

## APPENDIX S3

TOPSOIL ANALYSIS (2011-14)

# ANGAS PROCESSING FACILITY

MISCELLANEOUS PURPOSES LICENSE APPLICATION

2019/0826



ABN | 67 062 576 238

Unit 7 / 202-208 Glen Osmond Road | Fullarton SA 5063

# Topsoil

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All topsoil metals were measured below either NEPM HIL levels or 2006 and 2007 Topsoil Stockpile Baseline maximum values, with the exception of electrical conductivity and the exchangeable cations (calcium, magnesium and sodium), as shown in Table 1.

Cation exchange capacity (CEC) is the total capacity of a soil to hold exchangeable cations. The more calcium soil has when compared to magnesium is indicative of how tight or loose a soil is. As there is much more calcium, this indicates the soil is looser than it is tight, which is as observed in the field. The soil has a slightly higher pH, as it originates from being atop of the natural limestone foundation onsite. This also aids in breaking up compacted soil (clay particles/colloids) and decreasing penetrometer resistance. A high calcium soil has more oxygen, drains more freely and is more likely to support more aerobic breakdown of organic matter. The risk of increasing calcium is that the soil may lose its beneficial granulation and structure and interfere with the availability of other nutrients.

Over the preceding 5 years (2010-2014), exchangeable calcium and sodium has remained relatively stable, however, exchangeable magnesium has fluctuated from on average approximately 0.5 to 1.2 meq/100g, which is ideal for supporting vegetation development. As calcium loosens soil and magnesium tightens it, it is preferable to achieve a balance where water retention is at its most efficient. Presently, calcium accounts for approximately 90%, magnesium 5% and sodium 0.5%. The remaining approximate 5% of the CEC is likely filled with other bases including copper, zinc, iron and manganese and the remainder occupied by exchangeable hydrogen, H+. As the pH of the soil is almost stable, with an average acidity/alkalinity of 7.6 pH units, this shows that the soil is at an ideal pH for vegetation.

Before this topsoil is used in rehabilitation activities, it may be beneficial to apply gypsum. Gypsum is commonly used to flocculate (break-up) clay particles and effectively lowering the pH, as the sulphur will act to stimulate the release of trace elements previously “locked-up”, while at the same time providing calcium in safe amounts without affecting soil alkalinity and maintaining nutrient balance.

Table 1 Topsoil Stockpiles Nutrient and Metals Analysis

	Units	Detection Limit	HIL C	HIL D	2014								HISTORIC LIMIT (2006-07 baseline topsoil data)	
					1	2	3	4	5	6	7	8		average
pH	pH unit	0.1			7.8	6.6	7.7	7.7	7.8	7.7	7.8	7.7	7.6	9
Electrical Conductivity @ 25°C	µS/cm	1			135	99	165	159	129	121	100	120	128.5	119
Moisture Content (dried @ 103°C)	%	1			2.3	2	4.7	2.4	4.3	2.9	2.4	3.3	3.0375	

<b>Exchangeable Cations</b>														
Exchangeable Calcium	meq/100g	0.1			27.9	3.5	32.6	27.3	25.9	9.9	15.6	14.7	19.675	<b>13.79</b>
Exchangeable Magnesium	meq/100g	0.1			1.2	0.4	1.6	1.4	1.2	0.8	0.8	0.7	1.0125	<b>1.11</b>
Exchangeable Sodium	meq/100g	0.1			0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	<b>0.17</b>
Cation Exchange Capacity		0.1			29.8	4.3	35	29.4	27.6	11.1	16.8	15.8	21.225	
<b>Total Metals</b>														
Manganese	mg/kg	5	19000	60000	92	63	129	103	103	83	79	86	92.25	<b>340</b>
Arsenic	mg/kg	5	300	3000	17	6	44	31	35	10	10	12	20.625	<b>54</b>
Cadmium	mg/kg	1	90	900	1	1	1	1	1	1	1	1	1	
Copper	mg/kg	5	17000	240000	5	5	5	5	5	5	5	5	5	<b>7</b>
Lead	mg/kg	5	600	1500	12	14	11	14	9	13	12	12	12.125	<b>22</b>
Nickel	mg/kg	2	1200	6000	4	3	6	6	6	4	4	4	4.625	<b>17</b>
Zinc	mg/kg	5	30000	400000	15	12	21	27	13	11	11	11	15.125	<b>62</b>
Mercury	mg/kg	0.1	80	730	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	

■ - Under detection limits

NEPM Guidelines from "Health investigation levels for soil contaminants" Health Investigation Levels C & D (HILs).

**Topsoil Analysis 2011-2014**

2011			HISTORIC LIMIT	1TSP01	1TSP02	1TSP03	1TSP04	1TSP05	1TSP06	Average
pH	pH Unit	0.1	9	8.4	8.2	8.2	8.4	7.9	8	8.183333333
Electrical Conductivity @ 25°C	µS/cm	1	119	178	191	354	231	283	179	236
Moisture Content (dried @ 103°C)	%	1		5.6	8.3	5.4	8.5	11.8	11.7	8.55
Exchangeable Calcium	meq/100g	0.1	13.79	35.7	35.7	26.7	32.1	28.2	25.1	30.58333333
Exchangeable Magnesium	meq/100g	0.1	1.11	2.2	2.5	1.7	2.7	2.8	2.6	2.416666667
Exchangeable Sodium	meq/100g	0.1	0.17	0.3	0.3	0.6	0.4	0.2	0.2	0.333333333
Cation Exchange Capacity	meq/100g	0.1								
Manganese	mg/kg	5	340	69	84	88	75	81	98	82.5
Arsenic	mg/kg	5	54	11	11	12	11	13	11	11.5
Cadmium	mg/kg	1		1	1	1	1	1	1	1
Copper	mg/kg	5	7	5	5	5	5	5	6	5.166666667
Lead	mg/kg	5	22	13	24	16	22	34	41	25
Nickel	mg/kg	2	17	4	4	4	4	4	4	4
Zinc	mg/kg	5	62	32	48	24	50	73	96	53.83333333
Mercury	mg/kg	0.1		0.1	0.1	0.1	0.1	0.1	0.1	0.1
Total Organic Carbon				0.9	0.8	0.9	1.4	1.8	1.4	1.2

2012			HISTORIC LIMIT	1 Topsoil	2 Topsoil	3 Topsoil	4 Topsoil	5 Topsoil	6 Topsoil	7 Topsoil	8 Topsoil	9 Topsoil	Average
pH	pH Unit	0.1	9	8.6	8.6	8.8	8.9	8.6	8	8.7	8.8	8.8	8.644444444
Electrical Conductivity @ 25°C	µS/cm	1	119	105	131	99	124	124	113	110	108	151	118.3333333
Moisture Content (dried @ 103°C)	%	1		5.6	4.3	3.7	4.7	10.5	7.3	7.2	5.8	12	6.788888889
Exchangeable Calcium	meq/100g	0.1	13.79	13	20.8	18.1	23.7	28.1	23.8	20.9	17.6	19	20.55555556
Exchangeable Magnesium	meq/100g	0.1	1.11	0.7	1	0.8	1.2	1.4	1.4	1	0.7	2.2	1.155555556
Exchangeable Sodium	meq/100g	0.1	0.17	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Cation Exchange Capacity	meq/100g	0.1											
Manganese	mg/kg	5	340	70	80	78	96	143	120	117	77	153	103.7777778
Arsenic	mg/kg	5	54	9	13	16	20	39	68	38	21	5	25.44444444
Cadmium	mg/kg	1		1	1	1	1	1	1	1	1	1	1
Copper	mg/kg	5	7	5	5	5	5	5	5	5	5	9	5.444444444
Lead	mg/kg	5	22	10	13	11	12	12	12	12	9	8	10.33333333
Nickel	mg/kg	2	17	3	5	4	7	6	6	5	4	25	7.222222222
Zinc	mg/kg	5	62	12	14	10	17	12	15	13	8	17	13.11111111
Mercury	mg/kg	0.1		0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Total Organic Carbon				0.8	0.9	0.8	1.3	2.4	1.1	1.5	0.9	0.6	1.144444444

2013			HISTORIC LIMIT	TS - ONE	TS - TWO	TS - THREE	TS - FOUR	TS - FIVE	TS - SIX	Average
pH	pH Unit	0.1	9	7.7	7.8	7.7	7.9	7.8	7.8	7.783333333
Electrical Conductivity @ 25°C	µS/cm	1	119	105	80	97	104	99	108	98.83333333
Moisture Content (dried @ 103°C)	%	1								
Exchangeable Calcium	meq/100g	0.1	13.79	13.7	11	9.3	24.1	19.2	15.1	15.4
Exchangeable Magnesium	meq/100g	0.1	1.11	0.8	0.5	0.7	1	0.8	0.8	0.766666667
Exchangeable Sodium	meq/100g	0.1	0.17	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Cation Exchange Capacity	meq/100g	0.1								
Manganese	mg/kg	5	340	81	46	103	98	67	86	80.16666667
Arsenic	mg/kg	5	54	14	6	18	16	11	16	13.5
Cadmium	mg/kg	1		1	1	1	1	1	1	1
Copper	mg/kg	5	7	5	5	5	5	5	5	5
Lead	mg/kg	5	22	16	7	10	8	8	13	10.33333333
Nickel	mg/kg	2	17	5	2	4	4	4	4	3.833333333
Zinc	mg/kg	5	62	21	7	10	9	8	12	11.16666667
Mercury	mg/kg	0.1		0.1	0.1	0.1	0.1	0.1	0.1	0.1
Total Organic Carbon				0.76	0.46	0.55	0.61	0.55	0.66	0.598333333

2014			HISTORIC LIMIT	1 Topsoil	2 Topsoil	3 Topsoil	4 Topsoil	5 Topsoil	6 Topsoil	7 Topsoil	8 Topsoil	Average
pH	pH Unit	0.1	9	7.8	6.6	7.7	7.7	7.8	7.7	7.8	7.7	7.75555556
Electrical Conductivity @ 25°C	µS/cm	1	119	135	99	165	159	129	121	100	120	127.4444444
Moisture Content (dried @ 103°C)	%	1		2.3	2	4.7	2.4	4.3	2.9	2.4	3.3	3.0375
Exchangeable Calcium	meq/100g	0.1	13.79	27.9	3.5	32.6	27.3	25.9	9.9	15.6	14.7	19.02111111
Exchangeable Magnesium	meq/100g	0.1	1.11	1.2	0.4	1.6	1.4	1.2	0.8	0.8	0.7	1.023333333
Exchangeable Sodium	meq/100g	0.1	0.17	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.107777778
Cation Exchange Capacity	meq/100g	0.1		29.8	4.3	35	29.4	27.6	11.1	16.8	15.8	21.225
Manganese	mg/kg	5	340	92	63	129	103	103	83	79	86	119.7777778
Arsenic	mg/kg	5	54	17	6	44	31	35	10	10	12	24.33333333
Cadmium	mg/kg	1		1	1	1	1	1	1	1	1	1
Copper	mg/kg	5	7	5	5	5	5	5	5	5	5	5.222222222
Lead	mg/kg	5	22	12	14	11	14	9	13	12	12	13.22222222
Nickel	mg/kg	2	17	4	3	6	6	6	4	4	4	6
Zinc	mg/kg	5	62	15	12	21	27	13	11	11	11	20.33333333
Mercury	mg/kg	0.1		0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Total Organic Carbon												

2014			HISTORIC LIMIT	Average 2010	Average 2011	Average 2012	Average 2013	Average 2014
pH	pH Unit	0.1	9	8.233333333	7.516666667	8.644444444	7.8	7.6
Electrical Conductivity @ 25°C	µS/cm	1	119	151.6666667	128	118.3333333	98.8	128.5
Moisture Content (dried @ 103°C)	%	1			6.9	6.788888889	98.83333333	3.0375
Exchangeable Calcium	meq/100g	0.1	13.79	14.91666667	30.58333333	20.55555556	15.4	19.675
Exchangeable Magnesium	meq/100g	0.1	1.11	0.538333333		1.155555556	0.8	1.0125
Exchangeable Sodium	meq/100g	0.1	0.17	0.1		0.1	0.1	0.1
Cation Exchange Capacity	meq/100g	0.1						21.225
Manganese	mg/kg	5	340		82.5	103.7777778	80.2	92.25
Arsenic	mg/kg	5	54	23.83333333	16	28	13.5	20.625
Cadmium	mg/kg	1		Under detection	Under detection	Under detection	Under detection	Under detection
Copper	mg/kg	5	7		5.5	9	Under detection	Under detection
Lead	mg/kg	5	22		16.5	10.33333333	10.3	12.125
Nickel	mg/kg	2	17	5.333333333	5	7.222222222	3.8	4.625
Zinc	mg/kg	5	62	19.16666667	24.83333333	13.11111111	11.2	15.125
Mercury	mg/kg	0.1			Under detection	Under detection	Under detection	Under detection
Total Organic Carbon				1.033333333		1.144444444	0.598333333	0.6





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