REPORT NO. 17M-00008-00

CITY OF WINNIPEG BIOSOLIDS LAND APPLICATION

ENVIRONMENT ACT PROPOSAL

FINAL REPORT

CITY OF WINNIPEG
BIOSOLIDS LAND APPLICATION
ENVIRONMENT ACT PROPOSAL

SUBMITTED TO:

Manitoba Sustainable Development
Environmental Approvals Branch
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WSP Project No: 17M-00008-00

Issue Date: January 30, 2018
Effective Date: January 30, 2018

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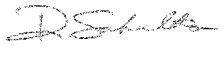

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EXECUTIVE SUMMARY

INTRODUCTION

This Environment Act Proposal is being submitted to the Manitoba Sustainable Development, Environmental Approvals Branch, as required under *The Environment Act* for the purpose of obtaining a Class 2 Environment Act Licence for the land application of biosolids material produced by the City of Winnipeg's North End Sewage Treatment Plant.

The City of Winnipeg (City) is proposing to apply approximately 20,000 wet metric tonnes of Class B municipal biosolids yearly, onto agricultural lands located within proximity to the City, for example, on lands within the Rural Municipalities of Rosser, Macdonald, and Cartier (land application program).

OBJECTIVE

The land application program will be completed in an agri-environmentally sustainable manner, will comply with applicable regulatory requirements, will be allied with participating agricultural producer fertilization and crop management practices and will implement best management practices that include good neighbour practices.

LAND APPLICATION PROGRAM BENEFITS

Currently, most of the biosolids (approximately 42,300 wet metric tonnes or 90% per year) produced by the City are sent to, and buried in the Brady Road Resource Management Facility (landfill). Landfill disposal of biosolids is not desirable in the long term as it increases the creation of methane and other greenhouse gases, takes up space and valuable nutrients from the biosolids are lost. Land application is a safe and sustainable way to manage biosolids.

STAKEHOLDER AND PUBLIC ENGAGEMENT

A stakeholder and public engagement program was completed for the land application program that involved a Capital Region workshop, seven municipal stakeholder meetings, two public open house events, one-on-one agricultural producer discussions and a promotion system that included newsletters, posters, radio ads and newspaper ads. The input provided by stakeholders, agricultural producers and the public informed program direction, principles and details, as well as assisted with identifying potential land application locations.

BASELINE DATA COLLECTION

A constraints map was developed during the initial stage of the land application program that aided in the identification of a regional study area to focus identification of Rural Municipalities and agricultural producers interested in participating in the land application program. The regional study area was defined for the land application program as the area of land within a 100 kilometer radius around the North End Sewage Treatment Plant. The constraints map was based on the following parameters: transport haul distance and route from the North End Sewage Treatment Plant, existing land use, regulatory requirements under *The Environment Act* and *The Water Protection Act*, as well as socio-economic factors.

Based on the constraints map, stakeholder and public input, and agricultural producer interest, the agricultural area to the west of the North End Sewage Treatment Plant that included the RMs of Cartier, Macdonald and Rosser were identified as the focus area for the land application program (note: although participating agricultural producers within the RMs of Cartier, Macdonald and Rosser have been identified for the commencement of the land application program in 2018, in the future, participating agricultural lands/interested agricultural producers may be expanded to include those in other RMs around the City such as Woodlands and Rockwood). In order to provide a description of the biophysical and socio-economic environments within the focus area, a desktop review of ecological, physical and socio-economic information for the land application program focus area was conducted that entailed an examination of applicable Federal and Provincial government databases, websites and mapping resources.

In addition, two pilot programs were completed in September – November of 2017 in order to demonstrate the feasibility and effectiveness of biosolids land application including a Land Application Pilot Program and a Field Storage Assessment. Both pilots were conducted under a Notice of Alteration to the City's current Environment Act License (EAL) No. 1089E RR.

BIOSOLIDS APPLICATION LOGISTICS

An initial estimate of land required for application of up to 20,000 wet metric tonnes of biosolids per year was determined to be between 300 hectares (740 acres) to 455 hectares (1,125 acres) per year depending upon the approach to the prescription for nitrogen or phosphorus. The approach to developing a sustainable program is to establish a 1 in 4-year land base rotation. This will require a net land base between 1,200 hectares and 1,820 hectares. This estimate for the annual land base does not account for soil residual nutrient concentrations, crop rotations or for other influences (e.g. buffer zones) on the program. Specific agricultural fields utilized in the land application of biosolids will be confirmed annually.

Biosolids prescription rates will be developed to target optimum available nitrogen and phosphorus levels for small grain and oil seed crops and set metal loading limits for the agricultural fields in the application program for a given year. Application rates will comply with applicable regulatory requirements, guidelines and best management practices. This objective meets the principals of environmentally sustainable land application outlined by MSD and within the Canadian Council of Ministers of the Environment Guidance Document for the Beneficial Use of Municipal Biosolids, Municipal Sludge and Treated Septage (December, 2012).

Application of the biosolids will occur after crop harvest (September – November) each year, and as such, temporary field storage will be required for the 3,000 – 4,000 wet metric tonnes of biosolids produced by the North End Sewage Treatment Plant each month that are to be used in the land application program. Based on the Field Storage Assessment, the three most feasible field biosolids storage options include covering of the biosolids stockpiles with straw cover, woodchip cover or hydro-mulch cover.

POTENTIAL ENVIRONMENTAL EFFECTS

Potential environmental effects associated with the proposed land application program include:

- → Biophysical Effects:
  - Soil Quality Effects
    - o Nutrient loading

    - Metals
    - Salinity and sodicity
    - Soil compaction
  - Water Quality Effects:
    - Surface water
    - Groundwater pollution
  - Natural vegetation, wildlife and species of conservation concern
- Socio-economic Effects:
  - Pathogens
  - Odour
  - Emerging substances of concern
  - Vehicle traffic
  - Noise and dust
  - Accidents and malfunctions

MITIGATION MEASURES

Appropriate mitigation measures will be employed in order to minimize risk to human and environmental health and safety from the land application of biosolids, including such measures as:

- Biosolids will only be applied to agricultural lands with a Canada Land Inventory Agricultural Capability of Class 1 to 4, and within Nutrient Management Zones N1, N2 or N3.
- Biosolids will not be applied on lands located within 30 metres of Provincial flood designated areas.
- Biosolids prescription rates will be developed based on targeted crop uptake, residual soil nutrient levels and participating agriculture producers' soil fertility management programs.
- Applicable setback distances around residential areas, residences, groundwater wells, surface water drainage systems and sensitive areas/features will be established as outlined in the provincial *Nutrient Management Regulation* under *The Water Protection Act* and the Farm Practices Guidelines for Pig Producers in Manitoba (April 2007).
- Best management practices including good neighbour practices will be employed, and a Transport Management Plan and a Spill Response Plan will be developed as part of the land application program.

FOLLOW-UP ACTIONS, MONITORING AND REPORTING

The City of Winnipeg is committed to completing the following monitoring and reporting requirements for the land application program:

- Completion of a yearly program review/start-up meeting between the City, applicator contractor, hauling contractor and consultant (if applicable), to review the procedure and requirements of the program including requirements outlined in the Environment Act Licence. Yearly meetings will be completed in January-February of each application year.

- At least two weeks prior to the commencement of the biosolids land application, the City will provide details of the biosolids and receiving field soil analysis as well as proposed prescription rates for biosolids application to the Director of the Manitoba Sustainable Development, Environmental Approvals Branch.
- By January 31 of each year following the application of biosolids for the land application program, the City will submit a report to the Director of the Manitoba Sustainable Development, Environmental Approvals Branch that summarizes soil fertility analytical results, prescribed biosolids application rates, and application activities completed for the program in a given year.
- Monitoring of odour control mechanisms (e.g. straw cover) at field storage locations will be completed periodically by visual observations and to evaluate odour generation based on established procedures developed from the field storage assessment completed in 2017 by the City.
- Recording of each scaled truck load and net biosolids weight transported to the field storage locations.
- Completion of weekly on-site inspections/monitoring during biosolids application.
- Post-harvest soil monitoring will be conducted on the participating agricultural fields for three years post application of biosolids in order to monitor nutrient loading within the soils. Soil samples will be collected at depth of, and analysis will include: sodium bicarbonate extractable phosphorus in 0-15 cm and nitrate-nitrogen and total nitrogen in 0-15 cm and 15-60 cm. Participating agricultural producers 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 Manitoba Sustainable Development, Environmental Approvals Branch by January 31 of each year following the application of biosolids.

SUMMARY

Based on regulatory requirements, public engagement and pilot studies, the City has identified potential agricultural area/cooperating agricultural producers for biosolids land application and proposes to apply biosolids in a sustainable manner at balanced agronomic rates using appropriate mitigation measures to optimize reuse of valuable nutrients.

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TABLES

APPENDICES

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
dry metric tonne ..... dmt
foot ..... ft
gram ..... g
grams per kilogram ..... g/kg
grams per litre ..... g/L
greater than ..... >
hectare ..... ha
hour(s) ..... hr
inch ..... in
kilogram ..... kg
kilometre ..... km
less than ..... <
litre L
litre per hour ..... L/hr
metre ..... m
microns ..... µm
microSiemens per cm ..... uS/cm
millimho per centimeter ..... mmho/cm
milligram ..... mg
milligram per gram ..... mg/g
milligrams per litre ..... mg/L
milligrams per kilogram ..... mg/kg
moles ..... mol
moles per gram ..... mol/g
sample size ..... n =
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
wet metric tonne ..... wmt

ACRONYMS

biological nutrient removal ..... BNR
Brady Road Resource Management Facility ..... Brady Facility
British Columbia ..... BC
Canadian Land Inventory CLI
Canadian Council of Ministers of the Environment ..... CCME
City of Winnipeg ..... the City
Manitoba Conservation Data Centre ..... MB CDC
Department of Fisheries and Oceans ..... DFO
electrical conductivity ..... E.C.
endocrine-disrupting chemicals ..... EDC
Environment Act License ..... EAL
Environment Act Proposal ..... EAP
Environmental Approvals Branch ..... EAB
emerging substances of concern ..... ESOCs
Ferric Chloride ..... $FeCl_3$
greenhouse gas ..... GHG
Iron ..... Fe
Iron (III) Phosphate ..... $FePO_4$
Local Urban District ..... LUD
Manitoba ..... MB

ACRONYMS (CONTINUED)

Manitoba Endangered Species and Ecosystems Act …	MESEA
Manitoba Sustainable Development	MSD
metres above sea level	amsl
Nitrogen	N
North End Sewage Treatment Plant	NEWPCC
Nutrient Management Regulations	NMR
personal care products	PPCP
Phosphorus	P
Phosphate	PO_4
Plant Available Nitrogen	PAN
Plant Available Phosphorus (P_2O_5)	PAP
Public Engagement Program	PEP
right-of-way	ROW
Rural Municipality	RM
South End Sewage Treatment Plant	SEWPCC
Sodium Absorption Ratio	SAR
Species at Risk Act	SARA
total solids	TS
United States Environmental Protection Agency	USEPA
West End Sewage Treatment Plant	WEWPCC
WSP Canada Group Limited.	WSP

1 INTRODUCTION

1.1 LAND APPLICATION PROGRAM OVERVIEW

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 land application of municipal biosolids produced by the City of Winnipeg's (City) North End Sewage Treatment Plant onto agricultural lands within rural municipalities (RMs) located in proximity to the City of Winnipeg (land application program).

1.1.1 PROPONENT

The proponent for the land application program is the City of Winnipeg, Water and Waste Department. The primary contact from the City for the land application program is Mr. Chris Carroll, P. Eng., MBA, Manager of Wastewater Services.

City of Winnipeg
109-1199 Pacific Avenue
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1.1.2 LOCATION OF LAND APPLICATION PROGRAM

The land application program will involve transporting biosolids via enclosed truck from the City's North End Sewage Treatment Plant (NEWPCC) located at 2230 Main Street, to agricultural fields within the RMs of Rosser and / or Macdonald and / or Cartier (Map 1, Appendix A). Suitable agricultural lands within other RMs may also be considered for inclusion in the land application program as applicable. Specific agricultural fields utilized in the land application of biosolids will be confirmed annually. The required land base will rotate on a 1 in 4 year basis, thereby allowing land application to occur on year 1 and again in fall of year 4 of the program, thus allowing for three years of crop nutrient removal before reapplication of biosolids. It is anticipated that all agricultural fields will be located within 100 kilometres (km) travel distance of the NEWPCC.

1.2 BACKGROUND

The City operates three wastewater treatment plants, the NEWPCC, South End Sewage Treatment Plant (SEWPCC) and the West End Sewage Treatment Plant (WEWPCC). Currently, all City municipal sludge is produced at, or hauled to, the NEWPCC where it is anaerobically digested to produce biosolids.

In January, 2011 the Provincial *Nutrient Management Regulation* was updated to include more stringent nutrient principles, which prohibited land application in winter and decreased the allowable biosolids application rate. Prior to January 2011, City biosolids were applied to agricultural land over the entire year (January through December) as part of the City's WinGRO program (EAL No. 1089E RR). Since 2011, due to these regulatory changes, City biosolids have been disposed of at the Brady Road Resource Management Facility (Brady Facility).

In 2014, the City submitted a Biosolids Master Plan to MSD (formerly Conservation and Water Stewardship). The Master Plan was developed in response to the updated *Water Protection Act*, which states that the City's wastewater biosolids must be beneficially re-used and nutrients must be recovered and recycled to the maximum extent possible. An extensive public engagement program (PEP) was conducted to assist in developing the Biosolids Master Plan and included establishment of a Stakeholder Advisory Committee, public meetings, surveys, etc. Some of the themes that emerged from the PEP included the need to re-use the nutrients in biosolids, the need to find long term management solutions and concerns about health impacts of biosolids re-use. The resulting Biosolids Master Plan is a 30-year vision for how the City will manage its biosolids in an environmentally sound, sustainable, and cost-effective manner, while meeting Provincial regulations. It includes multiple beneficial re-use strategies for maximum flexibility and robustness including a recommendation for the application of biosolids to agricultural land as one of the beneficial re-use strategies. The City received approval for the Biosolids Master Plan from MSD in March 2016.

1.2.1 FUTURE INFRASTRUCTURE DEVELOPMENT

Future plans for the treatment of the City's wastewater include completing major capital upgrade and expansion projects for its two largest wastewater treatment plants, SEWPCC and NEWPCC. The SEWPCC Upgrade/Expansion project includes upgrades to several major processes, including upgrading the secondary treatment to biological nutrient removal (BNR). The SEWPCC Upgrade/Expansion project is currently in the construction stage.

The NEWPCC Upgrade project includes upgrades to several major processes, including upgrading the secondary treatment to BNR. The NEWPCC Upgrade is currently in the early design stage. The NEWPCC Upgrade also includes new sludge treatment facilities for sludge pre-treatment, storage, handling, digestion and dewatering. The NEWPCC Upgrade includes design and construction of the following new sludge process facilities:

1. Sludge phosphorus release and thickening;
2. Sludge screens and intermediate dewatering;
3. Thermal hydrolysis facility;
4. Mesophilic anaerobic digesters;
5. Phosphorus recovery system;
6. Final dewatering facility; and,
7. Biosolids cake hauling station.

NEWPCC will continue to be the centralized location for sludge processing, during construction and after the upgrades are complete. Sludge from SEWPCC and WEWPCC will continue to be hauled to NEWPCC for treatment. Figure 1 shows the existing sludge handling process and Figure 2 shows the proposed future sludge handling process.

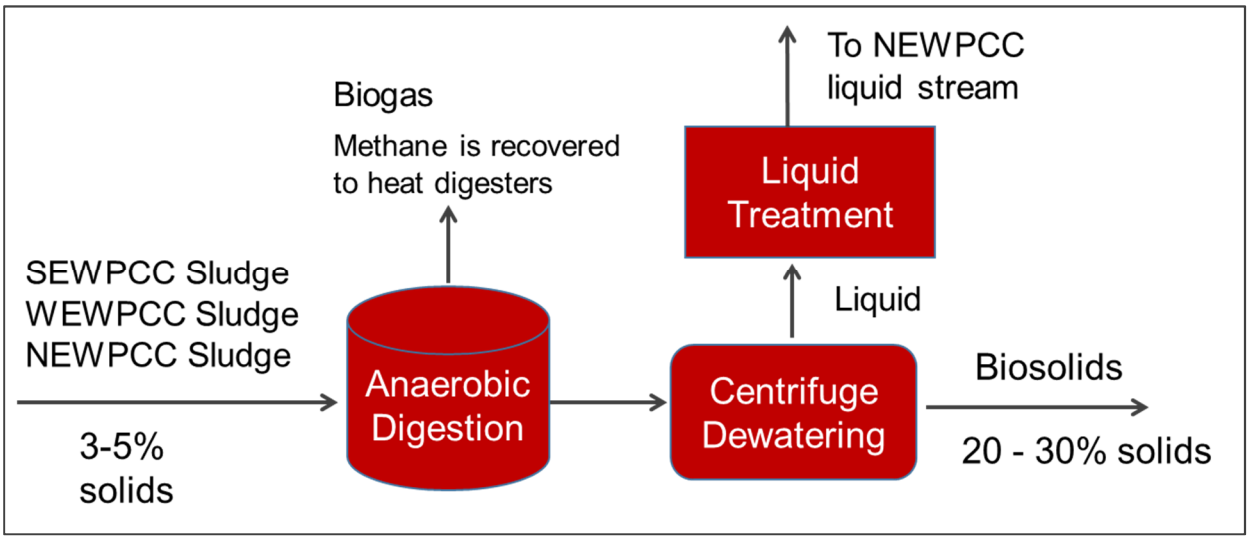

Figure 1. Current Sludge Treatment at NEWPCC

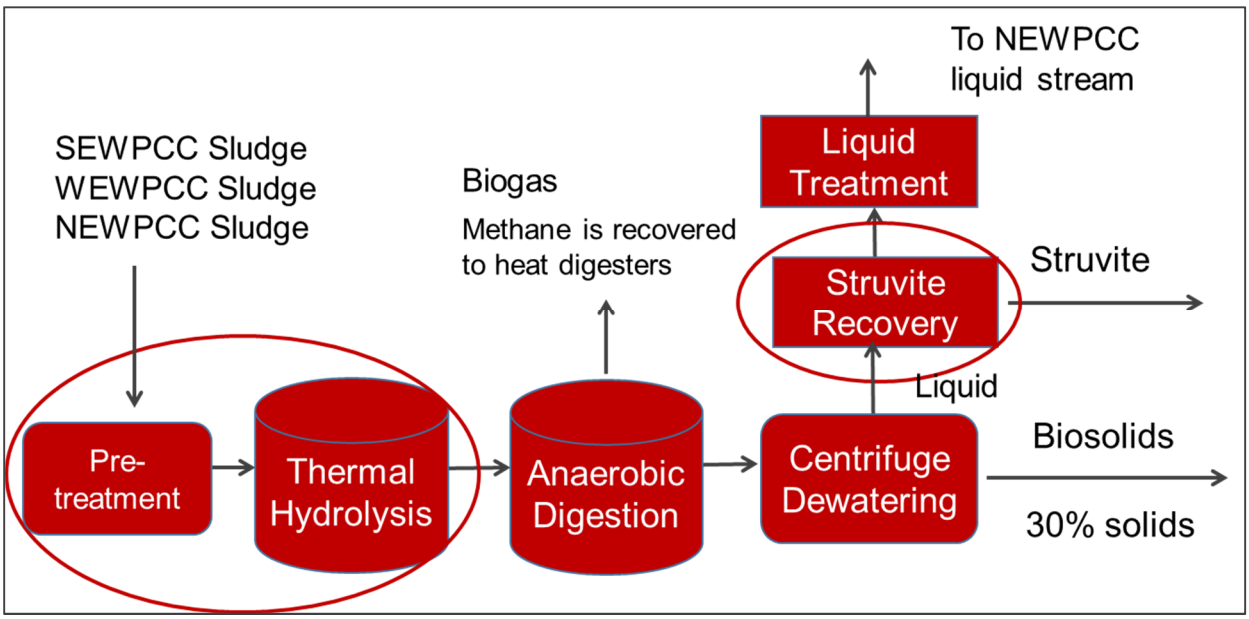

Figure 2. Future Sludge Treatment at NEWPCC

1.3 OBJECTIVE

The objective of this EAP is to provide documentation in support of attainment of an EAL for the City to complete an agronomically and environmentally sustainable land application program for up to 70% of the monthly biosolids produced during May through October of a given year (application season). This equates to approximately 20,000 wet metric tonnes (wmt) per application season of biosolids collected from the City's NEWPCC.

In addition to being completed in an agri-environmentally sustainable manner, the land application program will comply with all applicable regulations, will be allied with participating agricultural producer fertilization and crop management practices and will implement best management practices including incorporating good neighbour practices.

Biosolids loading limits will be determined to target optimum available nitrogen and phosphorus levels for small grain – oil seed crops and set metal loading limits for the agricultural fields in the application program. This objective meets the principals of environmentally sustainable land application outlined by MSD and within the Canadian Council of Ministers of the Environment (CCME) Guidance Document for the Beneficial Use of Municipal Biosolids, Municipal Sludge and Treated Septage (December, 2012).

1.4 LAND APPLICATION PROGRAM NEEDS, ALTERNATIVES, BENEFITS

1.4.1 NEEDS AND ALTERNATIVES

In 2016 the City produced 47,000 wmt of Class B[1] biosolids (average of 27% solids). Currently, most of the biosolids (approximately 42,300 wmt or 90%) produced by the City are sent to, and buried in the Brady Road Resource Management Facility (Brady Facility). Landfill disposal of biosolids is not desirable in the long term as it increases the creation of methane and other greenhouse gases (GHGs), takes up space, and valuable nutrients from the biosolids are lost.

Upgrades at the NEWPCC will result in the future production of Class A[1] biosolids which means that the biosolids will have fewer pathogens and a higher percentage of solids making the material easier to handle and transport, and the material will be subject to less regulatory restrictions in terms of public reuse and / or land application.

In the interim period, until the NEWPCC upgrade is complete, the City is implementing several strategies that support the beneficial re-use and recycling of biosolids nutrients including: 1) a biosolids composting project with approximately 10%-12% of available biosolids; 2) a soil fabrication project for the remediation of landfill sites; and, 3) a land application program (basis of this EAP report) that would divert approximately 20,000 wmt of biosolids from the Brady Facility.

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[1] The U.S. Environmental Protection Agency (EPA) guidelines (https://www.epa.gov/sites/production/files/2015-12/documents/biosolids_final_report.pdf) refer to different categories of biosolids: Class A and Class B. The difference between Class A and Class B is the level of pathogens, level of pollutants (e.g. metals) and degree of attractiveness to vectors. Class A biosolids are treated to a greater degree, and therefore have less pollutants, pathogens and are less attractive to vectors. The U.S. EPA therefore affords fewer restrictions on Class A biosolids re-use (refer to Section 6.2.1 of this EAP for additional information).

1.4.2 LAND APPLICATION PROGRAM BENEFITS

Land application is a sustainable way to manage biosolids. It provides an opportunity to re-use the biosolids, keeping them out of the landfill. Land application of biosolids:

- → Meets regulatory requirements.
- → Returns much needed nutrients to local agricultural land (nitrogen, phosphorus, potassium, sulfur and micronutrients).
- → Provides organic matter that improves soil structure, drainage, aeration and erosion protection.
- → Reduces GHGs through carbon sequestration.
- → Provides economic value for agricultural producers for multiple years, in reduced fertilizer cost and improved crop yields.
- → Removes significant volume of material from the landfill.

1.5 DESCRIPTION OF REGULATORY REQUIREMENTS

The following Acts and Regulations apply and will be adhered to throughout the completion of the land application program:

- → *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 OVERVIEW OF PROPOSED BIOSOLIDS LAND APPLICATION PROGRAM

The biosolids land application program was designed to include three (3) Phases. Phases 1 and 2 were completed in 2017. Both Phase 1 and 2 of the land application program provided direction and aided in developing the EAP for Phase 3, the proposed full scale land application program. Phase 3 is scheduled to begin in the summer of 2018 (pending EAL approval by the MSD, EAB).

→ Phase 1 – Constraints Mapping and Public Engagement Program

- The initial part of this Phase involved the development of a land suitability constraints map for an area that covered a 100 km distance radius from the NEWPCC. Constraints in the mapping exercise included such aspects as land classification (e.g. urban vs. agricultural), soil suitability, regulatory restrictions (e.g. Red River Valley Special Management Area), cropping systems, travel distance, road accessibility, and proximity to communities, natural areas and water bodies. This information aided in identifying a potential regional area that would be suitable for biosolids land application.
- Subsequent to the constraints mapping, a public engagement program (PEP) was undertaken to further refine a regional area, address stakeholder and public concerns, identify rural municipalities that would be accepting of having local agricultural producers participate in the land application program and to identify potential participating agricultural producers.

→ Phase 2 – Pilot Programs

- The second Phase of the land application program involved conducting pilot programs for a small-scale biosolids land application program and for a temporary field storage assessment. Both of these pilot programs were conducted under the City's existing EAL No.1089E RR.
- The intent of the pilot programs was to demonstrate the agronomic and environmental sustainability and feasibility of the land application program to various provincial regulators, stakeholders, the public and perspective agricultural landowners, while obtaining feedback and support for the program.
- A secondary result for the pilot programs was to better understand the logistics and lessons of biosolids land application. This included the needs for transport, off-loading, storage, direct haul, supply, incorporation, land access and participating agricultural producer needs.

→ Phase 3 – Land Application Program

- Phase 3 of the land application program involves conducting the full scale land application program including: determining the amount of land required for the program; defining the quantity and quality of the biosolids; identifying applicable land and land owners with agronomic practices for the program that meet the identified constraints; incorporating applicable regulatory requirements into the program; and, development of methodologies/plans for transportation, temporary field storage and land application and incorporation of the biosolids.

2.1.1 EAL TERMINATION

It is presently understood that Class B biosolids require an EAL and that Class A biosolids likely will not require an EAL for re-use management. This EAP and the granted licence will need to function until such a time as the upgrades at the City's NEWPCC are completed and Class A biosolids are produced. It is requested that the EAL granted for the land application program does not include a termination date.

2.2 TASKS AND SCHEDULE OF EVENTS

The following schedule outlines the tasks and timeframes associated with the land application program from initiation and planning through development of the EAP and first year of Phase 3, the full scale biosolids land application (refer to Table 1). The schedule for the biosolids land application includes consultation with the participating agricultural producers and their agronomic advisors in order to develop prescription rates that target crop nutrient uptake and removal and match agricultural producer agronomic needs. Application rates will be based on crop uptake and removal of phosphorus for a multi-year application event with the objective of returning to the same agricultural fields on a 1 in 4 year land rotation.

Table 1. Summary of Schedule for Biosolids Land Application Program

Task	Timeframe
Initiation & Planning, EAP Development, Granting of EAL by MSD	**January 2017 – June 2018**
Phase 1 - Planning	January – March 2017
Phase 1 - Public Engagement Program	April - August 2017
▪ Capital Region Workshop	April 2017
▪ Municipal Stakeholder Meetings	May - July 2017
▪ Public Open Houses	June - July 2017
Phase 1 - Sourcing Participating Agricultural Producers	June - September 2017
Phase 2 - Pilot Programs	
▪ Land Application Pilot Program	September - October 2017
▪ Field Storage Assessment	September - November 2017
Development of EAP Report	April - December 2017
▪ Report Completion	December 2017
▪ Submission to MSD	January 2018
▪ Granting of EAL by MSD	June 2018
Commence Phase 3, Full Land Application Program*	June - November 2018*
• Field Storage of Biosolids	June - November 2018
• Land Application	September – November 2018
Continuation of Land Application Program, Monitoring & Reporting	**2019 and on, as applicable**

*Dependent upon EAL approval from MSD.

Further details regarding the Phases 1, 2 and 3 of the land application program are provided in the remainder of this EAP report.

3 PHASE I – CONSTRAINTS MAPPING AND PUBLIC ENGAGEMENT PROGRAM

3.1 CONSTRAINTS MAPPING

During the initial stage of the land application program, a constraints map was developed in order to aid the project team in identifying Capital Region stakeholders and a potential regional study area that would provide the largest potential land base for the land application program. The constraints map for the land application program included mapping of the following parameters:

3.1.1 TRANSPORT HAUL DISTANCE AND ROUTE

A key component of the constraints map was the establishment of a maximum biosolids haul distance from the NEWPCC of 100 km. A preferred haul distance radius of 100 km from the NEWPCC was defined in order to accommodate the required number of truck round trips per day to provide the 20,000 wmt of biosolids (90 wmt per day) per application season scheduled for the annual program. Subsequently, a preferred target radius of 55 km was established for the constraints map as it was determined that schedule and cost limitations associated with the initial haul distance of 100 km were prohibitive to a successful land application program.

Haul route options were determined based on compliance with Manitoba Infrastructure's maximum gross vehicle weight restriction for the provincial highway and road network. In general Manitoba highways under the jurisdiction of the Minister of Infrastructure are classified as either Roads and Transportation Association of Canada (RTAC) routes, Class "A1" or Class" B1" highways. Each class of highway has its own specific axle loading and gross vehicle weight limits which can be found in Schedule H of the *Vehicle Weights and Dimensions on Classes of Highways Regulation MR 575/88*. This regulation will be used to aid in determining annual haul routes to agricultural fields participating in the land application program.

3.1.2 LAND USE

Land use within the 100 km travel distance from NEWPCC was also mapped in order to exclude potential areas from the program; excluded areas included urban/residential areas and centres, areas that were unavailable (e.g. fall within the Red River Valley Special Management Area or within a flood zone), and other non-agricultural areas (e.g. forested areas and waterbodies). Land use/suitability was also mapped (based on the Manitoba Land Inventory database) whereby only those lands identified as having an Agricultural Capability of Class 1 to 4, or a Nutrient Management Zone of N1, N2 or N3 under annual crop production were included, and all pasture/hay land and non-productive land (forested/wooded, urban areas/centres, parks and protected areas, water bodies) were excluded.

3.1.3 SOCIO-ECONOMIC FACTORS

Other socio-economic factors were also taken into account in the mapping exercise and included constraints such as First Nation and Metis lands, air strips, railway lines, and parks, protected areas and provincial forests.

3.1.4 CONSTRAINTS MAP SUMMARY

A final constraints map (refer to Map 1, Appendix A) was developed for a 100 km travel distance from the NEWPCC that identified suitable lands for the application program that met the following requirements:

- → Designated as “agricultural”
- → Agricultural Capability of Class 1 to 4
- → Nutrient Management Zone designation of N1, N2 or N3.
- → Annual cropland
- → Outside of special management and flood designated areas

3.2 PUBLIC ENGAGEMENT PROGRAM

Following the identification of a regional study area, a PEP was undertaken in order to inform the local rural municipalities within the regional area, regional stakeholders, agricultural producers and the public about the proposed land application program and to obtain feedback and support for the program.

3.2.1 OBJECTIVE OF THE PEP

The objective of the PEP was to work with landowners, stakeholders, and the public to identify a biosolids land application program which supports opportunities and needs, mitigates concerns and helps educate the public on biosolids land application. The goals of the public engagement strategy were:

- → To support an open and transparent engagement process;
- → To build a shared understanding of biosolids land application;
- → To seek out values, priorities, and interests in biosolids application, not validation of proposed solutions; and,
- → To support the EAP.

3.2.2 PEP OVERVIEW

The PEP was initiated in April of 2017 and continued through Phase 2 (the pilot programs) and was completed in November, 2017. The intent of the PEP was to:

- → Engage a wide range of stakeholders early in the process to maximize public input, identify critical issues early, and improve decision making;
- → Seek out stakeholder values and priorities through in-person and online public engagement;
- → Develop educational materials for stakeholders and the public to facilitate program understanding;
- → Differentiate between past biosolids application programs and the proposed program;
- → Secure support from municipal leadership where biosolids land application is proposed; and,
- → Maintain two-way communication with participating agricultural producers and site application neighbours through frequent communication during the pilot programs.

The PEP included: a Capital Region workshop, seven municipal stakeholder meetings, two public open house events, one-on-one agricultural producer discussions, and a promotion system that included newsletters and an online comment form. The input provided by stakeholders, agricultural producers and the public informed program direction, principles, and details, as well as assisted with identifying potential application locations. Details regarding the PEP are provided in the following sections.

3.2.2.1 WEBSITE

On April 3, 2017 a biosolids land application program webpage was launched on the City of Winnipeg Water and Waste's Public Engagement Projects website available at: winnipeg.ca/biosolidslandapplication.

The website featured bilingual materials including: background information, a timeline of events, frequently asked questions and information on how to get involved. Contact information for the WSP Public Engagement Lead for the land application program was also provided on the website including a dedicated toll free telephone number/ message service and email address, both of which were monitored by the Public Engagement Lead. Questions/comments/concerns received via telephone or email were recorded and responses from the project team were provided back within three days of receipt.

3.2.2.2 CAPTIAL REGION WORKSHOP

A half-day workshop was held to invite stakeholders to provide input on opportunities, constraints and community outreach strategies including development of guiding principles for the biosolids land application program. Regional stakeholders included representatives from agricultural organizations, environmental organizations, government departments and producer associations. Seventeen (17) stakeholders participated in the workshop. The workshop included a 30 minute presentation with a 10 minute question and answer period, followed by small group discussion and task work.

3.2.2.3 MUNICIPAL STAKEHOLDER MEETINGS

Seven (7) meetings were held with municipal stakeholders, including municipal councils, watershed basin commissions and local groups. Municipal stakeholders shared input on opportunities, constraints, potential agricultural producer concerns and potential public concerns, as well as approaches for odour management, leachate management, application rates, and monitoring and reporting. Stakeholder meetings included:

- → Red River Basin Commission (RRBC) Manitoba North Chapter, May 18, 2017, 7 p.m. to 8 p.m., Grosse Isle Community Hall, Grosse Isle. Approximately 30 members in attendance.
- → RRBC Manitoba South Chapter, May 19, 2017, 10 a.m. to 11 a.m., City of Winkler Municipal Office, Winkler. Approximately 60 members in attendance.
- → Partnership of the Manitoba Capital Region (PMCR), May 25, 2017, 10 a.m. to 11 a.m., PMCR Board Office, Winnipeg. Thirteen (13) members in attendance.
- → R.M. of Macdonald Council, May 23, 2017, 2 p.m. to 3 p.m., R.M. of Macdonald Municipal Office, Sanford. Seven (7) individuals representing R.M. Council and Administration.
- → R.M. of Cartier Council, May 23, 2017, 4 p.m. to 5 p.m., R.M. of Cartier Municipal Office, Elie. Eight (8) individuals representing R.M. Council and Administration.

- → R.M. of Rosser Council, June 13, 2017, 11 a.m. to 12 p.m., R.M. of Rosser Municipal Office. Five (5) individuals representing R.M. Council and Administration.
- → Assiniboine River Basin Initiative, July 20, 2017, 10:30 a.m. to 11:30 a.m. Marion Street, Winnipeg. One (1) member in attendance.

3.2.2.4 PUBLIC OPEN HOUSES

The public was invited to two open houses to learn about the proposed program, potential application site areas, speak with the project team and provide comments on the program. A survey form was provided at the open houses to collect feedback. A total of 12 people attend the two Public Open Houses and six surveys were completed. The Open Houses were held:

- → July 11, 2017, 4 p.m. to 7 p.m., Brunkild Memorial Recreation Centre, Brunkild.
- → July 12, 2017, 4 p.m. to 7 p.m., Elie Veteran's Hall, Elie.

The public engagement materials and survey were also made available online on the City's webpage for those unable to attend either Open House.

3.2.2.5 ONLINE SURVEY

The survey was available online on the City's webpage from June 28 to July 28, 2017 to collect public feedback. A total of 34 online survey responses were received – 30 responses came from individuals residing within Manitoba and four from outside Manitoba.

3.2.2.6 AGRICULTURAL PRODUCER DISCUSSIONS

The project team met one-on-one with interested agricultural producers to discuss property-specific information, nutrient management and farm agronomy.

3.2.2.7 PROMOTION

The land application program was promoted using the following methods:

- → Public Engagement Newsletter sent to approximately 5,500 subscribers of City email news on June 29, 2017, July 13, 2017, and July 27, 2017.
- → Program updates through the City's Facebook and Twitter account.
- → Newspaper ads placed in the Manitoba Co-operator (June 29, 2017), The Headliner (June 28, 2017), and the Cartier Times (July, 2017 edition).
- → Program posters for Public Open House events were posted in the towns of Rosser, Marquette, Grosse Isle, St. Francois Xavier, Oak Bluff, Sanford, Brunkild, Sperling, Starbuck, Springstein, and Elie on June 27, 2017.
- → A radio advertisement aired July 7, 8, and 10, 2017 on 93.1 CFRY, a Portage la Prairie based radio station, three times per day (morning, afternoon, and rush hour).
- → Notices were posted on the Rural Municipality of Macdonald, Cartier and Rosser websites in late June, 2017.
- → One-on-one meetings with agricultural producers helped further promote the program and the public open houses throughout the summer of 2017.

3.2.3 SUMMARY OF RESPONSES RECEIVED THROUGH THE PEP

Responses/questions/comments/concerns received from the public, stakeholders and agricultural producers during the PEP are summarized in Table 2. This information was utilized to aid in the development of the EAP and Phase 3 of the land application program.

Table 2. Summary of Responses Received Through the PEP

Opportunities and Constraints for Biosolids Land Application	
What We Heard	**How It Was Considered**
It is important that biosolids land application occurs with minimal risks to the environment.	To reduce risks to the environment, the program will include separation or setback distances from bodies of water, wetlands and groundwater features, no application on lands subject to flooding, application rates based on the agricultural producer agronomy, as well as consideration of the crop system, landscape features and soil conditions.
It is important that biosolids land application occurs with minimal risks to human health.	To reduce risks to human health, the program will include separation or setback distances to residential areas, cropping rotation and crop type restrictions for three years following application, as well as separation in time from land application to harvest.
There are gaps in the literature regarding the presence and potential harm of emerging substances of concern such as pharmaceuticals, antibiotics, etc., in biosolids.	Emerging substances of concern (ESOCs) in biosolids continue to be studied in Canada and around the world. The City will monitor ongoing scientific research on effects and mitigation measures. The biosolids land application program will comply with all applicable federal and provincial regulations, and it will operate under an Environment Act Licence from Manitoba Sustainable Development.
There is limited public awareness and public knowledge of biosolids as well as potentially uncooperative agricultural producers and/or municipalities may prevent biosolids land application from occurring.	The City developed a series of public engagement materials in both technical and plain language to make program information accessible to people of all backgrounds. Agricultural producers and municipalities were engaged early-on in the program to ensure that their concerns are heard and could be addressed.

Program Details	
What We Heard	**How It Was Considered**
Soil properties, local drainage patterns, risk of overland flooding, and other existing nutrient application programs will influence the location of where the biosolids may be applied.	A Professional Agrologist will manage the biosolids application rates, which will be prescribed to agronomic rates and ensure the sites selected for land application are suitable.
Trucks delivering biosolids may damage gravel roads.	The City is committed to maintaining and/or repairing roads damaged by trucks delivering biosolids to storage sites and/or application sites. Truck routes and site access will be important factors for selecting land application sites. Truck routes will adhere to the *Vehicle Weights and Dimensions on Classes of Highways Regulation*.
The program should avoid applying biosolids near built-up areas, especially residential, to reduce potential impacts to community residents (i.e., odour, traffic and dust).	The land application will not occur within 75 metres of any occupied residence (other than the residence on the land on which the biosolids are applied) and one kilometre of designated towns. Additionally, biosolids will be incorporated or tilled into the soil within 48 hrs of application.
Public Education and Awareness	
What We Heard	**How It Was Considered**
Educating the public on biosolids and wastewater treatment is important for meaningful public participation, and that efforts should be directed to making information easily available on the program.	The City developed a series of public engagement materials available at the in-person public engagement events and the program website. Public engagement materials were presented in both technical and plain language to make program information accessible to people of all backgrounds. In addition, the website and many of the public engagement materials have been translated into French.
The program should have scientific information available and include a transparent process through public reporting.	The City of Winnipeg biosolids are sampled and tested every two weeks for metals, nutrients (nitrogen and phosphorus), pH, and organic carbon content. The results are provided through the City's licensing and monitoring website. Annually, the City of Winnipeg prepares biosolids compliance reports to summarize the biosolids testing data. These reports are available on the City's licensing and monitoring website. The results of the biosolids land application program, including site locations, soil sampling results and biosolids data will be available on the City's licensing and monitoring website.

Public Education and Awareness CONTINUED	
What We Heard	**How It Was Considered**
The local municipal council and administration should be aware of biosolids land application occurring within their rural municipality.	Once land application sites are selected, the City will notify the local municipal council(s) and administration(s).
Municipal councils, conservation districts, agricultural producers, and residents should be engaged through one-on-one meetings, small group meetings and open houses.	Throughout the public engagement process, the project team engaged with municipal councils, conservation districts, agricultural producers and community residents through in-person and online engagement opportunities.

3.3 INDIGENOUS ENGAGEMENT

The City reached out to nearby First Nations communities and Mètis organizations to share information and receive input on the biosolids land application program.

3.3.1 IDENTIFICATION OF FIRST NATIONS AND MÉTIS COMMUNITIES

The land application program is located on Treaty One territory and is in an area of potential historical and current interest to First Nations and Métis people in Manitoba. The City considered a number of factors in determining which communities and organizations to contact:

1. First Nations or Northern Affairs Communities located near the target land application program area west and southwest of the City;
2. First Nation reserves located near the target land application program area west and southwest of the City; and,
3. Interest in the land application program.

Based on these factors Peguis First Nation, Roseau River Anishinabe First Nation and Swan Lake First Nation were contacted because of reserves located near the target land application program area. The Manitoba Métis Federation was contacted because it was anticipated that the organization may be interested in the land application program based on their mandate “to promote the participation and representation of the Métis people in key political and economic bodies and organizations” (MMF, 2017).

3.3.2 ENGAGEMENT APPROACH

The City sent introductory letters to First Nations and Métis leadership on May 9, 2017 by registered mail. The letters provided a brief description of the land application program while inviting community/organization leadership to a meeting. The intent of the meeting was to:

- → Introduce the program;
- → Gather input and ideas for the program;
- → Discuss questions and concerns regarding the program; and,
- → Determine how best to engage with the community/organization, if further engagement was desired.

A contact from the City's Water and Water Department was provided for follow-up. The introductory letters were received on May 15, 2017. Follow-up phone calls were made to the communities/organizations on May 24, 2017 to confirm that the letters were received and re-express interest in meeting with leadership to discuss the land application program. In total, the City notified and invited three First Nations communities and the Manitoba Métis Federation to participate in the program development.

3.3.3 ENGAGEMENT ACTIVITIES

The City met with the Manitoba Métis Federation August 17, 2017. The meeting was to introduce the program, gather feedback to be considered during the program development and determine if further engagement is required. A Quick Facts handout, Program Details and Proposed Approach handout, and the open house presentation boards were provided to all participants. Feedback from the meeting that was shared by the Manitoba Métis Federation is provided below. It is important to note that discussion points below are not intended to capture all feedback, but rather provide a high-level summary of key discussion topics.

- → The Manitoba Métis Federation representatives explained that they are primarily concerned with how the program could impact traditional land use practices and harvesting activities including changes to the quality of fish. There were also concerns about the cumulative effects with other projects in the area including wastewater discharged to the rivers from the City's three sewage treatment plants.
- → The Manitoba Métis Federation representatives described concerns about potential environmental and human health effects from the program including emerging substances of concern, metal content, nutrients.
- → The Manitoba Métis Federation representatives expressed an interest in the legislation, regulations and guidelines that are applicable to the land application program along with the licensing process.
- → The Manitoba Métis Federation representatives indicated that they would like to be kept updated on the status of the program.

The City remains open to meeting and engaging with any First Nations communities and Métis organizations regarding the program should there be any interest or concerns that arise. First Nations and Métis individuals were also able to participate and provide their input in the general public engagement program describe in Section 3.2.

3.4 SELECTION OF REGIONAL STUDY AREA

Land application program constraints identified during the planning process as well as information gathered during the PEP and initial constraints mapping (e.g. haul distances from the NEWPCC, availability of Class 1-4 agricultural land), were utilized to identify an initial Regional Study Area (RSA) for the land application program that included the RMs of Cartier, Macdonald and Rosser (refer to Maps 2, 3 and 4 in Appendix A). The RSA was defined in order to encompass sufficient land area for the initiation of the land application program and to examine potential effects on regional land use, development, recreation and stakeholder/public interests.

It is important to note that although participating agricultural producers within the RMs of Cartier, Macdonald and Rosser have been identified for the commencement of the land application program in 2018, in the future, participating agricultural lands/interested agricultural producers may be expanded to include those in other RMs such as Woodlands and Rockwood.

4 DESCRIPTION OF EXISTING SOCIO-ECONOMIC AND BIOPHYSICAL ENVIRONMENTS IN REGIONAL STUDY AREA

A desktop review of ecological, physical and socio-economic information for the RSA was conducted that entailed an examination of applicable Federal and Provincial government databases, websites and mapping resources in order to provide a description of the biophysical and socio-economic environments within the RSA. In addition, information collected for the PEP and constraints mapping was also included in the desktop review.

4.1 SOCIO-ECONOMIC ENVIRONMENT

4.1.1 POPULATION AND ECONOMIC CHARACTERISTICS

4.1.1.1 RM OF CARTIER

The RM of Cartier covers an area of approximately 56,287 ha and is located 10 km west of the City of Winnipeg along the south side of the Assiniboine River and on either side of the Trans-Canada Highway. Cartier's north boundary is formed by the Assiniboine River. Cartier shares a border with the RM of St. Francois Xavier to the north, the RM of Portage la Prairie to the west, the RM of Headingley to the east, and the RMs of Grey and Macdonald to the south. Between 2011 and 2016, Cartier saw moderate growth of 6.8%, just above the Provincial average of 5.8%, and boasts a population of 3,368 (Statistics Canada, 2016). Cartier's farming community covers 50,839 ha (125,627 acres) and represents a total market value of $530.1M (Census of Agriculture, 2016). There were a total of 83 farms in Carter in 2016 with the majority being oilseed and grain farms, followed by soybean, animal production, and vegetable and melon farms. Cartier is home to several rural communities including Dacotah, the Local Urban Districts (LUD) of Elie, St. Eustache, Springstein and White Plains.

4.1.1.2 RM OF MACDONALD

The RM of Macdonald covers an area of approximately 116,000 ha and borders the southwest perimeter of the City of Winnipeg. The Rural Municipality of Macdonald is located southwest of Winnipeg, centred on PTH 2 and PTH 3. Macdonald is surrounded by the RMs of Cartier and Headingley to the north, the RMs of Grey and Dufferin to the west, the RM of Morris to the south and the RM of Richot to the east. Between 2011 and 2016, Macdonald saw a significant growth rate of 14% with its total population reaching 7,162. Macdonald's farming community covers 110,280 ha (272,509 acres), representing over $1.1B in market value (Census of Agriculture, 2016). There were a total of 214 farms in Macdonald in 2016 with the majority being oilseed and grain farming, followed by wheat farming, animal production, cattle ranching and feedlots. Macdonald is home to several communities including Oakbluff, Sanford and La Salle as well as several rural settlement centres including Domain, Brunkild and Starbuck.

4.1.1.3 RM OF ROSSER

The RM of Rosser covers an area of approximately 44,324 ha and is located adjacent to the northwest corner of the City of Winnipeg. It shares its border with the RM of Rockwood and Woodlands to the north, the RM of St. François Xavier to the west, the RM of Headingley to the south and the RM of West St. Paul to the east. Between 2011 and 2016, Rosser saw a growth rate of 1.5%, with its total population reaching 1,372 (Statistics Canada, 2016). Rosser's farming community covers roughly 35,263 ha (87,137 acres) making up a total market value of over $387.7M (Census of Agriculture, 2016). There were a total of 77 farms in 2016 with oilseed and grain farms making up the largest share, followed by other types of grain farming, soybeans, cattle ranching and other animal farming. Rosser features several rural settlement centres including Rosser, Marquette, Meadows and Gross Isle (shared with Rockwood). Rosser is also home to a large section of CentrePort Canada which is an industrial inland port situated in the south east corner of the municipality bounded by the Winnipeg Airport and the Perimeter Highway.

4.2 BIOPHYSICAL ENVIRONMENT

All three of the RMs within the RSA are primarily located with the Winnipeg Ecodistrict of the Lake Manitoba Plain Ecoregion which is covered by the broader Prairies Ecozone in Manitoba. The Winnipeg Ecodistrict encompasses an area of approximately 9,212 km^2 (Smith, Veldhuis, Mils, Eilers, Fraser and Lelyk 1998).

4.2.1 CLIMATE

The Winnipeg Ecodistrict is the most humid subdivision of the Grassland Transition Ecoclimatic Region in southern Manitoba (Smith, et al. 1998). The ecodistrict is characterised by short, warm summers and cold winters with a mean average temperature of 2.4^0C (Smith, et al. 1998). The average crop growing season is 183 days with approximately 1,720 growing degree-days. Mean annual precipitation is 521 mm, one fifth of which is in the form of snowfall (Government of Canada, 2017). The Winnipeg Ecodistrict has a cool, subhumid to humid Boreal to a moderately cold, subhumid, Cryoboreal soil climate with an average annual soil moisture deficit of approximately 200 mm (Smith, et al. 1998).

4.2.2 PHYSIOGRAPHY AND DRAINAGE

The Winnipeg Ecodistrict lies within the central lowland of the Red River Plain with a mean elevation of approximately 236 meters above sea level (masl). The Red River Plain is a smooth, level to very gently sloping, clayey glaciolacustrine plain (Smith, et al. 1998). The Red River flows through the plain and empties into Lake Winnipeg. Relief in the ecodistrict follows about 0.4 m for every km from the western edge of the plain to the Red River and at a rate of 1.0 m per km from its eastern edge to the Red River. From south to north, relief thorough the basin is approximately 0.3 m per km (Smith et al, 1998). The main drainage pathways for the RSA are the La Salle and Assiniboine Rivers. Maps 5, 6 and 7 in Appendix A provided an overview of the drainage systems within the RMs of Cartier, Macdonald and Rosser respectively.

4.2.3 SURFICIAL AND BEDROCK GEOLOGY

Throughout most of the RM of Cartier, surficial deposits consist of thick clay deposits ranging from 9 to 15 m (30 to 50 feet) in thickness, underlain by glacial till. In areas along the Assiniboine River and creeks within the RM, the upper layer of deposits consist of silt that is up to 6 m (20 feet) thick; some pockets also contain sandy, alluvial deposits. These surficial deposits are underlain primarily

by carbonate bedrock (limestone and dolostone) that is approximately 122 m (400 feet) in thickness. Depth to bedrock generally ranges from 12 to 18 m (40 to 60 feet) (Rutulis, 1973).

Throughout most of the RM of Macdonald, surficial deposits consist of thick clay deposits ranging from 7.5 to 15 m (25 to 50 feet) in thickness, underlain by glacial till and a few sand and gravel deposits. The sand and gravel deposits associated with the glacial till are generally less than a metre thick and are not extensive. Beneath the surficial deposits lies the carbonate bedrock (limestone and dolostone) that is approximately 122 m (400 feet) in thickness. Depth to bedrock generally ranges from 9 to 27 m (30 to 90 feet) (Rutulis, 1973).

Within the RM of Rosser, surficial deposits generally consist of thick clay ranging from 0 to 18 m (0 to 40 feet) in thickness, underlain by glacial till. To the east of the Village of Rosser, surficial deposits are underlain by either shale or carbonate bedrock (limestone and dolostone) and to the west, bedrock consists of carbonate rock. Thin shale layers that can be up to 21 m (70 feet) thick in places are also common in the upper 15 m (50 feet) of the carbonate bedrock. The total thickness of the carbonate bedrock is over 152 m (500 feet) (Rutulis, 1973).

4.2.4 GROUNDWATER AND HYDROLOGY

The RSA is located in an area in southern Manitoba that is underlain by a continuous carbonate (limestone and dolomite) rock aquifer. This aquifer was formed by thick and extensive carbonate rock beds with minor shale beds. Domestic groundwater wells developed into this aquifer yield more than 1.0 litre per second (L/s) and water quality ranges from good to very salty (total dissolved solids concentration of 5000 milligram per litre [mg/L] to 100,000 mg/L) but generally is good to fair throughout most of the extent of this aquifer (Rutulis, 1986a).

In addition to the bedrock aquifer, the RSA lies within an area that contains a few widely scattered minor sand and gravel aquifers where the bedrock is at or near ground surface or where the surficial deposit consist of low permeability materials (Rutulis, 1986b). As well, there are a few scattered confined and unconfined alluvial and glaciofluvial sand and gravel aquifers located in valleys and meandering belts, within the RMs of Cartier and Macdonald. These alluvial and glaciofluvial sand and gravel aquifers range from very small thin pockets to some fairly thick and extensive aquifers with well yields of 0.1 L/s to 50 L/s and with water quality that ranges from poor to good (Rutulis 1986).

For the RMs of Cartier and Macdonald, outside of the alluvial and glaciofluvial sand and gravel aquifers and a gravel pit area in the vicinity of the town of Elie, the bedrock aquifer in the RMs is covered by thick clay deposits and therefore groundwater pollution is not likely (Rutulis, 1973).

In most of the RM of Rosser, the aquifers are covered by fairly thick clay and / or till deposits and groundwater pollution is not likely. However, there are a few small areas where sand and gravel deposits are at or near the surface of the ground and may be water producing, and where the carbonate aquifer is near ground surface, and it is in these locations that groundwater pollution is a concern (Rutulis, 1973) (refer to Map 8).

4.2.5 SOILS AND TERRAIN

4.2.5.1 RM OF CARTIER

Soils within the RM of Cartier consist of dominantly Black Chernozems and Humic Gleysols of the Red River association. In wood areas along the Assiniboine River, soils are classified as Chernozemic Dark Gray soils and within the channel containing the Assiniboine River, soils are classified as Regosolic of the Riverdale association. An extensive area of Black Chernozem, Humic

Gleysol and Regosol soils developed on alluvial deposits of the Oakville association also exist in the western part of the RM (Agriculture and Agri-Food Canada, 1999b).

Due to the flat topography throughout the RM and high clay content in the soils, most of the soils are classified as imperfectly to poorly drained. Management considerations in the RM relate primarily to heavy clay textures of the soil and wetness. No significant relief features or stoniness conditions are problematic in the RM, however during the spring runoff, poorly drained areas are subject to periodic flooding. Minor areas of weak salinity, primarily associated with poorly drained soils occur at scattered locations throughout the RM and subsoil salinity is common at depths below 50 cm. (Agriculture and Agri-Food Canada, 1999b).

Most of the soils within the RM are rated as Class 2 (53%) and Class 3 (44%) for agricultural capability with moderate to moderately severe limitations for agriculture (Agriculture and Agri-Food Canada, 1999b) (refer to Map 2, Appendix A).

4.2.5.2 RM OF MACDONALD

Soils within the RM of Macdonald consist of dominantly Black Chernozems and Humic Gleysols of the Red River association. In wood areas along the La Salle River soils are classified as Chernozemic Dark Gray soils and within the channel containing the La Salle River, soils are classified as Regosolic of the Riverdale association.

Due to the flat topography throughout the RM and high clay content in the soils, most of the soils are classified as imperfectly to poorly drained (Agriculture and Agri-Food Canada, 1999a). Management considerations in the RM relate primarily to heavy clay textures of the soil and wetness. No significant relief features or stoniness conditions are problematic in the RM, however during the spring runoff, poorly drained areas are subject to periodic flooding. Minor areas of weak salinity, primarily associated with poorly drained soils occur at scattered locations throughout the RM and subsoil salinity is common at depths below 50 cm.

Most of the soils within the RM of Macdonald are rated as Class 2 (56%) and Class 3 (42%) for agricultural capability with moderate to moderately severe limitations for agriculture (Agriculture and Agri-Food Canada, 1999a) (refer to Map 3, Appendix A).

4.2.5.3 RM OF ROSSER

Soils within the RM of Rosser consist of dominantly Black Chernozems and Humic Gleysols of the Red River, Lakeland and Marquette soil associations. In the northern part of the RM, better drained local portions of the Semple association show weak characteristics of Chernozemic Dark Gray soils. Both the Semple and Marquette associations are underlain by glacial till (Agriculture and Agri-Food Canada, 1999c).

Due to the generally flat topography throughout the RM and high clay content in the soils, most of the soils are classified as imperfectly to poorly drained. Management considerations in the RM relate primarily to heavy clay textures of the soil and wetness. No significant relief features are problematic in the RM, however during the spring runoff, poorly drained areas are subject to periodic flooding. Minor areas of weak salinity, primarily associated with poorly drained soils occur at scattered locations throughout the RM and subsoil salinity is common at depths below 50 cm. Slight to moderately stony and cobbly conditions occur on low ridge areas throughout the Semple and Marquette soil areas (Agriculture and Agri-Food Canada, 1999c).

Most of the soils within the RM of are rated as Class 2 (62%) and Class 3 (37%) for agricultural capability with moderate to moderately severe limitations for agriculture (Agriculture and Agri-Food Canada, 1999c) (refer to Map 4, Appendix A).

4.2.6 VEGETATION, WILDLIFE AND HABITAT

Originally, the native vegetation within the Winnipeg Ecodistrict consisted of tall grass prairie, meadow prairie grass and meadow grass plant communities which have all but disappeared due to cultivation. Forested areas remain along the margins of stream channels and in small pockets within cultivated areas of the ecodistrict. In more well drained areas native vegetation species consist of bur oak and trembling aspen with understory species consist of snowberry, hazelnut and red-oiser dogwood. Tree species such as white elm, basswood, cottonwood, Manitoba maple and green ash with an understory of willows, Saskatoon, high bush cranberry and nannyberry shrubs as well as ferns and herbaceous vegetation occur in areas of alluvial floodplain deposits and lower river terraces (Smith et al, 1998).

These natural areas provide habitat for a range of wildlife species including white-tailed deer, coyote, red fox, rabbits, and small mammals as well as for a variety of songbird, raptor and waterfowl species (Smith et al, 1998).

4.2.7 SURFACE WATER BODIES

Within the RM of Macdonald, the primary waterways include the La Salle River and major drains such as the Norquay and Boyne Channels. Within the RM of Cartier, the main waterways include the Assiniboine River and La Salle River. The main waterways within the RM of Rosser include Sturgeon Creek and Omands Creek.

Throughout each of the RM's there are a network of streams and drains of different sizes with the smallest being first order streams/drains, then second and third order streams/drains. Within each of the RM watershed networks, the different size drain orders will be identified prior to the commencement of biosolids land application and the applicable regulatory buffers will be applied during land application events (as outlined in Table 4).

4.2.8 POTENTIAL SPECIES OF CONSERVATION CONCERN

For the purposes of this EAP, Species of Conservation Concern (SOCC) are identified as floral or faunal species that are protected by the Federal *Species at Risk Act* (SARA), Manitoba's *Endangered Species and Ecosystems Act* (MBESEA), those listed by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) as threatened, endangered, or special concern and those that are tracked as S1, S2, and S3 by the Manitoba Conservation Data Centre (MBCDC). Identification of SOCC or their critical habitats will likely require additional mitigation measures, engagement and consultation with environmental regulatory bodies, and potential avoidance. Table B.1, Appendix B, provides a list of species of conservation concern that have been found to occur within the Lake Manitoba Ecoregion.

Once specific agricultural fields are identified for inclusion in the land application program, a request will be submitted to the MBCDC for a search of any records they may have for SOCC historically found to occur within 100 m of the identified agricultural fields. In addition, a desktop review for natural areas adjacent to the agricultural fields will be completed in order to identify potential habitat for SOCC. Based on the MBCDC search results and desktop review, should SOCC or their habitat be identified within 100 m of a selected agricultural field, appropriate mitigation measures will be developed and implemented (e.g. establishment of setback distances from natural area/habitat).

It should also be noted that potential SOCC within the RSA are likely limited to existing grassland and forested natural areas primarily located along stream channels and in small areas/pockets in non-cultivated areas where setback distances will be accounted for as part of the land application program. Thus potential negative effects to SOCC from the land application program are expected to be negligible to minimal.

4.2.9 PARKS AND PROTECTED AREAS, FIRST NATIONS AND CROWN LANDS

Within the RM of Cartier, Beaudry Provincial Park and an area of agricultural crown lands are located along the southeast border of the RM (refer to Map 9, Appendix A). Portions of the eastern and southern areas of the RM of Macdonald lie within or are within the 30 m buffer zone of a provincially designated flood area (refer to Map 10, Appendix A). Grant's Lake Wildlife Management Area is located along the northwestern border of the RM of Rosser. In addition, the Roseau River Anishinabe First Nation is located within the RM (refer to Map 11, Appendix A). As such, any agricultural lands adjacent (within 100 m) to these areas will be excluded from participating in the land application program. Any future agricultural lands participating in the land application program from other RMs not discussed in this EAP, will be reviewed for proximity to parks, protected areas, First Nation and Crown Lands prior to inclusion in the program.

5 PHASE 2 – PILOT PROGRAMS

5.1 OVERVIEW OF LAND APPLICATION PILOT PROGRAM

5.1.1 OBJECTIVE

A biosolids land application pilot program was conducted in September through October of 2017 under the City's current EAL No. 1089E RR to demonstrate the feasibility of biosolids land application. The 2018 growing season will be used to demonstrate the effectiveness of the land application program for re-using nutrients in the biosolids to participating agricultural producers, the RMs of Cartier, Macdonald and Rosser and other stakeholders/interested parties.

5.1.2 SUMMARY OF LAND APPLICATION PILOT PROGRAM ACTIVITIES

During the PEP, an agricultural producer in the RM of Macdonald was sourced to provide land for the pilot program. The pilot program was designed to meet constraints associated with regulatory requirements (e.g. agricultural fields receiving biosolids are not subject to annual inundation) and good neighbour practices (notification letter was sent to adjacent landowners).

The land application pilot program was completed in an agri-environmentally sustainable manner whereby the prescription rate for biosolids land application was:

- → Allied with the participating agricultural producer's fertilization and crop management practices.
- → Determined to target optimum available nitrogen and phosphorus levels for small grain – oil seed crops and set metal loading limits for the agricultural fields in the application program.
- → Based on laboratory analysis of residual nutrient and metals soil tests (0-15 cm and 15-60 cm depths) and biosolids quality sampling.

The 2018 crop is planned to be canola, with a target yield of 55 bu/ac, thus requiring an estimated 168 kg/ha (150 lb/ac) of nitrogen and 62 kg/ha (55 lb/ac) of P_2O_5 (Personal Communication with Cooperating Farm Producer). Canola nutrient uptake and removal of P_2O_5 is reported to be between 33 to 44 lbs/ac for a 35 bushels per acre (bu/ac) yield, this is approximately 1 lb P_2O_5 per bushel of canola or 55 lb/ac for the target yield (Manitoba Soil Fertility Guide, 2007).

It is important to note that since 2007, the City's wastewater treatment process has included chemical treatment with the iron salt Ferric Chloride ($FeCl_3$) at the NEWPCC to precipitate Total Phosphorus out of the waste stream. The addition of $FeCl_3$ affects the availability of phosphorus for land application. The anticipated reduced availability was accounted for in the prescription rate calculations by reducing the anticipated percent total phosphorus available to 25% instead of the typical 50% rule.

The biosolids prescription rates for the land application pilot program were submitted in a letter to MSD on September 11, 2017. Based on the Notice of Alteration approval, condition #2, the land application program was based on two times annual crop removal of phosphorous with an estimated 25% of total phosphorous being plant available.

In total, 2,621 wmt of biosolids materials were applied on approximately 55 ha (135 ac) of land during the pilot program. Biosolids were spread over the east half of NE31-08-01EPM and the north and east half of SE31-08-01EPM between September 21 and October 23, 2017. Biosolids were applied at a rate of approximately, 12 dry metric tonnes (dmt) per hectare or 48 wmt per hectare based on the calculated prescription rate.

The Fall 2017 soil nutrient levels demonstrate a field nearly depleted in plant available nitrogen and phosphorus, therefore permitting an application rate for suitable redevelopment of the plants' nutrient base. The basic assumptions that the application rate was based on are as follows:

- → Fall 2017 soil residual nitrogen and phosphorus concentrations, while low, were accounted for as a resource for plant uptake and removal in the 2018 cropping year.
- → Biosolids solids content was estimated at an average of 27%.
- → $FeCl_3$ biosolids Phosphate-P was approximately 4% of total phosphorous content. The advised estimate of 25% total phosphorus was assumed for plant available phosphate.
- → Organic nitrogen mineralization in Year 1 was estimated at 20%, Year 2 at 12% and Year 3 at 6% (based on anticipated mineralization rates for manure as discussed in the Tri-Provincial Manure Application and Use Guidelines).
- → Biosolids were surface applied and incorporated within 48 hours (hrs). The assumed volatilization loss was estimated to be 15% for ammonia.

This established a phosphate based application (123 kg/ha [110 lb/ac] of P_2O_5) of approximately 12 dmt per hectare (48 wmt per hectare) to provide 99 kg/ha (88 lbs/acre) of plant available nitrogen.

Based on review of the literature, there is significant concern that the $FeCl_3$ biosolids will not meet the estimated plant available phosphate in year 1 due to the means that the iron salt will fix with the phosphorus ion and not allow it to be mineralized. Throughout the growing season of 2018 the soil base and canola crop will be monitored for nitrogen and phosphorus deficiency and managed appropriately if identified. The cooperating farm producer has been advised of these potential effects of ferric chloride and anticipated deficiencies.

Additional details pertaining to the pilot program were recorded in a summary report and provided to MSD, EAB in December of 2017 as required under the Notice of Alteration for EAL No. 1089E RR. A copy of the report entitled "City of Winnipeg Biosolids Land Application Pilot Program Summary Report, December 2017" is provided as a supplemental report to this EAP.

5.2 OVERVIEW OF FIELD STORAGE ASSESSMENT

5.2.1 BACKGROUND

In the full City of Winnipeg Biosolids Land Application Program it is anticipated that approximately 20,000 wmt of Class B biosolids will be land applied annually. The NEWPCC produces nearly 4,000 wmt monthly and can only house a minimum volume on-site. This requires the biosolids produced between May and September (start of land application program) to be hauled daily from the NEWPCC to a temporary field storage site until land application can proceed after crop harvest in the late summer/fall of a given year.

5.2.2 OBJECTIVE

During initial discussions held with the MSD, EAB, odour management and the method of field storage containment were identified as key issues for the land application program. In order to address these issues, the City conducted a field storage assessment in September through October, 2017 under their current EAL No. 1089E RR. The objective of the field storage assessment was to aid in determining the feasibility of field storage for the City's annual biosolids land application program and to assess field storage options for nuisance odours.

Additional details on the field storage assessment have been summarized in a report entitled "Summary Report City of Winnipeg Biosolids Land Application Field Storage Assessment, November 2017". This report is provided as a supplemental report to this EAP.

5.2.3 SUMMARY OF FIELD STORAGE ASSESSMENT ACTIVITIES

5.2.3.1 METHODS

The field storage assessment was completed on City owned land located southwest of the WEWPCC within the City of Winnipeg limits, adjacent to the RM of Headingley. The assessment was designed to meet constraints associated with regulatory requirements (e.g. assessment area was located at least 100 m from any surface water course, sinkhole, and spring or well and in a manner that does not cause pollution of surface water, groundwater or soil) and good neighbour practices (notification letter was sent to adjacent landowners).

Seven biosolids stockpiles were set up, each with a different cover material for evaluation purposes. The following Seven (7) storage options (including one control) were included in the assessment:

1. 12 x 1 tonne totes with plastic liner
2. Earth berm with straw cover
3. Earth berm with poly cover
4. Earth berm with hydro-mulch cover
5. Earth berm with ag-lime cover
6. Earth berm with woodchips
7. Earth berm with no cover (control)

Each storage option site was established as a 6x6 m bermed plot in which approximately 20 wmt of biosolids were deposited and then covered with the appropriate type of cover material being tested (i.e. straw, hydro-mulch, woodchips, ag-lime or poly cover). Note that for option 1, biosolids were placed within plastic tote bags.

The biosolids were stored at the assessment site from September 12 to November 2, 2017. During this time, there were regular site assessments conducted by the project team and other stakeholders. During the site assessments the storage plots were evaluated for:

- → Logistics of management of biosolids (Assiniboine Injections was asked to provide their opinion of the handling and storage of the biosolids during plot setup);
- → Odour control;
- → Leaching;

→ Storm water management; and,

→ Vector exposure and control

5.2.3.2 ODOUR ASSESSMENT

A key component of the field storage assessment was the evaluation of the potential odour annoyance associated with each of the storage plots. The odour assessment was conducted over a period of five weeks (four times) by an Odour Assessment Panel (Panel) that consisted of:

→ City of Winnipeg staff associated with the land application program / WSP staff working on the program (potential biased Panel members).

→ MSD regulators (unbiased Panel members).

→ Rural Municipality representatives and interested local agricultural producers (unbiased Panel members).

At each assessment event the Panel visited a background odour baseline area (biosolids-free area), and each of the seven storage plots. The Panel evaluated the odour at each area/plot following a procedure and an odour annoyance scale (refer to Table 3) adapted from the Good Practices Guide for Odour Management in Alberta, 2015, Clean Air Strategic Alliance.

Table 3. Odour Scale

Numerical Value	Annoyance Level	Intensity Level[2]
0	no odour	No offending odour observed.
1	a little annoying	Faint - The odour is barely detectable: you need to stand still and inhale while facing into the wind to notice it.
2	annoying	Moderate - The odour is easily detected while walking and breathing normally but it is not overpowering.
3	very annoying	Strong - The odour is penetrating; you can't get away from it and it can easily be detected at all times.
4	extremely annoying	Pungent - suffocating, causing a gag reflex.

Findings of odour assessment are summarized as follows:

→ Based on the field storage assessment, the uncovered biosolids stockpile odour levels were recorded to be primarily at a level 3 (very annoying - strong - the odour is penetrating; you can't

[2] Adapted from: Good Practices Guide for Odour Management in Alberta, 2015, Clean Air Strategic Alliance.

get away from it and it can easily be detected at all times) or less even at a distance of 5 m from the biosolids pile.

→ By adding a cover material (straw, woodchips, ag-lime, hydro-mulch or poly textile), odour associated with field storage of biosolids can be reduced. The highest odour levels were recorded during the first week of storage and when disturbed for plot decommissioning.

→ Odour concerns by local neighbours can likely be further reduced by adhering to applicable best management practices and prescribed setback distances, that include establishing field storage sites that are at least:

- 1,000 m from designated residential area; and,
- 300 m from a residence

6 BIOSOLIDS PARAMETERS

This section provides details on the quantity and quality of biosolids available from the City's NEWPCC.

6.1 BIOSOLIDS QUANTITY

In 2016 the City produced 47,000 wmt of Class B biosolids (average 27% solids). It is anticipated that 20,000 wmt will be available between May and October each year for the land application program.

6.2 BIOSOLIDS QUALITY

6.2.1 BIOSOLIDS CLASS

The US EPA categorizes biosolids into one of two classes – Class A and Class B. For biosolids to be categorized as Class A, pathogens must be reduced to virtually non-detectable levels and the material must also comply with strict standards for metals and odours and potential vector[3] attractant (CCME, 2010, US EPA, 1994). As such, Class A biosolids have few restrictions on use and can be sold to the public as a source of organic fertilizer or compost. A Class A designation can be achieved by the biosolids treatment through various processes such as lime stabilization, composting and thermal hydrolysis. Class B biosolids are treated but contain higher levels of detectable pathogens than Class A biosolids, are more odorous and have land application restrictions for heavy metal loading and cropping type (i.e. restricted to small grain and oil seed crops). Both classes of biosolids contain important nutrients and organic matter. The City's biosolids that will be land applied in the program are considered to be Class B biosolids.

6.2.2 NUTRIENT CONTENT

Throughout the 1990s and the early 2000s a number of independent research studies were completed based on the City biosolids from NEWPCC and the land application program operated under EAL #1089E RR. The research studies characterized the biosolids, crops grown and the receiving soils in the land application program. The research studies, approved by the Technical Advisory Committee to EAL #1089E RR and conducted by the University of Manitoba Soil Science Department, evaluated effects of biosolids on the risks associated with cadmium in soils (1988), heavy metals and nitrogen mineralization rates in biosolids (1999) and three additional studies between 1992 and 1995 including an examination of nitrate distribution after biosolids application, evaluation of microbial biomass in soil after biosolids amendment and an assessment of transport characteristics of heavy metals as a result of surface application of biosolids (Wardrop, 2002). Components of the following discussion are based on this institutional research work.

[3] Vectors - species that have the potential for transmitting diseases directly to humans or can play a role in the life cycle of a pathogen as a host e.g., rodents, birds, insects, etc.

To determine environmentally sustainable and agronomically appropriate biosolids prescription rates, it is important to determine nutrient quality for the biosolids and then tailor the application rate based on targeted crop uptake and removal rates and soil fertility concentrations.

As a component of the overall biosolids management program, the City has maintained a comprehensive biosolids quality monitoring program, completing laboratory analysis for a wide spectrum of nutrients and metals. Biosolids analysis has been completed every two weeks by the City's Laboratory and an independent laboratory, ALS Laboratory.

An example of the nutrient profile reported for the City's biosolids is outlined in Table C.1 in Appendix C. In July/August preceding the fall biosolids application in a given year, an updated nutrient profile will be obtained from the City and will be utilized to evaluate the prescription rates for the land application program at that time. Details of the City's biosolids historic analytical profile can be reviewed in the annual biosolids compliance reports provided by the City for EAL #1089E RR licence requirements.

6.2.2.1 NITROGEN

The City biosolids nitrogen profile is between 31 to 44 percent total nitrogen with an average total nitrogen concentration of 38% (n=21); total Kjeldahl nitrogen concentration ranges between 24 and 42% with the average concentrations at 33% (n=115, dry); the average ammonium-nitrogen (NH_4-N) is 0.5% (ranging between 0.3 and 0.7%, n=14, wet), and Nitrate-N concentrations is generally less than laboratory detection. This provides an estimated organic nitrogen content of 36,700 mg/kg. Generally this nitrogen profile is consistent with the studies completed through the 1990s and is consistent in profile since 2012.

Significant findings reported by Fitzgerald and Racz (1999) and Ross et al (2003) is that the mineralization of organic nitrogen to inorganic, plant available nitrogen (nitrate and ammonium-nitrogen) was approximately 11% of biosolids N in year one and is highly dependent on soil temperature (micro-climate). It was further determined that approximately 67% of biosolids ammonium (17% of the total nitrogen) was lost as ammonia gas to volatilization when biosolids were not incorporated.

When utilizing an organic source as a fertilizer, only a portion of the total nitrogen is immediately available. A portion of the total nitrogen is in the organic form and goes through a mineralization process. Mineralization is the conversion of organic nitrogen to ammonium nitrogen. As a "rule of thumb", the anticipated available organic nitrogen in year one is 25%, for year two is 12% and for year three is 6% (as discussed in the Tri-Provincial Manure Application and Use Guidelines). In the pilot program the mineralization rate applied was 20%; as field monitoring continues and a better agronomic understanding of the program grows, this mineralization rate may be adjusted lower or higher depending on in-field observations and soil analysis monitoring.

At a Carbon to Nitrogen (C:N) ratio that exceeds 30:1, N becomes a limiting nitrogenous organic material for decomposer organisms, and this can reduce the rate of decomposition and results in N immobilization. The City of Winnipeg's average total carbon concentration is 29.4% (297,700 mg/kg) and total nitrogen average concentration is 38,014 mg/kg, the C:N ratio for the biosolids is approximately 8:1, thus mineralization will not be an inhibiting factor (Appendix C).

6.2.2.2 PHOSPHOROUS

Since 2007, the City's wastewater treatment process has included chemical treatment with the iron salt Ferric Chloride ($FeCl_3$) at the NEWPCC to reduce the total phosphorus in the waste stream. The reaction between phosphorus and metal salts is as follows:

$$FeCl_3 + PO_4^{3-} \longrightarrow FePO_4 \text{ (precipitate)} + 3Cl^-$$

In 2002, the City completed a number of studies on the process of chemical treatment. In Section 13 of the Nitrification Study (Earth Tech Inc., 2002), the chemical phosphorous removal alternatives are reviewed. In this study it is reported that on the basis of reaction stoichiometry, 162.3g of $FeCl_3$ will react with 95 grams (g) of $P0_4$ to form 150.8 g of $FePO_4$, resulting in a weight ratio of 5.2:1 of $FeCl_3$ to phosphorus. In general however, the chemicals required vary significantly depending upon the wastewater characteristics such as influent phosphorus concentrations, pH, alkalinity, quantity and nature of suspended solids, ionic constituents and the effluent phosphorus limit required. The NEWPCC feeds ferric chloride at the primary sludge feed influent to the digester (approximately 80 L/hr set rate) and at the digested sludge feed effluent from the holding tanks (approximate feed rate 15 L/hr, automatic flow adjusted ratio).

Laboratory analysis of the biosolids demonstrates (Table C.1.) Total Phosphorus is on average 18,097 mg/kg, dry and standard deviation of 3,275 mg/kg, dry (n=115). Further laboratory analysis between April and October 2017 establishes the average plant available Phosphate-P as 637 mg/kg, with a standard deviation of 281 mg/kg, dry (n=14) using the Modified Kelowna extraction (Table 6). The Modified Kelowna procedure was deemed to be most suitable based on personal communications with Laboratory supplier. The plant available Phosphate-P is approximately 3.5% to 4% of the Total Phosphorous (Table 2 and 3). This is far below the typical assumption that 50% of Total Phosphorous is made available in manure (Tri-Provincial Manure Application and Use Guidelines), and non-chemically treated biosolids (USEPA, 1995).

Studies have demonstrated that biosolids treated with metal salts (Ferric Chloride or Alum) greatly reduce plant available Phosphate-P. Pastene (1981) as reported in O'Connor et al (2002) recommended the molar ratio of (Al + Fe) to phosphorus as an indicator of the P-supplying power of the biosolids. It was suggested that ratio values of <1 were characteristic of biosolids capable of supplying large quantities of soluble phosphorus, whereas ratio values of >1 indicate sources of poor phosphorus supply. O'Connor et al's (2002) work determined that significantly lower phosphorus availability was characterized by biosolids containing very high (>50 g/kg) total Fe and Al concentrations and which have been processed by methods that result in dry materials (>60% solids). McCoy (1986) found that the aboveground corn, at maturity, for P uptake from sludges treated with $FeCl_3$ averaged 4% when compared to the uptake from monocalcium phosphate (MAP). The crop uptake from the sludge treated with Fe_3 and Alum was 0% relative to MAP and plant uptake of phosphorus from $FeCl_3$ treated sludge relative to triple superphosphate was only 10%. Vaneeckhaute et al (2015) demonstrated that FePO4 sludge was not suitable as a starter fertilizer for crop growth as it had a low phosphorus solubility in water and that the efficiency to provide direct available phosphorus was low. Vaneeckhaute (2015) also demonstrated that the phosphorus available capacity over time was slightly increasing and increased the amount of phosphorus that can be provided in the longer term.

It is worth noting that Smith et al (2002) concluded that biosolids have larger phosphorus fertilizer replacement value in calcareous soils compared with neutral or acidic soil types and this might be explained by the reaction and hydrolysis of Fe-P minerals applied to soil in sludge under these conditions and releasing phosphorus in soluble form.

Based on Pastene's approach, the calculated molar ratio for the City biosolids is 1.58594 suggesting a poor phosphorus supply. The sample calculation is provide below and is based on the average total concentrations, dry.

- → Total P = 18,097 mg/kg = 18.097 mg/g
- → Total Al = 6,771 mg/kg = 6.771 mg/g
- → Total Fe = 37,734 mg/kg = 37.734 mg/g
- → P mol = 18.097 mg/g x (1/30.973 mol/g) = 0.58428 mol/g
- → Al mol = 6.771 mg/g x (1/26.981 mol/g) = 0.25095 mol/g
- → Fe mol = 37.734 mg/g x (1/55.845 mol/g) = 0.67569 mol/g
- → Al - Fe mol = 0.92664
- → Ratio= Al-Fe mol / P mol = 0.92664 / 0.58428 = 1.58594

Based on the knowledge that the City of Winnipeg biosolids are treated with Ferric Chloride salt that achieves a reduction in the total phosphorus concentration in the wastewater stream, the Al-Fe to P molar ratio >1 the assumption is that the resulting biosolids (post Ferric Chloride treatment) provide a low percentage of plant available phosphorus to plants

Past research conducted by the City and University of Manitoba in the 1990s was not completed on a biosolids that was treated with iron salt and therefore the conclusions regarding phosphorus are not completely applicable.

The agri-environmental prudent approach to nutrient management planning for City's land application of biosolids program is to base land application rate recommendations on phosphorus with a soil monitoring program and preparedness to adapt if soil monitoring for plant available nitrogen (PAN) and plant available phosphorus (PAP) demonstrate limitations or excessive development of nutrient reserves. Regardless, the proposed approach to provide biosolids application prescriptions that ensure land application process will be compliant with; *The Environment Act (C.C.S.M c. E125) Livestock Manure and Mortalities Management Regulations* and the *Water Protection Act (C.C.S.M. c.W65) Nutrient Management Regulation*, emphasising the need for respecting buffer zones, limitations, soil constraints and agronomic practices.

6.2.3 SALINITY

Laboratory analysis of the biosolids indicated an electrical conductivity (E.C.) value of 9,512 microSiemens per centimetre (uS/cm). The biosolids may be considered as “non-saline” and as such does not pose an environmental risk for soil salinization. Ross et al. (2003) found no difference in salinity between lands treated with biosolids and not treated with biosolids.

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 samples Manitoba hog manure had a value of 16.0 dS/m and a SAR of 5.1. It is reported by Sullivan et al (2007) that repeated biosolids applications in soil did not result in detrimental salt accumulations in soil even at locations with low precipitation and no irrigation. Sullivan et al (2007) reported that annual applications of dewatered cake biosolids (80% moisture) applied for over 10 years did not increase soil salinity above 1 mmho/cm. The electrical conductivity profile for the City’s biosolids is provided in Table C.1., Appendix C.

6.2.4 TRACE METALS

In The Effect of Biosolids on Crops, Soil and Environmental Quality, A Summary of the Research conducted by the Department of Soil Science at the University of Manitoba, Fitzgerald and Racz (1999) reported that for loading rates for City of Winnipeg biosolids (i.e. 0, 50, 100 and 200 tonnes per hectare [t/ha]), cadmium was not mobile and was not plant available and that very little of the cadmium in the biosolids was taken up by wheat plants. It was also reported that for concentrations of other heavy metals (e.g. copper, zinc, nickel and lead) no consistent effect on the heavy metal content of wheat grain due to increasing rates of added biosolids was observed. 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.

Within the City’s biosolids, the metals of principal concern to agriculture include arsenic, cadmium, chromium, copper, lead, mercury, nickel and zinc. MSD 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 C.3 shows the number of application events of biosolids required to increase soil metal content to maximum levels permitted by the CCME based on soil metal analysis and application rate for the fall 2017 pilot land application program. Table C.3 outlines the number of application events based on the average, minimum and maximum metal concentrations. The number of re-applications of biosolids is limited based on copper (refer to Table C.3).

6.2.5 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 (CCME, 2012). ESOCs continue to emerge due to the development of new detection methods and changes in technologies (McCarthy, 2015). In general, most ESOCs 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, CCME 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 HHCB were the compounds most frequently detected (9 of 11 sites) above 1,000 nanograms per gram ng/g TS (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-H2O, 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. 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 ESOCs and pathogens after land application is complex, site-specific to ESOC and pathogen characterizations and properties (e.g. water solubility and partition coefficient) and 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 ESOCs 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 proponent for the land application program will continue to monitor academic literature and engage with provincial regulators to maintain a current understanding of ESOC as information becomes available.

7 PHASE 3 – BIOSOLIDS LAND APPLICATION PROGRAM

The approach for Phase 3 of the land application program, and the focus of this EAP, involves the development of a land application program that emphasizes the long-term sustainability of the program and that maximize the beneficial use of biosolids. The land application program will be completed in agri-environmental sustainable manner, be allied with participating agricultural producer fertilization and crop management practices and implement best management practices that include good neighbour practices.

In consultation with the participating agricultural producers and their agronomic advisors, the program will apply biosolids based on crop nutrient uptake and removal which will involve matching agronomic needs with biosolids prescription rates. Application rates will be based on crop uptake and removal of nitrogen and phosphorus for a multi-year application event with the objective of returning to the same agricultural fields on a four year land rotation in order to accommodate nutrient removal, post application monitoring and crop rotations. The annual cycle of the biosolids land application program will essentially consist of the steps outlined in Table 4.

Table 4. Proposed Schedule for Annual Biosolids Application Program

Task	Timeframe
Commence Phase 3 - Full Biosolids Land Application Program[1].	Upon granting of EAL
Annual program[2] will involve:	
1. Engagement with participating agricultural producers to ensure land use and potential future cropping plans.	February - March
2. Starting early in the growing season biosolids will be trucked to local storage sites (after highway weight restrictions) at a rate of approximately 3,000 wmt per month (for example, 8-10 trucks per day for three days per week).	May – September
3. Post-harvest, soil sampling will occur to confirm residual crop nitrogen, phosphorous and metal concentration, suitable application rates will then be determined.	August – September
4. Once prescription rates are determined, fall spreading of biosolids will be completed including incorporation of the biosolids within occur 48 hrs of application.	September – November 10
5. Submission to MSD annual biosolids compliance report that provides details of the land application including prescription rates.	By January 31
6. Provide biosolids application rates to participating agricultural producer(s) for soil fertility planning for following growing season.	By January 31
7. For three years following an application event, crop management data and soil nutrient profiles will be monitored.	Post harvest, annually

Notes:
[1]Full application program commencement date is dependent upon EAL granting timeframe.
[2]This is an example of the requirements for biosolids application on an annual basis.

The following sections provide further details regarding the biosolids land application program components.

7.1 LAND REQUIREMENTS

7.1.1 AMOUNT OF AGRICULTURAL LAND REQUIRED

An initial estimate of land required for application of up to 20,000 wmt of biosolids per year was determined to be between 300 ha (740 ac) to 455 ha (1,125 ac) per year depending upon the approach to the prescription for nitrogen or phosphorus. The approach to developing a sustainable program is to establish a 1 in 4-year land base rotation. This will require a net land base between 1,200 and 1,820 ha. This estimate for the annual land base does not account for soil residual nutrient concentrations, crop rotations or for other influences on the program such as setback distances.

7.1.2 SELECTION OF AGRICULTURAL LANDS

A database of agricultural producers from the RMs of Macdonald, Cartier and Rosser (and potentially other RMs) that express interest in receiving biosolids onto their agricultural fields is being developed. Agricultural fields put forward by these producers will be assessed for suitability based on soil characteristics (e.g. agricultural capability, residual soil nutrient levels) and agronomic practices (e.g. crop rotation, nutrient management). In addition, constraints and buffer zones as required by provincial nutrient management regulations will also be considered (e.g. haul distance, proximity to a water course, residential area). This information will then be mapped in order to select agricultural fields to be used in a four-year rotation for the program.

7.1.2.1 CANADA LAND INVENTORY – SOIL CAPABILITY FOR AGRICULTURE

The Water Protection Act (C.C.S.M. c. W65, 2005) *Nutrient Management Regulation* (NMR) (62/2008) outlines nutrient application restrictions based on Canada Land Inventory Soil Capability Classification for agriculture ratings (Manitoba Water Stewardship, 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 (Frazer 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 also thirteen different subclasses or limitations within each of the classes.

It is proposed that agricultural fields that have a CLI dry-land agriculture capability of Class 1, 2, 3, or 4 will be included in the biosolids land application program to ensure the most appropriate land base is available for the fullest nutrient use.

7.1.2.2 NUTRIENT MANAGEMENT AND SETBACK DISTANCES

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 parts per million (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.

Only agricultural fields that are located within NMR Zones N1, N2 or N3 will be included in the biosolids land application program to maximize the nutrient re-use potential.

In order 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 and surface water drainage systems and sensitive areas/features will be established as outlined in Table 5.

Table 5. Application Exclusions and 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

Description	Recommended Minimum Buffer Zone Distance for Biosolids Application
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)
Setback Distances for In-field Storage of Biosolids[2]	
Surface watercourse, sinkhole, spring, or well	100 m (328 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; and
- → 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 hrs.

7.1.3 AGRONOMY

Crops grown on lands receiving biosolids can include cereals, oils seeds, corn and soybeans. Application of biosolids will increase soil health (water-holding capacity, tilth) and provide beneficial macro (nitrogen, phosphorus, potassium, sulfur) and micro nutrients (boron, copper, zinc, magnesium) to the soil for crop production. Agricultural producers participating in the program will be advised of the benefits of biosolids application and understand that the application of commercial fertilizers should only be completed to supplement nutrient levels from the biosolids at agronomically sustainable rates. Specifically, producers will be advised of the anticipated effect that the ferric chloride treatment has on limiting available phosphorus from the biosolids and that a starter phosphorus should be considered at seeding time.

Any agricultural producers that participate in the biosolids land application program will be required to sign a land use agreement that meets the terms and conditions of the program. Listed below are a few of the articles included in the 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 (i.e. grazing can occur in 2022 if land applied in 2018);
- → Conducting a nutrient management program that accounts for residual nutrients from the biosolids application;
- → Incorporation of biosolids with 48 hrs of application;
- → Permit soil sampling and analysis monitoring for a period of 3 full years after application; and,
- → Land application occurs at no cost to the producer.

7.2 LAND APPLICATION RATE PARAMETERS

The prescription rate calculations are based on several key pieces of information and the basics of nutrient management with assumptions for determining available nutrient calculations. Table 6 provides a summary of these inputs and assumptions.

Table 6. 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 Manitoba Soil Fertility Guide. – Soil testing – soil sampling for nutrient and metals profile is completed (0-15 cm and 15-60 cm). – Biosolids testing – testing of the physical, nutrient and metals profile for the biosolids is maintained by the City.
Assumptions	Nitrogen Mineralization rates: - Between 11 and 20% in year one. - Less than 12% in year two and less than 6% in year 3. Plant available phosphorus - Between 5 and 25% of total phosphorus. - $FeCl_3$ treated biosolids limit available phosphorus.
Methods	- Biosolids are surface applied and then incorporated within 48 hrs therefore volatilization of ammonia loss is 13, 19, 31 and 57% depending on 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.

An example of the prescription calculation worksheet is provided in Table C.2., Appendix C.

7.3 TRANSPORTATION, ROUTE PLANNING AND SPILL CONTROL

The biosolids will be transported direct from the NEWPCC to the field in approved highway transport units to prevent the loss of biosolids and associated liquids during transport. Specifics of the enclosed trailers are: ejector trailer, sealed and gasket tailgate, rigid cover with four recessed load chutes, hydraulic operated end gate and 26 tonne capacity.

A transportation plan will be developed as a component of the land application program for the daily hauling of biosolids from the NEWPCC to the field storage sites in order to minimize impacts to environmental and human health and safety. The transportation plan will take into account factors such as; highway and provincial road-weight restrictions, spring road-weight limitations, bridge limitations, all-weather accessibility and site access driveways. Municipal and lower populated roadways will be utilized for transport of biosolids for the program where possible, and monitoring of road damage concerns voiced by local residents will also be completed as part of the transportation plan.

Spills or accidental releases are a potential hazard when involving loading, transporting and unloading of biosolids and a spill response or control plan will be an essential component of the transporting of biosolids to field locations. The spill response or control plan will address both hazardous materials (e.g. fuel or oil) and non-hazardous biosolids. The plan will include emergency contact information, project team contact numbers, and procedures to stop the source, contain the material, clean-up and reporting. An example of the Phase 3 Spill Response Plan for Fuel, Fluids and Biosolids is included in Appendix B.

7.4 FIELD STORAGE APPROACH

Application of the biosolids will occur after crop harvest (September – November) each year, and as such, temporary field storage will be required for the 3,000 – 4,000 wmt of biosolids produced by the NEWPCC each month that are to be used in the land application program. It is anticipated that the footprint of a field storage site to provide a suitable working area and storage of biosolids would be one acre per quarter section of land adjacent to, or within the land receiving the biosolids. Based on the experience in the pilot program, direct hauling biosolids after harvest limits the efficiency of land applying the biosolids as there is lag time between loads for application that can be exacerbated by daily biosolids availability from the NEWPCC, and from travel and weather delays. Logistically to achieve the objective of land applying the target quantity of biosolids annually, field storage is a required component of this program. On behalf of the City of Winnipeg, WSP submitted a memo to MSD EAB that reviewed Federal and Provincial regulatory requirements for field storage to occur and outlined a number of mitigation approaches to suitably develop a field storage program. This memo is included in Appendix B for reference.

During initial discussions held with MSD EAB, odour management and methods of field storage containment were identified as key concerns for the land application program. In order to address these issues, the City conducted an assessment of field storage options for biosolids in the fall of 2017. As a requirement of the NOA a summary report has been submitted to the MSD EAB[4]. The report outlines the methodology, field storage options, observations, findings and conclusions.

Overall, the three most feasible field biosolids storage options include straw cover, woodchip cover and hydro-mulch cover. It must be kept in mind however that the field storage assessment was completed on a small scale trial level and these results may differ for larger field storage sites utilized during the future full-scale land application program.

[4] Summary report entitled: City of Winnipeg Biosolids Land Application Field Storage Assessment Summary Report, December 2017

In addition, the following logistical items will be included as part of a full-scale field biosolids storage program:

- → Biosecurity is a concern for any organic matter (straw, woodchips, hydro-mulch) that is used as the cover for the field biosolids storage areas during the full field scale biosolids application program. If straw is used as the cover it should be sourced from the participating agricultural producer in order to reduce the risk of weed and disease transfer to agricultural fields.
- → Utilizing topsoil from the participating agricultural fields to create the berm for field storage sites is not a viable option as there is concern that the topsoil in the storage area will be disturbed and may result in decreased crop productivity in those areas. As a result, other materials will be utilized to create in-field berms (e.g. large square straw bales) to manage water run-off and leachate and contain the biosolids (refer to City of Winnipeg Biosolids Land Application Field Storage Assessment Summary Report, December 2017).
- → Field storage sites should be established at field entrances and equipment should travel along field edges in order to minimize soil compaction.

A summary of the approach that will be taken for the field storage program is provided in Table 7.

Table 7. Summary of Measures and Approach to Field Storage of Biosolids

Proposed Approach	Environmental Aspect to Mitigate	Supporting References for Proposed EAP Approach
Locate biosolids storage location at least 100 m from any surface water course, sinkhole, and spring or well and in a manner that does not cause pollution of surface water, groundwater or soil.	Access to surface water, sinkhole, spring or well.	• *The Environment Act, LMMMR*.
Only biosolids that contain more than 25% solids matter and/or meet a slump test requirement can be stored in field.	Access to surface water, sinkhole, spring or well.	• *The Environment Act, LMMMR*
Locate biosolids storage location at a site with the presence of clay and clay till to a depth of 1.5 m.	Access to groundwater impacts through leachate.	• The Environment Act Licence Schedule A as applied to biosolids land application programs.
Locate biosolids storage site at least 1,000 m from designated residential area, 300 m from a residence, at least 30 m from property line with residence and at least 15 m from property line without residence.	Odour buffer zone and good neighbour practices.	• Farm Practices Guidelines for Pig Producers in Manitoba (2007). Table 11 Recommended Distances from Residential Areas and Property Lines for Apply Manure. Application method: Irrigation – assumed to be most odour generating practice hence most separation distances applied. • USEPA Guide to Field Storage of Biosolids

Proposed Approach	Environmental Aspect to Mitigate	Supporting References for Proposed EAP Approach
		• National Manual of Good Practices for Biosolids, National Biosolids Partnership, June 2011.
Stored biosolids will be removed and land applied no earlier than May 1 and no later than November 10 of the year stored.	Odour, exposure management	• *The Environment Act, LMMMR*.
After the biosolids are removed, the field storage area must remain empty of biosolids for at least 12 months. Before storing biosolids in the area again, the site must grow a crop on the emptied biosolids storage area that will deplete the area of any leached nutrients.	Odour, exposure and nutrient management	• *The Environment Act, LMMMR*.
The field storage location would be established to be of sufficient capacity to store all the managed biosolids to be used on the land application site for the period of time needed for its application as a fertilizer.	Odour, exposure and nutrient management	• BC *Environment Management Act* Clause 18. • USEPA Guide to Field Storage of Biosolids. • National Manual of Good Practices for Biosolids, National Biosolids Partnership, June 2011.
Develop a Best Management Practice, site selection requirement and operations checklist prior to implementing a field storage location.	Beneficial Management Practices and good neighbour practices	• USEPA Guide to Field Storage of Biosolids. • National Manual of Good Practices for Biosolids, National Biosolids Partnership, June 2011.
Biosolids are to be covered. Cover materials are to be either woodchips, straw, or hydro-mulch to act as a biofilter and storm water absorbent.	Odour, exposure and storm water management.	• City Field Storage Assessment
Establishment of berms (straw, concrete, plastic or topsoil) around storage sites.	Water run-off and leachate, prevention of slumping	• City Field Storage Assessment
Site security and limited access. Perimeter of storage sites will be established and posted.	Public Health and Safety	• City Field Storage Assessment

7.5 BEST MANAGEMENT AND GOOD NEIGHBOUR PRACTICES

Develop a procedure that will outline best management and good neighbour practices to be implemented for the land application program that include:

- → Informing both the RM and residents of properties adjacent to the agricultural field which is to receive the biosolids of the date of the commencement of biosolids hauling to the storage site. Notifications will include: map of the application fields, application start date for the biosolids, and contact information for the City will also be included. Notices will be provided door-to-door or via direct mail delivery.
- → Restricting delivery, handling and application of biosolids to weekdays.
- → Addressing any odour or other concerns by the RM and local residents in a timely manner.
- → Locating field storage sites with prevailing winds downwind of major residential areas.

7.6 GEOGRAPHICAL INFORMATION SYSTEM (GIS) DATABASE

Due to the multi-year and multi-agricultural field aspects of the land application program, a GIS based database will be developed for the land application program that will aid in the tracking and monitoring of agricultural fields utilized in the program. Data that will be tracked through the database will likely include:

- → Information for the participating agricultural producers – contact information, available land locations, agronomic practices (crop rotation and nutrient management practices).
- → Information on the agricultural fields utilized in the program – any restrictions, pre and post application and 3-year residual soil nutrient levels and buffer zones required.
- → Application prescription rates.
- → RM and public notifications.
- → Export required reporting requirements to MSD.

8 EFFECTS AND MITIGATION MEASURES

The following sections outline the potential environmental and socio-economic effects associated with the biosolids land application program as well as the proposed mitigation measures that will be implemented for the program in order to minimize potential negative effects. A summary of the potential effects is provided in Table 8.

Table 8. Summary of Effects and Mitigation Measures

Potential Biophysical Effects	Proposed Mitigation Measures
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	City of Winnipeg Sewer By-law 92/2010, biosolids monitoring, soil monitoring, soil chemistry, CCME guidelines.
Salinity and Sodicity	City of Winnipeg Sewer By-law 92/2010, 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 of 20-15 m from groundwater wells[5] and 100 m from an identifiable boundary of an aquifer which is exposed to the ground surface or gravel and sand lenses (applicable to RM of Rosser), 1.5 m clay underlay at application sites and storage sites, targeted prescription rates, berm around field storage sites, soil monitoring.

[5] Dependent upon presence of vegetative cover in buffer area surrounding feature.

Potential Biophysical Effects	Proposed Mitigation Measures
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, berm around field storage sites, soil incorporation with 48 hrs of application, 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	Class B material, tillage, climate exposure, setback distances, restricted access, exposure time between application events and harvest.
Odour	Setback distances, tillage, biofilter covers on field storage area.
Emerging Substances of Concern	Class B material, climate exposure, microbial degradation, photo-degradation, soil incorporation within 48 hrs of application, 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 QUALITY EFFECTS AND MITIGATION

8.1.1.1 NUTRIENT LOADING TO SOIL

The objective of the proposed program is to manage nitrogen and phosphorus 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 land application program 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 zones N1, N2 and N3.

Post-harvest soil monitoring will be conducted on the participating agricultural fields for three years post application of biosolids in order to monitor nutrient loading within the soils. Soil sampling and analysis will be completed as follows; sodium bicarbonate extractable phosphorus in 0-15 cm and nitrate-nitrogen and total nitrogen in 0-15 cm and 15-60 cm. Participating agricultural producers 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 Environmental Approvals Branch 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 City currently has established by-laws that restrict disposal of industrial by-products that contain heavy metals into the municipal sewer system. This aids in minimizing the level of heavy metals within the biosolids. In addition, to prevent overloading of heavy metals into soils, the prescribed application rates will comply with the soil guidelines established by the CCME. Monitoring of biosolids quality and soil monitoring (0-15 cm) 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: City of Winnipeg Sewer By-law 92/2010, biosolids monitoring, soil monitoring, CCME guidelines

8.1.1.3 SALINITY AND SODICITY

The biosolids may be considered as “non-saline” and as such does not pose an environmental risk for soil salinization. The biosolids salinity is considered to be less than hog manure (Racz and Fitzgerald, 2001). 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.

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 for three years post biosolids application will also be conducted in order to monitor soil salinity levels in agricultural fields participating in the land application program.

Mitigation Measures: City of Winnipeg Sewer By-law 92/2010, biosolids monitoring, soil monitoring, CCME guidelines

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. The soil within the RMs is susceptible to physical compaction due to the clay texture and small pore spaces.

Soil compaction may occur at entrances to the fields due to heavy equipment traffic entering fields for biosolids application and during deposition at field storage sites for the program. Access by the contracted applicator and transport contractor to field storage sites and for biosolids application will be restricted to field entrances and the edges of the fields as much as possible to limit compaction. 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. All-weather "mud mats" may be used at field entrances and pathways to the field storage sites to aid in minimizing soil compaction and soil rutting during wet weather. In addition, winter frost action also aids in the mitigation of soil compaction. However, should an agricultural producer(s) have a concern with the potential compaction, field entrances and pathways to storage sites further accommodations will be considered to mitigate these impacts.

It should also be noted that the field equipment utilized to complete the land off-loading at storage sites and the field application of the biosolids is equipped with large floatation tires to minimize the compaction potential.

Mitigation Measures: Restrict travel to field entrance and field edges, use of all-weather mud mats, heavy equipment fitted with flotation tires, application equipment capable to provide even application with a wide row spacing

8.1.2 WATER QUALITY EFFECTS AND MITIGATION

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. As discussed in Section 7.2, nitrogen and phosphorus levels in the biosolids and soil will be managed through the annual development of targeted prescription rates.

Leaching to groundwater is not a significant concern (refer to Section 4.2.4) within the RMs as the soil texture is predominately clay throughout most of the area with the exception of several small sites within the RM of Rosser (refer to Map 8) where the carbonate aquifer is near ground surface and at sites where sand and gravel lenses occur; setback distances of 100 m from any such sites within the RM of Rosser will be established due to the potential for groundwater contamination at these sites. In addition, a 50 m setback distance will be established around groundwater wells for the program (refer to Table 4 for setback distance). Field biosolids storage sites will be located in areas with the presence of clay and clay till to a depth of 1.5 m. Field storage sites will be established at least 100 m from any sinks, groundwater wells, springs or surface aquifers.

As well, the risk of surface runoff into surface water channels or drains will be minimized by applying the biosolids at prescribed rates that optimize crop uptake and by establishing setback distances around surface water systems, drainage systems and sensitive features including 35 m from lakes and 15 m from rivers, creeks, and large unbermed Order 3 drains or greater. Field storage sites will be established at least 100 m away from any surface water course. As well, biosolids will be incorporated into the soil within 48 hrs of application to minimize surface runoff potential and a berm system will be established around the perimeter of the field storage sites to contain leachate/runoff.

Mitigation Measures: Targeted prescriptions, setback distances, 1.5 m clay underlay, berm around field storage sites, soil incorporation with 48 hrs of application, cropping systems, soil monitoring and compliance with Manitoba Acts and Regulations

8.1.3 VEGETATION, WILDLIFE AND SPECIES OF CONSERVATION CONCERN

Land use within the RMs of Cartier, Macdonald and Rosser is predominately agricultural. Application of biosolids will be completed on agricultural lands that are under an annual crop rotation (i.e. pastures and hay land are not included in program) and during the fall season outside of the breeding bird and wildlife breeding timings. Field storage sites will be sited at least 15 m from any natural areas (grasslands, forested areas), at least 100 m from any surface water course, sinkhole, and spring or well and 1,000 m from any parks and protected areas. Travel of heavy equipment to field storage sites will be on established pathways only. Therefore, due to the agricultural nature of the areas, timing of the biosolids application, use of annual crop land and establishment of appropriate setback distances, 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

8.2 SOCIO-ECONOMIC EFFECTS

8.2.1 PUBLIC SAFETY & HEALTH EFFECTS AND MITIGATION

8.2.1.1 PUBLIC ENGAGEMENT AND PERCEPTION

Phase one of the land application program included a substantial PEP to establish an understanding of stakeholder perceptions and legitimate concerns regarding the process of land application of biosolids. During the PEP a number of important issues were established, a few examples include; the need to minimize risks to the environment and human health, ESOCs, public awareness and knowledge, available scientific and transparent information and process through public reporting.

To ensure continued public engagement and transparency the City is committed to ensuring all annual reporting is made publically available. In addition the City will establish an advisory committee. The role of the committee will be established to address and respond to public perception issues or concerns and advise on technical components or implications. The City will establish and Chair an advisory committee within six months of receiving a licence. The format and membership of the committee has not yet been determined, but would likely include City staff, RM Council member or staff and representative(s) from MSD and Manitoba Agriculture.

8.2.1.2 BIOLOGICAL PATHOGENS

Biological pathogens such as *E. coli* and fecal coliforms associated with land application of biosolids may be considered to pose a public health and safety risk. The City's wastewater sludge is treated using anaerobic digestion to stabilize the solids and reduce the pathogens, which produces Class B biosolids. The human health and safety risks will be managed through the application of the biosolids onto private lands that have restricted public access. In addition, incorporation of the biosolids within 48 hrs of surface application will minimize odour and eliminate human exposure to pathogens. Pathogens from biosolids are often killed by exposure to sunlight UV, 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 includes non-root/vegetable crops and excludes livestock grazing.

In addition, appropriate setback distances including 1,000 m from residential areas, 75 m from occupied residence (other than the residence occupied by the owner of the land on which the biosolids are to be applied), 10 m from property lines with a residence and 1 m from property lines without a residence will be adhered to throughout the application program. Field biosolids storage sites will be established at least 1,000 m from a designated residential area, 300 m from a residence, at least 30 m from property line with residence and at least 15 m from property line without a residence. Each perimeter will be posted with "Do not Enter" signage.

Mitigation Measures: Class B material, soil incorporation within 48 hrs of application, climate exposure, setback distances, restricted access, separation in time between land application event (fall) and crop harvest (the next fall).

8.2.1.3 ODOUR MANAGEMENT

While it is impossible to eliminate odour associated with the biosolids as an effect from the program, mitigation measures that include the use of best management and good neighbour practices will be employed to minimize odour issues associated with the land application and field storage. Best management practices that will be employed include the incorporation of biosolids into the soil within 48 hrs of application and the use of an organic matter cover on the field storage sites to reduce odour and establishment of applicable setback distances from residences. Examples of good neighbour practices is to respect complaints, this includes recording the complaint details, investigate the complaint, identify corrective actions and respond back to the complainant about the findings and the corrections imposed.

Additional examples of odour management include; addressing concerns within a short time frame, restricting delivery, handling and application of biosolids to weekdays, locating storage sites downwind of communities based on prevailing winds when possible, and providing a City contact for odour issues to neighbours.

Mitigation Measures: Good neighbour policy, complaint resolution procedures, advisory committee, setback distances, tillage, and storage cover.

8.2.1.4 EMERGING SUBSTANCES OF CONCERN (ESOC)

ESOC include; 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 (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: Class B material, climate exposure, microbial degradation, photo-degradation, soil incorporation within 48 hrs of application, setback distances, restricted access, separation in time between land application event (fall) and crop harvest (the next fall), and academic literature monitoring by the advisory committee.

8.2.1.5 METAL ACCUMULATION IN CROPS

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. In The Effect of Biosolids on Crops, Soil and Environmental Quality, A Summary of the Research conducted by the Department of Soil Science at the University of Manitoba, Fitzgerald and Racz (1999) reported that for loading rates for City of Winnipeg biosolids (i.e. 0, 50, 100 and 200 wet metric tonnes per hectare [wmt/ha]) cadmium was not mobile and was not plant available and that very little of the cadmium in the biosolids was taken up by wheat plants. It was also reported that for concentrations of other heavy metals (e.g. copper, zinc, nickel and lead) no consistent effect on the heavy metal content of wheat grain due to increasing rates of added biosolids was observed. 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 wmt/ha did not affect grain quality. The land application program will comply with all applicable regulatory requirements and guidelines for metals in soil (e.g. CCME guidelines).

Mitigation Measures: City of Winnipeg Sewer By-law 92/2010, biosolids monitoring, soil monitoring, soil chemistry, and CCME guidelines and crop rotation.

8.2.1.6 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 weekly transport of biosolids to the field storage site(s) and transportation will be completed during regular weekly work hrs as much as possible.

Mitigation Measures: Good neighbour policy, use of paved roads, and hauling during regular work hrs.

8.2.1.7 ACCIDENTS AND MALFUNCTIONS

As part of the land application program, a spill response plan will be developed. The plan will include instructions to contractors on what to do in the case of an accidental release of biosolids during transport and at the field sites including reporting requirements to provincial regulators.

Mitigation Measures: Maintain equipment in good working order and develop spill control/response plan.

8.2.2 GREENHOUSE GASES

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 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. These three benefits are reported to counter balance the potential emissions due to mechanical needs for the land application program (CCME, 2012).

8.2.3 ECONOMIC BENEFITS

The application of biosolids to agricultural land provides a positive economic benefit to the agricultural producers and a sustainable re-use of a wastewater treatment by-product by the City of Winnipeg. The objective of providing prescription application rates for biosolids to crop specifics is to provide an organic source for nutrient management. As outlined, biosolids provide macro nutrients (nitrogen, phosphorous, potassium, and sulfur) and micro-nutrients (boron, copper, iron, chloride, manganese, molybdenum and zinc), all of which provide economic value to the agricultural producer. For example, based on fertilizer commodity price as of April 2017 for Urea (46-0-0) and Triple Super Phosphate (0-45-0), the following economic value as presented in Table 8 can be recognized from the prescribed biosolids land application of 12 dmt/ha as prescribed in the pilot land application program.

Table 9. Economic value for Nitrogen and Phosphorous in Applied Biosolids

Nutrient	Market Price (April 2017)	Application Rate	Value of Applied Biosolids
Available Nitrogen	$0.59 kg^{-1}	100 $kg\ ha^{-1}$	$59.00 ha^{-1}
Total Available P_2O_5	$1.08 kg^{-1}	125 $kg\ ha^{-1}$	$134.78 ha^{-1}

The biosolids are being provided at no charge to the agricultural producer, thus reducing their fertilizer bill by approximately $194 per ha (Table 9). Based on the anticipated maximum amount of land required (455 ha) required for the land application this equates to approximately $88,300 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 agricultural producer is substantial based on the savings they will incur for crop fertilizer amendments.

9 MONITORING AND REPORTING

9.1 FOLLOW-UP MONITORING AND REPORTING

The following monitoring and reporting requirements are proposed for the program:

1. Completion of a yearly program review/start-up meeting between the City, applicator contractor, hauling contractor and consultant (if applicable), to review the procedure and requirements of the program including requirements outlined in the EAL (e.g. on-site storage locations that will be utilized in a given year, fields scheduled in the rotation to receive biosolids in a given year, biosolids quantities, etc.). Yearly meetings will be completed in January-February of each application year. Participating agricultural producers will be engaged late winter/early spring to establish potential field sites for biosolids storage and land application.
2. At least two weeks prior to the commencement of the biosolids land application in a given year, the City will provide details of the biosolids and receiving field soil analysis as well as proposed prescription rates for biosolids application to the Director of the MSD EAB.
3. By January 31 of each year following the application of biosolids, the City 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:
   - → Description 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
4. Monitoring of application of odour control mechanisms (e.g. straw cover) at field storage locations periodically by visual observations and evaluate odour generation based on established procedures in the field storage assessment. If required, reapplication of cover will need to occur.
5. Recording of each scaled truck load and net biosolids weight transported to the field storage locations.
6. 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.

7. Post-harvest soil monitoring of application fields for three (3) 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. This information will be supplied to MSD EAB by January 31 of each year following the application of biosolids.

An example of the soil monitoring schedule for a 4-year rotation for the land application program is provided below.

	Soil Sampling Program - Fall of:											
Field in 4 Yr Rotation	**Fall 2018**	**Fall 2019**	**Fall 2020**	**Fall 2021**	**Fall 2022**	**Fall 2023**	**Fall 2024**	**Fall 2025**	**Fall 2026**	**Fall 2027**	**Fall 2028**	**Fall 2029**
Field A												
Field B												
Field C												
Field D												

4-year rotation continues based on residual soil nutrient and metal levels. Additional fields are also added to the program as required.

Notes:

Application Year - soil sample collected in fall prior to biosolids application and used in development of prescription rates.

Three-year post-application follow-up soil monitoring. If residual nutrient and metal levels are below guidelines, field is included in the rotation again.

10 SUMMARY

When applied at balanced agronomic rates, the land application of biosolids is a sustainable means to re-use nutrients within an agriculture system. 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. The objective of this program is for the City of Winnipeg to complete a land application of biosolids collected from their NEWPCC in an agronomically and environmentally sustainable manner. Based on the information provided within this EAP submission the biosolids land application program will contain several of significant features including the need to maintain field storage of biosolids and develop application rates based on nitrogen and phosphorus levels in the biosolids materials due to the pre-treatment of ferric chloride and soil residuals. All applicable regulatory requirements, guidelines and good neighbour policies and procedures will be adhered to for the City of Winnipeg biosolids land application program. With the employment of appropriate mitigation measures, potential negative effects associated with the City's biosolids land application can be minimized.

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