CITY OF STEINBACH

LONG-TERM BIOSOLIDS LAND APPLICATION PLAN

ENVIRONMENT ACT PROPOSAL

MAY 2019

WSP CANADA INC.
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WSP PROJECT NO. 15M-00649-01

LONG-TERM BIOSOLIDS LAND APPLICATION PLAN

ENVIRONMENT ACT PROPOSAL

CITY OF STEINBACH

Submitted to:
Manitoba Sustainable Development
Environmental Approvals Branch
1007 Century Street
Winnipeg, Manitoba R3H 0W4

Submitted on Behalf of:
The City of Steinbach
Waterworks Department
255 Reimer Avenue
Steinbach Manitoba R5G 2J1

Submitted By:
WSP Canada Group Limited
1600 Buffalo Place
Winnipeg Manitoba R3T 6B8
T: 204-477-6650
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FINAL REPORT

PROJECT NO.: 15M-00649-01
DATE: MAY 30, 2019

WSP.COM

May 30, 2019

Manitoba Sustainable Development
Environmental Approvals Branch
1007 Century Street
Winnipeg, Manitoba
R3H 0W4

Attention: Ms. Siobhan Burland Ross, Acting Director

Dear Ms. Burland Ross:

Subject: Environment Act Proposal, City of Steinbach Long-term Biosolids Management Plan

WSP Canada Group Limited has been retained by the City of Steinbach, Waterworks Department to submit an Environment Act Proposal (EAP) on their behalf, for a long-term biosolids management plan. The management plan will involve the periodic application (every three to five years) of biosolids material from the City of Steinbach's wastewater treatment lagoon, onto agricultural lands owned by the City of Steinbach in the City's jurisdiction and within the Rural Municipality of Hanover over a 25-year period. As per the *Classes of Development Regulation* under *The Environment Act*, we understand that this project would be considered a Class 2 Development.

The objective of this EAP is to provide documentation in support of attainment of an Environment Act License for this project.

For your consideration, please find enclosed an electronic copy (as a searchable .pdf file on a removable drive) and four (4) printed copies of the EAP document, the application form and the application fee for $7,500.00 as required for an EAP submission for a Class 2 Development. If you have any questions or concerns about this submission, please contact the undersigned at your convenience.

Yours sincerely,

Mr. Darren Keam, M.Sc., P.Ag.
Team Lead, Environmental Management

Encl. City of Steinbach, Long-term Biosolids Management Plan, Environment Act Proposal
cc: Mr. Mike Heppner, City of Steinbach
WSP ref.: 15M-00649-01

Environment Act Proposal Form

Manitoba
Sustainable Development

Name of the development: City of Steinbach Long-term Biosolids Land Application Plan	
Type of development per Classes of Development Regulation (Manitoba Regulation 164/88): Class 2	
Legal name of the applicant: City of Steinbach, Waterworks Department	
Mailing address of the applicant: 255 Reimer Avenue Contact Person: Mr. Mike Heppner, Manager, Waterworks Department City: Steinbach Province: Manitoba Postal Code: R5G 2J1 Phone Number: (204) 346-6214 Fax: (204) 346-6239 email: mheppner@steinbach.ca	
Location of the development: City of Steinbach Contact Person: Mr. Mike Heppner, Manager, Waterworks Department Street Address: 255 Reimer Avenue Legal Description: City/Town: Steinbach Province: Manitoba Postal Code: R5G 2J1 Phone Number: (204) 346-6214 Fax: email: mheppner@steinbach.ca	
Name of proponent contact person for purposes of the environmental assessment: Mr. Darren Keam	
Phone: (204) 259-1488 Fax: (204) 474-2864	Mailing address: 1600 Buffalo Place, Winnipeg, MB R3T 6B8
Email address: darren.keam@wsp.com	
Webpage address: wsp.com	
Date: April 24, 2019	Signature of proponent, or corporate principal of corporate proponent: Printed name: Mr. Mike Heppner

PRINT RESET

A complete **Environment Act Proposal (EAP)** consists of the following components:

- ☑ **Cover letter**
- ☑ **Environment Act Proposal Form**
- ☑ **Reports/plans supporting the EAP** (see "Information Bulletin - Environment Act Proposal Report Guidelines" for required information and number of copies)
- ☑ **Application fee** (Cheque, payable to Minister of Finance, for the appropriate fee)

Per Environment Act Fees Regulation (Manitoba Regulation 168/96):

Class 1 Developments	$1,000
Class 2 Developments	$7,500
Class 3 Developments:	
Transportation and Transmission Lines	$10,000
Water Developments	$60,000
Energy and Mining	$120,000

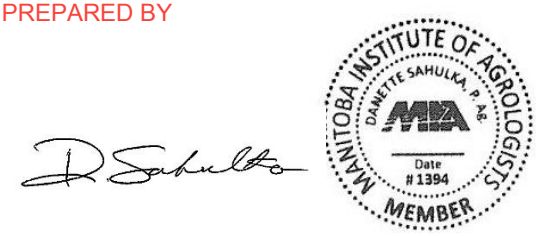
Submit the complete EAP to:

Director
Environmental Approvals Branch
Manitoba Conservation and Water Stewardship
Suite 160, 123 Main Street
Winnipeg, Manitoba R3C 1A5

For more information:
Phone: (204) 945-8321
Fax: (204) 945-5229
http://www.gov.mb.ca/sd/eal

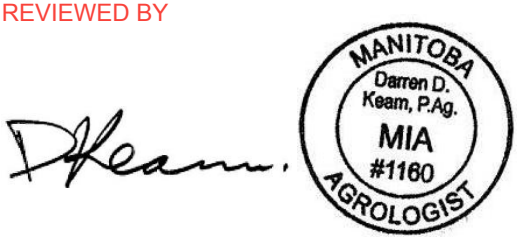
SIGNATURES

PREPARED BY



Danette Sahulka, M.Sc., P.Ag.
Senior Ecologist

REVIEWED BY



Darren Keam, M.Sc., P.Ag.
Senior Project Manager

EXECUTIVE SUMMARY

Introduction

This Environment Act Proposal (EAP) is submitted to the Manitoba Sustainable Development, Environmental Approvals Branch, as required under the Manitoba *Environment Act* for the purpose of obtaining a Class 2 Environment Act Licence for the City of Steinbach's proposed long-term biosolids land application plan.

The City of Steinbach has developed a proposed 25-year biosolids plan for their wastewater treatment lagoon that involves the periodic removal and land application (every three to five years) of biosolids materials from their lagoon onto neighbouring agricultural lands owned by the City of Steinbach. These lands lie within in the City's municipal jurisdiction or within the Rural Municipality (RM) of Hanover.

Objective

The long-term biosolids management plan includes the development of biosolids application rates and timings to agricultural land that will:

1. Comply with applicable regulatory requirements.
2. Be conducted in an agronomically and environmentally sustainable manner that targets crop uptake of nutrients in the biosolids material to abate nutrient loss to local surface and groundwater as well as minimizing accumulation of heavy metals in the soil.

Proposed Long-term Land Application Plan for Biosolids

In order to meet the City of Steinbach's wastewater treatment lagoon capacity and sustainability needs, it is projected that cleanout of the lagoon and corresponding land application of biosolids material will need to be completed every three to five years. To streamline this process, the City of Steinbach has developed a long-term (25-year) biosolids land application plan for their wastewater treatment lagoon that will include a land rotation and monitoring program for soil nutrients, salts and metals. The long-term biosolids plan forms the basis of this EAP report.

Development of the biosolids land application plan was based on:

1. A review of existing literature including:
   a. Nutrient management regulations.
   b. Past studies that the City of Steinbach has commissioned including a 2014 Sustainable Growth Strategy.
   c. Academic papers, studies and other biosolids management plans including potential impacts, environmental risk associated with, and mitigations of salt, heavy metal and phosphorus accumulations in the soil base.
2. At this time, it is proposed that eleven parcels of land owned by the City of Steinbach, will be used in a three to five-year rotation over the 25-year period for biosolids land application. This land base was assessed for:
   a. Land suitability including dominant soil series, Canada Land Inventory for soil capability for agriculture, nutrient management, buffer zones and agronomy.
   b. Identification of any biophysical and socio-economic constraints or concerns.

3. Development of a mass balance model of the proposed biosolids application rates for five to eight application events on the proposed land parcels. The mass balance model:
    a. Establishes typical applications of biosolids to the agricultural land base for nitrogen, phosphorous and trace elements (e.g., cadmium, mercury, arsenic, nickel, copper, chromium, lead and zinc).
    b. Is based on a single application (fresh land base for each event) and multiple biosolids applications to a single land base.
    c. Accounts for crop uptake and removal by a single cropping system.
    d. The objective of the model is to establish the sustainability of multiple land applications of biosolids.
4. Development of best management practices for the sampling, analysis, land application, monitoring and mitigation of potential concerns. This establishes legacy documentation for the biosolids management plan.
5. Establishment of templates and timelines for summary report submission to the Manitoba Sustainable Development, Environmental Approvals Branch for approval prior to land application including:
    a. Analytical results table for biosolids' and receiving land(s)' nutrient and metals levels.
    b. Biosolids land application prescription rates prior to each application event.
    c. Follow-up agricultural land monitoring reporting of results following each application event.

Summary

All applicable regulatory requirements, guidelines and good neighbour policies and procedures will be adhered to during the implementation of the City of Steinbach's long-term biosolids land application plan. With the employment of appropriate mitigation measures, potential negative effects associated with the City's biosolids land application can be minimized. When applied at balanced rates, the land application of biosolids is a sustainable means to reuse nutrients within an agriculture system as the application of biosolids organic material enhances the water holding capacity, structure and tilth of soils thereby providing benefits to land utilized for agricultural production.

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ABBREVIATIONS

UNITS OF MEASURE

acre	ac
bushels per acre	bu/ac
centimetre	cm
cubic metre	m^3
degrees Celsius	°C
deciSiemens per metre	dS/m
foot	ft
gram	g
grams per litre	g/L
hectare	ha
hour(s)	hr
kilogram	kg
kilometre	km
litre	L
litre per second	L/s
metre	m
metres above sea level	masl
microns	µm
microSiemens per cm	uS/cm
millimho per centimeter	mmho/cm
milligram	mg
milligrams per litre	mg/L
milligrams per kilogram	mg/kg
millimetre	mm
moles	mol
moles per gram	mol/g
nanograms per gram	ng/g
parts per million	ppm
percent	%
potential of hydrogen	pH
pound(s)	lb
pounds per acre	lb/ac
square foot	ft^2
square kilometre	km^2
square metre	m^2
tonne per hectare	t/ha

ACRONYMS

biological nutrient removal	BNR
Canadian Council of Ministers of the Environment	CCME
Canadian Land Inventory	CLI
Department of Fisheries and Oceans	DFO
East of the Prime Meridian	EPM
electrical conductivity	E.C.
emerging substances of concern	ESOC
Environmental Approvals Branch	EAB
Environment Act License	EAL
Environment Act Proposal	EAP
endocrine-disrupting chemicals	EDC
Ferric Chloride	$FeCl_3$
greenhouse gas	GHG
Historic Resources Branch	HRB
Iron	Fe
Iron (III) Phosphate	$FePO_4$
Local Study Area	LSA
Local Urban District	LUD
Manitoba	MB

ACRONYMS (CONTINUED)

Manitoba Conservation Data Centre ..... MB CDC
Manitoba Endangered Species and Ecosystems Act … ..... MESEA
Manitoba Sustainable Development ..... MSD
Nitrogen ..... N
Nutrient Management Regulations ..... NMR
personal care products ..... PCP
Phosphorus ..... P
Phosphate ..... P_2O_5
Plant Available Nitrogen ..... PAN
Plant Available Phosphorus (P_2O_5) ..... PAP
Project Study Area ..... PSA
Red River Valley Special Management Area ..... RRVSMA
Rural Municipality ..... RM
Sodium Absorption Ratio ..... SAR
Species at Risk Act ..... SARA
total solids ..... TS
United States Environmental Protection Agency ..... USEPA
WSP Canada Group Limited. ..... WSP

1 INTRODUCTION

This Environment Act Proposal (EAP) is submitted to the Manitoba Sustainable Development (MSD), Environmental Approvals Branch (EAB), as required under the Manitoba *Environment Act* for the purpose of obtaining a Class 2 Environment Act Licence (EAL) for the City of Steinbach's proposed long-term biosolids land application plan. The City of Steinbach has developed a proposed 25-year biosolids land application plan for their wastewater treatment lagoon that involves the periodic removal and land application of biosolids materials from their lagoon onto neighbouring agricultural lands.

1.1 Proponent

The proponent for the biosolids land application plan is the City of Steinbach, Waterworks Department. The primary contact from the City of Steinbach for the project is:

Mr. Mike Heppner, Manager, Waterworks Department
City of Steinbach
255 Reimer Avenue
Steinbach, Manitoba
R5G 2J1

Project work has been approved by the City Manager, City Corporate Manager, Mayor, City Councillors and the Waterworks Department Manager.

1.2 Location of Proposed Project

Regionally, the biosolids management plan will be implemented within the Rural Municipality (RM) of Hanover, located approximately 40 kilometres (km) southwest of the City of Winnipeg, and approximately 2.5 km west of the City of Steinbach (refer to Map 1, Appendix A).

1.3 Background

In 2016, the City of Steinbach Waterworks Department received a Class 2 EAL (EAL #3136) for the land application of biosolids material from their municipal wastewater treatment lagoon located on the southeast quarter of Section 8, Township 7, Range 6 East of the Prime Meridian (EPM) (Map 2, Appendix A). Biosolids material was dredged from treatment Cell 1 of the lagoon and applied to 46 hectares (ha) of agricultural land located on the southeast quarter of Section 9, Township 7, Range 6EPM; the material was applied from October 23 to October 30, 2016.

In the fall of 2018, approximately 11,249 cubic meters of biosolids material from Cell 2 was dredged and land applied onto approximately 28 ha of agricultural land on E1/2 08-07-06EPM. The application rates and timings of these biosolids material to agricultural land was conducted in an agronomically and environmentally sustainable manner that targets crop uptake of the nutrients in the biosolids material in order to abate nutrient loss to surface and groundwater in the area as well as minimizing accumulation of heavy metals in the soil.

It is anticipated that this current removal and application of biosolids material from the two cells will have lowered biosolids material in the lagoon system to a level that will provide the City of Steinbach with up to five to six years of storage capability before the biosolids material will have to be removed and land applied again to maintain wastewater treatment lagoon capacity and sustainability needs. It is projected that lagoon cell cleanout and land application of biosolids material will need to be completed every three to five years. To streamline this process,

the City of Steinbach retained WSP Canada Group Limited (WSP) to complete a long-term (25-year) biosolids land application plan for their wastewater treatment lagoon that will include a land rotation and monitoring program for soil nutrients, salts and metals. The long-term biosolids land application plan forms the basis of this EAP report.

1.4 Objective

The objective of this EAP is to demonstrate commitment by the City of Steinbach for a long-term sustainable biosolids land application plan and to provide documentation in support of the plan in order to obtain an EAL from the MSD, EAB for the periodic (every three to five years) land application of biosolids materials for a 25-year period.

The long-term biosolids land application plan includes the development of biosolids application rates and timings to agricultural land that will:

1. Comply with applicable regulatory requirements.
2. Be conducted in an agronomically and environmentally sustainable manner that targets crop uptake of the nutrients in the biosolids material to abate nutrient loss to local surface and groundwater as well as minimizing accumulation of heavy metals in the soil.

1.5 Description of Regulatory Requirements

The following Acts and Regulations apply to the biosolids plan and will be adhered to throughout the duration of the plan:

- The *Environment Act* C.C.S.M. c. E125 (1987)
  - Licensing Procedures Regulations 163/88
  - *Classes of Development Regulation* 164/88
  - Environment Act Fees Regulation 168/96
  - *Livestock Manure and Mortalities Management Regulation* 42/98
    - 14.1 Designation of Red River Valley Special Management Area
  - Environmental Regulations for Treatment and Disposal of Biosolids in Manitoba, Mike Van Den Bosch, P.Eng., Municipalities & Industrial Approvals, Manitoba Environment
- The *Water Protection Act* C.C.S.M. c. W65 (2005)
- *Nutrient Management Regulation* 62/2008

2 DESCRIPTION OF THE PROJECT

The City of Steinbach has developed a proposed 25-year biosolids land application plan for their wastewater treatment lagoon that involves the periodic removal and re-use of biosolids materials through land application on a suitable land base at agronomically and environmentally sustainable prescription rates.

2.1 Long-Term Biosolids Application Plan Components

Development of the biosolids land application plan was based on:

1. A review of existing literature including:
   a. Nutrient management regulations.
   b. Past studies that the City of Steinbach has commissioned including a 2014 Sustainable Growth Strategy.
   c. Academic papers, studies and other biosolids management plans including potential impacts, environmental risk associated with, and mitigations of salt, heavy metal and phosphorus accumulations in the soil base.
2. At this time, it is proposed that 11 parcels of land owned by the City of Steinbach in the City's municipal jurisdiction and in the RM of Hanover (refer to Table 1 and Map 3, Appendix A) will be used in a three to five-year rotation over the 25-year period for biosolids land application. This land base was assessed for:
   a. Land suitability including dominant soil series, Canada Land Inventory for soil capability for agriculture, nutrient management, buffer zones and agronomy.
   b. Identification of any biophysical and socio-economic constraints or concerns.
3. Development of a mass balance model of the proposed biosolids application rates for five to eight application events on the proposed land parcels. The mass balance model:
   a. Establishes typical applications of biosolids to the agricultural land base for nitrogen, phosphorous and trace elements (e.g., cadmium, mercury, arsenic, nickel, copper, chromium, lead and zinc).
   b. Is based on multiple biosolids applications to the defined land base.
   c. Accounts for crop uptake and removal by a four-year crop rotation typically farmed in the Steinbach region.

Mass balance modelling the biosolids application is viewed as an important component for the biosolids plan success; the modelling is utilized to establish a biosolids risk management assessment on a potentially limited land base. The land base is potentially limited due to the intensive livestock industry associated with the surrounding area and corresponding lack of suitable/available land for biosolids application. The objective of the model is to establish the sustainability of multiple land applications of biosolids. The model uses current known biosolids quality data from the City of Steinbach lagoon (treatment Cell 1 data from 2013 and treatment Cell 2 data from 2015) and typical crop rotation and removal rates for the elements of concern.

4. Development of best management practices for the sampling, analysis, land application, monitoring and mitigation of potential concerns. This establishes legacy documentation for the biosolids land application plan.
5. Establishment of templates and timelines for summary report submission to the MSD, EAB for approval prior to land application including:
   a. Analytical results table for biosolids and receiving land(s) nutrient and metals levels.
   b. Biosolids land application prescription rates prior to each application event.
   c. Reporting of results from follow-up land monitoring following each application event.

2.2 Existing Lagoon Infrastructure

The City of Steinbach's wastewater treatment lagoon is located within the City of Steinbach's boundaries, north of the Local Urban District (LUD) of Mitchell on the southeast quarter of Section 8, Township 7, Range 6EPM (refer to Map 2, Appendix A). The City of Steinbach wastewater collection system and wastewater treatment lagoon operates under EAL #2897. The lagoon is comprised of nine cells: one primary cell, two aeration cells (Cells 1 and 2), and seven holding cells (Cells 3 through 8). In 2011, new cells were added to the lagoon to support an additional ten years of wastewater capacity. The majority of the population in the City of Steinbach is serviced by a municipal gravity fed sewage system. There are also two large lot residential subdivisions on the east side of the City that are served by a low-pressure sewage system (Map 4, Appendix A). All wastewater is directed to the City's sewer collection system in the City of Steinbach. Holding tank sewage pump-outs from within the City are hauled by truck to the City's designated transfer station (MMM, 2014).

Results of a Sustainable Growth Strategy completed for the City of Steinbach (MMM, 2014) indicates that future expansion of the City would require the addition of a second municipal sewer trunk line in addition to the existing trunk line in order to properly service the City. The second line would likely be developed along the western boundary of the City and would serve the area just north and east of the current landfill (Map 4, Appendix A). This is a logical route as it utilizes the natural slope of the land and allows for the servicing of much of the development reserve land in the southern end of the City (MMM, 2014).

2.3 Study Area Definitions

To examine the potential effects of the biosolids land application plan in the local area, a Local Study Area (LSA) for the project was designated as including the lands within 5 km west of the City of Steinbach's limits (refer to Map 2). The LSA falls within the Red River Valley of Manitoba and is included in the Red River Valley Special Management Area (RRVSMA) as defined in section 14.1 of *The Livestock Manure and Mortalities Management Regulation* of *The Environment Act*. As such, biosolids land application within the LSA must follow restrictions outlined under Sections 14.1 and 14.2 of the Regulation.

The Project Study Area (PSA) is defined as the area that will be directly affected by the application of biosolids materials and includes the 11 parcels of land listed in Table 1 and depicted in Map 3, Appendix A. These lands are currently rented to local agricultural producers by the City, primarily for annual crop or hay production.

Table 1 List of Parcels of Land Proposed for the Long-term Biosolids Land Application Plan

Parcel #	Legal Land Location	Area (ha)	Municipal Area
1	SE 09-07-06EPM	65 ha (160 ac)	City of Steinbach
2	NE 10-07-06EPM (west half)	33 ha (81 ac)	City of Steinbach
3	NW 10-07-06EPM (south half)	33 ha (81 ac)	City of Steinbach
4	SW 15-07-06EPM	65 ha (161 ac)	City of Steinbach
5	Part of SW 08-07-06EPM & Part of E 1/2 08-07-06EPM	40 ha (100 ac)	RM of Hanover & City of Steinbach
6	SE-08-07-06EPM (east half)	32 ha (80 ac)	City of Steinbach
7	NE-08-07-06EPM (east half)	32 ha (80 ac)	City of Steinbach
8	NW-08-07-06EPM	65 ha (161 ac)	RM of Hanover
9	SE-17-07-06EPM (east half)	23 ha (56 ac)	City of Steinbach

Parcel #	Legal Land Location	Area (ha)	Municipal Area
10	Lot 1, Plan 14671 WLTO, in the City of Steinbach (east of the airstrip)	5 ha (12 ac)	City of Steinbach
11	Lot 1, Plan 14671 WLTO, in the City of Steinbach (north of the airstrip)	10 ha (26 ac)	City of Steinbach

3 INFORMING THE PUBLIC

The City of Steinbach has undertaken a public information campaign in order to apprise the local public of the City's plans to undertake a long-term biosolids management plan and to provide a forum for the public to ask questions and/or express concerns. A summary of the City's information campaign is outlined below.

3.1 Website Posting

The City of Steinbach has posted a "Biosolids Land Application Program" page on their website regarding the long-term biosolids program that provides information on the intent of the program, and information pertaining to "what are biosolids, what a land application program involves, public safety, and benefits of land application" (refer to Appendix B for a copy of the website posting). The website page also contains an inquiry submission form, whereby members of the public can contact the City and submit questions and/or concerns. The website page is monitored by the City of Steinbach Communications Coordinator for public inquiries.

- The website page was initiated on March 9, 2018 and remains open for questions/comments.
- To date, only one inquiry has been posted to the web tab, and this inquiry was from a local agricultural producer interested in participating in the land application program.
- The webpage was viewed 40 times between March 9, 2018 and October 2, 2018 (cannot determine however if it was 40 unique individuals or multiple views by the same individual).

3.2 2018 Spring/Summer Newsletter

The City also included information on the long-term biosolids management plan in their 2018 annual Spring/Summer Newsletter that was included in all residents' quarterly water bills that were mailed out to approximately 4,600 households the first week of May 2018 (refer to copy of newsletter provided in Appendix B). To date, the Communication Coordinator for the City has not received any other comments on any other City online channels or via phone calls from the public regarding the biosolids plan.

4 DESCRIPTION OF EXISTING ENVIRONMENT

4.1 Biophysical Environment

The LSA is located within the Steinbach Ecodistrict of the Interlake Plain Ecoregion which is covered by the broader Boreal Plains Ecozone (Smith, Veldhuis, Mils, Eilers, Fraser and Lelyk, 1998).

4.1.1 Climate

The Steinbach Ecodistrict lies in a more humid and cooler subdivision of the Subhumid Low Boreal Ecoclimatic Region. The ecodistrict is characterized by short, warm summers and cold winters with a mean average temperature of 2.4ºC (Smith, et al. 1998). The average crop-growing season is 184 days with approximately 1,700 growing degree-days. Mean annual precipitation is 510 millimeters (mm), one fifth of which is in the form of snowfall. The Steinbach Ecodistrict has a moderately cold, humid, Cryoboreal to cool, subhumid Boreal soil climate with an average annual soil moisture deficit of approximately 200-250 mm (Smith, et al. 1998).

4.1.2 Physiography and Drainage

The LSA is situated within the southeastern lake terrace section of the Manitoba Plain. The physiography ranges from smooth, level glaciolacustrine plain to gently undulating, terraced plain with water-worked glacial till and glaciofluvial materials. The mean area elevation is 297 metres above sea level (masl). The overall slope for the ecodistrict is northwestward from the eastern edge of the district towards the Red River in the west (Smith, et al. 1998).

Within the LSA, the Manning Canal, a fifth/fourth order drain, provides the main drainage system in the area, connecting to the northwest of the LSA with the Seine River Diversion. Numerous first, second, third and fourth order drains are also found around the LSA that contribute water into the Manning Canal (refer to Map 5, Appendix A).

4.1.3 Soils

Soils in the ecodistrict consist of well to imperfectly drained Dark Gray and Black Chernozems developed on thin, variably calcareous, discontinuous, sandy to loamy glaciolacustrine veneers. These veneers overlay extremely calcareous, water–worked glacial till that are loamy to clayey in texture (Smith, et al. 1998). Sandy deposits and till ridges in the eastern area of the ecodistrict contain imperfectly and well drained Luvisol and some Eutric Brunisol soils (Smith, et al. 1998). Depressional lowland areas in the ecodistrict contain poorly drained peaty Gleysols and organic Mesisols (Smith, et al. 1998). Specific soil characteristics of the LSA are discussed under Section 5 of this EAP.

4.1.4 Surficial and Bedrock Geology

Surficial deposits within the LSA consist of clay beds up to 24 m thick, underlain by glacial till. These surficial deposits are underlain by carbonate rock (limestone and dolostone) bedrock. Beneath the carbonate bedrock layer are sandstone and shale beds that occur at a depth of approximately 79 m near the City of Steinbach. These sandstone and shale beds are in turn underlain by granitic rock (Rutulis, 1973).

4.1.5 Groundwater and Hydrological Description

Extensive aquifers underlie the RM of Hanover, including the LSA. Near Steinbach, the carbonate aquifer that underlies the surficial deposits, ranges in depth from 24 to 45 m with the static water level (flowing well area) occurring at up to 9 m above ground level (Rutulis, 1973). This aquifer is formed by thick and extensive carbonate rock beds with minor shale beds (Rutulis and Mamott, 1986[1]). Most domestic wells in the RM draw their water from the carbonate aquifer and have been developed into the carbonate rock to a depth of 9 m or less (Rutulis, 1973). Domestic wells in the carbonate aquifer yield more than 1.0 litres per second (L/s) (Rutulis and Mamott, 1986[2]). Water quality in the carbonate aquifer is of good to excellent quality and can be used as a domestic supply without treatment. Total dissolved solids concentration and hardness is less than 500 parts per million (ppm) and 400 ppm, respectively (Rutulis and Mamott, 1986[2]).

Within the RM a sandstone aquifer lies beneath the carbonate rock formation. Near Steinbach, this extensive aquifer is found at a depth of approximately 79 m. Static water levels in wells drilled into the sandstone aquifer are similar to those of the carbonate aquifer. Water quality in the sandstone aquifer contains higher levels of dissolved solids, and hardness is several times lower compared to the carbonate aquifer (Rutulis, 1973). Potable water for residents of the City of Steinbach is drawn from three groundwater wells that have been developed into the aquifer; the groundwater is then pumped to water reservoirs and then to the City's water treatment facility for processing. Treated water is then distributed to the community via a network of underground metered water pipes. There are still a few areas within the City that are not serviced by the municipal water system (MMM, August 2014).

In the area around the town of Blumenort as well as south of provincial highway #52, discontinuous sand and gravel aquifers also occur above the carbonate aquifer (Rutulis and Mamott 1986[1]). These aquifers range in size from less than a hectare to several square kilometres in size. These sand and gravel aquifers may occur at less than 15 m up to a depth of more than 30 m and average thicknesses may range from a few metres to greater than 30 m (Rutulis 1973). These aquifers are common throughout most of the RM but are not continuous, thus, some wells in the area may be developed into these aquifers, but most have been developed into the carbonate aquifer. Water quality is generally better in the sand and gravel aquifers compared to the carbonate aquifer (Rutulis and Mamott 1986[1]). Well yields range from less than 0.1 to more than 10 L/s (Rutulis and Mamott 1986[1]).

A search of the Manitoba GWDrill (2012) logs for groundwater wells specific to the PSA found a total of eight groundwater wells in the PSA (refer to Table 2). The groundwater well search results are included in Appendix C.

Table 2 Groundwater Wells within the PSA

Legal Location	Number of Wells		
	Domestic Well	Test/Observation Well	Unknown/Other
08-07-06EPM	3	0	1
010-07-06EPM	2	0	2

4.1.6 Terrestrial Environment

The native vegetation of the Steinbach Ecodistrict originally consisted of trembling aspen and balsam poplar tree bluffs and tall grass prairie, with creeks and low-lying areas supporting willow and red-oiser dogwood shrubs as well as a variety of sedge species. As a result of settlement, much of the native vegetation in the district has been replaced by agricultural crops (Smith, et al. 1998). Local pockets of natural vegetation can still be found in areas of unbroken land.

Habitat for wildlife species is limited within the LSA due to the predominance of agricultural production. Examples of species which persist in the area and have adapted to the agricultural landscape include white-tailed deer, jack rabbit, raccoon, skunk, red fox, small mammal species (e.g. voles and mice) and various bird species such as crows, blackbirds and a variety of songbirds.

4.1.7 Surface Water Bodies and Aquatic Life

There are no natural lakes within or around the LSA and wetlands have been reduced to small ephemeral depressions and dugouts that are used for livestock watering. Historic drainage patterns in the region have been altered over time to accommodate agricultural production with the result of several "blind" creeks being established and the development of the Manning Canal in the late 1950s. The Manning Canal provides the main drainage system in the area with drainage water being collected from various "arms" and tributaries of the canal in the local area surrounding the City of Steinbach (refer to Map 5, Appendix A).

Aquatic life in the LSA is restricted to the Manning Canal and its tributaries and the narrow-vegetated buffer strips immediately adjacent to these drainage systems. Examples of species that may occur in these areas include frogs, dragonflies, turtles and garter snakes as well as various waterfowl species.

A survey conducted in 2006 by the City of Winnipeg Naturalist Services Branch for the presence of fish within certain upstream regions of Winnipeg creeks and streams observed that several minnow and fish species were entering Winnipeg drains and channels from the Seine River and its tributaries. These species included black bullhead and fathead minnows, common carp and white sucker (Penner 2007). Based on these findings it is possible for the Manning Canal and its tributaries to contain transient minnow and fish species.

4.1.8 Potential Species of Conservation Concern

An online request was made to the Manitoba Sustainable Development, Wildlife and Ecosystems Protection Branch, Manitoba Conservation Data Centre (MBCDC) on November 9, 2016, with respect to any recorded observation of species of conservation concern associated with the PSA (refer to Table 1 for PSA legal land locations). Mr. Chris Friesen, Biodiversity Information Manager of the MBCDC examined database records and provided a response on November 22, 2016 indicating that two bird species of conservation concern were identified in association with two of the land parcels within the PSA as follows (refer to Appendix C for a copy of Mr. Friesen's response):

- SW 15-07-06EPM
  - Bobolink (*Dolichonyx oryzivorus*) – small songbirds that inhabit tall grasslands, uncut pastures, overgrown fields and meadows and native prairie (Cornell University, 2015).
    - MBCDC rank of S4B – breeding occurrences for this species is considered to be "widespread, abundant, and apparently secure throughout its range or in the province, with many occurrences, but the element is of long-term concern (> 100 occurrences)" (Manitoba Sustainable Development, n.d).
    - The Committee on the Status of Endangered Wildlife in Canada[1] (COSEWIC) ranks this species as "Threatened" – "a wildlife species that is likely to become endangered if nothing is done to reverse the factors leading to its extirpation or extinction" (Government of Canada, 2016).

[1] "The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) assesses the national status of wild species, subspecies, varieties, or other designatable units that are considered to be at risk in Canada. Designations are made on all native species for the following taxonomic groups: mammals, birds, reptiles, amphibians, fishes, lepidopterans, molluscs, vascular plants, mosses, and lichens". (Government of Canada, 2018).

- Barn Swallow (*Hirundo rustica*) – small songbird that utilizes open habitat such as fields, parks, roadway edges, marches, meadows and ponds for feeding. Nests are typically located under eaves or inside sheds, barns, bridges and other structures where disturbance is minimal (Cornell University, 2015).
  - MBCDC rank of S4B – breeding occurrences for this species is considered to be "widespread, abundant, and apparently secure throughout its range or in the province, with many occurrences, but the element is of long-term concern (> 100 occurrences)" (Manitoba Sustainable Development, n.d).
  - COSEWIC status as "Threatened" – "a wildlife species that is likely to become endangered if nothing is done to reverse the factors leading to its extirpation or extinction" (Government of Canada, 2016).

– SW08-07-60EPM
  - Barn Swallow (*Hirundo rustica*)
    - MBCDC rank of S4B – breeding occurrences for this species is considered to be "widespread, abundant, and apparently secure throughout its range or in the province, with many occurrences, but the element is of long-term concern (> 100 occurrences)" (Manitoba Sustainable Development, n.d).
    - COSEWIC status as "Threatened" – "a wildlife species that is likely to become endangered if nothing is done to reverse the factors leading to its extirpation or extinction" (Government of Canada, 2016).

4.2 Parks and Protected Areas

Several community green space and sports parks are located within the Steinbach city limits and associated with the LUD of Mitchell. No protected areas or wildlife management areas were identified within the LSA.

4.3 Socio-economic Environment

4.3.1 Existing Land Uses

Land use associated with the City of Steinbach includes smaller residential development lots as well as various municipal buildings (e.g. schools) and private commercial and industrial businesses. Land surrounding the City of Steinbach is primarily used for agricultural production of small grain and forage crops and livestock production including hogs, dairy and poultry.

4.3.2 Current Land Use Development Controls

According to the RM of Hanover Zoning By-Law No. 2171, land within the LSA is designated as either Zone A – "Agricultural" or Zone R – "Rural". Under the Zoning By-law, "Agricultural" is defined as a district intended for general agriculture activities. "Rural" is defined as "this zone provides for general agricultural uses similar to the Agricultural Zone however, due to the proximity to urban centres, rural residential development areas and environmentally sensitive areas, certain uses that may conflict with these areas, such as livestock operations, are more restricted." Designated land use within the more populated areas of the PSA including the City of Steinbach and the LUD of Mitchell consist of a combination of rural/agricultural, rural residential, commercial, industrial, institutional, mixed use and parks/open spaces (refer to Map 6, Appendix A). The identified land use zoning districts under the By-law for the identified LSA and neighbouring properties do not prohibit the use of the land for spreading of biosolids.

4.3.3 Population

The total population of the RM of Hanover in 2016 was 15,733 individuals (Statistics Canada 2016). The settled populations within and adjacent to the LSA include the LUD of Blumenort with a population of 1,675 individuals, the hamlets of Randolph, New Bothwell, and Greenland with unreported population numbers and the LUD of Mitchell with a population of 2,523 individuals (Statistics Canada 2016). In 2016, the City of Steinbach had a population recorded as 15,824 individuals (Statistics Canada 2016).

In 2014 the City of Steinbach commissioned a Sustainable Growth Strategy (SGS) to determine the amount of land required to support growth in the City over the next 50 years (MMM, 2014). According to the SGS report, Steinbach's population grew from 11,066 in 2006 to 13,524 in 2011, an overall increase of 22.21 percent or an average yearly increase of 4.4 percent per year over the past five years (Table 3). Based on a 4.2 percent annual growth rate, the projected population in Steinbach in the year 2064 will be approximately 102,447 people resulting in a total population increase of 87,219 people over the next 50 years (2014 to 2064) (MMM, 2014). The SGS determined that the City of Steinbach will have a shortage of approximately 7,979 gross acres for future residential, commercial and industrial use. As such the SGS recommended that the City of Steinbach expand their boundary to meet this shortfall. Expansion to the west of the City was recommended as the most feasible option as this area has the least land fragmentation and constraints (e.g. livestock operations, drainage challenges). This provides additional challenges for available land for biosolids application near this urban centre.

Table 3 Summary of Population Growth for the City of Steinbach (1981-2016)

Demographics	Year							
	1981	1986	1991	1996	2001	2006	2011	2016
Population	6,676	7,473	8,213	8,478	9,227	11,066	13,524	15,829
% increase over 5 years	n/a	11.94	9.90	3.23	8.83	19.93	22.21	17.04
% increase per year	n/a	2.4	2.0	0.6	1.78	4.0	4.4	3.4

4.3.4 Heritage Resources

A request was made to the Manitoba Historic Resources Branch (HRB) on November 9, 2016 with respect to the location of heritage resources associated with the PSA (refer to Table 1 for PSA legal land locations). Ms. Suyoko Tsukamoto, Impact Assessment Archeologist with the HRB examined branch records and found that there are no known archaeological sites or designated heritage sites within the PSA (refer to Appendix C for a copy of the correspondence).

4.3.5 First Nation Communities

No First Nation communities or lands owned by First Nations are included in the LSA.

5 REQUIREMENTS FOR LONG-TERM BIOSOLIDS MANAGEMENT

In order for a long-term biosolids land application plan to be feasible and sustainable, numerous factors must be met including:

- Availability of enough suitable land for a 25-year program with land application events occurring at regular intervals; limitations include:
  - Proximity to urban centers in area.
  - Buffer zone requirements (e.g., around houses, wells, waterways, etc.).
- Biosolids materials must be applied in an environmentally sustainable manner to minimize long-term negative impacts to the soil resource; limitations include:
  - Restrictions in agricultural capability of soils, high existing soil phosphorus levels from previous livestock manure applications from intensive livestock operations in the area.
- There must be support from cooperating farm producers and local residents; limitations include:
  - Difficulties in retaining interested agricultural producers for land rental of City of Steinbach's land for a 25-year period and that have cropping rotations and fertility management practices conducive to biosolids application.

The following sections provide information on how the City of Steinbach's long-term biosolids land application plan will meet these factors.

5.1 Land Availability

It is estimated that approximately 65 ha of land will be required for a land application event to accommodate and to maintain the sustainability of the City of Steinbach's lagoon capacity. The 11 parcels of land (as listed in Table 1 and described as the PSA) that are being put forward as the available land base that will be used in the biosolids management plan. The plan includes use of these lands in the rotation for biosolids application as needed over the next 25 years (refer to Map 3, Appendix A). The City currently rents these land parcels to local agricultural producers for hay and annual crop production. It is the intent of the City to develop specific land rental agreements and to work more closely with their land renters in the future to establish cropping system rotations that are conducive to the periodic application of biosolids material. This will allow the City to better manage the land base in terms of minimizing the build-up of residual nutrients, salts and heavy metals in the soil resource to sustain the long-term application of biosolids material to these land parcels.

5.2 Land Suitability

5.2.1 Dominant Soil Series

There are four soil series within the PSA that include Osborne, Red River and Scanterbury. Single soil series or compound map series and the applicable number of hectares are outlined in Table 4 and characteristics of the soil series are outlined in Table 5 and shown in Map 7 (Appendix A).

Table 4 Soil Series and the Aerial Extent within the PSA

Field #	Field Number/Legal Location	Soil Series	Map Unit (percent area of polygon)	Aerial Extent (ha)
1	SE 09-07-06EPM	SCY8-RIV2	Scanterbury- Red River (71%)	46
		OBOd	Osbourne (29%)	19
2	NE 10-07-06EPM (west half)	SCY8-RIV2	Scanterbury Red River (100%)	33
3	NW 10-07-06EPM (south half)	SCY8-RIV2	Scanterbury (67%)	22
		OBOd	Osbourne (33%)	10
4	SW15-07-06EPM	OBOd	Osbourne (88%)	57
		SCY8-RIV2	Scanterbury (12%)	8
5	Part of SW-08-07-06EPM, Part of E 1/2 08-07-06EPM	OBOd7-RIV3	Osbourne-Red River (100%) – drained	40
6	SE-08-07-06EPM (East Half)	OBOd7-RIV3	Osbourne (81%) – drained	26
		OBOd	Osbourne (18%)	6
7	NE-08-07-06EPM (East Half)	OBOd7-RIV3	Osbourne-Red River (21%)	7
		SCY8-RIV2	Scanterbury-Red River (53%)	17
		OBOd	Osbourne (26%)	8
8	NW-08-07-06EPM	OBOd7-RIV3	Osbourne-Red River (68%)	44
		OBOd	Osbourne (32%)	21
9	SE-17-07-06EPM (East Half)	SCY8-RIV3	Scanterbury-Red River (100%)	23
10	Lot 1, Plan 14671 WLTO, in the City of Steinbach (east of the airstrip)	GNL7-PMG3	Glenella-Plum Ridge (96%)	5
		GUO	(4%)	0.2
11	Lot 1, Plan 14671 WLTO, in the City of Steinbach (north of the airstrip)	GNL7-PMG3	Glenella-Plum Ridge (100%)	10

Table 5 Description of Soils Series within the PSA

Order[2]	Great Group[2]	Subgroup	Soil Series, Family Description[3]
Chernozemic Soils with chernozemic Ah horizon more than 10 cm thick and with B or C horizons of high base saturation divalent cations, calcium usually common. Well to imperfectly drained soil.	Black A horizon with dry colour Munsell values darker than 3.5	Gleyed Black	Scanterbury (SCY) developed on moderately to strongly calcareous lacustrine clay, imperfectly drained
		Gleyed Rego Black	Red River (RIV) developed on moderately to strongly calcareous lacustrine clay, imperfectly drained
			Glenella (GLN) developed on dominantly coarse loamy sediments overlying clayey lacustrine sediments, imperfectly drained
			Plum Ridge (PMG) developed on very strongly to extremely calcareous, dominantly coarse loamy lacustrine sediments, imperfectly drained
Gleysolic Poorly drained soils which may have an organic and/or an A horizon. The subsoils show gleying and are dull coloured, but may have brighter colored prominent mottles. Soils associated with wetness.	Humic Gleysol	Rego Humic	Osborne (OBO) developed on moderately to strongly calcareous lacustrine clay, poorly drained. Drained phase

5.2.2 Canada Land Inventory – Soil Capability for Agriculture

The *Water Protection Act* (C.C.S.M.c. W65, 2005), *Nutrient Management Regulation* (62/2008) outlines nutrient application restrictions based on the Canada Land Inventory Soil Capability Classification for agriculture ratings (Government of Manitoba 2008). The Canada Land Inventory (CLI) is a dry-land agriculture capability inventory for rural Canada. The CLI limitations are based on climate, geology, soil chemical and physical characteristics (salinity and structure), droughtiness, inundation, erosion, stoniness and landscape topography of the soils.

The CLI groups mineral soils into seven classes with the same relative degree of limitation and then delineates subclasses within each class based on type of limitation (Fraser et al. 2001). Classes one to seven are based on increasing degree of limitation, the first three classes are capable of sustained cultivated crop production, class four is marginal for sustained arable cropping and class five is capable of pasture or hay, class six is capable of permanent pasture and class seven has no capability for arable crop or permanent pasture. There are thirteen different subclasses or limitations.

Soils series within the LSA range from Class 2 through to Class 7 with subclass designations of R, T, W, D and P. The soil series within the PSA are identified as being Class 2 (subclass w) and Class 3 (subclass w). The class descriptions are taken directly from Agriculture and Agri-food Canada, 2013:

– Class 1: Soils in this class have no significant limitations for crop selection. Topography of the soils are level to nearly level; they are deep, well to imperfectly drained and have moderate water holding capacity. The soils

[2] Source: Hopkins, L.A., et al. 1993
[3] Source: Manitoba Agri-Maps. Soil Series Descriptions. March 2010. Manitoba Agriculture, Food and Rural Initiatives. Retrieved February 9, 2018 from: https://agrimaps.gov.mb.ca/agrimaps/extras/info/Soil_Series_Descriptions.pdf.

have an abundance of available nutrients for plant growth, are easily maintained in good tilth and fertility; soil productivity is considered moderately high to high for a wide range of cereal and special crops (field crops).

- Class 2: Soils in this class have moderate limitations that restrict the range of crops or require moderate conservation practices. Class 2 soils have a good water-holding capacity, the limitations are moderate and productivity is moderately high. Limitations may be one of the following; adverse regional climate, moderate effects of accumulative undesirable characteristics; moderate effects of erosion, poor soil structure or slow permeability, low fertility (correctable with fertilization), gentle to moderate slopes, occasional damaging overflow, and wetness (correctable with drainage).
- Class 3: Soils in this class have moderately severe limitations that restrict the range of crops or require special conservation practices. The limitations are more severe than for Class 2 soils. They affect one or more of the following practices: timing and ease of tillage, planting and harvesting, choice of crops, and methods of conservation. Under good management they are fair to moderately high in productivity for a wide range of crops.
- Class 4: Soils in this class have severe limitations that restrict the range of crops or require special conservation practices, or both. The limitations seriously affect one or more of the following practices: timing and ease of tillage, planting and harvesting, choice of crops, and methods of conservation. The soils are low to fair in productivity for a fair range of crops but may have high productivity for a specially adapted crop.
- Class 5: Soils in this class have very severe limitations that restrict their capability to producing perennial forage crops, and improvement practices are feasible. The limitations are so severe that soils are not capable of use for sustained production of annual field crops. The soils are capable of producing native or tame species of perennial forage plants, and may be improved by use of farm machinery. The improvement practices may include clearing of bush, cultivation, seeding, fertilizing, or water control.
- Class 6: Soils in this class are capable only of producing perennial forage crops, and improvement practices are not feasible. The soils provide some sustained grazing for farm animals, but the limitations are so severe that improvement by use of farm machinery is impractical, terrain may be unsuitable for use of farm machinery, or the soils may not respond to improvement, or the grazing season may be very short.
- Class 7: Soils in this class have no capability for arable culture or permanent pasture. This class also includes rockland, other non-soil areas, and bodies of water too small to show on the maps.

The subclass descriptions are as follows (Agriculture and Agri-food Canada, 2013):

- ‘D’: Undesirable soil structure and/or low permeability - this subclass indicates soils that are difficult to till or soils where water is absorbed very slowly or where the depth of rooting zone is restricted by conditions other than a high-water table or consolidated bedrock.
- ‘P’: Stoniness – These soils are sufficiently stony to hinder tillage, planting and harvesting operations.
- ‘R’: Consolidated bedrock – This subclass includes soils where the presence of bedrock near the surface restricts their agricultural use. Consolidated bedrock at depths greater than 3 feet from the surface is not considered as a limitation except on irrigated lands where a greater depth of soil is desirable.
- ‘T’: Topography – This subclass is made up of soils where topography is a limitation. Both the percent of slope and the pattern or frequency of slopes in different directions affect the cost of farming and the uniformity of growth and maturity of crops as well as the hazard of erosion.
- ‘W’: Excess Water – this subclass includes soils where excess water other than brought about by inundation is a limitation to agricultural use. Excess water may result from inadequate soil drainage, a high-water table, seepage or from runoff from surrounding areas.

Table 6 and Map 8 provide a summary of the soil series found within the PSA and the corresponding dryland agricultural capability limitations.

5.2.3 Nutrient Management Zones

The *Nutrient Management Regulation* (NMR) also outlines criteria for the application of nutrients (nitrogen and phosphorous) to agricultural land. The purpose of the NMR is to protect water quality by encouraging responsible nutrient planning. The objective to regulate the application of substances containing nitrogen or phosphorous to land is a protective measure for sensitive water bodies and/or groundwater (Manitoba Water Stewardship 2008). The Water Quality Management Zone nitrogen application limits within Zones N1, N2 and N3 are summarized as a rate of application that results in a residual concentration of nitrate nitrogen within the top 0.6 m of soil at the end of the growing season, at any place within the application area no greater than:

- Zone N1: 157.1 kg/ha (140 lbs/ac)
- Zone N2: 101 kg/ha (90 lbs/ac)
- Zone N3: 33 kg/ha (30 lbs/ac)

The Water Quality Management Zone phosphorous application limits within zones N1 to N3 where soil test phosphorous levels (i.e., Olsen procedure) for any place in the application area is 60 ppm or more except at a rate of application that does not exceed:

- Two times the applicable phosphorous removal rate, if the soil test phosphorous levels are less than 120 ppm; or
- The applicable phosphorous removal rate if the soil test phosphorous levels are 120 ppm or more but less than 180 ppm.

All 11 of the land parcels proposed for the program fall within Zone N1 and are subject to the aforementioned nitrogen and phosphorus application restrictions.

5.2.4 Required Setback Distances

To minimize risk to human and environmental health and safety from the land application of biosolids, setback distances will be established as outlined in the NMR under *The Water Protection Act* and the Farm Practices Guidelines for Pig Producers in Manitoba (April 2007). Setback distances around residential areas, residences, groundwater wells, surface water drainage systems and sensitive areas/features associated with the PSA will be established as outlined in Table 6. In addition, Table 7 provides a summary of the soil and setback restrictions associated with the land parcels within the PSA; these soil and setback restrictions will also be adhered to during biosolids application.

Table 6 Summary of Soil Series and Agricultural Capability Limitations for the PSA

Parcel #	Legal Land Location	Area (ha)	Agricultural Capability	Water Quality Management Zone	Restrictions to Biosolids Application[1]
1	SE-09-07-06-EPM	65	2W – moderate limitations – excess water 3W – moderately severe limitations – excess water	N1	1, 2, 3
2	NE-10-07-06EPM (West Half)	33	2W – moderate limitations – excess water	N1	1, 2, 3, 4
3	NW-10-07-06EPM (South half)	33	2W – moderate limitations – excess water	N1	1, 2, 3, 4
4	SW-15-07-06EPM	65	3W – moderately severe limitations – excess water 2W – moderate limitations – excess water	N1	1, 2, 3
5	Part of SW-08-07-06EPM, Part of E 1/2 08-07-06EPM	40	2W – moderate limitations – excess water 3W – moderately severe limitations – excess water	N1	1, 2, 3, 4
6	SE-08-07-06EPM (East Half)	32	3W – moderately severe limitations – excess water	N1	1, 2, 3
7	NE-08-07-06EPM (East Half)	33	2W – moderate limitations – excess water	N1	1, 2, 3, 4
8	NW-08-07-06EPM	65	2W – moderate limitations – excess water	N1	1, 2, 3
9	SE-17-07-06EPM (East Half)	23	2W – moderate limitations – excess water	N1	1, 2, 3
10	Lot 1, Plan 14671 WLTO, in the City of Steinbach (east of the airstrip)	5	2W – moderate limitations – excess water	N1	1, 2, 3
11	Lot 1, Plan 14671 WLTO, in the City of Steinbach (north of the airstrip)	10	2W – moderate limitations – excess water	N1	1, 2, 3

Notes: [1] Restrictions:
1 Residual nitrate nitrogen levels cannot exceed 157.1 kg/ha (140 lbs/ac) within the top 0.6 m (2 feet) of soil.
2 Residual phosphorus levels (as determined by an Olsen-P test) cannot exceed 60 ppm within the top 0.15 m (6 inches) of soil.
3 75 m setback distance from residences on the quarter section.
4 8 m setback from 3rd order drains or higher required.

Table 7 Setback Distances for Biosolids Application

Description	Recommended Minimum Buffer Zone Distance for Biosolids Application
No application on land where there is less than 1.5 m of clay or clay till between the soil surface and the water table	Exclusion of such areas from the program
Identifiable boundary of an aquifer which is exposed to the ground surface	100 m (328 ft)
On soils with a pH of less than 6.0	Exclusion of such areas from the program
On land where the slope is greater than 5%	Exclusion of such areas from the program
Setback Distances on Land Adjacent to Surface Water or a Surface Water Course[1]	
A roadside ditch or an Order 1 or 2 drain	No direct application to ditches and Order 1 and 2 drains
A groundwater feature	15 m (49 ft) – vegetated buffer 20 m (66 ft) – non- vegetated buffer
A wetland, bog, marsh or swamp other than a major wetland, bog, marsh or swamp[a]	Distance between the water's edge and the high water mark[b]
A lake or reservoir designated as vulnerable[c]	30 m (98 ft) - vegetated buffer 35 m (115 ft) – non- vegetated buffer
A lake or reservoir (not including a constructed storm water retention pond) not designated as vulnerable[c] A river, creek or stream designated as vulnerable[c]	15 m (49 ft) - vegetated buffer 20 m (66 ft) – non- vegetated buffer
A river, creek or stream not designated as vulnerable[c] An Order 3, 4, 4 or 6 drain[d] A major wetland, bog, marsh or swamp[d] A constructed storm water retention pond	3 m (10 ft) – vegetated buffer 8 m (26 ft) – non- vegetated buffer
Setback Distances from Neighbours[2]	
Designated residential areas, parks and protected areas	1,000 m (3,280 ft)*
Occupied Residence (other than the residence occupied by the owner of the land on which the biosolids are to be applied)	75 m* (246 ft)
Property line with residence	10 m* (33 ft)
Property line without residence	1.0 m* (3.3 ft)

Notes:

[1] As outlined in the Nutrient Management Regulation

[a] As defined in 1(2) in the *Nutrient Management Regulation* under the *Water Protection Act*.

"For the purposes of this regulation, a wetland, bog, marsh or swamp is major if:

- It has an area greater than 2 ha (4.94 acres)
- It is connected to one or more downstream water bodies or groundwater features
- It contains standing water or saturated soils for periods of time sufficient to support the development of hydrophytic vegetation"

[b] Nutrient Buffer Zone is measured from the water body's high-water mark or the top of the outermost bank on that side of the waterbody, whichever is further from the water.

[c] Designated as vulnerable if listed in the Schedule in the *Nutrient Management Regulation* under *The Water Protection Act*.

[d] Designated on a Manitoba Water Stewardship plan that shows the designation of drains.

[2] As outlined in: Farm Practice for Pig Producers in Manitoba (April 2007) for material that is surface applied and incorporated within 48 hours.

6 BIOSOLIDS QUALITY

6.1.1 Nutrients - Nitrogen and Phosphorus

When utilizing an organic source as a fertilizer, only a portion of the total nitrogen is immediately available in the organic form and goes through a mineralization process. Mineralization is the conversion of organic nitrogen to ammonium nitrogen. Like hog manure, the anticipated mineralization rate for biosolids in year one is 25 percent, for year two, 12 percent and for year three, six percent.

When calculating the mineralization rate for Cell 1 and 2 biosolids materials in the model example, the following assumptions were made:

- At a Carbon to Nitrogen (C:N) ratio that exceeds 30:1, N becomes a limiting nutrient for decomposer organisms and this can reduce the rate of decomposition and results in N immobilization. The C:N ratio for the Cell 1 biosolids material is approximately 10:1, thus mineralization was assumed to continue at anticipated rates. Cell 2 is assumed to be similar.
- With a Carbon to Phosphorous (C:P) ratio between 200:1 and 300:1, mineralization and immobilization balance each other to result in no net release of P from the decomposing manure. When C:P is below this range, P is released and when above this range P will be tied up and not released for crop use. The Cell 1 biosolids material C:P ratio was below this range and P was anticipated to be released. Cell 2 is assumed to be similar.
- When animal and municipal wastes have N:P ratios ranging from 1:1 to 1:2 and are applied based on N rates on soils, over time P will accumulate. The Cell 1 biosolids material N:P ratio was 2.5:1, thus it was anticipated that P will not accumulate. Cell 2 is assumed to be similar.

Table 8 Example of Physical Characteristics, Nitrogen and Phosphorus Profiles from Cells 1 and 2

Parameter Name	Parameter Description	Unit	Cell 1 Results (Data from 2013)	Cell 2 Results (Data from 2015)
Reported Volume (plus 10% safety volume)	In-field	m^3	8,800	14,260
Specific Gravity	As Received	kg L^{-1}	1.00	1.03
Dry tonnes biosolids available (= wet tonnes × %solids)	Dried Basis	tonnes	1,267	456
Moisture	As Received	%	86.40	89.90
Total Solids	As Received	%	14.40	3.20[1]
Total Volatile Solids	Dry Basis	%	1,960	29.7
Organic Matter	Dry Basis	%	34.50	17.00
Mineral Content	Dry Basis	%	65.50	83.00
Nitrogen Profile				
Total Kjeldahl N	% Dried Basis	%	2.76	0.116
Total Kjeldahl N	Dried Basis	mg kg^{-1}	27,600	1,160
Total Kjeldahl N	Dried Basis	kg $Tonne^{-1}$	27.60	1.16
Ammonium - N	Dried Basis	mg kg^{-1}	876.00	397
Ammonium - N	Dried Basis	kg $Tonne^{-1}$	0.8760	0.3970

Parameter Name	Parameter Description	Unit	Cell 1 Results (Data from 2013)	Cell 2 Results (Data from 2015)
Available Nitrate	Dried Basis	mg kg^{-1}	0	0
Available Nitrate-N	Dried Basis	mg kg^{-1}	0	0
Organic N (= TKN – Ammonium-N)	Dried Basis	mg kg^{-1}	26,724	763
Organic N	Dried Basis	kg $Tonne^{-1}$	26.72	0.763
Method of Application			Injection	
Anticipated Weather			Cool/wet	
Anticipated Volatilization (Direct injection)				0%
Available Organic N	Dried Basis	kg $Tonne^{-1}$	2.67	0.191
Ammonium nitrogen available	Dried Basis	kg $Tonne^{-1}$	0.73	0.40
PAN (Year 1)	Dried Basis	kg $Tonne^{-1}$	3.40	0.59
PAN (Year 2)	Dried Basis	kg $Tonne^{-1}$	3.21	0.09
PAN (Year 3)	Dried Basis	kg $Tonne^{-1}$	1.60	0.05
Phosphorous Profile				
Total Phosphorous (Acid digestion)	Dried Basis	mg kg^{-1}	11,000	4,610
Phosphorus	Dried Basis	kg $Tonne^{-1}$	11.00	4.61
P_2O_5 equivalent	Dried Basis	kg $Tonne^{-1}$	25.30	10.60
Total Available P_2O_5	Dried Basis	kg $Tonne^{-1}$	12.65	5.30
Confirmation Characteristics				
Total Organic Carbon	Dry Basis	%	27.20	2.00
C:N Ratio	Dry Basis	x:1	9.86	17
C:P Ratio	Dry Basis	x:1	24.73	4
N:P Ratio	Dry Basis	x:1	2.51	0.25
pH	Saturated Paste	-	6.87	6.87

Note: Total Solids determined at time of land application event.

6.1.2 Trace Metals

The City of Steinbach's biosolids contain varying concentrations of metals as a result of discharges of metals via wastewater to the wastewater treatment system and the industrial nature of a community (e.g. residential vs industrial land use). Concerns regarding metals added to agricultural soil due to land application is justifiable due to the potential deleterious effects on soil quality, movement to surface and groundwater, phytotoxicity to crops, accumulation in crops and animal/human health effects.

A study completed by Fitzgerald and Racz (1999) reported that for loading rates of City of Winnipeg biosolids at 0, 50, 100 and 200 tonnes per hectare (t/ha), biosolids cadmium was not mobile, was not plant available and that very little of the cadmium was taken up by wheat plants. They also reported that for concentrations of other heavy metals (e.g., copper, zinc, nickel and lead), there was no consistent affect on the heavy metal content of wheat grain due to increasing rates of added biosolids. Fitzgerald and Racz (1999) concluded that heavy metals in the biosolids-treated soils was similar to that of wheat produced in the Canadian Prairies and that loading rates as high as 200 t/ha did not affect grain quality.

In Cell 1 and 2 biosolids material, the metals of principal concern to agriculture include: arsenic, cadmium, chromium, copper, lead, mercury, nickel and zinc. The trace metal concentrations of these elements and others are outlined in Table 9 for Cells 1 and 2 between 2013 and 2016 when laboratory data was available. Certificates of Analysis for biosolids analysis are provided in Appendix D. The mean concentration in mg/kg and kg/tonne are presented.

Manitoba Sustainable Development has established cumulative loading rates for each of these metals. The cumulative weight per hectare of each heavy metal in the soil is calculated by adding the amount of each metal in the biosolids at the prescription rate to the background soil level of the same metal (Table 10). The soil metal concentrations will be determined prior to each application event to ensure suitability of land parcel for application.

Table 9 Trace Metal Concentrations from Cell 1 (2013, 2016) and Cell 2 (2015)

Trace Element	Cell 1 (2013)	Cell 1 (North ½, 2016)	Cell 1 (South ½, 2016)	Cell 2 (2015)	Mean	
	mg kg^{-1}					kg $tonne^{-1}$
Arsenic (As)*	6.03	5.280	7.070	3.93	5.58	0.006
Cadmium (Cd) *	2.42	1.220	3.540	1.21	2.10	0.002
Chromium (Cr) * Total	36.3	27.6	49.2	26.4	34.88	0.035
Copper (Cu) *	1350	266	833	694	785.75	0.786
Lead (Pb) *	52.8	23.10	77.50	17.2	42.65	0.043
Mercury (Hg) *-Total	3.9	0.403	3.610	1.19	2.28	0.002
Nickel (Ni) *	19.7	16.1	19.8	15.4	17.75	0.018
Zinc (Zn) *	913	201	721.00	422	564.25	0.564
Antimony (Sb)	2.63	0.65	2.01	-	1.66	0.002
Barium (Ba)*	1240	529	784.00	683	809.00	0.809
Beryllium (Be)	<0.5	0.41	-	0.28	0.35	0.000
Cobalt (Co)	4.8	5.51	4.73	4.52	4.89	0.005
Molybdenum (Mo)	51.9	18.20	64.40	17.9	38.10	0.038
Selenium (Se)	6.98	1.88	5.62	3.42	4.48	0.004
Silver (Ag)	31.3	21.80	63.80	9.7	31.65	0.032
Thallium (Tl)	0.18	0.14	0.15	0.12	0.15	0.000
Tin (Sn)	25.9	9.66	31.10	12.9	19.89	0.020
Uranium (U)	16.9	5.05	13.10	8.47	10.88	0.011
Vanadium (V)	17.4	30.40	19.90	24	22.93	0.023

Notes: < less than detection limit
* Regulated metal

Table 10 Cumulative Weight of Heavy Metals Permitted by Guidelines

Metal	Cumulative Weight Allowed by Guidelines	
	mg kg^{-1}	kg ha^{-1}
Arsenic	12	21.6
Cadmium	1.4	2.5
Chromium (total)	64	115.2
Copper	63	113.4
Lead	70	126
Mercury	6.6	11.9
Nickel	50	90
Zinc	200	360

Note: Calculated based on an assumed soil bulk density of 1,200 kg per cubic metre and soil depth of 0.15 m.

6.1.3 Salts

The biosolids material from Cell 1 (2013) had an electrical conductivity (E.C.) value of 3.02 decisiemens per metre (dS/m) and a Sodium Absorption Ratio (SAR) of 4.60. It is assumed that Cell 2 is similar. The biosolids material may be considered as “slightly-saline” and as such does pose a slight environmental risk for soil salinization, as soil E.C., soluble ions (e.g., sodium, potassium, chloride and sulfate) and SAR increase directly with rate application. Comparatively, the reported salinity is less than or similar to hog manure as reported by Racz and Fitzgerald (2001), where it was found that the mean E.C of 145 hog manure samples from Manitoba had a value of 16.0 dS/m and a SAR of 5.1. It is reported by Sullivan, Cogger and Bary (2007) that repeated biosolids applications did not result in detrimental salt accumulations in soil even at locations with low precipitation and no irrigation. Further, they reported that annual applications of dewatered cake biosolids (80 percent moisture) made for over 10 years had not increased soil salinity above 1 mmho/cm.

Salinity analysis results for Cell 1 biosolids from the Steinbach lagoon are provided in Table 11.

Table 11 Detailed Salinity of Biosolids from Lagoon Cell #1

Parameter Name (Saturated Paste)	Unit	Analytical Results Cell 1	Mean values from Racz and Fitzgerald (2001)*
Electrical Conductivity (Dry)	dS/m	3.02	16.1
Sodium Absorption Ratio	-	4.60	5.1
% Saturation	mg kg-1	856.00	-
Calcium (Wet)	mg kg-1	128.00	-
Magnesium (Wet)	mg kg-1	83.00	-
Sodium (Wet)	mg kg-1	272.00	-
Chloride (Wet)	mg kg-1	297.00	-
Potassium (Wet)	mg kg-1	28.30	-
Sulfate-S (Wet)	mg kg-1	210.00	-

Note: * Mean values from 145 Manitoba Hog manure samples.

6.1.4 Emerging Substances of Concern

Emerging substances of concern (ESOC), including pharmaceuticals, antibiotics, endocrine-disrupting chemicals (EDCs), hormones and personal care products (PPCPs) continue to be studied in Canada and around the world to assure environmental and public safety (Canadian Council of Ministers of the Environment [CCME] 2012). ESOC continue to emerge due to the development of new detection methods and changes in technologies (McCarthy 2015). In general, most ESOC are found in very low concentrations (nanograms), in wastewater residuals and do not necessarily imply risk to the environment or human health based on detection (CCME 2012). In 2009, the CCCME reviewed ESOC concentrations and effects of treatment processes, and identified 22 significant findings, of which seven are reported below:

- Of the 24 pharmaceutical, alkyklphenolic and fragrance compounds found in detectable concentrations in more than 75% of the in-going sludge, only 14 of 71 pharmaceutical, alkyklphenolic and fragrance compounds (20%) were found in more than 75% of the treated biosolids samples likely to be land applied.
- The antibacterial compounds triclosan and triclocarban, the antibiotic ciprofloxacin and the fragrance compound galaxolide (HHCB) were the compounds most frequently detected (9 of 11 sites) above 1,000 nanograms per gram (ng/g) total solids (dry).
- A few pharmaceutical compounds appear to be removed readily by either aerobic or anaerobic biological treatment, including sulfamethoxazole, trimethoprim, caffeine and diltiazem.
- A limited number of pharmaceutical compounds appeared to be difficult to remove in almost all processes examined, when present at detectable concentrations. These included the diuretic furosemide, the anti-epileptic carbamazepine, and the antibiotic ofloxacin.
- Naproxen appears to increase substantially through aerobic composting, possibly due to biotransformation from other compounds, but it appears to be more efficiently removed by anaerobic digestion.
- While many of the ESOC remain associated with the solid phase of the sludges or biosolids, a number of compounds can be lost in any aqueous process sidestream (e.g., dewatering filtrate, leachate, digester supernatant), including furosemide, ibuprofen and 2-hydroxy-ibuprofen, naproxen, acetaminophen, caffeine, carbamazepine, clarithromycin, dehydronifedipine, erythromycin-H_2O, sulfamethoxazole and trimethoprim.
- Less than 1% of the mass of fragrance compounds in feed sludge resides in the process sidestreams or leachates from the treatment processes, while between 1% and 6% of the mass of bisphenol A in the feed sludges was transferred to the process sidestreams or leachates.

The Canadian Municipal Water Consortium (Canadian Water Network) commissioned Dr. Lynda McCarthy with Ryerson University to complete a literature review for information pertaining to ESOC that was entitled: Risks Associated with Application of Municipal Biosolids to Agricultural Lands in a Canadian Context. The literature review was conducted in order to summarize current knowledge on the occurrence, fate and potential risks of ESOC and pathogens present in biosolids after application to agricultural land (in conditions relevant to Canada). Based on the few existing risk assessments, it is suggested that the presence of ESOC and pathogens poses a low risk to human and environmental health. (Note: It was found that the limited number of risk assessments is due to limited data; toxicity and ecotoxicity data for ESOC is generally not available.)

McCarthy's literature review evaluated the fate of biosolids related ESOC and pathogens after land application. It was concluded that determining the fate of ESOC and pathogens after land application is complex, site-specific to ESOC and pathogen characterizations and properties (e.g., water solubility and partition coefficient), environmental variables (e.g., temperature, moisture, pH and organic matter content), and application methods, each factor of which limit the success of understanding the true fate.

Generally, studies have concluded that most of the compounds found in biosolids do not reach groundwater after land application and that the concentrations of ESOC and pathogens in tile drainage and surface runoff are much lower than typical concentrations found in wastewater treatment plant effluent.

McCarthy's literature review also concluded that ESOC uptake by plants may be an overestimate due to the proof of concept approach to demonstrating the uptake. The limited number of risk assessments has demonstrated however that the risk to human health from the consumption of plants grown in biosolids-amended soils under relevant conditions was considered minimal risk and that although the presence of ESOC in soil, crops or soil organisms may not be desirable, the sole presence of chemicals does not constitute proof of negative impact to the soil ecosystem.

Currently, there are no federal or provincial requirements to address ESOC in biosolids land application programs. The City of Steinbach will continue to monitor academic literature and engage with provincial regulators to maintain a current understanding of ESOC as information becomes available.

6.2 Agronomy

Crops grown on lands receiving biosolids can include cereals, oil seeds, corn and soybeans. Application of biosolids will increase soil health (water-holding capacity, tilth) and provide beneficial macro (nitrogen, phosphorus, potassium, sulfur) and micronutrients (boron, copper, zinc, magnesium) to the soil for crop production. The City of Steinbach will work with the agricultural producers that rent their land parcels within the PSA and will advise them of the benefits of biosolids application and that the application of commercial fertilizers should only be completed to supplement nutrient levels from the biosolids at agronomically sustainable rates.

Any agricultural producers that rent the land parcels within the PSA will be required to sign a land use agreement with the City of Steinbach that meets certain terms and conditions to ensure compliance with regulatory requirements are met and to promote longevity of the plan. Listed below are a few of the articles that may be included in an agreement:

- Maintaining an appropriate crop rotation for three years with cereal, oil seed, pulse, soybean and corn crops. No livestock grazing for a period of three years post application growing season (e.g., grazing can occur in 2023 if land applied in fall 2019).
- Conducting a nutrient management program that accounts for residual nutrients from the biosolids application.
- Direct soil injection of biosolids.
- Permit soil sampling and analysis monitoring for a period of three full years after application.
- Land application occurs at no cost to the producer.

6.3 Standard Biosolids Application Rates

Prior to each biosolids land application event, the City of Steinbach will provide the MSD, EAB with a summary letter that outlines the list of receiving lands for biosolids application, a description of the land suitability in terms of agricultural capability, proposed agronomy and prescribed biosolids application rates. The prescription rates for biosolids application will be calculated based on various inputs and assumptions discussed in Sections 6.1 through 6.2 and as outlined in Table 12. An example of the prescription rate calculations worksheet is provided in Appendix D.

Table 12 Land Application Nutrient Management Inputs and Assumptions

Categories	Inputs
Information Requirements	– Target crop and anticipated yield - this information is provided by the participating agricultural producer for three years following application. – Target nutrient recommendations to achieve the desired yield - this is based on understanding of crop uptake and removal. Source of this information is typically provided by the Manitoba Soil Fertility Guide. – Soil testing – soil sampling for nutrient and metals profiles is completed (0-15 cm and 15-60 cm). – Biosolids testing – testing of the physical, nutrient and metals profile for the biosolids.
Assumptions	Nitrogen Mineralization rates: – Between 20% and 25% in year one. – Less than 12% in year two and less than 6% in year three. Plant available phosphorus – Between 25% and 50% of total phosphorus.
Methods	Biosolids are surface applied and then incorporated within 48 hours; therefore, volatilization of ammonia loss is 13, 19, 31 and 57% depending upon weather (cool/wet, cool/dry, warm/wet and warm/dry, respectively).
Indicators	– If C:N exceeds 30:1 in the biosolids, then N becomes a limiting nutrient for decomposer organisms, and this can reduce the rate of decomposition and results in N immobilization and loss of plant available nitrogen. – When C:P ratio is between 200:1 and 300:1 in the biosolids, mineralization and immobilization balance each other to result in no net release of P from the decomposing biosolids. When C:P is below this range, P is released. – When animal and municipal wastes with N:P ratios ranging from 1:1 to 1:2 are applied based on N rates on soils, over time P will accumulate.

7 LAND APPLICATION

Biosolids application modelling was completed to provide an example of the sustainability of multiple land applications of biosolids based on current known biosolids quality data from the City of Steinbach's lagoon (treatment Cell 1 data from 2013 and treatment Cell 2 data from 2015) and typical crop rotation and removal rates for the elements of concern. Table 13 provides examples of the physical characteristics of the biosolids material collected in 2013 and 2015. It is anticipated that future biosolids material will have quality aspects similar to that measured in 2013 and 2015 and that the material will be direct pumped from the lagoon with a drag hose and land applied via injection. A summary of the information from the model is provided in the following sections.

7.1 Land Application Model based on Nitrogen and Phosphate-P

For the study area, the cooperating farm producers' typical crop rotation is as follows; grain corn, red spring wheat, canola and soybeans. Each crop has a suitable rate of nutrient uptake and removal of nitrogen and phosphorus that will permit a nutrient mass balance over the years from repeated application of the City of Steinbach's biosolids. Table 13 outlines several aspects of the land application model including crop rotation, 10-year average yield and nutrient removal by each crop. Subsequent to

that is the anticipated cumulative nutrient removal with a continuous crop rotation for a 4, 5, 6, 7, 8, 9, 10, 15, 20 and 25-year cropping system. The cumulative nutrient removal over a four-year crop rotation is the sum of the anticipated nitrogen and P_2O_5 from the four crops at an average yield (410 kg/ha and 154 kg/ha for nitrogen and phosphorus, respectively). The cumulative nutrient removal over a five-year crop rotation is the sum of the four-year rotation plus the crop nutrient removal for the fifth year (e.g. grain corn). Similarly, for the subsequent years the next crop's nutrient removal is added on to the previous cumulative removal rate. As a result of the typical crop rotation, the cumulative nutrient removal over 25-years is nearly 2,600 kg/ha of nitrogen and nearly 1,020 kg/ha of P_2O_5.

The next step in this model was to determine the cumulative nutrients applied in one or more application events of biosolids. Based on the laboratory data from 2013 the plant available nitrogen and P_2O_5 are calculated, based on total solids of 3.2%, ammonium volatilization of 15%, nitrogen mineralization of 25% and P_2O_5 availability of 50%, the anticipated plant available nitrogen is 72 kg/ha and 165 kg/ha of P_2O_5 in a 20 tonnes/ha (dry) application event. The focus being to meet a permitted two times crop removal of P_2O_5 in one application event for grain corn.

Cumulative nitrogen and P_2O_5 was summed up for 3, 4, 5, 6 and 7 events. It is anticipated that these application events would be spread over a 25-year period thus providing an application event ratio of 1:8, 1:6, 1:5, 1:4 and 1:3 rotation for comparison purposes.

The next step was to evaluate the nutrient mass balance between the cumulative nitrogen and P_2O_5 applied by biosolids vs removed by the crop rotation. In one application event in a four-year crop rotation, a single event, the total nitrogen applied would be short by nearly 340 kg/ha, thus requiring a commercial fertilizer supplement annually. And for P_2O_5 it was found that the cumulative residual would be just over 10 kg/ha positive, thus building the phosphorus profile for the soil bank. It is important to note that this is only based on removal of grains, no assumptions have been included for total cropping requirements of phosphorus for plant uptake nor for straw or stalk removal from the system. When the nutrient mass balance is evaluated for the application event ratios of 1:8, 1:6, 1:5, 1:4 and 1:3, it is observed that both nitrogen and P_2O_5 both are less than crop removal in all application event scenarios except for 1:3 where P_2O_5 is in excess of crop removal by nearly 139 kg/ha after seven application events. Thus, the desktop evaluation indicates that the frequency of land application onto a single crop rotation can be nearly six application events over 25-years. This is only an indicator as to the suitable frequency that land application may occur based on the cumulative P_2O_5 concentration and is not an indicator of actual soil residual phosphorus. It is still required to maintain a vigilant soil nutrient monitoring program for the study area.

Table 13 Nutrient Mass Balance of a Typical Four Crop Rotation Over a 25-Year Period

Crop	Provincial Yield – 10 Year Average (bu/ac)	Nutrient Removal (lb/bu)		Crop Nutrient Removal (lb/ac)		Crop Nutrient Removal (kg/ha)	
		TN	P_2O_5	TN	P_2O_5	TN	P_2O_5
Grain Corn	108	0.97	0.44	105	48	117	53
Red Spring Wheat	46	1.5	0.6	69	28	77	31
Canola	34	1.92	1.04	65	35	73	40
Soybean	33	3.85	0.83	127	27	142	31
Cumulative Removal over a 4-year cropping.				366	138	410	154
Cumulative Removal over a 5-year cropping				471	185	527	208
Cumulative Removal over a 6-year cropping				540	213	605	239
Cumulative Removal over a 7-years of cropping				605	248	678	278
Cumulative Removal over a 8-years of cropping				732	276	820	309

Crop	Provincial Yield – 10 Year Average (bu/ac)	Nutrient Removal (lb/bu)		Crop Nutrient Removal (lb/ac)		Crop Nutrient Removal (kg/ha)	
		TN	P_2O_5	TN	P_2O_5	TN	P_2O_5
Cumulative Removal over a 9-years of cropping				837	323	937	362
Cumulative Removal over a 10-years of cropping				906	351	1,015	393
Cumulative Removal over a 15-years of cropping				1,377	536	1,542	601
Cumulative Removal over a 20-years of cropping				1,848	722	2,069	808
Cumulative Removal over a 25-years of cropping				2,318	907	2,597	1,016
Cumulative Nutrient Applied in 1 event at 20 tonnes/ha (dry)				64	147	72	165
Cumulative Nutrients Applied in 3 events at 20 tonnes/ha (dry) over 25 years (1:8)				192	441	216	495
Cumulative Nutrients Applied in 4 events at 20 tonnes/ha (dry) over 25 years (1:6)				256	587	288	660
Cumulative Nutrients Applied in 5 events at 20 tonnes/ha (dry) over 25 years (1:5)				320	734	360	825
Cumulative Nutrients Applied in 6 events at 20 tonnes/ha (dry) over 25 years (1:4)				384	881	432	990
Cumulative Nutrients Applied in 7 events at 20 tonnes/ha (dry) over 25 years. (1:3)				449	1,028	504	1,155
Residual Nutrients Mass Balance for 1 application event in a 4-year crop rotation (Single Event, 1:25)				-302	9	-338	11
Residual Nutrients Mass Balance for 3 application events in 25-year crop rotation (1:8)				-2,126	-466	-2,381	-521
Residual Nutrients Mass Balance for 4 application events in 25-year crop rotation (1:6)				-2,062	-320	-2,309	-356
Residual Nutrients Mass Balance for 5 application events in 25-year crop rotation (1:5)				-1,998	-173	-2,237	-191
Residual Nutrients Mass Balance for 6 application events in 25-year crop rotation (1:4)				-1,934	-26	-2,165	-26
Residual Nutrients Mass Balance for 7 application events in 25-year crop rotation (1:3)				-1,870	121	-2,093	139

7.2 Land Application Model based on Metals

As outlined in Section 6.1.2 many trace elements are regulated under a cumulative weight per hectare of each heavy metal in the soil (Table 14). The cumulative weight is calculated by adding the amount of each heavy metal in the sludge solids applied to the background level of the same metal in the soil, thus ensuring the cumulative concentration of that metal is not exceeding the applied guideline. These cumulative guidelines are based on the CCME soil quality guidelines for the protection of the environment and human health. The mean concentration of the individual heavy metals of Cell 1 and 2 indicates that application of the biosolids would have metal concentrations below the applied CCME guidelines for agriculture soil.

The estimated loading rate of the metals of concern when the biosolids are applied at a rate to provide a two-times crop removal rate for P_2O_5 are shown in Table 14. The anticipated loading rate for biosolids is 20 tonnes per hectare (dry). Table 14 shows the number of applications of biosolids required to increase the soil metal content to the maximum levels permitted by the applied guideline. The number of applications of biosolids from the City of Steinbach lagoons is limited to about five, based on a limitation associated with the concentration of copper accumulation in the soil. While copper is a micro-nutrient required by crops, the uptake and removal of this element in the grain of crops is very minor and of little consequence to mass balance determinations.

Number of Application Events Permitted before meeting applied guideline example calculation for copper.

$$Total\ Amount\ of\ Metal\ Permitted\ before\ Meeting\ Guideline\ Level$$
$$= \left[\left(Soil\ Metal\ Guideline\frac{mg}{kg} - Soil\ Metal\ Concentration\frac{mg}{kg}\right) \div 1{,}000{,}000\right]$$
$$\times \left[Sample\ Depth\ (m) \times Soil\ Bulk\ Density\frac{kg}{m3} \times 10{,}000\frac{m2}{ha}\right]$$

$$Amount\ of\ Metal\ Added\ per\ Application$$
$$= \left[Biosolids\ Metal\ Concentration\frac{mg}{kg} \times \frac{Tonnes}{Hectare} \times \left(\frac{1000}{1{,}000{,}000}\right)\right]$$

$$Number\ of\ Application\ Events$$
$$= (Total\ Amount\ of\ Metal\ Permitted\ before\ Meeting\ Guideline\ Level)$$
$$\div (Amount\ of\ Metal\ Added\ per\ Application$$

Notes:
Copper guideline: 63 mg/kg
Mean Soil Metal Concentration =
Soil Bulk Density: 1,200 kg/m^3
Soil Depth: 0.15 m
Hectare: 10,000 m^2
Soil Mass: 1,000,000 mg/kg
Example Loading Rate (dry): 20 Tonnes/Hectare

$$= \left[\left(63\frac{mg}{kg} - 22.3\frac{mg}{kg}\right) \div 1{,}000{,}000\right] \times \left[0.15\ m \times 1{,}200\frac{kg}{m3}\ x\ 10{,}000\frac{m2}{ha}\right] \div \left(785.7\frac{mg}{kg} \times 20\frac{T}{Ha} \div 1{,}000\right)$$

$Number\ of\ Application\ Events = 73.3 \div 15.7$ = 4.66

Therefore, Application Events to meet Cumulative Guideline = approximately 5 events

Table 14 Metal Loading Rate and Number of Applications Permitted Before Meeting Applied Guidelines for Heavy Metals

Heavy Metal Element	Metal Loading Rate (kg/ha) at 20 T/ha (dry) Application	Number of Application Events Permitted
Arsenic	0.11	116
Cadmium	0.04	45
Chromium (total)	0.70	68
Copper	15.72	5
Lead	0.85	117
Mercury	0.05	160
Nickel	0.36	114
Zinc	11.29	16

7.3 Rotation Scenarios Based on Nutrient and Metal Constraints

Due to the limited number of parcels within the study area, land rotation is a key component to ensuring that sustainability is maintained within the land application program. Concurrent to the land rotation will be regular pre-application and post application monitoring to ensure nutrient uptake and removal is aligning with expectations and the metal loading is near anticipated accumulations.

As described in the discussions in Section 7.1 and 7.2, overall biosolids land applications on the proposed land parcels owned by the City of Steinbach will be limited by copper concentration and then phosphorus followed by zinc concentrations. Three scenarios are presented below that provide a visual representation of 6, 4 and two-year application cycles for the land parcels available for the program over the 25-years (for land application of biosolids by lagoon Cells 1 and 2). Based on past experience from both 2015 and 2018 (highlighted in red), the area required for land application is approximately 65 ha per application event. The likely eventuality is that the number of required acres and frequency of land application events will increase due biosolid volume increases from increasing population growth in the Steinbach area.

Based on the three scenarios, 6, 4 and 2-year application events, scenarios 1 and 2 are achievable over 25-years without exceeding the number of events that may eventually increase the copper concentrations at or near the applied regulatory guideline.

Scenario 1: Land Application Events on a 6-Year Cycle for a 25-Year Horizon

Year	2015	2018	2021	2024	2027	2030	2033	2036	2039	2042	2045	2048	2051
Cell #	2	1	2	1	2	1	2	1	2	1	2	1	2
Parcel #													
1													
2													
3													
4													
5													
6													
7													
8													
9													
10													
11													

Note: Fields 9, 10 and 11 are not required in this cycle, and are include as contingency if needed as enough land is available in the cycle associated with land parcels 1 through 8.

Scenario 2: Land Application Event on a 4-Year Cycle for a 25-Year Horizon

Year	2015	2018	2020	2022	2024	2026	2028	2030	2032	2034	2036	2038	2040	2042	2044	2046	2048	2050
Cell #	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	
Parcel #																		
1																		
2																		
3																		
4																		
5																		
6																		
7																		
8																		
9																		
10																		
11																		

Note: Fields 9, 10 and 11 are not required in this cycle, and are include as contingency if needed as enough land is available in the cycle associated with land parcels 1 through 8.

Scenario 3: Land Application Event on a 2-Year Cycle for a 25-Year Horizon

Year	2015	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043
Cell #	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2
Parcel #																											
1																											
2																											
3																											
4																											
5																											
6																											
7																											
8																											
9																											
10																											
11																											

8 POTENTIAL ENVIRONMENTAL EFFECTS

As part of the long-term biosolids land application plan, mitigation measures will be employed that minimize the impact to the biophysical and socio-economic environments associated with the PSA, LSA and surrounding area. A summary of the potential effects is provided in Table 15 with additional details provided in the following sections.

Table 15 Summary of Potential Environmental Effects

Potential Environmental Effects	Proposed Mitigation Measures
Biophysical Effects	
Soil Quality Effects	
Nutrient Loading	Targeted prescriptions, cropping systems, soil monitoring, participating agricultural producer nutrient management, uniform application procedures, GPS tracking of application loads, auto-steer equipment, calibrated equipment.
Metals	Biosolids monitoring, soil monitoring, soil chemistry, CCME guidelines.
Salinity and Sodicity	Biosolids monitoring, soil monitoring, CCME guidelines.
Soil Compaction	Restrict travel to field entrance and field edges, use of all-weather mud mats, heavy equipment fitted with flotation tires, calibrated equipment and wide row spacing.
Water Quality Effects	
Groundwater	Compliance with all Provincial regulations and the establishment of setback distances as outlined in Tables 6 and 7, targeted prescription rates, soil monitoring.
Surface Water	Compliance with all Provincial regulations. Targeted prescription rates, setback distance of 30 m from lakes and 15 m from rivers, creeks and Order 3 or greater drains, direct soil injection of biosolids, cropping systems, soil monitoring.
Natural Areas Effects	
Natural Vegetation, Wildlife and Species of Conservation Concern	Existing land use, timing of application, setback distances, cropping systems.
Socio-economic Effects	
Pathogens	Direct soil injection of biosolids, climate exposure, setback distances, restricted access, exposure time between application events and harvest.
Odour	Setback distances, direct soil injection of biosolids.
Emerging Substances of Concern	Climate exposure, microbial degradation, photo-degradation, direct soil injection of biosolids, setback distances, restricted access, separation in time between land application event (fall) and crop harvest (the next fall), academic literature monitoring.
Noise and Dust from Biosolids Transport	Use of paved roads where possible, hauling during regular work hours, maintain equipment in good working order, regular inspections.
Accidents and Malfunctions	Maintain equipment in good working order, spill control/response plan.

8.1 Potential Biophysical Effects

8.1.1 Soil Effects and Mitigation

A soil sampling program will be implemented for the land base included in the long-term biosolids land application plan to monitor concentrations of residual soil nutrients, salinity and heavy metals. The soil monitoring program will allow for appropriate biosolids prescription rates and crop and land rotation to be executed for the program to minimize impacts to the soil resource.

8.1.1.1 Management of Nitrogen and Phosphorus

Of primary concern associated with the land application of biosolids is the leaching and/or surface runoff of nitrogen and phosphorus into ground or surface water if application rates exceed crop removal rates and soil storing capacity. Nitrogen and phosphorus will be managed based on beneficial farm management practices and following prescription rates based on residual soil nutrient levels and biosolids quality, as well as per applicable regulations. Biosolids will be applied based on nutrient requirements for each agricultural field.

Prescribed nitrogen and phosphorus rates will target uptake and removal ability of small grains, oil seed, pulse and soybean crops and corn. The long-term management plan will be compliant with the regulatory requirements outlined in the *Nutrient Management Regulations* of *The Water Protection Act* for both maximum residual nitrogen and phosphorus criteria in nutrient management zone N1.

Post-harvest soil monitoring will be conducted on the participating agricultural fields for three-years post application of biosolids to monitor nutrient loading within the soils. Soil sampling and analysis will be completed as follows: sodium bicarbonate extractable phosphorus at 0-15 cm soil depth and nitrate-nitrogen and total nitrogen at 0-15 cm and 15-60 cm soil depths. Agricultural producers renting land in the PSA from the City of Steinbach will be required to manage their nutrient program based on the annual soil residual nitrogen and phosphorus levels assessed through the monitoring program. This information will be supplied to the Director of the MSD, EAB by January 31 of each year following the application of biosolids.

Mitigation Measures: Targeted prescriptions, cropping systems, soil monitoring, participating agricultural producer nutrient management

8.1.1.2 Metals

The soil sampling program of the receiving lands combined with the assessment of biosolids metals concentrations prior to each application will ensure that biosolids are applied based on permitted concentrations for each agricultural field as outlined in the CCME guidelines. To prevent overloading of heavy metals into soils, the prescribed application rates will provide cumulative weight criteria for metals that are below the permitted concentrations. Monitoring of biosolids quality and soil monitoring (0-15 cm soil depth) for three years post biosolids application will also be conducted in order to monitor heavy metal loading rates to agricultural fields participating in the land application program.

Mitigation Measures: Biosolids monitoring, soil monitoring, CCME guidelines

8.1.1.3 Salinity and Sodicity

It is reported by Sullivan et al (2007) that repeated biosolids applications in soil have not resulted in detrimental salt accumulations in soil even at locations with low precipitation and no irrigation. The soil series within the PSA are non-saline.

To prevent overloading of salts in the soils, the prescribed application rates will follow guidelines for soil salinity based on concentrations established by the CCME. Monitoring of biosolids quality and soil

monitoring of the land base as part of the biosolid management plan for three years post application will minimize impacts to the soil resource from the accumulation of salts. Crop rotations will also be established for the program to aid in the reduction of salt accumulation in the soil-rooting zone.

Mitigation Measures: Biosolids monitoring, soil monitoring, CCME guidelines, crop rotation

8.1.1.4 Soil Compaction

Soil compaction is the clasping together of soil particles, reducing the space available for air and water thus increasing the density of the soil. Soil compaction impacts water and air movement, seedling emergence, root growth and may reduce yield potential of an agricultural field.

Soil compaction may occur at entrances to the fields due to heavy equipment traffic entering fields for biosolids application. As these entrances are typically utilized by agricultural producers with heavy farm equipment for crop production activities, soil compaction in these areas is likely not of great concern. Winter frost action also aids in the mitigation of soil compaction.

Mitigation Measures: Restrict travel to field entrance and field edges, heavy equipment fitted with flotation tires, application equipment capable of providing an even application with a wide row spacing

8.1.2 Water Quality Effects and Mitigation

Potential impacts to surface water and aquatic species within the Manning Canal drainage system includes nutrient loading from surface runoff. However, the impact to surface water and aquatic species is considered to be low as biosolids material will be applied at agronomically appropriate rates and will be incorporated into the soil within 48 hours of application thereby minimizing the potential of overland flow to the drainage system. In addition, appropriate setback distances of 8 m will be established around all Order 3 or higher drains.

Groundwater pollution within the RM of Hanover is possible in areas where sand and gravel deposits are at or near the ground surface and where sand and gravel aquifers are used as a domestic water supply (Rutulis 1973). However, based on the groundwater pollution hazard map developed by Rutulis (1973) for the RM of Hanover, the LSA has a zero to minimal pollution hazard risk as most domestic wells in the area draw water from the carbonate aquifer which is overlain by thick clay and/or till deposits that act as barriers to movement of contaminates to the aquifer.

Application of the biosolids materials at agronomically appropriate rates for nitrogen and phosphorous will ensure plant uptake of these nutrients over the growing season, thereby further minimizing the potential of leaching to the groundwater. Direct soil injection of biosolids will minimize the potential of overland flow to groundwater wells. In addition, appropriate setback distances will be established around all residences and domestic wells as outlined in Table 7.

Mitigation Measures: Targeted prescriptions, setback distances, 1.5 m clay underlay, direct soil injection of biosolids, cropping systems, soil monitoring and compliance with regulations and setback distances as per Table 7

8.1.3 Vegetation, Wildlife and Species of Conservation Concern Effects and Mitigation

Potential impacts to wildlife and vegetation include habitat disruption and vehicle/wildlife collisions. However, the impact to wildlife/habitat is considered to be low as land within the PSA and surrounding LSA primarily consists of cultivated land with minimal natural vegetative cover available as habitat. Equipment traffic associated with the transfer of biosolids from the lagoons to the receiving fields will be below posted speed limits thus reducing the possibility of wildlife collisions.

Two bird species of conservation concern, the bobolink and the barn swallow, were identified to be associated with two land parcels within the PSA. The MBCDC has developed a list of recommended

setback distances from bird species of conservation concern during the breeding season. This includes restricting activity around active nest sites for bobolink between May 15 and August 15 and between May 15 and September 30 for barn swallows in a given year. Potential impact to these species from land application of biosolids is anticipated to be negligible to minimal as the timing of biosolids applications typically occur in the early spring or late fall, outside of the breeding windows for theses species. In addition, biosolids land application will occur over a short duration only every three to five years compared to annual agricultural production which involves numerous activities/site disturbance (e.g. seeding, herbicide application, harvest) each year.

Therefore, due to the agricultural nature of the PSA and LSA, timing of the biosolids application, use of annual crop land and establishment of appropriate setback distances as per Table 7, impact to native vegetation, wildlife and species of conservation concern is anticipated to be negligible to minimal.

Mitigation Measures: Existing land use, timing of application, setback distances, cropping systems

8.1.4 Greenhouse Gas Considerations

Greenhouse gas (GHG) emissions within the context of this biosolids land application program are carbon dioxide, methane and nitrous oxide. The activities related to GHG contributions are limited to the equipment emissions that will be used to transport, land apply and incorporate the biosolids material and natural decomposition of land applied organic matter in the soil. Land application of biosolids provides significant benefits through the reduction of GHG production that occurs with landfill disposal, carbon sequestration in soil organic matter and reduced use of inorganic commercial fertilizers from petroleum based sources within the PSA. These three benefits are reported to counter balance the potential emissions due to mechanical needs for the land application program (CCME, 2012).

8.2 Potential Socio-economic Effects

8.2.1 Public Safety & Health Risks and Mitigation

8.2.1.1 Biological Pathogens

Biological pathogens such as *Escherichia coli* (E. coli) and fecal coliforms as well as nuisance odour associated with land application of biosolids may be considered to pose a public health and safety risk. These human health and safety risks will be managed through the application of the biosolids onto private lands that have restricted public access. In addition, direct soil injection of biosolids will minimize odour and eliminate human exposure to pathogens. Pathogens from biosolids are often killed by exposure to sunlight ultra violet spectrum, drying conditions, unfavorable pH and other macro and micro environmental conditions. Lands that receive biosolids will also be managed on a crop rotation system for three years that excludes root/vegetable crops and livestock grazing.

In addition, appropriate setback distances including 1,000 m from residential areas, 75 m from occupied residence, 10 m from property lines with a residence and 1 m from property lines without a residence, will be adhered to throughout the plan.

Mitigation Measures: Direct soil injection of biosolids, climate exposure, setback distances, restricted access, separation in time between land application event (fall) and crop harvest (the next fall), restricted crop type

8.2.1.2 Odour Management

While it is impossible to eliminate odour associated with the biosolids applications, mitigation measures that include the use of best management and good neighbour practices will be employed to minimize odour issues associated with the land applications. Best management practices that will be employed

includes direct soil injection of biosolids. Additionally, the establishment of applicable setback distances from residences will aid in minimizing odour issues.

Mitigation Measures: Good neighbour policy, setback distances, direct soil injection of biosolids

8.2.1.3 Metal Accumulation in Crops

Heavy metal bioaccumulation in agricultural crops consumed by humans poses a minimal human health risk as uptake, removal and accumulation of metals by the harvested portions of crops is minimal. Harb (1999) concluded that the health risk to humans from the consumption of heavy metals in wheat and oats grown on land treated with biosolids is negligible and that there are environmental and economic benefits.

Mitigation Measures: Biosolids monitoring, soil monitoring, soil chemistry, CCME guidelines and crop rotation

8.2.1.4 Emerging Substances of Concern (ESOC)

ESOC including pharmaceuticals, antibiotics, EDCs) hormones and PPCPs continue to be studied in Canada and around the world to assure environmental and public safety (CCME, 2012). ESOC continue to emerge due to the development of new detection methods (e.g., culture and identification of pathogens) and changes in technologies (McCarthy 2015). In general, most ESOC are found in very low concentrations (nanograms), in wastewater residuals and do not necessarily imply risk to the environment or human health based on detection (CCME 2012).

Mitigation Measures: Climate exposure, microbial degradation, photo-degradation, direct soil injection of biosolids, setback distances, separation in time between land application event (fall) and crop harvest (the next fall), and academic literature monitoring

8.2.1.5 Noise and Dust from Transportation of Biosolids

In order to minimize the impacts to local residents from dust and noise, wherever possible paved roadways will be utilized during the transport of biosolids to the field sites and transportation will be completed during regular weekly work hours as much as possible.

Mitigation Measures: Good neighbour policy, use of paved roads, biosolids transport during regular work hours

8.3 Economic Benefits

The application of biosolids to agricultural land provides a positive economic benefit to both the farm producers and the City of Steinbach. The objective of providing biosolids prescription application rates that match crop requirements for nutrient management is both sustainable and highly economical. As outlined, biosolids provide macronutrients (nitrogen, phosphorous, potassium, and sulfur) and micronutrients (boron, copper, iron, chloride, manganese, molybdenum and zinc) to soils/crops, which provide economic value to the farm producer.

To determine the basic economic value of the N and P of the biosolids, the average fertilizer commodity price between January 2018 and February 2019 for Urea (46-0-0) and Triple Super Phosphate (0-45-0) was determined as $0.73/kg N and $1.02/kg P_2O_5, respectively. The following economic value as presented in Table 16 is based on the prescribed biosolids land application of 2x Crop removal of P_2O_5 (20 t/ha dry).

Table 16 Economic Value for Nitrogen and Phosphorus in Applied Biosolids

Nutrient	Market Price (April 2013)	Hypothetical Application Rate	Value of Applied Biosolids
Available Nitrogen	$0.73/kg	72 kg/ha	$52.56/ha
Total Available P_2O_5	$1.02/kg	165 kg/ha	$168.30/ha

The biosolids material is being provided at no charge to the farm producer and is reducing his/her fertilizer bill by approximately $220.86 per hectare (Table 16). Based on the anticipated 65 hectares required for the land application this equates to approximately $14,355.90 for just nitrogen and phosphorous fertilizer and does not account for the added benefit of potassium, sulfur and micro-nutrients. Hence the economic benefit to the farm producer is substantial based on the savings the farm producer will incur from crop fertilizer amendments. It should also be noted that the economic benefit to the City of Steinbach is recognized from no land use fees being paid to the farm producer for the application of the biosolids; whereas, if the biosolids were disposed of in the local landfill the tipping fee would represent a significant cost to the City of Steinbach.

9 MONITORING AND REPORTING

The life span of this project is anticipated to be 25 years and as such, periodic soil monitoring of the agricultural fields involved in the program, both pre- and post application will be required as well as reporting of this data along with biosolids prescription rates to the MSD, EAB. A proposed monitoring plan is outlined below; however, as it is difficult to predict how often lagoon cleanout will be required in the future, this plan is subject to change. The proponent will inform the MSD, EAB of any changes to the monitoring plan.

Proposed Monitoring Plan:

1. At least two weeks prior to the commencement of the biosolids land application in a given year, the City will provide the Director of the MSD, EAB, details of the biosolids and receiving field(s) soil analysis as well as proposed prescription rates for biosolids application.
2. By January 31 of each year following the application of biosolids, the City of Steinbach will submit a report to the Director of the MSD, EAB that summarizes soil fertility analytical results, prescribed biosolids application rates, and application activities completed for the program including:

- Location of each land parcel on which the biosolids were applied
  - Pre-application soil parameters
  - Dry weight of biosolids applied per hectare of land
  - Weight of each heavy metal (in mg/kg of soil) added to the receiving land parcels
  - Cumulative weight (kg/ha) of each heavy metal for each land parcel as calculated by adding the amount of each heavy metal applied to the soil background level of the same metal
  - Amount of nitrogen, phosphorus and potassium applied per hectare for each land parcel
  - Copy of the biosolids and soil sampling and analysis methods and results
  - Type of crops grown on the land parcels in the program for the three years post-application

3. Record of net biosolids weight transported to the field for application.
4. Completion of weekly on-site inspections/monitoring of biosolids during application including:
   - Monitoring adherence by the contracted applicator to buffer zones
   - Monitoring of application rates

5 Post-harvest soil monitoring of application fields for three years post-application for residual nutrients and heavy metals including: nitrate-nitrogen (0-60 cm soil depth) and phosphorus (Olsen-P test 0-15 cm soil depth) as well as information relating to the amounts of nutrients from other sources that are being applied by the participating agricultural producer. An annual review of this information will be completed to monitor soil nutrients, salts and metals and revise rotation of the land base as required. This information will be supplied to MSD, EAB by January 31 of each year following the application of biosolids.

10 SUMMARY

The objective of the City of Steinbach's long-term biosolids land application plan is to complete the periodic (every three to five years) land application of biosolids material collected from their wastewater treatment lagoon in an environmentally sustainable and agronomically suitable manner for a 25-year period. Long-term monitoring of the land base receiving biosolids will enable the City of Steinbach to make informed decisions regarding nutrient and metal loading to these land parcels to ensure their longevity in the long-term plan.

All applicable regulatory requirements, guidelines and good neighbour policies and procedures will be adhered to during the implementation of the City of Steinbach's long-term biosolids land application plan. With the employment of appropriate mitigation measures, potential negative effects associated with the City's biosolids land application plan can be minimized. When applied at balanced rates, the land application of biosolids is a sustainable means to reuse nutrients within an agriculture system as the application of biosolid organic material enhances the water holding capacity, structure and tilth of soils thereby providing benefits to land utilized for agricultural production.

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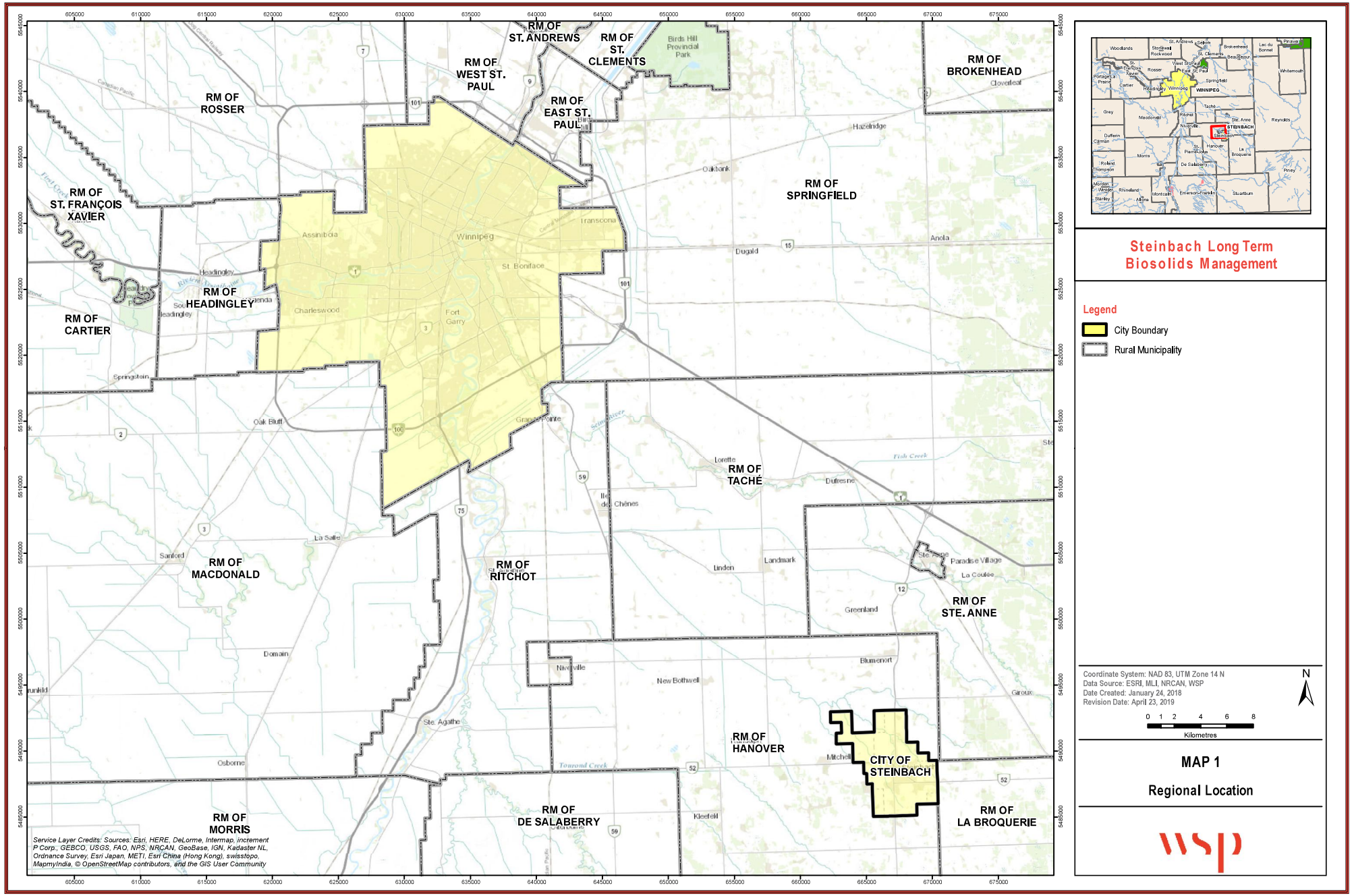
APPENDIX

A MAPS



Steinbach Long Term Biosolids Management

Legend

- City Boundary
- Rural Municipality

Coordinate System: NAD 83, UTM Zone 14 N
Data Source: ESRI, MLI, NRCAN, WSP
Date Created: January 24, 2018
Revision Date: April 23, 2019

N

0 1 2 4 6 8
Kilometres

MAP 1

Regional Location

wsp

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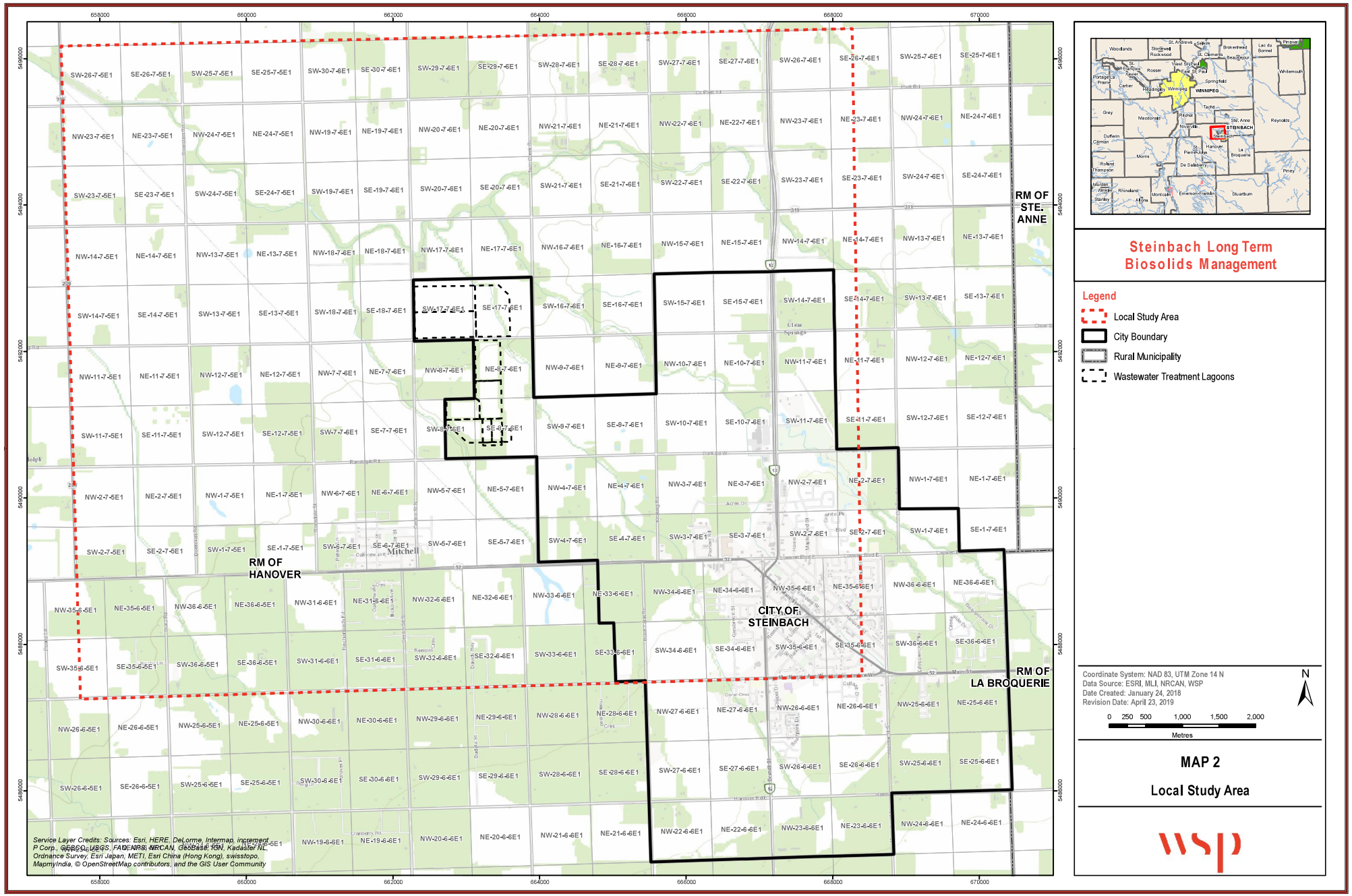

Steinbach Long Term Biosolids Management

Legend

- Local Study Area
- City Boundary
- Rural Municipality
- Wastewater Treatment Lagoons

Coordinate System: NAD 83, UTM Zone 14 N
Data Source: ESRI, MLI, NRCAN, WSP
Date Created: January 24, 2018
Revision Date: April 23, 2019

N

0 250 500 1,000 1,500 2,000
Metres

MAP 2

Local Study Area

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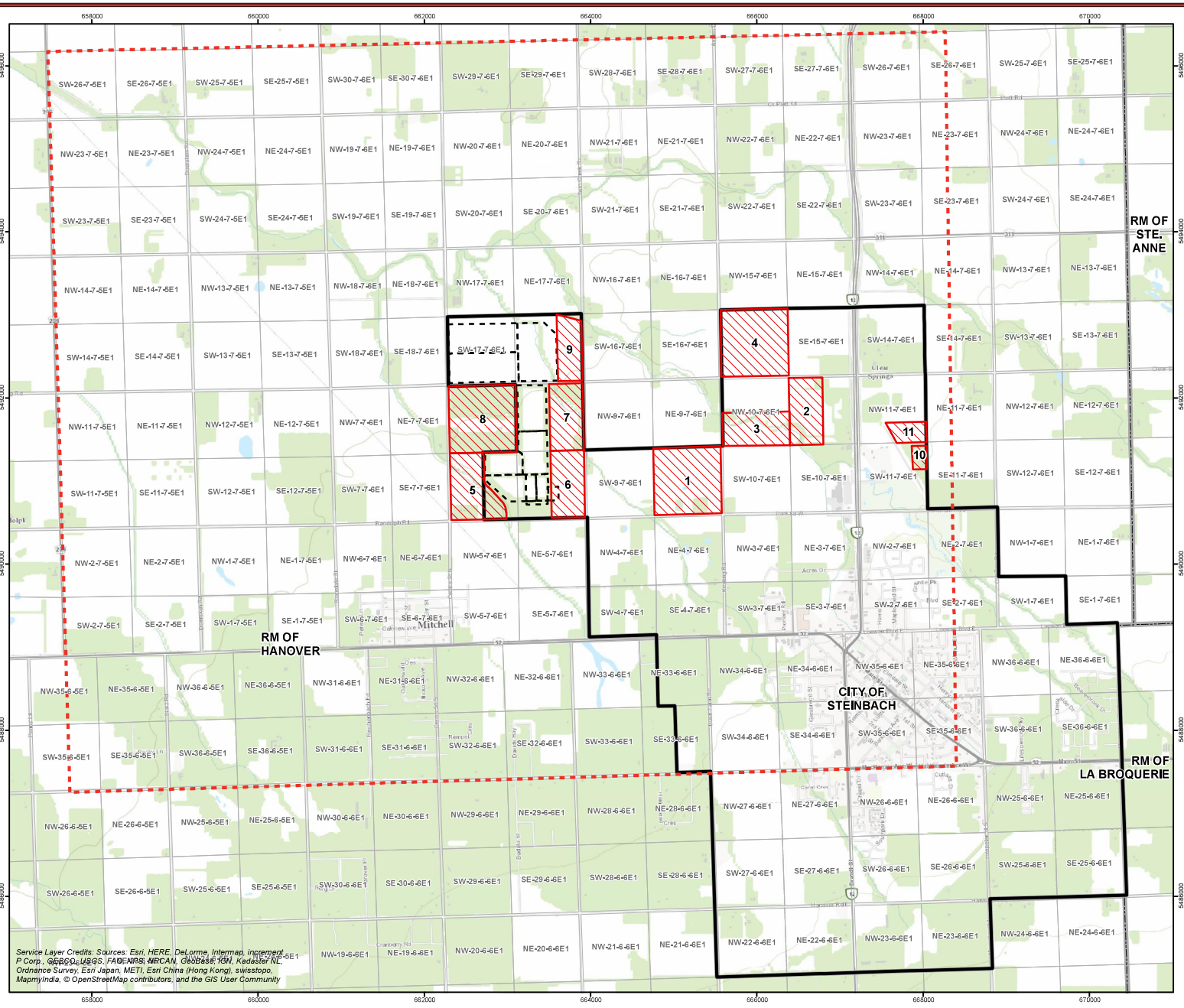

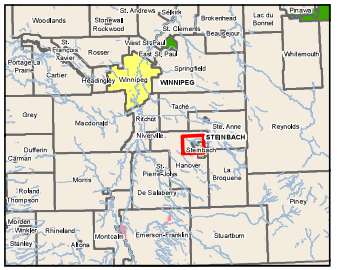

Steinbach Long Term Biosolids Management

Legend

- Suitable Parcel
- Local Study Area
- City Boundary
- Rural Municipality
- Wastewater Treatment Lagoons

Coordinate System: NAD 83, UTM Zone 14 N
Data Source: ESRI, MLI, NRCAN, WSP
Date Created: January 24, 2018
Revision Date: April 23, 2019

N

0 250 500 1,000 1,500 2,000
Metres

MAP 3

Project Study Area

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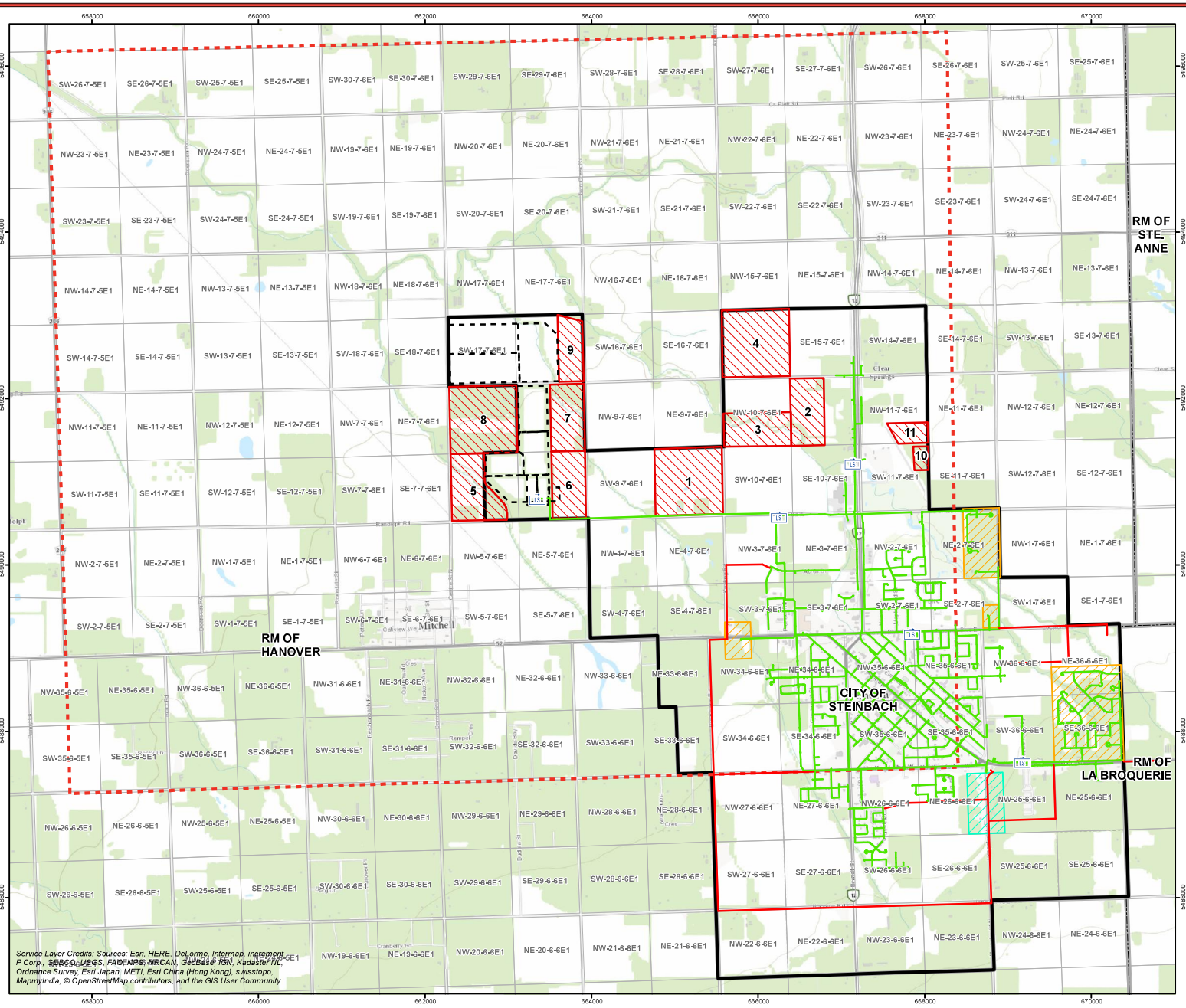
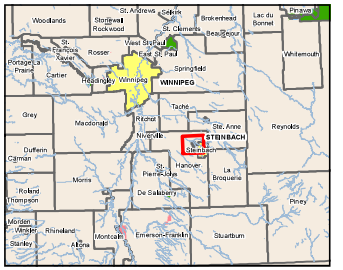




Steinbach Long Term Biosolids Management

Legend

- Lift Station
- Existing Wastewater
- Potential Wastewater
- Low Pressure Sewer
- On-Site Systems
- Suitable Parcel
- Local Study Area
- City Boundary
- Rural Municipality
- Wastewater Treatment Lagoons

Coordinate System: NAD 83, UTM Zone 14 N
Data Source: ESRI, MLI, NRCAN, WSP
Date Created: January 24, 2018
Revision Date: April 23, 2019

N

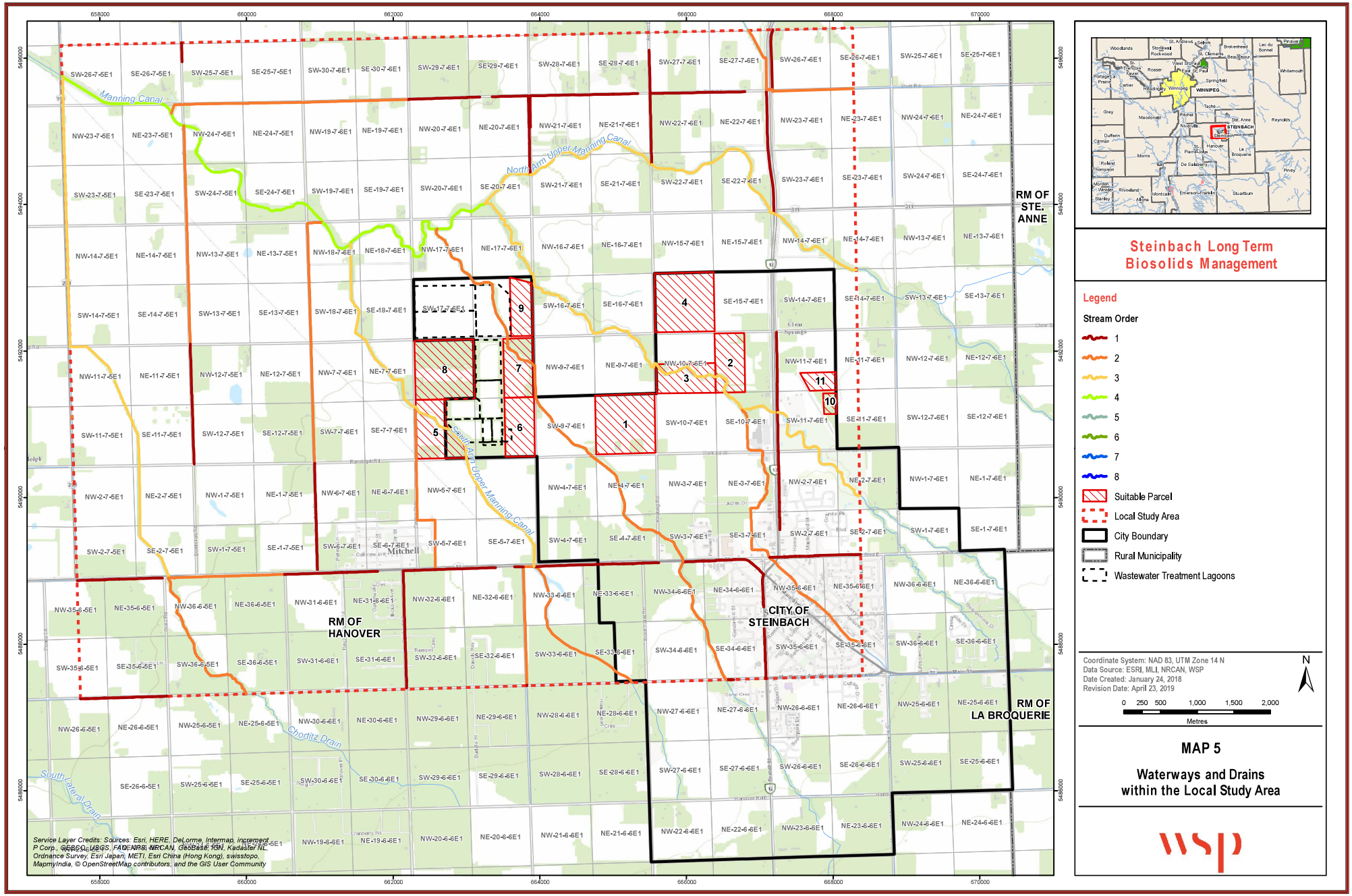
0 250 500 1,000 1,500 2,000
Metres

MAP 4

City of Steinbach Existing and Future Wastewater System

Service Layer Credits: Sources: Esri, HERE, DeLorme, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, MapmyIndia, © OpenStreetMap contributors, and the GIS User Community

U:\Projects\PROJECTS_2018\15M-00849-01_Steinbach\LongTermBiosolids\MXD\MAP4_WastewaterSystem_Batze_20190423.mxd



Steinbach Long Term Biosolids Management

Legend

Stream Order

- 1
- 2
- 3
- 4
- 5
- 6
- 7
- 8

- Suitable Parcel
- Local Study Area
- City Boundary
- Rural Municipality
- Wastewater Treatment Lagoons

Coordinate System: NAD 83, UTM Zone 14 N
Data Source: ESRI, MLI, NRCAN, WSP
Date Created: January 24, 2018
Revision Date: April 23, 2019

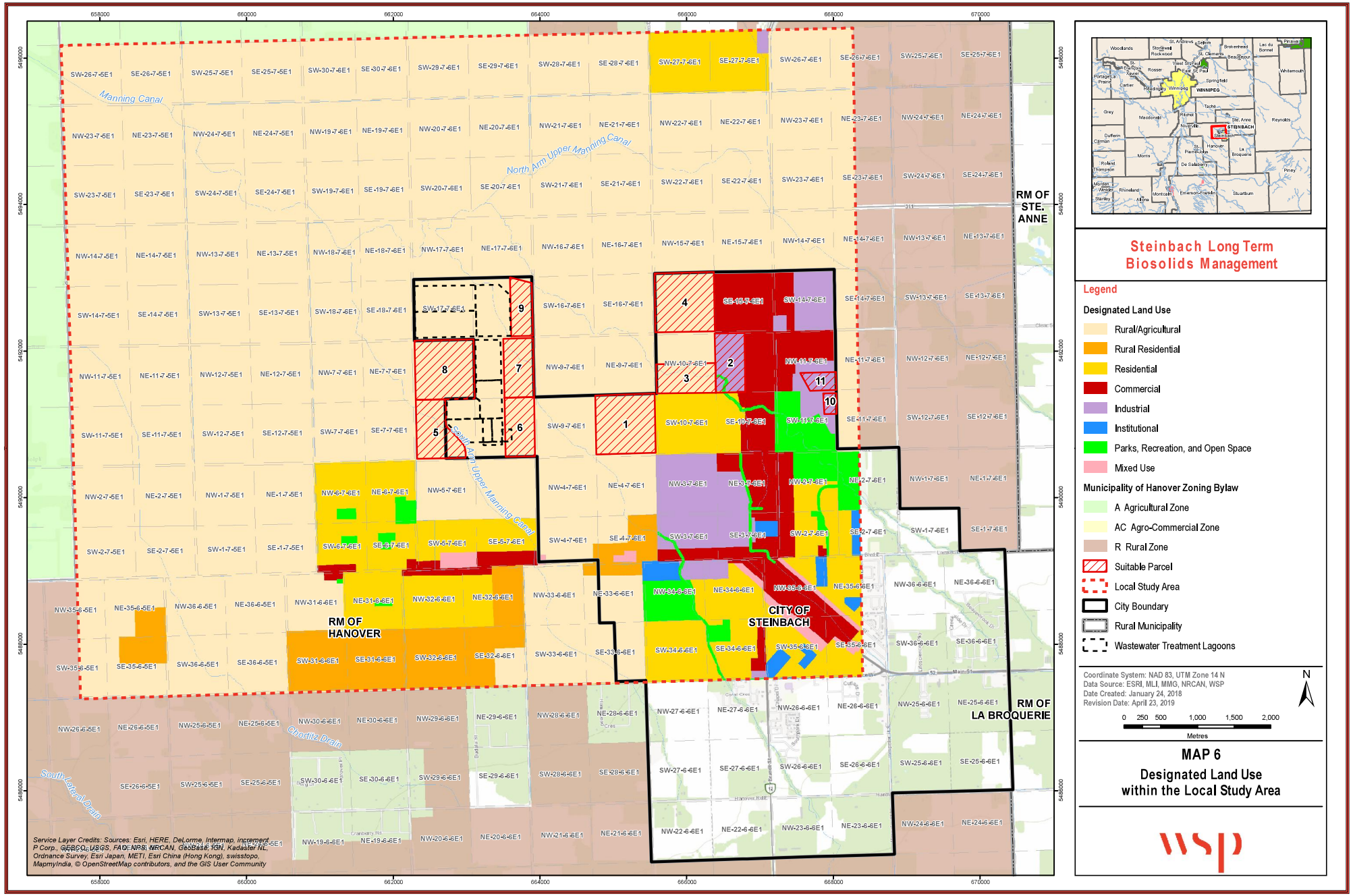
N

0 250 500 1,000 1,500 2,000
Metres

MAP 5

Waterways and Drains within the Local Study Area

U:\Projects\PROJECTS_2018\15M-00849-01_Steinbach\LongTermBiosolids\MXD\MAPS_WaterwaysAndDrains_Block_20190423.mxd



Steinbach Long Term Biosolids Management

Legend

Designated Land Use

- Rural/Agricultural
- Rural Residential
- Residential
- Commercial
- Industrial
- Institutional
- Parks, Recreation, and Open Space
- Mixed Use

Municipality of Hanover Zoning Bylaw

- A Agricultural Zone
- AC Agro-Commercial Zone
- R Rural Zone
- Suitable Parcel
- Local Study Area
- City Boundary
- Rural Municipality
- Wastewater Treatment Lagoons

Coordinate System: NAD 83, UTM Zone 14 N
Data Source: ESRI, MLI, MMG, NRCAN, WSP
Date Created: January 24, 2018
Revision Date: April 23, 2019

N

0 250 500 1,000 1,500 2,000
Metres

MAP 6

Designated Land Use within the Local Study Area

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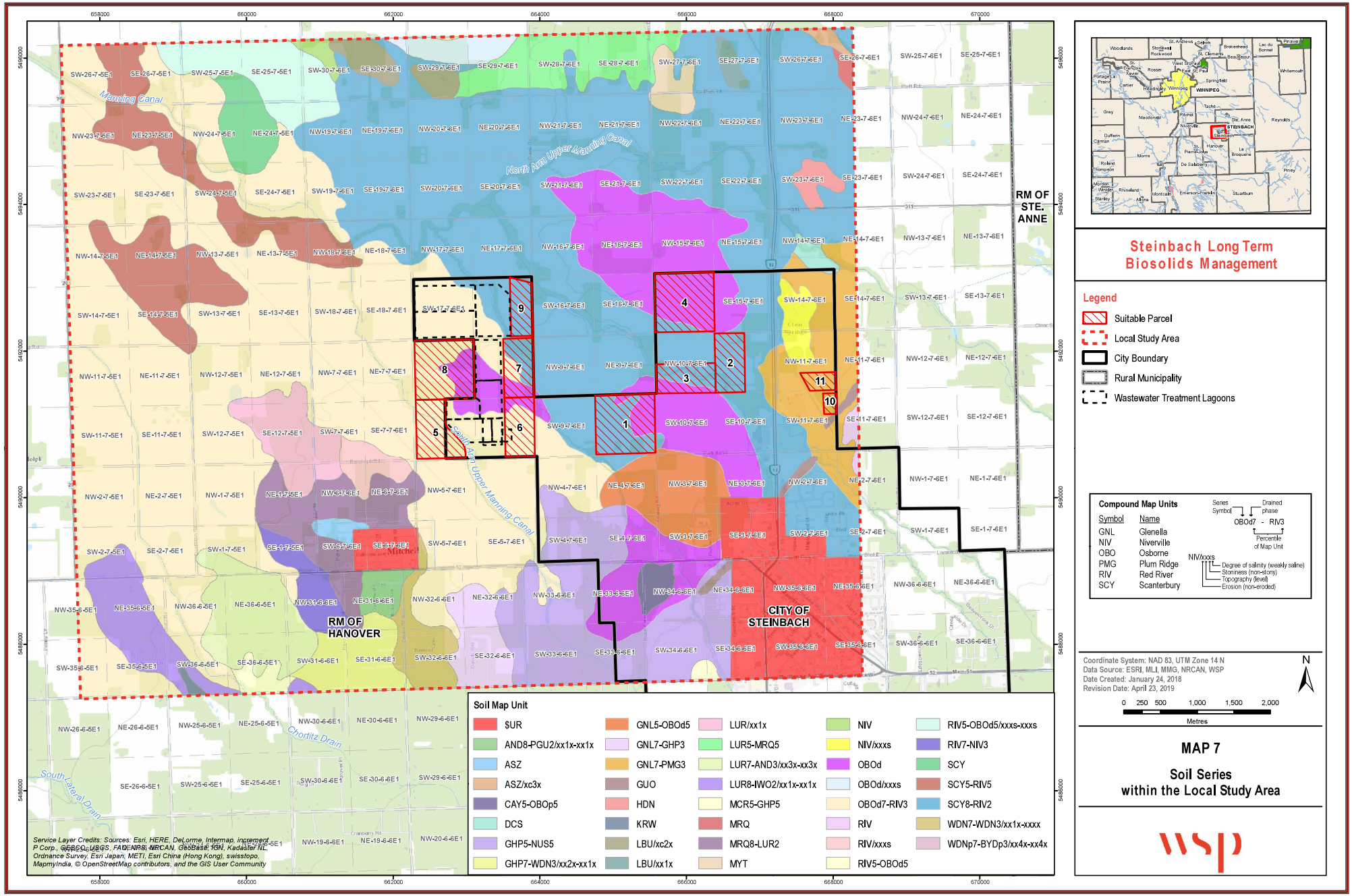

Steinbach Long Term Biosolids Management

Legend

- Suitable Parcel
- Local Study Area
- City Boundary
- Rural Municipality
- Wastewater Treatment Lagoons

Compound Map Units

Symbol	Name
GNL	Glenella
NIV	Niverville
OBO	Osborne
PMG	Plum Ridge
RIV	Red River
SCY	Scanterbury

Series Symbol – Drained phase: OBOd7 - RIV3 (Percentile of Map Unit)

NIV/xxxs: Degree of salinity (weakly saline); Stoniness (non-stony); Topography (level); Erosion (non-eroded)

Coordinate System: NAD 83, UTM Zone 14 N
Data Source: ESRI, MLI, MMG, NRCAN, WSP
Date Created: January 24, 2018
Revision Date: April 23, 2019

N

0 250 500 1,000 1,500 2,000
Metres

MAP 7

Soil Series within the Local Study Area

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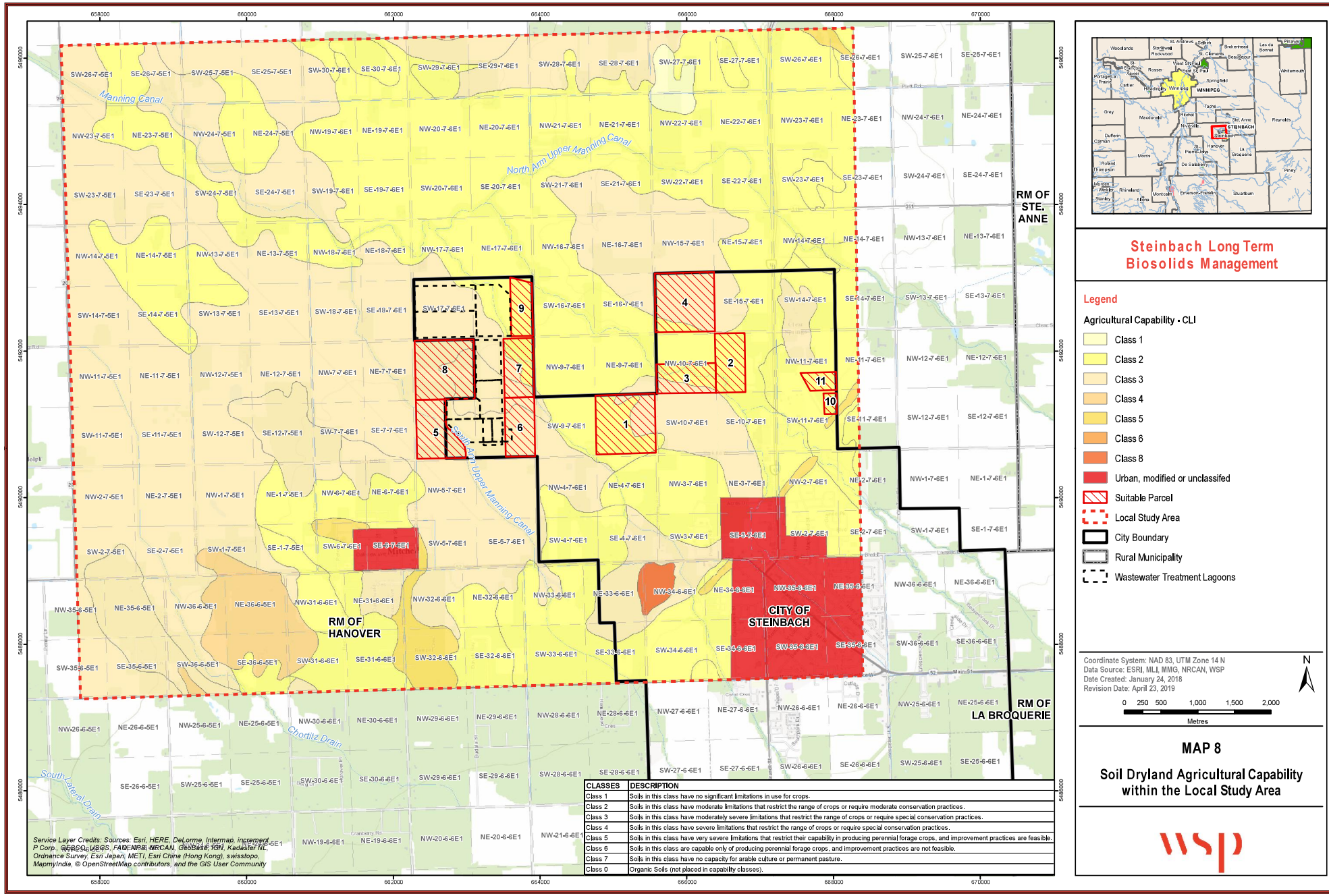

Steinbach Long Term Biosolids Management

Legend

Agricultural Capability - CLI

- Class 1
- Class 2
- Class 3
- Class 4
- Class 5
- Class 6
- Class 8
- Urban, modified or unclassifed
- Suitable Parcel
- Local Study Area
- City Boundary
- Rural Municipality
- Wastewater Treatment Lagoons

Coordinate System: NAD 83, UTM Zone 14 N
Data Source: ESRI, MLI, MMG, NRCAN, WSP
Date Created: January 24, 2018
Revision Date: April 23, 2019

N

0 250 500 1,000 1,500 2,000
Metres

MAP 8

Soil Dryland Agricultural Capability within the Local Study Area

CLASSES	DESCRIPTION
Class 1	Soils in this class have no significant limitations in use for crops.
Class 2	Soils in this class have moderate limitations that restrict the range of crops or require moderate conservation practices.
Class 3	Soils in this class have moderately severe limitations that restrict the range of crops or require special conservation practices.
Class 4	Soils in this class have severe limitations that restrict the range of crops or require special conservation practices.
Class 5	Soils in this class have very severe limitations that restrict their capability in producing perennial forage crops, and improvement practices are feasible.
Class 6	Soils in this class are capable only of producing perennial forage crops, and improvement practices are not feasible.
Class 7	Soils in this class have no capacity for arable culture or permanent pasture.
Class 0	Organic Soils (not placed in capability classes).

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APPENDIX

B PUBLIC INFORMATION

Water Conservation

Water conservation means doing the same with less, by using water more efficiently or reducing where appropriate, in order to protect the resource now, and for the future. Using water wisely will reduce pollution and health risks, lower water costs, and extend the useful life of existing supply and waste treatment facilities. To ensure that we have enough cost-effective water for current and future Steinbach residents, we need to work at reducing the amount of water we waste daily.

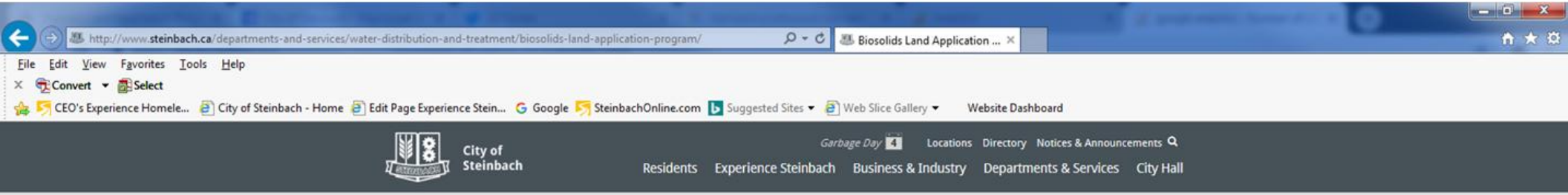
Water Conservation Tips

Biosolids Land Application Program

The City of Steinbach takes its water stewardship role seriously and is working towards a long-term land application license allowing for the dispersal of biosolids.

Learn More

Top



Biosolids Land Application Program

Program Background

The City of Steinbach takes its water stewardship role seriously. In 2018, the city is applying for a long-term land application license that allows for the dispersal of biosolids as required. Until now, a license request was submitted for every one time application. This process required the city to engage and pay for professional services (e.g. consulting engineers and agrologists), as well as complete a lengthy application process for every submission. A long-term license will allow the city to continue its operations, without the need for individual application requests, improving efficiency and decreasing associated costs.

The city's operations will not be changing, only the Environment Act License under which it operates.

Regardless of the license, the City of Steinbach continues to work with and adhere to all guidelines set out by Manitoba Sustainable Development and complies with all applicable acts and regulations, including the Manitoba Water Protection Act, the Manitoba Environment Act and the Nutrient Management Regulation.

What are Biosolids?
Biosolids, or sewage sludge, are the nutrient-rich organic materials resulting from treatment of sewage in a wastewater treatment facility.

What is Biosolids Land Application?
The process of applying biosolids to farmland, supplying nutrients and improved soil quality.

How else can Biosolids be disposed of?
There are three ways to dispose of biosolids - incineration, landfills, and land application. The City's Wastewater program utilizes the land application process to reuse and recycle nutrients in the biosolids. Other disposal options do not recover nutrients or provide reuse

What are the benefits of Biosolids Land Application?
This process provides many agricultural benefits including increased nutrients for local farmland, improved soil structure, drainage and erosion protection, reduction of fertilizer costs and improved crop yields. This process also benefits the environment by reducing greenhouse gases and eliminating disposal of biosolids into landfills.

What has Steinbach done in the past?
The City of Steinbach last completed a bisolids land application in 2015 and prior to that in 2002.

Where could Biosolids be land applied?
Biosolids could only be applied to agricultural land that is suitable based on established criteria by Manitoba Sustainable Development and cooperating farm producers' approval. Suitable agricultural land criteria are based on soil characteristics, farm management practices, and sensitive features. The City of Steinbach will work with local farm producers and Manitoba Sustainable Development to identify suitable local agricultural land and develop a comprehensive land application plan for biosolids land application.

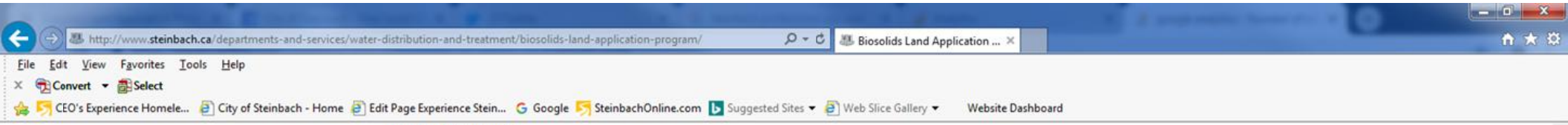
Are Biosolids Safe?
Biosolids land application is a safe, sustainable, provincially regulated strategy for biosolids management widely used in Canada and all over the world.

How often will Biosolids Land Application take place?
The City of Steinbach applies biosolids as warranted by the capacity of the City's wastewater treatment facility. As the City continues to grow, biosolids application requirements may also increase. The land application license that the City is applying for in 2018 takes into account the City's expected growth as well as wastewater treatment facility management requirements and plans accordingly.

I'm a Farm Producer in the Steinbach area, how can I learn about participating in this program?
The City of Steinbach encourages any agricultural producers interested in participating in the program to contact the City by calling 204-346-6214 or completing the form below. We are happy to provide further details about the program and answer any questions you may have.

How can I learn more?
To learn more about the City of Steinbach's Biosolids Land Application Program, complete

Top



How can I learn more?

To learn more about the City of Steinbach's Biosolids Land Application Program, complete and submit the below form.

Contact the City about the Biosolids Land Application Program

First Name *

Last Name *

Street Address *

City *

Province *

Postal Code *

Email Address *

Phone Number *

Comments/Questions?

Please include any specific comments or questions you have.

Submit

Top

No. 82

SPRING/SUMMER 2018

CITY OF STEINBACH

225 Reimer Avenue, Steinbach MB R5G 2J1 Phone 204.326.9877 steinbach.ca

IMPORTANT DATES

Community Pick Up 'n' Walk Event

Saturday, May 5 at 9am

Sign-up at a local church or simply show up at the T.G. Smith Arena on the day to help beautify the city!

Emergency Notification System Test

Wednesday, May 9, 2018 between 5 - 6pm

Coinciding with National Emergency Preparedness Week (May 6-12), the city will be conducting a test of its emergency notification system, Steinbach Alert Now. The test will be sent out to both residents and businesses. To guarantee you receive notifications during a real emergency be sure to register at steinbachalertnow.ca.

Community Compost Depots

Saturdays, from 9am - 3pm, May 12 to mid-October

Bring your compostable items to Steinbach's Community Compost Depots again this year:

- Woodlawn School (411 Henry St.)
- Stonybrook Middle School by the track (77 Lumber Avenue)

Residents are encouraged to use compostable yard waste bags. Visit steinbach.ca for more information.

Oil Recycling Day

Wednesday, June 13 from 9am - 5pm

For every 4 litres of used oil you bring to the Eco Centre at the Steinbach Landfill (max. 205 litres per vehicle), receive a coupon for 1 litre of Co-op 5W-30 Sonic Silver Motor Oil FREE! (max. 5 coupons per vehicle). Also, enjoy a hot dog and drink for $2 from 11am - 2pm.

Summer Swimming Lesson Registration

Wednesday, June 20, 2018 starting at 8am

Registration is available online. Visit our website www.steinbach.ca for more information. Please take a moment to read about how to create your new account prior to registration day.

2018 ELECTION NOTICES

Prospective municipal election candidates must register with the Senior Election Official (SEO) during the registration period before they may begin to accept contributions, incur expenses, fundraise or borrow money for their campaign. Deb Rempel will be receiving candidate registrations at Steinbach City Hall, 225 Reimer Avenue, between the hours of 9am and 4pm (Mon-Fri), for:

1) Mayor - Between May 1 and Sept. 18, 2018

2) Councillor - Between Jun. 30 and Sept. 18, 2018

To obtain a registration form, contact Deb Rempel, SEO at 204-346-6228 or e-mail drempel@steinbach.ca.

To be added or confirm that you are on the voters list call 204-326-6228 or visit City Hall at 225 Reimer Avenue, 9am - 4pm (Mon-Fri) by September 18, 2018. For more information about the 2018 Municipal Election, please visit steinbach.ca.

UTILITY RATE ADJUSTMENTS

The City of Steinbach has been authorized by the Public Utilities Board (Order No. 2718) to modify the sewer rates for billings after April 1, 2018. Adjustments to the rates are as follows:

		New Rates For Billings After	
	Old Rates	Apr. 1, 2018	Jan. 1, 2019
Per cubic meter:			
Water	$1.08	$1.08	$1.08
Sewer	$0.63	$0.70	0.76
Total	$1.71	$1.78	1.84
Minimum quarterly charge for regular residential metre (15 cubic metres)	$42.65	$43.84	$44.92
Basic Charge	$17.00	$17.14	$17.32

Overall, the rate adjustments are expected to have a minimal effect on resident's utility bills. Steinbach continues to enjoy some of the lowest utility rates in Manitoba.

SEASONAL CONSTRUCTION ZONES

Residents are asked to please use caution and obey all posted signs when traveling in or around the following construction zones this spring and summer.

- Asphalt overlay - Hespeler Street North, Tower Avenue to Loewen Boulevard.
- Sidewalk construction - Lyndhurst Gate, south side, Hespeler to Brighton.
- Sidewalk construction - Brighton Lane, west side, Ashford to Lyndhurst.
- Sidewalk construction - Parkhill Crescent, west side, McKenzie to north end.
- Concrete roadway construction - Mckenzie Avenue, Lilac to Brandt.

Thank you in advance for respecting pylons and other safety signs set up for the protection of City employees and contractors.

2017 DRINKING WATER REPORT

The 2017 Annual Report on Steinbach's Drinking Water Quality is now available. The report summarizes the utility's ability to produce safe potable water and meet provincial regulations. The report is available for viewing on steinbach.ca or at City Hall. Questions can be referred to the Waterworks Department at 204-346-6214.

PET CLEAN-UP & CARE

Residents are reminded to follow the rules if you own a pet in Steinbach, including using a leash, cleaning up after them and ensuring they are secure when traveling in a vehicle. For more information visit steinbach.ca.

STEINBACH LANDFILL & HOUSEHOLD HAZARDOUS WASTE DEPOT HOURS

Landfill summer hours now in effect:
Monday to Friday: 8:00am - 8:00pm
Saturday: 8:00am - 6:00pm

Hazardous Waste Depot hours:
Tuesday - Saturday: 9:00am - 4:00pm

The Steinbach Landfill and Depot are located at 104 Hanover Road East.

LANDSCAPE PROJECTS

Planning a landscaping project for your front yard this summer? If so, please contact the City Waterworks department to confirm locations for the water service at your front property line to avoid costly repairs. There is no charge for this service. Please call 204-346-6214.

eBILL ON ITS WAY

Residents will soon be able to view their quarterly utility bill information online and have the option to go paperless. The new service, which will be available through a simple online registration process, will allow residents to conveniently view their amount owing, consumption, and payment history. Registration for the new eBill service is expected to be available this summer. Stay tuned for more details!

EDUCATION PROPERTY TAX CREDIT CHANGES

The Education Property Tax Credit application process has changed for the 2018 tax year for NEW applications. To be eligible for the $700 credit, the following criteria must be met:

1. You must own and occupy your home as your principal residence as of January 1, 2018.
2. You must not currently receive the credit on any other property within Manitoba.

Please contact the City Tax Clerk at 204-346-6531 if you have recently moved and the above criteria is met. Homeowners who already receive the tax credit on their property tax statement are not impacted. Additional information can be found on the Province of Manitoba website at www.gov.mb.ca/finance/tao/eptc.html

BIOSOLIDS LAND APPLICATION PROGRAM

In 2018, the city is applying for a long-term land application license that allows for the dispersal of biosolids (the nutrient-rich organic materials resulting from treatment of sewage in a wastewater treatment facility) as required. A long-term license will allow the city to continue its operations, without the need for individual application requests, improving efficiency and decreasing associated costs. Regardless of the license, the City of Steinbach continues to work with and adhere to all guidelines set out by Manitoba Sustainable Development and complies with all applicable acts and regulations. The City of Steinbach encourages any agricultural producers interested in participating in the program to contact the city, or to learn more about this program, please visit steinbach.ca.

APPENDIX

C SUPPORTING DOCUMENTS

APPENDIX

C.1 GWDRILL GROUNDWATER WELL SEARCH RESULTS

Location: 8-7-6E

Well_PID: 33574
Owner: J NEUFELD
Driller: mondor drillers
Well Name:
Well Use: PRODUCTION
Water Use: Domestic
UTMX: 663111.75
UTMY: 5491355.25
Accuracy XY: UNKNOWN
UTMZ:
Accuracy Z:
Date Completed: 1978 Aug 17

WELL LOG

From (ft.)	To (ft.)	Log
0	15.0	CLAY
15.0	89.9	SILT, HARDPAN
89.9	98.9	FINE SAND& GRAVEL
98.9	117.9	FRACTURED LIMESTONE, LIMESTONE

WELL CONSTRUCTION

From (ft.)	To (ft.)	Casing Type	Inside Dia.(in)	Outside Dia.(in)	Slot Size(in)	Type	Material
0	98.9	casing	4.00			STANDARD	GALVANIZED
98.9	117.9	open hole					

Top of Casing: 0 ft. below ground

PUMPING TEST

Date:
Flowing Rate: 0 Imp. gallons/minute
Water level before pumping: 0 ft. below ground
Pumping level at end of test: ?? ft. below ground
Test duration: hours, minutes
Water temperature: ?? degrees F

Location: NW-8-7-6E

Well_PID: 22468
Owner: G TOPNIK
Driller: MANKEY, EMIL
Well Name:
Well Use: PRODUCTION
Water Use: Domestic,Livestock
UTMX: 662699.138
UTMY: 5491752.28
Accuracy XY: UNKNOWN
UTMZ:
Accuracy Z:
Date Completed: 1974 Oct 18

WELL LOG

From (ft.)	To (ft.)	Log
0	14.0	YELLOW CLAY
14.0	141.9	GREY SANDY CLAY
141.9	149.9	BROWN CLAY
149.9	194.9	LIMESTONE

WELL CONSTRUCTION

From (ft.)	To (ft.)	Casing Type	Inside Dia.(in)	Outside Dia.(in)	Slot Size(in)	Type	Material
0	149.9	casing	7.25			INSERT	BLACK IRON
149.9	194.9	open hole					

Top of Casing: 0 ft. below ground

PUMPING TEST

Date:
Pumping Rate: 19.987 Imp. gallons/minute
Water level before pumping: 25.0 ft. below ground
Pumping level at end of test: 40.0 ft. below ground
Test duration: 30 hours, minutes
Water temperature: ?? degrees F

REMARKS

GAS BESIDE CASING

Location: NW8-7-6E

Well_PID: 29507
Owner: MYRNA WAERLEN
Driller: Friesen Drillers Ltd.
Well Name:
Well Use: PRODUCTION
Water Use: Domestic
UTMX: 662378
UTMY: 5491882
Accuracy XY: 1 EXACT [<5M] [GPS]
UTMZ: 248
Accuracy Z: 4 FAIR - Shuttle at Centroid
Date Completed: 1977 Apr 18

WELL LOG

From (ft.)	To (ft.)	Log
0	13.0	CLAY
13.0	83.9	TILL
83.9	99.9	LIMESTONE

WELL CONSTRUCTION

From (ft.)	To (ft.)	Casing Type	Inside Dia.(in)	Outside Dia.(in)	Slot Size(in)	Type	Material
0	84.9	casing	4.25			INSERT	BLACK IRON
84.9	99.9	open hole	4.00				

Top of Casing: 0 ft. below ground

PUMPING TEST

Date:
Flowing Rate: 29.987 Imp. gallons/minute
Water level before pumping: 5.0 ft. above ground
Pumping level at end of test: 7.0 ft. below ground
Test duration: hours, minutes
Water temperature: ?? degrees F

REMARKS

SEINE RAT RIVER CD WELL INVENTORY 2009. G & ALBERT FRIESEN

Location: NW8-7-6E

Well_PID: 161862
Owner: VERN NEUFELD
Driller: UNKNOWN
Well Name:
Well Use: PRODUCTION
Water Use:
UTMX: 662405
UTMY: 5491807
Accuracy XY: 1 EXACT [<5M] [GPS]
UTMZ:
Accuracy Z: UNKNOWN
Date Completed: 1989 Jan 01

No well log data for this well.

No construction data for this well.

Top of Casing: 1.400 ft. above ground

No pump test data for this well.

REMARKS

SEINE RAT RIVER CD WELL INVENTORY 2009. NO LOG. APPROXIMATE DRILL DATE. WELL IS WEST OF HOUSE.

Location: 10-7-6E

Well_PID: 181024
Owner: THREE WAY BUILDERS
Driller: Echo Drilling Ltd.
Well Name:
Well Use: PRODUCTION
Water Use: Domestic
UTMX: 666436.953
UTMY: 5490154.837
Accuracy XY: 1 EXACT [<5M] [GPS]
UTMZ: 252
Accuracy Z: 4 FAIR [5-10M]
Date Completed: 2013 Mar 14

WELL LOG

From (ft.)	To (ft.)	Log
0	11.0	SANDY TILL
11.0	27.0	TILL
27.0	96.0	BLUE CLAY
96.0	101.0	BROWN TILL
101.0	107.0	LIGHT GREY TILL
107.0	180.0	LIMESTONE

WELL CONSTRUCTION

From (ft.)	To (ft.)	Casing Type	Inside Dia.(in)	Outside Dia.(in)	Slot Size(in)	Type	Material
0	109.0	CASING	5.00			INSERT	PVC
109.0	180.0	OPEN HOLE	4.00				
60.0	109.0	CASING GROUT					CEMENT

Top of Casing: 2.000 ft. above ground

PUMPING TEST

Date: 2013 Mar 14
Pumping Rate: 20.000 Imp. gallons/minute
Water level before pumping: 5.0 ft. below ground
Pumping level at end of test: 6.0 ft. below ground
Test duration: 1 hours, minutes
Water temperature: ?? degrees F

REMARKS

LOT 2 CARLTON DRIVE

Location: NE-10-7-6E

Well_PID: 28795
Owner: P J PENNER
Driller: Friesen Drillers Ltd.
Well Name:
Well Use: PRODUCTION
Water Use: Domestic,Livestock
UTMX: 666792.431
UTMY: 5491850.93
Accuracy XY: UNKNOWN
UTMZ:
Accuracy Z:
Date Completed: 1976 Oct 19

WELL LOG

From (ft.)	To (ft.)	Log
0	18.0	CLAY
18.0	35.0	TILL
35.0	84.9	CLAY
84.9	91.9	TILL
91.9	99.9	LIMESTONE

WELL CONSTRUCTION

From (ft.)	To (ft.)	Casing Type	Inside Dia.(in)	Outside Dia.(in)	Slot Size(in)	Type	Material
0	92.9	casing	4.25			INSERT	BLACK IRON
92.9	99.9	open hole	4.00				

Top of Casing: 0 ft. below ground

PUMPING TEST

Date:
Flowing Rate: 179.921 Imp. gallons/minute
Water level before pumping: 10.0 ft. above ground
Pumping level at end of test: 1.5 ft. above ground
Test duration: 2 hours, minutes
Water temperature: ?? degrees F

Location: NE10-7-6E

Well_PID: 150351
Owner: REIMER FARM SUPPLY
Driller: Echo Drilling Ltd.
Well Name: NW WELL
Well Use: PRODUCTION
Water Use: Air conditioning
UTMX: 666795
UTMY: 5491846
Accuracy XY: 3 ACCURATE [50-350M] [WITHIN 1/4-SECTION]
UTMZ: 253
Accuracy Z: 4 FAIR - Shuttle at Centroid
Date Completed: 2007 Aug 29

WELL LOG

From (ft.)	To (ft.)	Log
0	2.0	FILL
2.0	14.0	CLAY
14.0	27.0	TILL
27.0	33.0	FINE GREY BLACK SAND
33.0	79.0	DENSE GREY CLAY
79.0	86.0	DARK BROWN TILL
86.0	197.0	LIMESTONE

WELL CONSTRUCTION

From (ft.)	To (ft.)	Casing Type	Inside Dia.(in)	Outside Dia.(in)	Slot Size(in)	Type	Material
0	90.0	CASING	5.00	5.50		INSERT	PVC
90.0	197.0	OPEN HOLE	4.50				
35.0	55.0	CASING GROUT					CEMENT

Top of Casing: 2.000 ft. above ground

PUMPING TEST

Date: 2007 Aug 29
Pumping Rate: 90.000 Imp. gallons/minute
Water level before pumping: 3.5 ft. above ground
Pumping level at end of test: 3.0 ft. above ground
Test duration: ??? hours, ?? minutes
Water temperature: ?? degrees F

REMARKS
C/O DEERFIELD MECHANICAL, FARM CREDIT CORP. RECOMMEND AS RETURN WELL, MUST BE VENTED.

Location: NE10-7-6E

Well_PID: 150347
Owner: REIMER FARM SUPPLY
Driller: Echo Drilling Ltd.
Well Name: SE WELL
Well Use: PRODUCTION
Water Use: Air conditioning
UTMX: 666795
UTMY: 5491846
Accuracy XY: 3 ACCURATE [50-350M] [WITHIN 1/4-SECTION]
UTMZ: 253
Accuracy Z: 4 FAIR - Shuttle at Centroid
Date Completed: 2007 Aug 31

WELL LOG

From (ft.)	To (ft.)	Log
0	15.0	CLAY
15.0	28.0	TILL
28.0	35.0	SAND
35.0	72.0	STICKY CLAY
72.0	85.0	BROWN TILL
85.0	197.0	LIMESTONE

WELL CONSTRUCTION

From (ft.)	To (ft.)	Casing Type	Inside Dia.(in)	Outside Dia.(in)	Slot Size(in)	Type	Material
0	90.0	CASING	5.00	5.50		INSERT	PVC
90.0	197.0	OPEN HOLE	4.00				
78.0	97.0	CASING					GALVANIZED
10.0	40.0	CASING GROUT					CEMENT

Top of Casing: 2.000 ft. above ground

PUMPING TEST

Date: 2007 Aug 31
Pumping Rate: 100.000 Imp. gallons/minute
Water level before pumping: 3.0 ft. above ground
Pumping level at end of test: 14.0 ft. below ground
Test duration: ??? hours, ?? minutes
Water temperature: ?? degrees F

REMARKS
C/O DEERFIELD MECHANICAL, FARM CREDIT CORP. RECOMMEND AS PUMP WELL., MUST BE VENTED.

APPENDIX

C.2 MANITOBA CONSERVATION DATA CENTRE RESPONSE LETTER RE: SPECIES OF CONSERVATION CONCERN WITHIN PROJECT STUDY AREA

Sahulka, Danette

From: Friesen, Chris (SD) <Chris.Friesen@gov.mb.ca>
Sent: November-22-16 2:43 PM
To: Sahulka, Danette
Subject: City of Steinbach Long-term Biosolids Management

Follow Up Flag: Follow up
Flag Status: Flagged

Danette

Thank you for your information request. I completed a search of the MB Conservation Data Centre rare species database which resulted in the following occurrences:

SW 15-7-6E
Bobolink (Dolichonyx oryzivorus), S4B, COSEWIC: Threatened Barn Swallow (Hirundo rustica), S4B, COSEWIC: Threatened

SW 8-7-6E
Barn Swallow (Hirundo rustica), S4B, COSEWIC: Threatened

Further information on this ranking system can be found on our website at http://www.gov.mb.ca/conservation/cdc/consranks.html and these designations can be found at http://web2.gov.mb.ca/laws/statutes/ccsm/e111e.php, http://www.cosewic.gc.ca/ and http://www.sararegistry.gc.ca/default_e.cfm.

Manitoba's recommended setback distances can be found at http://www.gov.mb.ca/conservation/cdc/pubs.html

The information provided in this letter is based on existing data known to the Manitoba CDC of the Wildlife and Fisheries Branch at the time of the request. These data are dependent on the research and observations of our scientists and reflects our current state of knowledge. An absence of data does not confirm the absence of any rare or endangered species. Many areas of the province have never been thoroughly surveyed, however, and the absence of data in any particular geographic area does not necessarily mean that species or ecological communities of concern are not present. The information should, therefore, not be regarded as a final statement on the occurrence of any species of concern nor should it substitute for on-site surveys for species or environmental assessments. Also, because our Biotics database is continually updated and because information requests are evaluated by type of action, any given response is only appropriate for its respective request.

Please contact the Manitoba CDC for an update on this natural heritage information if more than six months passes before it is utilised.

Third party requests for products wholly or partially derived from the Biotics database must be approved by the Manitoba CDC before information is released. Once approved, the primary user will identify the Manitoba CDC as data contributors on any map or publication using data from our database, as the Manitoba Conservation Data Centre; Wildlife and Fisheries Branch, Manitoba Sustainable Development.

This letter is for information purposes only - it does not constitute consent or approval of the proposed project or activity, nor does it negate the need for any permits or approvals required by the Province of Manitoba.

We would be interested in receiving a copy of the results of any field surveys that you may undertake, to update our database with the most current knowledge of the area.

If you have any questions or require further information contact me directly at (204) 945-7747.

Chris Friesen
Coordinator
Manitoba Conservation Data Centre
204-945-7747
chris.friesen@gov.mb.ca
http://www.manitoba.ca/conservation/cdc/

-----Original Message-----
From:
Sent: November-09-16 10:49 AM
To: Friesen, Chris (SD)
Subject: WWW Form Submission

Below is the result of your feedback form. It was submitted by WWW Information Request () on Wednesday, November 9, 2016 at 10:49:13

DocumentID: Manitoba_Conservation

Project Title: City of Steinbach Long-term Biosolids Management

Date Needed: 2016/12/02

Name: Daentte Sahulka

Company/Organization: MMM/WSP

Address: 1600 Buffalo Place

City: Winnipeg

Province/State: MB

Phone: 204-477-6650 ext. 389

Email: sahulkad@mmm.ca

Project Description: Development of a long-term biosolid management plan for the City of Steinbach. The requested information is to confirm that there are no species of conservation concern on land parcels that may receive application of biosolids materials.

Information Requested: Any listing for plant or wildlife species of conservation concern recorded for the properties.

Format Requested: email - map, shapefile, spreadsheet

Location: SE 9-7-6EPM

West half of NE 10-7-6EPM
South half of NW 10-7-6EPM
SW 15-7-6EPM
SW8-7-6EPM
E1/2 8-7-6EPM
NW 8-7-6EPM

action: Submit

APPENDIX

C.3 HISTORIC RESOURCES BRANCH – RESPONSE LETTER REGARDING POTENTIAL HISTORIC RESOURCES WITHIN THE PROJECT STUDY AREA

Sahulka, Danette

From: +WPG574 - HRB Archaeology (SCH) <HRB.archaeology@gov.mb.ca>
Sent: February-06-17 6:41 PM
To: Sahulka, Danette
Subject: RE: 3315439 Steinbach Long Term Biosolids Mgmt - Request for Heritage Screening
Attachments: 2017-02-03 AAS 16-11425 (WSP).pdf

Follow Up Flag: Follow up
Flag Status: Flagged

Dear Danette,

Please find attached a copy of the heritage screening for the biosolids application program.

Christina Nesbitt has been on leave since October and I am the impact assessment archaeologist for the Eastman region (since May 2016). For future reference, for timely completion of heritage screening requests, please send requests to hrb.archaeology@gov.mb.ca. From there, the intakes will get directed towards the relevant archaeologist(s) overseeing respective regions.

You have my apologies for the delay.

Sincerely,
Suyoko

Suyoko Anne Tsukamoto
Impact Assessment Archaeologist
Historic Resources Branch
Manitoba Sport, Culture, and Heritage

Main Floor, 213 Notre Dame Avenue
Winnipeg, MB
R3B 1N3
T: (204) 945-3893
F: (204) 945-2384
e: suyoko.tsukamoto@gov.mb.ca

From: Nesbitt, Christina (SCH)
Sent: January-23-17 3:49 PM
To: +WPG574 - HRB Archaeology (SCH)
Subject: FW: 3315439 Steinbach Long Term Biosolids Mgmt - Request for Heritage Screening

For screening intake.

Thanks,

Christina Nesbitt
Impact Assessment Archaeologist
Historic Resources Branch

Main Floor - 213 Notre Dame Avenue, Winnipeg, MB R3B 1N3
Phone (204) 945-8145; Fax (204) 948-2384
E-mail: Christina.Nesbitt@gov.mb.ca

Manitoba
Sport, Culture and Heritage

From: Sahulka, Danette [mailto:SahulkaD@mmm.ca]
Sent: November-09-16 11:07 AM
To: Nesbitt, Christina (SCH)
Subject: 3315439 Steinbach Long Term Biosolids Mgmt - Request for Heritage Screening

Dear Ms. Nesbitt,

I would like to request a heritage screening for the following properties for due diligence purposes for a proposed biosolid application program in the area around the City of Steinbach. These properties have historically been used in the production of forage and annual crops.

Properties for screening include:
SE 9-7-6EPM
West half of NE 10-7-6EPM
South half of NW 10-7-6EPM
SW 15-7-6EPM
SW8-7-6EPM
E1/2 8-7-6EPM
NW 8-7-6EPM

If you have any questions or concerns, please feel free to contact me.

Thank you,
Danette

Please note, the Winnipeg Environmental Management Department is now located in our Buffalo Place Office. My change in address and office phone number is provided below. My cell number remains the same.

WSP MMM GROUP

Danette Sahulka, M.Sc., P.Ag.
Senior Ecologist
Environmental Management

WSP Canada Inc.
1600 Buffalo Place
Winnipeg, Manitoba R3T 6B8 Canada
T +1 204-477-6650 ext. 389
C +1 204-330-6078
sahulkad@mmm.ca

www.mmmgrouplimited.com / www.wspgroup.com

Manitoba
Sport, Culture and Heritage

Memorandum

DATE: 2017-02-06

TO: **Danette Sahulka**
Senior Ecologist
WSP Canada
1600 Buffalo Place
Winnipeg, MB
R3T 6B8

FROM: **Suyoko TSUKAMOTO**
Impact Assessment Archaeologist
Historic Resources Branch
Main Floor – 213 Notre Dame Avenue
Winnipeg, Manitoba
R3B 1N3

PHONE NO: (204) 945-3893
FAX: (204) 948-2384
E-MAIL: Suyoko.Tsukamoto@gov.mb.ca

SUBJECT: **3315439 Steinbach Long Term Biosolids Mgmt – Request for Heritage Screening**
AAS File No. AAS-16-11425

No concerns at this time.

Further to your general inquiry regarding the above noted heritage screening, the Historic Resources Branch has examined the locations in conjunction with Branch records for areas of potential concern. The potential to impact significant heritage resources has been deemed low in these areas, therefore, the Historic Resources Branch has no immediate concerns with the biosolid application program.

If at any time, however, heritage resources are encountered in association with these lands during testing and development, the Historic Resources Branch may require that an acceptable heritage resource management strategy be implemented by the developer to mitigate the effects of development on the heritage resources.

If you have any questions or comments, please feel free to contact me as above.

Suyoko Tsukamoto

APPENDIX

D BIOSOLIDS CHAIN OF ANALYSIS REPORTS

Field Prescription Application Rates (Example)

May 30, 2019

Field ID:	SE08-07-06EPM	
Land Area Available (ha):		28
2019 Crop	Winter Wheat	
2019 Target Yield:	140 bu/ac	
	lb/ac	kg/ha
Target Nitrogen recommended :	110	123.2
Fertilizer Phosphate (P2O5) Recommended:	50	56
1 x P2O5 Crop Removal @ target Yield:	73	81.76
2 x P2O5 Crop Removal @ target Yield:	146	163.52

Plant Available Nutrients Soil Test Data			
	STBCH003	STBCH003	
Sample Depth	0-15 cm	15-60 cm	Total Available
Units	mg kg^{-1}		kg ha-1
Available Nitrate-N	10.9	3.9	45
Available Phosphate-P	19.8		40
Available Potassium	214		428
Available Sulfate-S	1000	1000	8,000

Steinbach Biosolids Characteristics and Analysis

Parameter Name	Parameter Description	Unit	Biosolid Analysis (Cell 1)
Actual volume applied	In-field	m^3	11,249
Specific Gravity	As Received	kg L^{-1}	1.00
Estimated Biosolids		tonnes	11,249
Dry tonnes biosolids available (=wet tonnes x %solids)	Dried Basis	tonnes	366
Moisture	As Received	%	83.50
Total Solids	As Received	%	3.25
Total Volatile Solids	Dry Basis	%	29.7
Organic Matter	Dry Basis	%	22.05
Inorganic Content	Dry Basis	%	77.95
Total Organic Carbon	Dry Basis	%	27.20
C:N Ratio	Dry Basis	x:1	23.25
C:P Ratio	Dry Basis	x:1	37.91
N:P Ratio	Dry Basis	x:1	1.63
pH	Saturated Paste		6.87
Total Kjeldahl N	% Dried Basis	%	1.170
Total Kjeldahl N	Dried Basis	mg kg^{-1}	11,700
Total Kjeldahl N	Dried Basis	kg $Tonne^{-1}$	11.70
Ammonium - N	Dried Basis	mg kg^{-1}	876.00
Ammonium - N	Dried Basis	kg $Tonne^{-1}$	0.8760
Available Nitrate	Dried Basis	mg kg^{-1}	-
Available Nitrate-N	Dried Basis	mg kg^{-1}	-
Available Nitrate-N		kg $Tonne^{-1}$	-
Total Phosphorous	Dried Basis	mg kg^{-1}	7,175

Amount of Biosolids Nutrient Available to Crop

Organic N (=TKN-ammonium N)	Dried Basis	mg kg^{-1}	10,824.00
Organic N	Dried Basis	kg $Tonne^{-1}$	10.824
Method of Application:			Injections
Anticipated Weather			Warm/dry
Anticipated Volatilization (%)	incorp within 1 days		-
Available Organic N	Dried Basis	kg $Tonne^{-1}$	2.706
Ammonium nitrogen available	Dried Basis	kg $Tonne^{-2}$	0.88
Total available nitrogen (Year 1) (@25%)	Dried Basis	kg $Tonne^{-1}$	3.58
Mineralization N Year 2 (@12%)	Dried Basis	kg $Tonne^{-1}$	1.30
Mineralization N Year 3 (@6%)	Dried Basis	kg $Tonne^{-1}$	0.65
Phosphorus	Dried Basis	kg $Tonne^{-1}$	7.18
$P_2O_{5\ equivalent}$	Dried Basis	kg $Tonne^{-1}$	16.50
Total Available P2O5	Dried Basis	kg $Tonne^{-1}$	8.25

Application Rate based on Nitrogen				Land Area Required (Ha)
Nitrogen Based Application Rate	Dried Basis	tonnes ha^{-1}	34.39	**11**
Amount of Available P2O5 applied	Dried Basis	kg ha^{-1}	283.80	
P2O5 Application check		%	506.78	
Application Rate based on Phosphorous (1xCR)				**Land Area Required (Ha)**
Total Phosphorus Based Application Rate	Dried Basis	tonnes ha^{-1}	10	**37**
Amount of Nitrogen applied	Dried Basis	kg ha^{-1}	35	
Additional Nitrogen required		kg ha^{-1}	88	
Application Rate based on Phosphorous (2xCR)				**Land Area Required (Ha)**
Total Phosphorus Based Application Rate	Dried Basis	tonnes ha^{-1}	**19.82**	**18**
Amount of Nitrogen applied	Dried Basis	kg ha^{-1}	70.99	
Additional Nitrogen required		kg ha^{-1}	52.21	

Selected Application rate based on:		**2xCR**	**P2O5**
Selected Application rate based on P2O5	Dried Basis	tonnes ha^{-1}	**20**
		tons ac^{-1}	**9**
	Wet	tonnes ha^{-1}	610
		L ha^{-1}	628,066
		tons ac^{-1}	274
		igal ac^{-1}	**55,898**
Estimated Biosolids Volume Applied	Wet	Tonnnes	17,074
Estimated Biosolids Volume Remaining	Wet	Tonnes	- 5,825

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 0.25year 1

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

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

Phosphorous Total and Olsen methods.

* See Estimates of Ammonium-N Retained After Biosolids application

C:N exceeds 30:1, N becomes a limiting nutrient for decomposer organisms, and this can reduce the rate of decomposition and results in N immobilization

C:P ratio between 200:1 and 300:1, mineralization and immobilization balance each other to result in no net release of P from the decomposing manure. When C:P is below this range, P is released.

When animal and municipal wastes have N:P ratios ranging from 1:1 to 1:2 are applied based on N rates on soils, over time P will accumulate

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Total Available P2O5	Dried Basis	kg $Tonne^{-1}$	8.25

MMM Group Ltd.
ATTN: DARREN KEAM
111-93 Lombard Ave
Winnipeg MB R3B 3B1

Date Received: 11-APR-13
Report Date: 26-APR-13 11:57 (MT)
Version: FINAL

Client Phone: 204-272-2020

Certificate of Analysis

Lab Work Order #: L1288422

Project P.O. #: 5513035
Job Reference: 5513035
C of C Numbers:
Legal Site Desc:

Craig Riddell
Account Manager

ALS ENVIRONMENTAL ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	Batch
L1288422-1 STEINBACH LAGOON #1							
Sampled By: LY on 10-APR-13 @ 12:00							
Matrix: SEDIMENT (GRAB)							
Miscellaneous Parameters							
Ammonium (as N)	876		1.0	mg/kg	23-APR-13	23-APR-13	R2585628
Boron (B), Hot Water Ext.	7.60		0.20	mg/kg	18-APR-13	18-APR-13	R2581211
Available Phosphate-P	76.8		1.0	mg/kg	24-APR-13	24-APR-13	R2587190
Available Potassium	451		20	mg/kg	17-APR-13	17-APR-13	R2580860
Available Sulfate-S	923		3.0	mg/kg	17-APR-13	17-APR-13	R2580466
Mercury (Hg)	3.9		1.0	mg/kg	17-APR-13	19-APR-13	R2582374
Nitrate-N	<20		20	mg/kg	23-APR-13	23-APR-13	R2587248
Special Request	See Attached					25-APR-13	R2588808
Specific Gravity	1.00		0.010	kg/L		15-APR-13	R2578664
Total Carbon by Combustion	27.2		0.1	%	17-APR-13	17-APR-13	R2580404
Total Kjeldahl Nitrogen	0.376		0.020	%	17-APR-13	18-APR-13	R2581290
Note: Sample analyzed as received.							
Organic Matter by LOI at 375 deg C.							
Organic Matter	34.5		1.0	%	24-APR-13	25-APR-13	R2588829
Loss on Ignition @ 375 C	43.9		1.0	%	24-APR-13	25-APR-13	R2588829
Total Solids and Moisture at 70C							
Moisture	86.4		0.10	%	16-APR-13	16-APR-13	R2579888
Total Solids	13.6		0.10	%	16-APR-13	16-APR-13	R2579888
Total Solids and Total Volatile Solids							
Total Solids	14.4		0.10	%	18-APR-13	18-APR-13	R2581202
Total Volatile Solids (dry basis)	1960		0.10	%	18-APR-13	18-APR-13	R2581202
Detail Salinity in mg/kg							
Chloride (Cl)	2540	DLA	86	mg/kg		19-APR-13	
Calcium (Ca)	1100	DLA	86	mg/kg		19-APR-13	
Magnesium (Mg)	710	DLA	86	mg/kg		19-APR-13	
Potassium (K)	242	DLA	43	mg/kg		19-APR-13	
Sodium (Na)	2330	DLA	170	mg/kg		19-APR-13	
Sulfur (as SO4)	1800	DLA	210	mg/kg		19-APR-13	
Metals in Soil by CRC ICPMS							
Aluminum (Al)	11900		50	mg/kg	17-APR-13	18-APR-13	R2580951
Antimony (Sb)	2.63		0.10	mg/kg	17-APR-13	18-APR-13	R2580951
Arsenic (As)	6.03		0.10	mg/kg	17-APR-13	18-APR-13	R2580951
Barium (Ba)	1240	DLA	10	mg/kg	17-APR-13	18-APR-13	R2580951
Beryllium (Be)	<0.50		0.50	mg/kg	17-APR-13	18-APR-13	R2580951
Bismuth (Bi)	29.1		1.0	mg/kg	17-APR-13	18-APR-13	R2580951
Cadmium (Cd)	2.42		0.10	mg/kg	17-APR-13	18-APR-13	R2580951
Calcium (Ca)	45000		100	mg/kg	17-APR-13	18-APR-13	R2580951
Chromium (Cr)	36.3		0.50	mg/kg	17-APR-13	18-APR-13	R2580951
Cobalt (Co)	4.8		1.0	mg/kg	17-APR-13	18-APR-13	R2580951
Copper (Cu)	1350	DLA	10	mg/kg	17-APR-13	18-APR-13	R2580951
Iron (Fe)	18100		50	mg/kg	17-APR-13	18-APR-13	R2580951
Lead (Pb)	52.8		1.0	mg/kg	17-APR-13	18-APR-13	R2580951
Lithium (Li)	6.6		2.0	mg/kg	17-APR-13	18-APR-13	R2580951
Magnesium (Mg)	16000		100	mg/kg	17-APR-13	18-APR-13	R2580951
Manganese (Mn)	158		1.0	mg/kg	17-APR-13	18-APR-13	R2580951
Molybdenum (Mo)	51.9		1.0	mg/kg	17-APR-13	18-APR-13	R2580951
Nickel (Ni)	19.7		1.0	mg/kg	17-APR-13	18-APR-13	R2580951
Phosphorus (P)	11000		50	mg/kg	17-APR-13	18-APR-13	R2580951
Potassium (K)	1060		100	mg/kg	17-APR-13	18-APR-13	R2580951
Selenium (Se)	6.98		0.20	mg/kg	17-APR-13	18-APR-13	R2580951
Silver (Ag)	31.3		0.20	mg/kg	17-APR-13	18-APR-13	R2580951

* Refer to Referenced Information for Qualifiers (if any) and Methodology.

ALS ENVIRONMENTAL ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	Batch
L1288422-1 STEINBACH LAGOON #1							
Sampled By: LY on 10-APR-13 @ 12:00							
Matrix: SEDIMENT (GRAB)							
Metals in Soil by CRC ICPMS							
Sodium (Na)	2200		100	mg/kg	17-APR-13	18-APR-13	R2580951
Strontium (Sr)	208		1.0	mg/kg	17-APR-13	18-APR-13	R2580951
Thallium (Tl)	0.18		0.10	mg/kg	17-APR-13	18-APR-13	R2580951
Tin (Sn)	25.9		2.0	mg/kg	17-APR-13	18-APR-13	R2580951
Titanium (Ti)	28.3		5.0	mg/kg	17-APR-13	18-APR-13	R2580951
Uranium (U)	16.9		0.10	mg/kg	17-APR-13	18-APR-13	R2580951
Vanadium (V)	17.4		1.0	mg/kg	17-APR-13	18-APR-13	R2580951
Zinc (Zn)	913	DLA	50	mg/kg	17-APR-13	18-APR-13	R2580951
Detailed Salinity							
Chloride (Cl) (Saturated Paste)							
Chloride (Cl)	297	DLA	10	mg/L	19-APR-13	19-APR-13	R2582075
SAR, Cations and SO4 in saturated soil							
Calcium (Ca)	128	DLA	10	mg/L	19-APR-13	19-APR-13	R2582232
Potassium (K)	28.3	DLA	5.0	mg/L	19-APR-13	19-APR-13	R2582232
Magnesium (Mg)	83	DLA	10	mg/L	19-APR-13	19-APR-13	R2582232
Sodium (Na)	272	DLA	20	mg/L	19-APR-13	19-APR-13	R2582232
SAR	4.60		0.10	SAR	19-APR-13	19-APR-13	R2582232
Sulfur (as SO4)	210	DLA	25	mg/L	19-APR-13	19-APR-13	R2582232
pH and EC (Saturated Paste)							
% Saturation	856		1.0	%	18-APR-13	19-APR-13	R2581771
pH in Saturated Paste	6.87		0.10	pH	18-APR-13	19-APR-13	R2581771
Conductivity Sat. Paste	3.02		0.10	dS m-1	18-APR-13	19-APR-13	R2581771

* Refer to Referenced Information for Qualifiers (if any) and Methodology.

Reference Information

Sample Parameter Qualifier Key:

Qualifier	Description
DLA	Detection Limit Adjusted For required dilution

Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**
B-HOTW-SK	Soil	Available Boron, Hot Water	SSSA (1996) P. 610-611
Hot water is used to extract the plant-available and potentially plant-available boron from soil. Boron in the extract is determined by ICP-OES.			
C-TOT-LECO-SK	Soil	Total Carbon by combustion method	SSSA (1996) P. 973-974
The sample is ignited in a combustion analyzer where carbon in the reduced CO2 gas is determined using a thermal conductivity detector.			
CL-SAR-SK	Soil	Chloride (Cl) (Saturated Paste)	CSSS(1993) 18.2.2/APHA 4500-CL E
Chloride in a saturated soil extract is determined colorimetrically by auto-analyzer.			
HG-200.2-CVAF-SK	Soil	Mercury on Soil by CVAFS	EPA 200.2/EPA 245.7
A representative portion of dry < 2mm soil is digested with concentrated nitric and hydrochloric acids for 2 hours in an open vessel digestor at 95 degrees. Instrumental analysis is by cold vapour atomic fluorescence spectrophotometer.			
K-AVAIL-SK	Soil	Available Potassium	Comm. Soil Sci. Plant, 25 (5&6)
Plant available potassium is extracted from the soil using Modified Kelowna solution. Potassium in the soil extract is determined by flame emission at 770 nm.			
MET-200.2-CCMS-SK	Soil	Metals in Soil by CRC ICPMS	EPA 200.2/6020A
This analysis is carried out using procedures from CSR Analytical Method: "Strong Acid Leachable Metals (SALM) in Soil", BC Ministry of Environment, 26 June 2009, and procedures adapted from EPA Method 200.2. The sample is dried at 40 C, then ground to < 2 mm particle size using a stainless steel flail grinder. A representative portion is digested with concentrated nitric and hydrochloric acids for 2 hours in an open vessel digestor at 95 degrees. Instrumental analysis of the digested extract is by collision cell inductively coupled plasma - mass spectrometry (modifed from EPA Method 6020A).			
MOIST-70-SK	Biocompost	Total Solids and Moisture at 70C	TMECC 3.09-A
MOIST-DRY-70-SK	Biocompost	Moisture at 70C from air dry	TMECC 3.09-A
N-TOTKJ-COL-SK	Soil	Total Kjeldahl Nitrogen	CSSS (1993) 22.2.3
The soil is digested with sulfuric acid in the presence of CuSO4 and K2SO4 catalysts. Ammonia in the soil extract is determined colrimetrically at 660 nm.			
NH4-1:5-SK	Biocompost	Ammonia-N (1:5) - calc to 70C	TMECC 4.02-C
NO3-1:5-KCL-SK	Biocompost	Nitrate-N in biocompost - calc to 70C	TMECC 4.02-B
OM-LOI-SK	Soil	Organic Matter by LOI at 375 deg C.	CSSS (1978) p. 160
The dry-ash method involves the removal of organic matter by combustion at 375 degrees C for a minimum of 16 hours. Samples are dried prior to combustion.			
Reference: McKeague, J.A. Soil Sampling and Methods of Analysis. Can. Soc. Soil Sci.(1978) method 4.23			
PO4-AVAIL-OLSEN-SK	Soil	Available Phosphate-P by Olsen	CSSS (1993) 7.2,7.3.1
Plant available phosphorus is extracted from the sample with sodium bicarbonate. PO4-P in the filtered extract is determined colorimetrically at 880 nm.			
SAL-MG/KG-CALC-SK	Soil	Detail Salinity in mg/kg	Manual Calculation
SALINITY-INTCHECK-SK	Soil		CSSS 18.4-Calculation
SAR-CALC-SO4-SK	Soil	SAR, Cations and SO4 in saturated soil	APHA 3120B
Ca, Mg, Na, K and SO4 in a saturated soil extract are determined by ICP-OES.			
SAT/PH/EC-SK	Soil	pH and EC (Saturated Paste)	CSSS 18.2.2/CSSC 3.14/CSSS 18.3.1
pH of a saturated soil paste is measured using a pH meter. After equilibration, an extract is obtained by vacuum filtration with conductivity of the extract measured by a conductivity meter.			
SO4-AVAIL-SK	Soil	Available Sulfate-S	REC METH SOIL ANAL - AB. AG(1988)
Plant available sulfur in the soil is extracted with a weak calcium chloride solution. Total S in the extract is then determined by ICP-OES.			
SOLIDS-TOT/TOTVOL-SK	Manure	Total Solids and Total Volatile Solids	APHA 2540G
A well-mixed sample is evaporated in a weighed dish and dried to constant weight in an oven at 103-105”C. The increase in weight over that of the empty dish represents the Total Solids. The crucible is then ignited at 550”–10”C for 1 hour. The remaining solids represent the Total Fixed Solids,			

Reference Information

Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**
while the weight lost on ignition represents the Total Volatile Solids.			
SPECGRAV-ED	Soil	Specific Gravity	-
SPECIAL REQUEST-SK	Misc.	Special Request Sask Lab	SEE SUBLET LAB RESULTS

** ALS test methods may incorporate modifications from specified reference methods to improve performance.

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	Laboratory Location
SK	ALS ENVIRONMENTAL - SASKATOON, SASKATCHEWAN, CANADA
ED	ALS ENVIRONMENTAL - EDMONTON, ALBERTA, CANADA

Chain of Custody Numbers:

GLOSSARY OF REPORT TERMS

Surrogates are compounds that are similar in behaviour to target analyte(s), but that do not normally occur in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery. In reports that display the D.L. column, laboratory objectives for surrogates are listed there.
mg/kg - milligrams per kilogram based on dry weight of sample
mg/kg wwt - milligrams per kilogram based on wet weight of sample
mg/kg lwt - milligrams per kilogram based on lipid-adjusted weight
mg/L - unit of concentration based on volume, parts per million.
< - Less than.
D.L. - The reporting limit.
N/A - Result not available. Refer to qualifier code and definition for explanation.

Test results reported relate only to the samples as received by the laboratory.
UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.
Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.

Quality Control Report

Client: MMM Group Ltd.
111-93 Lombard Ave
Winnipeg MB R3B 3B1
Contact: DARREN KEAM

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
B-HOTW-SK	Soil							
Batch R2581211								
WG1655109-2 IRM		**SAL814**						
Boron (B), Hot Water Ext.			92.2		%		70-130	18-APR-13
WG1655109-1 MB								
Boron (B), Hot Water Ext.			<0.20		mg/kg		0.2	18-APR-13
C-TOT-LECO-SK	Soil							
Batch R2580404								
WG1655747-7 DUP		**L1288422-1**						
Total Carbon by Combustion		27.2	26.5		%	2.4	20	17-APR-13
WG1655747-8 IRM		**08-109_SOIL**						
Total Carbon by Combustion			102.5		%		80-120	17-APR-13
WG1655747-9 MB								
Total Carbon by Combustion			<0.1		%		0.1	17-APR-13
CL-SAR-SK	Soil							
Batch R2582075								
WG1656590-2 IRM		**ED-SAL_NAT1**						
Chloride (Cl)			91.9		%		70-130	19-APR-13
WG1656590-1 MB								
Chloride (Cl)			<2.0		mg/L		2	19-APR-13
HG-200.2-CVAF-SK	Soil							
Batch R2582374								
WG1655192-4 CRM		**TILL-1**						
Mercury (Hg)			100.8		%		70-130	19-APR-13
WG1655192-2 DUP		**L1288422-1**						
Mercury (Hg)		3.9	3.9		mg/kg	0.4	40	19-APR-13
WG1655192-1 MB								
Mercury (Hg)			<0.0050		mg/kg		0.005	19-APR-13
K-AVAIL-SK	Soil							
Batch R2580860								
WG1655110-2 IRM		**FARM2005**						
Available Potassium			93.2		%		70-130	17-APR-13
WG1655110-1 MB								
Available Potassium			<20		mg/kg		20	17-APR-13
MET-200.2-CCMS-SK	Soil							
Batch R2580951								
WG1655192-3 CRM		**PACS-2**						
Aluminum (Al)			90.9		%		70-130	18-APR-13
Antimony (Sb)			83.1		%		70-130	18-APR-13

Quality Control Report

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
MET-200.2-CCMS-SK	Soil							
Batch R2580951								
WG1655192-3 CRM		**PACS-2**						
Arsenic (As)			104.9		%		70-130	18-APR-13
Barium (Ba)			88.3		%		70-130	18-APR-13
Beryllium (Be)			85.7		%		50-150	18-APR-13
Bismuth (Bi)			78.4		%		50-150	18-APR-13
Cadmium (Cd)			106.0		%		70-130	18-APR-13
Calcium (Ca)			95.5		%		70-130	18-APR-13
Chromium (Cr)			98.3		%		70-130	18-APR-13
Cobalt (Co)			94.9		%		70-130	18-APR-13
Copper (Cu)			93.5		%		70-130	18-APR-13
Iron (Fe)			94.3		%		70-130	18-APR-13
Lead (Pb)			81.1		%		70-130	18-APR-13
Lithium (Li)			106.5		%		70-130	18-APR-13
Magnesium (Mg)			90.1		%		70-130	18-APR-13
Manganese (Mn)			94.3		%		70-130	18-APR-13
Molybdenum (Mo)			96.1		%		70-130	18-APR-13
Nickel (Ni)			94.8		%		70-130	18-APR-13
Phosphorus (P)			102.5		%		70-130	18-APR-13
Potassium (K)			86.8		%		70-130	18-APR-13
Selenium (Se)			98.2		%		70-130	18-APR-13
Silver (Ag)			81.5		%		70-130	18-APR-13
Sodium (Na)			93.8		%		70-130	18-APR-13
Strontium (Sr)			91.0		%		70-130	18-APR-13
Thallium (Tl)			81.2		%		50-150	18-APR-13
Tin (Sn)			88.4		%		70-130	18-APR-13
Titanium (Ti)			90.5		%		70-130	18-APR-13
Uranium (U)			75.7		%		70-130	18-APR-13
Vanadium (V)			97.3		%		70-130	18-APR-13
Zinc (Zn)			96.2		%		70-130	18-APR-13
WG1655192-4 CRM		**TILL-1**						
Aluminum (Al)			93.0		%		70-130	18-APR-13
Antimony (Sb)			105.2		%		70-130	18-APR-13
Arsenic (As)			106.4		%		70-130	18-APR-13
Barium (Ba)			106.7		%		70-130	18-APR-13
Beryllium (Be)			98.9		%		50-150	18-APR-13

Quality Control Report

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
MET-200.2-CCMS-SK	Soil							
Batch R2580951								
WG1655192-4 CRM		**TILL-1**						
Bismuth (Bi)			95.9		%		70-130	18-APR-13
Cadmium (Cd)			84.7		%		50-150	18-APR-13
Calcium (Ca)			100.2		%		70-130	18-APR-13
Chromium (Cr)			103.4		%		70-130	18-APR-13
Cobalt (Co)			99.6		%		70-130	18-APR-13
Copper (Cu)			96.9		%		70-130	18-APR-13
Iron (Fe)			91.6		%		70-130	18-APR-13
Lead (Pb)			92.4		%		70-130	18-APR-13
Lithium (Li)			100.3		%		70-130	18-APR-13
Magnesium (Mg)			95.9		%		70-130	18-APR-13
Manganese (Mn)			97.0		%		70-130	18-APR-13
Molybdenum (Mo)			105.0		%		70-130	18-APR-13
Nickel (Ni)			102.4		%		70-130	18-APR-13
Phosphorus (P)			107.1		%		70-130	18-APR-13
Potassium (K)			89.8		%		70-130	18-APR-13
Selenium (Se)			100.0		%		70-130	18-APR-13
Silver (Ag)			109.7		%		70-130	18-APR-13
Sodium (Na)			100.6		%		50-150	18-APR-13
Strontium (Sr)			111.9		%		70-130	18-APR-13
Thallium (Tl)			96.0		%		70-130	18-APR-13
Tin (Sn)			92.1		%		70-130	18-APR-13
Titanium (Ti)			90.7		%		70-130	18-APR-13
Uranium (U)			105.0		%		70-130	18-APR-13
Vanadium (V)			101.8		%		70-130	18-APR-13
Zinc (Zn)			95.2		%		70-130	18-APR-13
WG1655192-2 DUP		**L1288422-1**						
Aluminum (Al)		11900	13600		mg/kg	13	30	18-APR-13
Antimony (Sb)		2.63	2.86		mg/kg	8.3	30	18-APR-13
Arsenic (As)		6.03	6.65		mg/kg	9.9	30	18-APR-13
Barium (Ba)		1240	1250		mg/kg	0.9	30	18-APR-13
Beryllium (Be)		<0.50	<0.50	RPD-NA	mg/kg	N/A	30	18-APR-13
Bismuth (Bi)		29.1	32.0		mg/kg	9.5	30	18-APR-13
Cadmium (Cd)		2.42	2.82		mg/kg	15	30	18-APR-13
Calcium (Ca)		45000	45400		mg/kg	0.7	30	18-APR-13

Quality Control Report

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
MET-200.2-CCMS-SK	Soil							
Batch R2580951								
WG1655192-2 DUP		**L1288422-1**						
Chromium (Cr)		36.3	39.6		mg/kg	8.6	30	18-APR-13
Cobalt (Co)		4.8	5.1		mg/kg	6.5	30	18-APR-13
Copper (Cu)		1350	1390		mg/kg	3.4	30	18-APR-13
Iron (Fe)		18100	19900		mg/kg	9.5	30	18-APR-13
Lead (Pb)		52.8	56.8		mg/kg	7.2	40	18-APR-13
Lithium (Li)		6.6	7.8		mg/kg	17	30	18-APR-13
Magnesium (Mg)		16000	17700		mg/kg	10	30	18-APR-13
Manganese (Mn)		158	177		mg/kg	11	30	18-APR-13
Molybdenum (Mo)		51.9	59.8		mg/kg	14	30	18-APR-13
Nickel (Ni)		19.7	21.4		mg/kg	8.4	30	18-APR-13
Phosphorus (P)		11000	12400		mg/kg	11	30	18-APR-13
Potassium (K)		1060	1200		mg/kg	12	30	18-APR-13
Selenium (Se)		6.98	6.89		mg/kg	1.4	30	18-APR-13
Silver (Ag)		31.3	38.3		mg/kg	20	30	18-APR-13
Sodium (Na)		2200	2280		mg/kg	3.7	30	18-APR-13
Strontium (Sr)		208	239		mg/kg	14	30	18-APR-13
Thallium (Tl)		0.18	0.18		mg/kg	2.7	30	18-APR-13
Tin (Sn)		25.9	30.6		mg/kg	17	30	18-APR-13
Titanium (Ti)		28.3	34.0		mg/kg	18	30	18-APR-13
Uranium (U)		16.9	18.2		mg/kg	7.4	30	18-APR-13
Vanadium (V)		17.4	19.1		mg/kg	9.1	30	18-APR-13
Zinc (Zn)		913	945		mg/kg	3.4	30	18-APR-13
WG1655192-1 MB								
Aluminum (Al)			<50		mg/kg		50	18-APR-13
Antimony (Sb)			<0.10		mg/kg		0.1	18-APR-13
Arsenic (As)			<0.10		mg/kg		0.1	18-APR-13
Barium (Ba)			<1.0		mg/kg		1	18-APR-13
Beryllium (Be)			<0.50		mg/kg		0.5	18-APR-13
Bismuth (Bi)			<1.0		mg/kg		1	18-APR-13
Cadmium (Cd)			<0.10		mg/kg		0.1	18-APR-13
Calcium (Ca)			<100		mg/kg		100	18-APR-13
Chromium (Cr)			<0.50		mg/kg		0.5	18-APR-13
Cobalt (Co)			<1.0		mg/kg		1	18-APR-13
Copper (Cu)			<1.0		mg/kg		1	18-APR-13

Quality Control Report

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
MET-200.2-CCMS-SK	Soil							
Batch R2580951								
WG1655192-1 MB								
Iron (Fe)			<50		mg/kg		50	18-APR-13
Lead (Pb)			<1.0		mg/kg		1	18-APR-13
Lithium (Li)			<2.0		mg/kg		2	18-APR-13
Magnesium (Mg)			<100		mg/kg		100	18-APR-13
Manganese (Mn)			<1.0		mg/kg		1	18-APR-13
Molybdenum (Mo)			<1.0		mg/kg		1	18-APR-13
Nickel (Ni)			<1.0		mg/kg		1	18-APR-13
Phosphorus (P)			<50		mg/kg		50	18-APR-13
Potassium (K)			<100		mg/kg		100	18-APR-13
Selenium (Se)			<0.20		mg/kg		0.2	18-APR-13
Silver (Ag)			<0.20		mg/kg		0.2	18-APR-13
Sodium (Na)			<100		mg/kg		100	18-APR-13
Strontium (Sr)			<1.0		mg/kg		1	18-APR-13
Thallium (Tl)			<0.10		mg/kg		0.1	18-APR-13
Tin (Sn)			<2.0		mg/kg		2	18-APR-13
Titanium (Ti)			<5.0		mg/kg		5	18-APR-13
Uranium (U)			<0.10		mg/kg		0.1	18-APR-13
Vanadium (V)			<1.0		mg/kg		1	18-APR-13
Zinc (Zn)			<5.0		mg/kg		5	18-APR-13
N-TOTKJ-COL-SK	Soil							
Batch R2581290								
WG1656247-1 DUP		**L1288422-1**						
Total Kjeldahl Nitrogen		0.376	0.337		%	11	20	18-APR-13
WG1656247-2 IRM		**07-114_SOIL**						
Total Kjeldahl Nitrogen			94.6		%		70-130	18-APR-13
WG1656247-3 MB								
Total Kjeldahl Nitrogen			<0.020		%		0.02	18-APR-13
WG1656247-4 RB								
Total Kjeldahl Nitrogen			<0.020		%			18-APR-13
OM-LOI-SK	Soil							
Batch R2588829								
WG1660452-1 DUP		**L1288422-1**						
Organic Matter		34.5	34.1		%	1.2	20	25-APR-13
Loss on Ignition @ 375 C		43.9	43.4		%	1.2	25	25-APR-13
WG1660452-3 IRM		**FARM2009**						

Quality Control Report

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
OM-LOI-SK	Soil							
Batch R2588829								
WG1660452-3 IRM		**FARM2009**						
Organic Matter			4.3		%		3-5	25-APR-13
Loss on Ignition @ 375 C			5.1		%		4.2-6.2	25-APR-13
WG1660452-2 MB								
Organic Matter			<1.0		%		1	25-APR-13
Loss on Ignition @ 375 C			<1.0		%		1	25-APR-13
PO4-AVAIL-OLSEN-SK	Soil							
Batch R2587190								
WG1655117-2 IRM		**FARM2005**						
Available Phosphate-P			97.1		%		70-130	24-APR-13
WG1655117-1 MB								
Available Phosphate-P			<1.0		mg/kg		1	24-APR-13
SAR-CALC-SO4-SK	Soil							
Batch R2582232								
WG1656590-2 IRM		**ED-SAL_NAT1**						
Calcium (Ca)			119.9		%		70-130	19-APR-13
Potassium (K)			124.8		%		70-130	19-APR-13
Magnesium (Mg)			114.3		%		70-130	19-APR-13
Sodium (Na)			119.6		%		70-130	19-APR-13
Sulfur (as SO4)			112.0		%		70-130	19-APR-13
WG1656590-1 MB								
Calcium (Ca)			<2.0		mg/L		2	19-APR-13
Potassium (K)			<1.0		mg/L		1	19-APR-13
Magnesium (Mg)			<2.0		mg/L		2	19-APR-13
Sodium (Na)			<4.0		mg/L		4	19-APR-13
Sulfur (as SO4)			<5.0		mg/L		5	19-APR-13
SAT/PH/EC-SK	Soil							
Batch R2581771								
WG1656590-2 IRM		**ED-SAL_NAT1**						
% Saturation			38.0		%		38-48	19-APR-13
pH in Saturated Paste			6.83		pH		6.5-7.1	19-APR-13
Conductivity Sat. Paste			103.5		%		80-120	19-APR-13
WG1656590-1 MB								
Conductivity Sat. Paste			<0.10		dS m-1		0.1	19-APR-13
SO4-AVAIL-SK	Soil							

Quality Control Report

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
SO4-AVAIL-SK	Soil							
Batch R2580466								
WG1655115-2 IRM		**SAL814**						
Available Sulfate-S			110.6		%		70-130	17-APR-13
WG1655115-1 MB								
Available Sulfate-S			<3.0		mg/kg		3	17-APR-13
SPECGRAV-ED	Soil							
Batch R2578664								
WG1655042-2 DUP		**L1288422-1**						
Specific Gravity		1.00	1.00		kg/L	0.1	13	15-APR-13
WG1655042-1 IRM		**DI_H2O**						
Specific Gravity			99.0		%		94.7-104.7	15-APR-13
SOLIDS-TOT/TOTVOL-SK	Manure							
Batch R2581202								
WG1655758-1 DUP		**L1288422-1**						
Total Solids		14.4	13.5		%	6.6	25	18-APR-13
Total Volatile Solids (dry basis)		1960	1720		%	13	25	18-APR-13

Legend:

Limit	ALS Control Limit (Data Quality Objectives)
DUP	Duplicate
RPD	Relative Percent Difference
N/A	Not Available
LCS	Laboratory Control Sample
SRM	Standard Reference Material
MS	Matrix Spike
MSD	Matrix Spike Duplicate
ADE	Average Desorption Efficiency
MB	Method Blank
IRM	Internal Reference Material
CRM	Certified Reference Material
CCV	Continuing Calibration Verification
CVS	Calibration Verification Standard
LCSD	Laboratory Control Sample Duplicate

Sample Parameter Qualifier Definitions:

Qualifier	Description
RPD-NA	Relative Percent Difference Not Available due to result(s) being less than detection limit.

Hold Time Exceedances:

ALS Product Description	Sample ID	Sampling Date	Date Processed	Rec. HT	Actual HT	Units	Qualifier
Plant Available Nutrients							
Ammonia-N (1:5) - calc to 70C							
	1	10-APR-13 12:00	23-APR-13 14:01	7	13	days	EHT
Nitrate-N in biocompost - calc to 70C							
	1	10-APR-13 12:00	23-APR-13 15:20	7	13	days	EHT
Leachable Metals							
Available Boron, Hot Water							
	1	10-APR-13 12:00	18-APR-13	5	8	days	EHT

Legend & Qualifier Definitions:

EHTR-FM:	Exceeded ALS recommended hold time prior to sample receipt. Field Measurement recommended.
EHTR:	Exceeded ALS recommended hold time prior to sample receipt.
EHTL:	Exceeded ALS recommended hold time prior to analysis. Sample was received less than 24 hours prior to expiry.
EHT:	Exceeded ALS recommended hold time prior to analysis.
Rec. HT:	ALS recommended hold time (see units).

Notes*:
Where actual sampling date is not provided to ALS, the date (& time) of receipt is used for calculation purposes.
Where actual sampling time is not provided to ALS, the earlier of 12 noon on the sampling date or the time (& date) of receipt is used for calculation purposes. Samples for L1288422 were received on 11-APR-13 08:35.

ALS recommended hold times may vary by province. They are assigned to meet known provincial and/or federal government requirements. In the absence of regulatory hold times, ALS establishes recommendations based on guidelines published by the US EPA, APHA Standard Methods, or Environment Canada (where available). For more information, please contact ALS.

The ALS Quality Control Report is provided to ALS clients upon request. ALS includes comprehensive QC checks with every analysis to ensure our high standards of quality are met. Each QC result has a known or expected target value, which is compared against pre-determined data quality objectives to provide confidence in the accuracy of associated test results.

Please note that this report may contain QC results from anonymous Sample Duplicates and Matrix Spikes that do not originate from this Work Order.

STEINBACH LAGOON #1 L1288422-1

PRODUCT CODE	ANALYTE	RESULT (Dry)	RESULT (Wet)	QUALIFIER	UNITS	DL
SAR, Cations and SO4 in saturated soil	SAR	4.60			SAR	0.1
pH and EC (Saturated Paste)	% Saturation	856			%	1
pH and EC (Saturated Paste)	pH in Saturated Paste	6.87			pH	0.1
pH and EC (Saturated Paste)	Conductivity Sat. Paste	3.02			dS m-1	0.1
Detail Salinity in mg/kg	Chloride (Cl)	2540	345	DLA	mg/kg	86
Detail Salinity in mg/kg	Calcium (Ca)	1100	150	DLA	mg/kg	86
Detail Salinity in mg/kg	Magnesium (Mg)	710	96.6	DLA	mg/kg	86
Detail Salinity in mg/kg	Potassium (K)	242	32.9	DLA	mg/kg	43
Detail Salinity in mg/kg	Sodium (Na)	2330	317	DLA	mg/kg	170
Detail Salinity in mg/kg	Sulfur (as SO4)	1800	245	DLA	mg/kg	210
Available Boron, Hot Water	Boron (B), Hot Water Ext.	7.60	1.0		mg/kg	0.2
Available Phosphate-P by Olsen	Available Phosphate-P	76.8	10.4		mg/kg	1
Available Potassium	Available Potassium	451	61.3		mg/kg	20
Available Sulfate-S	Available Sulfate-S	923	126		mg/kg	3
Mercury on Soil by CVAFS	Mercury (Hg)	3.9	0.5		mg/kg	1
Metals in Soil by CRC ICPMS	Aluminum (Al)	11900	1618		mg/kg	50
Metals in Soil by CRC ICPMS	Antimony (Sb)	2.63	0.4		mg/kg	0.1
Metals in Soil by CRC ICPMS	Arsenic (As)	6.03	0.8		mg/kg	0.1
Metals in Soil by CRC ICPMS	Barium (Ba)	1240	168.6	DLA	mg/kg	10
Metals in Soil by CRC ICPMS	Beryllium (Be)	<0.50	<0.1		mg/kg	0.5
Metals in Soil by CRC ICPMS	Bismuth (Bi)	29.1	4.0		mg/kg	1
Metals in Soil by CRC ICPMS	Cadmium (Cd)	2.42	0.3		mg/kg	0.1
Metals in Soil by CRC ICPMS	Calcium (Ca)	45000	6120		mg/kg	100
Metals in Soil by CRC ICPMS	Chromium (Cr)	36.3	4.9		mg/kg	0.5
Metals in Soil by CRC ICPMS	Cobalt (Co)	4.8	0.7		mg/kg	1
Metals in Soil by CRC ICPMS	Copper (Cu)	1350	184	DLA	mg/kg	10
Metals in Soil by CRC ICPMS	Iron (Fe)	18100	2462		mg/kg	50
Metals in Soil by CRC ICPMS	Lead (Pb)	52.8	7.2		mg/kg	1
Metals in Soil by CRC ICPMS	Lithium (Li)	6.6	0.9		mg/kg	2
Metals in Soil by CRC ICPMS	Magnesium (Mg)	16000	2176		mg/kg	100
Metals in Soil by CRC ICPMS	Manganese (Mn)	158	21.5		mg/kg	1
Metals in Soil by CRC ICPMS	Molybdenum (Mo)	51.9	7.1		mg/kg	1
Metals in Soil by CRC ICPMS	Nickel (Ni)	19.7	2.7		mg/kg	1
Metals in Soil by CRC ICPMS	Phosphorus (P)	11000	1496		mg/kg	50
Metals in Soil by CRC ICPMS	Potassium (K)	1060	144		mg/kg	100
Metals in Soil by CRC ICPMS	Selenium (Se)	6.98	0.9		mg/kg	0.2

Metals in Soil by CRC ICPMS	Silver (Ag)	31.3	4.3		mg/kg	0.2
Metals in Soil by CRC ICPMS	Sodium (Na)	2200	299		mg/kg	100
Metals in Soil by CRC ICPMS	Strontium (Sr)	208	28.3		mg/kg	1
Metals in Soil by CRC ICPMS	Thallium (Tl)	0.18	0.0		mg/kg	0.1
Metals in Soil by CRC ICPMS	Tin (Sn)	25.9	3.5		mg/kg	2
Metals in Soil by CRC ICPMS	Titanium (Ti)	28.3	3.8		mg/kg	5
Metals in Soil by CRC ICPMS	Uranium (U)	16.9	2.3		mg/kg	0.1
Metals in Soil by CRC ICPMS	Vanadium (V)	17.4	2.4		mg/kg	1
Metals in Soil by CRC ICPMS	Zinc (Zn)	913	124	DLA	mg/kg	50
Total Carbon by combustion method	Total Carbon by Combustion	27.2	3.7		%	0.1
Total Kjeldahl Nitrogen	Total Kjeldahl Nitrogen	2.76	0.376		%	0.02
Nitrate-N in biocompost - calc to 70C	Nitrate-N	<20	<3		mg/kg	20
Ammonia-N (1:5) - calc to 70C	Ammonium (as N)	876	119		mg/kg	1
Total Solids and Moisture at 70C	Moisture	86.4			%	0.1
Total Solids and Moisture at 70C	Total Solids	13.6			%	0.1
Total Solids and Total Volatile Solids	Total Solids	14.4			%	0.1
Total Solids and Total Volatile Solids	Total Volatile Solids (dry basis)	1960			%	0.1
Specific Gravity	Specific Gravity	1.00			kg/L	0.01

ALS Environment

L1288422-COFC

Custody / Analytical Request Form
ada Toll Free: 1 800 668 9878
www.alsglobal.com

L1288422

COC # _____

Page 1 of 2

Report To				**t / Distribution**				**Service Requested** (Rush for routine analysis subject to availability)
Company:	MMM Group Limited			☑ Standard	☐ Other			◉ Regular (Standard Turnaround Times - Business Days)
Contact:	Darren Keam			☑ PDF	☑ Excel	☐ Digital	☐ Fax	○ Priority (2-4 Business Days) - 50% Surcharge - Contact ALS to Confirm TAT
Address:	111-93 Lombard Avenue			Email 1:	kearnd@mmm.ca			○ Emergency (1-2 Bus. Days) - 100% Surcharge - Contact ALS to Confirm TAT
	Winnipeg, MB R3B 3B1			Email 2:	YestrauL@mmm.ca			○ Same Day or Weekend Emergency - Contact ALS to Confirm TAT
Phone:	204-923-3178	Fax:	204-943-4948	Email 3:				
Invoice To	Same as Report ?	☑ Yes	☐ No	**Client / Project Information**				**Analysis Request**
Hardcopy of Invoice with Report?		☐ Yes	☑ No	Job #:	5513035			Please indicate below Filtered, Preserved or both (F, P, F/P)
Company:				PO / AFE:	5513035			
Contact:				LSD:				
Address:								
Phone:		Fax:		Quote #:	Q37455			
[redacted] Lab Work Order # (lab use only)	[redacted]			**ALS Contact:**		**Sampler:**	LY	

[redacted] Sample #	Sample Identification (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	Total Kjeldahl Nitrogen	Nitrate-N	Nitrite-N	Available Ammonium-N	total available nitrogen	total phosphorous	phosphate-p by olsen	total solids, total volatile solid	moisture	total carbon	available potassium	available sulfate-s	Number of Containers
[redacted]	Steinbach Lagoon #1	April 10/13	12:00pm	Grab	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	5
[redacted]																	
[redacted]																	
[redacted]																	
[redacted]																	
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[redacted]																	

Special Instructions / Regulations with water or land use (CCME-Freshwater Aquatic Life/BC CSR - Commercial/AB Tier 1 - Natural, etc) / Hazardous Details

*Lagoon biosolids.

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY.
By the use of this form the user acknowledges and agrees with the Terms and Conditions as provided on a separate Excel tab.
Also provided on another Excel tab are the ALS location addresses, phone numbers and sample container / preservation / holding time table for common analyses.

[redacted] SHIPMENT RELEASE (client use)			[redacted] SHIPMENT RECEPTION (lab use only)				[redacted] SHIPMENT VERIFICATION (lab use only)			
Released by:	Date (dd-mmm-yy)	Time (hh-mm)	Received by:	Date:	Time:	Temperature:	Verified by:	Date:	Time:	Observations: Yes / No ? If Yes add SIF
D Keam	11/04/13	830am	SA	Apr 11/13	8:35AM	1.1 °C				

GENF 18.01 Front

ALS Environment

L1288422-COFC

Custody / Analytical Request Form
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COC #

Page 2 of 2

Report To		/ Distribution		Service Requested (Rush for routine analysis subject to availability)
Company:	MMM Group Limited	☐ Other		◉ Regular (Standard Turnaround Times - Business Days)
Contact:	Darren Keam	☑ PDF ☑ Excel ☐ Digital ☐ Fax		○ Priority (2-4 Business Days) - 50% Surcharge - Contact ALS to Confirm TAT
Address:	111-93 Lombard Avenue	Email 1: keamd@mmm.ca		○ Emergency (1-2 Bus. Days) - 100% Surcharge - Contact ALS to Confirm TAT
	Winnipeg, MB R3B 3B1	Email 2: YestrauL@mmm.ca		○ Same Day or Weekend Emergency - Contact ALS to Confirm TAT
Phone:	204-923-3178 Fax: 204-943-4948	Email 3:		
Invoice To	Same as Report ? ☑ Yes ☐ No	Client / Project Information		Analysis Request
Hardcopy of Invoice with Report?	☐ Yes ☑ No	Job #: 5513035		Please indicate below Filtered, Preserved or both (F, P, F/P)
Company:		PO / AFE: 5513035		
Contact:		LSD:		
Address:				
Phone:	Fax:	Quote #: Q37455		
Lab Work Order # (lab use only)		ALS Contact:	Sampler: LY	

Sample #	Sample Identification (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	Boron-hotwater	mercury	CCME Metals	Detailed Salinity	pH	Special Request 1	2 Rush						Number of Containers
	Steinbach lagoon #1	10/04/13	12pm.	Grab	✓	✓	✓	✓	✓	✓	✓						5

Special Instructions / Regulations with water or land use (CCME-Freshwater Aquatic Life/BC CSR - Commercial/AB Tier 1 - Natural, etc) / Hazardous Details

lagoon biosolids.

Special Request 1 -SK-Analyze samples on As Received Basis. Report dry basis and as received results. Density - if possible?

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY.

By the use of this form the user acknowledges and agrees with the Terms and Conditions as provided on a separate Excel tab.

Also provided on another Excel tab are the ALS location addresses, phone numbers and sample container / preservation / holding time table for common analyses.

SHIPMENT RELEASE (client use)			SHIPMENT RECEPTION (lab use only)				SHIPMENT VERIFICATION (lab use only)			
Released by:	Date (dd-mmm-yy)	Time (hh-mm)	Received by:	Date:	Time:	Temperature:	Verified by:	Date:	Time:	Observations: Yes / No ? If Yes add SIF
Dkeam.	10/04/13	830am.	SA	Apr 11/13	8:35AM	1.1 °C				

GENF 18.01 Front

MMM Group Ltd.
ATTN: BRIAN MOONS
111-93 Lombard Ave
Winnipeg MB R3B 3B1

Date Received: 22-JUL-15
Report Date: 11-AUG-15 09:40 (MT)
Version: FINAL

Client Phone: 204-803-9488

Certificate of Analysis

Lab Work Order #: L1646440
Project P.O. #: STEINBACH BIOSOLIDS
Job Reference:
C of C Numbers:
Legal Site Desc:

Judy Dalmaijer
Account Manager

ALS ENVIRONMENTAL ANALYTICAL REPORT

Sample Details/Parameters	Result	MU	Qualifier*	D.L.	Units	Bias	Extracted	Analyzed	Batch
L1646440-1 CELL 2									
Sampled By: CLIENT on 22-JUL-15 @ 11:00									
Matrix: sludge									
Miscellaneous Parameters									
Boron (B), Hot Water Ext.	8.9	+/-1.6	DLM	2.6	mg/kg	0	28-JUL-15	28-JUL-15	R3234247
Note: Sample was analyzed on as received sample - reported on dry matter									
Available Phosphate-P	135	-		1.0	mg/kg	-	28-JUL-15	28-JUL-15	R3234717
Note: Done as Rec'd, back calc to dry									
Available Potassium	397	+/-50		30	mg/kg	-11.8%	27-JUL-15	27-JUL-15	R3235034
Note: Done as Rec'd, Back Calculated to Dry									
Available Sulfate-S	137	+/-25	DLM	39	mg/kg	0	28-JUL-15	28-JUL-15	R3234988
Note: Sample was analyzed on as received sample - reported on dry matter									
Mercury (Hg)	1.19	-	DLA	0.20	mg/kg	-	27-JUL-15	28-JUL-15	R3234750
% Moisture	89.8	+/-10		0.10	%	0	28-JUL-15	28-JUL-15	R3233737
% Saturation	Oversat	-		1.0	%	-	28-JUL-15	28-JUL-15	R3233966
Special Request	See Attached	-				-		07-AUG-15	R3242184
Specific Gravity	1.03	-		0.010	kg/L	-		31-JUL-15	R3236644
Total Carbon by Combustion	2.0	+/-0.2		0.1	%	0	27-JUL-15	27-JUL-15	R3234100
Note: Sample analyzed on as received, sample reported on as received.									
Total Kjeldahl Nitrogen	0.116	+/-0.023		0.020	%	0	28-JUL-15	29-JUL-15	R3234952
Note: Sample Ran As Rec'd, Results Back Calculated As Dry									
Organic Matter by LOI at 375 deg C.									
Organic Matter	17.0	+/-3.1		1.0	%	0	28-JUL-15	28-JUL-15	R3234721
Loss on Ignition @ 375 C	21.4	+/-3.6		1.0	%	0	28-JUL-15	28-JUL-15	R3234721
Total Solids and Total Volatile Solids									
Total Solids	8.80	-		0.10	%	-	29-JUL-15	29-JUL-15	R3235013
Total Volatile Solids (dry basis)	29.7	-		0.10	%	-	29-JUL-15	29-JUL-15	R3235013
pH and EC (1:2 Soil:Water Extraction)									
Conductivity (1:2)	4.05	-		0.050	dS m-1	-	07-AUG-15	07-AUG-15	R3234180
pH (1:2 soil:water)	7.59	-		0.10	pH	-	07-AUG-15	07-AUG-15	R3234180
Detailed Salinity in dry-weight mg/kg									
Chloride (Cl)	2340	-		35	mg/kg dwt	-		28-JUL-15	
Calcium (Ca)	859	-		35	mg/kg dwt	-		28-JUL-15	
Magnesium (Mg)	633	-		35	mg/kg dwt	-		28-JUL-15	
Potassium (K)	149	-		18	mg/kg dwt	-		28-JUL-15	
Sodium (Na)	1900	-		70	mg/kg dwt	-		28-JUL-15	
Sulfur (as SO4)	157	-		88	mg/kg dwt	-		28-JUL-15	
Detailed Salinity in wet-weight mg/kg									
Chloride (Cl)	239	-		3.6	mg/kg wwt	-		28-JUL-15	
Calcium (Ca)	87.6	-		3.6	mg/kg wwt	-		28-JUL-15	
Magnesium (Mg)	64.6	-		3.6	mg/kg wwt	-		28-JUL-15	
Potassium (K)	15.2	-		1.8	mg/kg wwt	-		28-JUL-15	
Sodium (Na)	194	-		7.2	mg/kg wwt	-		28-JUL-15	
Sulfur (as SO4)	16.0	-		9.0	mg/kg wwt	-		28-JUL-15	
Metals									
Aluminum (Al)	9680	+/-2400		5.0	mg/kg	0	27-JUL-15	27-JUL-15	R3233554
Antimony (Sb)	1.34	+/-0.30		0.10	mg/kg	0	27-JUL-15	27-JUL-15	R3233554
Arsenic (As)	3.93	+/-0.50		0.10	mg/kg	0	27-JUL-15	27-JUL-15	R3233554
Barium (Ba)	683	+/-190		0.50	mg/kg	0	27-JUL-15	27-JUL-15	R3233554
Beryllium (Be)	0.28	+/-0.09		0.10	mg/kg	0	27-JUL-15	27-JUL-15	R3233554
Bismuth (Bi)	11.4	+/-2.2		0.020	mg/kg	0	27-JUL-15	27-JUL-15	R3233554
Boron (B)	16	+/-5		10	mg/kg	0	27-JUL-15	27-JUL-15	R3233554

ALS ENVIRONMENTAL ANALYTICAL REPORT

Sample Details/Parameters	Result	MU	Qualifier*	D.L.	Units	Bias	Extracted	Analyzed	Batch
L1646440-1 CELL 2									
Sampled By: CLIENT on 22-JUL-15 @ 11:00									
Matrix: sludge									
Metals									
Cadmium (Cd)	1.21	+/-0.22		0.020	mg/kg	0	27-JUL-15	27-JUL-15	R3233554
Calcium (Ca)	77300	+/-14000		100	mg/kg	0	27-JUL-15	27-JUL-15	R3233554
Chromium (Cr)	26.4	+/-4.8		1.0	mg/kg	0	27-JUL-15	27-JUL-15	R3233554
Cobalt (Co)	4.52	+/-0.63		0.020	mg/kg	0	27-JUL-15	27-JUL-15	R3233554
Copper (Cu)	694	+/-100		1.0	mg/kg	0	27-JUL-15	27-JUL-15	R3233554
Iron (Fe)	16700	+/-2100		25	mg/kg	0	27-JUL-15	27-JUL-15	R3233554
Lead (Pb)	17.2	+/-3.4		0.20	mg/kg	0	27-JUL-15	27-JUL-15	R3233554
Magnesium (Mg)	34900	+/-6600		10	mg/kg	0	27-JUL-15	27-JUL-15	R3233554
Manganese (Mn)	189	+/-32		0.50	mg/kg	0	27-JUL-15	27-JUL-15	R3233554
Molybdenum (Mo)	17.9	+/-3.2		0.020	mg/kg	0	27-JUL-15	27-JUL-15	R3233554
Nickel (Ni)	15.4	+/-1.9		0.50	mg/kg	0	27-JUL-15	27-JUL-15	R3233554
Phosphorus (P)	4610	+/-800		100	mg/kg	0	27-JUL-15	27-JUL-15	R3233554
Potassium (K)	1590	+/-340		25	mg/kg	0	27-JUL-15	27-JUL-15	R3233554
Selenium (Se)	3.42	+/-0.61		0.50	mg/kg	0	27-JUL-15	27-JUL-15	R3233554
Silver (Ag)	9.69	+/-2.2		0.10	mg/kg	0	27-JUL-15	27-JUL-15	R3233554
Sodium (Na)	1440	+/-260		10	mg/kg	0	27-JUL-15	27-JUL-15	R3233554
Strontium (Sr)	113	+/-22		0.10	mg/kg	0	27-JUL-15	27-JUL-15	R3233554
Thallium (Tl)	0.12	+/-0.05		0.10	mg/kg	0	27-JUL-15	27-JUL-15	R3233554
Tin (Sn)	12.9	+/-2.5		5.0	mg/kg	0	27-JUL-15	27-JUL-15	R3233554
Titanium (Ti)	57.9	+/-11		0.50	mg/kg	0	27-JUL-15	27-JUL-15	R3233554
Uranium (U)	8.47	+/-1.7		0.020	mg/kg	0	27-JUL-15	27-JUL-15	R3233554
Vanadium (V)	24.0	+/-5.4		0.50	mg/kg	0	27-JUL-15	27-JUL-15	R3233554
Zinc (Zn)	422	+/-53		10	mg/kg	0	27-JUL-15	27-JUL-15	R3233554
Total Available N & NO3-N, NO2-N & NH4									
Available Ammonium-N									
Available Ammonium-N	397	+/-56	DLM	44	mg/kg	0	28-JUL-15	28-JUL-15	R3234532
Note: Done as rec'd, back caclulated to dry									
Available Ammonium-N - Calculation									
Total Available Nitrogen	397	-		48	mg/kg	-		29-JUL-15	
Nitrate, Nitrite & Nitrate+Nitrite-N(KCL									
Nitrite-N	<4.0	-	DLM	4.0	mg/kg	-	28-JUL-15	28-JUL-15	R3233911
Nitrate+Nitrite-N	<20	-	DLM	20	mg/kg	-	28-JUL-15	28-JUL-15	R3233911
Nitrate-N	<20	-	DLM	20	mg/kg	-	28-JUL-15	28-JUL-15	R3233911
Detailed Salinity -over sat'd waste									
Chloride (Cl)									
Chloride (Cl)	266	-	DLA	4.0	mg/L	-	28-JUL-15	28-JUL-15	R3233833
SAR and Cations (over sat'd)									
Calcium (Ca)	97.6	-	DLA	4.0	mg/L	-	28-JUL-15	28-JUL-15	R3233954
Potassium (K)	16.9	-	DLA	2.0	mg/L	-	28-JUL-15	28-JUL-15	R3233954
Magnesium (Mg)	71.9	-	DLA	4.0	mg/L	-	28-JUL-15	28-JUL-15	R3233954
Sodium (Na)	216	-	DLA	8.0	mg/L	-	28-JUL-15	28-JUL-15	R3233954
Sulfur (as SO4)	18	-	DLA	10	mg/L	-	28-JUL-15	28-JUL-15	R3233954
SAR	4.04	-		0.10	SAR	-	28-JUL-15	28-JUL-15	R3233954
pH and Conductivity									
pH	7.24	-		0.10	pH	-	28-JUL-15	28-JUL-15	R3233966
Conductivity (EC)	2.28	-		0.010	dS m-1	-	28-JUL-15	28-JUL-15	R3233966

* Refer to Referenced Information for Qualifiers (if any) and Methodology.

Reference Information

QC Samples with Qualifiers & Comments:

QC Type Description	Parameter	Qualifier	Applies to Sample Number(s)
Method Blank	Conductivity (EC)	B	
Duplicate	Total Kjeldahl Nitrogen	DLA	

Sample Parameter Qualifier Key:

Qualifier	Description
B	Method Blank exceeds ALS DQO. All associated sample results are at least 5 times greater than blank levels and are considered reliable.
DLA	Detection Limit adjusted for required dilution
DLM	Detection Limit Adjusted due to sample matrix effects.

Test Method References:

ALS Test Code	Matrix	Test Description	Preparation Method Reference	Method Reference**
B-HOTW-SK	Soil	Available Boron, Hot Water		SSSA (1996) P. 610-611
Hot water is used to extract the plant-available and potentially plant-available boron from soil. Boron in the extract is determined by ICP-OES.				
C-TOT-LECO-SK	Soil	Total Carbon by combustion method		SSSA (1996) P. 973-974
The sample is ignited in a combustion analyzer where carbon in the reduced CO2 gas is determined using a thermal conductivity detector.				
CL-COL-SK	Waste	Chloride (Cl)		APHA 4110B
ETL-N-TOT-AVAIL-SK	Soil	Available Ammonium-N - Calculation		Soil Methods of Analysis (1993) CSSS
HG-200.2-CVAF-WP	Soil	Mercury in Soil by CVAFS		EPA 200.2/1631E (mod)
Soil samples are digested with nitric and hydrochloric acids, followed by analysis by CVAFS.				
K-AVAIL-SK	Soil	Available Potassium		Comm. Soil Sci. Plant, 25 (5&6)
Plant available potassium is extracted from the soil using Modified Kelowna solution. Potassium in the soil extract is determined by flame emission at 770 nm.				
MET-200.2-MS-WP	Soil	Metals		EPA 200.2/6020A
Samples for analysis are homogenized, dried at 60 degrees Celsius, sieved through a 2 mm (10 mesh) sieve, and a representative subsample of the dry material is weighed. The sample is then digested by block digester (EPA 200.2). Instrumental analysis is by inductively coupled plasma - mass spectrometry (EPA Method 6020A). Method Limitation: This method is not a total digestion technique. It is a very strong acid digestion that is intended to dissolve those metals that may become "environmentally available." By design, elements bound in silicate structures are not normally dissolved by this procedure as they are not usually mobile in the environment.				
MOIST-SK	Soil	Moisture Content		ASTM D2216-80
The weighed portion of soil is placed in a 105 C oven overnight. The dried soil is allowed to cooled to room temperature, weighed and the % moisture is calculated. Reference: ASTM D2216-80				
N-TOTKJ-COL-SK	Soil	Total Kjeldahl Nitrogen		CSSS (1993) 22.2.3
The soil is digested with sulfuric acid in the presence of CuSO4 and K2SO4 catalysts. Ammonia in the soil extract is determined colrimetrically at 660 nm.				
N2/N3-AVAIL-KCL-SK	Soil	Nitrate, Nitrite & Nitrate+Nitrite-N(KCL		CSSS (1993) p. 26-28
Plant available nitrate and nitrite are extracted from the sample with 2N KCl. Nitrate and Nitrite in the filtered extract are determined colorimetrically by Technicon auto-analyzer or flow injection analyzer at 520 nm.				
NH4-AVAIL-SK	Soil	Available Ammonium-N		CSSS(1993) 4.2/COMM SOIL SCI 19(6)
Ammonium (NH4-N) is extracted from the soil using 2 N KCl. Ammonium in the extract is mixed with hypochlorite and salicylate to form indophenol blue, which is determined colorimetrically by auto analysis at 660 nm.				
OM-LOI-SK	Soil	Organic Matter by LOI at 375 deg C.		CSSS (1978) p. 160

Reference Information

Test Method References:

ALS Test Code	Matrix	Test Description	Preparation Method Reference	Method Reference**

The dry-ash method involves the removal of organic matter by combustion at 375 degrees C for a minimum of 16 hours. Samples are dried prior to combustion.

Reference: McKeague, J.A. Soil Sampling and Methods of Analysis. Can. Soc. Soil Sci.(1978) method 4.23

PH,EC-1:2-SK	Soil	pH and EC (1:2 Soil:Water Extraction)	CSSC 3.13/CSSS 18.3.1

1 part dry soil and 2 parts de-ionized water (by volume) is mixed. The slurry is allowed to stand with occasional stirring for 30 - 60 minutes. After equilibration, pH of the slurry is measured using a pH meter. Conductivity of the filtered extract is measured by a conductivity meter.

PH/EC-SK	Waste	pH and Conductivity	APHA 4500-H,2510
PO4-AVAIL-OLSEN-SK	Soil	Available Phosphate-P by Olsen	CSSS (1993) 7.2,7.3.1

Plant available phosphorus is extracted from the sample with sodium bicarbonate. PO4-P in the filtered extract is determined colorimetrically at 880 nm.

SAL-D50-DRYCALC-SK	Waste	Detailed Salinity in dry-weight mg/kg	Calculation

Conversion of Saturation Extract soluble ions from units of mg/L to dry-weight mg/kg.
For over-saturated wastes:
mg/kg dwt = mg/L * % Moisture / (100% - % Moisture)
For under-saturated wastes:
mg/kg dwt = mg/L * (% Saturation / 100%)

SAL-D50-WETCALC-SK	Waste	Detailed Salinity in wet-weight mg/kg	Calculation

Conversion of Saturation Extract soluble ions from units of mg/L to wet-weight mg/kg.
For over-saturated wastes:
mg/kg wwt = mg/L * % Moisture / 100%
For under-saturated wastes:
mg/kg wwt = mg/L * (% Saturation / 100%) * (100% - % Moisture) / 100%

SALINITY-INTCHECK-SK	Soil		CSSS 18.4-Calculation
SAR-CALC-SK	Waste	SAR and Cations (over sat'd)	APHA 3120B
SAT-PCNT-SK	Soil	Saturated Paste	CSSS (1993) 18.2.2
SO4-AVAIL-SK	Soil	Available Sulfate-S	REC METH SOIL ANAL - AB. AG(1988)

Plant available sulfate in the soil is extracted using a weak calcium chloride solution. Sulfate in the extract is determined by ICP-OES.

SOLIDS-TOT/TOTVOL-SK	Manure	Total Solids and Total Volatile Solids	APHA 2540G

A well-mixed sample is evaporated in a weighed dish and dried to constant weight in an oven at 103-105"C. The increase in weight over that of the empty dish represents the Total Solids. The crucible is then ignited at 550"–10"C for 1 hour. The remaining solids represent the Total Fixed Solids, while the weight lost on ignition represents the Total Volatile Solids.

SPECGRAV-CL	Soil	Specific Gravity	ASTM D 5057 - 90

A portion of sample is weighed in a container that is calibrated for volume. Specific Gravity is reported as the mass of sample per mass of an equal volume of pure water, where the density of pure water is taken to be 1.00 g/mL.

SPECIAL REQUEST-SK	Misc.	Special Request Sask Lab	SEE SUBLET LAB RESULTS

** The indicated Method Reference is the closest nationally or internationally recognized reference for the applicable ALS test method. ALS methods may incorporate modifications from the specified reference to improve performance.

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	Laboratory Location
SK	ALS ENVIRONMENTAL - SASKATOON, SASKATCHEWAN, CANADA
WP	ALS ENVIRONMENTAL - WINNIPEG, MANITOBA, CANADA
CL	ALS ENVIRONMENTAL - CALGARY, ALBERTA, CANADA

Chain of Custody Numbers:

Reference Information

GLOSSARY OF REPORT TERMS

Surr - Surrogates are compounds that are similar in behaviour to target analyte(s), but that do not normally occur in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery. In reports that display the D.L. column, laboratory objectives for surrogates are listed there.
mg/kg - milligrams per kilogram based on dry weight of sample
mg/kg wwt - milligrams per kilogram based on wet weight of sample
mg/kg lwt - milligrams per kilogram based on lipid-adjusted weight
mg/L - unit of concentration based on volume, parts per million.
< - Less than.
D.L. - The reporting limit.
N/A - Result not available. Refer to qualifier code and definition for explanation.
MU: Measurement Uncertainty. The reported uncertainty is an expanded uncertainty calculated using a coverage factor of 2 which gives a level of confidence of approximately 95%.
Bias: The reported method bias is the average long term deviation from the target value for a long term reference or control sample, measured in percent. Zero values indicate no detectable method bias.

Test results reported relate only to the samples as received by the laboratory.
UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.
Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.

Quality Control Report

Workorder: L1646440 Report Date: 11-AUG-15

Client: MMM Group Ltd.
111-93 Lombard Ave
Winnipeg MB R3B 3B1
Contact: BRIAN MOONS

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
B-HOTW-SK	Soil							
Batch R3234247								
WG2136173-1 DUP		**L1647598-2**						
Boron (B), Hot Water Ext.		1.40	1.47		mg/kg	5.1	30	28-JUL-15
WG2136173-3 IRM		**SAL814**						
Boron (B), Hot Water Ext.			105.3		%		70-130	28-JUL-15
WG2136173-2 MB								
Boron (B), Hot Water Ext.			<0.20		mg/kg		0.2	28-JUL-15
C-TOT-LECO-SK	Soil							
Batch R3234100								
WG2136651-2 DUP		**L1647562-2**						
Total Carbon by Combustion		1.6	1.6		%	2.7	20	27-JUL-15
WG2136651-3 IRM		**08-109_SOIL**						
Total Carbon by Combustion			102.6		%		80-120	27-JUL-15
WG2136651-5 MB								
Total Carbon by Combustion			<0.1		%		0.1	27-JUL-15
HG-200.2-CVAF-WP	Soil							
Batch R3234750								
WG2138700-3 CRM		**CANMET TILL-1**						
Mercury (Hg)			0.102		mg/kg		0.048-0.148	28-JUL-15
WG2138700-4 CRM		**PACS-3**						
Mercury (Hg)			105.0		%		70-130	28-JUL-15
WG2138700-5 DUP		**L1645935-1**						
Mercury (Hg)		0.081	0.080		mg/kg	0.7	40	28-JUL-15
WG2138700-2 LCS								
Mercury (Hg)			100.9		%		80-120	28-JUL-15
WG2138700-1 MB								
Mercury (Hg)			<0.050		mg/kg		0.05	28-JUL-15
K-AVAIL-SK	Soil							
Batch R3235034								
WG2137421-2 IRM		**FARM2005**						
Available Potassium			92.6		%		70-130	27-JUL-15
WG2137421-1 MB								
Available Potassium			<20		mg/kg		20	27-JUL-15
MET-200.2-MS-WP	Soil							
Batch R3233554								
WG2137408-3 CRM		**CANMET TILL-1**						
Aluminum (Al)			105.6		%		70-130	27-JUL-15
Antimony (Sb)			106.8		%		70-130	27-JUL-15

Quality Control Report

Client: MMM Group Ltd.
111-93 Lombard Ave
Winnipeg MB R3B 3B1
Contact: BRIAN MOONS

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
MET-200.2-MS-WP	Soil							
Batch R3233554								
WG2137408-3 CRM		**CANMET TILL-1**						
Arsenic (As)			112.4		%		70-130	27-JUL-15
Barium (Ba)			100.6		%		70-130	27-JUL-15
Beryllium (Be)			101.3		%		70-130	27-JUL-15
Bismuth (Bi)			101.0		%		70-130	27-JUL-15
Cadmium (Cd)			103.8		%		70-130	27-JUL-15
Calcium (Ca)			108.0		%		70-130	27-JUL-15
Chromium (Cr)			110.3		%		70-130	27-JUL-15
Cobalt (Co)			108.3		%		70-130	27-JUL-15
Copper (Cu)			103.4		%		70-130	27-JUL-15
Iron (Fe)			104.2		%		70-130	27-JUL-15
Lead (Pb)			94.2		%		70-130	27-JUL-15
Magnesium (Mg)			113.6		%		70-130	27-JUL-15
Manganese (Mn)			109.0		%		70-130	27-JUL-15
Molybdenum (Mo)			95.6		%		70-130	27-JUL-15
Nickel (Ni)			107.0		%		70-130	27-JUL-15
Phosphorus (P)			108.4		%		70-130	27-JUL-15
Potassium (K)			116.2		%		70-130	27-JUL-15
Selenium (Se)			105.0		%		70-130	27-JUL-15
Silver (Ag)			121.0		%		70-130	27-JUL-15
Sodium (Na)			113.6		%		70-130	27-JUL-15
Strontium (Sr)			109.5		%		70-130	27-JUL-15
Thallium (Tl)			0.15		mg/kg		0.03-0.23	27-JUL-15
Tin (Sn)			93.1		%		70-130	27-JUL-15
Titanium (Ti)			108.0		%		70-130	27-JUL-15
Uranium (U)			110.5		%		70-130	27-JUL-15
Vanadium (V)			112.5		%		70-130	27-JUL-15
Zinc (Zn)			102.1		%		70-130	27-JUL-15
WG2137408-4 CRM		**PACS-3**						
Aluminum (Al)			113.9		%		70-130	27-JUL-15
Antimony (Sb)			108.7		%		70-130	27-JUL-15
Arsenic (As)			105.8		%		70-130	27-JUL-15
Barium (Ba)			99.0		%		70-130	27-JUL-15
Beryllium (Be)			109.1		%		70-130	27-JUL-15
Boron (B)			99.7		%		70-130	27-JUL-15

Quality Control Report

Client: MMM Group Ltd.
111-93 Lombard Ave
Winnipeg MB R3B 3B1
Contact: BRIAN MOONS

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
MET-200.2-MS-WP	Soil							
Batch R3233554								
WG2137408-4 CRM		**PACS-3**						
Cadmium (Cd)			103.6		%		70-130	27-JUL-15
Calcium (Ca)			105.2		%		70-130	27-JUL-15
Chromium (Cr)			108.2		%		70-130	27-JUL-15
Cobalt (Co)			106.6		%		70-130	27-JUL-15
Copper (Cu)			110.2		%		70-130	27-JUL-15
Iron (Fe)			106.0		%		70-130	27-JUL-15
Lead (Pb)			97.9		%		70-130	27-JUL-15
Magnesium (Mg)			125.2		%		70-130	27-JUL-15
Manganese (Mn)			105.2		%		70-130	27-JUL-15
Molybdenum (Mo)			95.6		%		70-130	27-JUL-15
Nickel (Ni)			109.4		%		70-130	27-JUL-15
Phosphorus (P)			111.4		%		70-130	27-JUL-15
Potassium (K)			110.0		%		70-130	27-JUL-15
Selenium (Se)			1.00		mg/kg		0.51-1.51	27-JUL-15
Silver (Ag)			103.8		%		70-130	27-JUL-15
Sodium (Na)			114.5		%		70-130	27-JUL-15
Strontium (Sr)			92.7		%		70-130	27-JUL-15
Thallium (Tl)			0.39		mg/kg		0.23-0.43	27-JUL-15
Tin (Sn)			98.3		%		70-130	27-JUL-15
Titanium (Ti)			111.8		%		70-130	27-JUL-15
Uranium (U)			101.5		%		70-130	27-JUL-15
Vanadium (V)			113.1		%		70-130	27-JUL-15
Zinc (Zn)			103.3		%		70-130	27-JUL-15
WG2137408-5 CRM		**OGGEO08**						
Aluminum (Al)			110.7		%		70-130	27-JUL-15
Antimony (Sb)			105.6		%		70-130	27-JUL-15
Arsenic (As)			110.1		%		70-130	27-JUL-15
Barium (Ba)			88.5		%		70-130	27-JUL-15
Beryllium (Be)			117.8		%		70-130	27-JUL-15
Bismuth (Bi)			101.1		%		70-130	27-JUL-15
Cadmium (Cd)			93.3		%		70-130	27-JUL-15
Calcium (Ca)			96.7		%		70-130	27-JUL-15
Chromium (Cr)			102.4		%		70-130	27-JUL-15
Cobalt (Co)			96.6		%		70-130	27-JUL-15

Client: MMM Group Ltd.
111-93 Lombard Ave
Winnipeg MB R3B 3B1
Contact: BRIAN MOONS

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
MET-200.2-MS-WP	Soil							
Batch R3233554								
WG2137408-5 CRM		**OGGEO08**						
Copper (Cu)			98.3		%		70-130	27-JUL-15
Iron (Fe)			106.5		%		70-130	27-JUL-15
Lead (Pb)			89.7		%		70-130	27-JUL-15
Magnesium (Mg)			109.8		%		70-130	27-JUL-15
Manganese (Mn)			100.1		%		70-130	27-JUL-15
Molybdenum (Mo)			100.9		%		70-130	27-JUL-15
Nickel (Ni)			105.0		%		70-130	27-JUL-15
Phosphorus (P)			95.9		%		70-130	27-JUL-15
Potassium (K)			109.2		%		70-130	27-JUL-15
Selenium (Se)			97.9		%		70-130	27-JUL-15
Silver (Ag)			98.1		%		70-130	27-JUL-15
Sodium (Na)			122.4		%		70-130	27-JUL-15
Strontium (Sr)			99.3		%		70-130	27-JUL-15
Thallium (Tl)			98.3		%		70-130	27-JUL-15
Tin (Sn)			94.7		%		70-130	27-JUL-15
Titanium (Ti)			102.2		%		70-130	27-JUL-15
Uranium (U)			93.6		%		70-130	27-JUL-15
Vanadium (V)			102.6		%		70-130	27-JUL-15
Zinc (Zn)			100.8		%		70-130	27-JUL-15
WG2137408-7 DUP		**WG2137408-6**						
Aluminum (Al)		20000	18300		mg/kg	8.7	40	27-JUL-15
Antimony (Sb)		0.34	0.36		mg/kg	4.8	30	27-JUL-15
Arsenic (As)		10.8	9.76		mg/kg	9.8	30	27-JUL-15
Barium (Ba)		179	155		mg/kg	15	40	27-JUL-15
Beryllium (Be)		0.69	0.67		mg/kg	2.9	30	27-JUL-15
Bismuth (Bi)		0.274	0.270		mg/kg	1.3	30	27-JUL-15
Boron (B)		11	11		mg/kg	0.8	30	27-JUL-15
Cadmium (Cd)		0.405	0.417		mg/kg	2.8	30	27-JUL-15
Calcium (Ca)		7160	6940		mg/kg	3.2	30	27-JUL-15
Chromium (Cr)		45.6	41.3		mg/kg	9.8	30	27-JUL-15
Cobalt (Co)		15.9	14.6		mg/kg	8.1	30	27-JUL-15
Copper (Cu)		32.8	29.5		mg/kg	11	30	27-JUL-15
Iron (Fe)		26300	25200		mg/kg	4.2	30	27-JUL-15

Quality Control Report

Client: MMM Group Ltd.
111-93 Lombard Ave
Winnipeg MB R3B 3B1
Contact: BRIAN MOONS

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
MET-200.2-MS-WP	Soil							
Batch R3233554								
WG2137408-7 DUP		**WG2137408-6**						
Lead (Pb)		14.6	14.8		mg/kg	1.1	40	27-JUL-15
Magnesium (Mg)		9710	9380		mg/kg	3.5	30	27-JUL-15
Manganese (Mn)		1080	1000		mg/kg	7.6	30	27-JUL-15
Molybdenum (Mo)		0.453	0.454		mg/kg	0.1	40	27-JUL-15
Nickel (Ni)		44.0	40.4		mg/kg	8.3	30	27-JUL-15
Phosphorus (P)		960	930		mg/kg	3.6	30	27-JUL-15
Potassium (K)		4110	3730		mg/kg	9.7	40	27-JUL-15
Selenium (Se)		0.65	0.64		mg/kg	2.4	30	27-JUL-15
Silver (Ag)		0.15	0.16		mg/kg	3.1	40	27-JUL-15
Sodium (Na)		300	270		mg/kg	10	40	27-JUL-15
Strontium (Sr)		34.0	34.1		mg/kg	0.2	40	27-JUL-15
Thallium (Tl)		0.29	0.30		mg/kg	3.1	30	27-JUL-15
Tin (Sn)		<5.0	<5.0	RPD-NA	mg/kg	N/A	40	27-JUL-15
Titanium (Ti)		677	649		mg/kg	4.2	40	27-JUL-15
Uranium (U)		2.48	2.51		mg/kg	1.2	30	27-JUL-15
Vanadium (V)		66.5	61.4		mg/kg	8.0	30	27-JUL-15
Zinc (Zn)		74	68		mg/kg	8.5	30	27-JUL-15
WG2137408-2 LCS								
Aluminum (Al)			108.0		%		80-120	27-JUL-15
Antimony (Sb)			100.6		%		80-120	27-JUL-15
Arsenic (As)			103.3		%		80-120	27-JUL-15
Barium (Ba)			102.6		%		80-120	27-JUL-15
Beryllium (Be)			102.8		%		80-120	27-JUL-15
Bismuth (Bi)			92.0		%		80-120	27-JUL-15
Boron (B)			98.7		%		80-120	27-JUL-15
Cadmium (Cd)			104.1		%		80-120	27-JUL-15
Calcium (Ca)			100.7		%		80-120	27-JUL-15
Chromium (Cr)			102.8		%		80-120	27-JUL-15
Cobalt (Co)			103.4		%		80-120	27-JUL-15
Copper (Cu)			104.7		%		80-120	27-JUL-15
Iron (Fe)			97.1		%		80-120	27-JUL-15
Lead (Pb)			95.8		%		80-120	27-JUL-15
Magnesium (Mg)			112.6		%		80-120	27-JUL-15

Client: MMM Group Ltd.
111-93 Lombard Ave
Winnipeg MB R3B 3B1
Contact: BRIAN MOONS

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
MET-200.2-MS-WP	Soil							
Batch R3233554								
WG2137408-2 LCS								
Manganese (Mn)			104.3		%		80-120	27-JUL-15
Molybdenum (Mo)			99.0		%		80-120	27-JUL-15
Nickel (Ni)			103.2		%		80-120	27-JUL-15
Phosphorus (P)			101.1		%		80-120	27-JUL-15
Potassium (K)			106.3		%		80-120	27-JUL-15
Selenium (Se)			101.3		%		80-120	27-JUL-15
Silver (Ag)			94.5		%		80-120	27-JUL-15
Sodium (Na)			116.1		%		80-120	27-JUL-15
Strontium (Sr)			98.8		%		80-120	27-JUL-15
Thallium (Tl)			95.5		%		80-120	27-JUL-15
Tin (Sn)			101.1		%		80-120	27-JUL-15
Titanium (Ti)			100.7		%		80-120	27-JUL-15
Uranium (U)			95.4		%		80-120	27-JUL-15
Vanadium (V)			106.6		%		80-120	27-JUL-15
Zinc (Zn)			97.0		%		80-120	27-JUL-15
WG2137408-1 MB								
Aluminum (Al)			<5.0		mg/kg		5	27-JUL-15
Antimony (Sb)			<0.10		mg/kg		0.1	27-JUL-15
Arsenic (As)			<0.10		mg/kg		0.1	27-JUL-15
Barium (Ba)			<0.50		mg/kg		0.5	27-JUL-15
Beryllium (Be)			<0.10		mg/kg		0.1	27-JUL-15
Bismuth (Bi)			<0.020		mg/kg		0.02	27-JUL-15
Boron (B)			<10		mg/kg		10	27-JUL-15
Cadmium (Cd)			<0.020		mg/kg		0.02	27-JUL-15
Calcium (Ca)			<100		mg/kg		100	27-JUL-15
Chromium (Cr)			<1.0		mg/kg		1	27-JUL-15
Cobalt (Co)			<0.020		mg/kg		0.02	27-JUL-15
Copper (Cu)			<1.0		mg/kg		1	27-JUL-15
Iron (Fe)			<25		mg/kg		25	27-JUL-15
Lead (Pb)			<0.20		mg/kg		0.2	27-JUL-15
Magnesium (Mg)			<10		mg/kg		10	27-JUL-15
Manganese (Mn)			<0.50		mg/kg		0.5	27-JUL-15
Molybdenum (Mo)			<0.020		mg/kg		0.02	27-JUL-15
Nickel (Ni)			<0.50		mg/kg		0.5	27-JUL-15

Quality Control Report

Client: MMM Group Ltd.
111-93 Lombard Ave
Winnipeg MB R3B 3B1
Contact: BRIAN MOONS

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
MET-200.2-MS-WP	Soil							
Batch R3233554								
WG2137408-1 MB								
Phosphorus (P)			<100		mg/kg		100	27-JUL-15
Potassium (K)			<25		mg/kg		25	27-JUL-15
Selenium (Se)			<0.50		mg/kg		0.5	27-JUL-15
Silver (Ag)			<0.10		mg/kg		0.1	27-JUL-15
Sodium (Na)			<10		mg/kg		10	27-JUL-15
Strontium (Sr)			<0.10		mg/kg		0.1	27-JUL-15
Thallium (Tl)			<0.10		mg/kg		0.1	27-JUL-15
Tin (Sn)			<5.0		mg/kg		5	27-JUL-15
Titanium (Ti)			<0.50		mg/kg		0.5	27-JUL-15
Uranium (U)			<0.020		mg/kg		0.02	27-JUL-15
Vanadium (V)			<0.50		mg/kg		0.5	27-JUL-15
Zinc (Zn)			<10		mg/kg		10	27-JUL-15
MOIST-SK	Soil							
Batch R3233737								
WG2137339-1 DUP		**L1646440-1**						
% Moisture		89.8	89.2		%	0.6	20	28-JUL-15
N-TOTKJ-COL-SK	Soil							
Batch R3234952								
WG2138037-2 DUP		**L1647201-1**						
Total Kjeldahl Nitrogen		1.67	1.69		%	1.3	20	29-JUL-15
WG2138037-3 IRM		**08-109_SOIL**						
Total Kjeldahl Nitrogen			104.4		%		80-120	29-JUL-15
WG2138037-4 MB								
Total Kjeldahl Nitrogen			<0.020		%		0.02	29-JUL-15
WG2138037-5 RB								
Total Kjeldahl Nitrogen			<0.020		%			29-JUL-15
N2/N3-AVAIL-KCL-SK	Soil							
Batch R3233911								
WG2136178-3 IRM		**SAL814**						
Nitrate+Nitrite-N			90.4		%		70-130	28-JUL-15
WG2136178-2 MB								
Nitrite-N			<0.50		mg/kg		0.5	28-JUL-15
Nitrate+Nitrite-N			<2.0		mg/kg		2	28-JUL-15
NH4-AVAIL-SK	Soil							

Quality Control Report

Client: MMM Group Ltd.
111-93 Lombard Ave
Winnipeg MB R3B 3B1
Contact: BRIAN MOONS

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
NH4-AVAIL-SK	Soil							
Batch R3234532								
WG2137369-2 IRM		**SAL814**						
Available Ammonium-N			103.8		%		70-130	28-JUL-15
WG2137369-1 MB								
Available Ammonium-N			<1.0		mg/kg		1	28-JUL-15
OM-LOI-SK	Soil							
Batch R3234721								
WG2137282-1 DUP		**L1646600-1**						
Organic Matter		18.9	19.1		%	1.2	20	28-JUL-15
Loss on Ignition @ 375 C		23.9	24.1		%	1.2	25	28-JUL-15
WG2137282-3 IRM		**SAL2001**						
Loss on Ignition @ 375 C			91.4		%		80-120	28-JUL-15
WG2137282-2 MB								
Organic Matter			<1.0		%		1	28-JUL-15
Loss on Ignition @ 375 C			<1.0		%		1	28-JUL-15
PH,EC-1:2-SK	Soil							
Batch R3234180								
WG2138174-2 IRM		**SAL814**						
Conductivity (1:2)			115.9		%		80-120	07-AUG-15
pH (1:2 soil:water)			8.16		pH		7.65-8.25	07-AUG-15
WG2138174-1 MB								
Conductivity (1:2)			<0.050		dS m-1		0.05	07-AUG-15
PO4-AVAIL-OLSEN-SK	Soil							
Batch R3234717								
WG2138143-2 IRM		**FARM2005**						
Available Phosphate-P			76.0		%		70-130	28-JUL-15
WG2138143-1 MB								
Available Phosphate-P			<1.0		mg/kg		1	28-JUL-15
SO4-AVAIL-SK	Soil							
Batch R3234988								
WG2136181-3 IRM		**SAL814**						
Available Sulfate-S			95.0		%		70-130	28-JUL-15
WG2136181-2 MB								
Available Sulfate-S			<3.0		mg/kg		3	28-JUL-15
SPECGRAV-CL	Soil							

Quality Control Report

Client: MMM Group Ltd.
111-93 Lombard Ave
Winnipeg MB R3B 3B1
Contact: BRIAN MOONS

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
SPECGRAV-CL	Soil							
Batch R3236644								
WG2141116-2 DUP		**L1646440-1**						
Specific Gravity		1.03	1.02		kg/L	1.0	20	31-JUL-15
WG2141116-3 IRM		**DI_H2O**						
Specific Gravity			100.0		%		90-110	31-JUL-15
CL-COL-SK	Waste							
Batch R3233833								
WG2137331-1 MB								
Chloride (Cl)			<1.0		mg/L		1	28-JUL-15
PH/EC-SK	Waste							
Batch R3233966								
WG2137331-1 MB								
Conductivity (EC)			0.014	B	dS m-1		0.01	28-JUL-15
SAR-CALC-SK	Waste							
Batch R3233954								
WG2137331-1 MB								
Calcium (Ca)			<2.0		mg/L		2	28-JUL-15
Potassium (K)			<1.0		mg/L		1	28-JUL-15
Magnesium (Mg)			<2.0		mg/L		2	28-JUL-15
Sodium (Na)			<4.0		mg/L		4	28-JUL-15
Sulfur (as SO4)			<5.0		mg/L		5	28-JUL-15
SOLIDS-TOT/TOTVOL-SK	Manure							
Batch R3235013								
WG2137178-1 DUP		**L1646440-1**						
Total Solids		8.80	8.83		%	0.4	25	29-JUL-15
Total Volatile Solids (dry basis)		29.7	28.7		%	3.1	25	29-JUL-15

Client: MMM Group Ltd.
111-93 Lombard Ave
Winnipeg MB R3B 3B1
Contact: BRIAN MOONS

Legend:

Limit	ALS Control Limit (Data Quality Objectives)
DUP	Duplicate
RPD	Relative Percent Difference
N/A	Not Available
LCS	Laboratory Control Sample
SRM	Standard Reference Material
MS	Matrix Spike
MSD	Matrix Spike Duplicate
ADE	Average Desorption Efficiency
MB	Method Blank
IRM	Internal Reference Material
CRM	Certified Reference Material
CCV	Continuing Calibration Verification
CVS	Calibration Verification Standard
LCSD	Laboratory Control Sample Duplicate

Sample Parameter Qualifier Definitions:

Qualifier	Description
B	Method Blank exceeds ALS DQO. All associated sample results are at least 5 times greater than blank levels and are considered reliable.
DLA	Detection Limit adjusted for required dilution
RPD-NA	Relative Percent Difference Not Available due to result(s) being less than detection limit.

Quality Control Report

Workorder: L1646440 Report Date: 11-AUG-15

Client: MMM Group Ltd.
111-93 Lombard Ave
Winnipeg MB R3B 3B1
Contact: BRIAN MOONS

Hold Time Exceedances:

ALS Product Description	Sample ID	Sampling Date	Date Processed	Rec. HT	Actual HT	Units	Qualifier
Leachable Metals							
Available Boron, Hot Water							
	1	22-JUL-15 11:00	28-JUL-15	5	6	days	EHT

Legend & Qualifier Definitions:

EHTR-FM: Exceeded ALS recommended hold time prior to sample receipt. Field Measurement recommended.
EHTR: Exceeded ALS recommended hold time prior to sample receipt.
EHTL: Exceeded ALS recommended hold time prior to analysis. Sample was received less than 24 hours prior to expiry.
EHT: Exceeded ALS recommended hold time prior to analysis.
Rec. HT: ALS recommended hold time (see units).

Notes*:
Where actual sampling date is not provided to ALS, the date (& time) of receipt is used for calculation purposes.
Where actual sampling time is not provided to ALS, the earlier of 12 noon on the sampling date or the time (& date) of receipt is used for calculation purposes. Samples for L1646440 were received on 22-JUL-15 12:15.

ALS recommended hold times may vary by province. They are assigned to meet known provincial and/or federal government requirements. In the absence of regulatory hold times, ALS establishes recommendations based on guidelines published by the US EPA, APHA Standard Methods, or Environment Canada (where available). For more information, please contact ALS.

The ALS Quality Control Report is provided to ALS clients upon request. ALS includes comprehensive QC checks with every analysis to ensure our high standards of quality are met. Each QC result has a known or expected target value, which is compared against pre-determined data quality objectives to provide confidence in the accuracy of associated test results.

Please note that this report may contain QC results from anonymous Sample Duplicates and Matrix Spikes that do not originate from this Work Order.

Product	Work Order	Sample	Client ID	Analyte	Result (Dry)	Result (Wet)	Qualifier	Units	LOR (dry)
PH/EC-SK	L1646440	L1646440-1	CELL 2	Conductivity (Oversaturated)		2.28		dS m-1	0.010
PH,EC-1:2-SK	L1646440	L1646440-1	CELL 2	Conductivity (1:2)	4.05			dS m-1	0.050
OM-LOI-SK	L1646440	L1646440-1	CELL 2	Loss on Ignition @ 375 C	21.4			%	1.0
MOIST-SK	L1646440	L1646440-1	CELL 2	% Moisture		89.8		%	0.10
OM-LOI-SK	L1646440	L1646440-1	CELL 2	Organic Matter	17.0			%	1.0
PH/EC-SK	L1646440	L1646440-1	CELL 2	pH (Oversaturated)		7.24		pH	0.10
PH,EC-1:2-SK	L1646440	L1646440-1	CELL 2	pH (1:2 soil:water)	7.56			pH	0.10
SOLIDS-TOT/TOTVOL-SK	L1646440	L1646440-1	CELL 2	Total Volatile Solids (dry basis)	29.7	2.6		%	0.10
SOLIDS-TOT/TOTVOL-SK	L1646440	L1646440-1	CELL 2	Total Solids		8.80		%	0.10
N-TOTKJ-COL-SK	L1646440	L1646440-1	CELL 2	Total Kjeldahl Nitrogen	0.116	0.012		%	0.020
ETL-N-TOT-AVAIL-SK	L1646440	L1646440-1	CELL 2	Total Available Nitrogen	397	40.5		mg/kg	48
C-TOT-LECO-SK	L1646440	L1646440-1	CELL 2	Total Carbon by Combustion	19.6	2.0		%	0.1
NH4-AVAIL-SK	L1646440	L1646440-1	CELL 2	Available Ammonium-N	397	40.5	DLM	mg/kg	44
N2/N3-AVAIL-KCL-SK	L1646440	L1646440-1	CELL 2	Nitrate+Nitrite-N	<20	<2	DLM	mg/kg	20
N2/N3-AVAIL-KCL-SK	L1646440	L1646440-1	CELL 2	Nitrate-N	<20	<2	DLM	mg/kg	20
N2/N3-AVAIL-KCL-SK	L1646440	L1646440-1	CELL 2	Nitrite-N	<4.0	<0.4	DLM	mg/kg	4.0
PO4-AVAIL-OLSEN-SK	L1646440	L1646440-1	CELL 2	Available Phosphate-P	135	13.8		mg/kg	1.0
K-AVAIL-SK	L1646440	L1646440-1	CELL 2	Available Potassium	397	40.5		mg/kg	30
SO4-AVAIL-SK	L1646440	L1646440-1	CELL 2	Available Sulfate-S	137	14.0	DLM	mg/kg	39
SAR-CALC-SK	L1646440	L1646440-1	CELL 2	SAR	NA	4.04		SAR	0.10
SAL-D50-WETCALC-SK	L1646440	L1646440-1	CELL 2	Calcium (Ca)	859	87.6		mg/kg	3.6
SAL-D50-WETCALC-SK	L1646440	L1646440-1	CELL 2	Chloride (Cl)	2340	239		mg/kg	3.6
SAL-D50-WETCALC-SK	L1646440	L1646440-1	CELL 2	Magnesium (Mg)	633	64.6		mg/kg	3.6
SAL-D50-DRYCALC-SK	L1646440	L1646440-1	CELL 2	Potassium (K)	149	15.2		mg/kg	18
SAT-PCNT-SK	L1646440	L1646440-1	CELL 2	% Saturation	oversaturated	oversaturated		%	1.0
SAL-D50-DRYCALC-SK	L1646440	L1646440-1	CELL 2	Sodium (Na)	1900	194		mg/kg	70
SAL-D50-DRYCALC-SK	L1646440	L1646440-1	CELL 2	Sulfur (as SO4)	157	16.0		mg/kg	88
MET-200.2-MS-WP	L1646440	L1646440-1	CELL 2	Aluminum (Al)	9680	987		mg/kg	5.0
MET-200.2-MS-WP	L1646440	L1646440-1	CELL 2	Antimony (Sb)	1.34	0.137		mg/kg	0.10
MET-200.2-MS-WP	L1646440	L1646440-1	CELL 2	Arsenic (As)	3.93	0.401		mg/kg	0.10
MET-200.2-MS-WP	L1646440	L1646440-1	CELL 2	Barium (Ba)	683	70		mg/kg	0.50
MET-200.2-MS-WP	L1646440	L1646440-1	CELL 2	Beryllium (Be)	0.28	0.03		mg/kg	0.10
MET-200.2-MS-WP	L1646440	L1646440-1	CELL 2	Bismuth (Bi)	11.4	1.16		mg/kg	0.020
MET-200.2-MS-WP	L1646440	L1646440-1	CELL 2	Boron (B)	16	1.63		mg/kg	10
MET-200.2-MS-WP	L1646440	L1646440-1	CELL 2	Cadmium (Cd)	1.21	0.12		mg/kg	0.020
MET-200.2-MS-WP	L1646440	L1646440-1	CELL 2	Calcium (Ca)	77300	7885		mg/kg	100
MET-200.2-MS-WP	L1646440	L1646440-1	CELL 2	Chromium (Cr)	26.4	2.69		mg/kg	1.0
MET-200.2-MS-WP	L1646440	L1646440-1	CELL 2	Cobalt (Co)	4.52	0.46		mg/kg	0.020
MET-200.2-MS-WP	L1646440	L1646440-1	CELL 2	Copper (Cu)	694	71		mg/kg	1.0

MET-200.2-MS-WP	L1646440	L1646440-1	CELL 2	Iron (Fe)	16700	1703		mg/kg	25
MET-200.2-MS-WP	L1646440	L1646440-1	CELL 2	Lead (Pb)	17.2	1.75		mg/kg	0.20
MET-200.2-MS-WP	L1646440	L1646440-1	CELL 2	Magnesium (Mg)	34900	3560		mg/kg	10
MET-200.2-MS-WP	L1646440	L1646440-1	CELL 2	Manganese (Mn)	189	19		mg/kg	0.50
HG-200.2-CVAF-WP	L1646440	L1646440-1	CELL 2	Mercury (Hg)	1.19	1.19	DLA	mg/kg	0.20
MET-200.2-MS-WP	L1646440	L1646440-1	CELL 2	Molybdenum (Mo)	17.9	1.83		mg/kg	0.020
MET-200.2-MS-WP	L1646440	L1646440-1	CELL 2	Nickel (Ni)	15.4	1.57		mg/kg	0.50
MET-200.2-MS-WP	L1646440	L1646440-1	CELL 2	Phosphorus (P)	4610	470		mg/kg	100
MET-200.2-MS-WP	L1646440	L1646440-1	CELL 2	Potassium (K)	1590	162		mg/kg	25
MET-200.2-MS-WP	L1646440	L1646440-1	CELL 2	Selenium (Se)	3.42	0.35		mg/kg	0.50
MET-200.2-MS-WP	L1646440	L1646440-1	CELL 2	Silver (Ag)	9.69	0.99		mg/kg	0.10
MET-200.2-MS-WP	L1646440	L1646440-1	CELL 2	Sodium (Na)	1440	147		mg/kg	10
MET-200.2-MS-WP	L1646440	L1646440-1	CELL 2	Strontium (Sr)	113	11.53		mg/kg	0.10
MET-200.2-MS-WP	L1646440	L1646440-1	CELL 2	Thallium (Tl)	0.12	0.012		mg/kg	0.10
MET-200.2-MS-WP	L1646440	L1646440-1	CELL 2	Tin (Sn)	12.9	1.32		mg/kg	5.0
MET-200.2-MS-WP	L1646440	L1646440-1	CELL 2	Titanium (Ti)	57.9	5.91		mg/kg	0.50
MET-200.2-MS-WP	L1646440	L1646440-1	CELL 2	Uranium (U)	8.47	0.86		mg/kg	0.020
MET-200.2-MS-WP	L1646440	L1646440-1	CELL 2	Vanadium (V)	24.0	2.45		mg/kg	0.50
MET-200.2-MS-WP	L1646440	L1646440-1	CELL 2	Zinc (Zn)	422	43.0		mg/kg	10
B-HOTW-SK	L1646440	L1646440-1	CELL 2	Boron (B), Hot Water Ext.	8.9	0.91	DLM	mg/kg	2.6

ALS Environmental
www.alsglobal.com

Chain of Custody (COC) / Analytical Request Form

Canada Toll Free: 1 800 668 9878

L1646440-COFC

COC Number: 14 - 454252

Page 1 of 1

Report To		Report Format / Distribution		Turnaround Time (TAT) (Rush TAT is not available for all tests)
Company:	MMM GROUP	Select Report Format:	PDF, EXCEL, EDD (DIGITAL)	R: Regular (Standard TAT if received by 3pm)
Contact:	BRIAN MOONS	Quality Control (QC) Report with Report	Yes / No	P: Priority (2-4 business days if received by 3pm)
Address:	111-93 LOMBARD AVE, WPG	Criteria on Report - provide details below if box checked		E: Emergency (1-2 business days if received by 3pm)
Phone:	204 - 803 - 9488	Select Distribution:	EMAIL / MAIL / FAX	E2: Same day or weekend emergency if received by 10am -- contact ALS for surcharge.
		Email 1 or Fax	KEAMD@mmm.ca.	Specify Date Required for E2,E or P:
		Email 2	MOONSB@mmm.ca.	

Invoice To		Invoice Distribution	
	Same as Report To: Yes / No	Select Invoice Distribution:	EMAIL / MAIL / FAX
	Copy of Invoice with Report: Yes / No	Email 1 or Fax	accountspayable@mmm.ca
Company:		Email 2	
Contact:			

Project Information		Oil and Gas Required Fields (client use)	
ALS Quote #:	Q37455	Approver ID:	Cost Center:
Job #:		GL Account:	Routing Code:
PO / AFE:	Steinbach Biosolids	Activity Code:	
LSD:		Location:	

ALS Lab Work Order # (lab use only)	ALS Contact:	Sampler:

ALS Sample # (lab use only)	Sample Identification and/or Coordinates (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	TKN	Nitrate - N	Nitrite - N	Avail. Ammonium N	Total avail. Nitrogen	Total Phosphorus	Total solids, total volatile solids	Moisture	Total Carbon	Avail. Potassium	Avail. Sulfate	Partial salinity	Specific gravity	Number of Containers
	Cell 2	22/JUL/15	11:00	Sludge	X	X	X	X	X	X	X	X	X	X	X	X	X	4

Analysis Request: Indicate Filtered (F), Preserved (P) or Filtered and Preserved (F/P) below

Drinking Water (DW) Samples[1] (client use)	Special Instructions / Specify Criteria to add on report (client Use)
Are samples taken from a Regulated DW System? Yes / No	Lagoon sludge. 7°C.
Are samples for human drinking water use? Yes / No	

SAMPLE CONDITION AS RECEIVED (lab use only)

Frozen		SIF Observations	Yes / No
Ice packs	Yes / No	Custody seal intact	Yes / No
Cooling Initiated			

INITIAL COOLER TEMPERATURES °C			FINAL COOLER TEMPERATURES °C		

SHIPMENT RELEASE (client use)			INITIAL SHIPMENT RECEPTION (lab use only)			FINAL SHIPMENT RECEPTION (lab use only)		
Released by:	Date:	Time:	Received by:	Date:	Time:	Received by:	Date:	Time:
	22/JUL/15	12:15		7/22/15	12:15			

[1] REFER TO BACK PAGE FOR ALS LOCATIONS AND SAMPLING INFORMATION

WHITE - LABORATORY COPY YELLOW - CLIENT COPY

ALS FM-00206 v08 Front03 October 2013

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY. By the use of this form the user acknowledges and agrees with the Terms and Conditions as specified on the back page of the white - report copy.

1. If any water samples are taken from a Regulated Drinking Water (DW) System, please submit using an Authorized DW COC form.

Your Project #: 3315439
Your C.O.C. #: C#494719-01-01

Attention:BRIAN MOONS

MMM GROUP
SUITE 111
93 LOMBARD AVE
WINNIPEG, MB
CANADA R3B 3B1

Report Date: 2016/06/02
Report #: R2190249
Version: 1 - Final

CERTIFICATE OF ANALYSIS

MAXXAM JOB #: B638809
Received: 2016/05/19, 13:00

Sample Matrix: SLUDGE
Samples Received: 2

Analyses	Quantity	Date Extracted	Date Analyzed	Laboratory Method	Analytical Method
Boron (Hot Water Soluble) (1)	2	N/A	2016/05/25	BBY7SOP-00001 BBY7SOP-00018	EPA6020bR2m,6010cR3m
Chloride (soluble) (1)	2	2016/05/25	2016/05/26	BBY6SOP-00011	SM 22 4500-Cl- E m
Conductivity (Soluble) (1)	2	2016/05/25	2016/05/25	BBY6SOP-00029	SM 22 2510 B
Elements by ICPMS (total) (1)	2	2016/05/25	2016/05/25	BBY7SOP-00017,	BC SALM,EPA 6020bR2m
Loss on Ignition, Org. & Inorg. Residue (1, 3)	2	N/A	2016/05/26	BBY6SOP-00040	Carter 2nd ed 28.3
Moisture (1)	2	2016/05/21	2016/05/24	BBY8SOP-00017	BC MOE Lab Manual
Ammonium-NH4 (Available) (1)	2	N/A	2016/06/01	BBY6SOP-00009	SM 22 4500-NH3- G m
Ammonia-N (Available) (1)	2	2016/05/30	2016/06/01	BBY6SOP-00009	SM 22 4500-NH3- G m
Nitrate+Nitrite (N) (Available) (1)	2	N/A	2016/06/01	BBY6SOP-00010	SM 22 4500-NO3- I m
Organic Matter - Calculated from LOI (1)	2	N/A	2016/05/26	BBY6SOP-00040	Carter SSMA 44.3
pH (2:1 DI Water Extract) (1)	2	2016/05/25	2016/05/25	BBY6SOP-00028	BCMOE BCLM Mar2005 m
pH (Soluble) (1)	2	2016/05/25	2016/05/25	BBY6SOP-00025	SM 22 4500-H+ B
Sodium Adsorption Ratio SP (1)	2	N/A	2016/05/25	BBY6SOP-00030	Carter 2nd 15.2.1 m
Saturated Paste (1)	2	2016/05/25	2016/05/25	BBY6SOP-00030	Carter 2nd 15.2.1 m
Sulphur (Available) (2)	2	2016/05/26	2016/05/27	AB SOP-00029 / AB SOP-00042	EPA 200.7 CFR 2012 m
Specific Gravity - Dried and Ground (2)	2	2016/05/31	2016/05/31	AB SOP-00045	MSS 2nd Ed. 1978
Soluble Ions Calculation (mg/kg) (1)	2	N/A	2016/05/27	BBY WI-00033	Auto Calc
Sulphate (soluble) (soil) (1)	2	2016/05/25	2016/05/26	BBY6SOP-00017	SM 22 4500-SO42- E m
Soluble Cations (Ca,K,Mg,Na,S) (1)	2	N/A	2016/05/25	BBY7SOP-00001 BBY7SOP-00018	EPA6020bR2m,6010cR3m
Sublet (Inorganics)	2	N/A	2016/05/27		
Total Carbon in Soil by LECO (2, 4)	2	2016/05/27	2016/05/28	CAL SOP-00243	LECO 203-821-170 m
Total Kjeldahl Nitrogen - Soil (2)	2	2016/05/25	2016/05/26	AB SOP-00008	EPA 351.1 R1978 m
Total Solids (Fixed and Volatile) (1)	2	2016/05/26	2016/05/26	BBY6SOP-00050	SM 22 2540 G
Total Phosphorus in Soil Subcontract	2	2016/05/27	2016/05/27		

Reference Method suffix “m” indicates test methods incorporate validated modifications from specific reference methods to improve performance.
* RPDs calculated using raw data. The rounding of final results may result in the apparent difference.

Your Project #: 3315439
Your C.O.C. #: C#494719-01-01

Attention:BRIAN MOONS

MMM GROUP
SUITE 111
93 LOMBARD AVE
WINNIPEG, MB
CANADA R3B 3B1

Report Date: 2016/06/02
Report #: R2190249
Version: 1 - Final

CERTIFICATE OF ANALYSIS

MAXXAM JOB #: B638809
Received: 2016/05/19, 13:00

(1) This test was performed by Maxxam Vancouver
(2) This test was performed by Maxxam Calgary Environmental
(3) Loss on Ignition was reported on a dry weight basis.
(4) Updated the RPD limits from 50% to 35% as per standards. Updated on 2012/11/26.

Encryption Key

Please direct all questions regarding this Certificate of Analysis to your Project Manager.
Amanda Hung, B.Sc., Project Manager
Email: AHung@maxxam.ca
Phone# (204)772-7276 Ext:2215

==========

Maxxam has procedures in place to guard against improper use of the electronic signature and have the required "signatories", as per section 5.10.2 of ISO/IEC 17025:2005(E), signing the reports. For Service Group specific validation please refer to the Validation Signature Page.

Maxxam Job #: B638809
Report Date: 2016/06/02

MMM GROUP
Client Project #: 3315439

RESULTS OF CHEMICAL ANALYSES OF SLUDGE

Maxxam ID		OQ8911		OQ9336		
Sampling Date		2016/05/19 10:30		2016/05/19 10:30		
COC Number		C#494719-01-01		C#494719-01-01		
	UNITS	CELL 1 NORTH	RDL	CELL 1 SOUTH	RDL	QC Batch
Parameter						
Subcontract Parameter	N/A	ATTACHED	N/A	ATTACHED	N/A	8282346
ANIONS						
Soluble Sulphate (SO4)	mg/L	500	10	178	10	8279638
Soluble Chloride (Cl)	mg/L	1460	5.0	1190	5.0	8279637
Calculated Parameters						
Soluble Chloride (Cl)	mg/kg	1200	4.1	1260	5.3	8274748
Soluble Sodium (Na)	mg/kg	531	4.1	646	5.3	8274748
Soluble Calcium (Ca)	mg/kg	242	4.1	234	5.3	8274748
Soluble Magnesium (Mg)	mg/kg	157	4.1	155	5.3	8274748
Soluble Potassium (K)	mg/kg	46	16	49	21	8274748
Soluble Sulphur (S)	mg/kg	519	25	394	32	8274748
Soluble Sulphate (SO4)	mg/kg	411	8.2	189	11	8274748
Elements						
Soluble (Hot water) Boron (B)	mg/kg	0.89	0.10	1.26	0.10	8278657
Misc. Inorganics						
Organic Matter	%	17.7	1.0	39.3	1.0	8274746
Total Solids (Fixed)	%	82.6	0.10	58.3	0.10	8279939
Total Solids (Volatile)	%	17.4	0.10	41.7	0.10	8279939
Nutrients						
Available (KCl) Ammonia (N)	mg/kg	291 (1)	5.0	375 (1)	5.0	8283262
Available (KCl) Ammonium (NH4)	mg/kg	370	0.50	480	0.50	8274745
Nitrate plus Nitrite (N)	ug/g	ND (2)	20	ND (2)	20	8285236
Available (CaCl2) Sulphur (S)	mg/kg	530	2.0	1000	20	8279567
Total Kjeldahl Nitrogen	mg/kg	3300 (1)	250	14000 (1)	1000	8278211
Physical Properties						
Soluble (2:1) pH	pH	7.89	N/A	7.42	N/A	8278262
Soluble Parameters						
Soluble Conductivity	uS/cm	5030	1.0	4480	1.0	8278007
Soluble pH	pH	7.22	N/A	7.11	N/A	8278006
Soluble Calcium (Ca)	mg/L	295	5.0	221	5.0	8278315
Saturation %	%	82.1	1.0	106	1.0	8278000

RDL = Reportable Detection Limit
N/A = Not Applicable
(1) Detection limits raised due to dilution to bring analyte within the calibrated range.
(2) RDL raised due to sample matrix interference.

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Maxxam Job #: B638809
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MMM GROUP
Client Project #: 3315439

RESULTS OF CHEMICAL ANALYSES OF SLUDGE

Maxxam ID		OQ8911		OQ9336		
Sampling Date		2016/05/19 10:30		2016/05/19 10:30		
COC Number		C#494719-01-01		C#494719-01-01		
	UNITS	**CELL 1 NORTH**	**RDL**	**CELL 1 SOUTH**	**RDL**	**QC Batch**
Soluble Magnesium (Mg)	mg/L	192	5.0	146	5.0	8278315
Soluble Potassium (K)	mg/L	56	20	46	20	8278315
Soluble Sodium (Na)	mg/L	647	5.0	610	5.0	8278315
Soluble Sulphur (S)	mg/L	633	30	371	30	8278315
Sodium Adsorption Ratio	N/A	7.21	0.10	7.82	0.10	8274747
Physical Properties						
Loss on Ignition	%	17.7	1.0	39.3	1.0	8279934
Dry Specific Gravity	N/A	2.2	N/A	1.9	N/A	8283942

RDL = Reportable Detection Limit
N/A = Not Applicable

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PHYSICAL TESTING (SLUDGE)

Maxxam ID		OQ8911	OQ9336		
Sampling Date		2016/05/19 10:30	2016/05/19 10:30		
COC Number		C#494719-01-01	C#494719-01-01		
	UNITS	CELL 1 NORTH	CELL 1 SOUTH	RDL	QC Batch
Physical Properties					
Moisture	%	76	89	0.30	8276309
RDL = Reportable Detection Limit					

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ELEMENTS BY ATOMIC SPECTROSCOPY (SLUDGE)

Maxxam ID		OQ8911	OQ9336		
Sampling Date		2016/05/19 10:30	2016/05/19 10:30		
COC Number		C#494719-01-01	C#494719-01-01		
	UNITS	CELL 1 NORTH	CELL 1 SOUTH	RDL	QC Batch
Total Metals by ICPMS					
Total Aluminum (Al)	mg/kg	11200	11400	100	8278248
Total Antimony (Sb)	mg/kg	0.65	2.01	0.10	8278248
Total Arsenic (As)	mg/kg	5.28	7.07	0.50	8278248
Total Barium (Ba)	mg/kg	529	784	0.10	8278248
Total Beryllium (Be)	mg/kg	0.41	ND	0.40	8278248
Total Bismuth (Bi)	mg/kg	5.55	18.7	0.10	8278248
Total Cadmium (Cd)	mg/kg	1.22	3.54	0.050	8278248
Total Calcium (Ca)	mg/kg	86500	66200	100	8278248
Total Chromium (Cr)	mg/kg	27.6	49.2	1.0	8278248
Total Cobalt (Co)	mg/kg	5.51	4.73	0.30	8278248
Total Copper (Cu)	mg/kg	266	833	0.50	8278248
Total Iron (Fe)	mg/kg	15800	17600	100	8278248
Total Lead (Pb)	mg/kg	23.1	77.5	0.10	8278248
Total Lithium (Li)	mg/kg	12.1	7.8	5.0	8278248
Total Magnesium (Mg)	mg/kg	34800	25700	100	8278248
Total Manganese (Mn)	mg/kg	225	170	0.20	8278248
Total Mercury (Hg)	mg/kg	0.403	3.61	0.050	8278248
Total Molybdenum (Mo)	mg/kg	18.2	64.4	0.10	8278248
Total Nickel (Ni)	mg/kg	16.1	19.8	0.80	8278248
Total Phosphorus (P)	mg/kg	2990	7950	10	8278248
Total Potassium (K)	mg/kg	1860	1350	100	8278248
Total Selenium (Se)	mg/kg	1.88	5.62	0.50	8278248
Total Silver (Ag)	mg/kg	21.8	63.8	0.050	8278248
Total Sodium (Na)	mg/kg	1080	2480	100	8278248
Total Strontium (Sr)	mg/kg	93.5	141	0.10	8278248
Total Thallium (Tl)	mg/kg	0.140	0.146	0.050	8278248
Total Tin (Sn)	mg/kg	9.66	31.1	0.10	8278248
Total Titanium (Ti)	mg/kg	84.9	40.7	1.0	8278248
Total Uranium (U)	mg/kg	5.05	13.1	0.050	8278248
Total Vanadium (V)	mg/kg	30.4	19.9	2.0	8278248
Total Zinc (Zn)	mg/kg	201	721	1.0	8278248
Total Zirconium (Zr)	mg/kg	2.35	2.38	0.50	8278248

RDL = Reportable Detection Limit
ND = Not detected

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MISCELLANEOUS (SLUDGE)

Maxxam ID		OQ8911	OQ9336		
Sampling Date		2016/05/19 10:30	2016/05/19 10:30		
COC Number		C#494719-01-01	C#494719-01-01		
	UNITS	CELL 1 NORTH	CELL 1 SOUTH	RDL	QC Batch
Misc. Inorganics					
Total Carbon	%	10 (1)	24 (1)	0.20	8281457

RDL = Reportable Detection Limit
(1) Detection limits raised based on sample weight used for analysis.

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GENERAL COMMENTS

RESULTS OF CHEMICAL ANALYSES OF SLUDGE Comments

Sample OQ9336-04 Sulphur (Available): Due to the sample matrix, sample required dilution. Detection limit was adjusted accordingly

Results relate only to the items tested.

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QUALITY ASSURANCE REPORT

QA/QC Batch	Init	QC Type	Parameter	Date Analyzed	Value	Recovery	UNITS	QC Limits
8276309	LO1	Method Blank	Moisture	2016/05/24	ND, RDL=0.30		%	
8276309	LO1	RPD	Moisture	2016/05/24	1.2		%	20
8278000	JGD	QC Standard	Saturation %	2016/05/25		103	%	75 - 125
8278000	JGD	Method Blank	Saturation %	2016/05/25	ND, RDL=1.0		%	
8278000	JGD	RPD [OQ8911-08]	Saturation %	2016/05/25	0.76		%	30
8278006	JGD	QC Standard	Soluble pH	2016/05/25		102	%	97 - 103
8278006	JGD	Spiked Blank	Soluble pH	2016/05/25		101	%	97 - 103
8278006	JGD	RPD [OQ8911-08]	Soluble pH	2016/05/25	0.41		%	N/A
8278007	WAY	Spiked Blank	Soluble Conductivity	2016/05/25		97	%	80 - 120
8278007	WAY	Method Blank	Soluble Conductivity	2016/05/25	ND, RDL=1.0		uS/cm	
8278007	WAY	RPD [OQ8911-08]	Soluble Conductivity	2016/05/25	0.40		%	35
8278211	ZI	Matrix Spike	Total Kjeldahl Nitrogen	2016/05/26		NC	%	75 - 125
8278211	ZI	QC Standard	Total Kjeldahl Nitrogen	2016/05/26		93	%	75 - 125
8278211	ZI	Spiked Blank	Total Kjeldahl Nitrogen	2016/05/26		99	%	75 - 125
8278211	ZI	Method Blank	Total Kjeldahl Nitrogen	2016/05/26	ND, RDL=10		mg/kg	
8278211	ZI	RPD	Total Kjeldahl Nitrogen	2016/05/26	9.7		%	35
8278248	DJ	Matrix Spike	Total Antimony (Sb)	2016/05/25		93	%	75 - 125
			Total Arsenic (As)	2016/05/25		92	%	75 - 125
			Total Barium (Ba)	2016/05/25		NC	%	75 - 125
			Total Beryllium (Be)	2016/05/25		97	%	75 - 125
			Total Cadmium (Cd)	2016/05/25		99	%	75 - 125
			Total Chromium (Cr)	2016/05/25		98	%	75 - 125
			Total Cobalt (Co)	2016/05/25		98	%	75 - 125
			Total Copper (Cu)	2016/05/25		NC	%	75 - 125
			Total Lead (Pb)	2016/05/25		97	%	75 - 125
			Total Lithium (Li)	2016/05/25		95	%	75 - 125
			Total Manganese (Mn)	2016/05/25		NC	%	75 - 125
			Total Mercury (Hg)	2016/05/25		98	%	75 - 125
			Total Molybdenum (Mo)	2016/05/25		99	%	75 - 125
			Total Nickel (Ni)	2016/05/25		94	%	75 - 125
			Total Selenium (Se)	2016/05/25		97	%	75 - 125
			Total Silver (Ag)	2016/05/25		95	%	75 - 125
			Total Strontium (Sr)	2016/05/25		93	%	75 - 125
			Total Thallium (Tl)	2016/05/25		92	%	75 - 125
			Total Tin (Sn)	2016/05/25		92	%	75 - 125
			Total Titanium (Ti)	2016/05/25		NC	%	75 - 125
			Total Uranium (U)	2016/05/25		95	%	75 - 125
			Total Vanadium (V)	2016/05/25		NC	%	75 - 125
			Total Zinc (Zn)	2016/05/25		NC	%	75 - 125
8278248	DJ	QC Standard	Total Aluminum (Al)	2016/05/25		100	%	70 - 130
			Total Antimony (Sb)	2016/05/25		110	%	70 - 130
			Total Arsenic (As)	2016/05/25		88	%	70 - 130
			Total Barium (Ba)	2016/05/25		92	%	70 - 130
			Total Beryllium (Be)	2016/05/25		81	%	70 - 130
			Total Cadmium (Cd)	2016/05/25		111	%	70 - 130
			Total Calcium (Ca)	2016/05/25		101	%	70 - 130
			Total Chromium (Cr)	2016/05/25		97	%	70 - 130
			Total Cobalt (Co)	2016/05/25		93	%	70 - 130
			Total Copper (Cu)	2016/05/25		99	%	70 - 130
			Total Iron (Fe)	2016/05/25		96	%	70 - 130

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QUALITY ASSURANCE REPORT(CONT'D)

QA/QC Batch	Init	QC Type	Parameter	Date Analyzed	Value	Recovery	UNITS	QC Limits
			Total Lead (Pb)	2016/05/25		103	%	70 - 130
			Total Lithium (Li)	2016/05/25		94	%	70 - 130
			Total Magnesium (Mg)	2016/05/25		105	%	70 - 130
			Total Manganese (Mn)	2016/05/25		96	%	70 - 130
			Total Mercury (Hg)	2016/05/25		103	%	70 - 130
			Total Molybdenum (Mo)	2016/05/25		139 (1)	%	70 - 130
			Total Nickel (Ni)	2016/05/25		106	%	70 - 130
			Total Phosphorus (P)	2016/05/25		95	%	70 - 130
			Total Potassium (K)	2016/05/25		94	%	70 - 130
			Total Silver (Ag)	2016/05/25		107	%	70 - 130
			Total Sodium (Na)	2016/05/25		89	%	70 - 130
			Total Strontium (Sr)	2016/05/25		97	%	70 - 130
			Total Thallium (Tl)	2016/05/25		96	%	70 - 130
			Total Tin (Sn)	2016/05/25		93	%	70 - 130
			Total Uranium (U)	2016/05/25		96	%	70 - 130
			Total Vanadium (V)	2016/05/25		96	%	70 - 130
			Total Zinc (Zn)	2016/05/25		102	%	70 - 130
8278248	DJ	Spiked Blank	Total Antimony (Sb)	2016/05/25		92	%	75 - 125
			Total Arsenic (As)	2016/05/25		98	%	75 - 125
			Total Barium (Ba)	2016/05/25		100	%	75 - 125
			Total Beryllium (Be)	2016/05/25		102	%	75 - 125
			Total Cadmium (Cd)	2016/05/25		104	%	75 - 125
			Total Chromium (Cr)	2016/05/25		102	%	75 - 125
			Total Cobalt (Co)	2016/05/25		101	%	75 - 125
			Total Copper (Cu)	2016/05/25		101	%	75 - 125
			Total Lead (Pb)	2016/05/25		101	%	75 - 125
			Total Lithium (Li)	2016/05/25		102	%	75 - 125
			Total Manganese (Mn)	2016/05/25		103	%	75 - 125
			Total Mercury (Hg)	2016/05/25		96	%	75 - 125
			Total Molybdenum (Mo)	2016/05/25		105	%	75 - 125
			Total Nickel (Ni)	2016/05/25		107	%	75 - 125
			Total Selenium (Se)	2016/05/25		104	%	75 - 125
			Total Silver (Ag)	2016/05/25		98	%	75 - 125
			Total Strontium (Sr)	2016/05/25		95	%	75 - 125
			Total Thallium (Tl)	2016/05/25		99	%	75 - 125
			Total Tin (Sn)	2016/05/25		89	%	75 - 125
			Total Titanium (Ti)	2016/05/25		92	%	75 - 125
			Total Uranium (U)	2016/05/25		98	%	75 - 125
			Total Vanadium (V)	2016/05/25		103	%	75 - 125
			Total Zinc (Zn)	2016/05/25		106	%	75 - 125
8278248	DJ	Method Blank	Total Aluminum (Al)	2016/05/25	ND, RDL=100		mg/kg	
			Total Antimony (Sb)	2016/05/25	ND, RDL=0.10		mg/kg	
			Total Arsenic (As)	2016/05/25	ND, RDL=0.50		mg/kg	
			Total Barium (Ba)	2016/05/25	ND, RDL=0.10		mg/kg	
			Total Beryllium (Be)	2016/05/25	ND, RDL=0.40		mg/kg	
			Total Bismuth (Bi)	2016/05/25	ND, RDL=0.10		mg/kg	
			Total Cadmium (Cd)	2016/05/25	ND, RDL=0.050		mg/kg	

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QUALITY ASSURANCE REPORT(CONT'D)

QA/QC Batch	Init	QC Type	Parameter	Date Analyzed	Value	Recovery	UNITS	QC Limits
			Total Calcium (Ca)	2016/05/25	ND, RDL=100		mg/kg	
			Total Chromium (Cr)	2016/05/25	ND, RDL=1.0		mg/kg	
			Total Cobalt (Co)	2016/05/25	ND, RDL=0.30		mg/kg	
			Total Copper (Cu)	2016/05/25	ND, RDL=0.50		mg/kg	
			Total Iron (Fe)	2016/05/25	ND, RDL=100		mg/kg	
			Total Lead (Pb)	2016/05/25	ND, RDL=0.10		mg/kg	
			Total Lithium (Li)	2016/05/25	ND, RDL=5.0		mg/kg	
			Total Magnesium (Mg)	2016/05/25	ND, RDL=100		mg/kg	
			Total Manganese (Mn)	2016/05/25	ND, RDL=0.20		mg/kg	
			Total Mercury (Hg)	2016/05/25	ND, RDL=0.050		mg/kg	
			Total Molybdenum (Mo)	2016/05/25	ND, RDL=0.10		mg/kg	
			Total Nickel (Ni)	2016/05/25	ND, RDL=0.80		mg/kg	
			Total Phosphorus (P)	2016/05/25	ND, RDL=10		mg/kg	
			Total Potassium (K)	2016/05/25	ND, RDL=100		mg/kg	
			Total Selenium (Se)	2016/05/25	ND, RDL=0.50		mg/kg	
			Total Silver (Ag)	2016/05/25	ND, RDL=0.050		mg/kg	
			Total Sodium (Na)	2016/05/25	ND, RDL=100		mg/kg	
			Total Strontium (Sr)	2016/05/25	ND, RDL=0.10		mg/kg	
			Total Thallium (Tl)	2016/05/25	ND, RDL=0.050		mg/kg	
			Total Tin (Sn)	2016/05/25	ND, RDL=0.10		mg/kg	
			Total Titanium (Ti)	2016/05/25	ND, RDL=1.0		mg/kg	
			Total Uranium (U)	2016/05/25	ND, RDL=0.050		mg/kg	
			Total Vanadium (V)	2016/05/25	ND, RDL=2.0		mg/kg	
			Total Zinc (Zn)	2016/05/25	ND, RDL=1.0		mg/kg	
			Total Zirconium (Zr)	2016/05/25	ND, RDL=0.50		mg/kg	
8278248	DJ	RPD	Total Aluminum (Al)	2016/05/25	0.83		%	35

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QUALITY ASSURANCE REPORT(CONT'D)

QA/QC Batch	Init	QC Type	Parameter	Date Analyzed	Value	Recovery	UNITS	QC Limits
			Total Antimony (Sb)	2016/05/25	1.2		%	30
			Total Arsenic (As)	2016/05/25	NC		%	30
			Total Barium (Ba)	2016/05/25	1.5		%	35
			Total Beryllium (Be)	2016/05/25	NC		%	30
			Total Bismuth (Bi)	2016/05/25	NC		%	30
			Total Cadmium (Cd)	2016/05/25	11		%	30
			Total Calcium (Ca)	2016/05/25	2.7		%	30
			Total Chromium (Cr)	2016/05/25	4.2		%	30
			Total Cobalt (Co)	2016/05/25	1.3		%	30
			Total Copper (Cu)	2016/05/25	1.0		%	30
			Total Iron (Fe)	2016/05/25	2.8		%	30
			Total Lead (Pb)	2016/05/25	0.50		%	35
			Total Lithium (Li)	2016/05/25	NC		%	30
			Total Magnesium (Mg)	2016/05/25	2.4		%	30
			Total Manganese (Mn)	2016/05/25	4.2		%	30
			Total Mercury (Hg)	2016/05/25	NC		%	35
			Total Molybdenum (Mo)	2016/05/25	1.4		%	35
			Total Nickel (Ni)	2016/05/25	1.6		%	30
			Total Phosphorus (P)	2016/05/25	0.024		%	30
			Total Potassium (K)	2016/05/25	1.4		%	35
			Total Selenium (Se)	2016/05/25	NC		%	30
			Total Silver (Ag)	2016/05/25	NC		%	35
			Total Sodium (Na)	2016/05/25	NC		%	35
			Total Strontium (Sr)	2016/05/25	0.58		%	35
			Total Thallium (Tl)	2016/05/25	NC		%	30
			Total Tin (Sn)	2016/05/25	NC		%	35
			Total Titanium (Ti)	2016/05/25	0.054		%	35
			Total Uranium (U)	2016/05/25	4.5		%	30
			Total Vanadium (V)	2016/05/25	0.31		%	30
			Total Zinc (Zn)	2016/05/25	0.23		%	30
			Total Zirconium (Zr)	2016/05/25	NC		%	30
8278262	BCO	Spiked Blank	Soluble (2:1) pH	2016/05/25		100	%	97 - 103
8278262	BCO	RPD	Soluble (2:1) pH	2016/05/25	0.14		%	N/A
8278315	JXV	QC Standard	Soluble Calcium (Ca)	2016/05/25		99	%	75 - 125
			Soluble Magnesium (Mg)	2016/05/25		96	%	75 - 125
			Soluble Potassium (K)	2016/05/25		112	%	75 - 125
			Soluble Sodium (Na)	2016/05/25		97	%	75 - 125
8278315	JXV	Method Blank	Soluble Calcium (Ca)	2016/05/25	ND, RDL=5.0		mg/L	
			Soluble Magnesium (Mg)	2016/05/25	ND, RDL=5.0		mg/L	
			Soluble Potassium (K)	2016/05/25	ND, RDL=20		mg/L	
			Soluble Sodium (Na)	2016/05/25	ND, RDL=5.0		mg/L	
			Soluble Sulphur (S)	2016/05/25	ND, RDL=30		mg/L	
8278315	JXV	RPD [OQ8911-08]	Soluble Calcium (Ca)	2016/05/25	1.2		%	30
			Soluble Magnesium (Mg)	2016/05/25	0.30		%	30
			Soluble Potassium (K)	2016/05/25	NC		%	30
			Soluble Sodium (Na)	2016/05/25	1.0		%	30
			Soluble Sulphur (S)	2016/05/25	0.82		%	30
8278657	JXV	Spiked Blank	Soluble (Hot water) Boron (B)	2016/05/25		108	%	75 - 125

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Maxxam Job #: B638809
Report Date: 2016/06/02

MMM GROUP
Client Project #: 3315439

QUALITY ASSURANCE REPORT(CONT'D)

QA/QC Batch	Init	QC Type	Parameter	Date Analyzed	Value	Recovery	UNITS	QC Limits
8278657	JXV	Method Blank	Soluble (Hot water) Boron (B)	2016/05/25	ND, RDL=0.10		mg/kg	
8278657	JXV	RPD [OQ8911-07]	Soluble (Hot water) Boron (B)	2016/05/25	8.7		%	35
8279567	JHC	QC Standard	Available (CaCl2) Sulphur (S)	2016/05/27		101	%	75 - 125
8279567	JHC	Spiked Blank	Available (CaCl2) Sulphur (S)	2016/05/27		100	%	80 - 120
8279567	JHC	Method Blank	Available (CaCl2) Sulphur (S)	2016/05/27	ND, RDL=2.0		mg/kg	
8279567	JHC	RPD [OQ9336-04]	Available (CaCl2) Sulphur (S)	2016/05/27	4.4		%	35
8279637	BB3	Matrix Spike [OQ8911-08]	Soluble Chloride (Cl)	2016/05/26		NC	%	75 - 125
8279637	BB3	QC Standard	Soluble Chloride (Cl)	2016/05/26		108	%	75 - 125
8279637	BB3	Spiked Blank	Soluble Chloride (Cl)	2016/05/26		98	%	80 - 120
8279637	BB3	Method Blank	Soluble Chloride (Cl)	2016/05/26	ND, RDL=5.0		mg/L	
8279637	BB3	RPD [OQ8911-08]	Soluble Chloride (Cl)	2016/05/26	2.2		%	30
8279638	BB3	Matrix Spike [OQ8911-08]	Soluble Sulphate (SO4)	2016/05/26		NC	%	75 - 125
8279638	BB3	QC Standard	Soluble Sulphate (SO4)	2016/05/26		95	%	75 - 125
8279638	BB3	Spiked Blank	Soluble Sulphate (SO4)	2016/05/26		85	%	80 - 120
8279638	BB3	Method Blank	Soluble Sulphate (SO4)	2016/05/26	ND, RDL=10		mg/L	
8279638	BB3	RPD [OQ8911-08]	Soluble Sulphate (SO4)	2016/05/26	0.48		%	30
8279934	JGD	Method Blank	Loss on Ignition	2016/05/26	ND, RDL=1.0		%	
8279934	JGD	RPD [OQ8911-05]	Loss on Ignition	2016/05/26	0		%	35
8279939	JGD	Method Blank	Total Solids (Fixed)	2016/05/26	ND, RDL=0.10		%	
			Total Solids (Volatile)	2016/05/26	ND, RDL=0.10		%	
8279939	JGD	RPD [OQ8911-07]	Total Solids (Fixed)	2016/05/26	0.012		%	20
			Total Solids (Volatile)	2016/05/26	0.057		%	20
8281457	JLD	QC Standard	Total Carbon	2016/05/28		93	%	75 - 125
8281457	JLD	Spiked Blank	Total Carbon	2016/05/28		95	%	75 - 125
8281457	JLD	Method Blank	Total Carbon	2016/05/28	ND, RDL=0.020		%	
8281457	JLD	RPD	Total Carbon	2016/05/28	3.6		%	35
8283262	SF1	Matrix Spike [OQ9336-06]	Available (KCl) Ammonia (N)	2016/06/01		89	%	75 - 125
8283262	SF1	Spiked Blank	Available (KCl) Ammonia (N)	2016/06/01		99	%	75 - 125
8283262	SF1	Method Blank	Available (KCl) Ammonia (N)	2016/06/01	ND, RDL=0.50		mg/kg	
8283262	SF1	RPD [OQ9336-06]	Available (KCl) Ammonia (N)	2016/06/01	5.4		%	30
8283942	LZ0	Spiked Blank	Dry Specific Gravity	2016/05/31		100	%	97 - 103
8283942	LZ0	RPD [OQ8911-04]	Dry Specific Gravity	2016/05/31	0.45		%	35
8285236	IW1	Matrix Spike [OQ9336-06]	Nitrate plus Nitrite (N)	2016/06/01		89	%	70 - 130
8285236	IW1	Spiked Blank	Nitrate plus Nitrite (N)	2016/06/01		88	%	70 - 130
8285236	IW1	Method Blank	Nitrate plus Nitrite (N)	2016/06/01	ND, RDL=2.0		ug/g	

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Maxxam Job #: B638809
Report Date: 2016/06/02

MMM GROUP
Client Project #: 3315439

QUALITY ASSURANCE REPORT(CONT'D)

QA/QC Batch	Init	QC Type	Parameter	Date Analyzed	Value	Recovery	UNITS	QC Limits
8285236	IW1	RPD [OQ9336-06]	Nitrate plus Nitrite (N)	2016/06/01	NC		%	30

N/A = Not Applicable

Duplicate: Paired analysis of a separate portion of the same sample. Used to evaluate the variance in the measurement.

Matrix Spike: A sample to which a known amount of the analyte of interest has been added. Used to evaluate sample matrix interference.

QC Standard: A sample of known concentration prepared by an external agency under stringent conditions. Used as an independent check of method accuracy.

Spiked Blank: A blank matrix sample to which a known amount of the analyte, usually from a second source, has been added. Used to evaluate method accuracy.

Method Blank: A blank matrix containing all reagents used in the analytical procedure. Used to identify laboratory contamination.

NC (Matrix Spike): The recovery in the matrix spike was not calculated. The relative difference between the concentration in the parent sample and the spiked amount was too small to permit a reliable recovery calculation (matrix spike concentration was less than 2x that of the native sample concentration).

NC (Duplicate RPD): The duplicate RPD was not calculated. The concentration in the sample and/or duplicate was too low to permit a reliable RPD calculation (one or both samples < 5x RDL).

(1) Reference Material exceeds acceptance criteria for Mo. 10% of analytes failure in multielement scan is allowed.

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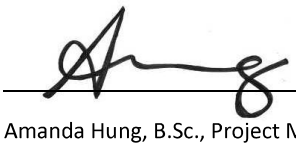
Maxxam Job #: B638809
Report Date: 2016/06/02

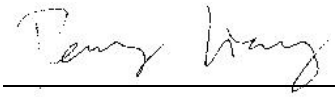
MMM GROUP
Client Project #: 3315439

VALIDATION SIGNATURE PAGE

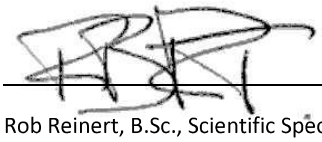
The analytical data and all QC contained in this report were reviewed and validated by the following individual(s).



Amanda Hung, B.Sc., Project Manager



Harry (Peng) Liang, Senior Analyst



Rob Reinert, B.Sc., Scientific Specialist

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Your Project #: B638809
Your C.O.C. #: N-A

Attention:Amanda Hung

MAXXAM ANALYTICS
675 BERRY ST
UNIT D
WINNIPEG, MB
CANADA R3H 1A7

Report Date: 2016/05/30
Report #: R2144526
Version: 1 - Final

CERTIFICATE OF ANALYSIS

MAXXAM JOB #: B630049
Received: 2016/05/20, 10:30

Sample Matrix: SLUDGE
Samples Received: 2

Analyses	Quantity	Date Extracted	Date Analyzed	Laboratory Method	Primary Reference
Total Extractable Metals by ICP*	2	2016/05/27	2016/05/27	QUE SOP-00132	MA 200-Met 1.2 R5 m
Inorganic Phosphorus*	2	2016/05/27	2016/05/27	QUE SOP-00124	MA 300-P.Ino 2.0 R2m

Reference Method suffix “m” indicates test methods incorporate validated modifications from specific reference methods to improve performance.
Note: RPDs calculated using raw data. The rounding of final results may result in the apparent difference.

* Maxxam is accredited as per the MDDELCC program.

Encryption Key

Please direct all questions regarding this Certificate of Analysis to your Project Manager.
Mathieu Letourneau, B. Sc., Chemist,
Email: MLetourneau@maxxam.ca
Phone# (418) 658-5784 Ext:6432

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Maxxam Job #: B630049
Report Date: 2016/05/30

MAXXAM ANALYTICS
Client Project #: B638809

TOTAL EXTRACTABLE METALS (SLUDGE)

Maxxam ID		CJ4932	CJ4934		
Sampling Date		2016/05/19 10:30	2016/05/19 10:30		
COC Number		N-A	N-A		
	Units	**CELL 1 NORTH (OQ8911)**	**CELL 1 SOUTH (OQ9336)**	**RDL**	**QC Batch**
% MOISTURE	%	93	84	N/A	N/A
METALS					
Total phosphorous	mg/kg	8800	4800	20	1610513

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch
N/A = Not Applicable

2016/05/30 09:18

Maxxam Analytics International Corporation o/a Maxxam Analytique 2690, Avenue Dalton, Sainte-Foy, Québec G1P 3S4 Tél.: (418) 658-5784 Télécopieur: (418) 658-6594

Maxxam Job #: B630049
Report Date: 2016/05/30

MAXXAM ANALYTICS
Client Project #: B638809

CONVENTIONAL PARAMETERS (SLUDGE)

Maxxam ID		CJ4932	CJ4934		
Sampling Date		2016/05/19 10:30	2016/05/19 10:30		
COC Number		N-A	N-A		
	Units	CELL 1 NORTH (OQ8911)	CELL 1 SOUTH (OQ9336)	RDL	QC Batch
% MOISTURE	%	93	84	N/A	N/A
CONVENTIONALS					
Inorganic phosphorous	mg/kg	9500	4200	1000	1610770

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch
N/A = Not Applicable

2016/05/30 09:18

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Maxxam Job #: B630049
Report Date: 2016/05/30

MAXXAM ANALYTICS
Client Project #: B638809

GENERAL COMMENTS

All results are calculated on a dry weight basis except where not applicable.

Condition of sample(s) upon receipt: GOOD

TOTAL EXTRACTABLE METALS (SLUDGE)

Please note that the results have not been corrected for QC recoveries nor for the method blank results.

CONVENTIONAL PARAMETERS (SLUDGE)

Please note that the results have not been corrected for QC recoveries nor for the method blank results.
Reported detection limits are multiplied by dilution factors used for sample analysis.

Results relate only to the items tested.

2016/05/30 09:18

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Maxxam Job #: B630049
Report Date: 2016/05/30

MAXXAM ANALYTICS
Client Project #: B638809

QUALITY ASSURANCE REPORT

QA/QC Batch	Init	QC Type	Parameter	Date Analyzed	Value	Recovery	Units
1610513	JB3	QC Standard	Total phosphorous	2016/05/27		97	%
1610513	JB3	Method Blank	Total phosphorous	2016/05/27	<20		mg/kg
1610770	DP3	QC Standard	Inorganic phosphorous	2016/05/27		104	%
1610770	DP3	Method Blank	Inorganic phosphorous	2016/05/27	<10		mg/kg

QC Standard: A sample of known concentration prepared by an external agency under stringent conditions. Used as an independent check of method accuracy.

Method Blank: A blank matrix containing all reagents used in the analytical procedure. Used to identify laboratory contamination.

2016/05/30 09:18

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Maxxam Job #: B630049
Report Date: 2016/05/30

MAXXAM ANALYTICS
Client Project #: B638809

VALIDATION SIGNATURE PAGE

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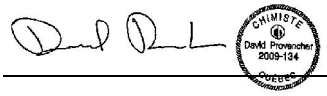

David Provencher, B.Sc., Chemist

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Application Rate based on Nitrogen				Land Area Required (Ha)
Nitrogen Based Application Rate	Dried Basis	tonnes ha^{-1}	34.39	**11**
Amount of Available P2O5 applied	Dried Basis	kg ha^{-1}	283.80	
P2O5 Application check		%	506.78	
Application Rate based on Phosphorous (1xCR)				**Land Area Required (Ha)**
Total Phosphorus Based Application Rate	Dried Basis	tonnes ha^{-1}	10	**37**
Amount of Nitrogen applied	Dried Basis	kg ha^{-1}	35	
Additional Nitrogen required		kg ha^{-1}	88	
Application Rate based on Phosphorous (2xCR)				**Land Area Required (Ha)**
Total Phosphorus Based Application Rate	Dried Basis	tonnes ha^{-1}	**19.82**	**18**
Amount of Nitrogen applied	Dried Basis	kg ha^{-1}	70.99	
Additional Nitrogen required		kg ha^{-1}	52.21	

Selected Application rate based on:		**2xCR**	**P2O5**
Selected Application rate based on P2O5	Dried Basis	tonnes ha^{-1}	**20**
		tons ac^{-1}	**9**
	Wet	tonnes ha^{-1}	610
		L ha^{-1}	628,066
		tons ac^{-1}	274
		igal ac^{-1}	**55,898**
Estimated Biosolids Volume Applied	Wet	Tonnnes	17,074
Estimated Biosolids Volume Remaining	Wet	Tonnes	- 5,825

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 0.25year 1

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

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

Phosphorous Total and Olsen methods.

* See Estimates of Ammonium-N Retained After Biosolids application

C:N exceeds 30:1, N becomes a limiting nutrient for decomposer organisms, and this can reduce the rate of decomposition and results in N immobilization

C:P ratio between 200:1 and 300:1, mineralization and immobilization balance each other to result in no net release of P from the decomposing manure. When C:P is below this range, P is released.

When animal and municipal wastes have N:P ratios ranging from 1:1 to 1:2 are applied based on N rates on soils, over time P will accumulate