Town of Niverville
where you belong

October 27, 2015

Ms. Tracey Braun,
Director, Environmental Approvals Branch,
Manitoba Conservation and Water Stewardship,
2nd floor, 123 Main Street
Winnipeg, MB R3C 1A5

Subject: Request for Alteration to the Town of Niverville's Environment Act Licence #2712

Dear Ms. Braun:

On behalf of the Town of Niverville, please find enclosed a request for partial removal for Environment Act Licence #2712, and an alteration to the existing Notice of Alteration (NoA) for the Town's sewage lagoon being decommissioning on SW 30-7-4 EPM in the Town of Niverville.

The alteration is with respect to the NoA on existing Environment Act Licence #2712, approved September 21, 2011. The request is for removal of the dry (i.e., secondary) cell from the Environment Act Licence. In addition, permission is requested to install fencing around lagoon areas to remain under the Environment Act Licence (i.e., wetland cell, holding cell and control cell). The existing outside fence will be maintained to control access to the site, while a newly installed inside fence will limit access to all lagoon areas containing sewage sludge while still allowing for public viewing as an interpretive area. Both fences will be a minimum of 1.2 metres high, have locking gates at all access points into the lagoon and be maintained over time, as under previous conditions (Condition #2).

The purpose to the requested licence removal and alteration to the NoA is to support the Town of Niverville's vision for developing the site as an interpretive area, allowing public access in the dry cell for interpretive and educational purposes. In addition, fencing around areas remaining under licence will permit public viewing from the top of the berms of the research being conducted in the lagoon by researchers from the Department of Soil Science, University of Manitoba and Native Plant Solutions, Ducks Unlimited Canada.

Research to date, as presented in this report, shows progress in decommissioning of the sewage sludge via *in-situ* phytoremediation since the project commenced in fall 2012. In addition, we present that there are no longer human health or environmental risks in biosolids of the dry cell, supporting the proposed alteration to the NoA and the request for removal of the Environmental Licence on the dry cell.

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To date, the Niverville Lagoon Bioremediation Project has provided considerable benefits at a Provincial level, by demonstrating an environmentally-friendly, sustainable and cost-effective option to decommission lagoons; and, more broadly, as a first of its kind project in Canada, it shows the potential to make a significant contribution to how municipalities across the country decommission their sewage lagoons.

The Town of Niverville has invested over $800,000 to date in the project to cover the expenses of re-design, construction, and plantings, including over $200,000 dedicated to research costs supporting two University of Manitoba Master of Science graduate students, one of which has continued on to their Ph.D. on the project. Excluding research costs, the *in-situ* bioremediation option for decommissioning a lagoon is only 30-40% of the estimated costs of traditional options for lagoon decommissioning (i.e., landfilling or spreading on agriculture land), indicating the option is economically viable. Demonstrating the Town's ongoing support for the project and its vision, Niverville has committed to funding the project $163,000 in 2015-2016 and $65,000 in 2016-2017 to support research costs for Phase III, as well as maintenance and infrastructure for the site's development as an interpretive area and continued monitoring supporting full decommissioning of the site.

The Town of Niverville would like to formally provide public access to the dry cell of the lagoon site by spring 2016, with earthworks in the dry cell to commence in late fall/early winter 2015/2016. Consequently, we would appreciate your consideration and approval of our request for alteration to the existing Notice of Alteration in November 2015.

Should you require any further information or clarification of this NoA, please contact myself at 204-388-4600 or Lisette Ross, Senior Wetland/Upland Specialist, Native Plant Solutions at 204-953-8205.

Yours truly,
TOWN OF NIVERVILLE

Jim Buys,
Chief Administrative Officer

Town of Niverville, Manitoba

Request for partial licence removal on

Environment Act Licence #2712

Prepared for:

Town of Niverville

Prepared by:

Native Plant Solutions/

Ducks Unlimited Canada

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October 27, 2015

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A. Introduction

1.0 Background

The use of wetland systems and plants to remove contaminants, both organic and inorganic, from soil and water is widely practiced in other parts of the world (Pilon-Smits 2005). Plant-based remediation approaches, also known as phytoremediation, have long been used for the cleanup of sites contaminated with inorganic (e.g., metals, nutrients) and organic (e.g., petroleum hydrocarbons, polycyclic aromatic hydrocarbons, chlorinated solvents) substances. Although there is increasing interest in employing constructed wetlands for wastewater treatment, particularly to meet nutrient guidelines for release, little consideration has been given to employing the same natural systems at the “back end” of the process, for decommissioning a wastewater treatment lagoon.

In 2011, the Town of Niverville (also referred to as ‘the Town’ in this report) proposed to explore remediating its sludge *in-situ* via phytoremediation, as an alternative to traditional lagoon decommissioning options (i.e., landfilling or spreading on agriculture land) for its old lagoon located on SW 30-7-4 EPM in the Town of Niverville. Reasoning for the Town exploring *in-situ* decommissioning was to consider an environmentally-friendly option, as the community prides itself on sustainability. Following extensive consultation with the Province of Manitoba and its expertise from Conservation and Water Stewardship, the Town of Niverville submitted a Notice of Alteration (NoA) to its existing Environmental Licence in order to obtain permission for pursuing this unique decommissioning option in a manner that posed no human or environmental health risks. Following approval of the proposed activities in September 2011, lagoon site decommissioning and research commenced in 2012.

Following two growing seasons in which the *in-situ* wetland and upland remediation systems have been operational (i.e., 2013 and 2014), as well as the completion of two graduate students conducting both laboratory and field research components of the project through the University of Manitoba, the project has compiled sufficient data to demonstrate the success of the system and progress towards meeting remediation targets.

As the long-term goal for the site for the Town of Niverville is, at the conclusion of the research and decommissioning period, to use the area as an interpretive/educational site and community park, the Town is proposing an alteration to the current NoA on the Environmental Licence with the removal of the dry (i.e., old secondary cell) to further this objective.

The Town of Niverville has provided annual reports on the progress of the project since 2012 to the Province of Manitoba, as per a condition of the NoA received to complete the research (Braun 2011). In addition, a meeting was held at the University of Manitoba in February 2015 with representatives from the Province (Brian Wiebe, Robert Boswick and Siobhan Burland-Ross), Town of Niverville (Jim Buys, Ryan Dyck), Native Plant Solutions (NPS; Lisette Ross, Lynn Dupuis and Phil Rose) and the University of Manitoba (Nicholson (Nick) Jeke, Francis Zvomuya) to inform the Province of decommissioning results to date and intentions going forward. A follow-up meeting, also held at the University of Manitoba in June 2015, with representatives from the Province (Robert Boswick, Curt Bueckert, Asit Dey), the Town of Niverville (Ryan Dyck), the University of Manitoba (Francis Zvomuya, Nick Jeke) and Native Plant Solutions (Lynn Dupuis, Bruce Friesen-Pankratz, Lisette Ross), helped to clarify what information would be required to support partial decommissioning of the lagoon. Based on discussions at these meetings, this document serves as a formal request for removal of the dry cell from Environment Act Licence #2712.

In order to support the request for this proposed alteration, this document provides a summary of the project site activities and research results to date; a background and description of the request for alteration; project remediation targets, risk mitigation and justification for human and environmental health and safety on site; and intentions going forward .

2.0 Existing licence

On January 23rd 2006, an Environment Act Licence (#2712) was granted to the Town of Niverville to construct a new lagoon on SW 7-8-4 EPM, Rural Municipality of Richot to replace the existing lagoon on SW 30-7-4 EPM, Town of Niverville. The existing lagoon was no longer of sufficient capacity and its construction did not meet current standards.

The existing licence requires that the Licencee follow conventional decommissioning protocols: removal of sludge to a disposal site or spreading on agricultural land under environmental licence. However, in 2011 after the submission of a request for NoA by the Town of Niverville, the Province of Manitoba approved the activities under the NoA (i.e., undertaking a research project to assess contaminant reduction in lagoon sludge using a wetland system and phytoremediation). Conditions under which the activities were approved included:

> *Clauses 38, 39 and 40 of Environment Act Licence No. 2712 are not required to be acted on by the Town at this time but to remain enforceable;*
>
> *A fence around the old lagoon to limit access must be installed and maintained. The fence shall be a minimum of 1.2 metres high and have a locking gate, which shall be locked at all times except to allow temporary access to the old lagoon;*
>
> *Discharge of water from the old lagoon shall only be via the delivery to the Town of Niverville's new lagoon or to another wastewater treatment facility operating under a Licence issues pursuant to The Environment Act;*
>
> *Sludge solids shall not be removed from the old lagoon site unless otherwise authorized by an Environment Officer;*
>
> *Annual reports of the previous year's related activities shall be submitted to the Environmental Assessment and Licensing Branch, Manitoba Conservation by not later than January 31st of the following year; and*
>
> *This approval shall be revisited not later than five years after the date of this letter.*

3.0 Project Infrastructure

In order to fulfill the research design of the project the original lagoon structure, composed of a primary cell and secondary cell, was redesigned (Figure 1). However the berms surrounding the two original cells have remained. The fact that the two cells started with different concentrations of contaminants in the biosolids allowed for comparison of two different phytoremediation conditions.

The primary cell, hereafter referred to as the wetland cell, serves as the wetland component of the research, where remediation is occurring by vegetative and aquatic processes. Around the wetland cell, 1 metre of freeboard was maintained, for rain events. The wetland cell was redesigned with benches to support the growth of wetland vegetation at their preferred growing depth, as the original depth of the cell was too deep for supporting plants (Figure 2). During construction in fall 2012, the wetland cell was recontoured, moving the sewage sludge into areas where cattail and other wetland plants were to be established, in order to maximize the bioremediation process. A center channel in the wetland of 1.5 m depth was left to limit the growth of wetland vegetation in this area. For research purposes, a control cell was designed and built in the footprint of the original primary cell that contained no wetland plantings. This allowed for comparison to determine the pathway of sludge contaminants in the presence and absence of wetland plants. Plants were established using propagules obtained from donor sites in the area, transplanted during the winter of 2012 to minimize impact to the health of the plan. In 2013 and 2014, as wetland plants were exposed to their first two growing seasons, commissioning of the water levels was important to construct a healthy, functioning wetland.

The original secondary cell has been divided by a berm to form two separate cells; the holding cell and the dry cell. The holding cell allows for the commitment to condition #3 of the NoA to be met, that no water discharged from the lagoon would leave the site when water levels in the new wetland cell needed to be lowered or raised in order to support the growth of young wetland plants. A weir manhole control structure with gate valve was installed between the wetland cell and the holding cell, controlling flow from the wetland cell to the holding cell. Note that all sewage sludge that was existing in the holding cell area was removed during construction and placed in the wetland cell, as it was required for the design of the wetland benches.

The dry cell, serves as the dryland phytoremediation component of the research, where remediation is occurring by native plants, and is the cell that we are requesting to be removed from the existing licence. Berms separate the dry cell from the holding cell and the wetland cell. There are no pipes or other physical structures that connect the dry cell to the other cells. Although the initial intention of the project was to use native grass species, such as switchgrass, that have been well-studied in phytoremediation science, in 2012 the dry cell had an established dense monoculture of cattail. Due to the quantity of cattail biomass, existing cattail seedbank in the cell and moist substrate conditions in the central part of the dry cell favoring cattail growth, the focus of the remediation research shifted to focus on cattail as the species of interest.

In the winter of 2014/2015, an all-weather access road was built within the dry cell, in order to improve access for maintenance of the site under wet conditions. This access road will be particularly important to the harvesting component of the research, where access will be required into the wetland and dry cell in order to harvest the vegetation biomass. An initial harvest in August 2014 was conducted; however, due to wet conditions the material could not be baled that fall. In order for the Town to harvest and remove vegetation from the dry cell in future years the dry cell will need to be recontoured to encourage more efficient water pooling in certain locations within the cell, or recontoured to allow positive drainage from the dry cell. The Town would formally like to request, to positively drain the dry cell so that water from this cell can drain to the outside connecting drainage system from time to time under larger rain events. It is calculated that only under some of these larger rain events that some of the dry cell surface water may need to be released from the dry cell to the external existing drainage network (see Section

2.3 Surface water retention potential in dry cell). For the harvested plant material the intention is for a local farmer to use the biomass for bioenergy production, as part of his flax-drying system. An alternative option for the biomass use is by Providence University College (Otterburne, MB), to be explored.

4.0 The need for licence removal and alteration to the Notice of Alteration

As presented at the meetings with stakeholders in February and June 2015, as well as in the NoA submitted to the Province of Manitoba in 2011, the Town of Niverville's long-term intention for the old lagoon site is to develop the area as both a park and educational site for the community and the surrounding area (Appendix A). The Town recognizes that opening the site to public access requires decommissioning of the old lagoon, in order to ensure all environmental and human health risks are mitigated, prior to the removal of the existing Environment Act Licence. The Town continues to partner with both the University of Manitoba and Native Plant Solutions to complete a strong monitoring program that provides the results needed for the Province of Manitoba to make an informed decision on the environmental status of this site. However, until sufficient time has elapsed for bioremediation of the entire site (i.e., the treatment of sewage sludge using both plants, or phytoremediation, in both the dry and wetland cells as well as and other biological processes in the wetland cell), the Town is considering a phased approach to decommissioning, as recommended by the Province of Manitoba, in order to allow partial access to the community in the interim for use of the area as an interpretive site and viewing of the research currently underway.

The phasing the Town is considering includes request for removal of the Environmental Licence from the dry cell, as well as installing fencing inside of the lagoon berms to limit public access to those areas still under Licence (Figure 3). This will allow the Town to commence development of the interpretive site in the dry cell while allowing community members to walk the perimeter of the lagoon and view the research being undertaken in the wetland cell, holding cell and control cell. To support this progress towards a community park, the Town is planning on installing an educational kiosk, interpretive signage and a parking pad, as well as removing portions of the south and east berms along the dry cell to increase visibility of the area from a distance. Minor earthworks may be conducted along the west berm of the dry cell, in order to improve safety, access and potentially support the establishment of native grasses.

This report outlines project results to date, how remediation targets are being met, and methods to mitigate risk to environmental or human health with the proposed licence removal and relocation of the lagoon fencing.

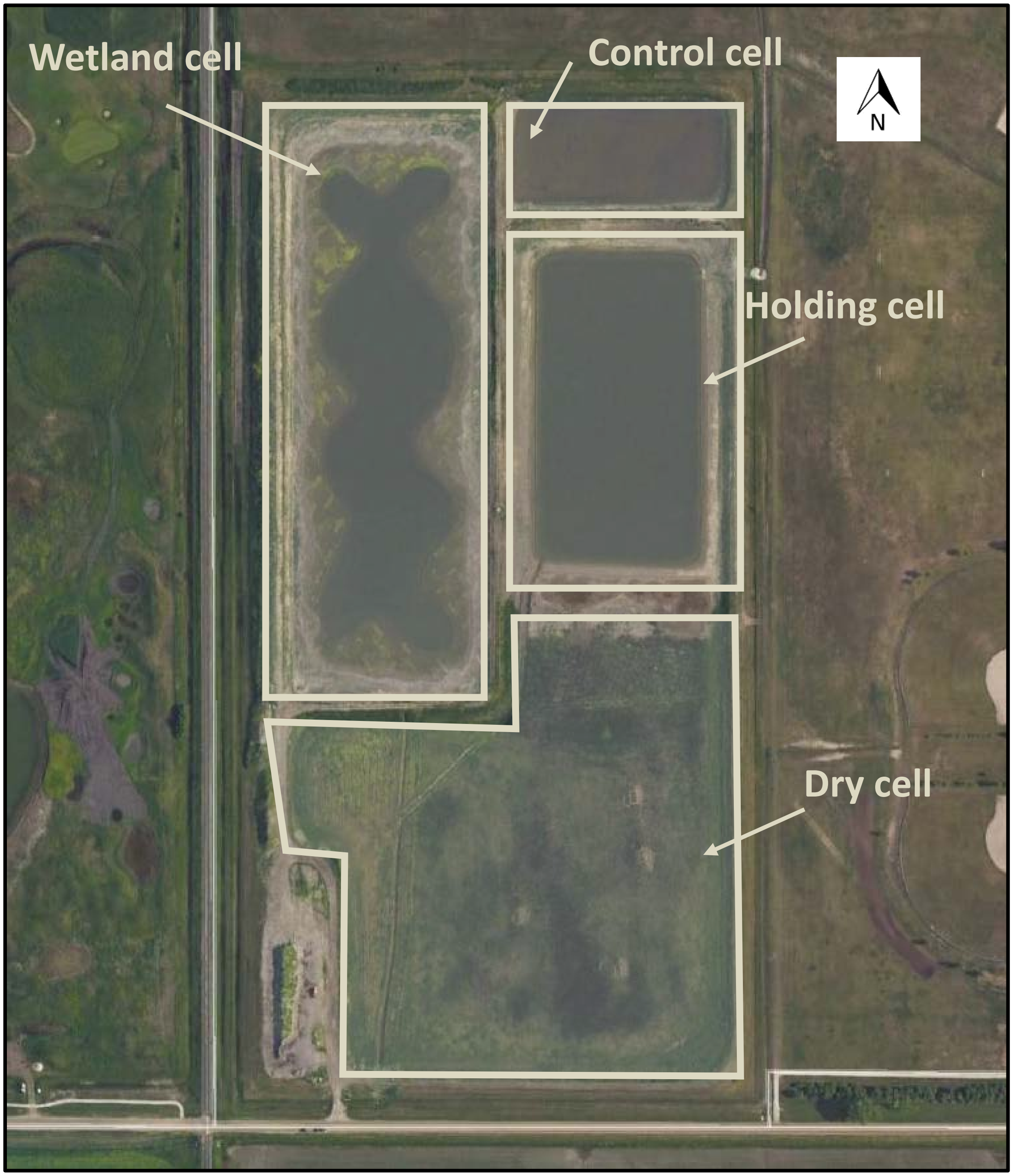

Figure 1. Niverville Lagoon Bioremediation Project site, including the wetland cell, control cell, holding cell and dry cell. Image courtesy of Google Earth (Imagery date: June 2013).

Figure 2. Niverville lagoon on SW 30-7-4 EPM during operation in 2002 (left; Image courtesy of Google Earth) and in 2013 after redesign for the Niverville Lagoon Bioremediation Project (right; Image courtesy of Google Earth.)

Figure 3. Recommended fencing location (red, dashed line) on the inside of the lagoon berms to limit access for those areas remaining under licence, should decommissioning of the dry cell be approved. Note that the fencing location shown is approximate and for discussion purposes only. The existing lagoon fencing (light-blue, dashed line) is also to be maintained. Image courtesy of Google Earth (Imagery date: June 2013).

B. Research in support of licence removal

When the Town of Niverville decided to pursue wetland and phytoremediation as an alternative to remediating its lagoon, it became apparent that research would provide, under controlled conditions, the needed data to demonstrate the effect of the alternative on lagoon decommissioning. In conjunction with researchers from the University of Manitoba and Native Plant Solutions/Ducks Unlimited Canada, a research design was developed, in order to support testing of this decommissioning option. We believe it was the research-based focus of the *in-situ* remediation option that gave regulators within the Province of Manitoba the confidence to approve a Notice of Alteration to Niverville's existing lagoon Environmental Licence, as well as being an innovative approach that achieves nutrient reduction, a 2006 Lake Winnipeg Stewardship Board recommendation (recommendation #20.1; Lake Winnipeg Stewardship Board 2006).

Research supporting the justification for license removal from the dry cell is described below. For abstracts of research and links to the full text research documents see Appendices B-E.

1.0 Plant Growth for Phytoremediation in Dry Cell Biosolids

At the beginning of the study it was unknown whether biosolids alone (i.e., without soil amendments) could support plant growth necessary for phytoremediation. Growth room experiments demonstrated that the wetland plant, Cattail (*Typha* sp.) could grow in un-amended biosolids collected from the dry cell (Hassan 2014; Appendix B). These results were corroborated in the field as cattail passively (i.e., it was not planted) colonized the dry cell after it was redesigned in 2012.

2.0 Optimum frequency and timing of harvest for phytoremediation

Optimum timing of Cattail harvest for phytoremediation will coincide with maximum aboveground nutrient levels. With Cattail this occurs prior to the late-summer/fall re-translocation of nutrients to belowground biomass. Thus, if plants could be harvested multiple times prior to re-translocation of nutrients, then phytoremediation efforts may be maximized.

Research exploring the optimum frequency and timing of plant harvest were explored through growth room experiments and field research. Growth room experiments showed that the optimum time for Cattail (grown in biosolids) harvest was day 83 (for N) and day 86 (for P) after transplanting (Jeke et al. 2015a; Appendix C). Growth room experiments also demonstrated that cattail harvested twice in a growth cycle allowed for higher amounts of contaminant removal as compared to a single harvest (Hassan 2014; Appendix B).

However, conditions in the field are more complex than the controlled environment of the growth room. To study harvest under field conditions research was conducted *in situ* in the dry cell in 2013 and 2014 (Figure 4). This research has not yet been published but is described below.

The dry cell was divided into randomized plots which were:

- harvested at different times during the growing season
- unharvested; harvested once; or harvested multiple times.

Data from the dry cell was used to determine the remedial effectiveness of the vegetation; how well the vegetation could withstand repeated mowing (harvesting); and the optimum time for mowing and the removal of vegetative matter.

Tissue testing was done to determine total uptake of contaminants/nutrients by plants under different management regimes (e.g., timing of harvest and number of harvests). Single harvest plots were harvested 49 days after the commencement of spring regrowth and the two harvest treatments were harvested at the 35 day period. For the two harvest plots it was found that insufficient regrowth occurred after the 35 day harvest point to allow for a second harvest. This was most likely due to the low N mineralization rate in the dry cell, which resulted in insufficient available N concentrations to support plant regrowth (Jeke et al. 2015b; Appendix D).

In the dry cell, between 2013 and 2014, biomass yield was fairly similar (Figure 5). In 2014, when single versus multiple harvests were compared, greater biomass yield was observed when only a single harvest was conducted (Figure 6). 2013 aboveground uptake, as determined in the field, was 78 kg ha^{-1} yr^{-1} for N, 15 kg ha^{-1} yr^{-1} for P and <0.08 kg ha^{-1} yr^{-1} for trace elements.

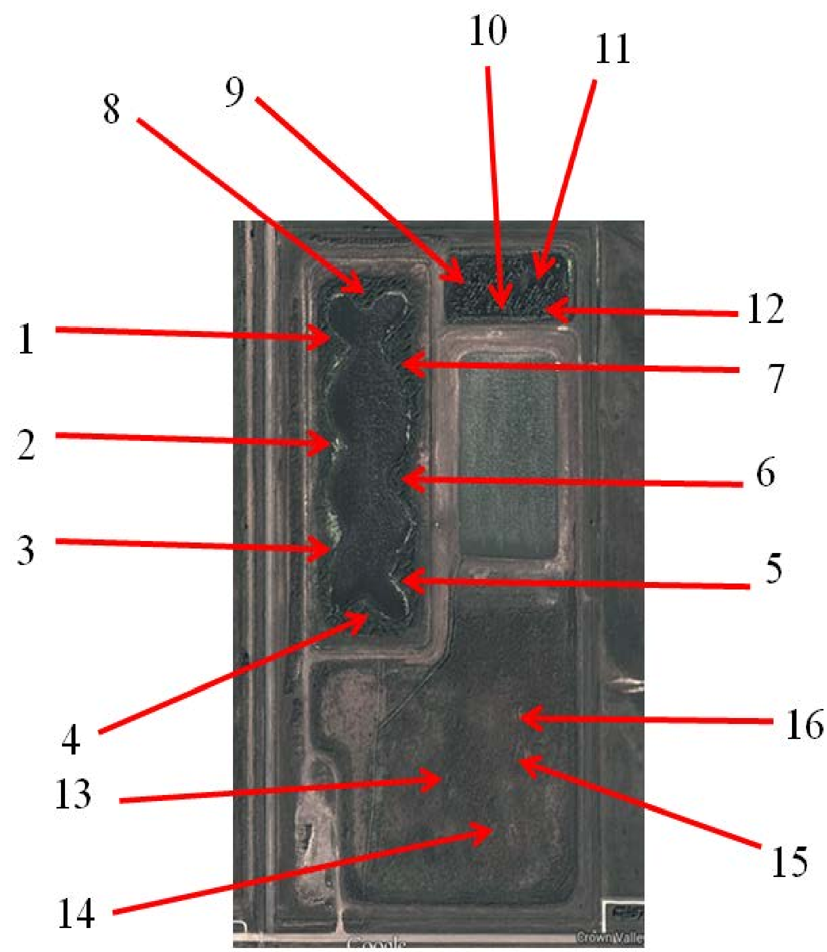

Figure 4. Vegetation transects established in 2013 in the dry cell (13-16).

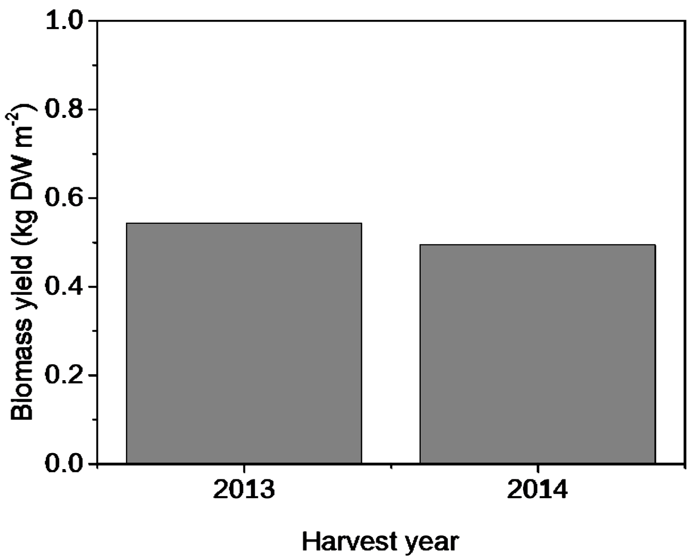

Figure 5. Field results for the dry cell, for cattail biomass yield (kg dry weight (DW) m^{-2}), in 2013 (first growing season) and 2014 (second growing season).

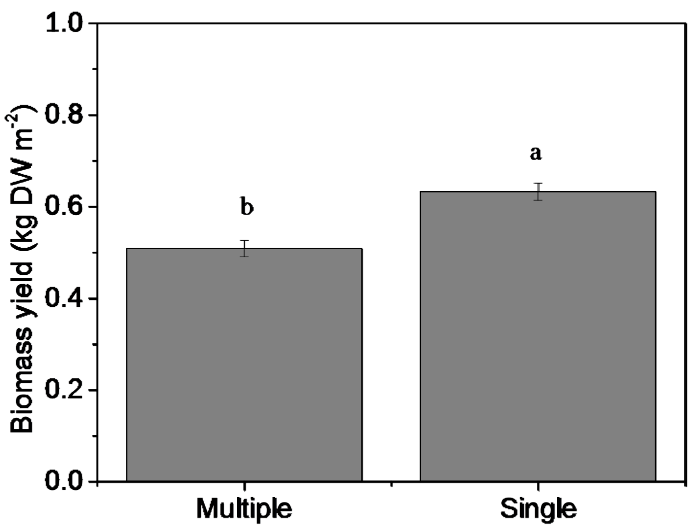

Figure 6. Field results for the dry cell, comparing cattail biomass yield (kg dry weight (DW) $m^{-2}$for single versus multiple harvests in 2014.

3.0 Nutrient availability in biosolids

Phosphorus and nitrogen occur in different fractions in biosolids. However, it is their bio-available inorganic forms that pose a risk to the health of aquatic environments. Mineralization is the process that transforms nutrients from organic to inorganic. Laboratory experiments demonstrated that dry cell biosolids have low N mineralization rates (Jeke et al. 2015b; Appendix D). This is most likely due to the fact that the labile organic pool of nitrogen in the dry cell has already been biodegraded during its long storage period leaving behind only the recalcitrant organic N fraction.

Laboratory experiments also showed that bio-available (Olsen) phosphorus concentration in dry cell biosolids decreased over time (Figure 7), which was likely caused by phosphorus fixation (Jeke 2014; Appendix E). The low bio-availability of phosphorus in the biosolids is an asset since this relates to low concentrations of the readily deleterious form of phosphorus in any surface runoff out of the dry cell.

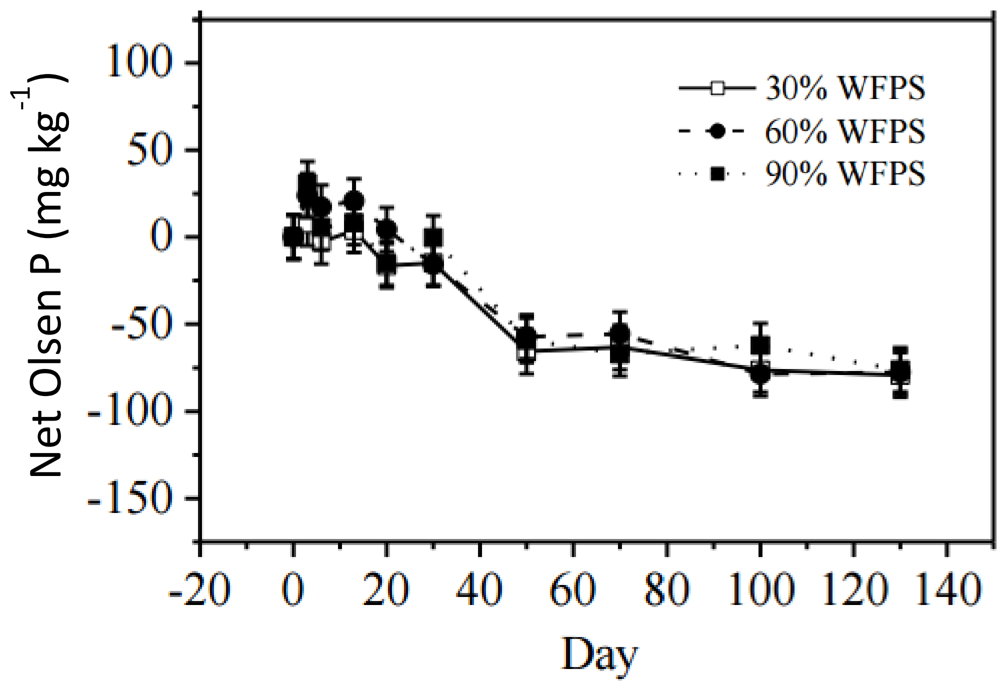

Figure 7. Net phosphorus concentration in and dry cell biosolids as affected by moisture content (percent water filled pore space (WFPS)). Vertical bars represent standard errors of the mean.

C. Request for Licence Removal and Alteration to the Existing Notice of Alteration

1.0 Alteration Description

This section provides a formal request for the removal of the Environmental Licence on the dry cell of the old Niverville lagoon (Figure 1). Justification for the removal of the Environmental Licence is that biosolids in the dry cell area demonstrate low risk to environmental or human health and are considered decommissioned. As the method for lagoon decommissioning that the Town of Niverville has selected for their lagoon has never been undertaken before in Manitoba or elsewhere, there is an absence of guidelines or precedence by which to compare the progress of this site. Therefore, we have suggested project remediation targets used in both Canada and the United States, to which biosolid concentrations in the lagoon can be compared. Section C - 2.0 presents these project remediation targets, provides justification for their usefulness in evaluating risk to environmental and human health, and compares concentrations of trace elements and nutrients in the old Niverville lagoon biosolids over the duration of

Once the environmental licence is removed from the dry cell, the Town's plan recommends that portions of the south berm and east berm along the dry cell be taken down in order to open the site and make it more visible to the public, allow connection to Hespeler Park via a pathway, and permit dry cell water release (Appendix A). Dry cell water release is necessary to create the dry conditions required for biomass harvesting as past biomass harvesting attempts within the cell have failed due to wet conditions.

In this case, the holding cell would be closed off from the dry cell, in order to maintain water on site in areas remaining under licence, and improved positive drainage in the dry cell would be directed to the south for release. At a meeting with the Province of Manitoba on June 23rd, concern existed for transport of nutrients (particularly phosphorus) from the biosolids in any water to be discharged. To explore the potential for phosphorus mobility and release from the dry cell in discharged water, water quality samples from the holding cell, are compared to Manitoba Tier I Water Quality Standards for municipal wastewater effluent discharge, as well as typical surface water quality runoff from adjacent vegetated agricultural fields as project remediation targets (see Section C - 2.0).

In addition, we outline the steps the Town of Niverville is intending to take on site in order to mitigate future risk to environmental and human health.

2.0 Project Phytoremediation Targets

As this type of *in-situ* lagoon remediation has never before been undertaken in Manitoba or elsewhere, remediation targets for trace elements that determine when a lagoon has been 'decommissioned', or no longer requires an Environmental Licence, do not exist. Therefore, alternative environmental guidelines need to be considered when assessing the status of the Niverville Lagoon Bioremediation Project site. The Town of Niverville, in conjunction with research partners at the University of Manitoba and Ducks Unlimited Canada, has focused on the Canadian Council of Ministers of the Environment (CCME) Environmental Quality Guidelines as project remediation targets. Manitoba Conservation and Water Stewardship has adopted these same guidelines in order to assess appropriate criteria and standards in terms of soil and water quality and minimize negative impacts to the environment and human health

(Manitoba Water Stewardship 2011). To assess the status of biosolid remediation at Niverville, we consider the soil quality guidelines for assessing the remediation status of the dry cell.

When considering the applicability of these suggested project remediation targets, note that the CCME Environmental Quality Guidelines are Tier 1 guidelines, which are designed to be the most restrictive. The remediation process that is occurring in order to reduce nutrient and trace element concentrations includes not only those removed from the system (i.e., through biomass harvesting) but also those sequestered in the unharvested biomass.

The following sections will compare established remediation targets to conditions in the dry cell as well as, when available, to conditions in the holding cell, and surrounding environments outside of the former lagoon's footprint.

2.1 Trace elements in biosolids

Soil quality guidelines are derived for upland areas and "specifically for the protection of ecological receptors in the environment or for the protection of human health associated with the identified land use" (CCME 2007). Threshold values were determined on a chemical-by-chemical basis using toxicological data. The limiting pathway for environmental soil quality guidelines (SQGs) was soil contact and the limiting pathway for Human Health SQG's was soil ingestion. The lower threshold between the Environmental Health SQG and the Human Health SQG is then used as the overall CCME recommended SQG.

Concentrations (mg/kg) have been measured for nine trace elements within the biosolid constituents of the dry cell in 2011, and 2013. All elements met CCME Canadian Soil Quality Guidelines during all years for the Protection of Environmental and Human Health in residential and parkland areas in the dry cell (Table 1).

In addition to the CCME Environmental Quality Guidelines as project remediation targets, the Province of Manitoba (June 23rd, 2015 meeting) also recommended comparison to the United States Environmental Protection Agency (US-EPA) biosolid regulations. The US-EPA developed their regulations (also known as Part 503 Rule) to protect public health and the environment from any reasonably anticipated adverse effects of certain pollutants that might be present in biosolids (US-EPA 1994a). The regulations are based on an extensive risk assessment and establishes requirements for the final use or disposal of sewage sludge when biosolids are applied to land, placed on a surface disposal site or incinerated. Although the Niverville project would not be strictly defined as 'land application' (i.e., to put biosolids on the land to take advantage of the nutrient content or soil conditions properties on the biosolids), the rules and requirements that apply to land application are considered for project remediation targets, taking into consideration site-specific conditions.

The US-EPA considers both pollutant (i.e., trace elements) and pathogen reduction limits. This section considers how the Niverville dry cell lagoon biosolids meet pollutant reduction limits, while Section C - 2.4 considers how the biosolids meet pathogen reduction limits.

Of the regulatory options available for pollutant reduction limits, Niverville dry cell biosolids meet pollutant concentration limits for either Exceptional Quality (EQ) or Pollutant Concentration (PC) biosolids, defined as biosolids that meet low-pollutant reduction limits (Table 1; US-EPA 1994b). Distinguishing between these two classifications depends on their pathogen reduction limits and site management practices. However, for the US-EPA, EQ biosolids are considered virtually unregulated for use; therefore, meeting this classification would justify to the Province of Manitoba a removal of the Environmental Licence on the dry cell area.

Table 1. Trace element levels (mg/kg) in biosolids samples taken from the dry cell from 2011 to 2013 and soil quality guidelines (parentheses indicate standard deviations).

Trace Element	2011	2013	CCME Soil Guideline[1]	US EPA EQ and PC Limits[2]
Arsenic	4.34 (0.2)	5.69 (0.6)	12	41
Cadmium	0.341 (0.01)	0.396 (0.02)	10	39
Chromium	35.07 (4.1)	46.12 (1.6)	64	1200
Copper	30.2 (1.7)	40.2 (1.9)	63	1500
Lead	10.08 (0.7)	14.65 (0.8)	140	300
Mercury	<0.05	0.04 (0.01)	6.6	17
Nickel	28.7 (3.9)	41.9 (1.7)	50	420
Selenium	<0.5	0.79 (0.1)	1	36
Zinc	68 (4.4)	108.75 (4.8)	200	2800

[1]CCME Recommended Soil Quality Guideline for the Protection of Environmental and Human Health in residential/parkland areas

[2]Pollutant concentration limits for Exceptional Quality (EQ) and Pollutant Concentration (PC) biosolids

2.2 Nutrients in biosolids

Similar to trace element concentrations in biosolids, as this type of *in-situ* lagoon remediation has never before been undertaken in Manitoba or elsewhere, remediation targets for nutrient concentrations that determine when a lagoon has been 'decommissioned', or no longer requires an Environmental Licence, do not exist. Following discussions in February and June 2015 with the Province of Manitoba, The Town of Niverville, in conjunction with research partners at the University of Manitoba and Native Plant Solutions, it was suggested to consider land application rates that are typically acceptable for biosolids application to agricultural land, as project remediation targets for nitrogen and phosphorus.

In order to consider land application rates, nutrient concentrations in the dry cell biosolids (Table 2) needed to be adjusted by the biosolids bulk density to generate nutrient/area measurements. Bulk density was measured using a core of known diameter hammered to a depth of about 15 cm, which is the biosolids layer thickness above the clay lining. Sixteen cores were collected to give a broad spatial coverage in the dry cell for determination of bulk density. An additional six cores were taken to determine root-excluding bulk density by taking into account the volume and weight of the root biomass. The bulk density for dry cell biosolids is 0.87 tonnes/m^3 and total tonnage of biosolids is 9104 tonnes. Table 3 presents total P (TP) and total N (TN) as tonnes/ha in the dry cell with comparisons to a range of typical agricultural application rates for biosolids. Typical TP and TN loading from biosolids applied on agricultural fields was calculated from a suggested biosolids application range of 10 -15 t/ha and ranges of biosolids TN and TP obtained from the literature.

While the dry cell has higher TP levels than those typical of biosolid application to agricultural fields, it must be noted that agricultural fields have greater risk of nutrient runoff as compared to the dry cell. This is due to the environment in the dry cell always being under extensive living vegetation or standing litter, unlike agricultural fields that typically have no cover during snowmelt and during rainfall early in the growing season when the risk of runoff is usually highest. It also must be recognized that nutrients in dry cell biosolids also have limited bioavailability due to their low nitrogen mineralization rate and the high amount of phosphorus fixation (Appendices C and E). Considering the above site specific conditions, nutrient loss from the dry cell is expected to be minimal and much less than that from neighboring cropland.

Table 2. Dry cell biosolid nutrient concentrations, as recorded from existing data (2011-2014).

Nutrients (mg/kg)	2011	2013	2014
TP	1440 (17.3)	1930 (343)	1902 (331)
Olsen P	72.9 (4.2)	101 (8.8)	97.9 (9)
NH_4-N	12 (1.7)	43.9 (6.9)	27.5 (5.9)
NO_3-N	29.6 (2.1)	11.8 (1.9)	16.4 (10.6)
TN	2446 (304)	2287 (302)	2533 (546)

Table 3. Dry cell biosolid nutrients (mass per area) as compared to agricultural field conditions after typical biosolid application (10 to 15 tonnes/ha of biosolids).

Nutrients (tonnes/ha)	Dry Cell	Agricultural application rate (10 -15 tonnes biosolids/ha[1])	Agricultural field after biosolid application
TP	2.5	0.05 – 0.75[1]	1.26- 1.96[1]
TN	3.3	0.1 – 0.45[2]	5.14 - 5.58[2]

[1] Phosphorus calculated with a P range of 5 to 50 g kg^{-1} (LeBlanc 2008).
[2] Total nitrogen range from 10 - 30 g kg^{-1} which is characteristic of Low N biosolids (Brown and Henry 2002).

2.3 Surface water retention potential in dry cell

The current contours of the dry cell along with its vegetated soil give the dry cell a large capacity to hold water following precipitation events and limit runoff. Approximately 25% of the dry cell contains shallow depressions of 4-6 inch depths in which micro-pools form after precipitation events. The dry cell micro-pool storage capacity can be calculated and compared to the amount of surface water expected for various rain scenarios to determine the runoff potential from the dry cell. A model for high vegetation cover sites was used in conjunction with local precipitation data (55 years of data from 1960-2014) to determine surface runoff potential from the dry cell. Surface runoff from the dry cell was calculated based upon the Ration Runoff Method (runoff volume = C*rainfall*area; where C=runoff coefficient). The runoff coefficients used for the dry cell were those for high vegetated sites under dry and wet soil conditions. The calculated range of expected surface runoff, under normal precipitation events, does not exceed the storage capacity of the micro-pools within the dry cell under both dry and wet (i.e., field capacity) soil conditions (Table 4). Thus, under a normal rain event the micro-pools alone have a large enough volume to contain all the surface water generated within the dry cell.

In addition to the micro-pools, the dry cell soil has a natural capacity to retain surface water within the soil profile. The high vegetation cover of the dry cell, by slowing the flow of surface runoff, allows water more time to infiltrate into the soil resulting in limited or reduced surface runoff from the cell. The storage capacity of the dry cell soil under both dry and wet soil conditions is large relative to the amount of rainfall that the cell receives under a normal (25 mm in a day) rain event and thus the potential for surface runoff from the dry cell is low (Table 5).

Considering both the water holding capacity of the dry cell soil and the numerous micro-depressions, the likelihood of runoff from the cell during normal rain events is minimal and it is not anticipated that there will be large release events from the dry cell.

Table 4. Calculated surface water runoff in dry cell under various precipitation events compared to existing storage capacity in shallow micro-pools of the dry cell.

Calculated surface water in dry cell[1] (m^3)			**Existing storage capacity of dry cell micro-pools (m^3)**
Normal rain event (25mm in a day)	1 in every 2 year event (45 mm in a day)	1 in 10 year event (68 mm in a day)	875
88-618[2]	157-1096	238-1665	

[1]Based on the Ration Runoff Method for high vegetated sites.

[2]Low number indicates surface water under dry soil conditions and high number indicates surface water under wet soil conditions.

Table 5. Calculated natural soil storage capacity of the dry cell under wet/dry soil conditions (i.e., wilting point to field capacity).

Natural Storage Capacity of Dry Cell Soil (m^3)		
Total volume of rain falling on the dry cell during a normal (25 mm in a day) rain event	Dry Soil Storage capacity	Wet Soil Storage capacity
1765	1677	1147

2.4 Nutrients in dry cell surface water

In the summer of 2015, following advice from the Province, nutrient concentrations after storm events were monitored in dry cell micro-pools and in nearby agricultural ditches. Four water samples were collected along a drainage ditch when water was flowing following heavy storms. The drainage ditch is located across from the lagoon and spans across three fields. Two of the fields were planted with corn and the other one with canola. Four composite water samples were collected in the dry cell from micro-pools after rain events.

Nutrient concentrations in dry cell micro-pools, although slightly higher than those in nearby agricultural ditches, never exceeded Provincial guidelines for the protection of aquatic environments (Table 6). Thus, in the event of surface runoff from the dry cell, the water leaving the cell would not present a risk to receiving environments as it would contain nutrient levels below the Provincial guidelines for the protection of aquatic environments. In fact, with sufficient flooding to cause runoff, nutrient concentration would be lower since the concentrations presented herein represent those in localized shallow micro-pools which likely reflect pore-water concentrations at concentrated levels.

Table 6. Mean nutrient concentrations in water from dry cell micro-pools and agricultural ditches after storm events in the summer of 2015.

Nutrient (mg/L)	Dry cell micro-pool		Nearby Ditch		Provincial Guideline
TP	June 24 0.764 (0.197)	July 7 0.863 (0.253)	June 24 0.609 (0.001)	July 7 0.572 (0.057)	1.0
Ammonia	<0.1	<0.1	<0.1	< 0.1	1.08 to 4.82[1]

[1]Represents guideline within the pH and temperature range of the dry cell.

2.4 Pathogen levels

In addition to the pollutant level remediation targets set out by the US-EPA, the Province of Manitoba also recommended considering the US-EPA pathogen concentration requirements. The US-EPA designates biosolids as Class A or Class B based on pathogens, and indicates the density of pathogens where applicable (US-EPA 1994c). Pathogen reduction requirements can either be met by certain specified technologies to treat biosolids or by showing that the quality of the biosolids meets certain performance requirements.

During the spring and summer of 2015 the sludge in the dry cell was sampled for fecal coliforms. Six composited biosolids samples were collected to cover the entire area of the dry cell. Biosolids were sampled to the entire depth of the biosolids which was approximately 15 cm. Samples were sent to ALS laboratory in Winnipeg for assessment. Analysis of fecal coliform was carried out using EPA Method 1680 Fecal Coliforms in Sewage Sludge (Biosolids) by multiple tube fermentation.

Total coliform levels were below EPA standards (< 1000 MPN/g) for Class B biosolids at all sites in 2015 (Table 7). It should be noted that water sampled from the holding cell in 2015 also had total coliform (23-93 MPN/100 mL) counts that were well below Provincial recreation guidelines of 200 MPN/100 mL (https://www.gov.mb.ca/waterstewardship/water_quality/ wq_beach_info-bulletin.html).

Class B requirements have site restrictions, including those for harvesting crops (i.e., for food, feed or fibre) and turf, grazing of animals and public contact. Although harvesting and grazing restrictions would not apply for Niverville's long-term vision for the site, public contact restrictions would apply. As land that has a potential for public exposure (i.e., a park or ballfield), the US-EPA recommends access be restricted for 1 year after biosolids application (US-EPA 1994b). Since there is no physical application date for the Niverville lagoon bioremediation project, this timeline is up to interpretation. However, these biosolids have been heavily vegetated for roughly 5 years, which is equivalent to more than one year post-application, and lab tests indicate as such. Also, since access has only been allowed for research since project commencement in spring 2013, we suggest that the Town has already met this restriction.

Table 7. Fecal coliform bacteria in the dry cell sludge, 2015.

	Coliform ($MPNg^{-1}$)†
May	<2
June	<2 - 6
July	106 (99)

† MPN, most probable number; Standard deviations in parentheses; Detection limit < 2 $MPNg^{-1}$
FC density less than 1000 Most Probable Number (MPN)/g TS (US EPA, 1993)
200 fecal coliform organisms / 100 mL or 200 Escherichia coli organisms / 100 mL

3.0 Risk Mitigation

If the Town of Niverville's proposal for removal of the Environmental Licence on the dry cell is approved, a portion of the site will be open for public access (i.e., the dry cell and surrounding berms) while the remaining area will continue to be under Environmental Licence (i.e., wetland cell, holding cell, control cell). Therefore, in order to protect public health and the environment, Niverville has considered a number of risk mitigation practices. These include managing surface water on site; continuing to monitor site nutrient and trace element concentrations in biosolids, sewage sludge, and surface water, tracking their progress to remediation targets; establishing zones under Environmental Licence where no public access is allowed, using fencing and signage; and maintaining vegetation on site to prevent wind or water erosion of biosolids or sewage sludge.

3.1 Surface water discharge

As Environmental Licence #2712 will continue to apply to portions of the site, berms will be maintained around the cells that will continue to hold water (i.e., the wetland cell, control cell and holding cell). If, for any unforeseen reason, water does need to be released from the wetland cell, control cell or holding cell, it will first be confirmed with the Province and tested and then handled according to test results and Provincial regulations. It should be noted that water from the dry cell was released in 2010 under environmental licence into an adjacent municipal ditch having met release standards for contaminants. A formal request allowing surface water to be released infrequently, and only under larger rain events, from the dry cell, is included as one part of this decommissioning submission for the dry cell.

3.2 Continued monitoring

For areas that will remain under Environmental Licence #2712, ongoing monitoring of the site will take place. This monitoring will inform future decommissioning targets for the wetland, control and holding cells of the lagoon, as part of Nick Jeke's Ph.D. research, as well as ongoing water quality monitoring by the Town of Niverville. This monitoring program has been developed in order to better understand the risks of the area to environmental and human health.

3.3 Fencing

For areas to remain under Environmental Licence (i.e., wetland cell, control cell and holding cell), public access to the site will be restricted. Restriction will be by fencing installed on the inside of the berms around licenced areas (Figure 3), in order to keep the public out of areas with sewage sludge or water. However, fencing is to be installed on the inside side of the berm, in order to partially allow public to observe the progress of Phase III research, as well as any wildlife on site. Fencing used around licenced areas will be installed to the same standard as is currently required for the Niverville lagoon (i.e., minimum of 1.2 m in height or of sufficient height to limit access from berms into the lagoon, locked in areas, and maintained). Note that existing lagoon fencing around the outside of the lagoon will also be maintained to restrict access to the site outside of park visiting hours s8ained6.6(oe) 1ghooi.2(g)n.5(o)ten-36dugo, go 5kgu7e3o

4.0 Justification for Dry Cell Licence Removal

The work conducted to date provides evidence that the dry cell demonstrates a low risk to human and environmental health and should be considered decommissioned:

- Human pathogen concentrations meet targets in dry cell biosolids.
- Trace element concentrations meet targets in dry cell biosolids.
- Nutrient concentrations of dry cell ponded water meet discharge targets.
- Low nutrient bioavailability within dry cell biosolids.
- High surface water retention potential in dry cell.

The current site conditions (Table 8), in conjunction with our risk mitigation strategy (Section C.3.), warrant the removal of the licence from the dry cell. Licence removal will allow the Town of Niverville to continue pursuing its progressive and sustainable vision for the Niverville Lagoon site as an interpretive and educational park site.

Table 8. Decommissioned status of the dry cell.

Dry cell variable	Decommission target	Dry cell status
Biosolid fecal coliform	US-EPA Class B Biosolid target:	Decommissioned: - Dry cell biosolids meet the target level.
Trace elements in biosolids	CCME Soil Guidelines and US EPA EQ and PC Limits:	Decommissioned: - Dry cell biosolids meet target levels for all trace elements.
Nutrient concentrations in surface runoff	Manitoba Tier I Water Quality Standards	Decommissioned: - Nutrient concentrations in dry cell micro-pools meet target levels.
Bioavailability of biosolid nutrients	Low bioavailability of biosolid nutrients.	Decommissioned: - Low bioavailability of nutrients due to low mineralization and high fixation of nutrients in dry cell biosolids.
Public access to biosolids	US- EPA Part 503 Biosolids Rule: - Restrict public access for one year after biosolid application.	Decommissioned - Dry cell has had restricted public access since its development and has been heavily vegetated for 5 years.
Surface water retention in dry cell	Demonstrate ability of dry cell to retain surface water after normal rain events.	Decommissioned - Dry cell micro-pools and vegetated soil provide large water storage capacity.

D. References

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Appendix A. Excerpts from: Niverville Bioremediation: Lagoon Site Plan

Niverville Bioremediation Lagoon Site Plan

A high-level site plan for the Town of Niverville

June 2015

NATIVE PLANT SOLUTIONS

Native Plant Solutions / Ducks Unlimited Canada
Unit A, 1238 Chevrier Blvd
Winnipeg, Manitoba

Figure 1. Site plan design. Dry cell area outlined in red.

Photo 1: Fence and native grass planting example from NPS project at Henteliff Park (Winnipeg, MB).

Photo 2: Path and native grass planting example from NPS project at Assiniboine Forest (Winnipeg, MB).

Appendix B. Phytoremediation of municipal biosolids: Terrestrial and wetland approaches.

Hassan, Adenike Olabisi. M.Sc., University of Manitoba, August, 2014.
Advisor: Dr. Francis Zvomuya
Full text available at: http://mspace.lib.umanitoba.ca/handle/1993/25170

ABSTRACT

Growth room experiments were conducted to examine terrestrial and wetland-based phytoremediation approaches as alternatives to biosolids management. Results from both experiments show that biosolids do not need to be amended with soil to encourage plant growth and optimize biomass yields. In the terrestrial phytoremediation approach, two harvests per growth cycle produced greater switchgrass biomass yield than a single harvest but had no significant effect on cattail biomass yield during the first cycle.

Repeated harvesting also significantly increased mean nutrient uptake in Cycle 1, reflecting the greater biomass yield from two harvests compared with a single harvest. In the wetland experiment, nutrient phytoextraction under two harvests was 4.25% of initial
N content and 2.28% of initial P content compared with 2.9% and 1.58%, respectively, under a single harvest. Terrestrial phytoremediation could be beneficial to small communities that cannot afford the costly excavation, trucking, and eventual spreading of biosolids on agricultural land.

Appendix C. Biomass, Nutrient, and Trace Element Accumulation and Partitioning in Cattail (*Typha latifolia* L.) during Wetland Phytoremediation of Municipal Biosolids.

Jeke, N.N., Zvomuya, F., Cicek, N., Ross, L. and Badiou, P. 2015.
Journal of Environmental Quality 44:1541–1549.
Full text available at: file:///C:/Users/duc1081/Downloads/jeq-0-0-jeq2015.02.0084%20(2).pdf

ABSTRACT

Biomass and contaminant accumulation and partitioning in plants determine the harvest stage for optimum contaminant uptake during phytoremediation of municipal biosolids. This wetland microcosm bioassay characterized accumulation and partitioning of biomass, nutrients (N and P), and trace elements (Zn, Cu, Cr, and Cd) in cattail (*Typha latifolia* L.) in a growth room. Four cattail seedlings were transplanted into each 20-L plastic pail containing 3.9 kg (dry wt.) biosolids from an endof-life municipal lagoon. A 10-cm-deep water column was maintained above the 12-cm-thick biosolids layer. Plants were harvested every 14 d over a period of 126 d for determination of aboveground biomass (AGB) and belowground biomass (BGB) yields, along with contaminant concentrations in these plant tissues. Logistic model fits to biomass yield data indicated no significant difference in asymptotic yield between AGB and BGB. Aboveground biomass accumulated significantly greater amounts of N and P and lower amounts of trace elements than BGB. Maximum N accumulation in AGB occurred 83 d after transplanting (DAT), and peak P uptake occurred at 86 DAT. Harvesting at maximum aboveground accumulation removed (percent of the initial element concentration in the biosolids) 4% N, 3% P, 0.05% Zn, 0.6% Cu, 0.1% Cd, and 0.2% Cr. Therefore, under the conditions of this study, phytoremediation would be most effective if cattail is harvested at 86 DAT. These results contribute toward the identification of the harvest stage that will optimize contaminant uptake and enhance in situ phytoremediation of biosolids using cattail.

Appendix D. Moisture Effects on Nitrogen Availability in Municipal Biosolid from End-of-Life Municipal Lagoons.

Jeke, N.N., Zvomuya, and Ross, L. 2015b.
Full text available at: Journal of Environmental Quality doi:10.2134/jeq2015.02.0084.

ABSTRACT

Nitrogen (N) availability affects plant biomass yield and, hence, phytoextraction of contaminants during phytoremediation of end-of-life municipal lagoons. End-of-life lagoons are characterized by fluctuating moisture conditions, but the effects on biosolid N dynamics have not been adequately characterized. This 130-d laboratory incubation investigated effects of three moisture levels (30, 60, and 90% water-filled pore space [WFPS]) on N mineralization (Nmin) in biosolids from a primary (PB) and a secondary (SB) municipal lagoon cell. Results showed a net increase in Nmin with time at 60% WFPS and a net decrease at 90% WFPS in PB, while Nmin at 30% WFPS did not change significantly. Moisture level and incubation time had no significant effect on Nmin in SB. Nitrogen mineralization rate in PB followed threehalf-order kinetics. Potentially mineralizable N (N0) in PB was significantly greater at 60% WFPS (222 mg kg−1) than at 30% WFPS (30 mg kg−1), but rate constants did not differ significantly between the moisture levels. Nitrogen mineralization in SB followed first-order kinetics, with N0 significantly greater at 60% WFPS (68.4 mg kg−1) and 90% WFPS (94.1 mg kg−1) than at 30% WFPS (32 mg kg−1). Low Nmin in SB suggests high-N-demanding plants may eventually have limited effectiveness to remediate biosolids in the secondary cell. While high Nmin in PB would provide sufficient N to support high biomass yield, phytoextraction potential is reduced under dry and near-saturated conditions. These results have important implications on the management of moisture during phytoextraction of contaminants in end-oflife municipal lagoons.

Appendix E: Biomass, Nutrient and Trace Element Dynamics in Cattail and Switchgrass during Wetland and Terrestrial Phytoremediation of Municipal Biosolids.

Full text available at:
http://mspace.lib.umanitoba.ca/bitstream/handle/1993/30172/Jeke_Nicholson.pdf?sequence=3&isAllowed=y

Jeke, Nicholson Ngoni. M.Sc., University of Manitoba, December, 2014.
Advisor: Dr. Francis Zvomuya

ABSTRACT

Knowledge of nutrient accumulation and partitioning in plants is important to determine the optimum timing of harvesting during phytoremediation of biosolids. This research showed that a greater proportion of nitrogen (N) and phosphorus (P) absorbed by cattail and switchgrass was partitioned to the aboveground biomass (AGB), but this partition decreased after the onset of nutrient retranslocation to roots. Therefore, AGB should be harvested prior to retranslocation in order to optimize nutrient phytoextraction. Trace elements partitioned preferentially to the root biomass, indicating that AGB harvesting will have little impact on their phytoextraction. Net mineralized N concentration (Nmin) in biosolids from the primary lagoon cell was optimized near field capacity [60% water filled pore space (WFPS) but changed little under drier conditions (30% WFPS). Under near-saturation conditions (90% WFPS), net Nmin decreased with incubation time, likely due to reduced mineralization and denitrification. Available (Olsen) P concentration was not affected by moisture content.