

APPENDIX

C TABLES



Table C.1. Analytical Summary of City of Winnipeg Biosolids Analysis (2012 to Present)

Statistical Analysis Summary	Sample Number	Date Sampled	TS	Moisture	Total Organic Carbon (dry)	TKNwt	TN-Slu-ext	pH (units)	Conductivity	SluAl, Total	SluAs, Total	SluCd, Total	SluCo, Total	SluCr, Total	SluCu, Total	SluFe, Total
			<i>(%)</i>			<i>(mg/kg N)</i>			<i>(µS/cm)</i>	<i>Total (mg/kg dry)</i>						
Min			21.5	68.7	23.2	23600.0	30900.0	5.8	5260.0	27.4	2.5	0.9	4.0	39.3	286.0	8000.0
Max			34.1	79.8	34.8	42000.0	44200.0	7.3	20600.0	11600.0	6.3	9.8	24.9	352.0	954.0	68000.0
Average			26.9	73.1	27.6	32686.1	38014.3	6.1	9512.2	6771.4	4.3	2.3	6.5	117.6	590.9	37734.2
95th percentile			31.3	77.9	32.5	38155.0	42475.0	6.7	15330.0	9534.0	5.6	4.1	8.4	197.4	810.2	59600.0
Standard Deviation			2.9	2.9	3.2	3747.0	3828.1	0.3	3294.8	1731.1	0.7	1.2	2.3	47.8	125.9	10633.9
Count (n=)			115	120	111	115	21	61	57	117	117	117	113	117	117	117

Notes:
 Data provided by City of Winnipeg
 Raw data entry and for Total Carbon entered by WSP
 Data cross checked against provided COA for 2016

Updated: Nov 8, 2017

Table C.1. Analytical Summary of City of Winnipeg Biosolids Analysis (2012 to Present)

SluHg, Total	sluK, Total	SluMo, Total	SluNi, Total	SluP, Total	SluPb, Total	SluSe, Total	SluZn, Total	Ammonium-N	Phosphate-P
<i>Total (mg/kg dry)</i>								<i>(mg/Kg) (wet)</i>	
0.6	705.0	5.8	12.2	12000.0	16.5	1.9	632.0	3120.0	226.0
1.8	8880.0	30.6	121.0	26800.0	325.0	106.0	5080.0	6940.0	1380.0
1.0	1803.1	14.7	53.2	18097.4	70.7	5.2	1412.3	4795.0	637.1
1.4	2370.0	20.3	82.6	24650.0	119.5	5.4	2844.0	5804.0	1188.0
0.2	744.2	3.9	17.1	3274.5	45.2	12.3	759.7	1235.1	281.2
101	114	116	115	115	115	117	118	14	14

Table C.1. Analytical Summary of City of Winnipeg Biosolids Analysis (2012 to Present)

Sulfate-S	Potassium	Nitrite-N	Nitrate-N	Nitrate + Nitrite-N	Loss On Ignition	AmmTitration	Inorganic Carbon as CaCO3	Total Carbon by combustion	Total Inorganic Carbon in Soil	Total Organic Carbon Calculation
<i>(mg/kg dry)</i>					<i>(%)</i>	<i>(mg/Kg N)</i>	<i>(%)</i>			
554.0	530.0	1.0	4.6	3.0	40.5	6510.0	5.7	25.5	0.7	24.3
2540.0	690.0	1.8	6.5	6.5	52.7	12900.0	10.2	32.5	1.2	31.8
1978.5	608.7	1.4	5.6	3.8	47.0	8943.7	7.6	29.4	0.9	28.5
2516.0	683.2	1.7	4.6	3.3	52.5	10597.5	10.1	31.8	1.2	30.9
522.0	56.9	0.2	1.0	1.2	3.8	1261.2	1.3	2.1	0.2	2.1
11	13	6	2	6	10	19	19	19	19	19

Table C.2. Example of Field Prescription Application Rate, 20,000 Tonnes

Nov. 8, 2017

Field ID:	Sample	
Land Area Available (ha):	64	
2018 Crop:	Canola	
2018 Target Yield:	55 bu/ac	
	lb/ac	kg/ha
Target Nitrogen total less soil residual:	135	151
Fertilizer Phosphate (P2O5) total less soil residual:	40	45
1 x P2O5 Crop Removal @ target Yield:	55	62
2 x P2O5 Crop Removal @ target Yield:	110	123
3 x P2O5 Crop Removal @ target Yield:	165	185
Sulfate-S target:	20	22

Plant Available Nutrients Soil Test Data			
	W0001	W0001	
Sample Depth	0-15 cm	15-60 cm	Total Available
Units	mg kg ⁻¹		kg ha ⁻¹
Total Nitrogen	0.318	0.202	
Available Nitrate-N	02.6	2	17
Available Phosphate-P	12.6		25
Available Potassium	418		836
Available Sulfate-S			-

	W0002	W0002	
Sample Depth	0-15 cm	15-60 cm	Total Available
Units	mg kg ⁻¹		kg ha ⁻¹
Total Nitrogen	0.238	0.254	
Available Nitrate-N	02.0	2	16
Available Phosphate-P	07.0		14
Available Potassium	309		618
Available Sulfate-S			-

City of Winnipeg Biosolids Characteristics and Analysis

Parameter Name	Parameter Description	Unit	Biosolid Analysis Pilot Project
Estimated Biosolid Volume	In-field	m ³	20,000
Specific Gravity	As Received	g cm ⁻³	1.00
Estimated Biosolids		tonnes	20,000
Dry tonnes biosolids available (=wet tonnes x %solids)	Dried Basis	tonnes	5,379
Moisture	As Received	%	73.1
Total Solids	As Received	%	26.9
Total Volatile Solids	Dry Basis	%	
Organic Matter	Dry Basis	%	-
Inorganic Content	Dry Basis	%	-
Total Organic Carbon	Dry Basis	%	29.42
N:P Ratio	Dry Basis	x:1	2.10
pH	Saturated Paste		6.15
Total N	Dried Basis	%	3.8
	Dried Basis	mg kg ⁻¹	38,014
	Dried Basis	kg Tonne ⁻¹	38.0
Ammonium - N (NH4-N)	wet	mg kg ⁻¹	4,795.0
	Dried Basis	mg kg ⁻¹	1,290.4
	Dried Basis	kg Tonne ⁻¹	1.3
Available Nitrate-N	Dried Basis	mg kg ⁻¹	3.77
Available Nitrate-N		kg Tonne ⁻¹	0.004
Total Phosphorous	Dried Basis	mg kg ⁻¹	18,097
Phosphate-P (Modified Kelowna solution)	Dried Basis	mg kg ⁻¹	637
Total P:Phosphate-P ratio	Dried Basis	x:1	28
Percent Phosphate of Total		%	4

Amount of Biosolids Nutrient Available to Crop

Organic N (=TN-ammonium N)	Dried Basis	mg kg ⁻¹	36,724
Organic N	Dried Basis	kg Tonne ⁻¹	37
Method of Application:			Incorporated
Anticipated Weather			Cool/dry
Anticipated Volatilization (%)	within 1 day		15
Available Organic N (@ 20%)	Dried Basis	kg Tonne ⁻¹	7.3
Ammonium nitrogen available	Dried Basis	kg Tonne ⁻²	1.10
Plant Available Nitrogen (PAN) (Year 1)	Dried Basis	kg Tonne ⁻¹	8.4
PAN Year 2 (@12% mineralization)	Dried Basis	kg Tonne ⁻¹	4.4
PAN Year 3 (@6% mineralization)	Dried Basis	kg Tonne ⁻¹	2.2
Phosphorous	Dried Basis	kg Tonne ⁻¹	18.1
P ₂ O ₅ equivalent	Dried Basis	kg Tonne ⁻¹	41.6
Total Available P ₂ O ₅	Dried Basis	kg Tonne ⁻¹	10.4

Application Rate based on Nitrogen				Land Area Required
Nitrogen Based Application Rate	Dried Basis	tonnes ha ⁻¹	18	301 Ha
Amount of Available P2O5 applied	Dried Basis	kg ha ⁻¹	186	744 Ac
P ₂ O ₅ Application check		%	415	
Application Rate based on Phosphorous (1xCR)				Land Area Required
Total Phosphorus Based Application Rate	Dried Basis	tonnes ha ⁻¹	6	909 Ha
Amount of Nitrogen applied	Dried Basis	kg ha ⁻¹	50	2,244 Ac
		lb ac ⁻¹	44	
Additional Nitrogen required		kg ha ⁻¹	101	
		lb ac ⁻¹	90	
Application Rate based on Phosphorous (2xCR)				Land Area Required
Total Phosphorus Based Application Rate	Dried Basis	tonnes ha ⁻¹	12	454 Ha
Amount of Nitrogen applied	Dried Basis	kg ha ⁻¹	100	1,122 Ac
Additional Nitrogen required		kg ha ⁻¹	51	
Application Rate based on Phosphorous (3xCR)				Land Area Required
Total Phosphorus Based Application Rate	Dried Basis	tonnes ha ⁻¹	18	303 Ha
Amount of Nitrogen applied	Dried Basis	kg ha ⁻¹	150	748 Ac
Additional Nitrogen required		kg ha ⁻¹	1	

Selected Application rate based on:			
Selected Application Rate	Dried Basis	tonnes ha ⁻¹	18
		tons ac ⁻¹	8
	Wet Basis	tonnes ha ⁻¹	70
		tons ac ⁻¹	31
Estimated Biosolids Volume Applied	Wet	Tonnes	4,479
Estimated Biosolids Volume Remaining	Wet	Tonnes	15,521

Notes:

Available Ammonium N - Volatilization loss associated with different application methods (0% with Injection)

Organic N - TKN - Ammonium N

Available Organic N - Organic N x 0.20 year 1 (Ross and Racz, 2003)

Mineralization of Year 2 = 12%, Year 3 = 6%

Plant Available Nitrogen= (NO3-N)+Volatilization factor (NH4-N)+Organic N Mineralization

Estimated P2O5 Available based on 25% of total Phosphorous as directed by MSD.

Note: the biosolids are FeCl treated and fixes the majority of the total P.

Soil Phosphorous Olsen method.

* See Estimates of Ammonium-N Retained After Biosolids application

Table C.3. City of Winnipeg Biosolids Trace Element Content and Field Application Events Permitted Based on CCME Guidelines.

Analyte	Statistical Analysis Summary			Soil Metals Concentration NE31-08-01EPM (0-15cm)	Cumulative Weight Allowed by Guideline ²		Applications Events Permitted before meeting applied Criteria based on Average Metal Concentrations	Applications Events Permitted before meeting applied Criteria based on Minimum Metal Concentrations	Applications Events Permitted before meeting applied Criteria based on Maximum Metal Concentrations
	Minimum	Maximum	Mean		(mg/kg)	(kg/ha)			
	Total Concentrations (mg/kg - Dry)			(mg/kg)	(mg/kg)	(kg/ha)	Count		
Arsenic	2.5	6.3	4.3	8.99	12	21.6	104	184	72
Cadmium	0.9	9.8	2.3	0.20	1.4	2.5	80	194	18
Copper	286.0	954.0	590.9	44.5	63	113.4	5	10	3
Chromium	39.3	352.0	117.6	32.2	64	115.2	41	121	14
Lead	16.5	325.0	70.7	15.1	70	126	117	499	25
Mercury	0.6	1.8	1.0	00.0	6.6	11.9	972	1739	544
Nickle	12.2	121.0	53.2	44.0	50	90	17	74	7
Zinc	632.0	5080.0	1412.3	092	200	360	11	26	3

Notes:

² = Cumulative Weight Allowed by Guideline includes the metals in soils.

Inputs/Assumptions

Soil Bulk Density	1,200	kg/m3
Sample Depth	0.15	m
Hectare	10,000	m2/ha
Soil Mass	1,000,000	mg/kg
Pilot Program Application Rate	12.0	T/ha - dry

