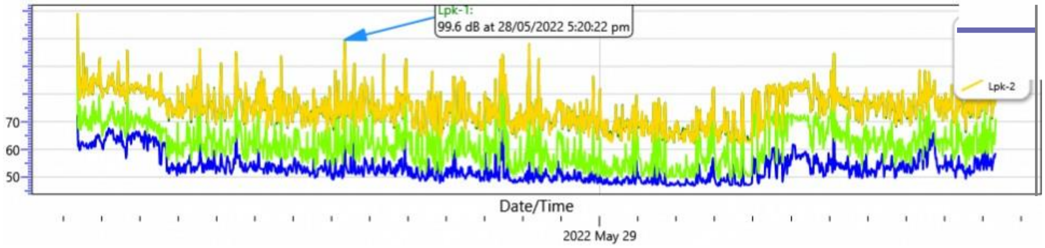
Calibration History

Date	Cali b rati on Acti on	Level	Cal. Model Type	S er i al Number	Cert . Due Date
28/05/2022 9:44:03 am	CalibraΘon	114.0			

Logged Data Chart

S008_BGV120002_03072022_163314: Logged Data Chart - Read Only





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Session Report

12/1/2022

General Information

Name	S007_BGV120003_08062022_143554
Comments	
Start Time	28/05/2022 10:30:02 am
Stop Time	29/05/2022 10:30:02 am
Run Time	1.00:00:00
Model Type	SoundPro DL
Serial Number	BGV120003
Device Firmware Rev	R.13H
Company Name	
DescripƟon	
LocaƟon	
User Name	

Summary Data

Descri pti on	Meter	V alue	Descri pti on	Meter	V alue
Dose	1	0 %	Pdose (1:00)	1	0 %
Lavg	1	--	Lpk	1	115.3 dB
Leq	1	51.5 dB	TWA	1	56.3 dB
UL Time	1	00:00:00	SEL	1	100.9 dB
ProjectedTWA (1:00)	1	42.5 dB	MnƟme	1	29/05/2022 6:46:11 am

MxΘme	1	28/05/2022 10:31:07 am	PKΘme	1	28/05/2022 10:31:07 am
WeighΘng	1	--	Range Ceiling	1	--
Criterion Level	1	--	ULL	1	--
Dynamic Range	1	--	Exchange Rate	1	--
Response	1	--	Int Threshold	1	--
Alarm Level 1	1	--	AlarmLevel2	1	--
Dosimeter Name	1	--			
Dose	2	0.1 %	Pdose (1:00)	2	0 %
Lavg	2	--	Lpk	2	115.3 dB
Leq	2	51.5 dB	TWA	2	56.3 dB
UL Time	2	00:00:00	SEL	2	100.9 dB

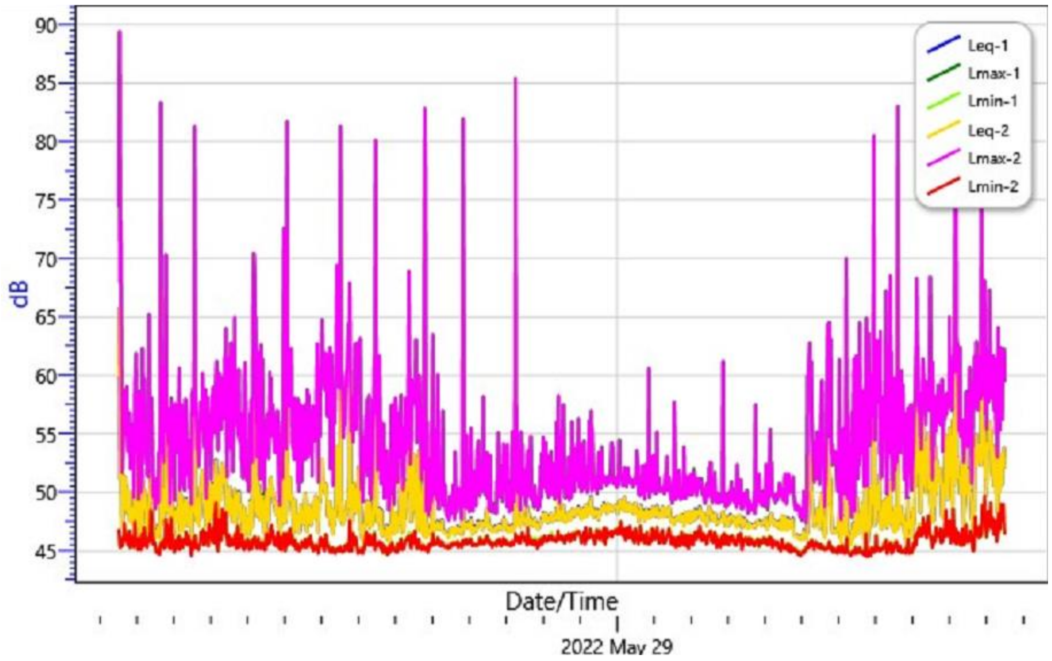
ProjectedTWA (1:00)	2	42.5 dB	MnΘme	2	28/05/2022 5:46:25 pm
MxΘme	2	28/05/2022 10:31:07 am	PKΘme	2	28/05/2022 10:31:07 am
WeighΘng	2	A	Range Ceiling	2	--
Criterion Level	2	85 dB	ULL	2	115 dB
Dynamic Range	2	--	Exchange Rate	2	3 dB
Response	2	FAST	IntegraΘng Threshold	2	80 dB
Alarm Level 1	2	--	AlarmLevel2	2	--
Dosimeter Name	2	--			

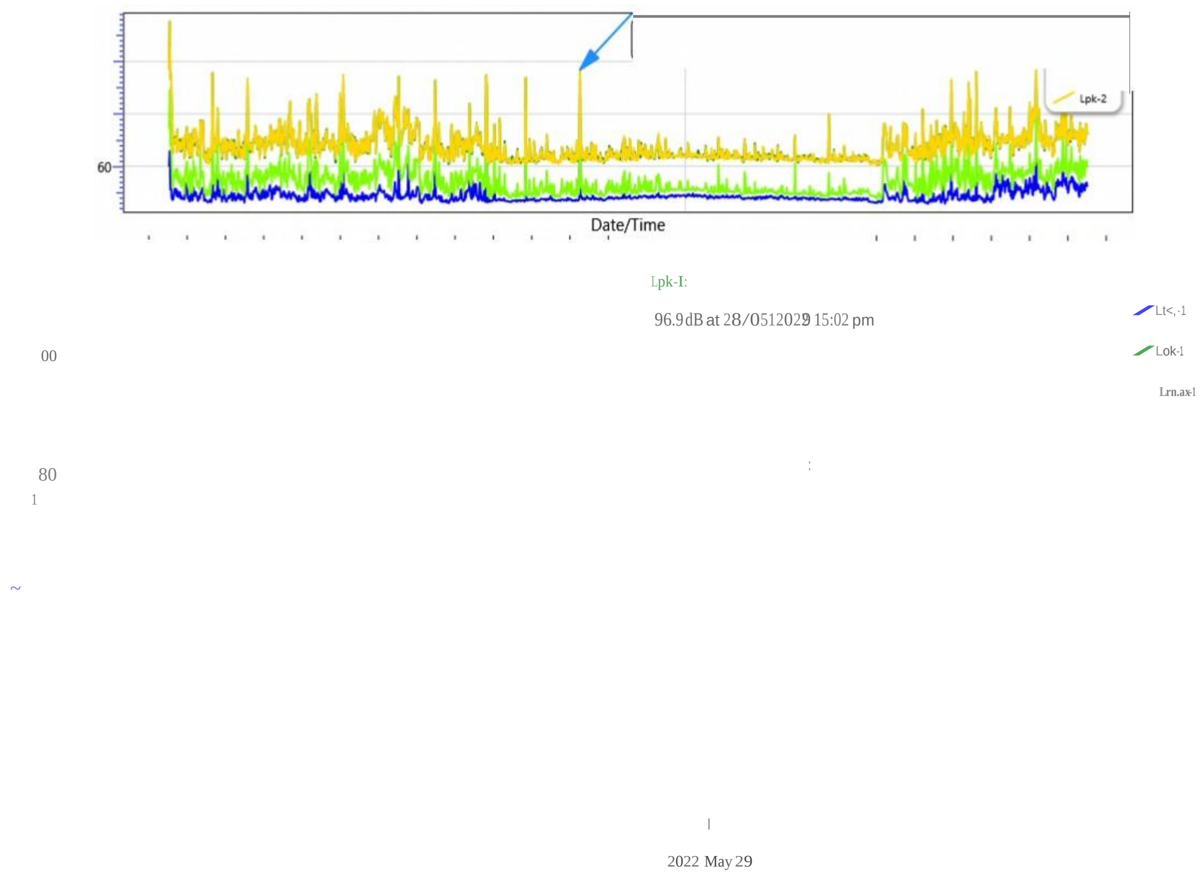
Calibration History

Date	Cali b rati on Acti on	Level	Cal. Model Type	S er i al Number	Cert . Due Date
28/05/2022 9:44:25 am	CalibraΘon	114.0			

Logged Data Chart

S007_BGV120003_08062022_143554: Logged Data Chart - Read Only




60
Date/Time
Lpk-2
Lpk-I:
96.9dB at 28/0512029 15:02 pm
Lt<,-1
Lok-1
Lrn.ax-1
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80
2022 May 29

Session Report

12/2/2022

General Information

Name	S031_BGV080001_12102022_085229
Comments	
Start Time	06/10/2022 4:46:08 pm
Stop Time	07/10/2022 4:46:08 pm
Run Time	1.00:00:00
Model Type	SoundPro DL
Serial Number	BGV080001
Device Firmware Rev	R.13H
Company Name	
DescripΘon	
LocaΘon	
User Name	

Summary Data

Descri pti on	Meter	Value	Descri pti on	Meter	Value
Dose	1	0.3 %	Pdose (1:00)	1	0 %
Lavg	1	--	Lpk	1	129.4 dB
Leq	1	54.8 dB	TWA	1	59.6 dB
UL Time	1	00:00:00	SEL	1	104.2 dB
ProjectedTWA (1:00)	1	45.8 dB	MnΘme	1	06/10/2022 5:08:24 pm

MxƟme	1	06/10/2022 4:47:02 pm	PKƟme	1	06/10/2022 4:47:02 pm
WeighƟng	1	--	Range Ceiling	1	--
Criterion Level	1	--	ULL	1	--
Dynamic Range	1	--	Exchange Rate	1	--
Response	1	--	Int Threshold	1	--
Alarm Level 1	1	--	AlarmLevel2	1	--
Dosimeter Name	1	--			
Dose	2	0.3 %	Pdose (1:00)	2	0 %
Lavg	2	--	Lpk	2	129.3 dB
Leq	2	54.8 dB	TWA	2	59.5 dB
UL Time	2	00:00:00	SEL	2	104.1 dB

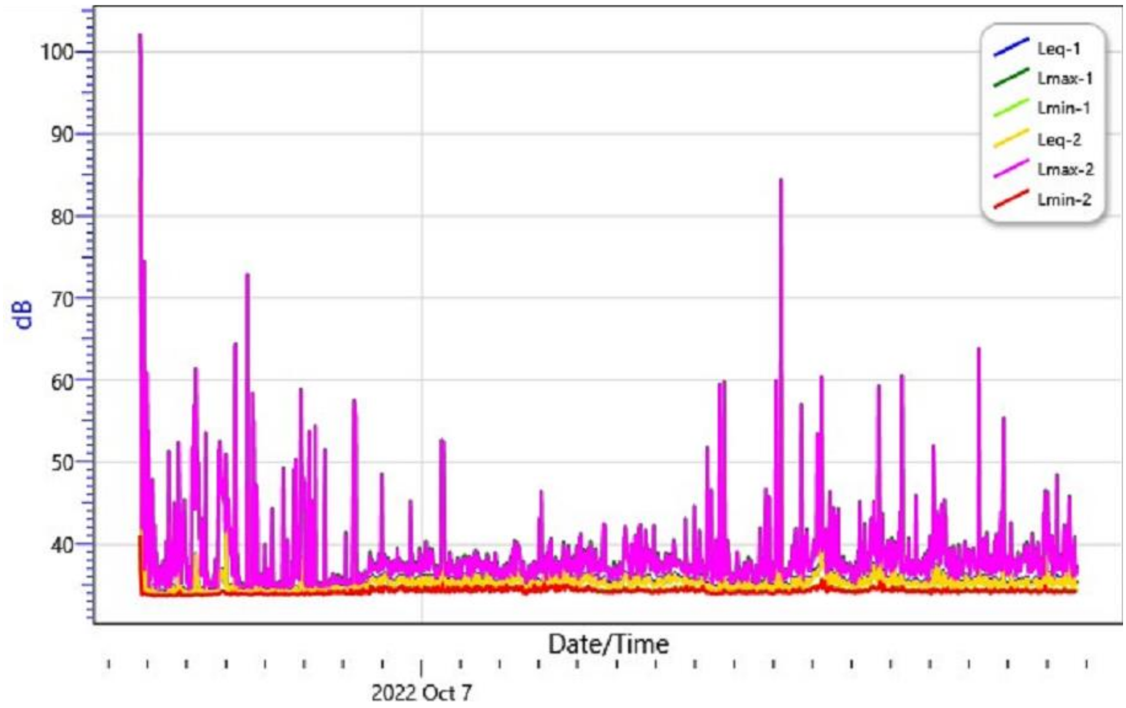
ProjectedTWA (1:00)	2	45.7 dB	MnΘme	2	06/10/2022 5:07:30 pm
MxΘme	2	06/10/2022 4:47:02 pm	PKΘme	2	06/10/2022 4:47:02 pm
WeighΘng	2	A	Range Ceiling	2	--
Criterion Level	2	85 dB	ULL	2	115 dB
Dynamic Range	2	--	Exchange Rate	2	3 dB
Response	2	FAST	IntegraΘng Threshold	2	80 dB
Alarm Level 1	2	--	AlarmLevel2	2	--
Dosimeter Name	2	--			

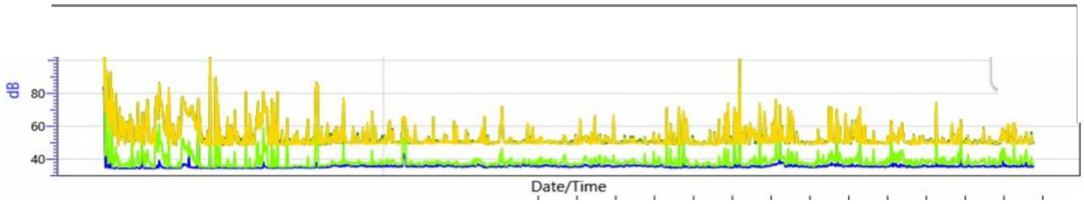
Calibration History

Date	Cali b rati on Acti on	Level	Cal. Model Type	S er i al Number	Cert . Due Date
05/10/2022 2:53:05 pm	CalibraΘon	114.0			

Logged Data Chart

S031_BGV080001_12102022_085229: Logged Data Chart - Read Only





100 Lm»:1

Lpk-2

Lpk-1:

120 102.2 dB at 06/10/2022 7:32:08 pm L•q-1

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Session Report

12/2/2022

General Information

Name	S020_BGV120003_12102022_085058
Comments	
Start Time	06/10/2022 3:08:02 pm
Stop Time	07/10/2022 3:08:02 pm
Run Time	1.00:00:00
Model Type	SoundPro DL
Serial Number	BGV120003
Device Firmware Rev	R.13H
Company Name	
DescripΘon	
LocaΘon	
User Name	

Summary Data

Descri pti on	Meter	Value	Descri pti on	Meter	Value
Dose	1	0.2 %	Pdose (1:00)	1	0 %
Lavg	1	--	Lpk	1	129.1 dB
Leq	1	58.3 dB	TWA	1	63.1 dB
UL Time	1	00:00:00	SEL	1	107.7 dB
ProjectedTWA (1:00)	1	49.3 dB	MnΘme	1	07/10/2022 7:28:35 am

MxӨme	1	06/10/2022 3:10:01 pm	PKӨme	1	06/10/2022 3:10:01 pm
WeighӨng	1	--	Range Ceiling	1	--
Criterion Level	1	--	ULL	1	--
Dynamic Range	1	--	Exchange Rate	1	--
Response	1	--	Int Threshold	1	--
Alarm Level 1	1	--	AlarmLevel2	1	--
Dosimeter Name	1	--			
Dose	2	0.7 %	Pdose (1:00)	2	0 %
Lavg	2	--	Lpk	2	129.1 dB
Leq	2	58.3 dB	TWA	2	63.1 dB
UL Time	2	00:00:00	SEL	2	107.7 dB

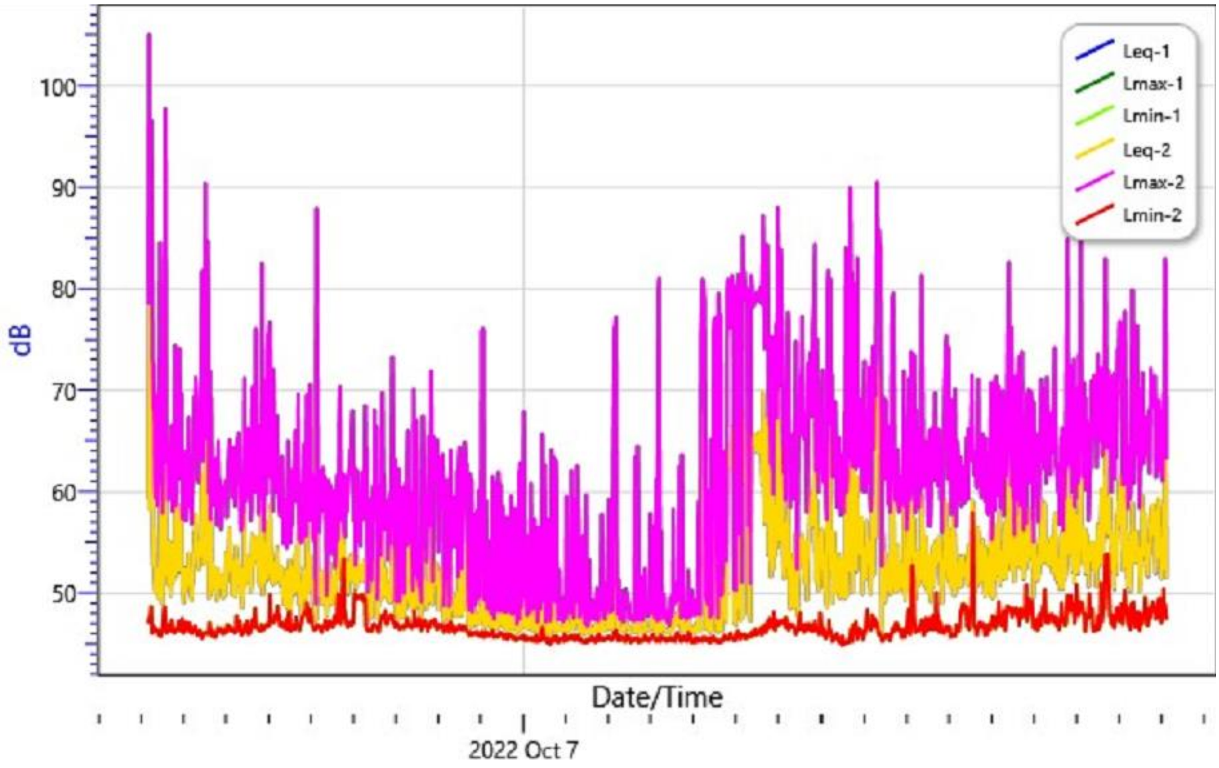
ProjectedTWA (1:00)	2	49.3 dB	MnΘme	2	07/10/2022 12:36:52 am
MxΘme	2	06/10/2022 3:10:01 pm	PKΘme	2	06/10/2022 3:10:01 pm
WeighΘng	2	A	Range Ceiling	2	--
Criterion Level	2	85 dB	ULL	2	115 dB
Dynamic Range	2	--	Exchange Rate	2	3 dB
Response	2	FAST	IntegraΘng Threshold	2	80 dB
Alarm Level 1	2	--	AlarmLevel2	2	--
Dosimeter Name	2	--			

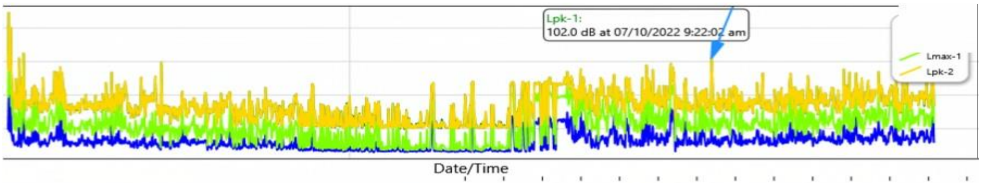
Calibration History

Date	Cali b rati on Acti on	Level	Cal. Model Type	S er i al Number	Cert . Due Date
05/10/2022 2:48:26 pm	CalibraΘon	114.0			

Logged Data Chart

S020_BGV120003_12102022_085058: Logged Data Chart - Read Only




Lpk-1:
102.0 dB at 07/10/2022 9:22:02 am
Lmax-1
Lpk-2
Date/Time


leq-1
Lpk-1
120
100
80
60
2022 Oct 7

Session Report

12/2/2022

General Information

Name	S018_BGV120001_12102022_085152
Comments	
Start Time	06/10/2022 3:52:26 pm
Stop Time	07/10/2022 3:52:26 pm
Run Time	1.00:00:00
Model Type	SoundPro DL
Serial Number	BGV120001
Device Firmware Rev	R.13H
Company Name	
DescripƟon	
LocaƟon	
User Name	

Summary Data

Descri pti on	Meter	Value	Descri pti on	Meter	Value
Dose	1	0 %	Pdose (1:00)	1	0 %
Lavg	1	--	Lpk	1	111.6 dB
Leq	1	49.6 dB	TWA	1	54.4 dB
UL Time	1	00:00:00	SEL	1	99 dB
ProjectedTWA (1:00)	1	40.6 dB	MnƟme	1	06/10/2022 6:39:15 pm

MxƟme	1	07/10/2022 11:49:08 am	PKƟme	1	07/10/2022 11:49:08 am
WeighƟng	1	--	Range Ceiling	1	--
Criterion Level	1	--	ULL	1	--
Dynamic Range	1	--	Exchange Rate	1	--
Response	1	--	Int Threshold	1	--
Alarm Level 1	1	--	AlarmLevel2	1	--
Dosimeter Name	1	--			
Dose	2	0.1 %	Pdose (1:00)	2	0 %
Lavg	2	--	Lpk	2	111.6 dB
Leq	2	49.6 dB	TWA	2	54.4 dB
UL Time	2	00:00:00	SEL	2	98.9 dB

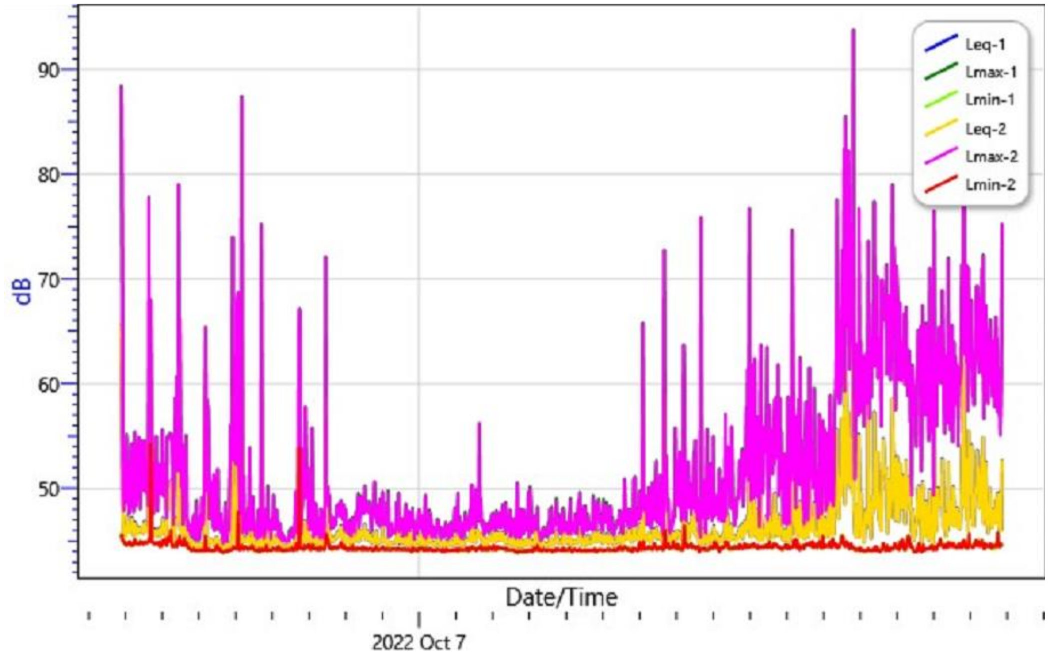
ProjectedTWA (1:00)	2	40.6 dB	MnΘme	2	06/10/2022 6:39:29 pm
MxΘme	2	07/10/2022 11:49:08 am	PKΘme	2	07/10/2022 11:49:08 am
WeighΘng	2	A	Range Ceiling	2	--
Criterion Level	2	85 dB	ULL	2	115 dB
Dynamic Range	2	--	Exchange Rate	2	3 dB
Response	2	FAST	IntegraΘng Threshold	2	80 dB
Alarm Level 1	2	--	AlarmLevel2	2	--
Dosimeter Name	2	--			

Calibration History

Date	Cali b rati on Acti on	Level	Cal. Model Type	S er i al Number	Cert . Due Date
05/10/2022 2:35:56 pm	CalibraΘon	114.0			

Logged Data Chart

S018_BGV120001_12102022_085152: Logged Data Chart - Read Only



Session Report

12/2/2022

General Information

Name	S032_BGV080001_12102022_085231
Comments	
Start Time	07/10/2022 5:31:00 pm
Stop Time	08/10/2022 5:31:00 pm
Run Time	1.00:00:00
Model Type	SoundPro DL
Serial Number	BGV080001
Device Firmware Rev	R.13H
Company Name	
DescripΘon	
LocaΘon	
User Name	

Summary Data

Descri pti on	Meter	V alue	Descri pti on	Meter	V alue
Dose	1	0.1 %	Pdose (1:00)	1	0 %
Lavg	1	--	Lpk	1	126.6 dB
Leq	1	51.7 dB	TWA	1	56.5 dB
UL Time	1	00:00:00	SEL	1	101.1 dB
ProjectedTWA (1:00)	1	42.7 dB	MnΘme	1	08/10/2022 5:16:35 pm

MxƟme	1	07/10/2022 5:32:10 pm	PKƟme	1	07/10/2022 5:32:10 pm
WeighƟng	1	--	Range Ceiling	1	--
Criterion Level	1	--	ULL	1	--
Dynamic Range	1	--	Exchange Rate	1	--
Response	1	--	Int Threshold	1	--
Alarm Level 1	1	--	AlarmLevel2	1	--
Dosimeter Name	1	--			
Dose	2	0.1 %	Pdose (1:00)	2	0 %
Lavg	2	--	Lpk	2	126.5 dB
Leq	2	51.7 dB	TWA	2	56.4 dB
UL Time	2	00:00:00	SEL	2	101 dB

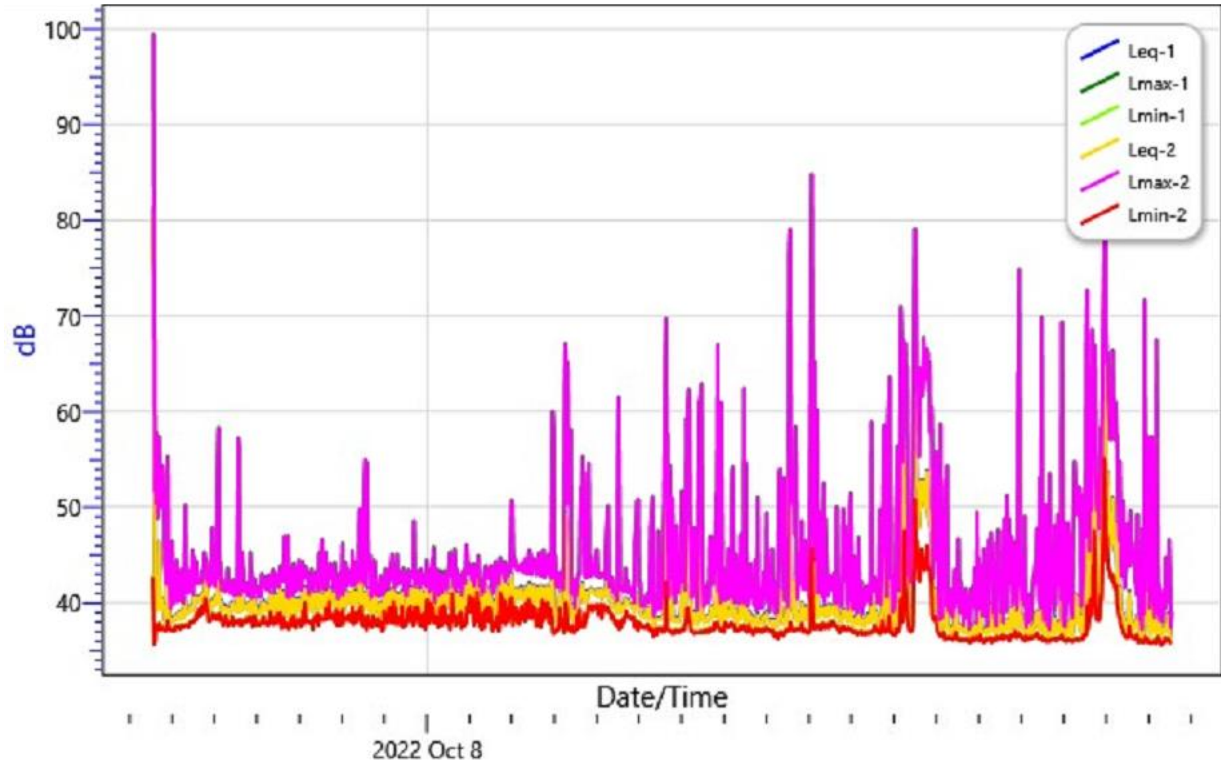
ProjectedTWA (1:00)	2	42.6 dB	MnΘme	2	08/10/2022 5:15:33 pm
MxΘme	2	07/10/2022 5:32:10 pm	PKΘme	2	07/10/2022 5:32:10 pm
WeighΘng	2	A	Range Ceiling	2	--
Criterion Level	2	85 dB	ULL	2	115 dB
Dynamic Range	2	--	Exchange Rate	2	3 dB
Response	2	FAST	IntegraΘng Threshold	2	80 dB
Alarm Level 1	2	--	AlarmLevel2	2	--
Dosimeter Name	2	--			

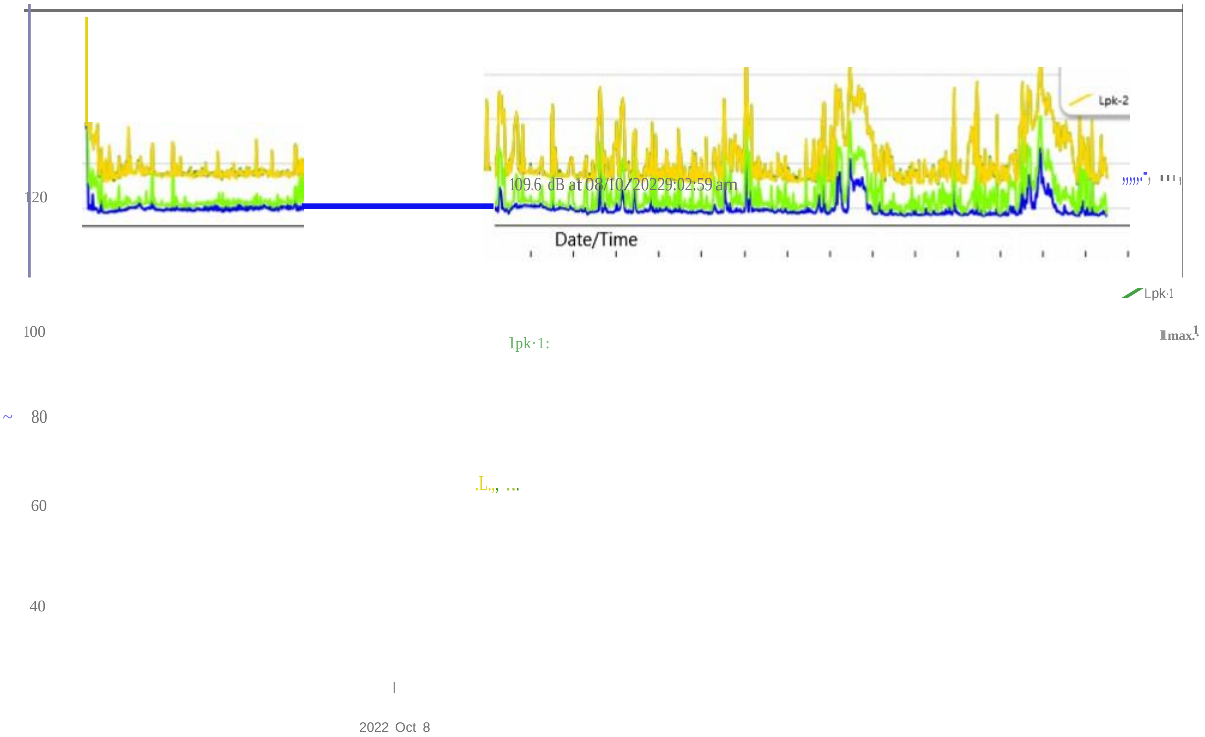
Calibration History

Date	Cali b rati on Acti on	Level	Cal. Model Type	S er i al Number	Cert . Due Date
07/10/2022 5:27:53 pm	CalibraΘon	114.0			

Logged Data Chart

S032_BGV080001_12102022_085231: Logged Data Chart - Read Only




Lpk-2
120
109.6 dB at 08/10/2022 9:02:59 am
Date/Time
Lpk-1
100
80
60
40
2022 Oct 8

Session Report

12/2/2022

General Information

Name	S021_BGV120003_12102022_085100
Comments	
Start Time	07/10/2022 4:21:47 pm
Stop Time	08/10/2022 4:21:47 pm
Run Time	1.00:00:00
Model Type	SoundPro DL
Serial Number	BGV120003
Device Firmware Rev	R.13H
Company Name	
DescripӨon	
LocaӨon	
User Name	

Summary Data

Descri pti on	Meter	Value	Descri pti on	Meter	Value
Dose	1	0.4 %	Pdose (1:00)	1	0 %
Lavg	1	--	Lpk	1	118.9 dB
Leq	1	60.6 dB	TWA	1	65.4 dB
UL Time	1	00:00:00	SEL	1	110 dB
ProjectedTWA (1:00)	1	51.6 dB	MnӨme	1	08/10/2022 1:26:42 am

MxƟme	1	08/10/2022 2:18:36 pm	PKƟme	1	08/10/2022 2:18:36 pm
WeighƟng	1	--	Range Ceiling	1	--
Criterion Level	1	--	ULL	1	--
Dynamic Range	1	--	Exchange Rate	1	--
Response	1	--	Int Threshold	1	--
Alarm Level 1	1	--	AlarmLevel2	1	--
Dosimeter Name	1	--			
Dose	2	1.1 %	Pdose (1:00)	2	0 %
Lavg	2	--	Lpk	2	118.9 dB
Leq	2	60.7 dB	TWA	2	65.4 dB
UL Time	2	00:00:00	SEL	2	110 dB

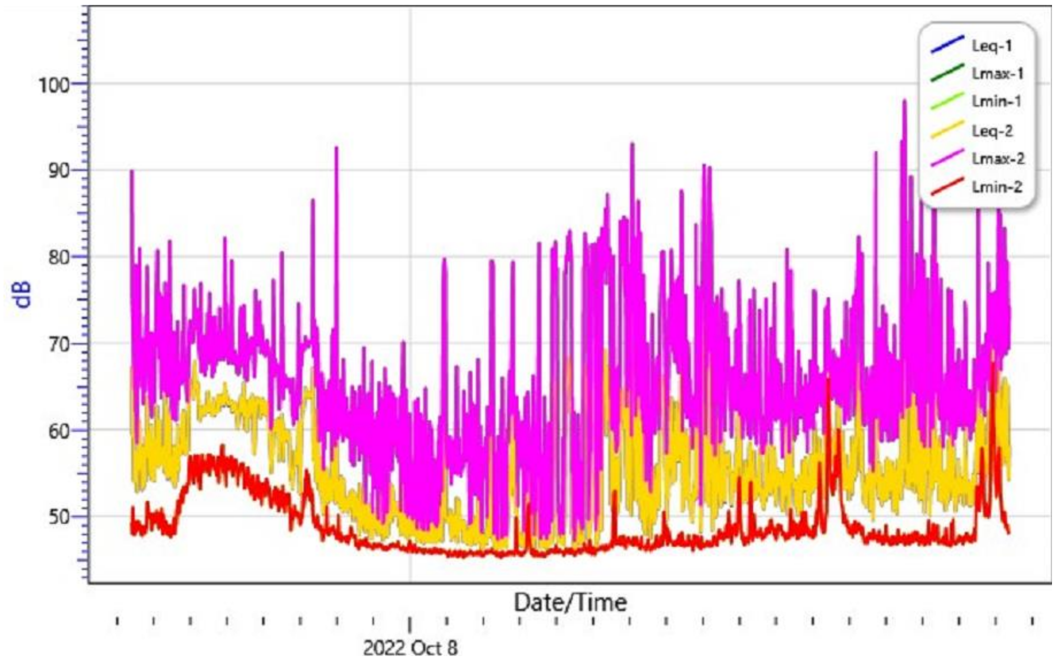
ProjectedTWA (1:00)	2	51.6 dB	MnΘme	2	08/10/2022 2:27:34 am
MxΘme	2	08/10/2022 2:18:36 pm	PKΘme	2	08/10/2022 2:18:36 pm
WeighΘng	2	A	Range Ceiling	2	--
Criterion Level	2	85 dB	ULL	2	115 dB
Dynamic Range	2	--	Exchange Rate	2	3 dB
Response	2	FAST	IntegraΘng Threshold	2	80 dB
Alarm Level 1	2	--	AlarmLevel2	2	--
Dosimeter Name	2	--			

Calibration History

Date	Cali b rati on Acti on	Level	Cal. Model Type	S er i al Number	Cert . Due Date
07/10/2022 4:19:22 pm	CalibraΘon	114.0			

Logged Data Chart

S021_BGV120003_12102022_085100: Logged Data Chart - Read Only



Session Report

12/2/2022

General Information

Name	S019_BGV120001_12102022_085153
Comments	
Start Time	07/10/2022 6:08:25 pm
Stop Time	08/10/2022 6:08:25 pm
Run Time	1.00:00:00
Model Type	SoundPro DL
Serial Number	BGV120001
Device Firmware Rev	R.13H
Company Name	
DescripƟon	
LocaƟon	
User Name	

Summary Data

Descri pti on	Meter	V alue	Descri pti on	Meter	V alue
Dose	1	0 %	Pdose (1:00)	1	0 %
Lavg	1	--	Lpk	1	94.8 dB
Leq	1	44.9 dB	TWA	1	49.7 dB
UL Time	1	00:00:00	SEL	1	94.3 dB
ProjectedTWA (1:00)	1	35.9 dB	MnƟme	1	07/10/2022 8:18:57 pm

MxΘme	1	07/10/2022 6:08:33 pm	PKΘme	1	07/10/2022 6:08:33 pm
WeighΘng	1	--	Range Ceiling	1	--
Criterion Level	1	--	ULL	1	--
Dynamic Range	1	--	Exchange Rate	1	--
Response	1	--	Int Threshold	1	--
Alarm Level 1	1	--	AlarmLevel2	1	--
Dosimeter Name	1	--			
Dose	2	0 %	Pdose (1:00)	2	0 %
Lavg	2	--	Lpk	2	94.8 dB
Leq	2	44.9 dB	TWA	2	49.7 dB
UL Time	2	00:00:00	SEL	2	94.3 dB

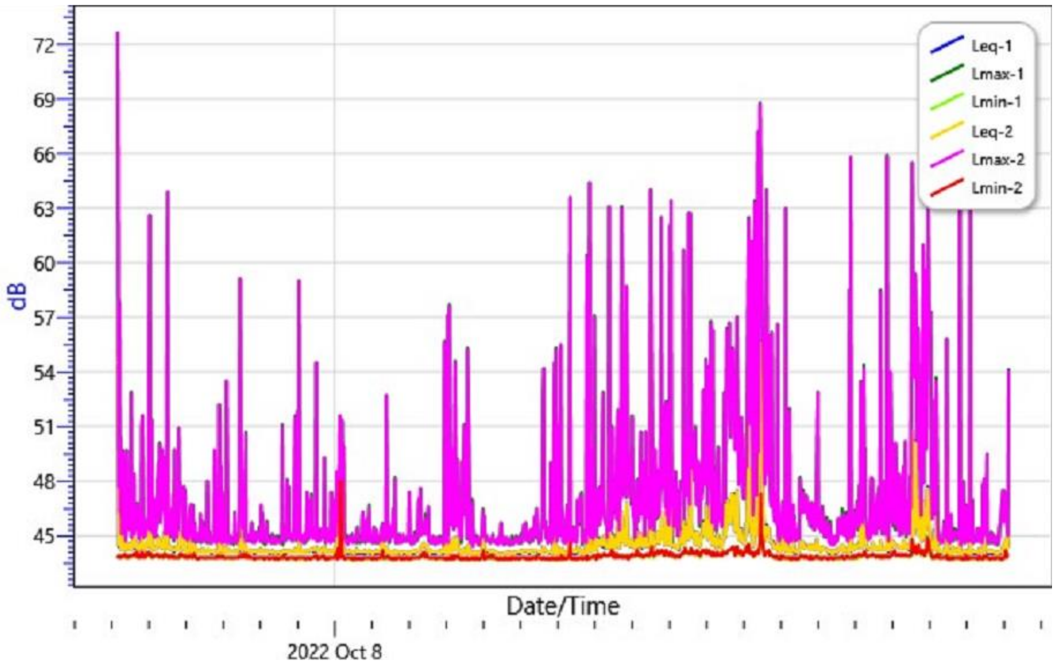
ProjectedTWA (1:00)	2	35.9 dB	MnƟme	2	08/10/2022
MxƟme	2	07/10/2022	PKƟme	2	07/10/2022
WeighƟng	2	A	Range Ceiling	2	--
Criterion Level	2	85 dB	ULL	2	115 dB
Dynamic Range	2	--	Exchange Rate	2	3 dB
Response	2	FAST	IntegraƟng	2	80 dB
Alarm Level 1	2	--	AlarmLevel2	2	--
Dosimeter Name	2	--			

Calibration History

Date	Calibration Action	Level	Cal. Model Type	Serial Number	Cert. Due Date
07/10/2022 6:04:39 pm	CalibraƟon	114.0			

Logged Data Chart

S019_BGV120001_12102022_085153: Logged Data Chart - Read Only



Calibration Certificates

TSI INCORPORATED – OCONOMOWOC
1060 Corporate Center Drive, Oconomowoc, WI 53066 USA
tel 651 490 2811 + toll free 800 245 0779 + web www.tsi.com

An ISO 9001 Registered Company

Certificate of Calibration

Certificate Number: 2108200751BGV080001

Model: SoundPro SP DL-2
S/N: BGV080001

Date Issued: 20-Aug-2021

On this day of manufacture and calibration, TSI certifies that the above listed product meets or exceeds the performance requirements of the following acoustic standard(s):

ANSI S1.4 1983 (R 2006) - Specification for Sound Level Meters / Type 2
ANSI S1.43 1997 (R 2007) - Specification for Integrating - Averaging Sound Level Meters / Type 2
IEC 61672-1 (2002) - Electro acoustics – Sound Level Meters – Part 1: Specifications / Class 2

Test Conditions: Temp: 18-25°C Humidity: 20-80% R.H. Barometric Pressure: 950-1050 mBar
Test Procedure: S053-899

Subassemblies:

QE7052	53138
SPro Preamp	6215122

Reference Standard(s):

Device	Ref Standard Cal Due	Uncertainty - Estimated at 95% Confidence Level (k=2)
B&K Ensemble	22-May-2022	+/- 0.19dB Acoustic
Fluke 45	23-Feb-2023	+/- 1.4% AC Voltage, +/-0.1% DC Voltage

Calibrated By: Michele Hust
Michele Hust - Assembler

In order to maintain best instrument performance over time, and in the event of inspection, audit or litigation, we recommend the instrument be recalibrated annually. Any number of factors may cause the calibration to drift before the recommended interval has expired. See user manual for more information.

All equipment used in the test and calibration of this instrument is traceable to NIST, and applies only to the unit identified above. This report must not be reproduced, except in its entirety, without the written approval of TSI, Inc.

098-642 Rev F

Page 1 of 1

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Certificate of Calibration

Certificate No:1000424 AC300002258

Submitted By: ROSE ENVIRONMENTAL LTD
UNIT 7, LOT 2C CHOOTOO RD
O EL SOCORRO TRINIDAD AND TOBAGO

Serial Number: AC300002258

Customer ID:

Model: AC-300 CALIBRATOR

Test Conditions:

Temperature: 18°C to 29°C
Humidity: 20% to 80%
Barometric Pressure: 890 mbar to 1050 mbar

Date Received: 2/23/2022
Date Issued: 3/1/2022
Valid Until: 3/1/2023

Model Conditions:

As Found: IN TOLERANCE
As Left: IN TOLERANCE

SubAssemblies:

Description:

Serial Number:

Calibrated per Procedure: 057V879

Reference Standard(s):

I.D. Number	Device	Last Calibration	Date Calibration Due
ET0000556	B&K ENSEMBLE	6/18/2020	6/18/2022

Measurement Uncertainty:

ACOUSTIC +/- 0.19DB FREQUENCY +/- 0.058%
Estimated at 95% Confidence Level (k=2)

Calibrated By: WILLIAM MALONEY Service Technician 3/1/2022

This report certifies that all calibration equipment used in the test is traceable to NIST, and applies only to the unit identified under equipment above. This report must not be reproduced except in its entirety without the written approval of TSI Incorporated.

098-393 Rev. B

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An ISO 9C
Registered Compa

Certificate of Calibration

Certificate Number: 2112160841BGV120001

Date Issued: 16-Dec-2021

Model: SoundPro SP DL-2
S/N: BGV120001

On this day of manufacture and calibration, TSI certifies that the above listed product meets or exceeds the performance requirements of the following acoustic standard(s):

ANSI S1.4 1983 (R 2006) - Specification for Sound Level Meters / Type 2
ANSI S1.43 1997 (R 2007) - Specification for Integrating - Averaging Sound Level Meters / Type 2
IEC 61672-1 (2002) - Electro acoustics – Sound Level Meters – Part 1: Specifications / Class 2

Test Conditions: Temp: 18-25°C Humidity: 20-80% R.H. Barometric Pressure: 950-1050 mBar
Test Procedure: S053-899

Subassemblies:

QE7052	53407
SPro Preamp	11210114

Reference Standard(s):

Device	Ref Standard Cal Due	Uncertainty - Estimated at 95% Confidence Level (k=2)
B&K Ensemble	22-May-2022	+/- 0.19dB Acoustic
Fluke 45	23-Feb-2023	+/- 1.4% AC Voltage, +/-0.1% DC Voltage

Calibrated By: Michele Hust
Michele Hust - Assembler

In order to maintain best instrument performance over time, and in the event of inspection, audit or litigation, we recommend the instrument be recalibrated annually. Any number of factors may cause the calibration to drift before the recommended interval has expired. See user manual for more information.

All equipment used in the test and calibration of this instrument is traceable to NIST, and applies only to the unit identified above. This report must not be reproduced, except in its entirety, without the written approval of TSI, Inc.

098-642 Rev F

Page 1 of

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An ISO 90
Registered Compa

Certificate of Calibration

Certificate Number: 2112160842BGV120003

Model: SoundPro SP DL-2
S/N: BGV120003

Date Issued: 16-Dec-2021

On this day of manufacture and calibration, TSI certifies that the above listed product meets or exceeds the performance requirements of the following acoustic standard(s):

ANSI S1.4 1983 (R 2006) - Specification for Sound Level Meters / Type 2
ANSI S1.43 1997 (R 2007) - Specification for Integrating - Averaging Sound Level Meters / Type 2
IEC 61672-1 (2002) - Electro acoustics – Sound Level Meters – Part 1: Specifications / Class 2

Test Conditions: Temp: 18-25ºC Humidity: 20-80% R.H. Barometric Pressure: 950-1050 mBar
Test Procedure: S053-899

Subassemblies:

QE7052	53541
SPro Preamp	11210061

Reference Standard(s):

Device	Ref Standard Cal Due	Uncertainty - Estimated at 95% Confidence Level (k=2)
B&K Ensemble	22-May-2022	+/- 0.19dB Acoustic
Fluke 45	23-Feb-2023	+/- 1.4% AC Voltage, +/-0.1% DC Voltage

Calibrated By: Michele Hust
Michele Hust - Assembler

In order to maintain best instrument performance over time, and in the event of inspection, audit or litigation, we recommend the instrument be recalibrated annually. Any number of factors may cause the calibration to drift before the recommended interval has expired. See user manual for more information.

All equipment used in the test and calibration of this instrument is traceable to NIST, and applies only to the unit identified above. This report must not be reproduced, except in its entirety, without the written approval of TSI, Inc.

098-642 Rev F

TSI INCORPORATfD OCONOMOWOC

tel 651 490 2811 • toll free

Certificate of Calibration

Certificate Number:2108201135AC300015178

Date Issued:20-Aug-2021

Model: AC-300 Acoustic Calibrator

S/N: AC300015178

On this day of manufacture and calibration, TSI certifies that the above listed product meets or exceeds the perfonnance requirements of the following acoustic standard(s):

ANSI S1 40-2006 (R2011}. Specof,cat,ons and Verof,cation Procedures for Sound Ca',brators

IEC 60942 2003 / EN60942-2003 Electroacoushcs Sound Calibrators / Class 1

Teat Conditions: Temp 18-25°C Humidity 20-80% R H Barometric Pressure· 950-1050 mBar

Test Procedure: S057-879

Reference Standard(&):

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An ISO 9001 Registered Company

Certificate of Calibration

Certificate Number: 2112160842BGV120002

Model: SoundPro SP DL-2
S/N: BGV120002

Date Issued: 16-Dec-2021

On this day of manufacture and calibration, TSI certifies that the above listed product meets or exceeds the performance requirements of the following acoustic standard(s):

ANSI S1.4 1983 (R 2006) - Specification for Sound Level Meters / Type 2
ANSI S1.43 1997 (R 2007) - Specification for Integrating - Averaging Sound Level Meters / Type 2
IEC 61672-1 (2002) - Electro acoustics – Sound Level Meters – Part 1: Specifications / Class 2

Test Conditions: Temp: 18-25°C Humidity: 20-80% R.H. Barometric Pressure: 950-1050 mBar
Test Procedure: S053-899

Subassemblies:

QE7052	53542
SPro Preamp	11210106

Reference Standard(s):

Device	Ref Standard Cal Due	Uncertainty - Estimated at 95% Confidence Level (k=2)
B&K Ensemble	22-May-2022	+/- 0.19dB Acoustic
Fluke 45	23-Feb-2023	+/- 1.4% AC Voltage, +/-0.1% DC Voltage

Calibrated By: Michele Hust
Michele Hust - Assembler

In order to maintain best instrument performance over time, and in the event of inspection, audit or litigation, we recommend the instrument be recalibrated annually. Any number of factors may cause the calibration to drift before the recommended interval has expired. See user manual for more information.

All equipment used in the test and calibration of this instrument is traceable to NIST, and applies only to the unit identified above. This report must not be reproduced, except in its entirety, without the written approval of TSI, Inc.

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Field Logs

Noise Monitoring Field Record Sheet

Monitoring Location		Upwind - Tyson Hall
Description of Location		Rural Farm
Date of Monitoring		16.05.2022
Measurement Start Time (hh:mm)		5:18pm
Measurement Time Length (min.)		24 hrs
Noise Meter Model/Identification		BGU 12001
Calibrator Model/Identification		AC3000 15178
Measurement Results	~~L_{90}~~ PEAK (dB~~(A)~~)	95.6
	L_{10} (dB(A))	
	L_{EQ} (dB(A))	53.0
Major Construction Noise Source(s) During Monitoring		N.A.
Other Noise Source(s) During Monitoring		minimal vehicular traffic in area
Remarks		

	Name & Designation	Signature	Date
Recorded By :			
Checked By :	[signature]	NEIL HARPER	16.05.2022

Noise Monitoring Field Record Sheet

Monitoring Location		Downwind - Store Bay Local Rd.
Description of Location		Carpark of minimart + grill
Date of Monitoring		16.05.2022
Measurement Start Time (hh:mm)		4:38 pm
Measurement Time Length (min.)		24 hrs
Noise Meter Model/Identification		BGV 120003
Calibrator Model/Identification		AC 300015178
Measurement Results	PEAK ~~L_{90}~~ (dB(A))	112.3
	L_{10} (dB(A))	
	LEQ (dB(A))	58.5
Major Construction Noise Source(s) During Monitoring		NA
Other Noise Source(s) During Monitoring		voices + vehicles from patrons behind building
Remarks		

	Name & Designation	Signature	Date
Recorded By :			
Checked By :	NEIL HARPER		16.05.2022

Noise Monitoring Field Record Sheet

Monitoring Location		Downwind - Crown Point
Description of Location		Adjacent to Airport Runway
Date of Monitoring		16.05.2022
Measurement Start Time (hh:mm)		6:11pm
Measurement Time Length (min.)		24hrs
Noise Meter Model/Identification		BGV060001
Calibrator Model/Identification		AC30001'5178
Measurement Results	~~L_{90}~~ PEAK (dB~~(A)~~)	103.6
	L_{10} (dB(A))	
	LEQ (dB(A))	54
Major Construction Noise Source(s) During Monitoring		N.A.
Other Noise Source(s) During Monitoring		minimal vehicular traffic
Remarks		windy location

	Name & Designation	Signature	Date
Recorded By :			
Checked By :	[signature]	NEIL THARPER	16.05.2022

Noise Monitoring Field Record Sheet

Monitoring Location		Upwin - Tyson Hall
Description of Location		Rural farm
Date of Monitoring		28.05.2022
Measurement Start Time (hh:mm)		10:03 a.m.
Measurement Time Length (min.)		24hrs
Noise Meter Model/Identification		BGV 120001
Calibrator Model/Identification		AC 300015178
Measurement Results	~~L_{90}~~ PEAK (dB)	103.7
	L_{10} (dB(A))	
	LEQ (dB(A))	53.4
Major Construction Noise Source(s) During Monitoring		N.A.
Other Noise Source(s) During Monitoring		minimal vehicular traffic in area
Remarks		

	Name & Designation	Signature	Date
Recorded By :			
Checked By :	NEIL HARPER	[signature]	28.05.2022

Noise Monitoring Field Record Sheet

Monitoring Location		[illegible]
Description of Location		[illegible] + grill
Date of Monitoring		28.05.2022
Measurement Start Time (hh:mm)		10:20 am
Measurement Time Length (min.)		24hrs.
Noise Meter Model/Identification		BGV 120002
Calibrator Model/Identification		AC 300015178
Measurement Results	~~L90~~ PEAK (dB(~~A~~))	99.6
	L_{10} (dB(A))	
	LEQ (dB(A))	56.8
Major Construction Noise Source(s) During Monitoring		N.A.
Other Noise Source(s) During Monitoring		voices + vehicles from [illegible] behind building
Remarks		

	Name & Designation	Signature	Date
Recorded By :			
Checked By :	NEIL HARPER	[signature]	28.05.2022

Noise Monitoring Field Record Sheet

Monitoring Location		Downward Crown Point
Description of Location		Adjacent to Airport Runway
Date of Monitoring		28.05.2022
Measurement Start Time (hh:mm)		10:30 am
Measurement Time Length (min.)		24 hrs
Noise Meter Model/Identification		BGV 120003
Calibrator Model/Identification		AC300 15176
Measurement Results	PEAK L_{90} (dB(A))	96.9
	L_{10} (dB(A))	
	LEQ (dB(A))	51.5
Major Construction Noise Source(s) During Monitoring		N.A.
Other Noise Source(s) During Monitoring		minimal vehicular traffic
Remarks		windy location

	Name & Designation	Signature	Date
Recorded By :			
Checked By :	NEIL HARPER	[signature]	28.05.2021

Noise Monitoring Field Record Sheet

Monitoring Location		Upwind - Tyson Hall
Description of Location		Rural Farm
Date of Monitoring		06.10.2022
Measurement Start Time (hh:mm)		4:46 pm
Measurement Time Length (min.)		24 hrs
Noise Meter Model/Identification		BGV080001
Calibrator Model/Identification		AC 300002258
Measurement Results	PEAK L_{90} (dB(A))	102.2
	L_{10} (dB(A))	
	LEQ (dB(A))	54.8
Major Construction Noise Source(s) During Monitoring		N.A.
Other Noise Source(s) During Monitoring		minimal vehicular traffic
Remarks		

	Name & Designation	Signature	Date
Recorded By :			
Checked By :	[signature]	NEIL HARPAR	06.10.2022

Noise Monitoring Field Record Sheet

Monitoring Location		Dawnwind – Store Bay Local Rd.
Description of Location		Car Park & mini mart + grill
Date of Monitoring		06.10.2022
Measurement Start Time (hh:mm)		3:08pm
Measurement Time Length (min.)		24hrs.
Noise Meter Model/Identification		BGV 120003
Calibrator Model/Identification		AC 30000 2258
Measurement Results	L_{PEAK} (dB)	102.0
	L_{10} (dB(A))	
	LEQ (dB(A))	58.3
Major Construction Noise Source(s) During Monitoring		N.A.
Other Noise Source(s) During Monitoring		voices + vehicles from patrons behind building
Remarks		

	Name & Designation	Signature	Date
Recorded By :			
Checked By :	NEIL HARPER	[signature]	06.10.2022

Noise Monitoring Field Record Sheet

Monitoring Location		Downwind – Crown Point
Description of Location		Adjacent to Airport Runway
Date of Monitoring		06.10.22
Measurement Start Time (hh:mm)		3:52 pm
Measurement Time Length (min.)		24 hrs
Noise Meter Model/Identification		BGV120001
Calibrator Model/Identification		AC 30000 2258
Measurement Results	L_{PEAK} (dB())	111.6
	L_{10} (dB(A))	
	L_{EQ} (dB(A))	49.6
Major Construction Noise Source(s) During Monitoring		N.A.
Other Noise Source(s) During Monitoring		minimal vehicular traffic
Remarks		windy location.

	Name & Designation	Signature	Date
Recorded By :			
Checked By :	NEIL HARPER	[signature]	06.10.2022

Noise Monitoring Field Record Sheet

Monitoring Location		Upani-d - Tysen Hall
Description of Location		Rural Farm
Date of Monitoring		07.10.22
Measurement Start Time (hh:mm)		5:31pm
Measurement Time Length (min.)		24hrs
Noise Meter Model/Identification		BGV080001
Calibrator Model/Identification		AC 300002258
Measurement Results	PEAK L_{80} (dB(A))	109.6
	L_{10} (dB(A))	
	L_{EQ} (dB(A))	51.7
Major Construction Noise Source(s) During Monitoring		N.A.
Other Noise Source(s) During Monitoring		minimal vehicular traffic
Remarks		

	Name & Designation	Signature	Date
Recorded By :			
Checked By :	[signature]	NEIL HARPER	07.10.2022

Noise Monitoring Field Record Sheet

Monitoring Location		Downwind - [illegible] Rd.
Description of Location		At back of minimart + grill
Date of Monitoring		07.10.2022
Measurement Start Time (hh:mm)		4:21 pm
Measurement Time Length (min.)		24 hrs
Noise Meter Model/Identification		BGU120003
Calibrator Model/Identification		AC300002258
Measurement Results	L_{90} PEAK (dB(A))	118.9
	L_{10} (dB(A))	
	L_{EQ} (dB(A))	60.6
Major Construction Noise Source(s) During Monitoring		N.A.
Other Noise Source(s) During Monitoring		voices + vehicles from patrons behind building.
Remarks		

	Name & Designation	Signature	Date
Recorded By :			
Checked By :	[signature]	NEIL HARPER	07.10.2022

Noise Monitoring Field Record Sheet

Monitoring Location		Downwind - Crown Point
Description of Location		Adjacent to Airport Runway
Date of Monitoring		07.10.2022
Measurement Start Time (hh:mm)		6:08 pm
Measurement Time Length (min.)		24hrs
Noise Meter Model/Identification		3GV120001
Calibrator Model/Identification		AC30002258
Measurement Results	PEAK L (dB)	94.8
	L_{10} (dB(A))	
	LEQ (dB(A))	44.9
Major Construction Noise Source(s) During Monitoring		N.A.
Other Noise Source(s) During Monitoring		minimal vehicular traffic
Remarks		windy location.

	Name & Designation	Signature	Date
Recorded By :			
Checked By :	[signature]	NEIL HARPER	07.10.2022

E4 – Biological Environment

E4.1 – Raw Data Sheets

RAW DATA Floral Surveys

Dry Season Mangrove Data

Plot A

Tree Species	DBH (cm)	CBH (cm)	Basal Area (cm2)	Above Ground Biomass estimate (Kg)	Estimated Dry Weight Kg	Estimated Carbon Weight (Kg)	Estimated CO2 Sequestered (Kg)
Black	14.959	47.000	175.7638447	5.853832092	4.244028267	2.122014133	7.78779187
Black	14.322	45.000	161.1234882	5.245112012	3.802706209	1.901353104	6.97796589
White	15.913	50.000	198.9178867	6.843723122	4.961699264	2.480849632	9.10471815
White	14.004	44.000	154.0420115	4.955770408	3.592933546	1.796466773	6.59303306
White	29.281	92.000	673.4563972	31.91225062	23.1363817	11.56819085	42.4552604
White	14.959	47.000	175.7638447	5.853832092	4.244028267	2.122014133	7.78779187
White	14.322	45.000	161.1234882	5.245112012	3.802706209	1.901353104	6.97796589
Black	14.640	46.000	168.3640993	5.544427321	4.019709808	2.009854904	7.3761675
White	9.866	31.000	76.46403565	2.04682846	1.483950633	0.741975317	2.72304941
White	18.141	57.000	258.5136856	9.527461018	6.907409238	3.453704619	12.675096
White	16.550	52.000	215.1495863	7.556168128	5.478221893	2.739110947	10.0525372
White	26.098	82.000	535.0095481	23.86564341	17.30259147	8.651295734	31.7502553
White	30.554	96.000	733.2908975	35.53268561	25.76119707	12.88059854	47.2717966

Tree Species	**DBH (cm)**	**CBH (cm)**	**Basal Area (cm2)**	**Above Ground Biomass estimate (Kg)**	**Estimated Dry Weight Kg**	**Estimated Carbon Weight (Kg)**	**Estimated CO2 Sequestered (Kg)**
White	22.597	71.000	401.0980267	16.5890112	12.02703312	6.013516561	22.0696058
White	15.913	50.000	198.9178867	6.843723122	4.961699264	2.480849632	9.10471815
Black	14.322	45.000	161.1234882	5.245112012	3.802706209	1.901353104	6.97796589
Black	12.094	38.000	114.8949714	3.422525963	2.481331323	1.240665662	4.55324298
White	15.595	49.000	191.0407384	6.503367136	4.714941173	2.357470587	8.65191705
Black	12.412	39.000	121.0216423	3.654528076	2.649532855	1.324766427	4.86189279
White	20.369	64.000	325.9070656	12.76431767	9.254130314	4.627065157	16.9813291
White	13.367	42.000	140.3564609	4.406539101	3.194740849	1.597370424	5.86234946
Black	12.094	38.000	114.8949714	3.422525963	2.481331323	1.240665662	4.55324298
Red	13.686	43.000	147.119669	4.676285523	3.390307004	1.695153502	6.22121335
Red	8.275	26.000	53.78739656	1.312806969	0.951785053	0.475892526	1.74652557
Total			**5657.14513**				
Estimated tree density and Relative Coverage							
Species	Number of trees per 0.001 Ha	Number of Trees per Ha	Basal Area cm2 per 0.001Ha	Basal Area cm2 per Ha	Relative Coverage%		
Red	2	2000	200.9070656	200907.0656	3.551386095		

Tree Species	DBH (cm)	CBH (cm)	Basal Area (cm2)	Above Ground Biomass estimate (Kg)	Estimated Dry Weight Kg	Estimated Carbon Weight (Kg)	Estimated CO2 Sequestered (Kg)
White	15	15000	4439.05156	4439051.56	78.46805159		
Black	7	7000	1017.186505	1017186.505	17.98056231		
Assumption: Half of a tree's dry weight is carbon, and about 72.5% of a trees total weight is dry weight							

Plot B

Tree Species	DBH (cm)	CBH (cm)	Basal Area (cm2)	Above Ground Biomass estimate (Kg)	Estimated Dry Weight Kg	Estimated Carbon Weight (Kg)	Estimated CO2 Sequestered (Kg)
Red	38.511	121.000	1164.942712	63.74207984	46.21300789	23.10650394	84.80086947
Red	7.002	22.000	38.51050286	0.861014448	0.624235475	0.312117737	1.145472096
Red	11.776	37.000	108.9274348	3.199650357	2.319746509	1.159873254	4.256734844
Red	9.548	30.000	71.61043921	1.884188454	1.366036629	0.683018314	2.506677214
Red	7.638	24.000	45.83068109	1.072572247	0.777614879	0.388807439	1.426923303
Red	8.593	27.000	58.00445576	1.444064775	1.046946962	0.523473481	1.921147675
Red	38.829	122.000	1184.27753	65.0806291	47.1834561	23.59172805	86.58164194
Red	35.328	111.000	980.3469128	51.26650266	37.16821443	18.58410721	68.20367347
Red	33.100	104.000	860.598345	43.49129622	31.53118976	15.76559488	57.85973321
Red	30.554	96.000	733.2908975	35.53268561	25.76119707	12.88059854	47.27179662

Tree Species	**DBH (cm)**	**CBH (cm)**	**Basal Area (cm2)**	**Above Ground Biomass estimate (Kg)**	**Estimated Dry Weight Kg**	**Estimated Carbon Weight (Kg)**	**Estimated CO2 Sequestered (Kg)**
Red	32.145	101.000	811.6645449	40.3928632	29.2848 2582	14.64241 291	53.73765 538
Red	34.055	107.000	910.9643539	46.7290776 2	33.8785 8127	16.93929 064	62.16719 664
Red	34.691	109.000	945.3373647	48.9660506 2	35.5003 867	17.75019 335	65.14320 96
Red	37.874	119.000	1126.750477	61.1152014 2	44.3085 2103	22.15426 052	81.30613 61
Red	48.377	152.000	1838.319542	113.383074 6	82.2027 2908	41.10136 454	150.8420 079
Black	16.550	52.000	215.1495863	7.55616812 8	5.47822 1893	2.739110 947	10.05253 717
Total			**11094.52578**				
Estimated tree density and Relative Coverage							
Species	Number of trees per 0.001 Ha	Number of Trees per Ha	Basal Area cm2 per 0.001Ha	Basal Area cm2 per Ha	Relative Coverage%		
Red	15	15000	10879.37619	10879376.19	98.06075906		
White	0	0	0	0	0		
Black	1	1000	215.1495863	215149.5863	1.939240942		

Assumption: Half of a tree's dry weight is carbon, and about 72.5% of a trees total weight is dry weight

Plot C

Tree Species	DBH (m)	CBH (cm)	Basal Area (cm2)	Above Ground Biomass estimate (Kg)	Estimated Dry Weight Kg	Estimated Carbon Weight (Kg)	Estimated CO2 Sequestered (Kg)
Black	27.053	85.000	574.8726926	26.13219904	18.9458443	9.472922151	34.7656243
Black	26.098	82.000	535.0095481	23.86564341	17.3025915	8.651295734	31.7502553
White	14.004	44.000	154.0420115	4.955770408	3.59293355	1.796466773	6.59303306
White	19.414	61.000	296.0693826	11.30709402	8.19764316	4.098821582	15.0426752
White	16.550	52.000	215.1495863	7.556168128	5.47822189	2.739110947	10.0525372
Red	24.188	76.000	459.5798854	19.69915015	14.2818839	7.140941929	26.2072569
Black	11.776	37.000	108.9274348	3.199650357	2.31974651	1.159873254	4.25673484
Black	16.868	53.000	223.5041375	7.928476453	5.74814543	2.874072714	10.5478469
Black	15.277	48.000	183.3227244	6.173440892	4.47574465	2.237872323	8.21299143
Red	16.550	52.000	215.1495863	7.556168128	5.47822189	2.739110947	10.0525372
Black	25.143	79.000	496.5786123	21.72208833	15.748514	7.874257021	28.8985233
White	13.686	43.000	147.119669	4.676285523	3.390307	1.695153502	6.22121335
White	17.823	56.000	249.5225971	9.111039681	6.60550377	3.302751885	12.1210994
White	16.868	53.000	223.5041375	7.928476453	5.74814543	2.874072714	10.5478469
Black	41.375	130.000	1344.684914	76.40119202	55.3908642	27.69543211	101.642236

Tree Species	**DBH (m)**	**CBH (cm)**	**Basal Area (cm2)**	**Above Ground Biomass estimate (Kg)**	**Estimated Dry Weight Kg**	**Estimated Carbon Weight (Kg)**	**Estimated CO2 Sequestered (Kg)**
Red	14.322	45.000	161.1234882	5.245112012	3.80270621	1.901353104	6.97796589
White	20.369	64.000	325.9070656	12.7643176 7	9.25413031	4.627065157	16.9813291
White	22.915	72.000	412.4761299	17.1853239 6	12.4593599	6.229679936	22.8629254
Black	19.096	60.000	286.4417568	10.8448881 5	7.86254391	3.931271954	14.4277681
Black	17.505	55.000	240.6906429	8.705805515	6.311709	3.155854499	11.581986
Red	14.004	44.000	154.0420115	4.955770408	3.59293355	1.796466773	6.59303306
White	18.460	58.000	267.6639083	9.955173966	7.21750113	3.608750563	13.2441146
White	16.868	53.000	223.5041375	7.928476453	5.74814543	2.874072714	10.5478469
White	8.912	28.000	62.38064927	1.582950007	1.14763875	0.573819377	2.10591712
White	8.912	28.000	62.38064927	1.582950007	1.14763875	0.573819377	2.10591712
Black	15.913	50.000	198.9178867	6.843723122	4.96169926	2.480849632	9.10471815
Black	10.821	34.000	91.97963081	2.58450535	1.87376638	0.936883189	3.4383613
Black	13.686	43.000	147.119669	4.676285523	3.390307	1.695153502	6.22121335
Black	13.367	42.000	140.3564609	4.406539101	3.19474085	1.597370424	5.86234946
Red	7.002	22.000	38.51050286	0.861014448	0.62423547	0.312117737	1.1454721
Total			**8240.531509**				

Tree Species	DBH (m)	CBH (cm)	Basal Area (cm2)	Above Ground Biomass estimate (Kg)	Estimated Dry Weight Kg	Estimated Carbon Weight (Kg)	Estimated CO2 Sequestered (Kg)
Estimated tree density and Relative Coverage							
Species	Number of trees per 0.001 Ha	Number of Trees per Ha	Basal Area cm2 per 0.001Ha	Basal Area cm2 per Ha	Relative Coverage%		
Red	5	5000	1028.405474	1028405.474	12.479844		
White	12	12000	2639.719924	2639719.924	32.0333697		
Black	13	13000	4572.406111	4572406.111	55.4867863		
Assumption: Half of a tree's dry weight is carbon, and about 72.5% of a trees total weight is dry weight							

Plot D

Tree Species	DBH (cm)	CBH (cm)	Basal Area (cm2)	Above Ground Biomass estimate (Kg)	Estimated Dry Weight Kg	Estimated Carbon Weight (Kg)	Estimated CO2 Sequestered (Kg)
Black	29.281	92.000	673.2421254	31.91225062	23.1363817	11.56819085	42.45526042
Black	32.463	102.000	827.553293	41.41032163	30.0224832	15.01124159	55.09125664
Black	27.053	85.000	574.6897868	26.13219904	18.9458443	9.472922151	34.7656243
Red	7.002	22.000	38.49825008	0.861014448	0.62423547	0.312117737	1.145472096
Red	6.047	19.000	28.71460388	0.594628899	0.43110595	0.215552976	0.791079422

Tree Species	DBH (cm)	CBH (cm)	Basal Area (cm2)	Above Ground Biomass estimate (Kg)	Estimated Dry Weight Kg	Estimated Carbon Weight (Kg)	Estimated CO2 Sequestered (Kg)
Red	12.412	39.000	120.9831371	3.654528076	2.64953285	1.324766427	4.861892789
Red	6.684	21.000	35.077951	0.765591123	0.55505356	0.277526782	1.01852329
Black	32.782	103.000	843.85937	42.4431064	30.7712521	15.38562607	56.46524768
White	42.648	134.000	1428.253261	82.47698674	59.7958154	29.89790769	109.7253212
Black	22.915	72.000	412.3448934	17.18532396	12.4593599	6.229679936	22.86292536
Black	25.780	81.000	521.8740057	23.13757516	16.774742	8.387370997	30.78165156
Black	29.599	93.000	687.9573656	32.79537604	23.7766476	11.88832382	43.6301484
White	15.277	48.000	183.2643971	6.173440892	4.47574465	2.237872323	8.212991427
White	25.143	79.000	496.4206172	21.72208833	15.748514	7.874257021	28.89852327
White	20.369	64.000	325.8033726	12.76431767	9.25413031	4.627065157	16.98132913
Red	5.411	17.000	22.98759147	0.449031384	0.32554775	0.162773877	0.597380128
Red	5.729	18.000	25.77155584	0.518747773	0.37609214	0.188046068	0.690129069
Red	14.322	45.000	161.072224	5.245112012	3.80270621	1.901353104	6.977965893
Red	9.866	31.000	76.43970729	2.04682846	1.48395063	0.741975317	2.723049412
Red	5.411	17.000	22.98759147	0.449031384	0.32554775	0.162773877	0.597380128
Red	4.774	15.000	17.89691378	0.327358483	0.2373349	0.11866745	0.435509541

Tree Species	**DBH (cm)**	**CBH (cm)**	**Basal Area (cm2)**	**Above Ground Biomass estimate (Kg)**	**Estimated Dry Weight Kg**	**Estimated Carbon Weight (Kg)**	**Estimated CO2 Sequestered (Kg)**
Red	5.729	18.000	25.77155584	0.518747773	0.37609214	0.188046068	0.690129069
Red	4.137	13.000	13.44257079	0.228086791	0.16536292	0.082681462	0.303440964
Black	16.868	53.000	223.4330258	7.928476453	5.74814543	2.874072714	10.54784686
Black	21.642	68.000	367.8014636	14.87572614	10.7849015	5.392450727	19.79029417
Black	27.371	86.000	588.2914413	26.91545707	19.5137064	9.756853189	35.8076512
Red	22.597	71.000	400.9704104	16.5890112	12.0270331	6.013516561	22.06960578
Red	23.870	75.000	447.4228444	19.05122297	13.8121367	6.906068328	25.34527076
White	15.913	50.000	198.8545975	6.843723122	4.96169926	2.480849632	9.104718149
Black	22.597	71.000	400.9704104	16.5890112	12.0270331	6.013516561	22.06960578
Black	63.972	201.000	3213.569838	229.5954171	166.456677	83.22833869	305.448003
White	26.098	82.000	534.8393255	23.86564341	17.3025915	8.651295734	31.75025535
White	8.275	26.000	53.77028317	1.312806969	0.95178505	0.475892526	1.746525572
White	22.279	70.000	389.7550111	16.0053701	11.6038933	5.801946661	21.29314425
White	21.961	69.000	378.6986955	15.43430663	11.1898723	5.594936154	20.53341568
Red	9.230	29.000	66.89468661	1.72960971	1.25396704	0.62698352	2.301029517
Total			**14830.17817**				

Tree Species	DBH (cm)	CBH (cm)	Basal Area (cm2)	Above Ground Biomass estimate (Kg)	Estimated Dry Weight Kg	Estimated Carbon Weight (Kg)	Estimated CO2 Sequestered (Kg)
Estimated tree density and Relative Coverage							
Species	Number of trees per 0.001 Ha	Number of Trees per Ha	Basal Area cm2 per 0.001Ha	Basal Area cm2 per Ha	Relative Coverage%		
Red	15	15000	1504.931594	1504931.594	10.1477648		
White	9	9000	3989.659561	3989659.561	26.9023036		
Black	12	12000	9335.587019	9335587.019	62.9499316		
Assumption: Half of a tree's dry weight is carbon, and about 72.5% of a trees total weight is dry weight							

Plot E

Tree Species	DBH (cm)	CBH (cm)	Basal Area (cm2)	Above Ground Biomass estimate (Kg)	Estimated Dry Weight Kg	Estimated Carbon Weight (Kg)	Estimated CO2 Sequestered (Kg)
Black	22.597	71.000	401.098	16.589	12.02703312	6.013516561	22.06960578
Red	4.774	15.000	17.903	0.327	0.2373349	0.11866745	0.435509541
Red	6.365	20.000	31.827	0.677	0.490717917	0.245358959	0.900467379
Black	17.823	56.000	249.523	9.111	6.605503769	3.302751885	12.12109942
Red	5.729	18.000	25.780	0.519	0.376092135	0.188046068	0.690129069

Tree Species	DBH (cm)	CBH (cm)	Basal Area (cm2)	Above Ground Biomass estimate (Kg)	Estimated Dry Weight Kg	Estimated Carbon Weight (Kg)	Estimated CO2 Sequestered (Kg)
Black	23.234	73.000	424.013	17.794	12.90094127	6.450470637	23.67322724
Black	28.326	89.000	630.251	29.350	21.27849675	10.63924837	39.04604153
White	7.002	22.000	38.511	0.861	0.624235475	0.312117737	1.145472096
Black	23.234	73.000	424.013	17.794	12.90094127	6.450470637	23.67322724
Red	3.819	12.000	11.458	0.186	0.135102636	0.067551318	0.247913337
Red	4.137	13.000	13.447	0.228	0.165362923	0.082681462	0.303440964
Black	30.872	97.000	748.647	36.475	26.44416179	13.22208089	48.52503688
White	3.819	12.000	11.458	0.186	0.135102636	0.067551318	0.247913337
Black	4.137	13.000	13.447	0.228	0.165362923	0.082681462	0.303440964
White	48.377	152.000	1838.320	113.383	82.20272908	41.10136454	150.8420079
Red	5.729	18.000	25.780	0.519	0.376092135	0.188046068	0.690129069
Red	4.137	13.000	13.447	0.228	0.165362923	0.082681462	0.303440964
Red	4.774	15.000	17.903	0.327	0.2373349	0.11866745	0.435509541
Red	3.501	11.000	9.628	0.150	0.108454532	0.054227266	0.199014067
Red	22.915	72.000	412.476	17.185	12.45935987	6.229679936	22.86292536
White	28.962	91.000	658.896	31.044	22.50664144	11.25332072	41.29968704

Tree Species	DBH (cm)	CBH (cm)	Basal Area (cm2)	Above Ground Biomass estimate (Kg)	Estimated Dry Weight Kg	Estimated Carbon Weight (Kg)	Estimated CO2 Sequestered (Kg)
Red	5.092	16.000	20.369	0.385	0.279340646	0.139670323	0.512590085
Black	9.548	30.000	71.610	1.884	1.366036629	0.683018314	2.506677214
Black	17.187	54.000	232.018	8.312	6.02594856	3.01297428	11.05761561
Total			**6341.820496**				
Estimated tree density and Relative Coverage							
Species	Number of trees per 0.001 Ha	Number of Trees per Ha	Basal Area cm2 per 0.001Ha	Basal Area cm^2 per Ha	Relative Coverage%		
Red	11	11000	600.0159134	600015.9134	9.46125665		
White	4	4000	2547.183323	2547183.323	40.16485998		
Black	9	9000	3194.62126	3194621.26	50.37388337		
Assumption: Half of a tree's dry weight is carbon, and about 72.5% of a trees total weight is dry weight							

Wet Season Data

Plot A

Tree Species	DBH (m)	CBH (m)	Basal Area (m2)	Above Ground Biomass estimate (Kg)	Estimated Dry Weight Kg	Estimated Carbon Weight (Kg)	Estimated CO2 Sequestered (Kg)
Red	13.38	42	140.4458599	4.413629494	3.199881	1.599941	5.871782
White	16.24	51	207.0859873	7.206196651	5.224493	2.612246	9.586944
White	15.29	48	183.4394904	6.183374338	4.482946	2.241473	8.226207
White	10.19	32	81.52866242	2.221238079	1.610398	0.805199	2.95508
White	14.33	45	161.2261146	5.25355172	3.808825	1.904412	6.989194
White	14.01	44	154.1401274	4.963744547	3.598715	1.799357	6.603642
White	15.29	48	183.4394904	6.183374338	4.482946	2.241473	8.226207
White	14.01	44	154.1401274	4.963744547	3.598715	1.799357	6.603642
White	13.06	41	133.8375796	4.153083406	3.010985	1.505493	5.525158
White	15.61	49	191.1624204	6.513831453	4.722528	2.361264	8.665839
Red	16.24	51	207.0859873	7.206196651	5.224493	2.612246	9.586944
White	16.56	52	215.2866242	7.568326467	5.487037	2.743518	10.06871
White	15.29	48	183.4394904	6.183374338	4.482946	2.241473	8.226207
White	12.10	38	114.9681529	3.428033018	2.485324	1.242662	4.560569

Tree Species	DBH (m)	CBH (m)	Basal Area (m2)	Above Ground Biomass estimate (Kg)	Estimated Dry Weight Kg	Estimated Carbon Weight (Kg)	Estimated CO2 Sequestered (Kg)
White	20.38	64	326.1146497	12.7848562 5	9.26902 1	4.63451	17.00865
White	13.38	42	140.4458599	4.41362949 4	3.19988 1	1.599941	5.871782
White	14.01	44	154.1401274	4.96374454 7	3.59871 5	1.799357	6.603642
White	27.07	85	575.2388535	26.1742473 5	18.9763 3	9.488165	34.82156
White	18.15	57	258.6783439	9.54279128 8	6.91852 4	3.459262	12.69549
White	14.01	44	154.1401274	4.96374454 7	3.59871 5	1.799357	6.603642
White	13.69	43	147.2133758	4.68380995 3	3.39576 2	1.697881	6.231224
White	25.16	79	496.8949045	21.7570405 1	15.7738 5	7.886927	28.94502
Red	8.92	28	62.42038217	1.58549707 1	1.14948 5	0.574743	2.109306
Black	23.89	75	447.8503185	19.0818775 6	13.8343 6	6.917181	25.38605
Black	15.92	50	199.044586	6.85473509 3	4.96968 3	2.484841	9.119368
White	17.20	54	232.1656051	8.32502714 7	6.03564 5	3.017822	11.07541
White	27.07	85	575.2388535	26.1742473 5	18.9763 3	9.488165	34.82156
Total			**6080.812102**				
Estimated tree density and Relative Coverage							

Tree Species	DBH (m)	CBH (m)	Basal Area (m2)	Above Ground Biomass estimate (Kg)	Estimated Dry Weight Kg	Estimated Carbon Weight (Kg)	Estimated CO2 Sequestered (Kg)
Species	Number of trees per 0.001 Ha	Number of Trees per Ha	Basal Area cm2 per 0.001Ha	Basal Area cm2 per Ha	Relative Coverage%		
Red	3	3000	409.9522293	409952.2293	6.741735		
White	22	22000	5023.964968	5023964.968	82.61997		
Black	2	2000	1551.83121	1551831.21	25.52013		
Assumption: Half of a tree's dry weight is carbon, and about 72.5% of a trees total weight is dry weight							

Plot D

Tree Species	DBH (m)	CBH (m)	Basal Area (m2)	Above Ground Biomass estimate (Kg)	Estimated Dry Weight Kg	Estimated Carbon Weight (Kg)	Estimated CO2 Sequestered (Kg)
Black	29.30	92	673.8853503	31.96359939	23.17361	11.58680478	42.52357
Red	7.32	23	42.11783439	0.964837558	0.699507	0.349753615	1.283596
Black	16.56	52	215.2866242	7.568326467	5.487037	2.743518344	10.06871
Black	10.19	32	81.5286242	2.221238079	1.610398	0.805198804	2.95508
Black	43.31	136	1472.611465	85.7584965	62.17491	31.08745498	114.091
White	25.80	81	522.3726115	23.17480494	16.80173	8.400866792	30.83118

Tree Species	DBH (m)	CBH (m)	Basal Area (m2)	Above Ground Biomass estimate (Kg)	Estimated Dry Weight Kg	Estimated Carbon Weight (Kg)	Estimated CO2 Sequestered (Kg)
Black	28.66	90	644.9044586	30.2380479 3	21.92258	10.96129238	40.22794
Black	21.02	66	346.8152866	13.8178302 2	10.01793	5.008963453	18.3829
Red	5.73	18	25.79617834	0.51958247	0.376697	0.188348645	0.69124
Black	22.29	70	390.1273885	16.0311237 2	11.62256	5.81128235	21.32741
White	20.70	65	336.3853503	13.2952846 6	9.639081	4.81954069	17.68771
Black	15.61	49	191.1624204	6.51383145 3	4.722528	2.361263902	8.665839
Black	14.97	47	175.8757962	5.86325126 8	4.250857	2.125428584	7.800323
White	14.65	46	168.4713376	5.55334864 6	4.026178	2.013088884	7.388036
Black	9.87	31	76.51273885	2.05012193 2	1.486338	0.7431692	2.727431
White	23.25	73	424.2834395	17.8230340 4	12.9217	6.460849841	23.71132
White	27.39	86	588.8535032	26.9587657	19.54511	9.772552565	35.86527
Black	23.57	74	435.9872611	18.4459703 9	13.37333	6.686664266	24.54006
White	16.56	52	215.2866242	7.56832646 7	5.487037	2.743518344	10.06871
White	10.19	32	81.52866242	2.22123807 9	1.610398	0.805198804	2.95508
White	17.52	55	240.843949	8.71981369 1	6.321865	3.160932463	11.60062
White	17.83	56	249.6815287	9.12569990 4	6.616132	3.308066215	12.1406

Tree Species	DBH (m)	CBH (m)	Basal Area (m2)	Above Ground Biomass estimate (Kg)	Estimated Dry Weight Kg	Estimated Carbon Weight (Kg)	Estimated CO2 Sequestered (Kg)
Black	16.56	52	215.2866242	7.568326467	5.487037	2.743518344	10.06871
Black	18.79	59	277.1496815	10.41100714	7.54798	3.773990087	13.85054
Black	11.15	35	97.53184713	2.785243868	2.019302	1.009650902	3.705419
Black	17.52	55	240.843949	8.719813691	6.321865	3.160932463	11.60062
White	26.75	84	561.7834395	25.40367875	18.41767	9.208833548	33.79642
White	24.20	76	459.8726115	19.73084729	14.30486	7.152432143	26.24943
Black	15.92	50	199.044586	6.854735093	4.969683	2.484841471	9.119368
White	34.39	108	928.6624204	47.91664447	34.73957	17.36978362	63.74711
Black	26.43	83	548.4872611	24.6469735	17.86906	8.934527893	32.78972
Black	14.33	45	161.2261146	5.25355172	3.808825	1.904412498	6.989194
White	27.71	87	602.6273885	27.75731971	20.12406	10.0620284	36.92764
White	35.03	110	963.3757962	50.18893092	36.38697	18.19348746	66.7701
Black	22.29	70	390.1273885	16.03112372	11.62256	5.81128235	21.32741
Black	27.07	85	575.2388535	26.17424735	18.97633	9.488164665	34.82156
Black	28.34	89	630.6528662	29.39687608	21.31274	10.65636758	39.10887
Black	31.85	100	796.1783439	39.45403403	28.60417	14.30208734	52.48866

Tree Species	**DBH (m)**	**CBH (m)**	**Basal Area (m2)**	**Above Ground Biomass estimate (Kg)**	**Estimated Dry Weight Kg**	**Estimated Carbon Weight (Kg)**	**Estimated CO2 Sequestered (Kg)**
Red	9.55	30	71.65605096	1.887220229	1.368235	0.684117333	2.510711
Total			**15320.06369**				
Estimated tree density and Relative Coverage							
Species	Number of trees per 0.001 Ha	Number of Trees per Ha	Basal Area cm2 per 0.001Ha	Basal Area cm2 per Ha	Relative Coverage%		
Red	3	3000	139.5700637	139570.0637	0.911028		
White	14	14000	6344.028662	6344028.662	41.40994		
Black	22	22000	8836.464968	8836464.968	57.67904		
Assumption: Half of a tree's dry weight is carbon, and about 72.5% of a trees total weight is dry weight							

Plot E

Tree Species	**DBH (m)**	**CBH (m)**	**Basal Area (m2)**	**Above Ground Biomass estimate (Kg)**	**Estimated Dry Weight Kg**	**Estimated Carbon Weight (Kg)**	**Estimated CO2 Sequestered (Kg)**
White	5.41	17	23.0095541	0.449753903	0.32607158	0.16303579	0.598341
Red	8.92	28	62.4203822	1.585497071	1.14948538	0.574742688	2.109306
Red	5.41	17	23.0095541	0.449753903	0.32607158	0.16303579	0.598341

Tree Species	DBH (m)	CBH (m)	Basal Area (m2)	Above Ground Biomass estimate (Kg)	Estimated Dry Weight Kg	Estimated Carbon Weight (Kg)	Estimated CO2 Sequestered (Kg)
Red	2.87	9	6.44904459	0.090272143	0.0654473	0.032723652	0.120096
Red	5.73	18	25.7961783	0.51958247	0.37669729	0.188348645	0.69124
Red	4.14	13	13.455414	0.228453796	0.165629	0.082814501	0.303929
Red	6.37	20	31.8471338	0.677941397	0.49150751	0.245753756	0.901916
Black	28.03	88	616.56051	28.56999484	20.7132463	10.35662313	38.00881
White	17.52	55	240.843949	8.719813691	6.32186493	3.160932463	11.60062
Red	4.14	13	13.455414	0.228453796	0.165629	0.082814501	0.303929
Red	6.05	19	28.7420382	0.595585694	0.43179963	0.215899814	0.792352
Black	47.77	150	1791.40127	109.8302176	79.6269077	39.81345387	146.1154
Black	35.67	112	998.726115	52.52510413	38.0807005	19.04035025	69.87809
Black	30.25	95	718.550955	34.66119393	25.1293656	12.5646828	46.11239
Red	4.78	15	17.9140127	0.327885223	0.23771679	0.118858393	0.43621
White	23.57	74	435.987261	18.44597039	13.3733285	6.686664266	24.54006
Black	27.71	87	602.627389	27.75731971	20.1240568	10.0620284	36.92764
Red	5.73	18	25.7961783	0.51958247	0.37669729	0.188348645	0.69124
Red	11.46	36	103.184713	2.990578655	2.16816952	1.084084762	3.978591

Tree Species	**DBH (m)**	**CBH (m)**	**Basal Area (m2)**	**Above Ground Biomass estimate (Kg)**	**Estimated Dry Weight Kg**	**Estimated Carbon Weight (Kg)**	**Estimated CO2 Sequestered (Kg)**
Total			**5779.77707**				
Estimated tree density and Relative Coverage							
Species	Number of trees per 0.001 Ha	Number of Trees per Ha	Basal Area cm2 per 0.001Ha	Basal Area cm2 per Ha	Relative Coverage%		
Red	11	11000	352.070064	352070.0637	6.09141251		
White	3	3000	699.840764	699840.7643	12.1084387		
Black	5	5000	4727.86624	4727866.242	81.8001488		
Assumption: Half of a tree's dry weight is carbon, and about 72.5% of a trees total weight is dry weight							

Littoral Forest Transect Field Data

Plant Number	**Species: Black Jessie**	**Species: *Bumelia* sp**	**Species: Scleria sp.**	**Species: Fimbristylis sp.**	**Species: Wild tamarind**	**Species: Noni**	**Species: Black mangrove**	**Species: Unidentified**	**Species: Indian Almond**	**Species: Trichilia trifolia**	**Species: Coconut tree**
	Intercept Length (l) cm	**Intercept Length (l) cm**	**Intercept Length (l) cm**	**Intercept Length (l) cm**	**Intercept Length (l) cm**	**Intercept Length (l) cm**	**Intercept Length (l) cm**	**Intercept Length (l) cm**	**Intercept Length (l) cm**	**Intercept Length (l) cm**	**Intercept Length (l) cm**
1	200	100	20	2	10	8	40	30	30	50	35
2	60	82	15	10		7			10		
3	89	90	35	15		6			25		
4	60		10	20		10			30		
5	150		20	18		12			35		
6	70		18			9			40		

Plant Number	Species: Black Jessie	Species: *Bumelia* sp	Species: Scleria sp.	Species: Fimbristylis sp.	Species: Wild tamarind	Species: Noni	Species: Black mangrove	Species: Unidentified	Species: Indian Almond	Species: Trichilia trifolia	Species :Coconut tree
	Intercept Length (I) cm	Intercept Length (I) cm	Intercept Length (I) cm	Intercept Length (I) cm	Intercept Length (I) cm	Intercept Length (I) cm	Intercept Length (I) cm	Intercept Length (I) cm	Intercept Length (I) cm	Intercept Length (I) cm	Intercept Length (I) cm
7	80		19			10					
8	100		10			22					
9	200					5					
10						4					

Intercept Summary

Species	Unit	Interval Intercept										Total for Species
		1	2	3	4	5	6	7	8	9	10	
Black Jessie	cm	200	60	89	60	150	70	80	100	200		1009
Bumelia sp	cm	100	82	90								272
Scleria sp.	cm	20	15	35	10	20	18	19	10			147
Fimbristylis sp.	cm	2	10	15	20	18						65
Wild tamarind	cm	10										10
Noni	cm	8	7	6	10	12	9	10	22	5	4	93
Black mangrove	cm	40										40
Unidentified	cm	30										30
Indian Almond	cm	30	10	25	30	35	40					170
Trichilia trifolia	cm	50										50
Coconut tree	cm	35										35

Littoral Forest Importance Value of Species

Species (i)	Number of Individuals (ni)	Linear Density Index (IDi)	Relative Density (RDi)	Present in how many transect intervals (ji)	Frequency (fi)	Relative frequency (Rfi)	Intercept length (li)	Linear Coverage Index ((ICi)	Relative Coverage Index (RCi)	Importance Value (IVi)
Black Jessie	9	0.09	0.195652	5	0.5	0.2083333	10.09	0.1009	0.5252473	0.929232774
Bumelia sp	3	0.03	0.065217	2	0.2	0.0833333	2.72	0.0272	0.1415929	0.290143645
Scleria sp.	8	0.08	0.173913	1	0.1	0.0416667	1.47	0.0147	0.0765226	0.292102355
Fimbristylis sp.	5	0.05	0.108696	2	0.2	0.0833333	0.65	0.0065	0.0338365	0.225865529
Wild tamarind	1	0.01	0.021739	1	0.1	0.0416667	0.1	0.001	0.0052056	0.068611419
Noni	10	0.1	0.217391	7	0.7	0.2916667	0.93	0.0093	0.0484123	0.557470256
Black mangrove	1	0.01	0.021739	1	0.1	0.0416667	0.4	0.004	0.0208225	0.084228285
Unidentified	1	0.01	0.021739	1	0.1	0.0416667	0.3	0.003	0.0156169	0.079022663
Indian Almond	6	0.06	0.130435	2	0.2	0.0833333	1.7	0.017	0.0884956	0.302263691
Trichilia trifolia	1	0.01	0.021739	1	0.1	0.0416667	0.5	0.005	0.0260281	0.089433907
Coconut tree	1	0.01	0.021739	1	0.1	0.0416667	0.35	0.0035	0.0182197	0.081625474
Totals	**46**	**0.46**			**2.4**			**0.1921**		

Number of intervals 10

Species (i)	Number of Individuals (ni)	Linear Density Index (IDi)	Relative Density (RDi)	Present in how many transect intervals (ji)	Frequency (fi)	Relative frequency (Rfi)	Intercept length (li)	Linear Coverage Index ((ICi)	Relative Coverage Index (RCi)	Importance Value (IVi)

Transect length 100m

Disturbed Seasonal Dry Forest Transect Field Data

Plant Num ber	Species: Bamboo	Species: Black Jessie	Species: Wild Tamarind	Species: Quick Stick	Species: Tamarind	Species: Unknown Seedlings	Species: Black mangrove	Species: Hog Plum	T ot al
	Intercept Length (l) cm	Intercept Length (l) cm	Intercept Length (l) cm	Intercept Length (l) cm	Intercept Length (l) cm	Intercept Length (l) cm	Intercept Length (l) cm	Intercept Length (l) cm	
1	400	10	10	14	150	2	10	134	73 0
2	580	15	13			4	14		62 6
3		8	15			2	12		37
4		18	8			7			33
5		18				3			21
6		9				3			12

Disturbed Seasonal Dry Forest Intercept Data Summary

Species	Unit	Interval Intercept						
		1	2	3	4	5	6	Total
Bamboo	cm	400	580					980
Black Jessie	cm	10	15	8	18	18	9	78
Wild Tamarind	cm	10	13	15	8			46
Quick Stick	cm	14						14
Tamarind	cm	150						150
Unknown Seedlings	cm	2	4	2	7	3	3	21
Black mangrove	cm	10	14	12				36
Hog Plum	cm	134						134

Disturbed Seasonal Dry Forest Importance Value of Species

Species (i)	**Number of Individuals (ni)**	**Linear Density Index (IDi)**	**Relative Density (RDi)**	**Present in how many transect intervals (ji)**	**Frequency (fi)**	**Relative frequency (Rfi)**	**Intercept length (li)**	**Linear Coverage Index ((ICi)**	**Relative Coverage Index (RCi)**	**Importance Value (IVi)**
Bamboo	2	0.05	0.083333	2	0.25	0.104167	9.8	0.098	0.671693	0.859193
Black Jessie	6	0.15	0.25	5	0.625	0.260417	0.78	0.0078	0.053461	0.563878
Wild Tamarind	4	0.1	0.166667	3	0.375	0.15625	0.46	0.0046	0.031528	0.354445
Quick Stick	1	0.025	0.041667	2	0.25	0.104167	0.14	0.0014	0.009596	0.155429
Tamarind	1	0.025	0.041667	1	0.125	0.052083	1.5	0.015	0.10281	0.19656
Unknown Seedlings	6	0.15	0.25	3	0.375	0.15625	0.21	0.0021	0.014393	0.420643
Black mangrove	3	0.075	0.125	1	0.125	0.052083	0.36	0.0036	0.024674	0.201758
Hog Plum	1	0.025	0.041667	1	0.125	0.052083	1.34	0.0134	0.091844	0.185594
Totals	**24**	**0.6**			**2.25**			**0.1459**		

Number of intervals 8

Transect length 40m