

TABLES





Table 3-1. Well Construction Details

Station Name	Well Tag ID	Target Stratigraphic Unit	Installed By	Easting	Northin g	Well Standpipe Diameter	Well Standpipe Type	Well Screen or Open Hole Diameter	Well Screen Type	Surface Casing Diameter	Surface Casing Type	Elevations				Depths					Comments
												Ground Surface	Top of Pipe	Top of Screen	Bottom of Screen	Stickup	Borehole Depth	Depth to Top of Screen or open interval	Depth to Bottom of Screen or open interval	Depth to Bottom of Screen or open interval	
				m	m	m	-	m	-	m	-	m ASL	m ASL	m ASL	m ASL	m AGS	m BGS	m BGS	m BGS	m BTOP	
Groundwater Monitoring Wells																					
Bru 95-5	-	Red River Carbonate	Friesen Drillers	682208	5527628	N/A	N/A	0.121	Open hole	0.127	PVC	275.193	276.225	237.38	230.94	1.03	44.25	37.81	44.25	45.28	Previously installed by Canwhite.
Bru 95-6	4506	Winnipeg Sandstone	Friesen Drillers	682199	5527624	0.051	PVC	0.051	PVC	0.127	PVC	275.041	275.843	222.59	219.54	0.802	57.00	52.45	55.50	56.30	
Bru 95-9	4544	Winnipeg Shale	Friesen Drillers	682203	5527621	0.051	PVC	0.051	PVC	0.127	PVC	275.191	275.844	227.34	227.03	0.653	48.16	47.85	48.16	48.81	
Bru 96-1	4558	Winnipeg Sandstone	Friesen Drillers	683064	5527787	0.051	PVC	0.051	PVC	0.127	PVC	273.215	273.799	223.99	220.94	0.584	53.34	49.23	52.28	52.86	
Bru 96-2	4559	Red River Carbonate	Friesen Drillers	683062	5527791	0.051	PVC	0.121	Open hole	0.127	PVC	273.304	274.005	237.34	231.55	0.701	41.76	35.97	41.76	42.46	Shale trap used to secure 0.051m well standpipe against limestone borehole wall immediately below the socket and 0.13m diameter PVC liner.
Water Supply Wells																					
Bru 95-7	4560	Winnipeg Sandstone	Friesen Drillers	681865	5527612	0.305	Steel	0.305	Stainless Steel	N/A	N/A	277.120	277.927	223.17	204.88	0.807	74.98	53.95	72.24	73.04	Drilled with a 0.41m diameter surface casing, which was removed after the well install.
Vibrating Wire Piezometers																					
Bru 95-8 (Four nested VWP sensors)	N/A	Red River Carbonate (2) Winnipeg Shale (1) Winnipeg Sandstone (1)	Paddock Drilling	681953	5527630	N/A	N/A	NA	N/A	0.110	Steel	277.271	278.387	N/A	N/A	1.116	55.09	N/A	N/A	N/A	Tripletube HQ drilling from top of limestone to bottom of hole. Borehole diameter 0.096m. HW casing at surface with a 0.025m VWP housing box welded to the top.

Notes:
m BGS = meters below ground surface.
m AGS = meters above ground surface.
m ASL = meters above sea level.
m BTOP = meters below top of piezometer pipe.
1 - Pre-existing monitoring well installed by Canwhite
- unknown
Survey data taken on Dec 1, 2020 by David Atkinson (AECOM).

Table 4-1. Description of Rock Samples for Geochemical Assessment

Sample ID	Lithology	Northing	Easting	Depth	Geological Unit	Description/Comments
		m	m	m BGS		
Bru 121-1_24.38 - 24.83	Carbonate	5515834	685310	24.38 to 24.83	Red River Carbonate	Carobonate rock core collected from core box in CanWhite storage in Steinbach.
Bru 146_36.82 - 37.13		5504548	685001	36.82 to 37.13	Red River Carbonate	Carobonate rock core collected from core box in CanWhite storage in Steinbach.
Bru 95-8_40.16 - 40.65		5527630	681953	40.16 to 40.65	Red River Carbonate	Carbonate sample collected at drill pad during drilling.
Bru 121-1_36.57 - 37.00	Shale	5515834	685310	36.57 to 37.00	Winnipeg Shale	Shale rock core collected from core box in CanWhite storage in Steinbach.
Bru 146_49.86 - 50.29		5504548	685001	49.86 to 50.29	Winnipeg Shale	Shale rock core collected from core box in CanWhite storage in Steinbach.
Bru 95-8_49.39 - 49.79		5527630	681953	49.39 to 49.79	Winnipeg Shale	Shale sample collected at drill pad during drilling.
Bru 95-3	Sandstone	5527622	682214	NA	Winnipeg Sandstone	Sample collected from surface pile.
Bru121-1_174-179		5515834	685310	174 to 179	Winnipeg Sandstone	Sample contains concretions of brown color containing iron oxide minerals.
Bru146_189-194		5504548	685001	189 to 194	Winnipeg Sandstone	Sample contains concretions of brown color containing iron oxide minerals and remnants from overlying shale.

Table 4-2. Results of Semi-quantitative Phase Analysis (wt.%) XRD-Rietveld

Sample ID		Bru 121-1_ 24.38 - 24.83	Bru 146_ 36.82 - 37.13	Bru 95-8_ 40.16 - 40.65	Bru 121-1_ 36.57 - 37.00	Bru 146_ 49.86 - 50.29	Bru 95-8_ 49.39 - 49.79	Bru 95-3	Bru121-1_ 174-179	Bru146_ 189-194
Depth (m.b.g.s)		24.38 to 24.83	36.82 to 37.13	40.16 to 40.65	36.57 to 37.00	49.86 to 50.29	49.39 to 49.79	NA	174 to 179	189 to 194
Geological Unit		Red River Carbonate	Red River Carbonate	Red River Carbonate	Winnipeg Shale	Winnipeg Shale	Winnipeg Shale	Winnipeg Sandstone	Winnipeg Sandstone	Winnipeg Sandstone
Lithology Description		Carbonate	Carbonate	Carbonate	Shale	Shale	Shale	Sandstone	Sandstone	Sandstone
Acid Generating Status		Non-PAG	Non-PAG	Non-PAG	Uncertain	Non-PAG	Uncertain	Non-PAG	Non-PAG	Non-PAG
Mineral Composition (Formula)										
Quartz	SiO ₂	3.2	3.7	3.0	32.4	11.3	0.4	98.3	97.3	98.7
Pyrite	FeS ₂	-	-	-	0.6	-	1.3	-	-	-
Illite/Muscovite	KAl ₂ (AlSi ₃ O ₁₀)(OH) ₂	1.0	1.0	1.4	35.3	55.4	31.1	-	-	-
Calcite	CaCO ₃	79.1	80.4	79.2	0.3	0.5	2.7	0.2	-	0.2
Ankerite	CaFe(CO ₃) ₂	13.0	10.9	11.8	0.5	1.0	-	-	-	-
K-Feldspar	K(AlSi ₃ O ₈)	3.3	3.6	4.2	26.5	26.3	35.3	-	-	-
Albite-low calcian	NaAlSi ₃ O ₈ - CaAl ₂ Si ₂ O ₈	-	-	-	-	-	-	0.4	0.9	0.7
Clinochlore	Mg ₅ Al(AlSi ₃ O ₁₀)(OH) ₈	-	-	-	-	-	2.3	-	-	-
Siderite	FeCO ₃	0.2	0.2	0.2	0.3	-	-	-	0.9	0.1
Hematite	Fe ₂ O ₃	0.2	0.2	0.2	0.3	0.7	-	-	-	-
Dolomite	CaMg(CO ₃) ₂	-	-	-	-	-	0.9	0.2	-	-
Anatase	TiO ₂	-	-	-	0.2	0.8	0.7	-	-	-
Goethite	α-Fe ³⁺ O(OH)	-	-	-	-	-	5.1	-	-	-
Rutile	TiO ₂	-	-	-	-	-	0.9	-	-	-
Iron	α-Fe	-	-	-	-	-	-	-	0.1	0.1
Gypsum	CaSO ₄ ·2H ₂ O	-	-	-	-	-	1.0	-	-	-
Kaolinite	Al ₂ Si ₂ O ₅ (OH) ₄	-	-	-	3.6	4.0	18.4	0.9	0.8	0.2
Total		100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Notes:
"-": Minerals were not identified by XRD

Table 4-3. Comparison of Total Recoverable Constituents to Crustal Abundance

Sample ID	Units	Detection Limit	Average Crustal Abundance in Rocks						Bru 121-1_ 24.38 - 24.83	Bru 146_ 36.82 - 37.13	Bru 95-8_ 40.16 - 40.65	Bru 121-1_ 36.57 - 37.00	Bru 146_ 49.86 - 50.29	Bru 95-8_ 49.39 - 49.79	Bru 95-3	Bru 121-1_ 174 to 179	Bru 146_ 189 to 194	Correlation between Trace Metals and Al, Fe and Mn			Organic Carbon ^a
Depth (m.b.g.s)			Price (1997) ^b						24.38 - 24.83	36.82 - 37.13	40.16 - 40.65	36.57 - 37.00	49.86 - 50.29	49.39 - 49.79	NA	174 - 179	189 - 194				
Lithology Description			Carbonate ^b	CarbonateX5c	Shale ^b	Shale X5 ^c	Sandstone ^b	Sandstone X5 ^c	Carbonate	Carbonate	Carbonate	Shale	Shale	Shale	Sandstone	Sandstone	Sandstone				
Geological Unit									Red River Formation	Red River Formation	Red River Formation	Red River Formation	Red River Formation	Red River Formation	Winnipeg Formation	Winnipeg Formation	Winnipeg Formation	Aluminum	Iron	Manganese	
Acid Generating Status									Non-PAG	Non-PAG	Non-PAG	Uncertain	Non-PAG	Uncertain	Non-PAG	Non-PAG	Non-PAG				
Parameters																					
Organic Carbon (C) ^a	%	-	-	-	-	-	-	-	0.2	0.1	0.2	0.04	0	0.19	0.03	0.03	0.02	-0.11	0.28	0.91	1.00
Aluminum (Al)	%	0.01	0.42	2.1	8	40	2.5	12.5	0.15	0.16	0.2	1.56	1.7	1.49	0.1	0.09	0.05	1.00	0.75	-0.14	-0.11
Antimony (Sb)	ppm	0.05	0.2	1	1.5	7.5	0.01 ^d	0.05 ^d	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	-	-	-	-
Arsenic (As)	ppm	1	1	5	13	65	1	5	1.7	0.8	0.7	30.4	13.3	24.2	0.9	1.5	0.2	0.90	0.73	-0.11	-0.02
Barium (Ba)	ppm	5	10	50	580	2900	10 ^d	50 ^d	10	10	10	30	40	30	<10	<10	<10	0.98	0.63	-0.93	-0.67
Beryllium (Be)	ppm	0.1	0.1 ^d	0.5 ^d	3	15	0.1 ^d	0.5 ^d	0.18	0.18	0.24	1.01	1.26	0.92	<0.05	<0.05	<0.05	0.99	0.62	-0.94	-0.67
Bismuth (Bi)	ppm	0.02	-	-	-	-	-	-	0.02	0.02	0.02	0.18	0.1	0.12	0.01	0.01	0.01	0.93	0.65	-0.10	-0.08
Boron	ppm	10	20	100	100	500	35	175	10	10	10	70	70	50	<10	<10	<10	0.98	0.54	-0.96	-0.71
Cadmium (Cd)	ppm	0.01	0.035	0.175	0.3	1.5	0.01 ^d	0.05 ^d	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	-	-	-	-
Caesium (Cs)	ppm	0.05	0.1 ^d	0.5 ^d	5	25	0.1 ^d	0.5 ^d	0.25	0.21	0.32	1.05	1.04	0.73	0.05	<0.05	<0.05	0.97	0.57	-0.37	-0.36
Calcium (Ca)	%	0.01	30.23	151.15	2.21	11.05	3.91	19.55	>25.0	>25.0	>25.0	0.81	0.43	1.32	0.21	0.03	0.12	0.77	0.91	0.96	0.83
Cerium (Ce)	ppm	0.05	11.5	57.5	59	295	92	460	9.41	8.86	13.5	54.6	28.7	36.1	2.19	1.67	1.48	0.90	0.63	0.04	0.05
Chromium (Cr)	ppm	1	11	55	90	450	35	175	4	4	5	24	42	58	2	3	2	0.90	0.95	-0.03	0.10
Cobalt (Co)	ppm	0.1	0.1	0.5	19	95	0.3	1.5	1.7	1.6	1.5	16.9	22	20.6	0.4	0.6	0.2	0.99	0.81	-0.12	-0.07
Copper (Cu)	ppm	0.5	4	20	45	225	1 ^d	5 ^d	3.3	5.7	3.2	24.9	24.8	7.4	6.6	1	0.8	0.85	0.31	-0.26	-0.39
Gallium (Ga)	ppm	0.1	4	20	19	95	12	60	0.75	0.73	0.97	6.65	7.8	8.17	0.27	0.18	0.12	0.99	0.83	-0.08	-0.02
Germanium (Ge)	ppm	0.1	0.2	1	1.6	8	8	40	<0.05	<0.05	<0.05	0.13	0.05	0.07	<0.05	<0.05	<0.05	-0.42	-0.42	-0.03	-0.08
Gold (Au)	ppm	0.02	0.001 ^d	0.005 ^d	0.001 ^d	0.005 ^d	0.001 ^d	0.005 ^d	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	-	-	-	-
Hafnium (Hf)	ppm	0.05	0.3	1.5	2.8	14	3.9	19.5	0.09	0.09	0.12	0.08	0.26	0.34	0.15	0.13	0.09	0.63	0.88	-0.09	0.12
Indium (In)	ppm	0.02	0.01 ^d	0.05 ^d	0.1	0.5	0.01 ^d	0.05 ^d	0.011	0.008	0.01	0.016	0.02	0.047	<0.005	<0.005	<0.005	0.63	1.00	-0.29	0.15
Iron (Fe)	%	0.01	0.38	1.9	4.72	23.6	0.98	4.9	0.49	0.47	0.58	1.59	0.23	5.56	0.22	0.65	0.3	0.75	1.00	0.07	0.28
Lanthenum (La)	ppm	0.1	1 ^d	5 ^d	92	460	30	150	4.1	3.8	5.2	18.7	12.6	15	1	0.8	0.7	0.95	0.71	0.06	0.07
Lead (Pb)	ppm	0.2	9	45	20	100	7	35	1.3	1.3	1.1	13.1	7.4	4.6	1.1	0.9	6.3	0.75	0.31	-0.37	-0.40
Lithium (Li)	ppm	1	5	25	66	330	15	75	2.8	2.5	3.5	17.6	25.7	25.7	1.9	1.9	1.3	0.98	0.85	-0.10	-0.03
Magnesium (Mg)	%	0.01	4.7	23.5	1.5	7.5	0.7	3.5	1.53	1.3	1.49	0.39	0.45	0.41	0.04	0.01	0.02	-0.19	-0.16	0.95	0.75
Manganese (Mn)	ppm	2	1100	5500	850	4250	10 ^d	50 ^d	305	265	321	101	64	206	24	45	33	-0.14	0.07	1.00	0.91
Mercury (Hg)	ppm	0.01	0.04	0.2	0.4	2	0.03	0.15	0.01	0.01	0.01	0.25	0.05	0.03	<0.01	<0.01	<0.01	0.57	0.04	-0.63	-0.55
Molybdenum (Mo)	ppm	0.05	0.4	2	2.6	13	0.2	1	0.07	0.14	0.13	0.22	0.41	0.54	0.06	0.09	0.06	0.86	0.94	0.04	0.14
Nickel (Ni)	ppm	0.5	20	100	68	340	2	10	3	4	3.1	38	52.6	25.8	1.2	1.3	0.5	0.96	0.57	-0.21	-0.27
Niobium (Nb)	ppm	0.05	0.3	1.5	11	55	0.01 ^d	0.05 ^d	0.07	0.07	0.08	<0.05	<0.05	0.21	0.06	<0.05	<0.05	1.00	1.00	0.01	0.42
Phosphorus (P)	ppm	0.01	400	2000	700	3500	170	850	820	600	870	2180	490	580	30	30	20	0.52	0.16	0.32	0.20
Potassium (K)	%	0.01	0.27	1.35	2.66	13.3	1.07	5.35	0.08	0.09	0.11	0.88	0.95	0.49	0.02	0.01	0.01	0.96	0.54	-0.17	-0.24
Rhenium	ppm	0.001	-	-	-	-	-	-	0.002	0.001	0.001	0.013	0.01	0.003	<0.001	<0.001	<0.001	0.80	0.14	-0.92	-0.81
Rubidium (Rb)	ppm	0.2	3	15	140	700	60	300	3.9	3.8	5.4	36.8	41.2	22.7	1	0.3	0.2	0.97	0.57	-0.15	-0.21
Scandium (Sc)	ppm	0.1	1	5	13	65	1	5	0.9	0.9	1.1	4.2	3.4	6.1	0.1	0.1	0.1	0.92	0.91	0.10	0.21
Selenium (Se)	ppm	1	0.08	0.4	0.6	3	0.05	0.25	0.3	0.5	0.7	13.1	<0.2	0.3	<0.2	0.2	<0.2	0.65	0.00	-0.44	-0.52
Silver (Ag)	ppm	0.01	0.01 ^d	0.05 ^d	0.07	0.35	0.01 ^d	0.05 ^d	<0.01	0.01	0.01	0.4	0.1	0.02	0.01	0.01	0.01	0.62	0.10	-0.16	-0.26
Sodium (Na)	%	0.01	0.04	0.2	0.96	4.8	0.33	1.65	0.02	0.02	0.02	0.03	0.02	0.02	0.01	<0.01	<0.01	0.55	0.21	0.18	0.03
Strontium (Sr)	ppm	0.5	610	3050	300	1500	20	100	198.5	205	205	91.7	141.5	34.2	3	1.9	1.9	0.00	-0.18	0.81	0.52
Sulfur (S)	%	0.01	0.12	0.6	0.24	1.2	0.024	0.12	0.07	0.03	0.05	0.23	0.07	0.69	<0.01	0.01	0.01	0.61	0.95	0.11	0.39
Tantalum (Ta)	ppm	0.05	0.01 ^d	0.05 ^d	0.8	4	0.01 ^d	0.05 ^d	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	-	-	-	-
Tellurium (Te)	ppm	0.05	-	-	-	-	-	-	<0.01	<0.01	<0.01	0.03	0.01	0.09	<0.01	<0.01	<0.01	-0.89	0.92	1.00	1.00
Thallium (Tl)	ppm	0.02	0.01 ^d	0.05 ^d	1.4	7	0.82	4.1	0.03	0.02	0.02	0.21	0.29	0.1	0.02	0.03	<0.02	0.90	0.41	-0.41	-0.48
Thorium (Th)	ppm	0.01	1.7	8.5	12	60	1.7	8.5	0.9	0.9	1.2	10.8	11.5	11.6	0.4	0.3	0.3	1.00	0.80	-0.11	-0.07
Tin (Sn)	ppm	0.3	0.1 ^d	0.5 ^d	6	30	0.1 ^d	0.5 ^d	<0.2	0.2	<0.2	0.4	<0.5	0.6	<0.2	<0.2	<0.2	0.85	0.89	-0.45	0.23
Titanium (Ti)	%	0.01	0.04	0.2	0.46	2.3	0.15	0.75	<0.005	<0.005	<0.005	0.007	0.006	0.036	0.006	<0.005	<0.005	0.26	0.93	0.93	0.98
Tungsten (W)	ppm	0.1	0.6	3	1.8	9	1.6	8	<0.05	<0.05	<0.05	0.2	0.07	0.12	<0.05	<0.05	<0.05	-0.55	-0.28	0.12	0.07
Uranium (U)	ppm	0.05	2.2	11	3.7	18.5	0.45	2.25	0.64	0.6	0.73	30	11.65	0.4	0.14	0.16	0.14	0.68	0.13	-0.23	-0.35
Vanadium (V)	ppm	1	20	100	130	650	20	100	6	6	8	17	18	60	1	1	1	0.71	0.99	0.19	0.39
Yttrium (Y)	ppm	0.05	30	150	26	130	40	200	2.83	2.62	3.16	19.95	4.68	8.9	0.51	0.33	0.27	0.75	0.44	0.03	0.02
Zinc (Zn)	ppm	1	20	100	95	475	16	80	6	11	6	28	34	38	12	2	2	0.95	0.83	-0.08	-0.02
Zirconium (Zr)	ppm	0.5	-	-	-	-	-	-	2.3	2.2	2.8	5.1	8.3	10.7	4.4	3.8	2.9	0.83	0.92	-0.22	-0.02

Notes:

^a Organic Carbon is calculated from the difference between Total Carbon and Total inorganic Carbon (derived from ABA test, see Table X-4).

^b From Price (1997), Appendix 3, Distribution of the elements in the Earth's crust (Sedimentary Rocks).

^c Enrichment criteria based upon crustal abundance data multiplied by a factor of 5.

^d Order of magnitude estimate from Price (1997) - most conservative value used.

^e From Vine and Tourtelot (1970), Table 2.

- : Data not available for these elements.

Exceeds Screening Criteria for Carbonates.

ExceedsScreening Criteria for Shales.

ExceedsScreening Criteria for Sandstones.

Lower limit of detection exceeds criteria from one or both compilations.

Table 4-4. Acid Base Accounting (ABA) Results

Sample ID	Depth (m.bgs)	Lithology Description	Geological Unit	Weight, Sample Received	Fizz Test	Paste pH	Total C	Total Inorganic Carbon (TIC)	Carbon Dioxide (CO ₂)	CaCO ₃ Equiv.	Total S	Sulphate Sulphur - HCl Extractable	Sulphate Sulphur - Carbonate Extractable	Sulphide Sulphur Total minus Carbonate Leach	Acid Generation Potential (AP)	Mod. ABA Neutralization Potential (NP)	Net Neutralization Potential NNP=NP-AP	Neutralization Potential Ratio NPR = NP/AP	Acid Generation Status
				kg			%	%	%	t CaCO ₃ /kt	%	%	%	wt%	tCaCO ₃ /kt	tCaCO ₃ /kt	tCaCO ₃ /kt	-	
Detection Limit				0.02	1	0.10	0.05	0.01	0.20	-	0.010	0.01	0.01	0.01	0.3	1	1	0.01	-
Bru 121-1_24.38 to 24.83	24.83-24.83	Carbonate	Red River Formation	3.36	4	8.00	11.00	10.80	39.6	900.00	0.07	< 0.01	< 0.01	< 0.01	2.2	868	866	394.55	Non-PAG
Bru 146_36.82 to 37.13	36.82-37.13	Carbonate	Red River Formation	3.18	4	8.00	10.90	10.80	39.6	900.00	0.04	< 0.01	< 0.01	< 0.01	1.3	820	819	630.77	Non-PAG
Bru 95-8_40.16 to 40.65	40.16-40.65	Carbonate	Red River Formation	3.66	4	8.30	10.85	10.65	39	887.50	0.05	< 0.01	< 0.01	< 0.01	1.6	821	819	513.13	Non-PAG
Bru 121-1_36.57 to 37.00	36.57-37.00	Shale	Winnipeg Formation	2.5	1	7.40	0.11	0.07	0.3	5.83	0.23	< 0.01	0.06	< 0.01	7.2	10	3	1.39	Uncertain
Bru 146_49-86 to 50.29	49.86-50.29	Shale	Winnipeg Formation	2.24	1	7.80	0.05	0.05	0.2	4.17	0.07	< 0.01	0.01	< 0.01	2.2	5	3	2.27	Non-PAG
Bru 95-8_49.39 to 49.79	49.39-49.79	Shale	Winnipeg Formation	2.54	2	7.50	0.55	0.36	1.3	30.00	0.64	< 0.01	0.12	< 0.01	20	25	5	1.25	Uncertain
Bru 95-3	NA	Sandstone	Winnipeg Formation	6.00	1	8.50	0.12	0.09	0.3	7.50	0.02	< 0.01	< 0.01	< 0.01	0.6	6	5	10.00	Non-PAG
Bru 121-1_174 to 179	174-179	Sandstone	Winnipeg Formation	1.04	1	7.00	0.12	0.09	0.3	7.50	0.01	< 0.01	0.01	< 0.01	0.3	3	3	10.00	Non-PAG
Bru 146_189 to 194	189-194	Sandstone	Winnipeg Formation	0.3	1	8.10	0.07	0.05	0.2	4.17	< 0.01	< 0.01	0.02	< 0.01	< 0.3	4	< 4	> 13.33	Non-PAG

Notes:
AP = Total Sulphur*31.25
CaCO₃ Equivalency = Total Inorganic Carbon (TIC)*(100/12)*10
NNP = Modified NP-AP
Sulphate Sulphur determined by 25% HCl Leach with S by ICP.
Sulphide Sulphur determined by Sobek 1:7 Nitric Acid Leach with S by ICP Finish.
Insoluble S is acid insoluble S (Total S - (Sulphate S + Sulphide S)).
Mod. ABA Neutralization Potential - MEND Acid Rock Drainage Prediction Manual,
MEND Project 1.16.1b (pages 6.2-11 to 17), March 1991.

SIMbA Project
Hydrogeology and Geochemistry Assessment Report



Table 4-5. MEND Shake Flask Extraction Results

Sample ID		Units	CDWQ MAC	CDWQ AO	MWQSOG MAC	MWQSOG AO	CCME FAL Acute	CCME FAL Chronic	MWQSOG FAL Acute	MWQSOG FAL Chronic	Bru 121-1_24.38 - 24.83	Bru 146_36.82 - 37.13	Bru 95-8_40.16 - 40.65	Bru 121-1_36.57 - 37.00	Bru 146_49.86 - 50.29	Bru 95-8_49.39 - 49.79	Bru 95-3	Bru 121-1_174 to 179	Bru 146_189 to 194	Correlation with Trace Metals and Al, Fe and Mn		
Depth (m.b.g.s)											24.38 to 24.83	36.82 to 37.13	40.16 to 40.65	36.57 to 37.00	49.86 to 50.29	49.39 to 49.79	NA	174-179	189-194			
Lithology Description											Carbonate	Carbonate	Carbonate	Shale	Shale	Shale	Sandstone	Sandstone	Sandstone			
Geological Unit											Red River Formation	Red River Formation	Red River Formation	Winnipeg Formation	Winnipeg Formation	Winnipeg Formation	Winnipeg Formation	Winnipeg Formation	Winnipeg Formation	Aluminum	Iron	Manganese
Acid Generating Status											Non-PAG	Non-PAG	Non-PAG	Uncertain	Non-PAG	Uncertain	Non-PAG	Non-PAG	Non-PAG			
Inorganic																						
Hardness (as CaCO ₃)		mg/L	NG	NG	NG	NG	NG	NG	NG	NG	68.2	63.3	70	292	106	839	19.6	4.36	17.2	-	-	-
pH (Lab)		-	NG	7.0-10.5	NG	6.5-8.5	6.5-9	6.5-9	NG	NG	8.08	8.17	8.2	8.07	8.18	7.94	7.05	-	-	-	-	-
Dissolved Metals																						
Aluminum (Al)	mg/L	NG	NG	NG	NG	0.005-0.1 ¹	0.005-0.1 ¹	NG	NG	0.131	0.179	0.144	<0.0050	<0.0050	<0.0050	1.26	1.88	0.713	1.00	0.37	0.92	
Antimony (Sb)	mg/L	0.006	NG	0.006	NG	NG	NG	NG	NG	0.00016	0.00013	<0.00010	0.00012	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	-1.00	-	-1.00
Arsenic (As)	mg/L	0.01	NG	0.01	NG	0.005	0.005	0.34	0.15	<0.0010	<0.0010	<0.0010	0.0302	0.0029	<0.0010	0.0014	<0.0010	<0.0010	<0.0010	-	-	1.00
Barium (Ba)	mg/L	1	NG	1	NG	NG	NG	NG	NG	0.0106	0.0084	0.0128	0.0937	0.0961	0.0845	0.0052	0.0118	0.0051	-0.13	-0.10	0.59	
Beryllium (Be)	mg/L	NG	NG	NG	NG	NG	NG	NG	NG	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	-	-	-	
Bismuth (Bi)	mg/L	NG	NG	NG	NG	NG	NG	NG	NG	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	-	-	-	
Boron (B)	mg/L	5	NG	5	NG	29	1.5	NG	NG	0.068	0.042	0.071	0.415	0.204	1.2	0.025	0.016	<0.010	-0.89	1.00	0.95	
Cadmium (Cd)	mg/L	0.007	NG	0.005	NG	0.00221 - 0.0057 ²	0.00017-0.00036 ¹	0.00221 - 0.0058 ¹	0.00026 - 0.00051 ¹	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	-	-	-
Calcium (Ca)	mg/L	NG	NG	NG	NG	NG	NG	NG	NG	16.8	16.2	17.7	77.4	27.2	246	6.25	0.96	4.94	-0.92	0.35	0.96	
Chromium (Cr) ⁶	mg/L	0.05	NG	0.0089	0.05	NG	0.0089	0.616-1.347 ³	0.08-0.175 ¹	<0.00050	<0.00050	<0.00050	<0.00050	0.00098	<0.00050	0.00194	0.00376	0.00103	0.99	0.22	1.00	
Cobalt (Co)	mg/L	NG	NG	NG	NG	NG	NG	NG	NG	0.00011	<0.00010	<0.00010	0.00153	0.00017	0.00141	0.00022	0.00015	0.00014	0.54	0.96	0.57	
Copper (Cu)	mg/L	2	1	NG	≤ 1	0.00257 - 0.004 ⁴	0.00257 - 0.004 ⁴	0.0147 - 0.0362 ¹	0.00972 - 0.022 ²	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	-	-	-
Iron (Fe)	mg/L	NG	0.3	NG	≤ 0.3	0.3	0.3	NG	NG	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	0.311	0.161	0.06	0.37	1.00	1.00	
Lead (Pb)	mg/L	0.005	NG	0.01	NG	0.00359-0.007	0.00359-0.007	0.072 - 0.198 ¹	0.0028 - 0.0077 ²	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	0.00094	0.00028	0.00016	0.11	0.96	1.00	
Lithium (Li)	mg/L	NG	NG	NG	NG	NG	NG	NG	NG	0.0052	0.005	0.0069	0.0821	0.0496	0.0908	<0.0050	0.0089	0.0091	0.75	-1.00	0.68	
Magnesium (Mg)	mg/L	NG	NG	NG	NG	NG	NG	NG	NG	6.37	5.55	6.28	24	9.23	54.5	0.974	0.476	1.18	-0.89	-0.18	0.92	
Manganese (Mn)	mg/L	0.12	≤ 0.02	NG	≤ 0.050	7.24 - 14.88 ^k	0.12 - 0.64 ^k	NG	NG	0.00067	<0.00050	0.0005	0.00149	<0.00050	0.054	0.00103	<0.00050	0.00071	0.92	1.00	1.00	
Mercury (Hg)	mg/L	0.001	NG	0.001	NG	0.000026	0.000026	NG	NG	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	-	-	-	-	
Molybdenum (Mo)	mg/L	NG	NG	NG	NG	0.073	0.073	NG	NG	0.00099	0.00092	0.00077	0.00623	0.00608	0.00016	0.00012	0.00032	0.00077	-0.86	-0.95	-0.27	
Nickel (Ni)	mg/L	NG	NG	NG	NG	0.103 - 0.150	0.103 - 0.150	0.508 - 1.14 ¹	0.056 - 0.127 ²	<0.00050	0.00059	<0.00050	0.0101	<0.00050	0.00162	0.00083	0.00067	<0.00050	0.47	1.00	-0.43	
Phosphorus (P)	mg/L	NG	NG	NG	NG	NG	NG	NG	NG	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	-	-	-	
Potassium (K)	mg/L	NG	NG	NG	NG	NG	NG	NG	NG	6.82	6.32	8.03	53.9	29.7	63.9	1.16	0.493	0.313	-0.84	0.98	0.72	
Selenium (Se)	mg/L	0.05	NG	0.01	NG	0.001	0.001	NG	NG	0.0022	0.00897	0.0165	1.64	0.00747	0.0118	<0.00050	0.00203	<0.00050	-0.54	-	-0.32	
Silicon (Si)	mg/L	NG	NG	NG	NG	NG	NG	NG	NG	1.44	1.79	2.14	2.26	2.32	4.61	2.68	2.96	1.56	0.83	0.68	0.92	
Silver (Ag)	mg/L	NG	NG	NG	NG	NG	0.00025	NG	NG	<0.000050	<0.000050	<0.000050	0.000066	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	-	-	-	
Sodium (Na)	mg/L	NG	≤ 200	NG	≤ 200	NG	NG	NG	NG	2.23	1.99	2.16	19.5	9.87	15.4	0.354	0.757	0.356	-0.77	-0.12	0.52	
Strontium (Sr)	mg/L	7.0	NG	NG	NG	NG	NG	NG	NG	0.12	0.109	0.123	0.505	0.164	1.03	0.017	0.00841	0.0165	-0.88	0.16	0.90	
Sulphur (S)	mg/L	NG	NG	NG	NG	NG	NG	NG	NG	6.6	4.87	13.2	86.2	9.59	288	2.45	<0.50	0.7	-0.65	1.00	0.96	
Thallium (Tl)	mg/L	NG	NG	NG	NG	0.0008	0.0008	NG	NG	<0.00010	<0.00010	<0.00010	0.00024	<0.00010	0.00012	<0.00010	<0.00010	<0.00010	-	-	-1.00	
Tin (Sn)	mg/L	NG	NG	NG	NG	NG	NG	NG	NG	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	-	-	-	
Titanium (Ti)	mg/L	NG	NG	NG	NG	NG	NG	NG	NG	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	0.115	0.037	0.025	0.09	0.96	1.00	
Uranium (U)	mg/L	0.02	NG	0.02	NG	0.033	0.015	NG	NG	0.00065	0.000931	0.000456	0.117	0.0137	0.000182	0.000228	0.000207	0.000134	-0.70	0.91	-0.19	
Vanadium (V)	mg/L	NG	NG	NG	NG	NG	NG	NG	NG	0.0032	0.0042	0.004	<0.0010	0.0016	<0.0010	0.002	<0.0010	<0.0010	-0.83	1.00	-0.76	
Zinc (Zn)	mg/L	NG	≤ 5	NG	≤ 5	0.075 - 0.209 ^d	0.007 - 0.036 ^d	0.127 - 0.286 ¹	0.128 - 0.288 ¹	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	-	-	-	

Notes:

CDWQ MAC: Canadian Drinking Water Quality Maximum Acceptable Concentration Guidelines (Updated in February 2024 version)

CDWQ Other: Canadian Drinking Water Quality (CDWQ) Aesthetic Objective (AO) (Updated in February 2024 Version)

CCME Irrigation: Canadian Council of Ministers of the Environment Water Quality Guidelines for the Protection of Agricultural Water - Irrigation Water Use

CCME Livestock: Canadian Council of Ministers of the Environment Water Quality Guidelines for the Protection of Agricultural Water - Livestock Water Use

FIGQG Agricultural: Federal Interim Groundwater Quality Guidelines - Groundwater Quality Guidelines for Federal Contaminated Sites - Agricultural Land Use - Tables 1.1-1.7 (coarse grain size)

MWQSOG MAC: Manitoba Water Quality Standards, Objectives, and Guidelines (Tier III) - Protection of Drinking Water Use - Maximum Acceptable Concentration

MWQSOG AO: Manitoba Water Quality Standards, Objectives, and Guidelines (Tier III) - Protection of Drinking Water Use - Aesthetic Objectives

MWQSOG Irrigation: Manitoba Water Quality Standards, Objectives, and Guidelines (Tier III) - Protection of Irrigation Water Use

MWQSOG Livestock: Manitoba Water Quality Standards, Objectives, and Guidelines (Tier III) - Protection of Livestock Water Use

CCME FAL: Canadian Council of Ministers of the Environment Water Quality Guidelines to protect freshwater aquatic life

Chronic: Guidelines to protect freshwater aquatic life, (30-day average guidelines)

Acute: Guidelines to protect freshwater aquatic life, (Maximum allowable concentration [MAC] guidelines)

MWQSOG FAL: Manitoba Water Quality Standards, Objectives, and Guidelines (Tier II) - Protection of Aquatic Life and Wildlife

Chronic: Guidelines to protect freshwater aquatic life, (30-day or 4-day average guidelines)

Acute: Guidelines to protect freshwater aquatic life, (one-hour Maximum guidelines)

² Applicable guideline varies depending on the water filtration method.

³ Applicable guideline varies depending on the type of crop irrigated.

⁴ The concentration should not exceed 10 µg/L for continuous use on all soils, or 50 µg/L for short-term use on acidic soils.

^d Applicable guideline is 20 µg/L for continuous use on all soils, 50 µg/L for intermittent use on all soils.

^e Applicable guideline is pH dependant.

^f Applicable guideline is dependant on the type of livestock.

^g The Cr guideline varies with speciation. Most stringent Cr(VI) guideline is applied

^h The maximum concentration in livestock drinking water should not exceed 2000 µg/L, or 1000 µg/L in cases where the feed of animals contains fluoride.

ⁱ Applicable guideline is pH dependant.

^j Applicable guideline varies with water hardness (110-286 mg/L). The guideline was calculated based on the range of hardness values observed in the samples.

^k Applicable manganese long-term guideline is calculated using the CWQG calculator (Provided in Appendix B, CCME). Applicable manganese short-term guideline is calculated using the Benchmark calculator (Provided in Appendix B, CCME).

^l Applicable guideline calculated based on pH, hardness and dissolved organic carbon.

NG= No Guideline

< :Denotes concentration less than indicated detection limit

- :Not analyzed

NS: No Standard

Exceeds CCME FAL Chronic

Exceeds CCME FAL Acute

Exceeds MWQSOG Chronic

Exceeds MWQSOG Acute

Exceeds at least one (Federal or Manitoba) applicable guideline for protection of drinking water

Exceeds two or more applicable guidelines

Detection limit exceeds one or more applicable guidelines

* When the value of the acute and chronic guidelines are equal, exceedances are denoted as exceeding for acute exposure

Table 4-6. Isotope Analysis - Oxygen-18 and Deuterium

Sample ID	Hydrostratigraphic Unit	Depth (mBGS)	δ2H (‰)	δ18O (‰)
BRU 95-8 33.61 - 33.83	Red River Carbonate	33.61	-96.85	-10.90
BRU 95-8 35.06 - 35.16	Red River Carbonate	35.06	-99.78	-11.44
BRU 95-8 37.12 - 37.28	Red River Carbonate	37.12	-101.23	-13.14
BRU 95-8 38.28 - 38.4	Red River Carbonate	38.28	-100.56	-12.04
BRU 95-8 38.85 - 38.97	Red River Carbonate	38.85	-103.83	-12.11
BRU 95-8 40.8 - 40.92	Red River Carbonate	40.8	-98.98	-11.91
BRU 95-8 42.14 - 42.25	Red River Carbonate	42.14	-100.63	-12.41
BRU 95-8 43.25 - 43.37	Red River Carbonate	43.25	-100.23	-12.23
BRU 95-8 44.5 - 44.61	Red River Carbonate	44.5	-100.79	-12.34
BRU 95-8 45.695 - 45.83	Red River Carbonate	45.695	-102.37	-12.75
BRU 95-8 46.76 - 46.885	Red River Carbonate	46.76	-102.26	-12.75
BRU 95-8 47.94 - 48.115	Red River Carbonate	47.94	-104.57	-11.86
BRU 95-8 48.91 - 49.07	Winnipeg Shale	48.6	-107.90	-10.76
BRU 95-8 48.6 - 48.85	Winnipeg Shale	48.91	-111.68	-9.95
BRU 95-8 49.27 - 49.39	Winnipeg Shale	49.27	-110.21	-9.13
BRU 95-8 49.94 - 50.045	Winnipeg Shale	49.94	-108.01	-12.61
BRU 95-8 50.17 - 50.29	Winnipeg Shale	50.17	-109.11	-8.23
BRU 95-8 50.5 - 50.6	Winnipeg Shale	50.5	-107.35	-10.22
BRU 95-8 52.02 - 52.12	Winnipeg Shale	52.02	-105.52	-12.90
BRU 95-8 Drill Water 8:40 am	Winnipeg Sandstone	-	-103.8	-13.97
BRU 95-8 Drill WAter 11:30 am	Winnipeg Sandstone	-	-103.8	-14.03
BRU 95-8 Drill Water 12:30 pm	Winnipeg Sandstone	-	-104.7	-14.38
BRU Drill Water 1:30 Pm	Winnipeg Sandstone	-	-104.5	-14.26
BRU Drill Water 9:00 am	Winnipeg Sandstone	-	-105.7	-14.72
BRU 95-7 S1	Winnipeg Sandstone	-	-105.8	-14.14
BRU 95-7 S2	Winnipeg Sandstone	63.1	-106.4	-14.27
BRU 95-7 S3	Winnipeg Sandstone	63.1	-106.4	-14.48
BRU 95-7 S3-2	Winnipeg Sandstone	63.1	-106.4	-14.53
BRU 95-7 S4	Winnipeg Sandstone	63.1	-106.2	-14.3
BRU 95-7 S5	Winnipeg Sandstone	63.1	-107.4	-14.76
BRU 95-7 S6	Winnipeg Sandstone	63.1	-106.6	-14.44
BRU 95-7 S7	Winnipeg Sandstone	63.1	-106.8	-14.46

Notes:
m BGS: meter below ground surface

Table 4-7. Groundwater Quality Analytical Results - Discharge to Groundwater

Sample ID											BRU 95-5	BRU 95-5	BRU 95-6	BRU 95-6	BRU 95-7 (S1)	BRU 95-7 (S4)	BRU 95-7	BRU 95-9	BRU 95-9	BRU 95-9	BRU 95-9	BRU 96-1	BRU 96-1
Pre/Mid/Post Pump Test											Pre-test	Post-test	Pre-test	Post-test	Pre-test	Mid-test	Post-test	Pre-test	Post-test	NA	Pre-test	Post-test	
Lithology											Carbonate	Carbonate	Sandstone	Sandstone	Sandstone	Sandstone	Sandstone	Shale	Shale	Shale	Sandstone	Sandstone	
Sample Date											2020-Nov-15	2020-Dec-02	2020-Nov-15	2020-Dec-02	2020-Nov-25	2020-Nov-29	2020-Dec-01	2020-Nov-24	2020-Dec-02	2021-Feb-04	2020-Nov-13	2020-Dec-02	
Lab Sample ID											L2530033-1	L2536193-4	L2530033-2	L2536193-2	L2533700-2	L2535510-2	L2535510-1	L2533700-1	L2536193-3	L2554881-1	L2530033-3	L2536193-5	
Lab Job Number											L2530033	L2536193	L2530033	L2536193	L2533700	L2535510	L2535510	L2533700	L2536193	L2554881	L2530033	L2536193	
Parameter	CDWQ MAC	CDWQ AO	MWQSOG MAC	MWQSOG AO	FIGQG Agricultural	CCME Irrigation	CCME Livestock	MWQSOG Irrigation	MWQSOG Livestock	Units													
Field Parameters																							
Temperature, Field	NS	≤ 15	NS	≤ 15	NS	NS	NS	NS	NS	°C	4.2	4.4	4.7	4.8	6.2	5.6	5.6	5.1	4.4	5.34	5.2	5.5	
pH, Field	NS	7.0-10.5	NS	6.5-8.5	6.5-9	NS	NS	NS	NS	pH units	7.54	7.73	7.72	8.50	7.84	7.89	7.97	7.56	8.04	7.75	8.01	9.44	
pH, Lab	NS	7.0-10.5	NS	6.5-8.5	6.5-9	NS	NS	NS	NS	pH units	8.33	8.16	8.35	8.12	8.11	-	8.36	8.09	8.35	8.11	8.44	8.49	
Specific Conductivity, Field	NS	NS	NS	NS	NS	NS	NS	NS	NS	µS/cm	535	525	483	594	439.8	443.2	444.2	482.1	502	322	581	569	
Specific Conductivity, Lab	NS	NS	NS	NS	NS	NS	NS	NS	NS	µS/cm	543	535	497	518	428	-	453	471	617	515	594	589	
Conductivity, Field	NS	NS	NS	NS	NS	NS	NS	NS	NS	µS/cm	323	318.5	298	364.8	281.5	279.4	279.2	298.8	304.4	515	361	357.3	
Salinity	NS	NS	NS	NS	NS	NS	NS	NS	NS	ppt	0.26	0.25	0.23	0.29	0.21	0.21	0.21	0.23	0.24	-	-	0.28	
Dissolved Oxygen, Field	NS	NS	NS	NS	NS	NS	NS	NS	NS	%L	-	43.3	-	2.1	47.2	43.3	74.8	1.7	8.4	-	-	4.0	
Dissolved Oxygen, Lab	NS	NS	NS	NS	NS	NS	NS	NS	NS	mg/L	3.95	5.48	3.1	0.27	5.60	5.33	9.09	0.21	1.06	0.28	5.6	0.49	
ORP	NS	NS	NS	NS	NS	NS	NS	NS	NS	mV	-62	60.7	10.0	23.0	-31.3	-61.3	-49.1	-76.1	94.3	115	63	91.4	
Turbidity, Field	≤ 0.1 - 1 ^a	NS	≤ 0.1 - 1 ^a	NS	NS	NS	NS	NS	NS	NTU	42	21.05	31	-	8.35	0.33	24.74	-	-	-	105	-	
Turbidity, Lab	≤ 0.1 - 1 ^a	NS	≤ 0.1 - 1 ^a	NS	NS	NS	NS	NS	NS	NTU	-	-	-	-	6.50	-	-	-	1240	-	171	-	
Total Suspended Solids	NS	NS	NS	NS	NS	NS	NS	NS	NS	mg/L	4.2	11.1	69.6	403	5.7	-	< 3	1150	9450	186	117	78.7	
Total Dissolved Solids (Lab)	NS	500	NS	500	3000	500 - 3500 ^b	3000	500 - 3500 ^b	3000	mg/L	277	258	264	292	239	-	245	269	489	302	358	340	
General Parameters and Anions																							
Hardness (as CaCO3)	NS	NS	NS	NS	NS	NS	NS	NS	NS	mg/L	268	265	238	-	196	-	197	211	-	204	116	110	
Alkalinity, Total (As CaCO3)	NS	NS	NS	NS	NS	NS	NS	NS	NS	mg/L	302	299	273	302	246	-	244	276	1010	285	260	271	
Hydroxide (OH)	NS	NS	NS	NS	NS	NS	NS	NS	NS	mg/L	< 0.34	< 0.34	< 0.34	< 0.34	< 0.34	-	< 0.34	< 0.34	< 0.34	<0.340	< 0.34	< 0.34	
Bicarbonate (as CaCO3)	NS	NS	NS	NS	NS	NS	NS	NS	NS	mg/L	358	365	322	369	300	-	287	337	1230	348	304	313	
Biochemical Oxygen Demand	NS	NS	NS	NS	NS	NS	NS	NS	NS	mg/L	-	-	-	-	< 2	-	11.3	< 6	-	9.3	-	-	
Carbonate (as CaCO3)	NS	NS	NS	NS	NS	NS	NS	NS	NS	mg/L	4.92	< 0.6	5.16	< 0.6	< 0.6	-	5.28	< 0.6	5.52	<0.6	6.72	9	
Chemical Oxygen Demand	NS	NS	NS	NS	NS	NS	NS	NS	NS	mg/L	-	-	-	-	< 20	-	< 20	38	-	40	-	-	
Dissolved Organic Carbon (DOC)	NS	NS	NS	NS	NS	NS	NS	NS	NS	mg/L	1.74	2.01	0.87	2.12	1.55	-	1.58	1.75	16.9	7.03	0.5	1.66	
Fluoride	1.5	NS	1.5	NS	0.12	1	1 - 2 ^g	1	1 - 2	mg/L	0.325	0.331	0.383	0.382	0.406	0.416	0.411	0.302	0.481	0.397	0.882	0.876	
Ammonia-N	NS	NS	NS	NS	NS	NS	NS	NS	NS	mg/L	0.41	0.202	0.415	0.389	0.498	-	0.59	0.446	0.81	0.318	0.415	0.38	
Nitrate plus Nitrite (N)	NS	NS	10	NS	100	NS	100	NS	100	mg/L	< 0.07	< 0.0051	< 0.07	< 0.0051	< 0.0051	-	< 0.0051	< 0.0051	< 0.0051	0.0083	< 0.07	< 0.0051	
Nitrate (as N)	10	NS	10	NS	13	NS	NS	NS	NS	mg/L	< 0.02	< 0.005	< 0.02	< 0.005	< 0.005	< 0.02	< 0.005	< 0.005	< 0.005	0.0069	< 0.02	< 0.005	
Nitrite (as N)	1	NS	3.2	NS	0.06	NS	10	NS	10	mg/L	< 0.01	< 0.001	< 0.01	< 0.001	< 0.001	< 0.01	< 0.001	< 0.001	< 0.001	0.0013	< 0.01	< 0.001	
Chloride	NS	≤ 250	NS	≤ 250	100	100 - 900 ^b	NS	100 - 900 ^b	NS	mg/L	1.78	1.01	1.48	1.63	1.04	1.32	1.52	1.87	37.4	7.03	22.9	22.4	
Sulphide	NS	0.05	NS	NS	NS	NS	NS	NS	NS	mg/L	< 0.018	0.078	< 0.018	< 0.018	0.023	-	0.02	< 0.18	< 1.8	<0.018	< 0.018	< 0.018	
Sulphide (as H2S)	NS	NS	NS	0.05	0.002	NS	NS	NS	NS	mg/L	< 0.019	0.083	< 0.019	< 0.019	0.024	-	0.021	< 0.19	< 1.9	<0.019	< 0.019	< 0.019	
Sulphate	NS	500	NS	≤ 500	100	NS	1000	NS	1000	mg/L	4.6	3.22	6.92	8.01	5.23	5.69	5.83	6.84	37.2	10.9	33.5	32.1	
Dissolved Metals																							
Aluminum	NS	NS	NS	NS	NS	5	5	5	5	mg/L	< 0.001	< 0.001	0.0032	0.0029	< 0.001	< 0.001	< 0.001	0.0012	0.006	0.003	0.0085	0.0027	
Antimony	0.006	NS	0.006	NS	2.0	NS	NS	NS	NS	mg/L	< 0.0001	< 0.0001	< 0.0001	0.00015	< 0.0001	< 0.0001	< 0.0001	< 0.0001	0.00065	0.00048	< 0.0001	0.00033	
Arsenic	0.01	NS	0.01	NS	0.005	0.1	0.025	0.1	0.025	mg/L	0.00155	0.00153	0.00052	0.00056	0.00031	< 0.0001	0.00088	0.00179	0.00128	0.00036	0.00063	0.00063	
Barium	1	NS	1	NS	0.5	NS	NS	NS	NS	mg/L	0.11	0.11	0.0835	0.0898	0.0951	0.0952	0.0964	0.0567	0.054	0.049	0.0473	0.0426	
Beryllium	NS	NS	NS	NS	0.0053	0.1	0.1	0.1	0.1	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	<0.00010	< 0.0001	< 0.0001	
Bismuth	NS	NS	NS	NS	NS	NS	NS	NS	NS	mg/L	< 0.00005	< 0.00005	< 0.00005	< 0.00005	< 0.00005	< 0.00005	< 0.00005	< 0.00005	< 0.00005	<0.000050	< 0.00005	< 0.00005	
Boron	5	NS	5	NS	0.5	0.5 - 6 ^b	5	0.5 - 6 ^b	5	mg/L	0.156	0.155	0.251	0.339	0.214	0.202	0.212	0.334	0.299	0.346	0.692	0.605	
Cadmium	0.007	NS	0.005	NS	0.000017	0.0051	0.080	0.0051	0.080	mg/L	< 0.000005	< 0.000005</											

SiMba Project
Hydrogeology and Geochemistry Assessment Report



Sample ID											BRU 95-5	BRU 95-5	BRU 95-6	BRU 95-6	BRU 95-7 (S1)	BRU 95-7 (S4)	BRU 95-7	BRU 95-9	BRU 95-9	BRU 95-9	BRU 96-1	BRU 96-1
Pre/Mid/Post Pump Test											Pre-test	Post-test	Pre-test	Post-test	Pre-test	Mid-test	Post-test	Pre-test	Post-test	NA	Pre-test	Post-test
Lithology											Carbonate	Carbonate	Sandstone	Sandstone	Sandstone	Sandstone	Sandstone	Shale	Shale	Shale	Sandstone	Sandstone
Sample Date											2020-Nov-15	2020-Dec-02	2020-Nov-15	2020-Dec-02	2020-Nov-25	2020-Nov-29	2020-Dec-01	2020-Nov-24	2020-Dec-02	2021-Feb-04	2020-Nov-13	2020-Dec-02
Lab Sample ID											L2530033-1	L2536193-4	L2530033-2	L2536193-2	L2533700-2	L2535510-2	L2535510-1	L2533700-1	L2536193-3	L2554881-1	L2530033-3	L2536193-5
Lab Job Number											L2530033	L2536193	L2530033	L2536193	L2533700	L2535510	L2535510	L2533700	L2536193	L2554881	L2530033	L2536193
Parameter	CDWQ MAC	CDWQ AO	MWQSOG MAC	MWQSOG AO	FIGQG Agricultural	CCME Irrigation	CCME Livestock	MWQSOG Irrigation	MWQSOG Livestock	Units												
Phenanthrene	NS	NS	NS	NS	0.0004	NS	NS	NS	NS	mg/L	-	-	-	-	< 0.00005	-	< 0.00005	-	-	-	-	-
Benz(a)anthracene	NS	NS	NS	NS	0.000018	NS	NS	NS	NS	mg/L	-	-	-	-	< 0.00001	-	< 0.00001	-	-	-	-	-
Benzo(a)pyrene	0.00004	NS	0.00001	NS	0.00001	NS	NS	NS	NS	mg/L	-	-	-	-	< 0.000005	-	< 0.000005	-	-	-	-	-
Benzo(b+j)fluoranthene	NS	NS	NS	NS	0.00048	NS	NS	NS	NS	mg/L	-	-	-	-	< 0.00001	-	< 0.00001	-	-	-	-	-
Benzo(g,h,i)perylene	NS	NS	NS	NS	0.00017 ^b	NS	NS	NS	NS	mg/L	-	-	-	-	< 0.00002	-	< 0.00002	-	-	-	-	-
Benzo(k)fluoranthene	NS	NS	NS	NS	0.00048	NS	NS	NS	NS	mg/L	-	-	-	-	< 0.00001	-	< 0.00001	-	-	-	-	-
Chrysene	NS	NS	NS	NS	0.0001	NS	NS	NS	NS	mg/L	-	-	-	-	< 0.00002	-	< 0.00002	-	-	-	-	-
Dibenz(a,h)anthracene	NS	NS	NS	NS	0.00026 ^h	NS	NS	NS	NS	mg/L	-	-	-	-	< 0.000005	-	< 0.000005	-	-	-	-	-
Fluoranthene	NS	NS	NS	NS	0.00004	NS	NS	NS	NS	mg/L	-	-	-	-	< 0.00002	-	< 0.00002	-	-	-	-	-
Indeno(1,2,3-c,d)pyrene	NS	NS	NS	NS	0.00021 ^h	NS	NS	NS	NS	mg/L	-	-	-	-	< 0.00001	-	< 0.00001	-	-	-	-	-
Methylnaphthalene, 1-	NS	NS	NS	NS	0.18	NS	NS	NS	NS	mg/L	-	-	-	-	< 0.00002	-	< 0.00002	-	-	-	-	-
Methylnaphthalene, 2-	NS	NS	NS	NS	0.18	NS	NS	NS	NS	mg/L	-	-	-	-	< 0.00002	-	< 0.00002	-	-	-	-	-
Pyrene	NS	NS	NS	NS	0.000025	NS	NS	NS	NS	mg/L	-	-	-	-	< 0.00001	-	< 0.00001	-	-	-	-	-
Quinoline	NS	NS	NS	NS	0.0034	NS	NS	NS	NS	mg/L	-	-	-	-	< 0.00002	-	< 0.00002	-	-	-	-	-
Phenols and PHC																						
Phenols (Phenolics)	NS	NS	NS	NS	0.002	NS	0.002	NS	0.002	mg/L	-	-	-	-	< 0.001	-	< 0.001	< 0.001	-	-	-	-
Benzene	0.005	NS	0.005	NS	0.088	NS	NS	NS	NS	mg/L	-	-	-	-	< 0.0005	-	< 0.0005	-	-	-	-	-
Toluene	0.06	0.024	NS	≤ 0.024	0.083	NS	0.024	NS	0.024	mg/L	-	-	-	-	< 0.001	-	< 0.001	-	-	-	-	-
Ethylbenzene	0.14	0.0016	NS	≤ 0.024	3.2	NS	0.024	NS	0.024	mg/L	-	-	-	-	< 0.0005	-	< 0.0005	-	-	-	-	-
Xylene, O-	NS	NS	NS	NS	NS	NS	NS	NS	NS	mg/L	-	-	-	-	< 0.0005	-	< 0.0005	-	-	-	-	-
Xylene, p+m-	NS	NS	NS	NS	NS	NS	NS	NS	NS	mg/L	-	-	-	-	< 0.0004	-	< 0.0004	-	-	-	-	-
Xylenes, Total	0.09	0.02	NS	≤ 0.3	3.9	NS	NS	NS	NS	mg/L	-	-	-	-	< 0.00064	-	< 0.00064	-	-	-	-	-
PHC F1 (C6-C10 range)	NS	NS	NS	NS	0.81 ^h	NS	NS	NS	NS	mg/L	-	-	-	-	< 0.1	-	< 0.1	-	-	0	-	-
PHC F1 (C6-C10) minus BTEX	NS	NS	NS	NS	NS	NS	NS	NS	NS	mg/L	-	-	-	-	< 0.1	-	< 0.1	-	-	0	-	-
PHC F2 (>C10-C16)	NS	NS	NS	NS	1300 ^h	NS	NS	NS	NS	µg/L	-	-	-	-	< 100	-	< 100	-	-	0	-	-
PHC F2 (>C10-C16) minus Naphthalene (	NS	NS	NS	NS	NS	NS	NS	NS	NS	mg/L	-	-	-	-	< 0.1	-	< 0.1	-	-	0	-	-
PHC F3 (>C16-C34 range)	NS	NS	NS	NS	NS	NS	NS	NS	NS	µg/L	-	-	-	-	< 250	-	< 250	-	-	0	-	-
PHC F3 (>C16-C34) minus PAH	NS	NS	NS	NS	NS	NS	NS	NS	NS	mg/L	-	-	-	-	< 0.25	-	< 0.25	-	-	0	-	-
PHC (>C6-C50)	NS	NS	NS	NS	NS	NS	NS	NS	NS	mg/L	-	-	-	-	< 0.38	-	< 0.38	-	-	0	-	-
PHC F4 (>C34-C50 range)	NS	NS	NS	NS	NS	NS	NS	NS	NS	µg/L	-	-	-	-	< 250	-	< 250	-	-	0	-	-
Chromatogram to baseline at nC50										N/A	-	-	-	-	< 99999	-	< 99999	-	-	0	-	-

Notes:

CDWQ MAC: Canadian Drinking Water Quality Maximum Acceptable Concentration Guidelines (Updated in February 2024 version)

CDWQ Other: Canadian Drinking Water Quality (CDWQ) Aesthetic Objective (AO) (Updated in February 2024 Version)

CCME Irrigation: Canadian Council of Ministers of the Environment Water Quality Guidelines for the Protection of Agricultural Water - Irrigation Water Use

CCME Livestock: Canadian Council of Ministers of the Environment Water Quality Guidelines for the Protection of Agricultural Water - Livestock Water Use

FIGQG Agricultural: Federal Interim Groundwater Quality Guidelines - Groundwater Quality Guidelines for Federal Contaminated Sites - Agricultural Land Use - Tables 1.1-1.7 (coarse grain size)

MWQSOG MAC: Manitoba Water Quality Standards, Objectives, and Guidelines (Tier III) - Protection of Drinking Water Use - Maximum Acceptable Concentration

MWQSOG AO: Manitoba Water Quality Standards, Objectives, and Guidelines (Tier III) - Protection of Drinking Water Use - Aesthetic Objectives

MWQSOG Irrigation: Manitoba Water Quality Standards, Objectives, and Guidelines (Tier III) - Protection of Irrigation Water Use

MWQSOG Livestock: Manitoba Water Quality Standards, Objectives, and Guidelines (Tier III) - Protection of Livestock Water Use

a Applicable guideline varies depending on the water filtration method.

b Applicable guideline varies depending on the type of crop irrigated.

c The concentration should not exceed 10 µg/L for continuous use on all soils, or 50 µg/L for short-term use on acidic soils.

d Applicable guideline is 20 µg/L for continuous use on all soils, 50 µg/L for intermittent use on all soils.

e Applicable guideline is pH dependant.

f Applicable guideline is dependant on the type of livestock.

g The maximum concentration in livestock drinking water should not exceed 2000 µg/L, or 1000 µg/L in cases where the feed of animals contains fluoride.

h Applicable guideline varies with soil grain size.

i Additions should not change the thermal stratification or the maximum weekly average temperature of the aquatic receiving body. Thermal additions to receiving waters should be such that the short-term exposure to maximum temperatures are not exceeded.

j Applicable guideline dependant on species and life stage.

k Applicable guideline dependant on background levels of the aquatic receiving water body.

l Applicable guideline varies with water hardness. The guideline was calculated based on the range of hardness values observed in the samples.

m The Cr guideline varies with speciation. Cr(III) guideline is applied as Cr(III) is dominate speceis under natural conditions

nApplicable manganese long-term guideline is calculated using the CWQG calculator (Provided in Appendix B, CCME). Applicable manganese short-term guideline is calculated using the Benchmark calculator (Provided in Appendix B, CCME).

oApplicable guideline based on trigger range for nutrients in aquatic systems.

p Applicable guideline calculated based on pH, hardness and dissolved organic carbon. The minimum and maximum guidelines for the site are shown.

qApplicable guideline varies with temperature and pH according to a look up table. The minimum and maximum guidelines for the site are shown.

r Applicable guideline temperature, and/or pH dependant using various equations according to conditions within the aquatic receiving body. The minimum and maximum guidelines for the site are shown.

s Guideline is a surface water objective.

t Seven (7) day averaging duration.

u Applicable guideline dependant on background suspended sediment concentrations.

h The Cr guideline varies with speciation. Cr(III) guideline is applied as Cr(III) is dominate species under natural conditions

< :Denotes concentration less than indicated detection limit

- :Not analyzed

NC: Not Calculated (Results <5x laboratory detection limit)

NS: No Guideline

BOLD Reportable Detection Limit (RDL) exceeds the regulatory guideline

Light Blue Exceeds at least one (Federal or Manitoba) applicable guideline for protection of drinking water (MAC or AO)

Orange Exceeds at least one (Federal or Manitoba) applicable guideline for protection of agriculture/irrigation

Dark Blue Exceeds at least one (Federal or Manitoba) applicable guideline for protection of livestock

Light Grey Exceeds at least two types of applicable guidelines for all applicable pathways

Grey RPD values above alert limit of 30%

SiMba Project
Hydrogeology and Geochemistry Assessment Report



Table 4-7. Groundwater Quality Analytical Results - Discharge to Groundwater

											Sample ID	BRU 96-2	BRU 96-2 (DUP)	RPD	BRU 96-2	Unknown	Unknown	Well 66124	Well 23901	Well 23901
											Pre-test	Pre-test	Post-test		Pre-test	Post-test	Pre-test	Pre-test	Post-test	
											Carbonate	Carbonate	Carbonate		Sandstone	Sandstone	Shale	Carbonate	Carbonate	
											2020-Nov-14	2020-Nov-14	2020-Nov-14		2020-Nov-15	2020-Dec-02	2020-Nov-15	2020-Nov-18	2020-Dec-02	
											L2530033-4	L2530033-5	L2536193-7		L2530033-7	L2536193-1	L2530033-6	L2532264-1	L2536193-6	
											Lab Sample ID	L2530033	L2530033		L2536193	L2530033	L2536193	L2530033	L2532264	L2536193
											Lab Job Number	L2530033	L2530033							
Parameter	CDWQ MAC	CDWQ AO	MWQSOG MAC	MWQSOG AO	FIGQG Agricultural	CCME Irrigation	CCME Livestock	MWQSOG Irrigation	MWQSOG Livestock	Units										
Field Parameters																				
Temperature, Field	NS	≤ 15	NS	≤ 15	NS	NS	NS	NS	NS	°C	5.2	5.2	0	5.5	6.5	-	10.1	6.2	-	
pH, Field	NS	7.0-10.5	NS	6.5-8.5	6.5-9	NS	NS	NS	NS	pH units	7.91	7.91	0	7.91	7.64	-	8.13	8.03	-	
pH, Lab	NS	7.0-10.5	NS	6.5-8.5	6.5-9	NS	NS	NS	NS	pH units	8.39	8.38	0	8.18	8.27	8.18	8.46	8.48	8.13	
Specific Conductivity, Field	NS	NS	NS	NS	NS	NS	NS	NS	NS	µS/cm	383	383	0	415.5	511	-	562	541	-	
Specific Conductivity, Lab	NS	NS	NS	NS	NS	NS	NS	NS	NS	µS/cm	395	396	0	421	510	515	578	536	546	
Conductivity, Field	NS	NS	NS	NS	NS	NS	NS	NS	NS	µS/cm	238	238	0	261.1	330.2	-	402.4	346.5	-	
Salinity	NS	NS	NS	NS	NS	NS	NS	NS	NS	ppt	-	-	NC	0.20	0.25	-	0.27	0.26	-	
Dissolved Oxygen, Field	NS	NS	NS	NS	NS	NS	NS	NS	NS	%L	-	-	NC	3.1	62.4	-	68.6	59.1	-	
Dissolved Oxygen, Lab	NS	NS	NS	NS	NS	NS	NS	NS	NS	mg/L	3.6	3.6	0	0.39	7.36	-	7.39	7.01	-	
ORP	NS	NS	NS	NS	NS	NS	NS	NS	NS	mV	-93	-93	0	4.5	-46.2	-	60.2	70.0	-	
Turbidity, Field	≤ 0.1 - 1 ^a	NS	≤ 0.1 - 1 ^a	NS	NS	NS	NS	NS	NS	NTU	25	25	0	29.83	1.14	-	-0.10	0.33	-	
Turbidity, Lab	≤ 0.1 - 1 ^a	NS	≤ 0.1 - 1 ^a	NS	NS	NS	NS	NS	NS	NTU	-	-	-	-	-	-	-	0.26	-	
Total Suspended Solids	NS	NS	NS	NS	NS	NS	NS	NS	NS	mg/L	36.8	88.4	-	31.5	< 3	< 3	< 3	< 3	< 3	
Total Dissolved Solids (Lab)	NS	500	NS	500	3000	500 - 3500 ^b	3000	500 - 3500 ^b	3000	mg/L	224	229	2	217	259	247	337	319	313	
General Parameters and Anions																				
Hardness (as CaCO3)	NS	NS	NS	NS	NS	NS	NS	NS	NS	mg/L	112	113	1	125	247	249	0.99	0.51	0.42	
Alkalinity, Total (As CaCO3)	NS	NS	NS	NS	NS	NS	NS	NS	NS	mg/L	197	199	1	212	284	283	309	284	290	
Hydroxide (OH)	NS	NS	NS	NS	NS	NS	NS	NS	NS	mg/L	< 0.34	< 0.34	NC	< 0.34	< 0.34	< 0.34	< 0.34	< 0.34	< 0.34	
Bicarbonate (as CaCO3)	NS	NS	NS	NS	NS	NS	NS	NS	NS	mg/L	231	233	1	258	346	346	362	330	353	
Biochemical Oxygen Demand	NS	NS	NS	NS	NS	NS	NS	NS	NS	mg/L	-	-	NC	-	-	-	-	-	-	
Carbonate (as CaCO3)	NS	NS	NS	NS	NS	NS	NS	NS	NS	mg/L	4.68	4.44	5	< 0.6	< 0.6	< 0.6	7.08	8.04	< 0.6	
Chemical Oxygen Demand	NS	NS	NS	NS	NS	NS	NS	NS	NS	mg/L	-	-	NC	-	-	-	-	< 20	-	
Dissolved Organic Carbon (DOC)	NS	NS	NS	NS	NS	NS	NS	NS	NS	mg/L	1.45	1.46	1	3.65	2.89	2.06	1.66	1.99	1.87	
Fluoride	1.5	NS	1.5	NS	0.12	1	1 - 2 ^g	1	1 - 2	mg/L	0.549	0.544	1	0.499	0.358	0.35	0.343	0.286	0.276	
Ammonia-N	NS	NS	NS	NS	NS	NS	NS	NS	NS	mg/L	0.322	0.305	5	0.288	0.418	0.429	0.011	0.043	0.018	
Nitrate plus Nitrite (N)	NS	NS	10	NS	100	NS	100	NS	100	mg/L	< 0.07	< 0.07	NC	< 0.0051	< 0.07	< 0.0051	< 0.07	< 0.0051	< 0.0051	
Nitrate (as N)	10	NS	10	NS	13	NS	NS	NS	NS	mg/L	< 0.02	< 0.02	NC	< 0.005	< 0.02	< 0.005	< 0.02	< 0.005	< 0.005	
Nitrite (as N)	1	NS	3.2	NS	0.06	NS	10	NS	10	mg/L	< 0.01	< 0.01	NC	< 0.001	< 0.01	< 0.001	< 0.01	< 0.001	< 0.001	
Chloride	NS	≤ 250	NS	≤ 250	100	100 - 900 ^b	NS	100 - 900 ^b	NS	mg/L	2.56	2.57	0	2.76	1.04	1.03	2.7	2.87	2.94	
Sulphide	NS	0.05	NS	NS	NS	NS	NS	NS	NS	mg/L	< 0.018	< 0.018	NC	< 0.018	< 0.018	0.021	< 0.018	0.024	0.03	
Sulphide (as H2S)	NS	NS	NS	0.05	0.002	NS	NS	NS	NS	mg/L	< 0.019	< 0.019	NC	< 0.019	< 0.019	0.022	< 0.019	0.026	0.032	
Sulphate	NS	500	NS	≤ 500	100	NS	1000	NS	1000	mg/L	14.4	14.5	1	13.4	4.14	3.81	5.68	9.07	8.37	
Dissolved Metals																				
Aluminum	NS	NS	NS	NS	NS	5	5	5	5	mg/L	0.0025	0.0011	NC	0.0025	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	
Antimony	0.006	NS	0.006	NS	2.0	NS	NS	NS	NS	mg/L	< 0.0001	< 0.0001	NC	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	
Arsenic	0.01	NS	0.01	NS	0.005	0.1	0.025	0.1	0.025	mg/L	0.00018	0.00018	0	0.00027	0.00168	0.00149	0.00046	0.0007	0.00061	
Barium	1	NS	1	NS	0.5	NS	NS	NS	NS	mg/L	0.0564	0.0564	0	0.0556	0.1	0.105	0.00125	0.00024	0.00019	
Beryllium	NS	NS	NS	NS	0.0053	0.1	0.1	0.1	0.1	mg/L	< 0.0001	< 0.0001	NC	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	
Bismuth	NS	NS	NS	NS	NS	NS	NS	NS	NS	mg/L	< 0.00005	< 0.00005	NC	< 0.00005	< 0.00005	< 0.00005	< 0.00005	< 0.00005	< 0.00005	
Boron	5	NS	5	NS	0.5	0.5 - 6 ^b	5	0.5 - 6 ^b	5	mg/L	0.302	0.28	8	0.266	0.196	0.18	0.147	0.142	0.097	
Cadmium	0.007	NS	0.005	NS	0.000017	0.0051	0.080	0.0051	0.080	mg/L	< 0.000005	< 0.000005	NC	< 0.000005	< 0.000005	< 0.000005	< 0.000005	< 0.000005	< 0.000005	
Calcium	NS	NS	NS	NS	NS	NS	1000	NS	1000	mg/L	24.7	24.5	1	27.1	44.6	43.5	0.206	0.118	0.102	
Cesium	NS	NS	NS	NS	NS	NS	NS	NS	NS	mg/L	< 0.00001	< 0.00001	NC	< 0.00001	< 0.00001	< 0.00001	< 0.00001	< 0.00001	< 0.00001	
Chromium ^h	0.05	NS	0.05	NS	0.05	0.0049	0.05	NS	NS	mg/L	< 0.0001	< 0.0001	NC	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	
Cobalt	NS	NS	NS	NS	0.05	0.05	1	0.05	1	mg/L	< 0.0001	< 0.0001	NC	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	
Copper	2	1	NS	≤ 1	2	0.2-1 ^b	0.5 - 5 ^f	0.2-1 ^b	0.5 - 5 ^f	mg/L	< 0.0002	< 0.0002	NC	< 0.0002	< 0.0002	< 0.0002	0.0241	0.00035	0.0005	
Iron	NS	0.3	NS	≤ 0.3	0.3	5	NS	5	NS	mg/L	0.259	0.24	8	0.199	0.864	0.016	0.015	< 0.01	< 0.01	
Lead	0.005	NS	0.01	NS	0.005	0.2	0.1	0.2	0.1	mg/L	< 0.00005	< 0.00005	NC	< 0.00005	< 0.00005	< 0.00005	0.000177	< 0.00005	< 0.00005	
Lithium	NS	NS	NS	NS	NS	2.5	NS	2.5	NS	mg/L	0.0114	0.0109	4	0.0121	0.0171	0.0173	0.0017	< 0.001	< 0.001	
Magnesium	NS	NS	NS	NS	NS	NS	NS	NS	NS	mg/L	12.4	12.5	1	13.9	32.8	34.1	0.116	0.0524	0.0405	
Manganese	0.12	≤ 0.02	NS	≤ 0.050	0.2	0.2	NS	0.2	NS	mg/L	0.00306	0.00303	1	0.00297	0.0155	0.0151	0.00147	0.00018	< 0.0001	
Mercury	0.001	NS	0.001	NS	0.001	NS	0.003	NS	0.003	mg/L	< 0.000005	< 0.000005	NC	< 0.000005	< 0.000005	< 0.000005	< 0.000005			

Sample ID											BRU 96-2	BRU 96-2 (DUP)	RPD	BRU 96-2	Unknown	Unknown	Well 66124	Well 23901	Well 23901
Pre/Mid/Post Pump Test											Pre-test	Pre-test		Post-test	Pre-test	Post-test	Pre-test	Pre-test	Post-test
Lithology											Carbonate	Carbonate		Carbonate	Sandstone	Sandstone	Shale	Carbonate	Carbonate
Sample Date											2020-Nov-14	2020-Nov-14		2020-Dec-02	2020-Nov-15	2020-Dec-02	2020-Nov-15	2020-Nov-18	2020-Dec-02
Lab Sample ID											L2530033-4	L2530033-5		L2536193-7	L2530033-7	L2536193-1	L2530033-6	L2532264-1	L2536193-6
Lab Job Number											L2530033	L2530033		L2536193	L2530033	L2536193	L2530033	L2532264	L2536193
Parameter	CDWQ MAC	CDWQ AO	MWQSOG MAC	MWQSOG AO	FIGQG Agricultural	CCME Irrigation	CCME Livestock	MWQSOG Irrigation	MWQSOG Livestock	Units									
Phenanthrene	NS	NS	NS	NS	0.0004	NS	NS	NS	NS	mg/L	-	-	NC	-	-	-	-	-	-
Benz(a)anthracene	NS	NS	NS	NS	0.000018	NS	NS	NS	NS	mg/L	-	-	NC	-	-	-	-	-	-
Benzo(a)pyrene	0.00004	NS	0.00001	NS	0.00001	NS	NS	NS	NS	mg/L	-	-	NC	-	-	-	-	-	-
Benzo(b+j)fluoranthene	NS	NS	NS	NS	0.00048	NS	NS	NS	NS	mg/L	-	-	NC	-	-	-	-	-	-
Benzo(g,h,i)perylene	NS	NS	NS	NS	0.00017 ^h	NS	NS	NS	NS	mg/L	-	-	NC	-	-	-	-	-	-
Benzo(k)fluoranthene	NS	NS	NS	NS	0.00048	NS	NS	NS	NS	mg/L	-	-	NC	-	-	-	-	-	-
Chrysene	NS	NS	NS	NS	0.0001	NS	NS	NS	NS	mg/L	-	-	NC	-	-	-	-	-	-
Dibenz(a,h)anthracene	NS	NS	NS	NS	0.00026 ^h	NS	NS	NS	NS	mg/L	-	-	NC	-	-	-	-	-	-
Fluoranthene	NS	NS	NS	NS	0.00004	NS	NS	NS	NS	mg/L	-	-	NC	-	-	-	-	-	-
Indeno(1,2,3-c,d)pyrene	NS	NS	NS	NS	0.00021 ^h	NS	NS	NS	NS	mg/L	-	-	NC	-	-	-	-	-	-
Methylnaphthalene, 1-	NS	NS	NS	NS	0.18	NS	NS	NS	NS	mg/L	-	-	NC	-	-	-	-	-	-
Methylnaphthalene, 2-	NS	NS	NS	NS	0.18	NS	NS	NS	NS	mg/L	-	-	NC	-	-	-	-	-	-
Pyrene	NS	NS	NS	NS	0.000025	NS	NS	NS	NS	mg/L	-	-	NC	-	-	-	-	-	-
Quinoline	NS	NS	NS	NS	0.0034	NS	NS	NS	NS	mg/L	-	-	NC	-	-	-	-	-	-
Phenols and PHC													NC						
Phenols (Phenolics)	NS	NS	NS	NS	0.002	NS	0.002	NS	0.002	mg/L	-	-	NC	-	-	-	-	-	-
Benzene	0.005	NS	0.005	NS	0.088	NS	NS	NS	NS	mg/L	-	-	NC	-	-	-	-	-	-
Toluene	0.06	0.024	NS	≤ 0.024	0.083	NS	0.024	NS	0.024	mg/L	-	-	NC	-	-	-	-	-	-
Ethylbenzene	0.14	0.0016	NS	≤ 0.024	3.2	NS	0.024	NS	0.024	mg/L	-	-	NC	-	-	-	-	-	-
Xylene, O-	NS	NS	NS	NS	NS	NS	NS	NS	NS	mg/L	-	-	NC	-	-	-	-	-	-
Xylene, p+m-	NS	NS	NS	NS	NS	NS	NS	NS	NS	mg/L	-	-	NC	-	-	-	-	-	-
Xylenes, Total	0.09	0.02	NS	≤ 0.3	3.9	NS	NS	NS	NS	mg/L	-	-	NC	-	-	-	-	-	-
PHC F1 (C6-C10 range)	NS	NS	NS	NS	0.81 ^h	NS	NS	NS	NS	mg/L	-	-		-	-	-	-	-	-
PHC F1 (C6-C10) minus BTEX	NS	NS	NS	NS	NS	NS	NS	NS	NS	mg/L	-	-		-	-	-	-	-	-
PHC F2 (>C10-C16)	NS	NS	NS	NS	1300 ^h	NS	NS	NS	NS	µg/L	-	-		-	-	-	-	-	-
PHC F2 (>C10-C16) minus Naphthalene (	NS	NS	NS	NS	NS	NS	NS	NS	NS	mg/L	-	-		-	-	-	-	-	-
PHC F3 (>C16-C34 range)	NS	NS	NS	NS	NS	NS	NS	NS	NS	µg/L	-	-		-	-	-	-	-	-
PHC F3 (>C16-C34) minus PAH	NS	NS	NS	NS	NS	NS	NS	NS	NS	mg/L	-	-		-	-	-	-	-	-
PHC (>C6-C50)	NS	NS	NS	NS	NS	NS	NS	NS	NS	mg/L	-	-		-	-	-	-	-	-
PHC F4 (>C34-C50 range)	NS	NS	NS	NS	NS	NS	NS	NS	NS	µg/L	-	-		-	-	-	-	-	-
Chromatogram to baseline at nC50										N/A	-	-		-	-	-	-	-	-

Notes:

CDWQ MAC: Canadian Drinking Water Quality Maximum Acceptable Concentration Guidelines (Updated in February 2024 version)

CDWQ Other: Canadian Drinking Water Quality (CDWQ) Aesthetic Objective (AO) (Updated in February 2024 Version)

CCME Irrigation: Canadian Council of Ministers of the Environment Water Quality Guidelines for the Protection of Agricultural Water - Irrigation Water Use

CCME Livestock: Canadian Council of Ministers of the Environment Water Quality Guidelines for the Protection of Agricultural Water - Livestock Water Use

FIGQG Agricultural: Federal Interim Groundwater Quality Guidelines - Groundwater Quality Guidelines for Federal Contaminated Sites - Agricultural Land Use - Tables 1.1-1.7 (coarse grain size)

MWQSOG MAC: Manitoba Water Quality Standards, Objectives, and Guidelines (Tier III) - Protection of Drinking Water Use - Maximum Acceptable Concentration

MWQSOG AO: Manitoba Water Quality Standards, Objectives, and Guidelines (Tier III) - Protection of Drinking Water Use - Aesthetic Objectives

MWQSOG Irrigation: Manitoba Water Quality Standards, Objectives, and Guidelines (Tier III) - Protection of Irrigation Water Use

MWQSOG Livestock: Manitoba Water Quality Standards, Objectives, and Guidelines (Tier III) - Protection of Livestock Water Use

a Applicable guideline varies depending on the water filtration method.

b Applicable guideline varies depending on the type of crop irrigated.

c The concentration should not exceed 10 µg/L for continuous use on all soils, or 50 µg/L for short-term use on acidic soils.

d Applicable guideline is 20 µg/L for continuous use on all soils, 50 µg/L for intermittent use on all soils.

e Applicable guideline is pH dependant.

f Applicable guideline is dependant on the type of livestock.

g The maximum concentration in livestock drinking water should not exceed 2000 µg/L, or 1000 µg/L in cases where the feed of animals contains fluoride.

h Applicable guideline varies with soil grain size.

i Additions should not change the thermal stratification or the maximum weekly average temperature of the aquatic receiving body. Thermal additions to receiving waters should be such that the short-term exposure to maximum temperatures are not exceeded.

j Applicable guideline dependant on species and life stage.

k Applicable guideline dependant on background levels of the aquatic receiving water body.

l Applicable guideline varies with water hardness. The guideline was calculated based on the range of hardness values observed in the samples.

m The Cr guideline varies with speciation. Cr(III) guideline is applied as Cr(III) is dominate speceis under natural conditlions

nApplicable manganese long-term guideline is calculated using the CWQG calculator (Provided in Appendix B, CCME). Applicable manganese short-term guideline is calculated using the Benchmark calculator (Provided in Appendix B, CCME).

oApplicable guideline based on trigger range for nutrients in aquatic systems.

p Applicable guideline calculated based on pH, hardness and dissolved organic carbon. The minimum and maximum guidelines for the site are shown.

qApplicable guideline varies with temperature and pH according to a look up table. The minimum and maximum guidelines for the site are shown.

r Applicable guideline temperature, and/or pH dependant using various equations according to conditions within the aquatic receiving body. The minimum and maximum guidelines for the site are shown.

s Guideline is a surface water objective.

t Seven (7) day averaging duration.

u Applicable guideline dependant on background suspended sediment concentrations.

h The Cr guideline varies with speciation. Cr(III) guideline is applied as Cr(III) is dominate species under natural conditions

<:Denotes concentration less than indicated detection limit

- :Not analyzed

NC: Not Calculated (Results <5x laboratory detection limit)

NS: No Guideline

BOLD Reportable Detection Limit (RDL) exceeds the regulatory guideline

Alert Exceeds at least one (Federal or Manitoba) applicable guideline for protection of drinking water (MAC or AO)

Orange Exceeds at least one (Federal or Manitoba) applicable guideline for protection of agriculture/irrigation

Green Exceeds at least one (Federal or Manitoba) applicable guideline for protection of livestock

Blue Exceeds at least two types of applicable guidelines for all applicable pathways

Grey RPD values above alert limit of 30%

SiMBA Project
Hydrogeology and Geochemistry Assessment Report



Table 4-8. Groundwater Quality Results - Discharge to Surface Water

Sample ID						BRU 95-5	BRU 95-5	BRU 95-6	BRU 95-6	BRU 95-7 (S1)	BRU 95-7 (S4)	BRU 95-7	BRU 95-9	BRU 95-9	BRU 95-9
Pre/Post Pump Test						Pre-test	Post-test	Pre-test	Post-test	Pre-test	Mid-test	Post-test	Pre-test	Post-test	NA
Lithology						Red River Carbonate	Carbonate	Red River Carbonate	Red River Carbonate	Red River Carbonate	Red River Carbonate	Red River Carbonate	Winnipeg Shale	Winnipeg Shale	Winnipeg Shale
Sample Date						2020-Nov-15	2020-Dec-02	2020-Nov-15	2020-Dec-02	2020-Nov-25	2020-Nov-29	2020-Dec-01	2020-Nov-24	2020-Dec-02	2021-Feb-04
Lab Sample ID						L2530033-1	L2536193-4	L2530033-2	L2536193-2	L2533700-2	L2535510-2	L2535510-1	L2533700-1	L2536193-3	L2554881-1
Lab Job Number						L2530033	L2536193	L2530033	L2536193	L2533700	L2535510	L2535510	L2533700	L2536193	L2554881
Parameter	CCME FAL Acute	CCME FAL Chronic	MWQSOG FAL Acute	MWQSOG FAL Chronic	Units										
Field Parameters															
Temperature, Field	NS	NS	NS	NS	°C	4.2	4.4	4.7	4.8	6.2	5.6	5.6	5.1	4.4	5.34
pH, Field	6.5-9	6.5-9	NS	NS	-	7.54	7.73	7.72	8.50	7.84	7.89	7.97	7.56	8.04	7.75
pH, Lab	6.5-9	6.5-9	NS	NS	pH units	8.33	8.16	8.35	8.12	8.11	-	8.36	8.09	8.35	8.11
Specific Conductivity, Lab	NS	NS	NS	NS	µS/cm	543	535	497	518	428	-	453	471	617	515
Specific Conductivity, Field	NS	NS	NS	NS	µS/cm	535	525	483	594	439.8	443.2	444.2	482.1	502	322
Conductivity, Field	NS	NS	NS	NS	µS/cm	323	319	298	365	282	279	279	299	304	515
Salinity	NS	NS	NS	NS	ppt	0.26	0.25	0.23	0.29	0.21	0.21	0.21	0.23	0.24	-
Dissolved Oxygen, Field	NS	NS	NS	NS	%L	-	43.3	-	2.1	47.2	43.3	74.8	1.7	8.4	-
Dissolved Oxygen ^b , Field	NS	NS	NS	NS	mg/L	3.95	5.48	3.1	0.27	5.60	5.33	9.09	0.21	1.06	0.28
ORP	NS	NS	NS	NS	mV	-62	60.7	10.0	23.0	-31.3	-61.3	-49.1	-76.1	94.3	115.0
Turbidity, Field	Variable ^d	Variable ^d	Variable ^d	Variable ^d	NTU	42	21.05	31	-	8.35	0.33	24.74	-	-	-
Turbidity, Lab	Variable ^d	Variable ^d	Variable ^d	Variable ^d	NTU	-	-	-	-	6.50	-	-	1240	-	171
Total Dissolved Solids (Lab)	NS	NS	NS	NS	mg/L	277	258	264	292	239	-	245	269	489	302
Total Suspended Solids	Variable ^c	Variable ^c	NS	NS	mg/L	4.2	11.1	69.6	403	5.7	-	< 3	1150	9450	186
General Parameters and Anions															
Hardness (as CaCO3)	NS	NS	NS	NS	mg/L	268	265	238	247	196	-	197	211	133	204
Alkalinity, Total (As CaCO3)	NS	NS	NS	NS	mg/L	302	299	273	302	246	-	244	276	1010	285
Hydroxide (OH)	NS	NS	NS	NS	mg/L	< 0.34	< 0.34	< 0.34	< 0.34	< 0.34	-	< 0.34	< 0.34	< 0.34	<0.340
Bicarbonate (as CaCO3)	NS	NS	NS	NS	mg/L	358	365	322	369	300	-	287	337	1230	348
Biochemical Oxygen Demand	NS	NS	NS	NS	mg/L	-	-	-	-	< 2	-	11.3	< 6	-	9.3
Carbonate (as CaCO3)	NS	NS	NS	NS	mg/L	4.92	< 0.6	5.16	< 0.6	< 0.6	-	5.28	< 0.6	5.52	<0.6
Chemical Oxygen Demand	NS	NS	NS	NS	mg/L	-	-	-	-	< 20	-	< 20	38	-	40
Dissolved Organic Carbon (DOC)	NS	NS	NS	NS	mg/L	1.74	2.01	0.87	2.12	1.55	-	1.58	1.75	16.9	7.03
Fluoride	0.12	0.12	NS	NS	mg/L	0.325	0.331	0.383	0.382	0.406	0.416	0.411	0.302	0.481	0.397
Ammonia-N	0.14 -12.6 ^h	0.14 -12.6 ^h	0.854 - 23.98 ^{g,h}	0.79 - 9.60 ^{f,h}	mg/L	0.41	0.202	0.415	0.389	0.498	-	0.59	0.446	0.81	0.318
Nitrate plus Nitrite (N)	NS	NS	10	10	mg/L	< 0.07	< 0.0051	< 0.07	< 0.0051	< 0.0051	-	< 0.0051	< 0.0051	< 0.0051	0.0083
Nitrate (as N)	124	3	NS	NS	mg/L	< 0.02	< 0.005	< 0.02	< 0.005	< 0.005	< 0.02	< 0.005	< 0.005	< 0.005	0.0069
Nitrite (as N)	0.06	0.06	NS	NS	mg/L	< 0.01	< 0.001	< 0.01	< 0.001	< 0.001	< 0.01	< 0.001	< 0.001	< 0.001	0.0013
Chloride	640	120	NS	NS	mg/L	1.78	1.01	1.48	1.63	1.04	1.32	1.52	1.87	37.4	7.03
Sulphide	NS	NS	NS	NS	mg/L	< 0.018	0.078	< 0.018	< 0.018	0.023	-	0.02	< 0.18	< 1.8	<0.018
Sulphide (as H2S)	NS	NS	NS	NS	mg/L	< 0.019	0.083	< 0.019	< 0.019	0.024	-	0.021	< 0.19	< 1.9	<0.019
Sulphate	NS	NS	NS	NS	mg/L	4.6	3.22	6.92	8.01	5.23	5.69	5.83	6.84	37.2	10.9
Dissolved Metals															
Aluminum	0.005-0.1 ^a	0.005-0.1 ^a	NS	NS	mg/L	< 0.001	< 0.001	0.0032	0.0029	< 0.001	< 0.001	< 0.001	0.0012	0.006	0.003
Antimony	NS	NS	NS	NS	mg/L	< 0.0001	< 0.0001	< 0.0001	0.00015	< 0.0001	< 0.0001	< 0.0001	< 0.0001	0.00065	0.00048
Arsenic	0.005	0.005	0.34	0.15	mg/L	0.00155	0.00153	0.00052	0.00056	0.00031	< 0.0001	< 0.0001	0.00088	0.00179	0.00128
Barium	NS	NS	NS	NS	mg/L	0.11	0.11	0.0835	0.0898	0.0951	0.0952	0.0968	0.0567	0.054	0.049
Beryllium	NS	NS	NS	NS	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	<0.00010
Bismuth	NS	NS	NS	NS	mg/L	< 0.00005	< 0.00005	< 0.00005	< 0.00005	< 0.00005	< 0.00005	< 0.00005	< 0.00005	< 0.00005	<0.000050
Boron	29	1.5	NS	NS	mg/L	0.156	0.155	0.234	0.339	0.214	0.202	0.212	0.334	0.299	0.346
Cadmium	0.0023-0.0057 ^e	0.00017-0.00036 ^e	0.00221 - 0.0058 ^e	0.00026 - 0.00051 ^e	mg/L	< 0.000005	< 0.000005	< 0.000005	< 0.000005	< 0.000005	< 0.000005	< 0.000005	< 0.000005	< 0.000005	0.0000847
Calcium	NS	NS	NS	NS	mg/L	50.7	48.5	45.1	45.1	36.4	36.7	35.2	43.1	22.1	39.7
Cesium	NS	NS	NS	NS	mg/L	< 0.00001	< 0.00001	0.000018	0.000059	0.000014	< 0.00001	< 0.00001	0.000011	0.000089	0.000102
Chromium ⁱ	0.0089	0.0089	0.616-1.347 ^e	0.08-0.175 ^e	mg/L	< 0.0001	< 0.0001	< 0.0001	0.0002	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	<0.00010
Cobalt	NS	NS	NS	NS	mg/L	< 0.0001	< 0.0001	0.00072	0.0007	0.0004	< 0.0001	< 0.0001	< 0.0001	0.0007	0.00034
Copper	0.00257 - 0.004 ^e	0.00257 - 0.004 ^e	0.0147 - 0.0362 ^e	0.00972 - 0.022 ^e	mg/L	< 0.0002	0.0007	< 0.0002	0.00028	< 0.0002	< 0.0002	< 0.0002	< 0.0002	0.0007	0.00052
Iron	0.3	0.3	NS	NS	mg/L	0.609	0.845	0.054	< 0.01	0.198	< 0.01	0.474	0.623	< 0.01	<0.010
Lead	0.00359-0.007	0.00359-0.007	0.072 - 0.198 ^e	0.0028 - 0.0077 ^e	mg/L	< 0.00005	< 0.00005	< 0.00005	< 0.00005	< 0.00005	< 0.00005	< 0.00005	< 0.00005	< 0.00005	0.000168
Lithium	NS	NS	NS	NS	mg/L	0.0161	0.0164	0.0159	0.0166	0.018	0.0194	0.0189	0.0221	0.0334	0.0265
Magnesium	NS	NS	NS	NS	mg/L	34.4	35	30.4	32.8	25.5	26.5	26.4	25.2	19	25.5
Manganese	7.24 - 14.88 ^j	0.12 - 0.64 ^j	NS	NS	mg/L	0.00903	0.00932	0.0279	0.0454	0.0256	0.017	0.0168	0.0146	0.00464	0.00538
Mercury	0.000026	0.000026	NS	NS	mg/L	< 0.000005	< 0.000005	< 0.000005	< 0.000005	< 0.000005	-	< 0.000005	< 0.000005	< 0.000005	<0.0000050
Molybdenum	0.073	0.073	NS	NS	mg/L	0.00215	0.00146	0.00205	0.00392	0.00224	0.00195	0.00193	0.00154	0.0344	0.00693
Nickel	0.103 - 0.150	0.103 - 0.150	0.508 - 1.14 ^e	0.056 - 0.127 ^e	mg/L	< 0.0005	< 0.0005	< 0.0005	0.00087	< 0.0005	< 0.0005	< 0.0005	< 0.0005	0.00158	0.00114
Phosphorus (Dissolved)	NS	NS	NS	NS	mg/L	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.030	0.033	< 0.03	< 0.03	<0.030
Phosphorus (Total)	NS	NS	NS	NS	mg/L	0.0156	0.0108	0.088	0.206	0.0281	-	0.0321	0.852	9.6	-
Potassium	NS	NS	NS	NS	mg/L	4.33	4.71	4.88	5.66	4.39	4.74	4.57	7.58	32.1	16.4
Rubidium	NS	NS	NS	NS	mg/L	0.00223	0.00255	0.00293	0.00569	0.00182	0.00168	0.00164	0.00473	0.0332	0.0249
Selenium	0.001	0.001	NS	NS	mg/L	< 0.00005	< 0.00005	< 0.00005	0.000066	< 0.00005	< 0.00005	< 0.00005	< 0.00005	0.000912	0.000096
Silicon	NS	NS	NS	NS	mg/L	7.9	7.46	6.71	7.11	7.46	7.15	7.19	5.19	5.13	5.5
Silver	NS	0.00025	NS	NS	mg/L	< 0.00001	< 0.00001	< 0.00001	< 0.00001	< 0.00001	< 0.00001	< 0.00001	< 0.00001	< 0.00001	<0.000010
Sodium	NS	NS	NS	NS	mg/L	14.2	14.7	17	18.6	19.4	22.8	25.5	19.1	72.7	31.3
Strontium	NS	NS	NS	NS	mg/L	0.325	0.318	0.321	0.334	0.258	0.254	0.246	0.304	0.208	0.336
Sulfur, elemental	NS	NS	NS	NS	mg/L	1.35	1.29	2.2	3.11	1.88	2.07	2.29	2.42	14.3	4.1
Tellurium	NS	NS	NS	NS	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	<0.00020
Thallium	0.0008	0.0008	NS	NS	mg/L	< 0.00001	< 0.00001	< 0.00001	< 0.00001	< 0.00001	< 0.00001	< 0.00001	< 0.00001	0.000035	<0.000010
Thorium	NS	NS	NS	NS	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	<0.00010

Sample ID						BRU 95-5	BRU 95-5	BRU 95-6	BRU 95-6	BRU 95-7 (S1)	BRU 95-7 (S4)	BRU 95-7	BRU 95-9	BRU 95-9	BRU 95-9
Pre/Post Pump Test						Pre-test	Post-test	Pre-test	Post-test	Pre-test	Mid-test	Post-test	Pre-test	Post-test	NA
Lithology						Red River Carbonate	Carbonate	Red River Carbonate	Red River Carbonate	Red River Carbonate	Red River Carbonate	Red River Carbonate	Winnipeg Shale	Winnipeg Shale	Winnipeg Shale
Sample Date						2020-Nov-15	2020-Dec-02	2020-Nov-15	2020-Dec-02	2020-Nov-25	2020-Nov-29	2020-Dec-01	2020-Nov-24	2020-Dec-02	2021-Feb-04
Lab Sample ID						L2530033-1	L2536193-4	L2530033-2	L2536193-2	L2533700-2	L2535510-2	L2535510-1	L2533700-1	L2536193-3	L2554881-1
Lab Job Number						L2530033	L2536193	L2530033	L2536193	L2533700	L2535510	L2535510	L2533700	L2536193	L2554881
Parameter	CCME FAL Acute	CCME FAL Chronic	MWQSOG FAL Acute	MWQSOG FAL Chronic	Units										
Tin	NS	NS	NS	NS	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	0.00021
Titanium	NS	NS	NS	NS	mg/L	< 0.0003	< 0.0003	< 0.0003	< 0.0003	< 0.0003	< 0.0003	< 0.0003	< 0.0003	< 0.0003	<0.00030
Tungsten	NS	NS	NS	NS	mg/L	< 0.0001	< 0.0001	0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	0.00293	0.00053
Uranium	0.033	0.015	NS	NS	mg/L	0.0001	0.000058	0.000308	0.000208	0.000083	0.000028	0.00003	0.000062	0.00121	0.000542
Vanadium	NS	NS	NS	NS	mg/L	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	0.00103	<0.00050
Zinc	0.075 - 0.209 ^k	0.007 - 0.036 ^k	0.127 - 0.286 ^e	0.128 - 0.288 ^e	mg/L	< 0.001	0.0023	0.009	0.0197	0.0106	0.0013	0.0034	< 0.001	< 0.001	0.0044
Zirconium	NS	NS	NS	NS	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	<0.00020
PAHs															
Acenaphthene	0.0058	0.0058	NS	NS	mg/L	-	-	-	-	< 0.00002	-	< 0.00002	-	-	-
Acenaphthylene	NS	NS	NS	NS	mg/L	-	-	-	-	< 0.00002	-	< 0.00002	-	-	-
Acridine	0.0044	0.0044	NS	NS	mg/L	-	-	-	-	< 0.00002	-	< 0.00002	-	-	-
Anthracene	0.000012	0.000012	NS	NS	mg/L	-	-	-	-	< 0.00001	-	< 0.00001	-	-	-
Fluorene	0.003	0.003	NS	NS	mg/L	-	-	-	-	< 0.00002	-	< 0.00002	-	-	-
Naphthalene	0.0011	0.0011	NS	NS	mg/L	-	-	-	-	< 0.00005	-	< 0.00005	-	-	-
Phenanthrene	0.0004	0.0004	NS	NS	mg/L	-	-	-	-	< 0.00005	-	< 0.00005	-	-	-
Benz(a)anthracene	0.000018	0.000018	NS	NS	mg/L	-	-	-	-	< 0.00001	-	< 0.00001	-	-	-
Benzo(a)pyrene	0.000015	0.000015	NS	NS	mg/L	-	-	-	-	< 0.000005	-	< 0.000005	-	-	-
Benzo(b+j)fluoranthene	NS	NS	NS	NS	mg/L	-	-	-	-	< 0.00001	-	< 0.00001	-	-	-
Benzo(g,h,i)perylene	NS	NS	NS	NS	mg/L	-	-	-	-	< 0.00002	-	< 0.00002	-	-	-
Benzo(k)fluoranthene	NS	NS	NS	NS	mg/L	-	-	-	-	< 0.00001	-	< 0.00001	-	-	-
Chrysene	NS	NS	NS	NS	mg/L	-	-	-	-	< 0.00002	-	< 0.00002	-	-	-
Dibenz(a,h)anthracene	NS	NS	NS	NS	mg/L	-	-	-	-	< 0.000005	-	< 0.000005	-	-	-
Fluoranthene	0.00004	0.00004	NS	NS	mg/L	-	-	-	-	< 0.00002	-	< 0.00002	-	-	-
Indeno(1,2,3-c,d)pyrene	NS	NS	NS	NS	mg/L	-	-	-	-	< 0.00001	-	< 0.00001	-	-	-
Methylnaphthalene, 1-	NS	NS	NS	NS	mg/L	-	-	-	-	< 0.00002	-	< 0.00002	-	-	-
Methylnaphthalene, 2-	NS	NS	NS	NS	mg/L	-	-	-	-	< 0.00002	-	< 0.00002	-	-	-
Pyrene	0.000025	0.000025	NS	NS	mg/L	-	-	-	-	< 0.00001	-	< 0.00001	-	-	-
Quinoline	0.0034	0.0034	NS	NS	mg/L	-	-	-	-	< 0.00002	-	< 0.00002	-	-	-
Phenols and PHC															
Phenols (Phenolics)	0.004	0.004	NS	NS	mg/L	-	-	-	-	< 0.001	-	< 0.001	< 0.001	-	-
Benzene	0.37	0.37	NS	NS	mg/L	-	-	-	-	< 0.0005	-	< 0.0005	-	-	-
Toluene	0.002	0.002	NS	NS	mg/L	-	-	-	-	< 0.001	-	< 0.001	-	-	-
Ethylbenzene	0.09	0.09	NS	NS	mg/L	-	-	-	-	< 0.0005	-	< 0.0005	-	-	-
Xylene, O-	NS	NS	NS	NS	mg/L	-	-	-	-	< 0.0005	-	< 0.0005	-	-	-
Xylene, p+m-	NS	NS	NS	NS	mg/L	-	-	-	-	< 0.0004	-	< 0.0004	-	-	-
Xylenes, Total	NS	NS	NS	NS	mg/L	-	-	-	-	< 0.00064	-	< 0.00064	-	-	-

Notes:

CCME FAL: Guidelines to protect freshwater aquatic life

Chronic: Guidelines to protect freshwater aquatic life, (30-day average guidelines)

Acute: Guidelines to protect freshwater aquatic life, (Maximum allowable concentration [MAC] guidelines)

MWQSOG FAL: Manitoba Water Quality Standards, Objectives, and Guidelines (Tier II) - Protection of Aquatic Life and Wildlife

Chronic: Guidelines to protect freshwater aquatic life, (30-day or 4-day average guidelines)

Acute: Guidelines to protect freshwater aquatic life, (one-hour Maximum guidelines)

When the value of the acute and chronic guidelines are equal, exceedances are denoted as exceeding for acute exposure

^a Applicable guideline is pH dependant.

^b DO guideline is depedent on life stage, which are not applicable to the Site

^c Applicable guideline dependant on background levels of the aquatic receiving water body.

^d Applicable guideline varies with"change from background" and flow condition dependent. No background station was established for this site.

^e Applicable guideline varies with water hardness (110-286 mg/L). The guideline was calculated based on the range of hardness values observed in the samples.

^f Equation 4 and 10 (cool and cold water, early life stages are absent) are applied (mwqsog_2011_calculations)

^g Equation 5 and 11 (cool and Cold water, early life stages are absent) are applied (mwqsog_2011_calculations)

^h Applicable guideline varies with temperature and pH. The guideline is calculated based on field pH range (i.e, 7.0 - 9.0) and field annual average temperature of 5°C;

ⁱ The Cr guideline varies with speciation. Cr(III) guideline is applied as Cr(III) is dominate species under natural conditions

^j Applicable manganese long-term guideline is calculated using the CWQG calculator (Provided in Appendix B, CCME). Applicable manganese short-term guideline is calculated using the Benchmark calculator (Provided in Appendix B, CCME).

^k Applicable guideline calculated based on pH, hardness and dissolved organic carbon.

< :Denotes concentration less than indicated detection limit

-:Not analyzed

NS: No Standard

Exceeds CCME FAL Chronic

Exceeds CCME FAL Acute

Exceeds MWQOG Chronic

Exceeds MWQOG Acute

Exceeds duplicate RPD limit

SiMBA Project
Hydrogeology and Geochemistry Assessment Report



Table 4-8. Groundwater Quality Results - Discharge to Surface Water

Sample ID						BRU-96-1	BRU 96-1	BRU 96-2	BRU 96-2 (DUP)	RPD	BRU 96-2	Unknown	Unknown	Well 66124	Well 23901	Well 23901
Pre/Post Pump Test						Pre-test	Post-test	Pre-test	Pre-test		Post-test	Pre-test	Post-test	Pre-test	Pre-test	Post-test
Lithology						Winnipeg Sandstone	Winnipeg Sandstone	Red River Carbonate	Red River Carbonate		Red River Carbonate	Winnipeg Sandstone	Winnipeg Sandstone	Winnipeg Shale	Red River Carbonate	Red River Carbonate
Sample Date						2020-Nov-13	2020-Dec-02	2020-Nov-14	2020-Nov-14		2020-Dec-02	2020-Nov-15	2020-Dec-02	2020-Nov-15	2020-Nov-18	2020-Dec-02
Lab Sample ID						L2530033-3	L2536193-5	L2530033-4	L2530033-5		L2536193-7	L2530033-7	L2536193-1	L2530033-6	L2532264-1	L2536193-6
Lab Job Number						L2530033	L2536193	L2530033	L2530033		L2536193	L2530033	L2536193	L2530033	L2532264	L2536193
Parameter	CCME FAL Acute	CCME FAL Chronic	MWQSOG FAL Acute	MWQSOG FAL Chronic	Units											
Field Parameters																
Temperature, Field	NS	NS	NS	NS	°C	5.2	5.5	5.2	5.2	0	5.5	6.5	-	10.1	6.2	-
pH, Field	6.5-9	6.5-9	NS	NS	-	8.01	9.44	7.91	7.91	0	7.91	7.64	-	8.13	8.03	-
pH, Lab	6.5-9	6.5-9	NS	NS	pH units	8.44	8.49	8.39	8.38	0	8.18	8.27	8.18	8.46	8.48	8.13
Specific Conductivity, Lab	NS	NS	NS	NS	µS/cm	594	589	395	396	0	421	510	515	578	536	546
Specific Conductivity, Field	NS	NS	NS	NS	µS/cm	581	569	383	383	0	415.5	511	-	562	541	-
Conductivity, Field	NS	NS	NS	NS	µS/cm	361	357	238	238	0	261	330	-	402	347	-
Salinity	NS	NS	NS	NS	ppt	-	0.28	-	-	NC	0.20	0.25	-	0.27	0.26	-
Dissolved Oxygen, Field	NS	NS	NS	NS	%L	-	4.0	-	-	NC	3.1	62.4	-	68.6	59.1	-
Dissolved Oxygen ^b , Field	NS	NS	NS	NS	mg/L	5.6	0.49	3.6	3.6	0	0.39	7.36	-	7.39	7.01	-
ORP	NS	NS	NS	NS	mV	63	91.4	-93	-93	0	4.5	-46.2	-	60.2	70.0	-
Turbidity, Field	Variable ^d	Variable ^d	Variable ^d	Variable ^d	NTU	105	-	25	25	0	29.83	1.14	-	-0.10	0.33	-
Turbidity, Lab	Variable ^d	Variable ^d	Variable ^d	Variable ^d	NTU	-	-	-	-	-	-	-	-	-	0.26	-
Total Dissolved Solids (Lab)	NS	NS	NS	NS	mg/L	358	340	224	229	2	217	259	247	337	319	313
Total Suspended Solids	Variable ^c	Variable ^c	NS	NS	mg/L	117	78.7	36.8	88.4	82	31.5	< 3	< 3	< 3	< 3	< 3
General Parameters and Anions																
Hardness (as CaCO3)	NS	NS	NS	NS	mg/L	116	110	112	113	1	125	247	249	0.99	0.51	0.42
Alkalinity, Total (As CaCO3)	NS	NS	NS	NS	mg/L	260	271	197	199	1	212	284	283	309	284	290
Hydroxide (OH)	NS	NS	NS	NS	mg/L	< 0.34	< 0.34	< 0.34	< 0.34	NC	< 0.34	< 0.34	< 0.34	< 0.34	< 0.34	< 0.34
Bicarbonate (as CaCO3)	NS	NS	NS	NS	mg/L	304	313	231	233	1	258	346	346	362	330	353
Biochemical Oxygen Demand	NS	NS	NS	NS	mg/L	-	-	-	-	NC	-	-	-	-	-	-
Carbonate (as CaCO3)	NS	NS	NS	NS	mg/L	6.72	9	4.68	4.44	5	< 0.6	< 0.6	< 0.6	7.08	8.04	< 0.6
Chemical Oxygen Demand	NS	NS	NS	NS	mg/L	-	-	-	-	NC	-	-	-	-	< 20	-
Dissolved Organic Carbon (DOC)	NS	NS	NS	NS	mg/L	0.5	1.66	1.45	1.46	1	3.65	2.89	2.06	1.66	1.99	1.87
Fluoride	0.12	0.12	NS	NS	mg/L	0.882	0.876	0.549	0.544	1	0.499	0.358	0.35	0.343	0.286	0.276
Ammonia-N	0.14 -12.6 ^h	0.14 -12.6 ^h	0.854 - 23.98 ^{g,h}	0.79 - 9.60 ^{f,h}	mg/L	0.415	0.38	0.322	0.305	5	0.288	0.418	0.429	0.011	0.043	0.018
Nitrate plus Nitrite (N)	NS	NS	10	10	mg/L	< 0.07	< 0.0051	< 0.07	< 0.07	NC	< 0.0051	< 0.07	< 0.0051	< 0.07	< 0.0051	< 0.0051
Nitrate (as N)	124	3	NS	NS	mg/L	< 0.02	< 0.005	< 0.02	< 0.02	NC	< 0.005	< 0.02	< 0.005	< 0.02	< 0.005	< 0.005
Nitrite (as N)	0.06	0.06	NS	NS	mg/L	< 0.01	< 0.001	< 0.01	< 0.01	NC	< 0.001	< 0.01	< 0.001	< 0.01	< 0.001	< 0.001
Chloride	640	120	NS	NS	mg/L	22.9	22.4	2.56	2.57	0	2.76	1.04	1.03	2.7	2.87	2.94
Sulphide	NS	NS	NS	NS	mg/L	< 0.018	< 0.018	< 0.018	< 0.018	NC	< 0.018	< 0.018	0.021	< 0.018	0.024	0.03
Sulphide (as H2S)	NS	NS	NS	NS	mg/L	< 0.019	< 0.019	< 0.019	< 0.019	NC	< 0.019	< 0.019	0.022	< 0.019	0.026	0.032
Sulphate	NS	NS	NS	NS	mg/L	33.5	32.1	14.4	14.5	1	13.4	4.14	3.81	5.68	9.07	8.37
Dissolved Metals																
Aluminum	0.005-0.1 ^a	0.005-0.1 ^a	NS	NS	mg/L	0.0085	0.0027	0.0025	0.0011	NC	0.0025	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Antimony	NS	NS	NS	NS	mg/L	< 0.0001	0.00033	< 0.0001	< 0.0001	NC	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Arsenic	0.005	0.005	0.34	0.15	mg/L	0.00036	0.00063	0.00018	0.00018	0	0.00027	0.00168	0.00149	0.00046	0.00070	0.00061
Barium	NS	NS	NS	NS	mg/L	0.0473	0.0426	0.0564	0.0564	0	0.0556	0.1	0.105	0.00125	0.00024	0.00019
Beryllium	NS	NS	NS	NS	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001	NC	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Bismuth	NS	NS	NS	NS	mg/L	< 0.00005	< 0.00005	< 0.00005	< 0.00005	NC	< 0.00005	< 0.00005	< 0.00005	< 0.00005	< 0.00005	< 0.00005
Boron	29	1.5	NS	NS	mg/L	0.692	0.605	0.302	0.28	8	0.266	0.196	0.18	0.147	0.142	0.097
Cadmium	0.0023-0.0057 ^e	0.00017-0.00036 ^e	0.00221 - 0.0058 ^e	0.00026 - 0.00051 ^e	mg/L	< 0.000005	< 0.000005	< 0.000005	< 0.000005	NC	< 0.000005	< 0.000005	< 0.000005	< 0.000005	< 0.000005	< 0.000005
Calcium	NS	NS	NS	NS	mg/L	26.4	22.9	24.7	24.5	1	27.1	44.6	43.5	0.206	0.118	0.102
Cesium	NS	NS	NS	NS	mg/L	0.000012	0.000056	< 0.00001	< 0.00001	NC	< 0.00001	< 0.00001	< 0.00001	< 0.00001	< 0.00001	< 0.00001
Chromium ⁱ	0.0089	0.0089	0.616-1.347 ^e	0.08-0.175 ^e	mg/L	< 0.0001	0.00013	< 0.0001	< 0.0001	NC	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Cobalt	NS	NS	NS	NS	mg/L	0.00025	0.00022	< 0.0001	< 0.0001	NC	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Copper	0.00257 - 0.004 ^e	0.00257 - 0.004 ^e	0.0147 - 0.0362 ^e	0.00972 - 0.022 ^e	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002	NC	< 0.0002	< 0.0002	< 0.0002	0.0241	0.00035	0.0005
Iron	0.3	0.3	NS	NS	mg/L	< 0.01	< 0.01	0.259	0.24	8	0.199	0.864	0.016	0.015	< 0.01	< 0.01
Lead	0.00359-0.007	0.00359-0.007	0.072 - 0.198 ^e	0.0028 - 0.0077 ^e	mg/L	< 0.00005	< 0.00005	< 0.00005	< 0.00005	NC	< 0.00005	< 0.00005	< 0.00005	0.000177	< 0.00005	< 0.00005
Lithium	NS	NS	NS	NS	mg/L	0.0314	0.0336	0.0114	0.0109							

Sample ID						BRU-96-1	BRU 96-1	BRU 96-2	BRU 96-2 (DUP)	RPD	BRU 96-2	Unknown	Unknown	Well 66124	Well 23901	Well 23901
Pre/Post Pump Test						Pre-test	Post-test	Pre-test	Pre-test		Post-test	Pre-test	Post-test	Pre-test	Pre-test	Post-test
Lithology						Winnipeg Sandstone	Winnipeg Sandstone	Red River Carbonate	Red River Carbonate		Red River Carbonate	Winnipeg Sandstone	Winnipeg Sandstone	Winnipeg Shale	Red River Carbonate	Red River Carbonate
Sample Date						2020-Nov-13	2020-Dec-02	2020-Nov-14	2020-Nov-14		2020-Dec-02	2020-Nov-15	2020-Dec-02	2020-Nov-15	2020-Nov-18	2020-Dec-02
Lab Sample ID Lab Job Number						L2530033-3 L2530033	L2536193-5 L2536193	L2530033-4 L2530033	L2530033-5 L2530033		L2536193-7 L2536193	L2530033-7 L2530033	L2536193-1 L2536193	L2530033-6 L2530033	L2532264-1 L2532264	L2536193-6 L2536193
Parameter	CCME FAL Acute	CCME FAL Chronic	MWQSOG FAL Acute	MWQSOG FAL Chronic	Units											
Tin	NS	NS	NS	NS	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001	NC	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Titanium	NS	NS	NS	NS	mg/L	0.00045	< 0.0003	< 0.0003	< 0.0003	NC	< 0.0003	< 0.0003	< 0.0003	< 0.0003	< 0.0003	< 0.0003
Tungsten	NS	NS	NS	NS	mg/L	< 0.0001	0.00043	< 0.0001	< 0.0001	NC	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Uranium	0.033	0.015	NS	NS	mg/L	0.000391	0.000992	0.000069	0.000071	3	0.000135	0.000062	0.000068	0.000019	0.000094	0.000105
Vanadium	NS	NS	NS	NS	mg/L	< 0.0005	< 0.0005	< 0.0005	< 0.0005	NC	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
Zinc	0.075 - 0.209 ^k	0.007 - 0.036 ^k	0.127 - 0.286 ^e	0.128 - 0.288 ^e	mg/L	0.0023	0.0035	< 0.001	< 0.001	NC	0.0011	< 0.001	0.0011	0.0075	< 0.001	0.0014
Zirconium	NS	NS	NS	NS	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002	NC	< 0.0002	< 0.0002	< 0.0002	0.00038	< 0.0002	< 0.0002
PAHs										NC						
Acenaphthene	0.0058	0.0058	NS	NS	mg/L	-	-	-	-	NC	-	-	-	-	-	-
Acenaphthylene	NS	NS	NS	NS	mg/L	-	-	-	-	NC	-	-	-	-	-	-
Acridine	0.0044	0.0044	NS	NS	mg/L	-	-	-	-	NC	-	-	-	-	-	-
Anthracene	0.000012	0.000012	NS	NS	mg/L	-	-	-	-	NC	-	-	-	-	-	-
Fluorene	0.003	0.003	NS	NS	mg/L	-	-	-	-	NC	-	-	-	-	-	-
Naphthalene	0.0011	0.0011	NS	NS	mg/L	-	-	-	-	NC	-	-	-	-	-	-
Phenanthrene	0.0004	0.0004	NS	NS	mg/L	-	-	-	-	NC	-	-	-	-	-	-
Benz(a)anthracene	0.000018	0.000018	NS	NS	mg/L	-	-	-	-	NC	-	-	-	-	-	-
Benzo(a)pyrene	0.000015	0.000015	NS	NS	mg/L	-	-	-	-	NC	-	-	-	-	-	-
Benzo(b+j)fluoranthene	NS	NS	NS	NS	mg/L	-	-	-	-	NC	-	-	-	-	-	-
Benzo(g,h,i)perylene	NS	NS	NS	NS	mg/L	-	-	-	-	NC	-	-	-	-	-	-
Benzo(k)fluoranthene	NS	NS	NS	NS	mg/L	-	-	-	-	NC	-	-	-	-	-	-
Chrysene	NS	NS	NS	NS	mg/L	-	-	-	-	NC	-	-	-	-	-	-
Dibenz(a,h)anthracene	NS	NS	NS	NS	mg/L	-	-	-	-	NC	-	-	-	-	-	-
Fluoranthene	0.00004	0.00004	NS	NS	mg/L	-	-	-	-	NC	-	-	-	-	-	-
Indeno(1,2,3-c,d)pyrene	NS	NS	NS	NS	mg/L	-	-	-	-	NC	-	-	-	-	-	-
Methylnaphthalene, 1-	NS	NS	NS	NS	mg/L	-	-	-	-	NC	-	-	-	-	-	-
Methylnaphthalene, 2-	NS	NS	NS	NS	mg/L	-	-	-	-	NC	-	-	-	-	-	-
Pyrene	0.000025	0.000025	NS	NS	mg/L	-	-	-	-	NC	-	-	-	-	-	-
Quinoline	0.0034	0.0034	NS	NS	mg/L	-	-	-	-	NC	-	-	-	-	-	-
Phenols and PHC										NC						
Phenols (Phenolics)	0.004	0.004	NS	NS	mg/L	-	-	-	-	NC	-	-	-	-	-	-
Benzene	0.37	0.37	NS	NS	mg/L	-	-	-	-	NC	-	-	-	-	-	-
Toluene	0.002	0.002	NS	NS	mg/L	-	-	-	-	NC	-	-	-	-	-	-
Ethylbenzene	0.09	0.09	NS	NS	mg/L	-	-	-	-	NC	-	-	-	-	-	-
Xylene, O-	NS	NS	NS	NS	mg/L	-	-	-	-	NC	-	-	-	-	-	-
Xylene, p+m-	NS	NS	NS	NS	mg/L	-	-	-	-	NC	-	-	-	-	-	-
Xylenes, Total	NS	NS	NS	NS	mg/L	-	-	-	-	NC	-	-	-	-	-	-

Notes:

CCME FAL: Guidelines to protect freshwater aquatic life

Chronic: Guidelines to protect freshwater aquatic life, (30-day average guidelines)

Acute: Guidelines to protect freshwater aquatic life, (Maximum allowable concentration [MAC] guidelines)

MWQSOG FAL: Manitoba Water Quality Standards, Objectives, and Guidelines (Tier II) - Protection of Aquatic Life and Wildlife

Chronic: Guidelines to protect freshwater aquatic life, (30-day or 4-day average guidelines)

Acute: Guidelines to protect freshwater aquatic life, (one-hour Maximum guidelines)

When the value of the acute and chronic guidelines are equal, exceedances are denoted as exceeding for acute exposure

^a Applicable guideline is pH dependant.

^b DO guideline is depedent on life stage, which are not applicable to the Site

^c Applicable guideline dependant on background levels of the aquatic receiving water body.

^d Applicable guideline varies with"change from background" and flow condition dependent. No background station was established for this site.

^e Applicable guideline varies with water hardness (110-286 mg/L). The guideline was calculated based on the range of hardness values observed in the samples.

^f Equation 4 and 10 (cool and cold water, early life stages are absent) are applied (mwqsog_2011_calculations)

^g Equation 5 and 11 (cool and Cold water, early life stages are absent) are applied (mwqsog_2011_calculations)

^h Applicable guideline varies with temperature and pH. The guideline is calculated based on field pH range (i.e, 7.0 - 9.0) and field annual average temperature of 5°C;

ⁱ The Cr guideline varies with speciation. Cr(III) guideline is applied as Cr(III) is dominate species under natural conditions

^j Applicable manganese long-term guideline is calculated using the CWQG calculator (Provided in Appendix B, CCME). Applicable manganese short-term guideline is calculated using the Benchmark cal

^k Applicable guideline calculated based on pH, hardness and dissolved organic carbon.

< :Denotes concentration less than indicated detection limit

- :Not analyzed

NS: No Standard

Exceeds CCME FAL Chronic

Exceeds CCME FAL Acute

Exceeds MWQOG Chronic

Exceeds MWQOG Acute

Exceeds duplicate RPD limit

Table 4-9. Summary of Water Quality Exceedances

Well ID	Pre/Post Pumping Test	Sample Date	Hydrostratigraphic Unit	Drinking Water		Agricultural/Irrigation			Livestock		Aquatic Life	
				CDWQ	MWQSOG	CCME	FIGQG	MWQSOG	CCME	MWQSOG	CCME (Acute)	MWQSOG (Acute)
BRU 95-5	Pre-test	2020-Nov-15	Red River Carbonate	Turbidity (MAC); Fe (AO)	Turbidity (MAC); Fe (AO)	-	F; S(as H2S); Fe	-	-	-	F; Fe	-
	Post-test	2020-Dec-02	Red River Carbonate/ Winnipeg Shale	Turbidity (MAC); Fe (AO)	Turbidity (MAC); Fe (AO)	-	F; Fe	-	-	-	F; Fe	-
BRU 95-6	Pre-test	2020-Nov-15	Winnipeg Sandstone	Turbidity (MAC); Mn (AO)	Turbidity (MAC)	-	F	-	-	-	F	-
	Post-test	2020-Dec-02	Winnipeg Sandstone	Mn (AO)	-	-	F; Zn	-	-	-	F	-
BRU 95-7	Pre-test	2020-Nov-25	Winnipeg Sandstone	Turbidity (MAC); Mn (AO)	Turbidity (MAC)	-	F; S (as H2S); Zn	-	-	-	F	-
	Mid-test	2020-Nov-29	Winnipeg Sandstone	Turbidity (MAC)	Turbidity (MAC)	-	F	-	-	-	F	-
	Post-test	2020-Dec-01	Winnipeg Sandstone	Turbidity (MAC); Fe (AO)	Turbidity (MAC); Fe (AO)	-	F; S(as H2S); Fe	-	-	-	F; Fe	-
BRU 95-9	Pre-test	2020-Nov-24	Winnipeg Shale	Fe (AO)	Fe (AO)	-	F; Fe	-	-	-	F; Fe	-
	Post-test	2020-Dec-02	Winnipeg Shale	-	-	Mo	F	Mo	-	-	F	-
	NA	2021-Feb-04	Winnipeg Shale	Turbidity (MAC)	Turbidity (MAC)	-	F, Cd	-	-	-	F	
BRU-96-1	Pre-test	2020-Nov-13	Winnipeg Sandstone	Turbidity (MAC)	Turbidity (MAC)	B	B	B	-	-	F	-
	Post-test	2020-Dec-02	Winnipeg Sandstone	Mn (AO)	-	B	-	B	-	-	F	-
BRU 96-2	Pre-test	2020-Nov-14	Red River Carbonate	Turbidity (MAC)	Turbidity (MAC)	-	F	-	-	-	F	-
	Post-test	2020-Dec-02	Red River Carbonate	Turbidity (MAC)	Turbidity (MAC)	-	F	-	-	-	F	-
Unknown ^a	Pre-test	2020-Nov-15	Winnipeg Sandstone	Turbidity (MAC), Fe (AO)	Turbidity (MAC)	-	F; Fe	-	-	-	F; Fe	-
	Post-test	2020-Dec-02	Winnipeg Sandstone	-	-	-	F; S(as H2S)	-	-	-	F	-
66124 ^a	Pre-test	2020-Nov-15	Red River Carbonate/ Winnipeg Shale	-	-	-	F	-	-	-	F; Cu; Zn	-
23901 ^a	Pre-test	2020-Nov-18	Red River Carbonate	Turbidity (MAC)	Turbidity (MAC)	-	F; S(as H2S)	-	-	-	F	-
	Post-test	2020-Dec-02	Red River Carbonate	-	-	-	F; S(as H2S)	-	-	-	F	-

Notes:

a: Private domestic wells

CDWQ MAC: Canadian Drinking Water Quality Maximum Acceptable Concentration Guidelines (Updated in February 2024 version)

CDWQ Other: Canadian Drinking Water Quality (CDWQ) Aesthetic Objective (AO) (Updated in February 2024 Version)

CCME Irrigation: Canadian Council of Ministers of the Environment Water Quality Guidelines for the Protection of Agricultural Water - Irrigation Water Use

CCME Livestock: Canadian Council of Ministers of the Environment Water Quality Guidelines for the Protection of Agricultural Water - Livestock Water Use

FIGQG Agricultural: Federal Interim Groundwater Quality Guidelines - Groundwater Quality Guidelines for Federal Contaminated Sites - Agricultural Land Use - Tables 1.1-1.7 (coarse grain size)

MWQSOG MAC: Manitoba Water Quality Standards, Objectives, and Guidelines (Tier III) - Protection of Drinking Water Use - Maximum Acceptable Concentration

MWQSOG AO: Manitoba Water Quality Standards, Objectives, and Guidelines (Tier III) - Protection of Drinking Water Use - Aesthetic Objectives

MWQSOG Irrigation: Manitoba Water Quality Standards, Objectives, and Guidelines (Tier III) - Protection of Irrigation Water Use

MWQSOG Livestock: Manitoba Water Quality Standards, Objectives, and Guidelines (Tier III) - Protection of Livestock Water Use

NA - not available

Table 4-10. Comparison of Water Quality Before and After Pumping Test

Hydrogeostratigraphic Unit	Red River Carbonate								Winnipeg Sandstone											Winnipeg Shale				
Parameters	BRU 95-5		Magnitude of Change	RPD (%)	BRU 96-2		Magnitude of Change	RPD (%)	BRU 95-6		Magnitude of Change	RPD (%)	BRU 95-7		Magnitude of Change	RPD (%)	BRU 96-1		Magnitude of Change	RPD (%)	BRU 95-9		Magnitude of Change	RPD (%)
	Pre	Post			Pre	Post			Pre	Post			Pre	Post			Pre	Post			Pre	Post		
pH	8.33	8.16	-0.17	-2%	8.39	8.18	-0.21	-3%	8.35	8.12	-0.23	-3%	8.11	8.36	0.25	3%	8.44	8.49	0.05	1%	8.09	8.35	0.26	3%
Conductivity	535	525	-10	-2%	383	415.5	32.5	8%	483	594	111	21%	439.8	444.2	4.4	1%	581	569	-12	-2%	482.1	502	19.9	4%
TDS	277	258	-19	-7%	224	217	-7	-3%	264	292	28	10%	239	245	6	2%	358	340	-18	-5%	269	489	220	58%
Hardness (as CaCO3)	268	265	-3	-1%	112	125	13	11%	238	-		NC	196	197	1	1%	116	110	-6	-5%	211	-		NC
Alkalinity, Total (As CaCO3)	302	299	-3	-1%	197	212	15	7%	273	302	29	10%	246	244	-2	-1%	260	271	11	4%	276	1010	734	114%
Bicarbonate (as CaCO3)	358	365	7	2%	231	258	27	11%	322	369	47	14%	300	287	-13	-4%	304	313	9	3%	337	1230	893	114%
Dissolved Organic Carbon (DOC)	1.74	2.01	0.27	14%	1.45	3.65	2.2	86%	0.87	2.12	1.25	84%	1.55	1.58	0.03	2%	0.5	1.66	1.16	107%	1.75	16.9	15.15	162%
Ammonia-N	0.41	0.202	-0.208	-68%	0.322	0.288	-0.034	-11%	0.415	0.389	-0.026	-6%	0.498	0.59	0.092	17%	0.415	0.38	-0.035	-9%	0.446	0.81	0.364	58%
Boron	0.156	0.155	-0.001	-1%	0.302	0.266	-0.036	-13%	0.251	0.339	0.088	30%	0.214	0.212	-0.002	-1%	0.692	0.605	-0.087	-13%	0.334	0.299	-0.035	-11%
Fluoride	0.325	0.331	0.006	2%	0.549	0.499	-0.05	-10%	0.383	0.382	-0.001	0%	0.406	0.411	0.005	1%	0.882	0.876	-0.006	-1%	0.302	0.481	0.179	46%
Calcium	50.7	48.5	-2.2	-4%	24.7	27.1	2.4	9%	45.1	45.1	0	0%	36.4	35.2	-1.2	-3%	26.4	22.9	-3.5	-14%	43.1	22.1	-21	-64%
Magnesium	34.4	35	0.6	2%	12.4	13.9	1.5	11%	30.4	32.8	2.4	8%	25.5	26.4	0.9	3%	12.2	12.8	0.6	5%	25.2	19	-6.2	-28%
Potassium	4.33	4.71	0.38	8%	3.86	3.98	0.12	3%	4.88	5.66	0.78	15%	4.39	4.57	0.18	4%	7.93	10.8	2.87	31%	7.58	32.1	24.52	124%
Sodium	14.2	14.7	0.5	3%	41.4	43.3	1.9	4%	17	18.6	1.6	9%	19.4	25.5	6.1	27%	82.4	87.1	4.7	6%	19.1	72.7	53.6	117%
Chloride	1.78	1.01	-0.77	-55%	2.56	2.76	0.2	8%	1.48	1.63	0.15	10%	1.04	1.52	0.48	38%	22.9	22.4	-0.5	-2%	1.87	37.4	35.53	181%
Sulphide	< 0.018	0.078		NC	< 0.018	< 0.018		NC	< 0.018	< 0.018		NC	0.023	0.02	-0.003	-14%	< 0.018	< 0.018		NC	< 0.18	< 1.8		NC
Sulphide (as H2S)	< 0.019	0.083		NC	< 0.019	< 0.019		NC	< 0.019	< 0.019		NC	0.024	0.021	-0.003	-13%	< 0.019	< 0.019		NC	< 0.19	< 1.9		NC
Sulphate	4.6	3.22	-1.38	-35%	14.4	13.4	-1	-7%	6.92	8.01	1.09	15%	5.23	5.83	0.6	11%	33.5	32.1	-1.4	-4%	6.84	37.2	30.36	138%
Iron	0.609	0.845	0.236	32%	0.259	0.199	-0.06	-26%	0.054	< 0.01		NC	0.198	0.474	0.276	82%	< 0.01	< 0.01		NC	0.623	< 0.01		NC
Manganese	0.00903	0.00932	0.00029	3%	0.00306	0.00297	-9E-05	-3%	0.0279	0.0454	0.0175	48%	0.0256	0.0168	-0.0088	-42%	0.0107	0.0313	0.0206	98%	0.0146	0.00464	-0.00996	-104%
Molybdenum	0.00215	0.00146	-0.00069	-38%	0.0084	0.0076	-0.0008	-10%	0.00205	0.00392	0.00187	63%	0.00224	0.00193	-0.00031	-15%	0.00332	0.00534	0.00202	47%	0.00154	0.0344	0.03286	183%
Zinc	< 0.001	0.0023		NC	< 0.001	0.0011		NC	0.009	0.0197	0.0107	75%	0.0106	0.0034	-0.0072	-103%	0.0023	0.0035	0.0012	41%	< 0.001	< 0.001		NC

Note:
All concentration data presented in mg/L.
NC: Not Calculated (Results <5x laboratory detection limit)
RPD = Relative Percent Difference. Positive RPD indicates "post" concentration is greater than "pre" value. Negative RPD indicates "post" concentration is lower than "pre" value
Calculated RPD in excess of 30%.

Table 4-11. Simulated Groundwater Quality in Response to Changing Redox Conditions

Hydrogeostratigraphic Unit	Red River Carbonate			Winnipeg Sandstone			Winnipeg Shale		
	BRU 95-5		RPD (%)	BRU 95-7		RPD (%)	BRU 95-9		RPD (%)
	Exisiting	Operations		Exisiting	Operations		Exisiting	Operations	
pH	7.54	8.7	14%	7.84	8.8	12%	7.56	8.8	16%
Pe	2.68	13.8	135%	3.2	13.5	123%	2.44	13.6	139%
Hardness (as CaCO3)	268	154	-54%	196	196	0%	211	211	0%
Alkalinity, Total (As CaCO3)	302	184	-48%	246	242	-2%	276	272	-2%
Ammonia-N	0.41	0	-200%	0.50	0	-200%	0.45	0	-200%
Chloride	1.78	1.78	0%	1.04	1.04	0%	1.9	1.9	0%
Sulphate	4.6	4.6	0%	5.2	5.2	0%	6.8	6.8	0%
Calcium	50.7	5.19	-163%	36.4	36.4	0%	43.1	43.1	0%
Magnesium	34.4	34.4	0%	25.5	25.5	0%	25.2	25.2	0%
Fluoride	0.325	0.325	0%	0.406	0.406	0%	0.302	0.302	0%
Sodium	14.2	14.2	0%	19.4	19.4	0%	19.1	19.1	0%
Potassium	4.33	4.33	0%	4.39	4.39	0%	7.58	7.58	0%
Aluminum	0.001	0.0002	-133%	0.001	0.0004	-80%	0.001	0.0004	-87%
Arsenic	0.00155	0.00155	0%	0.0003	0.0003	0%	0.0009	0.0009	0%
Iron	0.60924	0.00016	-200%	0.1981	0.0002	-200%	0.6232	0.0002	-200%
Manganese	0.00903	0.00903	0%	0.0256	0.0256	0%	0.0146	0.0146	0%
Molybdenum	0.00215	0.00215	0%	0.0022	0.0022	0%	0.0015	0.0015	0%
Uranium	0.0001	0.0001	0%	0.0001	0.0001	0%	0.0001	0.0001	0%
Strontium	0.32514	0.32513	0%	0.2581	0.2581	0%	0.3041	0.3041	0%
Zinc	<0.001	0.001	NC	0.0106	0.0106	0%	<0.001	0.0010	NC
Saturated Indices									
Calcite (CaCO3)	0.04	0.00	-	0.16	1.06	-	-0.02	1.19	-
Diaspore (AlOOH)	0.98	0.00	-	0.98	0.00	-	1.10	0.00	-
Ferrihydrite (FeOOH)	2.29	0.00	-	2.77	0.00	-	2.23	0.00	-
Gypsum (CaSO4.2H2O)	-3.02	-3.93	-	-3.07	-3.08	-	-2.89	-2.91	-
Manganite (MnOOH)	-7.04	7.37	-	-5.14	7.61	-	-7.38	7.53	-
Rhodochrosite (MnCO3)	-1.69	-0.91	-	-0.98	-0.47	-	-1.48	-0.67	-
Siderite (FeCO3)	-0.48	-16.40	-	-1.33	-16.34	-	-0.43	-16.38	-
Strontianite (SrCO3)	-1.59	-0.64	-	-1.44	-0.52	-	-1.61	-0.39	-

Table 4-12. Simulated Groundwater Quality in Winnipeg Sandstone in Response to Downward Mixing

Parameters	CDWQ MAC	CDWQ AO	Fraction of Sandstone Water									
			100%	90%	80%	70%	60%	50%	40%	30%	20%	10%
pH	NS	7.0-10.5	7.84	7.79	7.75	7.71	7.68	7.65	7.62	7.60	7.58	7.56
Pe	NS	NS	3.2	2.95	2.85	2.79	2.76	2.74	2.72	2.71	2.70	2.69
Hardness (as CaCO3)	NS	NS	196	203	210	217	225	232	239	246	253	261
Alkalinity, Total (As CaCO3)	NS	NS	246	251	257	263	268	274	279	285	291	296
Ammonia-N	NS	NS	0.50	0.49	0.48	0.47	0.46	0.45	0.45	0.44	0.43	0.42
Chloride	NS	250	1.04	1.11	1.19	1.26	1.34	1.41	1.48	1.56	1.63	1.71
Sulphate	NS	500	5.2	5.2	5.1	5.0	5.0	4.9	4.9	4.8	4.7	4.7
Calcium	NS	NS	36.4	37.8	39.3	40.7	42.1	43.6	45.0	46.4	47.9	49.3
Magnesium	NS	NS	25.5	26.4	27.3	28.2	29.1	30.0	30.9	31.7	32.6	33.5
Fluoride	1.5	NS	0.406	0.398	0.390	0.382	0.374	0.366	0.358	0.349	0.341	0.333
Sodium	NS	200	19.4	18.9	18.4	17.8	17.3	16.8	16.3	15.8	15.2	14.7
Potassium	NS	NS	4.39	4.3846	4.3787	4.3727	4.3667	4.3607	4.3548	4.3488	4.3428	4.3369
Aluminum	NS	NS	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Arsenic	0.01	NS	0.0003	0.0004	0.0006	0.0007	0.0008	0.0009	0.0011	0.0012	0.0013	0.0014
Iron	NS	0.3	0.198	0.239	0.280	0.321	0.363	0.404	0.445	0.486	0.527	0.568
Manganese	0.12	0.02	0.0256	0.0240	0.0223	0.0206	0.0190	0.0173	0.0157	0.0140	0.0123	0.0107
Molybdenum	NS	NS	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022
Uranium	0.02	NS	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
Strontium	7.0	NS	0.2581	0.2648	0.2715	0.2782	0.2849	0.2916	0.2983	0.3050	0.3117	0.3184
Zinc	NS	5	0.0106	0.0096	0.0087	0.0077	0.0068	0.0058	0.0048	0.0039	0.0029	0.0020

Notes:

CDWQ MAC: Canadian Drinking Water Quality Maximum Acceptable Concentration Guidelines (Updated in September 2020 version)

CDWQ Other: Canadian Drinking Water Quality (CDWQ) Aesthetic Objective (AO) (Updated in September 2020 Version)

 Exceeds applicable CDWQ guideline for protection of drinking water (MAC)

 Exceeds applicable CDWQ guideline for protection of drinking water (AO)

Table 4-13. Simulated Groundwater Quality in Winnipeg Sandstone in Response to Downward Mixing

Parameters	CDWQ MAC	CDWQ AO	Fraction of Water from Winnipeg Sandstone									
			100%	90%	80%	70%	60%	50%	40%	30%	20%	10%
pH	NS	7.0-10.5	7.84	7.79	7.75	7.71	7.68	7.65	7.62	7.60	7.58	7.56
Pe	NS	NS	3.2	2.95	2.85	2.79	2.76	2.74	2.72	2.71	2.70	2.69
Hardness (as CaCO3)	NS	NS	196	203	210	217	225	232	239	246	253	261
Alkalinity, Total (As CaCO3)	NS	NS	246	251	257	263	268	274	279	285	291	296
Ammonia-N	NS	NS	0.50	0.49	0.48	0.47	0.46	0.45	0.45	0.44	0.43	0.42
Chloride	NS	250	1.04	1.11	1.19	1.26	1.34	1.41	1.48	1.56	1.63	1.71
Sulphate	NS	500	5.2	5.2	5.1	5.0	5.0	4.9	4.9	4.8	4.7	4.7
Calcium	NS	NS	36.4	37.8	39.3	40.7	42.1	43.6	45.0	46.4	47.9	49.3
Magnesium	NS	NS	25.5	26.4	27.3	28.2	29.1	30.0	30.9	31.7	32.6	33.5
Fluoride	1.5	NS	0.406	0.398	0.390	0.382	0.374	0.366	0.358	0.349	0.341	0.333
Sodium	NS	200	19.4	18.9	18.4	17.8	17.3	16.8	16.3	15.8	15.2	14.7
Potassium	NS	NS	4.39	4.3846	4.3787	4.3727	4.3667	4.3607	4.3548	4.3488	4.3428	4.3369
Aluminum	NS	NS	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Arsenic	0.01	NS	0.0003	0.0004	0.0006	0.0007	0.0008	0.0009	0.0011	0.0012	0.0013	0.0014
Iron	NS	0.3	0.198	0.239	0.280	0.321	0.363	0.404	0.445	0.486	0.527	0.568
Manganese	0.12	0.02	0.0256	0.0240	0.0223	0.0206	0.0190	0.0173	0.0157	0.0140	0.0123	0.0107
Molybdenum	NS	NS	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022
Uranium	0.02	NS	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
Strontium	7.0	NS	0.2581	0.2648	0.2715	0.2782	0.2849	0.2916	0.2983	0.3050	0.3117	0.3184
Zinc	NS	5	0.0106	0.0096	0.0087	0.0077	0.0068	0.0058	0.0048	0.0039	0.0029	0.0020

Notes:

CDWQ MAC: Canadian Drinking Water Quality Maximum Acceptable Concentration Guidelines (Updated in February 2024 version)

CDWQ Other: Canadian Drinking Water Quality (CDWQ) Aesthetic Objective (AO) (Updated in February 2024 Version)

 Exceeds applicable CDWQ guideline for protection of drinking water (MAC)

 Exceeds applicable CDWQ guideline for protection of drinking water (AO)

Table 4-14. Groundwater Quality and Shake Flask Extraction Data Used for Water Quality Assessment and Geochemical Modeling

Sample ID	Units	¹ CDWQ MAC	² CDWQ AO	³ MWQSOG MAC	⁴ MWQSOG AO	Average Concentration			Average SFE Concentrations			Simulated Water Quality in Collapsed Cavity
						Winnipeg Sandstone Aquifer	Winnipeg Shale Porewater	Red River Carbonate Aquifer	Red River Carbonate	Winnipeg Shale	Winnipeg Sandstone	
pH (Lab)	-	NG	7.0-10.5	NG	6.5-8.5	8.20	7.78	7.77	8.15	8.06	7.05	7.05
Dissoved Oxygen	mg/L	NG	NG	NG	NG	4.2	0.5	3.4	5	5	5	9.1
Bicarbonate (HCO3)	mg/L	NG	NG	NG	NG	316	343	303	-	-	-	315.5
Chloride (Cl)	mg/L	NG	250	NG	NG	7.47	15.4	2.03	-	-	-	7.24
Sulphate (SO4)	mg/L	NG	500	NG	NG	13.9	18.3	8.91	-	-	-	13.6
Aluminum (Al)	mg/L	NG	NG	NG	NG	0.00285	0.0034	0.00175	0.15	<0.005	1.28	1.17
Arsenic (As)	mg/L	0.01	NG	0.01	NG	4.80x10 ⁻⁴	0.00132	8.80x10 ⁻⁴	0.001	0.012	0.0014	0.0021
Calcium (Ca)	mg/L	NG	NG	NG	NG	35.4	35	37.8	16.9	116.9	4.05	43.12
Iron (Fe)	mg/L	NG	0.3	NG	≤ 0.3	0.109	0.214	0.478	<0.030	<0.030	0.18	0.3
Magnesium (Mg)	mg/L	NG	NG	NG	NG	23.8	23.2	23.9	6.07	29.24	0.88	25.7
Manganese (Mn)	mg/L	0.12	≤ 0.02	NG	≤ 0.050	0.025	0.0082	0.0061	6.0x10 ⁻⁴	0.028	9.0x10 ⁻⁴	0.0247
Potassium (K)	mg/L	NG	NG	NG	NG	6.14	18.7	4.22	7.06	49.17	0.66	8.2
Selenium (Se)	mg/L	0.05	NG	0.01	NG	6.0x10 ⁻⁵	3.5x10 ⁻⁴	1.0x10 ⁻⁴	0.0096	0.55	0.002	0.015
Silicon (Si)	mg/L	NG	NG	NG	NG	6.16	5.27	6.21	1.79	3.06	2.40	8.55
Sodium (Na)	mg/L	NG	≤ 200	NG	≤ 200	38.97	41.0	28.4	2.13	14.92	0.49	39.16
Uranium (U)	mg/L	0.02	NG	0.02	NG	2.91x10 ⁻⁴	6.10x10 ⁻⁴	9.10x10 ⁻⁵	7.0x10 ⁻⁴	0.044	1.9x10 ⁻⁴	0.0015

Notes:

¹ CDWQ MAC: Canadian Drinking Water Quality Maximum Acceptable Concentration Guidelines (Updated in September 2020 version)

² CDWQ Other: Canadian Drinking Water Quality (CDWQ) Aesthetic Objective (AO) (Updated in September 2020 Version)

³ MWQSOG MAC: Manitoba Water Quality Standards, Objectives, and Guidelines (Tier III) - Protection of Drinking Water Use - Maximum Acceptable Concentration

⁴ MWQSOG AO: Manitoba Water Quality Standards, Objectives, and Guidelines (Tier III) - Protection of Drinking Water Use - Aesthetic Objectives

Table 5-1. Summary of Aquifer Properties

Hydrostratigraphic Unit	Hydraulic Conductivity (m/s)			Transmissivity (US gallons/day/ft)		Storativity (-)		Comments	Study Location	Source
	Minimum	Maximum	Geometric Mean	Minimum	Maximum	Minimum	Maximum			
Quaternary Sediments	1×10^{-12}	1						Glacial till to gravel	Literature	Freeze and Cherry (1979)
	8.2×10^{-6}	2.4×10^{-4}						Multiple slug tests (sand)	SE Manitoba (Sandilands Area)	Cherry (2000)
	8.3×10^{-9}	6.8×10^{-6}						Multiple slug tests (till)	SE Manitoba (Sandilands Area)	Cherry (2000)
	1.5×10^{-5}	1.3×10^{-4}						Multiple permeameter tests	SE Manitoba (Sandilands Area)	Ferguson (2004)
			2.5×10^{-3}	430,000				Sand and gravel	Moosenose Ridge Deposit	Woodbury (1995)
Red River Carbonate	1.0×10^{-9}	5.0×10^{-6}						Limestone and Dolomite	Literature	Freeze and Cherry (1979)
	1.7×10^{-5}	5.0×10^{-4}		5,000	150,000	1.0×10^{-6}	1.0×10^{-3}		SE Manitoba	Render (1970)
						2.0×10^{-5}	3.0×10^{-4}		SE Manitoba	Kennedy (2002)
			8.0×10^{-4}					76 short term pumping tests	SE Manitoba	Wang et al. (2008)
			2.5×10^{-4}	75,000					SE Manitoba (Steinbach)	Bell (2009)
	1.5×10^{-5}	3.9×10^{-4}	7.7×10^{-5}					2 slug tests	SE Manitoba (Project Site)	AECOM (this study)
Winnipeg Shale	1.0×10^{-13}	1.0×10^{-9}							Literature	Freeze and Cherry (1979)
			2.8×10^{-8}					1 slug test	SE Manitoba (Project Site)	AECOM (this study)
Winnipeg Sandstone	1.0×10^{-10}	1.0×10^{-6}							Literature	Freeze and Cherry (1979)
	1.0×10^{-6}	1.0×10^{-3}							SE Manitoba	Betcher (1986) cited in jeff bell
	2.2×10^{-5}	4.4×10^{-5}	2.4×10^{-5}	5,000	10,000			11 short term pumping tests	SE Manitoba	Wang et al. (2008)
	3.6×10^{-6}	1.1×10^{-3}						16 of 20 tests between 10^{-4} and 10^{-6} m/s	Southern Manitoba	Ferguson et al. (2007)
	7.9×10^{-5}		8.0×10^{-5}	10,000		2.0×10^{-5}	6.0×10^{-5}	24-hour pumping test (3,000 m ³ /day; s = 58m)	SE Manitoba (Dougald and Oakbank)	Friesen (2019a)
			3.0×10^{-5}			2.0×10^{-5}	6.0×10^{-5}	24-hour pumping test	SE Manitoba (RM Springfield)	Friesen (2019b)
			5.2×10^{-5}	12,000		1.0×10^{-5}		60-hour pumping test (2,400 m ³ /day; s = 24.4m)	SE Manitoba (Park Road)	Friesen (2015)
			3.9×10^{-5}	9,000					SE Manitoba (Granny's Poultry)	Friesen (2014)
						2.0×10^{-5}	1.0×10^{-4}		SE Manitoba	Kennedy (2002)
	5.2×10^{-5}	6.2×10^{-5}	5.7×10^{-5}					2 slug tests	SE Manitoba (Project Site)	AECOM (this study)
	4.8×10^{-5}	1.1×10^{-4}	9.5×10^{-5}			1.2×10^{-4}	1.7×10^{-4}	62-hour pumping test (2,295 m ³ /day; s = 36m)	SE Manitoba (Project Site)	AECOM (this study)
Precambrian Bedrock	5.0×10^{-9}	1.0×10^{-4}							Literature	Freeze and Cherry (1979)

Notes:
Italics: Calculated from reported transmissivity values.

Table 6-1. Scenario Testing Results

Observation Point Name	E 0801029NW	E 0801029NE	E 0801029SW	E 0801029SE	E 0801029NW	E 0801029NE	E 0801029SW	E 0801029SE
Distance to Production Wells (m)	725	910	200	550	725	910	200	550
Scenario	Simulated Groundwater Elevation (m) in the Red River Carbonate				Simulated Groundwater Elevation (m) in the Winnipeg Sandstone			
1) 0% Re-injection, Winnipeg Shale Degredation	269.2	269.3	268.0	268.7	269.2	269.3	268.0	268.7
2) 0% Re-injection, No Degredation of Winnipeg Shale	269.2	269.3	268.2	268.7	269.2	269.3	267.5	268.7
3) 42.5% Re-injection, Winnipeg Shale Degredation	269.8	269.8	269.0	269.3	269.8	269.8	268.9	269.3
Scenario	Simulated Drawdown (m) in the Red River Carbonate				Simulated Drawdown (m) in the Winnipeg Sandstone			
1) 0% Re-injection, Winnipeg Shale Degredation	1.4	1.2	2.3	1.5	1.1	1.0	2.1	1.3
2) 0% Re-injection, No Degredation of Winnipeg Shale	1.4	1.2	2.1	1.5	1.1	1.0	2.6	1.5
3) 42.5% Re-injection, Winnipeg Shale Degredation	0.8	0.7	1.3	0.9	0.5	0.5	1.1	0.7

Table 6-2. Sensitivity Analysis Results

Observation Point Name	30-10-8E1	29-10-8E1	31-10-8E1	32-10-8E1	36-10-7E1	20-10-8E1	G05SA015	33-10-8E1	3-11-7E1	G05OJ175
Distance to Production Well (m)	146	1,504	1,537	2,186	2,223	2,313	2,916	3,515	4,416	7,462
Sensitivity Analysis	Simulated Groundwater Elevation (m) in Red River Carbonate									
Base Case (Scenario 1)	262.9	269.1	268.2	270.2	266.6	269.2	269.8	270.1	263.1	259.4
Recharge - 20%	262.0	268.2	267.3	269.3	266.0	268.7	269.2	269.5	262.9	259.0
Recharge + 20%	263.5	269.6	269.0	270.9	267.1	269.5	270.2	270.4	263.2	259.6
Carbonate K = Min (1.5 x 10 ⁻⁵)	257.5	269.4	269.3	271.6	267.6	269.5	271.0	270.8	263.4	260.1
Carbonate K = Max (8.25 x 10 ⁻⁴)	256.6	258.8	256.4	258.3	255.1	259.6	259.3	259.8	252.2	250.2
Shale K ÷ 10	262.5	268.8	268.2	270.5	266.6	269.1	269.8	270.2	263.0	259.4
Shale K x 10	262.6	268.8	267.9	269.8	266.4	269.1	269.6	269.9	263.1	259.3
Sandstone K = Min (1.0 x 10 ⁻⁶)	260.7	269.1	268.6	270.9	266.9	269.3	270.0	270.4	263.1	259.5
Sandstone K = Max (1.0 x 10 ⁻⁴)	264.6	268.7	267.7	269.4	266.1	268.9	269.4	269.6	262.8	259.1
Sensitivity Analysis	Simulated Drawdown (m) in Red River Carbonate									
Base Case (Scenario 1)	7.5	2.1	2.2	1.3	1.3	0.9	0.8	0.4	0.1	0.0
Recharge - 20%	7.9	2.4	2.4	1.5	1.6	1.3	1.1	0.6	0.2	0.0
Recharge + 20%	7.2	2.0	1.8	1.1	1.0	0.9	0.6	0.3	0.1	0.0
Carbonate K = Min (1.5 x 10 ⁻⁵)	14.4	3.5	2.7	1.8	1.2	1.2	0.6	0.3	0.0	0.0
Carbonate K = Max (8.25 x 10 ⁻⁴)	1.5	0.8	0.8	0.7	0.7	0.7	0.6	0.6	0.4	0.2
Shale K ÷ 10	7.6	2.2	2.1	1.2	1.3	1.0	0.8	0.4	0.1	0.0
Shale K x 10	7.8	2.4	2.4	1.6	1.4	1.1	0.9	0.5	0.1	0.0
Sandstone K = Min (1.0 x 10 ⁻⁶)	10.3	2.9	2.5	1.5	1.3	1.1	0.8	0.4	0.1	0.0
Sandstone K = Max (1.0 x 10 ⁻⁴)	4.5	0.9	1.4	0.6	1.0	0.5	0.6	-0.1	0.2	0.0
Observation Point Name	30-10-8E1	29-10-8E1	31-10-8E1	32-10-8E1	36-10-7E1	20-10-8E1	G05SA014	33-10-8E1	3-11-7E1	G05OJ163
Distance to Production Well (m)	146	1,504	1,537	2,186	2,223	2,313	2,916	3,515	4,416	7,462
Sensitivity Analysis	Simulated Groundwater Elevation (m) in Winnipeg Sandstone									
Base Case (Scenario 1)	262.9	269.1	267.9	269.7	266.4	269.2	269.4	269.8	263.2	259.1
Recharge - 20%	262.0	268.2	267.1	268.9	265.8	268.7	268.9	269.3	262.9	258.8
Recharge + 20%	263.6	269.6	268.6	270.3	266.9	269.5	269.8	270.1	263.4	259.4
Carbonate K = Min (1.5 x 10 ⁻⁵)	257.5	269.4	268.6	270.8	267.2	269.5	270.1	270.5	263.6	260.0
Carbonate K = Max (8.25 x 10 ⁻⁴)	256.6	258.8	256.4	258.2	255.0	259.6	259.3	259.7	252.4	250.2
Shale K ÷ 10	262.5	268.8	266.7	268.3	265.1	269.1	268.8	268.4	262.3	258.1
Shale K x 10	262.6	268.8	267.8	269.7	266.4	269.1	269.6	269.9	263.1	259.3
Sandstone K = Min (1.0 x 10 ⁻⁶)	260.2	269.1	268.6	270.8	266.9	269.3	270.0	270.3	263.1	259.5
Sandstone K = Max (1.0 x 10 ⁻⁴)	264.6	268.7	267.1	268.6	265.6	268.9	268.8	268.9	262.7	258.6
Sensitivity Analysis	Simulated Drawdown (m) in Winnipeg Sandstone									
Base Case (Scenario 1)	7.5	2.1	2.2	1.4	1.2	0.9	0.8	0.4	0.2	0.0
Recharge - 20%	7.9	2.4	2.5	1.7	1.5	1.3	1.1	0.6	0.3	0.1
Recharge + 20%	7.2	2.0	1.8	1.2	1.0	0.9	0.6	0.4	0.1	0.0
Carbonate K = Min (1.5 x 10 ⁻⁵)	14.3	3.5	2.9	1.9	1.3	1.2	0.8	0.4	0.1	0.0
Carbonate K = Max (8.25 x 10 ⁻⁴)	1.5	0.8	0.8	0.7	0.7	0.7	0.6	0.6	0.4	0.2
Shale K ÷ 10	7.6	2.2	2.5	1.7	1.6	1.0	0.9	0.6	0.6	0.2
Shale K x 10	7.8	2.4	2.4	1.6	1.4	1.1	0.9	0.5	0.1	0.0
Sandstone K = Min (1.0 x 10 ⁻⁶)	10.7	2.9	2.5	1.5	1.3	1.1	0.8	0.4	0.1	0.0
Sandstone K = Max (1.0 x 10 ⁻⁴)	4.5	0.9	1.4	0.7	0.9	0.5	0.6	-0.1	0.3	0.1

Notes:
K = Hydraulic Conductivity

Appendix **A**

Groundwater Exploration Permit

Drainage and Water Rights Licensing Branch
Box 16, 200 Saulteaux Crescent,
Winnipeg, Manitoba, Canada R3J 3W3
T 204-945-3983 F 204-948-2357 E: wateruse@gov.mb.ca
www.manitoba.ca

November 5, 2020

File: HD Minerals Ltd. (-13)

Laura Weeden, P.Eng.
Vice President, Operations
HD Minerals Ltd./CanWhite Sands Corp.
Suite 2650, 645 - 7th Ave. SW
Calgary, AB T2P 4G8

Dear Ms. Weeden:

Re: Authorization for HD Minerals Ltd. to Divert and Use Groundwater for Testing and Analysis as Part of the Company's Hydrogeological Study in Connection with the Plan Submission of the Environmental Act Proposal for Sand Extraction Project to the Environmental Approvals Branch of Manitoba and to the RM of Springfield for Review.

This letter is in response to an application registered on October 29, 2020 for authorization to HD Minerals Ltd. to divert and use groundwater for testing and analysis as described above.

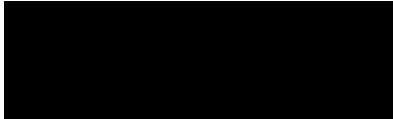
As Acting Head of Groundwater Licensing, Drainage and Water Rights Licensing Branch, I have the delegated authority on behalf of the Minister of Conservation and Climate, for administration of *The Water Rights Act*, which includes the issuance of authorizations, permits, and licences. Therefore, HD Minerals Ltd. may consider this letter to be authorization under *The Water Rights Act* to withdraw and divert groundwater from six (6) new wells to be drilled in SE 32-10-8 EPM, SW 32-10-8 EPM, and SW 33-10-8 EPM, in the RM Springfield, Manitoba, subject to the following conditions:

1. This authorization is issued upon the express condition that it shall be subject to the provisions of *The Water Rights Act* and Regulations and all amendments thereto.
2. The total amount of water that may be pumped from the well for testing and analysis is not to exceed 16,500 cubic metres (16,500,000 litres).
3. The rate at which water may be diverted shall not exceed 500 gallons per minute.
4. This authorization shall expire on April 30, 2021.

5. HD Minerals Ltd., shall prior to the diversion of water, acquire the necessary approvals from other relevant municipal, provincial, and federal agencies.
6. HD Minerals Ltd. shall comply with all regulations concerning cleaning, fueling, and servicing of equipment used in the procedure.
7. HD Minerals Ltd. shall assume any liability that may ensue as a result of diversion of water as authorized by this letter.
8. The Minister or Minister's agents may, under certain conditions, instruct HD Minerals Ltd. to reduce or terminate withdrawal of water from the aquifer to accommodate existing senior licensed water users, domestic users, and environmental needs, if applicable.
9. HD Minerals Ltd. is responsible to correct any water supply problems or provide temporary water supply to anyone whose well(s) are negatively impacted as a result of pumping.

Please contact Ronaldo Miranda at (204) 945-6475 if you have any questions concerning this Temporary Authorization.

Yours truly,



Kylene Wiseman, P.Geo.
A/Head of Groundwater Licensing
Drainage and Water Rights Licensing Branch

cc: Colleen Draper, CAO, RM of Springfield
Sirena Ketchen, Mines Branch
Ronaldo Miranda, (CC)

Appendix **B**

Combined Borehole Logs



PROJECT: Vivian Sand Facility Project			CLIENT: CanWhite Sands Corp.			TESTHOLE NO: Bru 95-6		
LOCATION: Vivian, MB N 5,527,624.0 E 682,199.0						PROJECT NO.: 60640258		
CONTRACTOR: Friesen Drillers Ltd.				METHOD: Mud Rotary			ELEVATION (m): 275.041	
SAMPLE TYPE		☒ GRAB	☐ SHELBY TUBE	☐ SPLIT SPOON	☐ BULK	☐ NO RECOVERY	☐ CORE	
BACKFILL TYPE		☒ BENTONITE	☐ GRAVEL	☐ SLOUGH	☐ GROUT	☐ CUTTINGS	☐ SAND	

DEPTH (m)	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #	VAPOUR READINGS	COMMENTS	ELEVATION (m)
0		SAND, fine grained with minor (15%) medium sand -White -Loose -Non-cohesive, non-plastic					274
1							273
2							272
3							271
4							270
5							269
6							268
7		SILTY CLAY with fine sand (20%), trace gravel and cobbles (5%) -Brown -Medium dense -Cohesive, medium to high plasticity					267
8							266
9							
10							

	LOGGED BY: Stephen Dickinson	COMPLETION DEPTH: 57.00 m
	REVIEWED BY: Reuben Dandurand	COMPLETION DATE: 11/13/20
	PROJECT ENGINEER: Ryan Mills	Page 1 of 7

ENVIRO (VAPOUR/F2/F3) 60640258 CANWHITE MW.GPJ UMA.GDT 2/9/21

PROJECT: Vivian Sand Facility Project			CLIENT: CanWhite Sands Corp.			TESTHOLE NO: Bru 95-6		
LOCATION: Vivian, MB N 5,527,624.0 E 682,199.0						PROJECT NO.: 60640258		
CONTRACTOR: Friesen Drillers Ltd.			METHOD: Mud Rotary			ELEVATION (m): 275.041		
SAMPLE TYPE		☒ GRAB	☐ SHELBY TUBE	☐ SPLIT SPOON	☐ BULK	☐ NO RECOVERY	☐ CORE	
BACKFILL TYPE		☒ BENTONITE	☐ GRAVEL	☐ SLOUGH	☐ GROUT	☐ CUTTINGS	☐ SAND	

DEPTH (m)	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #	VAPOUR READINGS	COMMENTS	ELEVATION (m)
10		SILTY MEDIUM TO COARSE SAND, -Brown -Medium dense -Cohesive, low plasticity					264
11							263
12							262
13							261
14							260
15							259
16							258
17							257
18							256
19							
20							

ENVIRO (VAPOUR/F2/F3) 60640258 CANWHITE MW.GPJ UMA.GDT 2/9/21



LOGGED BY: Stephen Dickin	COMPLETION DEPTH: 57.00 m
REVIEWED BY: Reuben Dandurand	COMPLETION DATE: 11/13/20
PROJECT ENGINEER: Ryan Mills	Page 2 of 7

PROJECT: Vivian Sand Facility Project			CLIENT: CanWhite Sands Corp.			TESTHOLE NO: Bru 95-6		
LOCATION: Vivian, MB N 5,527,624.0 E 682,199.0						PROJECT NO.: 60640258		
CONTRACTOR: Friesen Drillers Ltd.			METHOD: Mud Rotary			ELEVATION (m): 275.041		
SAMPLE TYPE		☒ GRAB	☐ SHELBY TUBE	☐ SPLIT SPOON	☐ BULK	☐ NO RECOVERY	☐ CORE	
BACKFILL TYPE		☒ BENTONITE	☐ GRAVEL	☐ SLOUGH	☐ GROUT	☐ CUTTINGS	☐ SAND	

DEPTH (m)	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #	VAPOUR READINGS	COMMENTS	ELEVATION (m)
20							
21							254
22							253
23							252
24							251
25		COARSE SAND AND GRAVEL -Brown -Loose -Non-cohesive, non-plastic					250
26							249
27							248
28							247
29							246
30							

	LOGGED BY: Stephen Dickin	COMPLETION DEPTH: 57.00 m
	REVIEWED BY: Reuben Dandurand	COMPLETION DATE: 11/13/20
	PROJECT ENGINEER: Ryan Mills	Page 3 of 7

ENVIRO (VAPOUR/F2/F3) 60640258 CANWHITE MW.GPJ UMA.GDT 2/9/21

PROJECT: Vivian Sand Facility Project			CLIENT: CanWhite Sands Corp.			TESTHOLE NO: Bru 95-6		
LOCATION: Vivian, MB N 5,527,624.0 E 682,199.0						PROJECT NO.: 60640258		
CONTRACTOR: Friesen Drillers Ltd.				METHOD: Mud Rotary			ELEVATION (m): 275.041	
SAMPLE TYPE		☒ GRAB	☐ SHELBY TUBE	☐ SPLIT SPOON	☐ BULK	☐ NO RECOVERY	☐ CORE	
BACKFILL TYPE		☒ BENTONITE	☐ GRAVEL	☐ SLOUGH	☐ GROUT	☐ CUTTINGS	☐ SAND	

DEPTH (m)	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #	VAPOUR READINGS	COMMENTS	ELEVATION (m)
30							
31							244
32							243
33							242
34							241
35							240
36							239
37		LIMESTONE -Beige -Minor weathering -Competent rock					238
38							237
39							236
40							

ENVIRO (VAPOUR/F2/F3) 60640258 CANWHITE MW.GPJ UMA.GDT 2/9/21



LOGGED BY: Stephen Dickinson	COMPLETION DEPTH: 57.00 m
REVIEWED BY: Reuben Dandurand	COMPLETION DATE: 11/13/20
PROJECT ENGINEER: Ryan Mills	Page 4 of 7

PROJECT: Vivian Sand Facility Project				CLIENT: CanWhite Sands Corp.				TESTHOLE NO: Bru 95-6			
LOCATION: Vivian, MB N 5,527,624.0 E 682,199.0								PROJECT NO.: 60640258			
CONTRACTOR: Friesen Drillers Ltd.				METHOD: Mud Rotary				ELEVATION (m): 275.041			
SAMPLE TYPE		☒ GRAB	☐ SHELBY TUBE	☐ SPLIT SPOON	☐ BULK	☐ NO RECOVERY	☐ CORE				
BACKFILL TYPE		☒ BENTONITE	☐ GRAVEL	☐ SLOUGH	☐ GROUT	☐ CUTTINGS	☐ SAND				

DEPTH (m)	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #	VAPOUR READINGS	COMMENTS	ELEVATION (m)
40							
41							234
42							233
43							232
44							231
45							230
46							229
47		SHALE -Reddish brown -Highly weathered, can be shaped/peeled with a knife -Cuttings are cohesive and exhibit high plasticity					228
48		-Becomes greenish brown					227
49		SANDSTONE -White -Fine grained -Well sorted -Weakly cemented, low strength					226
50							

ENVIRO (VAPOUR/F2/F3) 60640258 CANWHITE MW.GPJ UMA.GDT 2/9/21



LOGGED BY: Stephen Dickin	COMPLETION DEPTH: 57.00 m
REVIEWED BY: Reuben Dandurand	COMPLETION DATE: 11/13/20
PROJECT ENGINEER: Ryan Mills	Page 5 of 7

PROJECT: Vivian Sand Facility Project			CLIENT: CanWhite Sands Corp.			TESTHOLE NO: Bru 95-6		
LOCATION: Vivian, MB N 5,527,624.0 E 682,199.0						PROJECT NO.: 60640258		
CONTRACTOR: Friesen Drillers Ltd.			METHOD: Mud Rotary			ELEVATION (m): 275.041		
SAMPLE TYPE		☒ GRAB	☐ SHELBY TUBE	☐ SPLIT SPOON	☐ BULK	☐ NO RECOVERY	☐ CORE	
BACKFILL TYPE		☒ BENTONITE	☐ GRAVEL	☐ SLOUGH	☐ GROUT	☐ CUTTINGS	☐ SAND	

DEPTH (m)	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #	VAPOUR READINGS	COMMENTS	ELEVATION (m)
50							224
51							223
52							222
53							221
54							220
55							219
56							218
57		-Hole not daylighted and no utility locates completed -UTM coordinate and elevation data surveyed by David Atkinson (AECOM) -Bru 95-6 Water Well Tag Number: 4506 -0.13m (5") diameter surface casing was installed from surface to 0.91m below the top of the limestone contact. The annulus between the surface casing and the borehole wall was sealed with bentonite-cement grout. -Drilling through overburden was conducted using a 7 7/8th inch outer diameter tricone drill bit. A 6 1/4 inch (OD) tricone bit was using to advance the hole 0.91m into the limestone unit to create a "socket" for the bottom of the 5" PVC casing to rest in. The remainder of the hole was drilled using a 4 3/4 inch (OD) PDC cutting drag bit. -Grab samples of cuttings were collected for logging purposes only.					
58		Monitoring well completion details: Well Stick-up: 0.802 m AGS 2" Diameter PVC well pipe, Schedule 40, 10-slot screen Bentonite-cement grout: 0 - 50.29 m BGS Sand: 50.29 - 57.00 m BGS Screen: 52.45 - 55.50 m BGS End of Bore: 57.00 m BGS					
59							216
60							

	LOGGED BY: Stephen Dickin	COMPLETION DEPTH: 57.00 m
	REVIEWED BY: Reuben Dandurand	COMPLETION DATE: 11/13/20
	PROJECT ENGINEER: Ryan Mills	Page 6 of 7

PROJECT: Vivian Sand Facility Project			CLIENT: CanWhite Sands Corp.			TESTHOLE NO: Bru 95-6		
LOCATION: Vivian, MB N 5,527,624.0 E 682,199.0						PROJECT NO.: 60640258		
CONTRACTOR: Friesen Drillers Ltd.			METHOD: Mud Rotary			ELEVATION (m): 275.041		
SAMPLE TYPE			☒ GRAB	☐ SHELBY TUBE	☐ SPLIT SPOON	☐ BULK	☐ NO RECOVERY	☐ CORE
BACKFILL TYPE			☒ BENTONITE	☐ GRAVEL	☐ SLOUGH	☐ GROUT	☐ CUTTINGS	☐ SAND

DEPTH (m)	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #	VAPOUR READINGS	COMMENTS	ELEVATION (m)
60		Depth to water: 8.42 m BGS on Nov 15, 2020 2:20 PM Top of Pipe Elevation: 275.843 m ASL					
61							214
62							213
63							212
64							211
65							210
66							209
67							208
68							207
69							206
70							

	LOGGED BY: Stephen Dickinson	COMPLETION DEPTH: 57.00 m
	REVIEWED BY: Reuben Dandurand	COMPLETION DATE: 11/13/20
	PROJECT ENGINEER: Ryan Mills	Page 7 of 7

ENVIRO (VAPOUR/F2/F3) 60640258 CANWHITE MW.GPJ UMA.GDT 2/9/21

PROJECT: Vivian Sand Facility Project			CLIENT: CanWhite Sands Corp.			TESTHOLE NO: Bru 95-7		
LOCATION: Vivian, MB N 5,527,612.0 E 681,865.0						PROJECT NO.: 60640258		
CONTRACTOR: Friesen Drillers Ltd.			METHOD: Dual Rotary			ELEVATION (m): 277.12		
SAMPLE TYPE		☒ GRAB	☐ SHELBY TUBE	☐ SPLIT SPOON	☐ BULK	☐ NO RECOVERY	☐ CORE	
BACKFILL TYPE		☒ BENTONITE	☐ GRAVEL	☐ SLOUGH	☐ GROUT	☐ CUTTINGS	☐ SAND	

DEPTH (m)	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #	VAPOUR READINGS	COMMENTS	ELEVATION (m)
0		SAND & GRAVEL -Brown -Non-cohesive, non-plastic					277
1							276
2							275
3							274
4							273
5							272
6		SILTY SAND -Grey					271
7							270
8							269
9		CLAY -Grey					268
10							

ENVIRO (VAPOUR/F2/F3) 60640258 CANWHITE MW.GPJ UMA.GDT 2/7/21



LOGGED BY: Reuben Dandurand	COMPLETION DEPTH: 74.98 m
REVIEWED BY: Reuben Dandurand	COMPLETION DATE: 11/23/20
PROJECT ENGINEER: Ryan Mills	Page 1 of 8

PROJECT: Vivian Sand Facility Project			CLIENT: CanWhite Sands Corp.			TESTHOLE NO: Bru 95-7		
LOCATION: Vivian, MB N 5,527,612.0 E 681,865.0						PROJECT NO.: 60640258		
CONTRACTOR: Friesen Drillers Ltd.			METHOD: Dual Rotary			ELEVATION (m): 277.12		
SAMPLE TYPE		☒ GRAB	☐ SHELBY TUBE	☐ SPLIT SPOON	☐ BULK	☐ NO RECOVERY	☐ CORE	
BACKFILL TYPE		☒ BENTONITE	☐ GRAVEL	☐ SLOUGH	☐ GROUT	☐ CUTTINGS	☐ SAND	

DEPTH (m)	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #	VAPOUR READINGS	COMMENTS	ELEVATION (m)
10							267
11							266
12			☒				265
13							264
14							263
15			☒				262
16		SILTY SAND with gravel -Grey					261
17							260
18			☒				259
19							258
20							

ENVIRO (VAPOUR/F2/F3) 60640258 CANWHITE MW.GPJ UMA.GDT 2/7/21

LOGGED BY: Reuben Dandurand	COMPLETION DEPTH: 74.98 m
REVIEWED BY: Reuben Dandurand	COMPLETION DATE: 11/23/20
PROJECT ENGINEER: Ryan Mills	Page 2 of 8

PROJECT: Vivian Sand Facility Project			CLIENT: CanWhite Sands Corp.			TESTHOLE NO: Bru 95-7		
LOCATION: Vivian, MB N 5,527,612.0 E 681,865.0						PROJECT NO.: 60640258		
CONTRACTOR: Friesen Drillers Ltd.			METHOD: Dual Rotary			ELEVATION (m): 277.12		
SAMPLE TYPE			☒ GRAB	☐ SHELBY TUBE	☐ SPLIT SPOON	☐ BULK	☐ NO RECOVERY	☐ CORE
BACKFILL TYPE			☒ BENTONITE	☐ GRAVEL	☐ SLOUGH	☐ GROUT	☐ CUTTINGS	☐ SAND

DEPTH (m)	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #	VAPOUR READINGS	COMMENTS	ELEVATION (m)
20							257
21							256
22							255
23		SILTY SAND with gravel and boulders -Grey					254
24							253
25							252
26							251
27							250
28							249
29							248
30							

ENVIRO (VAPOUR/F2/F3) 60640258 CANWHITE MW.GPJ UMA.GDT 2/7/21



PROJECT: Vivian Sand Facility Project			CLIENT: CanWhite Sands Corp.			TESTHOLE NO: Bru 95-7		
LOCATION: Vivian, MB N 5,527,612.0 E 681,865.0						PROJECT NO.: 60640258		
CONTRACTOR: Friesen Drillers Ltd.			METHOD: Dual Rotary			ELEVATION (m): 277.12		
SAMPLE TYPE		☒ GRAB	☐ SHELBY TUBE	☐ SPLIT SPOON	☐ BULK	☐ NO RECOVERY	☐ CORE	
BACKFILL TYPE		☒ BENTONITE	☐ GRAVEL	☐ SLOUGH	☐ GROUT	☐ CUTTINGS	☐ SAND	

DEPTH (m)	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #	VAPOUR READINGS	COMMENTS	ELEVATION (m)
30							247
31							246
32							245
33							244
34							243
35							242
36		LIMESTONE -Beige -Minor weathering -Competent rock					241
37							240
38							239
39							238
40							

ENVIRO (VAPOUR/F2/F3) 60640258 CANWHITE MW.GPJ UMA.GDT 2/7/21



LOGGED BY: Reuben Dandurand	COMPLETION DEPTH: 74.98 m
REVIEWED BY: Reuben Dandurand	COMPLETION DATE: 11/23/20
PROJECT ENGINEER: Ryan Mills	Page 4 of 8

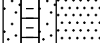
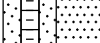
PROJECT: Vivian Sand Facility Project			CLIENT: CanWhite Sands Corp.			TESTHOLE NO: Bru 95-7		
LOCATION: Vivian, MB N 5,527,612.0 E 681,865.0						PROJECT NO.: 60640258		
CONTRACTOR: Friesen Drillers Ltd.			METHOD: Dual Rotary			ELEVATION (m): 277.12		
SAMPLE TYPE		☒ GRAB	☐ SHELBY TUBE	☐ SPLIT SPOON	☐ BULK	☐ NO RECOVERY	☐ CORE	
BACKFILL TYPE		☒ BENTONITE	☐ GRAVEL	☐ SLOUGH	☐ GROUT	☐ CUTTINGS	☐ SAND	

DEPTH (m)	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #	VAPOUR READINGS	COMMENTS	ELEVATION (m)
40							237
41							236
42							235
43							234
44							233
45							232
46							231
47							230
48							229
49							228
50		SHALE -Reddish brown -Highly weathered, can be shaped/peeled with a knife -Cuttings are cohesive and exhibit high plasticity					

	LOGGED BY: Reuben Dandurand	COMPLETION DEPTH: 74.98 m
	REVIEWED BY: Reuben Dandurand	COMPLETION DATE: 11/23/20
	PROJECT ENGINEER: Ryan Mills	Page 5 of 8

ENVIRO (VAPOUR/F2/F3) 60640258 CANWHITE MW.GPJ UMA.GDT 2/7/21

PROJECT: Vivian Sand Facility Project			CLIENT: CanWhite Sands Corp.			TESTHOLE NO: Bru 95-7		
LOCATION: Vivian, MB N 5,527,612.0 E 681,865.0						PROJECT NO.: 60640258		
CONTRACTOR: Friesen Drillers Ltd.			METHOD: Dual Rotary			ELEVATION (m): 277.12		
SAMPLE TYPE		☒ GRAB	☐ SHELBY TUBE	☐ SPLIT SPOON	☐ BULK	☐ NO RECOVERY	☐ CORE	
BACKFILL TYPE		☒ BENTONITE	☐ GRAVEL	☐ SLOUGH	☐ GROUT	☐ CUTTINGS	☐ SAND	

DEPTH (m)	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #	VAPOUR READINGS	COMMENTS	ELEVATION (m)
50		SANDSTONE -White -Fine grained -Well sorted -Weakly cemented, low strength	☒				227
51							226
52							225
53							224
54							223
55							222
56							221
57							220
58							219
59							218
60							

	LOGGED BY: Reuben Dandurand	COMPLETION DEPTH: 74.98 m
	REVIEWED BY: Reuben Dandurand	COMPLETION DATE: 11/23/20
	PROJECT ENGINEER: Ryan Mills	Page 6 of 8

ENVIRO (VAPOUR/F2/F3) 60640258 CANWHITE MW.GPJ UMA.GDT 2/7/21

PROJECT: Vivian Sand Facility Project			CLIENT: CanWhite Sands Corp.			TESTHOLE NO: Bru 95-7		
LOCATION: Vivian, MB N 5,527,612.0 E 681,865.0						PROJECT NO.: 60640258		
CONTRACTOR: Friesen Drillers Ltd.			METHOD: Dual Rotary			ELEVATION (m): 277.12		
SAMPLE TYPE		☒ GRAB	☐ SHELBY TUBE	☐ SPLIT SPOON	☐ BULK	☐ NO RECOVERY	☐ CORE	
BACKFILL TYPE		☒ BENTONITE	☐ GRAVEL	☐ SLOUGH	☐ GROUT	☐ CUTTINGS	☐ SAND	

DEPTH (m)	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #	VAPOUR READINGS	COMMENTS	ELEVATION (m)
60							217
61							216
62							215
63							214
64							213
65							212
66							211
67							210
68							209
69							208
70							

	LOGGED BY: Reuben Dandurand	COMPLETION DEPTH: 74.98 m
	REVIEWED BY: Reuben Dandurand	COMPLETION DATE: 11/23/20
	PROJECT ENGINEER: Ryan Mills	Page 7 of 8

ENVIRO (VAPOUR/F2/F3) 60640258 CANWHITE MW.GPJ UMA.GDT 2/7/21

PROJECT: Vivian Sand Facility Project			CLIENT: CanWhite Sands Corp.			TESTHOLE NO: Bru 95-7		
LOCATION: Vivian, MB N 5,527,612.0 E 681,865.0						PROJECT NO.: 60640258		
CONTRACTOR: Friesen Drillers Ltd.			METHOD: Dual Rotary			ELEVATION (m): 277.12		
SAMPLE TYPE		☒ GRAB	☐ SHELBY TUBE	☐ SPLIT SPOON	☐ BULK	☐ NO RECOVERY	☐ CORE	
BACKFILL TYPE		☒ BENTONITE	☐ GRAVEL	☐ SLOUGH	☐ GROUT	☐ CUTTINGS	☐ SAND	

DEPTH (m)	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #	VAPOUR READINGS	COMMENTS	ELEVATION (m)
70							207
71							206
72							205
73		- The presence of several thin shale interbeds were noted between 72.24 m and 74.68. the thickness of the shale interbeds increased with depth					204
74							203
75		SHALE					202
76		-Hole not daylighted and no utility locates completed -UTM coordinate and elevation data surveyed by David Atkinson (AECOM) -Bru 95-7 Water Well Tag Number: 4560 - A surface seal was completed to a depth of 7.62 m (25ft) BGS using 0.51 m (20") diameter tricone drill bit and bentonite-cement grout. -Casing diameter (i.e. borehole diameter): 0.41 m (16") -Grab samples of cuttings were collected for logging purposes only. -Well development was completed using airlift and cable tool methods Water supply well completion details: Well Stick-up: 0.807 m AGS 0.305 m (12") Diameter steel well pipe 0.305 m (12") Diameter stainless Steel Wirewound Screen, 15 slot Bentonite-cement grout: 0 - 52.43 m BGS Silica sand (0.55): 52.43 - 74.98 m BGS Screen: 53.95 - 72.24 m BGS End of Bore: 74.98 m BGS Depth to water: 10.958 m BGS on Nov 25, 2020 12:55 PM Top of Pipe Elevation: 277.927 m ASL				201	
77							200
78							199
79							198
80							

	LOGGED BY: Reuben Dandurand	COMPLETION DEPTH: 74.98 m
	REVIEWED BY: Reuben Dandurand	COMPLETION DATE: 11/23/20
	PROJECT ENGINEER: Ryan Mills	Page 8 of 8

Project: Vivian Sand Facility Project

Project Location: Vivian, MB

Project Number: 60640258

Log of Bru 95-8

Sheet 1 of 10

Date(s) Drilled	Nov 16 to 19, 2020	Logged By	Reuben Dandurand	Checked By	Stephen Dickin
Drilling Method	Rotary	Drill Bit Size/Type	See notes at bottom	Total Depth Drilled (meters)	55.1
Drill Rig Type	Acker MP8	Drilling Contractor	Paddock Drilling Ltd.	Approximate Surface Elevation	277.3 m
Groundwater Level		Borehole Backfill	Bentonite-Cement Grout	Inclination from Horizontal/Bearing	Vertical
Location	681953 E 5527630 N			Hammer Data	N/A

Elevation, meters	Depth, meters	ROCK CORE						Lithology	MATERIAL DESCRIPTION	Discontinuity Description								REMARKS AND OTHER TESTS		
		Run No.	Recovery, %	RQD, %	Fractures/Run	Strength Index	Weathering Index			Type	Alpha, °	Surface Shape	Surface Roughness	Infill Type	Thickness Rating	Openness Rating	Jr		Ja	Jn
277.3	0								SAND & GRAVEL -Brown -Non-cohesive, non-plastic											
278.3	1																			
279.3	2																			
280.3	3																			
281.3	4																			
282.3	5																			

GEO_CORE_BURNABY_BRE_C:\USERS\REUBEN.DANDURAND\DOCUMENTS\GINT\60640258_CANWHITE_BRU_95-8.GPJ_URSSEA3.GLB_BRE_TINNEL_FS.GDT_1/21/21

Project: Vivian Sand Facility Project

Project Location: Vivian, MB

Project Number: 60640258

Log of Bru 95-8

Sheet 2 of 10

GEO_CORE_BURNABY_BRE C:\USERS\REUBEN.DANDURAND\DOCUMENTS\GINT\60640258 CANWHITE BRU 95-8.GPJ URSSEA3.GLB BRE TINNEL FS.GDT 1/21/21

Elevation, meters	Depth, meters	ROCK CORE						Lithology	MATERIAL DESCRIPTION	Discontinuity Description										REMARKS AND OTHER TESTS		
		Run No.	Recovery, %	RQD, %	Fractures/Run	Strength Index	Weathering Index			Type	Alpha, °	Surface Shape	Surface Roughness	Infill Type	Thickness Rating	Openness Rating	Jr	Ja	Jn		Jcon	
282.3	5																					
283.3	6																					
284.3	7								SILTY SAND -Grey													
285.3	8																					
286.3	9								CLAY -Grey													
287.3	10																					
288.3	11																					

Project: Vivian Sand Facility Project

Project Location: Vivian, MB

Project Number: 60640258

Log of Bru 95-8

Sheet 3 of 10

GEO_CORE_BURNABY_BRE C:\USERS\REUBEN.DANDURAND\DOCUMENTS\GINT\60640258 CANWHITE BRU 95-8.GPJ_URSSEA3.GLB BRE TINNEL FS.GDT 1/21/21

Elevation, meters	Depth, meters	ROCK CORE						MATERIAL DESCRIPTION	Discontinuity Description										REMARKS AND OTHER TESTS		
		Run No.	Recovery, %	RQD, %	Fractures/Run	Strength Index	Weathering Index		Lithology	Type	Alpha, °	Surface Shape	Surface Roughness	Infill Type	Thickness Rating	Openess Rating	Jr	Ja		Jn	Jcon
289.3	12																				
290.3	13																				
291.3	14	R12	0	0		-	-														
		R13	0	0		-	-														
292.3	15																				
293.3	16							SILTY SAND with gravel -Grey													
294.3	17																				

Project: Vivian Sand Facility Project

Project Location: Vivian, MB

Project Number: 60640258

Log of Bru 95-8

Sheet 4 of 10

GEO_CORE_BURNABY_BRE C:\USERS\REUBEN.DANDURAND\DOCUMENTS\GINT\60640258 CANWHITE BRU 95-8.GPJ_URSSEA3.GLB BRE TINNEL FS.GDT 1/21/21

Elevation, meters	Depth, meters	ROCK CORE						Lithology	MATERIAL DESCRIPTION	Discontinuity Description										REMARKS AND OTHER TESTS	
		Run No.	Recovery, %	RQD, %	Fractures/Run	Strength Index	Weathering Index			Type	Alpha, °	Surface Shape	Surface Roughness	Infill Type	Thickness Rating	Openness Rating	Jr	Ja	Jn		Jcon
295.3	18																				
296.3	19																				
297.3	20																				
298.3	21																				
299.3	22																				
300.3	23							SILTY SAND with gravel and boulders Grey													

Project: Vivian Sand Facility Project

Project Location: Vivian, MB

Project Number: 60640258

Log of Bru 95-8

Sheet 5 of 10

Elevation, meters	Depth, meters	ROCK CORE						MATERIAL DESCRIPTION	Discontinuity Description										REMARKS AND OTHER TESTS		
		Run No.	Recovery, %	RQD, %	Fractures/Run	Strength Index	Weathering Index		Lithology	Type	Alpha, °	Surface Shape	Surface Roughness	Infill Type	Thickness Rating	Openness Rating	Jr	Ja		Jn	Jcon
301.3	24																				
302.3	25																				
303.3	26																				
304.3	27																				
305.3	28																				
306.3	29																				
307.3	30																				

GEO_CORE_BURNABY BRE C:\USERS\REUBEN.DANDURAND\DOCUMENTS\GINT\60640258 CANWHITE BRU 95-8.GPJ_URSSEA3.GLB BRE TINNEL FS.GDT 1/21/21

Project: Vivian Sand Facility Project

Project Location: Vivian, MB

Project Number: 60640258

Log of Bru 95-8

Sheet 6 of 10

GEO_CORE_BURNABY_BRE C:\USERS\REUBEN.DANDURAND\DOCUMENTS\GINT\60640258 CANWHITE BRU 95-8.GPJ URSSEA3.GLB BRE TINNEL FS.GDT 1/21/21

Elevation, meters	Depth, meters	ROCK CORE						Lithology	MATERIAL DESCRIPTION	Discontinuity Description											REMARKS AND OTHER TESTS		
		Run No.	Recovery, %	RQD, %	Fractures/Run	Strength Index	Weathering Index			Type	Alpha, °	Surface Shape	Surface Roughness	Infill Type	Thickness Rating	Openess Rating	Jr	Ja	Jn	Jcon			
307.3	30																						
308.3	31																						
309.3	32																						
									WEATHERED / INCOMPETENT BEDROCK														
310.3	33																						
311.3	34																						
312.3	35																						
															</								

Project: Vivian Sand Facility Project

Project Location: Vivian, MB

Project Number: 60640258

Log of Bru 95-8

Sheet 7 of 10

Elevation, meters	Depth, meters	ROCK CORE						MATERIAL DESCRIPTION	Discontinuity Description											REMARKS AND OTHER TESTS
		Run No.	Recovery, %	RQD, %	Fractures/Run	Strength Index	Weathering Index		Type	Alpha, °	Surface Shape	Surface Roughness	Infill Type	Thickness Rating	Openness Rating	Jr	Ja	Jn	Jcon	
314.3	37	R1	68	48		R4	W2	LIMESTONE -Beige -Minor weathering -Competent rock	FRZ	90	U	R	Cm St	T4	A4	3	10	3	0	36.49 m BGS
									JN	90	P	R	Ox	T0	A3	1.5	4	3	10	36.97 m BGS
									JN	90	U	R	-	T0	A2	3	0	3	10	37.35 m BGS
									JN	60	U	R	-	T0	A3	3	0	3	10	37.44 m BGS
315.3	38	R2	100	83	6	R4	W2	Small vugs (<2mm)	JN	90	U	R	-	T0	A2	3	0	3	10	37.55 m BGS
									JN	90	U	R	-	T0	A3	3	0	3	10	37.79 m BGS
									JN	90	U	R	-	T0	A2	3	0	3	10	38.15 m BGS
									JN	88	U	R	Cm	T1	A2	3	4	2	10	38.47 m BGS
316.3	39				5			Clay rich beds 5 cm thick	JN	90	U	R	Ox	T1	A1	3	1	2	25	38.71 m BGS
									JN	90	U	R	Cm Ox	T2	A2	3	4	2	10	38.84 m BGS
									JN	90	U	S	Cm	T1	A2	3	4	2	10	38.93 m BGS
		R3	100	94		R4	W2													
317.3	40								JN	90	U	S	Ox	T1	A2	3	1	2	10	39.8 m BGS
									JN	90	U	S	Cm Ox	T1	A2	3	4	2	10	40.16 m BGS
									JN	90	P	S	Cm	T1	A2	1	4	2	10	40.63 m BGS
		R4	100	100	4	R3	W2													
318.3	41							Bedding is horizontal/planar, fractures align with bedding	JN	90	P	S	Ox	T1	A2	1	1	2	10	41.03 m BGS
									JN	88	U	VR	Ox	T1	A2	3	0.75	2	10	41.26 m BGS
									JN	90	P	S	-	T0	A1	1	0	2	25	41.55 m BGS
									JN	90	P	P	-	T0	A1	.5	0	2	5	42.01 m BGS
319.3	42	R5	100	93		R4	W2													
									JN	85	U	R	-	T0	A2	3	0	2	10	42.41 m BGS
									JN	90	P	K	Ox Cm	T2	A2	0.5	4	2	5	42.45 m BGS
																				42.51 m BGS

GEO_CORE_BURNABY_BRE C:\USERS\REUBEN.DANDURAND\DOCUMENTS\GINT\60640258 CANWHITE BRU 95-8.GPJ_URSSEA3.GLB BRE TINNEL FS.GDT 1/21/21

Project: Vivian Sand Facility Project

Project Location: Vivian, MB

Project Number: 60640258

Log of Bru 95-8

Sheet 8 of 10

GEO_CORE_BURNABY_BRE_C:\USERS\REUBEN.DANDURAND\DOCUMENTS\GINT\60640258_CANWHITE_BRU_95-8.GPJ_URSSEA3.GLB_BRE_TUNNEL_FS.GDT 1/21/21

Elevation, meters	Depth, meters	ROCK CORE						MATERIAL DESCRIPTION	Discontinuity Description											REMARKS AND OTHER TESTS
		Run No.	Recovery, %	RQD, %	Fractures/Run	Strength Index	Weathering Index		Lithology	Type	Alpha, °	Surface Shape	Surface Roughness	Infill Type	Thickness Rating	Openness Rating	Jr	Ja	Jn	
320.3	43	R5	100	93	5	R4	W2		JN 88	P	S	-	T0	A2	1	0	2	10	43.18 m BGS 43.23 m BGS 43.25 m BGS	
					6				JN 83	P	S	Cm	T1	A2	1	4	2	10		
									JN 90	U	R	Ox	T1	A3	3	4	2	10		
321.3	44	R6	100	91		R4	W2		JN 90	P	S	-	T0	A2	1	0	2	10	43.82 m BGS 43.9 m BGS 44.02 m BGS	
									JN 90	P	S	Cm	T1	A3	1	4	2	10		
									JN 90	P	S	Cm Ox	T1	A2	1	4	2	25		
322.3	45	R7	100	90		R3	W2		JN 90	U	S	Cm Ox	T5	A5	2	14	2	0	44.8 m BGS	
					4				JN 90	P	S	Cm Ox	T1	A1	1	4	2	10		
									JN 90	P	K	Cm	T2	A1	0.5	4	2	5		
323.3	46								JN 90	P	S	Cm	T2	A1	1	4	2	10	45.54 m BGS 45.65 m BGS 45.8 m BGS	
324.3	47	R8	100	97	4	R4	W2	Shale Bed 5 cm thick	JN 80	P	R	-	T0	A2	1.5	0	2	10	46.39 m BGS 46.72 m BGS 46.77 m BGS 46.89 m BGS	
									JN 90	P	P	Cm Ox	T1	A1	0.5	4	2	5		
									JN 90	P	S	Cm	T2	A2	1	8	2	10		
325.3	48								JN 90	P	S	Cm Ox	T2	A2	1	8	2	10	47.76 m BGS 48.13 m BGS	
		R9	87	81	3	R3	W2	INTERBEDDED LIMESTONE & SHALE											48.79 m BGS	
								Trace sulphides noted along joint plane	JN 90	P	R	Cm Ox	T3	A3	1.5	12	2	5		

Project: Vivian Sand Facility Project

Project Location: Vivian, MB

Project Number: 60640258

Log of Bru 95-8

Sheet 9 of 10

Elevation, meters	Depth, meters	ROCK CORE						Lithology	MATERIAL DESCRIPTION	Discontinuity Description											REMARKS AND OTHER TESTS			
		Run No.	Recovery, %	RQD, %	Fractures/Run	Strength Index	Weathering Index			Type	Alpha, °	Surface Shape	Surface Roughness	Infill Type	Thickness Rating	Openness Rating	Jr	Ja	Jn	Jcon				
326.3	49	R9	87	81			R3 W2	SHALE -Reddish brown -Highly weathered, can be shaped/peeled with a knife -Cuttings are cohesive and exhibit high plasticity																
									JN	30	P	S	Cm	T1	A1	1	4	3	10	49.57 m BGS				
									JN	90	P	R	Cm Ox	T2	A2	1.5	8	3	10	49.64 m BGS				
327.3	50	R10	100	98	3		R1 W4		JN	90	P	K	Cm Ox	T2	A2	0.5	8	3	5	50.04 m BGS				
328.3	51							Sand bed 10 cm thick Blue and very clayey below sand bed																
		R11	95	83			R1 W3																	
329.3	52				3				FR	85	U	S	Ox	T1	A2	2	4	2	10	51.83 m BGS				
									FR	90	U	S	Ox	T2	A2	2	8	2	10	51.86 m BGS				
									FR	90	U	S	Ox	T1	A2	2	4	2	10	51.88 m BGS				
330.3	53							SANDSTONE -White -Fine grained -Well sorted -Weakly cemented, low strength																
								borehole will not stay open without drill mud																
331.3	54																							
332.3	55																							

Project: Vivian Sand Facility Project

Project Location: Vivian, MB

Project Number: 60640258

Log of Bru 95-8

Sheet 10 of 10

GEO_CORE_BURNABY_BRE C:\USERS\REUBEN.DANDURAND\DOCUMENTS\GINT\60640258 CANWHITE BRU 95-8.GPJ_URSSEA3.GLB BRE TINNEL FS.GDT 1/21/21

Elevation, meters	Depth, meters	ROCK CORE						Lithology	MATERIAL DESCRIPTION	Discontinuity Description										REMARKS AND OTHER TESTS																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																											
		Run No.	Recovery, %	RQD, %	Fractures/Run	Strength Index	Weathering Index			Type	Alpha, °	Surface Shape	Surface Roughness	Infill Type	Thickness Rating	Openness Rating	Jr	Ja	Jn		Jcon																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																										
332.3	55							•		○																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																					

PROJECT: Vivian Sand Facility Project			CLIENT: CanWhite Sands Corp.			TESTHOLE NO: Bru 95-9		
LOCATION: Vivian, MB N 5,527,621.0 E 682,203.0						PROJECT NO.: 60640258		
CONTRACTOR: Friesen Drillers Ltd.			METHOD: Mud Rotary			ELEVATION (m): 275.191		
SAMPLE TYPE		☒ GRAB	☐ SHELBY TUBE	☐ SPLIT SPOON	☐ BULK	☐ NO RECOVERY	☐ CORE	
BACKFILL TYPE		☒ BENTONITE	☐ GRAVEL	☐ SLOUGH	☐ GROUT	☐ CUTTINGS	☐ SAND	

DEPTH (m)	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #	VAPOUR READINGS	COMMENTS	ELEVATION (m)
0		SAND, fine grained with minor (15%) medium sand -White -Loose -Non-cohesive, non-plastic					275
1							274
2							273
3							272
4							271
5							270
6							269
7		SILTY CLAY with fine sand (20%), trace gravel and cobbles (5%) -Brown -Medium dense -Cohesive, medium to high plasticity					268
8							267
9							266
10							

LOGGED BY: Reuben Dandurand	COMPLETION DEPTH: 48.16 m
REVIEWED BY: Stephen Dickin	COMPLETION DATE: 11/23/20
PROJECT ENGINEER: Ryan Mills	Page 1 of 6

ENVIRO (VAPOUR/F2/F3) 60640258 CANWHITE MW.GPJ UMA.GDT 2/7/21

PROJECT: Vivian Sand Facility Project				CLIENT: CanWhite Sands Corp.				TESTHOLE NO: Bru 95-9			
LOCATION: Vivian, MB N 5,527,621.0 E 682,203.0								PROJECT NO.: 60640258			
CONTRACTOR: Friesen Drillers Ltd.				METHOD: Mud Rotary				ELEVATION (m): 275.191			
SAMPLE TYPE		☒ GRAB	☐ SHELBY TUBE	☐ SPLIT SPOON	☐ BULK	☐ NO RECOVERY	☐ CORE				
BACKFILL TYPE		☒ BENTONITE	☐ GRAVEL	☐ SLOUGH	☐ GROUT	☐ CUTTINGS	☐ SAND				
DEPTH (m)	SOIL SYMBOL	SOIL DESCRIPTION				SAMPLE TYPE	SAMPLE #	VAPOUR READINGS	COMMENTS	ELEVATION (m)	
10		SILTY MEDIUM TO COARSE SAND, -Brown -Medium dense -Slightly plastic, cohesive								265	
11										264	
12										263	
13										262	
14										261	
15										260	
16										259	
17										258	
18										257	
19										256	
20		SILTY CLAY with sand (20%) and trace gravel/cobbles (5%) -Brown -Dense -Plastic, cohesive								256	
						LOGGED BY: Reuben Dandurand		COMPLETION DEPTH: 48.16 m			
						REVIEWED BY: Stephen Dickin		COMPLETION DATE: 11/23/20			
						PROJECT ENGINEER: Ryan Mills		Page 2 of 6			

PROJECT: Vivian Sand Facility Project				CLIENT: CanWhite Sands Corp.				TESTHOLE NO: Bru 95-9			
LOCATION: Vivian, MB N 5,527,621.0 E 682,203.0								PROJECT NO.: 60640258			
CONTRACTOR: Friesen Drillers Ltd.				METHOD: Mud Rotary				ELEVATION (m): 275.191			
SAMPLE TYPE		☒ GRAB	☐ SHELBY TUBE	☐ SPLIT SPOON	☐ BULK	☐ NO RECOVERY	☐ CORE				
BACKFILL TYPE		☒ BENTONITE	☐ GRAVEL	☐ SLOUGH	☐ GROUT	☐ CUTTINGS	☐ SAND				

DEPTH (m)	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #	VAPOUR READINGS	COMMENTS	ELEVATION (m)
20							255
21							254
22							253
23							252
24							251
25		COARSE SAND AND GRAVEL -Brown -Loose -Non-plastic, non-cohesive					250
26							249
27							248
28							247
29							246
30							



LOGGED BY: Reuben Dandurand
 REVIEWED BY: Stephen Dickin
 PROJECT ENGINEER: Ryan Mills

COMPLETION DEPTH: 48.16 m
 COMPLETION DATE: 11/23/20
 Page 3 of 6

ENVIRO (VAPOUR/F2/F3) 60640258 CANWHITE MW.GPJ UMA.GDT 2/7/21

PROJECT: Vivian Sand Facility Project			CLIENT: CanWhite Sands Corp.			TESTHOLE NO: Bru 95-9		
LOCATION: Vivian, MB N 5,527,621.0 E 682,203.0						PROJECT NO.: 60640258		
CONTRACTOR: Friesen Drillers Ltd.			METHOD: Mud Rotary			ELEVATION (m): 275.191		
SAMPLE TYPE		☒ GRAB	☐ SHELBY TUBE	☐ SPLIT SPOON	☐ BULK	☐ NO RECOVERY	☐ CORE	
BACKFILL TYPE		☒ BENTONITE	☐ GRAVEL	☐ SLOUGH	☐ GROUT	☐ CUTTINGS	☐ SAND	

DEPTH (m)	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #	VAPOUR READINGS	COMMENTS	ELEVATION (m)
30							245
31							244
32							243
33							242
34							241
35							240
36		LIMESTONE -Beige -Minor weathering -Competent rock					239
37							238
38							237
39							236
40							



LOGGED BY: Reuben Dandurand
 REVIEWED BY: Stephen Dickin
 PROJECT ENGINEER: Ryan Mills

COMPLETION DEPTH: 48.16 m
 COMPLETION DATE: 11/23/20
 Page 4 of 6

ENVIRO (VAPOUR/F2/F3) 60640258 CANWHITE MW.GPJ UMA.GDT 2/7/21

ENVIRO (VAPOUR/F2/F3) 60640258 CANWHITE MW.GPJ UMA.GDT 2/7/21

PROJECT: Vivian Sand Facility Project			CLIENT: CanWhite Sands Corp.			TESTHOLE NO: Bru 95-9		
LOCATION: Vivian, MB N 5,527,621.0 E 682,203.0						PROJECT NO.: 60640258		
CONTRACTOR: Friesen Drillers Ltd.			METHOD: Mud Rotary			ELEVATION (m): 275.191		
SAMPLE TYPE		☒ GRAB	☐ SHELBY TUBE	☐ SPLIT SPOON	☐ BULK	☐ NO RECOVERY	☐ CORE	
BACKFILL TYPE		☒ BENTONITE	☐ GRAVEL	☐ SLOUGH	☐ GROUT	☐ CUTTINGS	☐ SAND	

DEPTH (m)	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #	VAPOUR READINGS	COMMENTS	ELEVATION (m)
40							235
41							234
42							233
43							232
44							231
45							230
46							229
47		SHALE -Redish brown -Soft -Highly plastic -Wet					228
48		Hole not daylighted and no utility locates completed -UTM coordinate and elevation data surveyed by David Atkinson (AECOM) -Bru 95-9 Water Well Tag Number: 4544 -Bru 95-9 is located adjacent to deeper well Bru 95-6 -0.13m (5") diameter surface casing was installed from surface to 0.91m below the top of the limestone contact. The annulus between the surface casing and the borehole wall was sealed with bentonite-cement grout. -Drilling through overburden was conducted using a 7 7/8th inch outer diameter tricone drill bit. A 6 1/4 inch (OD) tricone bit was used to advance the hole 0.91m into the limestone unit to create a "socket" for the bottom of the 0.13m (5") PVC casing to rest in. The remainder of the hole was drilled using a 4 3/4 inch (OD) PDC cutting drag bit.					227
49							226
50							

		LOGGED BY: Reuben Dandurand	COMPLETION DEPTH: 48.16 m
		REVIEWED BY: Stephen Dickin	COMPLETION DATE: 11/23/20
		PROJECT ENGINEER: Ryan Mills	Page 5 of 6

PROJECT: Vivian Sand Facility Project			CLIENT: CanWhite Sands Corp.			TESTHOLE NO: Bru 95-9		
LOCATION: Vivian, MB N 5,527,621.0 E 682,203.0						PROJECT NO.: 60640258		
CONTRACTOR: Friesen Drillers Ltd.			METHOD: Mud Rotary			ELEVATION (m): 275.191		
SAMPLE TYPE		☒ GRAB	☐ SHELBY TUBE	☐ SPLIT SPOON	☐ BULK	☐ NO RECOVERY	☐ CORE	
BACKFILL TYPE		☒ BENTONITE	☐ GRAVEL	☐ SLOUGH	☐ GROUT	☐ CUTTINGS	☐ SAND	

DEPTH (m)	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #	VAPOUR READINGS	COMMENTS	ELEVATION (m)
50		-Grab samples of cuttings were collected for logging purposes only.					225
51		Monitoring well completion details: Well Stick-up: 0.653 m AGS 2" Diameter PVC well pipe, Schedule 40, 10 slot Bentonite-cement grout: 0 - 47.24 m BGS Sand: 47.24 - 48.16 m BGS Screen: 47.85 - 48.16 m BGS End of Bore: 48.16 m BGS Depth to water: 11.478 m BGS on Nov 25, 2020 10:37 AM Top of Pipe Elevation: 275.844 m ASL					224
52							223
53							222
54							221
55							220
56							219
57							218
58							217
59							216
60							

	LOGGED BY: Reuben Dandurand	COMPLETION DEPTH: 48.16 m
	REVIEWED BY: Stephen Dickin	COMPLETION DATE: 11/23/20
	PROJECT ENGINEER: Ryan Mills	Page 6 of 6

PROJECT: Vivian Sand Facility Project			CLIENT: CanWhite Sands Corp.			TESTHOLE NO: Bru 96-1		
LOCATION: Vivian, MB N 5,527,787.0 E 683,064.0						PROJECT NO.: 60640258		
CONTRACTOR: Friesen Drillers Ltd.			METHOD: Mud Rotary			ELEVATION (m): 273.215		
SAMPLE TYPE		☒ GRAB	☐ SHELBY TUBE	☐ SPLIT SPOON	☐ BULK	☐ NO RECOVERY	☐ CORE	
BACKFILL TYPE		☒ BENTONITE	☐ GRAVEL	☐ SLOUGH	☐ GROUT	☐ CUTTINGS	☐ SAND	

DEPTH (m)	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #	VAPOUR READINGS	COMMENTS	ELEVATION (m)
0		SAND, fine grained with minor (15%) medium sand -White -Loose -Non-cohesive, non-plastic					273
1							272
2		SILTY COARSE SAND with some gravel (20%) and trace clay (5%) -Grey -Medium dense -Cohesive, low plasticity	☒				271
3		SILTY MEDIUM TO COARSE SAND, with trace gravel (10%) -Brown -Medium dense -Non-cohesive, non-plastic	☒				270
4							269
5							268
6			☒				267
7							266
8							265
9		SILTY SAND with trace clay (8%) gravel and cobbles (5%) -Grey -Dense -Cohesive, low plasticity	☒				264
10							

AZCOM	LOGGED BY: Stephen Dickin	COMPLETION DEPTH: 53.34 m
	REVIEWED BY: Reuben Dandurand	COMPLETION DATE: 11/10/20
	PROJECT ENGINEER: Ryan Mills	Page 1 of 6

PROJECT: Vivian Sand Facility Project			CLIENT: CanWhite Sands Corp.			TESTHOLE NO: Bru 96-1		
LOCATION: Vivian, MB N 5,527,787.0 E 683,064.0						PROJECT NO.: 60640258		
CONTRACTOR: Friesen Drillers Ltd.			METHOD: Mud Rotary			ELEVATION (m): 273.215		
SAMPLE TYPE		☒ GRAB	☐ SHELBY TUBE	☐ SPLIT SPOON	☐ BULK	☐ NO RECOVERY	☐ CORE	
BACKFILL TYPE		☒ BENTONITE	☐ GRAVEL	☐ SLOUGH	☐ GROUT	☐ CUTTINGS	☐ SAND	

DEPTH (m)	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #	VAPOUR READINGS	COMMENTS	ELEVATION (m)
10							263
11							262
12							261
13							260
14							259
15							258
16							257
17							256
18							255
19							254
20							

LOGGED BY: Stephen Dickinson
 REVIEWED BY: Reuben Dandurand
 PROJECT ENGINEER: Ryan Mills

COMPLETION DEPTH: 53.34 m
 COMPLETION DATE: 11/10/20
 Page 2 of 6

ENVIRO (VAPOUR/F2/F3) 60640258 CANWHITE MW.GPJ UMA.GDT 2/7/21

PROJECT: Vivian Sand Facility Project			CLIENT: CanWhite Sands Corp.			TESTHOLE NO: Bru 96-1		
LOCATION: Vivian, MB N 5,527,787.0 E 683,064.0						PROJECT NO.: 60640258		
CONTRACTOR: Friesen Drillers Ltd.			METHOD: Mud Rotary			ELEVATION (m): 273.215		
SAMPLE TYPE		☒ GRAB	☐ SHELBY TUBE	☐ SPLIT SPOON	☐ BULK	☐ NO RECOVERY	☐ CORE	
BACKFILL TYPE		☒ BENTONITE	☐ GRAVEL	☐ SLOUGH	☐ GROUT	☐ CUTTINGS	☐ SAND	

DEPTH (m)	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #	VAPOUR READINGS	COMMENTS	ELEVATION (m)
20		COARSE SAND AND GRAVEL -Brown -Loose -Non-cohesive, non-plastic					253
21							252
22							251
23							250
24							249
25							248
26							247
27							246
28							245
29							244
30							

LOGGED BY: Stephen Dickinson
 REVIEWED BY: Reuben Dandurand
 PROJECT ENGINEER: Ryan Mills

COMPLETION DEPTH: 53.34 m
 COMPLETION DATE: 11/10/20
 Page 3 of 6

ENVIRO (VAPOUR/F2/F3) 60640258 CANWHITE MW.GPJ UMA.GDT 2/7/21

PROJECT: Vivian Sand Facility Project			CLIENT: CanWhite Sands Corp.			TESTHOLE NO: Bru 96-1		
LOCATION: Vivian, MB N 5,527,787.0 E 683,064.0						PROJECT NO.: 60640258		
CONTRACTOR: Friesen Drillers Ltd.			METHOD: Mud Rotary			ELEVATION (m): 273.215		
SAMPLE TYPE		☒ GRAB	☐ SHELBY TUBE	☐ SPLIT SPOON	☐ BULK	☐ NO RECOVERY	☐ CORE	
BACKFILL TYPE		☒ BENTONITE	☐ GRAVEL	☐ SLOUGH	☐ GROUT	☐ CUTTINGS	☐ SAND	

DEPTH (m)	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #	VAPOUR READINGS	COMMENTS	ELEVATION (m)
30			☒				243
31							242
32							241
33							240
34							239
35							238
36							237
37							236
38							235
39							234
40							

LIMESTONE

- Beige with purple laminations
- Minor weathering
- Competent rock

	LOGGED BY: Stephen Dickinson	COMPLETION DEPTH: 53.34 m
	REVIEWED BY: Reuben Dandurand	COMPLETION DATE: 11/10/20
	PROJECT ENGINEER: Ryan Mills	Page 4 of 6

ENVIRO (VAPOUR/F2/F3) 60640258 CANWHITE MW.GPJ UMA.GDT 2/7/21

PROJECT: Vivian Sand Facility Project			CLIENT: CanWhite Sands Corp.			TESTHOLE NO: Bru 96-1		
LOCATION: Vivian, MB N 5,527,787.0 E 683,064.0						PROJECT NO.: 60640258		
CONTRACTOR: Friesen Drillers Ltd.				METHOD: Mud Rotary			ELEVATION (m): 273.215	
SAMPLE TYPE		☒ GRAB	☐ SHELBY TUBE	☐ SPLIT SPOON	☐ BULK	☐ NO RECOVERY	☐ CORE	
BACKFILL TYPE		☒ BENTONITE	☐ GRAVEL	☐ SLOUGH	☐ GROUT	☐ CUTTINGS	☐ SAND	

DEPTH (m)	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #	VAPOUR READINGS	COMMENTS	ELEVATION (m)
40		SHALE -Reddish brown -Highly weathered, can be shaped/peeled with a knife -Cuttings are cohesive and exhibit high plasticity					233
41			232				
42			231				
43			230				
44			229				
45		SANDSTONE -White -Fine grained -Well sorted -Weakly cemented, low strength					228
46			227				
47			226				
48			225				
49			224				
50							

	LOGGED BY: Stephen Dickin	COMPLETION DEPTH: 53.34 m
	REVIEWED BY: Reuben Dandurand	COMPLETION DATE: 11/10/20
	PROJECT ENGINEER: Ryan Mills	Page 5 of 6

ENVIRO (VAPOUR/F2/F3) 60640258 CANWHITE MW.GPJ UMA.GDT 2/7/21

PROJECT: Vivian Sand Facility Project			CLIENT: CanWhite Sands Corp.			TESTHOLE NO: Bru 96-1		
LOCATION: Vivian, MB N 5,527,787.0 E 683,064.0						PROJECT NO.: 60640258		
CONTRACTOR: Friesen Drillers Ltd.			METHOD: Mud Rotary			ELEVATION (m): 273.215		
SAMPLE TYPE		☒ GRAB	☐ SHELBY TUBE	☐ SPLIT SPOON	☐ BULK	☐ NO RECOVERY	☐ CORE	
BACKFILL TYPE		☒ BENTONITE	☐ GRAVEL	☐ SLOUGH	☐ GROUT	☐ CUTTINGS	☐ SAND	

DEPTH (m)	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #	VAPOUR READINGS	COMMENTS	ELEVATION (m)
50							223
51							222
52							221
53							220
54		Hole not daylighted and no utility locates completed -UTM coordinate and elevation data surveyed by David Atkinson (AECOM) -Bru 96-1 Water Well Tag Number: 4558 -0.13m (5") diameter surface casing was installed from surface to 0.91m below the top of the limestone contact. The annulus between the surface casing and the borehole wall was sealed with bentonite-cement grout. -Drilling through overburden was conducted using a 7 7/8th inch outer diameter tricone drill bit. A 6 1/4 inch (OD) tricone bit was using to advance the hole 0.91m into the limestone unit to create a "socket" for the bottom of the 0.13m (5") PVC casing to rest in. The remainder of the hole was drilled using a 4 3/4 inch (OD) PDC cutting drag bit. -Grab samples of cuttings were collected for logging purposes only. Monitoring well completion details: Well Stick-up: 0.584 m AGS 2" Diameter PVC well pipe, Schedule 40, 10-slot screen Bentonite-cement grout: 0 - 45.72 m BGS Sand: 45.72 - 53.34 m BGS Screen: 49.23 - 52.28 m BGS End of Bore: 53.34 m BGS Depth to water: 6.838 m BGS on Nov 10, 2020 3:30 PM Top of Pipe Elevation: 273.799 m ASL				219	
55							218
56							217
57							216
58							215
59							214
60							

		LOGGED BY: Stephen Dickin	COMPLETION DEPTH: 53.34 m
		REVIEWED BY: Reuben Dandurand	COMPLETION DATE: 11/10/20
		PROJECT ENGINEER: Ryan Mills	Page 6 of 6

PROJECT: Vivian Sand Facility Project			CLIENT: CanWhite Sands Corp.			TESTHOLE NO: Bru 96-2		
LOCATION: Vivian, MB N 5,527,791.0 E 683,062.0						PROJECT NO.: 60640258		
CONTRACTOR: Friesen Drillers Ltd.			METHOD: Mud Rotary			ELEVATION (m): 273.304		
SAMPLE TYPE		☒ GRAB	☐ SHELBY TUBE	☐ SPLIT SPOON	☐ BULK	☐ NO RECOVERY	☐ CORE	
BACKFILL TYPE		☒ BENTONITE	☐ GRAVEL	☐ SLOUGH	☐ GROUT	☐ CUTTINGS	☐ SAND	

DEPTH (m)	SLOTTED PIEZOMETER	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #	VAPOUR READINGS	COMMENTS	ELEVATION (m)	
0			SAND, fine grained with minor (15%) medium sand -White -Loose -Non-cohesive, non-plastic					273	
1								272	
2									271
3									270
4								269	
5								268	
6								267	
7								266	
8								265	
9								264	
10									

	LOGGED BY: Stephen Dickin	COMPLETION DEPTH: 41.76 m
	REVIEWED BY: Reuben Dandurand	COMPLETION DATE: 11/10/20
	PROJECT ENGINEER: Ryan Mills	Page 1 of 5

PROJECT: Vivian Sand Facility Project			CLIENT: CanWhite Sands Corp.			TESTHOLE NO: Bru 96-2		
LOCATION: Vivian, MB N 5,527,791.0 E 683,062.0						PROJECT NO.: 60640258		
CONTRACTOR: Friesen Drillers Ltd.			METHOD: Mud Rotary			ELEVATION (m): 273.304		
SAMPLE TYPE			☒ GRAB	☐ SHELBY TUBE	☐ SPLIT SPOON	☐ BULK	☐ NO RECOVERY	☐ CORE
BACKFILL TYPE			☒ BENTONITE	☐ GRAVEL	☐ SLOUGH	☐ GROUT	☐ CUTTINGS	☐ SAND

DEPTH (m)	SLOTTED PIEZOMETER	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #	VAPOUR READINGS	COMMENTS	ELEVATION (m)
10								263
11								262
12								261
13								260
14								259
15								258
16								257
17								256
18								255
19								254
20								

	LOGGED BY: Stephen Dickinson	COMPLETION DEPTH: 41.76 m
	REVIEWED BY: Reuben Dandurand	COMPLETION DATE: 11/10/20
	PROJECT ENGINEER: Ryan Mills	Page 2 of 5

ENVIRO (VAPOUR/F2/F3) 60640258 CANWHITE MW.GPJ UMA.GDT 2/7/21

PROJECT: Vivian Sand Facility Project				CLIENT: CanWhite Sands Corp.				TESTHOLE NO: Bru 96-2			
LOCATION: Vivian, MB N 5,527,791.0 E 683,062.0								PROJECT NO.: 60640258			
CONTRACTOR: Friesen Drillers Ltd.				METHOD: Mud Rotary				ELEVATION (m): 273.304			
SAMPLE TYPE		☒ GRAB	☐ SHELBY TUBE	☐ SPLIT SPOON	☐ BULK	☐ NO RECOVERY	☐ CORE				
BACKFILL TYPE		☒ BENTONITE	☐ GRAVEL	☐ SLOUGH	☐ GROUT	☐ CUTTINGS	☐ SAND				

DEPTH (m)	SLOTTED PIEZOMETER	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #	VAPOUR READINGS	COMMENTS	ELEVATION (m)
20								253
21								252
22			COARSE SAND AND GRAVEL -Brown -Loose -Non-cohesive, non-plastic					251
23								250
24								249
25								248
26								247
27								246
28								245
29								244
30								

	LOGGED BY: Stephen Dickinson	COMPLETION DEPTH: 41.76 m
	REVIEWED BY: Reuben Dandurand	COMPLETION DATE: 11/10/20
	PROJECT ENGINEER: Ryan Mills	Page 3 of 5

PROJECT: Vivian Sand Facility Project			CLIENT: CanWhite Sands Corp.			TESTHOLE NO: Bru 96-2		
LOCATION: Vivian, MB N 5,527,791.0 E 683,062.0						PROJECT NO.: 60640258		
CONTRACTOR: Friesen Drillers Ltd.			METHOD: Mud Rotary			ELEVATION (m): 273.304		
SAMPLE TYPE		☒ GRAB	☐ SHELBY TUBE	☐ SPLIT SPOON	☐ BULK	☐ NO RECOVERY	☐ CORE	
BACKFILL TYPE		☒ BENTONITE	☐ GRAVEL	☐ SLOUGH	☐ GROUT	☐ CUTTINGS	☐ SAND	

DEPTH (m)	SLOTTED PIEZOMETER	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #	VAPOUR READINGS	COMMENTS	ELEVATION (m)
30								243
31								242
32								241
33								240
34								239
35								238
36			LIMESTONE -Beige with purple laminations -Minor weathering -Competent rock					237
37								236
38								235
39								234
40								

	LOGGED BY: Stephen Dickinson	COMPLETION DEPTH: 41.76 m
	REVIEWED BY: Reuben Dandurand	COMPLETION DATE: 11/10/20
	PROJECT ENGINEER: Ryan Mills	Page 4 of 5

ENVIRO (VAPOUR/F2/F3) 60640258 CANWHITE MW.GPJ UMA.GDT 2/7/21

PROJECT: Vivian Sand Facility Project			CLIENT: CanWhite Sands Corp.			TESTHOLE NO: Bru 96-2		
LOCATION: Vivian, MB N 5,527,791.0 E 683,062.0						PROJECT NO.: 60640258		
CONTRACTOR: Friesen Drillers Ltd.			METHOD: Mud Rotary			ELEVATION (m): 273.304		
SAMPLE TYPE		☒ GRAB	☐ SHELBY TUBE	☐ SPLIT SPOON	☐ BULK	☒ NO RECOVERY	☐ CORE	
BACKFILL TYPE		☒ BENTONITE	☐ GRAVEL	☐ SLOUGH	☐ GROUT	☒ CUTTINGS	☐ SAND	

DEPTH (m)	SLOTTED PIEZOMETER	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #	VAPOUR READINGS	COMMENTS	ELEVATION (m)
40								233
41								232
42			Hole not daylighted and no utility locates completed -UTM coordinate and elevation data surveyed by David Atkinson (AECOM) -Bru 96-2 Water Well Tag Number: 4559 -Located in a borehole adjacent to Bru 96-1 -0.13m (5") diameter surface casing was installed from surface to 0.91m below the top of the limestone contact. The annulus between the surface casing and the borehole wall was sealed with bentonite-cement grout. -Drilling through overburden was conducted using a 7 7/8th inch outer diameter tricone drill bit. A 6 1/4 inch (OD) tricone bit was using to advance the hole 0.91m into the limestone unit to create a "socket" for the bottom of the 0.13m (5") PVC casing to rest in. The remainder of the hole was drilled using a 4 3/4 inch (OD) PDC cutting drag bit. - A 0.13m (5") OD 8mm thick rubber shale trap was affixed to the bottom and outside of the 2" PVC well standpipe and was lowered to 35.97m BGS, which was immediately below the bottom of the socket and 0.13m (5") surface casing. -Grab samples of cuttings were collected for logging purposes only. Monitoring well completion details: Well Stick-up: 0.701 m AGS 2" Diameter PVC well pipe, Schedule 40 open at bottom (35.97 m BGS) Screen: No screen. Exposed borehole wall between: 35.97 - 41.76 m BGS Bentonite-cement grout: 0 - 35.97 m BGS End of Bore: 41.76 m BGS Depth to water: 6.919 m BGS on Nov 10, 2020 3:30 PM Top of Pipe Elevation: 274.005 m ASL					231
43								230
44								229
45								228
46								227
47								226
48								225
49								224
50								

	LOGGED BY: Stephen Dickin	COMPLETION DEPTH: 41.76 m
	REVIEWED BY: Reuben Dandurand	COMPLETION DATE: 11/10/20
	PROJECT ENGINEER: Ryan Mills	Page 5 of 5

Appendix **C**

Photographic Logs

Appendix C.1. Core Photo Logs

Core Photo Log – Bru 95-8



Bru95-8 - Box 1 and 2 of 7 - 30.78 to 38.40 mBGS

Core Photo Log – Bru 95-8



Bru95-8 - Box 3 and 4 of 7 - 38.40 to 43.90 mBGS

Core Photo Log – Bru 95-8



Bru95-8 - Box 5, 6 and 7 of 7 - 43.90 to 50.60 mBGS

Appendix C.2. Compiled Chip Tray Photo Logs

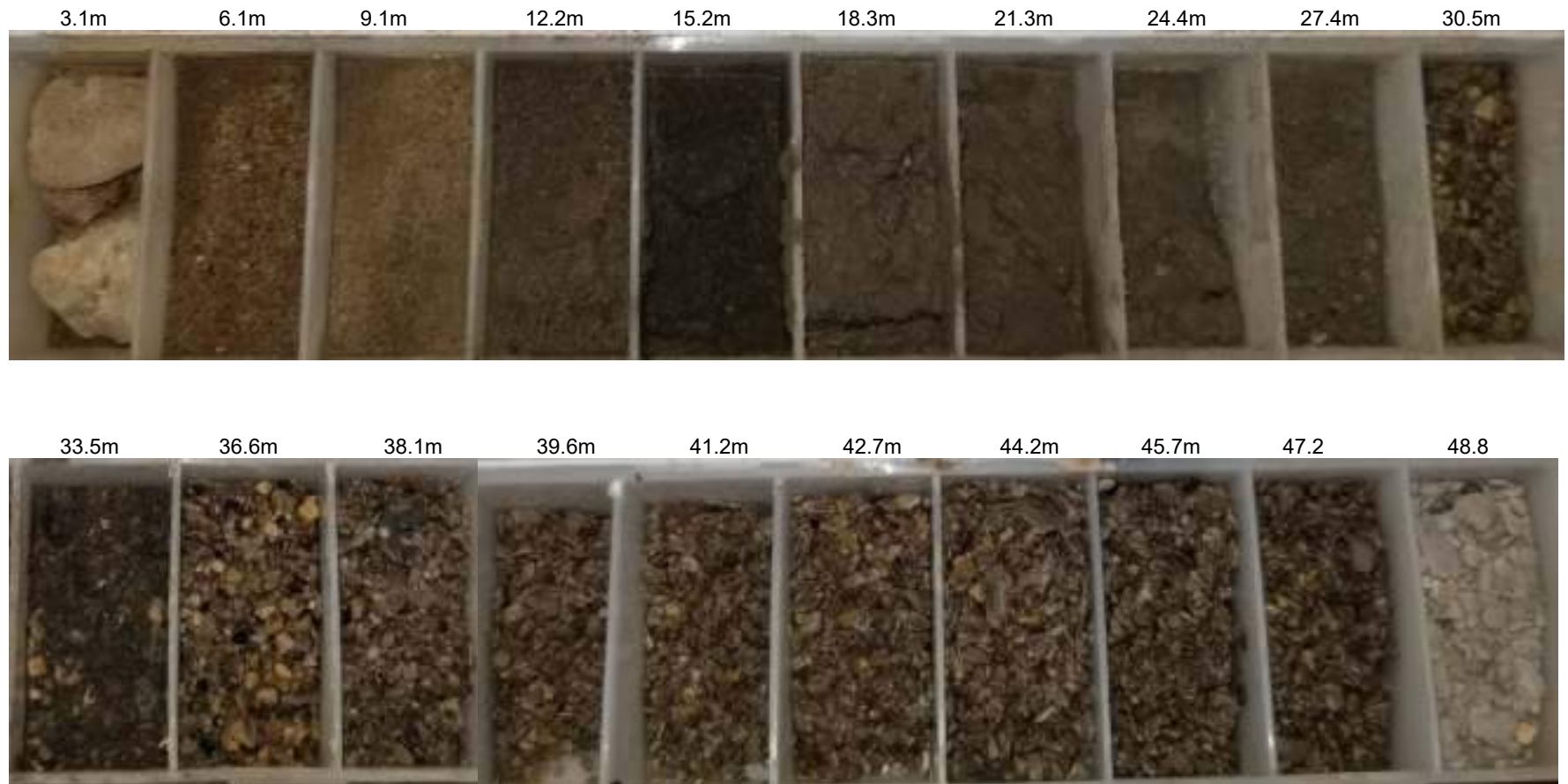
Chip Tray Photo Log

Bru 95-6 (adjacent to Bru 95-5 and Bru 95-9)



Chip Tray Photo Log

Bru 95-7 (Water Well)



Chip Tray Photo Log

Bru 95-7 (Water Well)

50.3m

51.8m

53.3m

54.9m

56.4m

57.9m

59.4m

61.0m

62.5m

64.0m



65.5m

67.1m

68.6m

70.1m

71.6m

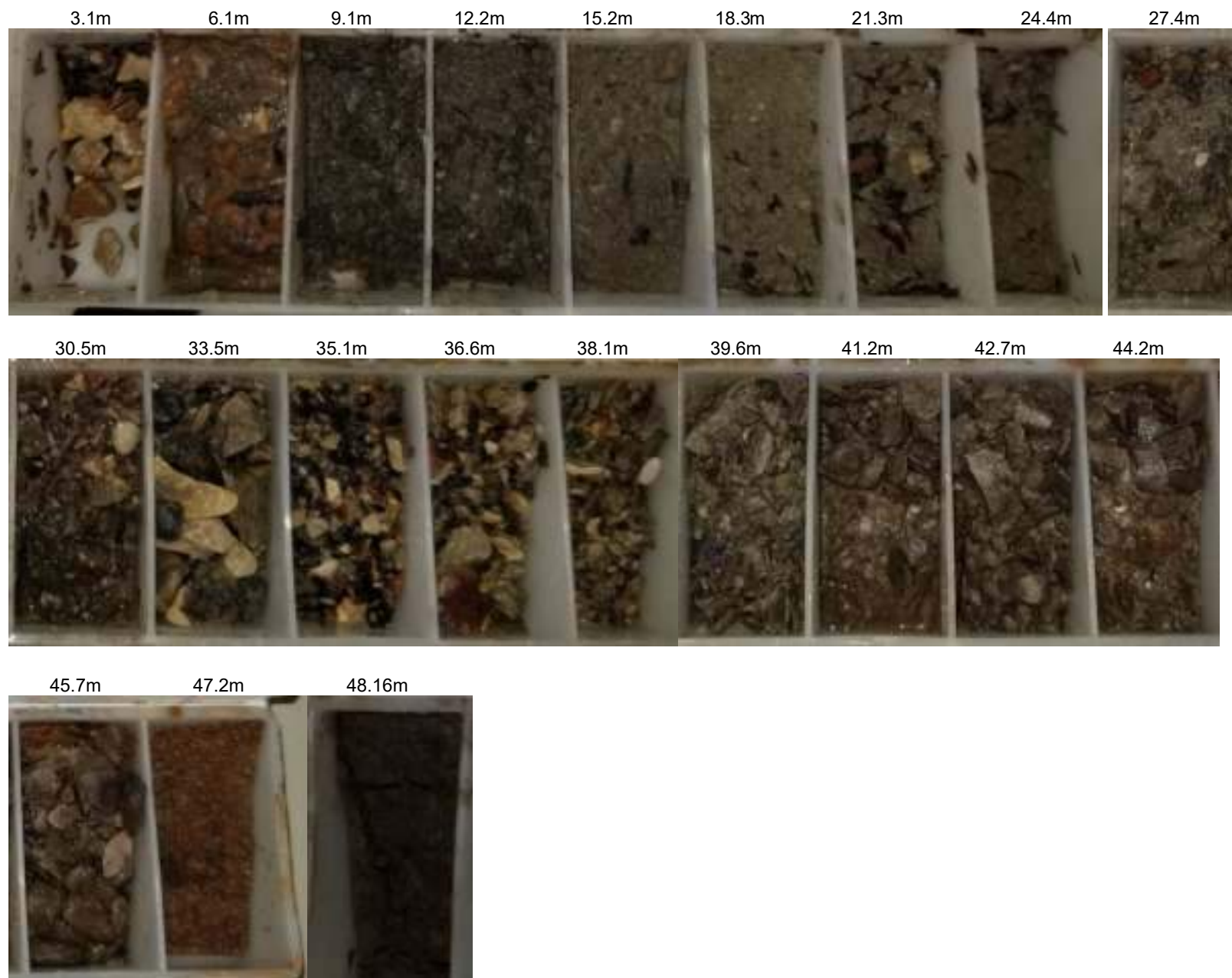
73.2m

74.7m



Chip Tray Photo Log

Bru 95-9 (adjacent to Bru 95-5 and Bru 95-6)



Chip Tray Photo Log

Bru 96-1 (adjacent to Bru 96-2)



Appendix C.3. Geochemistry Sample Photo Logs

GEOCHEMISTRY SAMPLE PHOTOGRAPHIC LOG

Photo No. 1

Description:

Sample ID: Bru 121-1
Depth: 24.38 – 24.83m
Lithology: Carbonate

Core Sample



Photo No. 2

Description:

Sample ID: Bru 121-1
Depth: 24.38 – 24.83m
Lithology: Carbonate

Core Sample

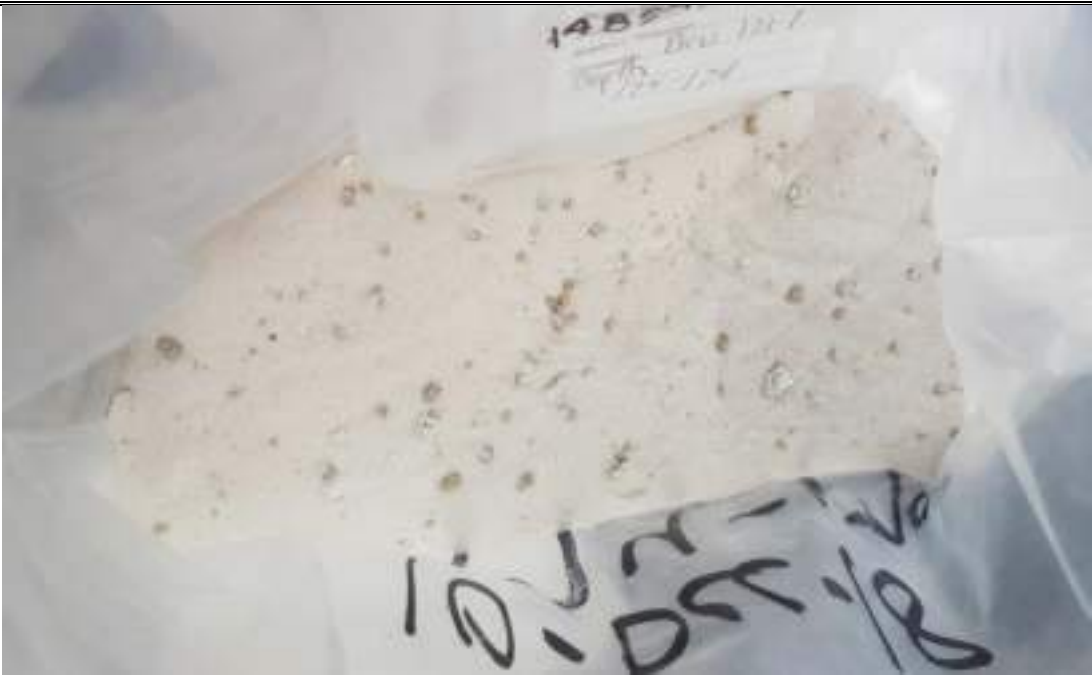
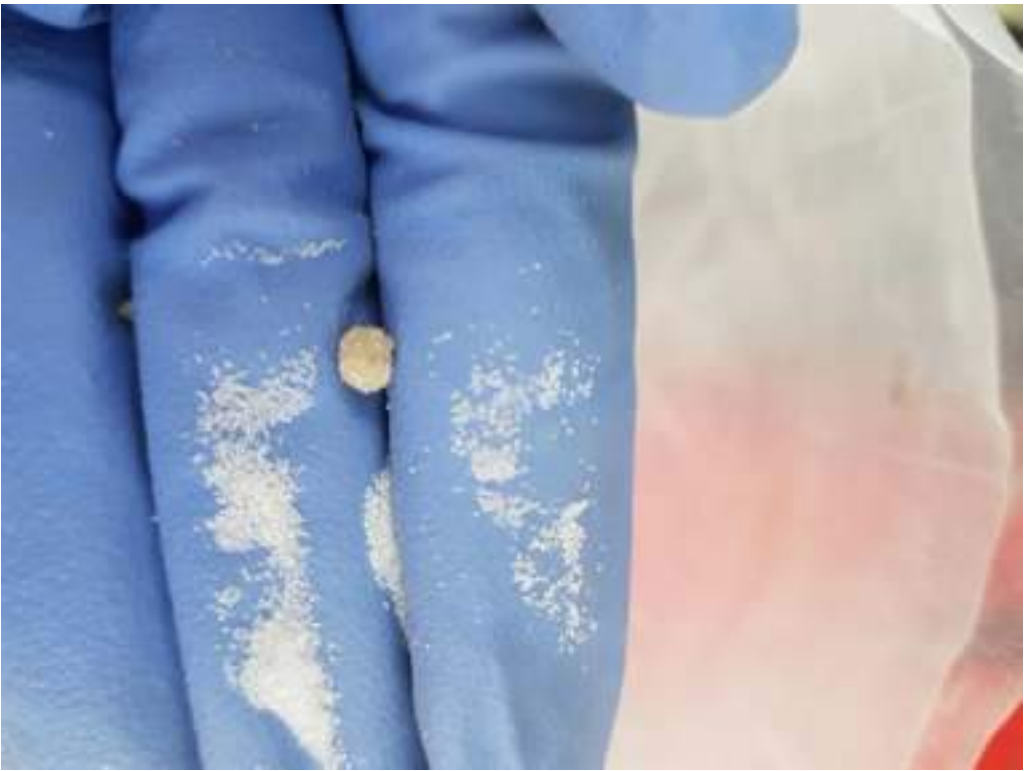


GEOCHEMISTRY SAMPLE PHOTOGRAPHIC LOG

Photo No. 3	
Description: Sample ID: Bru 121-1 Depth: 36.57 – 37.00m Lithology: Shale Core Sample	

GEOCHEMISTRY SAMPLE PHOTOGRAPHIC LOG

Photo No. 5	
-------------	--

Description: Sample ID: Bru 121-1 Depth: 174 – 179m Lithology: Sandstone Grab Sample	
Photo No. 6	
Description: Sample ID: Bru 121-1 Depth: 174 – 179m Lithology: Sandstone Grab Sample	

GEOCHEMISTRY SAMPLE PHOTOGRAPHIC LOG

Photo No. 7	
---------------------------	--

Description: Sample ID: Bru 146 Depth: 36.82 – 37.13m Lithology: Carbonate Core Sample	
Photo No. 8	
Description: Sample ID: Bru 146 Depth: 36.82 – 37.13m Lithology: Carbonate Core Sample	

GEOCHEMISTRY SAMPLE PHOTOGRAPHIC LOG

Photo No. 9	
---------------------------	--

Description: Sample ID: Bru 146 Depth: 49.86 – 50.29m Lithology: Shale Core Sample	
--	--

Photo No. 10	
Description: Sample ID: Bru 146 Depth: 49.86 – 50.29m Lithology: Shale Core Sample	

GEOCHEMISTRY SAMPLE PHOTOGRAPHIC LOG

Photo No. 11	
----------------------------	--

Description: Sample ID: Bru 146 Depth: 189 – 194m Lithology: Sandstone Grab Sample	
Photo No. 12	
Description: Sample ID: Bru 146 Depth: 189 – 194m Lithology: Sandstone Grab Sample	

GEOCHEMISTRY SAMPLE PHOTOGRAPHIC LOG

Photo No. 13	
----------------------------	--

Description: Sample ID: Bru 95-8 Depth: 40.16 – 40.65m Lithology: Carbonate Core Sample	
---	--

Photo No. 14	
Description: Sample ID: Bru 95-8 Depth: 40.16 – 40.65m Lithology: Carbonate Core Sample	

GEOCHEMISTRY SAMPLE PHOTOGRAPHIC LOG

Photo No. 15	
----------------------------	--

Description: Sample ID: Bru 95-8 Depth: 49.39 – 49.79m Lithology: Shale Core Sample	
---	--

Photo No. 16	
Description: Sample ID: Bru 95-8 Depth: 49.39 – 49.79m Lithology: Shale Core Sample	

GEOCHEMISTRY SAMPLE PHOTOGRAPHIC LOG

Photo No. 17	
----------------------------	--

Description:

Sample ID: Bru 95-3
Depth: Unknown
Lithology: Sandstone

Grab Sample From Test
Extraction Pile

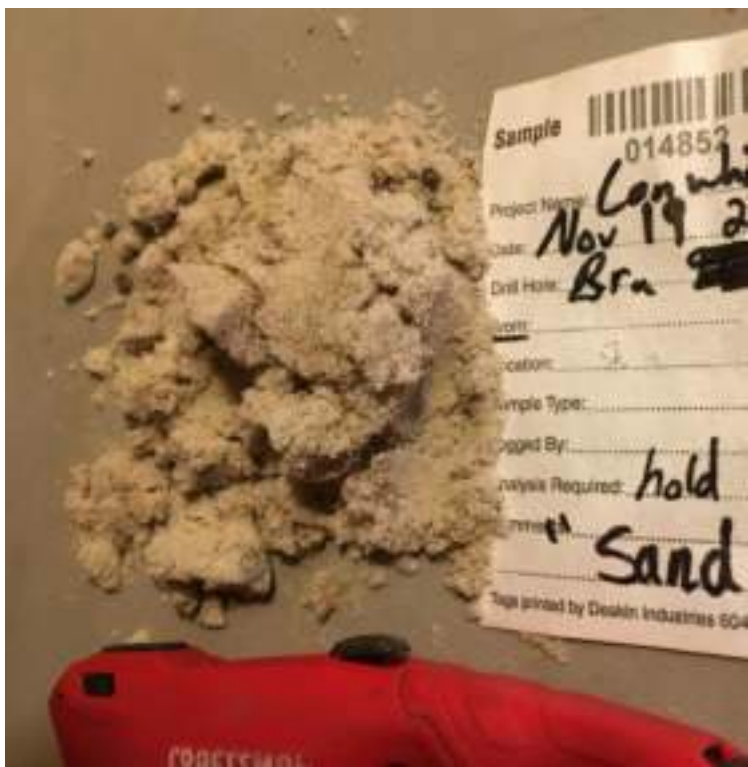


Photo No. 18

Description:

Sample ID: Bru 95-3
Depth: Unknown
Lithology: Sandstone

Grab Sample From Test
Extraction Pile



Appendix **D**

Vibrating Wire Piezometer Instrumentation Records





Vibrating Wire Piezometer Instrumentation Record

Project Number: 60640258
Project Name: Canadian White Sands
Client: CanWhite

AECOM Staff: Steve Dickin / Reuben Dandurand
Date of install: Nov 19 2020
Drill Company: Paddock Drilling Ltd.
Lead Driller: Gord

Borehole Details

ID: Bru 95-8
UTM: E: 681953
UTM: N: 5527630
Drilling Method: Rotary
Drill Rig: Acker MP8
Completion Date: Nov 19 2020

Total Hole Length: 55.09 m
Inclination (from vertical): -90
Azimuth: N/A
Elevation: 277.271 m AS(ground) / top of pipe / top of casing
Casing Stick up: 1.116 m AGS Casing Diameter: HW
Hole Diameter: HQ
Mechanical Hole Plug (Y/N): N if yes, Depth btoc: N/A

True Vertical Depth = $\sin(\text{inclination}) \times \text{Total Hole Length}$
True BH TOE Vertical Depth = 55.09 m
True Plug Vertical Depth = N/A
True Casing Toe Vertical Depth = N/A

Data Logger Details

Type (e.g. Therm, VW)	Name	Model No.	Serial No	Logging frequency	Start date dd/mm/yy	Start time 24hr time	Comment
1 VW	Bru 95-8	DT2055B	11732	30 sec	21/11/20	12:36:00 pm	5 Channel
2							
3							
4							

Vibrating Wire Piezometers Details

Type (e.g. RST)	Name	Model No.	Serial No	Installed Depth (m below ground)
1 RST	Bru 95-8D	VW2100-2.0	VW71104	54.689 m BGS
2 RST	Bru 95-8I	VW2100-2.0	VW71102	50.832 m BGS
3 RST	Bru 95-8S bottom	VW2100-2.0	VW71101	43.759 m BGS
4 RST	Bru 95-8S top	VW2100-2.0	VW71103	40.762 m BGS

Completion Details and Materials Used

1 inch, 2.975 m long PVC Tremie Pipe (19 pieces in total)
Bentonite-Cement grout mixture (1:1 ratio)
Protective Casing: RST 8inch protective box welded to the top of the HW casing at surface.

VIBRATING WIRE INSTRUMENT INSTALLATION - PHOTOGRAPHIC LOG

Client Name: Canadian White Sands		Site Location: Vivian Sand Facility Project	Project Number: 60640258
Photo No. 1	Date: Nov 2020		
Direction Photo Taken: N/A			
Description: Vibrating wire piezometer completion.			
Photo No. 2	Date: Nov 2020		
Direction Photo Taken: N/A			
Description: Vibrating wire piezometer completion.			



Monitor
with
Confidence

Calibration Record

RST Instruments Ltd., 11545 Kingston St., Maple Ridge, British Columbia, Canada V2X 0Z5
Tel: 604 540 1100 • Fax: 604 540 1005 • Toll Free: 1 800 665 5599 (North America only)
e-mail: info@rstinstruments.com • Website: www.rstinstruments.com

Vibrating Wire Piezometer

Customer: AECOM CANADA LTD
Sales Order: 226278
Customer ID:
Model: VW2100-2.0
Serial Number: VW71103
Mfg Number: P124601
Range: 2.0 MPa
Cable Length: 55 meters
Cable Marking: 644347 m to 644401 m
Cable Type: EL380004
Cable Colour Code: Red/Black (Coil) Green/White (Thermistor)
Thermistor Type: 3K

Brw 95-8
Shallow Top
VW1 (Sensor 1) Thermal (Sensor 2)

Applied Pressure (MPa)	First Reading (B units)	Second Reading (B units)	Average Reading (B units)	Calculated Linear (MPa)	Linearity Error (%FS)	Calculated Polynomial (MPa)	Polynomial Error (%FS)
0.000	8937	8943	8940	0.002	0.08	-0.000	-0.01
0.400	8276	8277	8276	0.400	0.00	0.400	0.02
0.800	7613	7613	7613	0.798	-0.06	0.800	-0.00
1.200	6947	6947	6947	1.196	-0.06	1.200	-0.01
1.600	6278	6279	6278	1.600	-0.02	1.600	-0.00
2.000	5609	5609	5609	2.002	0.09	2.000	0.00
Max Error (%)					0.09		0.02

Linear Calibration Factor: CF = $6.6951e-04$ MPa/B unit
Temperature Correction Factor: Tk = $-3.7832e-04$ MPa/°C rise

Polynomial Gauge Factor:

A = $-1.2183e-03$ MPa/(B unit)² B = $-5.8278e-04$ MPa/B unit C = calculate (see below) MPa

Users must establish site zero readings for calculation purposes

Polynomial C = $-[A(L_0^2) + B(L_0)]$

Pressure is calculated with the following equations:

Linear: $P = CF(L_0 - L) - Tk(T_0 - T) + (S_0 - S)$

Polynomial: $P = A(L^2) + B(L) + C - Tk(T_0 - T) + (S_0 - S)$

L_0 , L = initial (installation) and current readings, in B units

T_0 , T = initial (installation) and current temperature, in °C

S_0 , S = initial (installation) and current barometric pressure readings, in MPa

B units = Hz/1000 ie: 1700 Hz = 2890 B units

Shipped Zero Readings:	Date	VW Reading (B Units)	Temperature (°C)	Baro (mbar)
	13 Nov 2020	8944	21.1	985.9

This instrument has been calibrated using standards traceable to the NIST in compliance with ANSI Z540-1

Technician: Kalah Toews

Date: 13/11/2020

Approved: Ora Nygren

Date: 13/11/2020



Monitor
with
Confidence

Calibration Record

RST Instruments Ltd., 11545 Kingston St., Maple Ridge, British Columbia, Canada V2X 0Z5
Tel: 604 540 1100 • Fax: 604 540 1005 • Toll Free: 1 800 665 5599 (North America only)
e-mail: info@rstinstruments.com • Website: www.rstinstruments.com

Vibrating Wire Piezometer

Customer: AECOM CANADA LTD
Sales Order: 226278
Customer ID:
Model: VW2100-2.0
Serial Number: VW71101
Mfg Number: P117704
Range: 2.0 MPa
Cable Length: 50 meters
Cable Marking: 644241 m to 644290 m
Cable Type: EL380004
Cable Colour Code: Red/Black (Coil) Green/White (Thermistor)
Thermistor Type: 3K

Bru 95-8 Shallow (Limestone)
bottom

VW 2 (sensor 3) Therm 2
(S-2014)

Applied Pressure (MPa)	First Reading (B units)	Second Reading (B units)	Average Reading (B units)	Calculated Linear (MPa)	Linearity Error (%FS)	Calculated Polynomial (MPa)	Polynomial Error (%FS)
0.000	8627	8630	8628	0.002	0.10	0.000	0.02
0.400	7846	7847	7847	0.399	-0.04	0.400	-0.02
0.800	7061	7062	7061	0.798	-0.09	0.799	-0.03
1.200	6272	6273	6273	1.199	-0.06	1.200	0.01
1.600	5482	5482	5482	1.601	0.03	1.601	0.05
2.000	4693	4694	4694	2.001	0.05	1.999	-0.03
Max Error (%)					0.10		0.05

Linear Calibration Factor: CF = $5.0801e-04$ MPa/B unit
Temperature Correction Factor: Tk = $4.6991e-05$ MPa/°C rise

Polynomial Gauge Factor:
A = $-8.0347e-10$ MPa/(B unit)² B = $-4.9730e-04$ MPa/B unit C = calculate (see below) MPa

Users must establish site zero readings for calculation purposes
Polynomial C = $-[A(L_0^2) + B(L_0)]$

Pressure is calculated with the following equations:

Linear: $P = CF(L_0 - L) - Tk(T_0 - T) + (S_0 - S)$

Polynomial: $P = A(L^2) + B(L) + C - Tk(T_0 - T) + (S_0 - S)$

L_0 , L = initial (installation) and current readings, in B units

T_0 , T = initial (installation) and current temperature, in °C

S_0 , S = initial (installation) and current barometric pressure readings, in MPa

B units = Hz/1000 ie: 1700 Hz = 2880 B units

Shipped Zero Readings:	Date	VW Reading (B Units)	Temperature (°C)	Baro (mbar)
	13 Nov 2020	8628	20.9	985.9

This instrument has been calibrated using standards traceable to the NIST in compliance with ANSI Z540-1

Technician: Kailah Toews Date: 13/11/2020

Approved: Ora Nygren Date: 13/11/2020



Monitor
with
Confidence

Calibration Record

RST Instruments Ltd., 11545 Kingston St., Maple Ridge, British Columbia, Canada V2X 0Z5
Tel: 604 540 1100 • Fax: 604 540 1005 • Toll Free: 1 800 665 5599 (North America only)
e-mail: info@rstinstruments.com • Website: www.rstinstruments.com

Vibrating Wire Piezometer

Customer: AECOM CANADA LTD
Sales Order: 226278
Customer ID:
Model: VW2100-2.0
Serial Number: VW71102
Mfg Number: P117735
Range: 2.0 MPa
Cable Length: 55 meters
Cable Marking: 644291 m to 644345 m
Cable Type: EL380004
Cable Colour Code: Red/Black (Coil) Green/White (Thermistor)
Thermistor Type: 3K

Bru 95-8 Intermediate (shale)

VW 3 Therm 3
(Sensor 5) (Sensor 6)

Applied Pressure (MPa)	First Reading (B units)	Second Reading (B units)	Average Reading (B units)	Calculated Linear (MPa)	Linearity Error (%FS)	Calculated Polynomial (MPa)	Polynomial Error (%FS)
0.000	8608	8610	8609	0.003	0.14	0.000	0.02
0.400	7835	7836	7835	0.399	-0.04	0.400	-0.02
0.800	7057	7057	7057	0.798	-0.12	0.800	-0.02
1.200	6275	6275	6275	1.198	-0.09	1.200	0.01
1.600	5490	5490	5490	1.600	0.01	1.601	0.04
2.000	4706	4707	4706	2.002	0.10	2.000	-0.02
Max Error (%)					0.14		0.04

Linear Calibration Factor: CF = $5.1224e-04$ MPa/B unit
Temperature Correction Factor: Tk = $-1.2806e-04$ MPa/°C rise

Polynomial Gauge Factor:
A = $-1.1911e-09$ MPa/(B unit)² B = $-4.9636e-04$ MPa/B unit C = calculate (see below) MPa

Users must establish site zero readings for calculation purposes
Polynomial C = $-(A(L_0^2) + B(L_0))$

Pressure is calculated with the following equations:

Linear: $P = CF(L_0 - L) - Tk(T_0 - T) + (S_0 - S)$

Polynomial: $P = A(L^2) + B(L) + C - Tk(T_0 - T) + (S_0 - S)$

L_0 , L = initial (installation) and current readings, in B units

T_0 , T = initial (installation) and current temperature, in °C

S_0 , S = initial (installation) and current barometric pressure readings, in MPa

B units = Hz/1000 ie: 1700 Hz = 2890 B units

Shipped Zero Readings:	Date	VW Reading (B Units)	Temperature (°C)	Baro (mbar)
	13 Nov 2020	8611	21.0	985.9

This instrument has been calibrated using standards traceable to the NIST in compliance with ANSI Z540-1

Technician: Kailah Toews Date: 13/11/2020

Approved: Ors Nygren Date: 13/11/2020



Waste 100%



Monitor
with
Confidence

Calibration Record

RST Instruments Ltd., 11545 Kingston St., Maple Ridge, British Columbia, Canada V2X 0Z5
Tel: 604 540 1100 • Fax: 604 540 1005 • Toll Free: 1 800 665 5599 (North America only)
e-mail: info@rstinstruments.com • Website: www.rstinstruments.com

Vibrating Wire Piezometer

Customer: AECOM CANADA LTD
Sales Order: 226278
Customer ID:
Model: VW2100-2.0
Serial Number: VW71104
Mfg Number: P124605
Range: 2.0 MPa
Cable Length: 75 meters
Cable Marking: 644402 m to 644476 m
Cable Type: EI380004
Cable Colour Code: Red/Black (Coil) Green/White (Thermistor)
Thermistor Type: 3K

Bru 95-8 Deep (sandstone)
VW 4 (sensor 7)
Therm 4 (sensor 8)

Applied Pressure (MPa)	First Reading (B units)	Second Reading (B units)	Average Reading (B units)	Calculated Linear (MPa)	Linearity Error (%FS)	Calculated Polynomial (MPa)	Polynomial Error (%FS)
0.000	9041	9045	9043	0.002	0.12	0.000	0.01
0.400	8333	8334	8333	0.399	-0.03	0.400	-0.00
0.800	7620	7621	7621	0.798	-0.10	0.800	-0.01
1.200	6905	6906	6905	1.198	-0.09	1.200	-0.00
1.600	6187	6188	6187	1.600	-0.01	1.600	0.02
2.000	5468	5468	5468	2.002	0.11	2.000	-0.01
Max Error (%)					0.12		0.02

Linear Calibration Factor: $CF = 5.5938e-04$ MPa/B unit
Temperature Correction Factor: $Tk = 3.6360e-05$ MPa/°C rise

Polynomial Gauge Factor:
 $A = -1.3405e-09$ MPa/(B unit)² $B = -5.3993e-04$ MPa/B unit $C = \text{calculate (see below)}$ MPa

Users must establish site zero readings for calculation purposes
Polynomial $C = -[A(L_0^2) + B(L_0)]$

Pressure is calculated with the following equations:

Linear: $P = CF(L_0 - L) - Tk(T_0 - T) + (S_0 - S)$

Polynomial: $P = A(L^2) + B(L) + C - Tk(T_0 - T) + (S_0 - S)$

L_0 , L = initial (installation) and current readings, in B units

T_0 , T = initial (installation) and current temperature, in °C

S_0 , S = initial (installation) and current barometric pressure readings, in MPa

B units = Hz/1000 ie: 1700 Hz = 2890 B units

Shipped Zero Readings:	Date	VW Reading (B Units)	Temperature (°C)	Baro (mbar)
	13 Nov 2020	9047	21.1	985.9

This instrument has been calibrated using standards traceable to the NIST in compliance with ANSI Z540-1

Technician: Kailah Tseng Date: 13/11/2020

Approved: Ora Nygren Date: 13/11/2020



50011802