EXECUTIVE SUMMARY

Biosolids as a Tool in Non-Agricultural Land Application Management Options

Presented to:	Josh Frederick, Capital Regional District
Presented by:	John Lavery, SYLVIS Environmental
Presentation date:	September 17, 2019

Introduction

This document summarizes three white papers prepared by SYLVIS that detail the background, process, regulatory requirements, recommended stakeholder engagement, benefits, and risks of the following management options for Class A heat-dried biosolids:

1. Mine Reclamation and Ecosystem Restoration

Many mineral and aggregate mines are challenged by a shortage in total volumes of productive topsoil required to reclaim mined lands. Biosolids have proven to be an effective tool in mine reclamation and can be used as a fertilizer, a soil amendment, or as a feedstock for soil fabrication. Ecosystem restoration is a component of mine reclamation, but it is not exclusive to mines. The use of biosolids as a tool for wildfire restoration has frequently been hypothesized, but rarely tested.

2. Forest Fertilization

Most North American forest soils, particularly forests that are managed for wood products, are deficient in the nutrients required for optimal tree growth. Biosolids represent an alternative to chemical fertilization that is both renewable and less carbon intensive, improving growth, tree nutrition, and overall ecosystem health and productivity.

3. Turf and Landscaping Management

There are several types of turf and landscaping applications that can be considered for biosolids application. “Turf” includes high performance turf (golf courses and athletic fields) and seeding or sod placement for new turf establishment. Sod production is an agricultural crop, but agronomically similar to new turf establishment. Landscaping includes public landscaping in grass and garden areas, private residential landscaping, and marginal landscaping of publicly managed greenways and roadside buffers. In these industries, heat-dried biosolids are generally marketed as a slow-release fertilizer that is comparable to the handling and application of traditional inorganic fertilizers.

Biosolids Management Process

The following process components are required for a biosolids land application program:

- A landowner or land manager project partner;
- Amendments to mine permit or forest tenure permit (if applicable to management option);

- A Land Application Plan (LAP) written by a Qualified Professional, which specifies the agronomic, environmental, and practical requirements for the specific application site; and
- A project design including biosolids transportation and storage, detailed site assessment and mapping, site management and biosolids application.

A well conceived biosolids land application program engages numerous additional stakeholders. It is recommended that all stakeholders, neighbours, and interested parties are kept apprised of the project from the proposal phase through project completion.

Regulatory Requirements

The Ministry of Environment and Climate Change Strategy (ENV) strictly regulates the production and application of biosolids through the Organic Matter Recycling Regulation (OMRR); land application of biosolids requires the preparation of a LAP by a Qualified Professional. The OMRR is currently under comprehensive review by ENV.

In addition, the following regulatory requirements are necessary based on the management option:

Mine Reclamation – The Ministry of Energy, Mines and Petroleum Resources (MEMPR) requires a closure plan as per the mine permit. In some instances, biosolids can be applied in accordance to a Permit issued through ENV.

Forest Fertilization – Fertilization of crown land requires notification of the Ministry of Forests, Lands, Natural Resource Operations & Rural Development (FLNRORD), First Nations recognized to have overlapping traditional rights and/or title to the landbase, and any overlapping tenure holders, such as mineral resource tenures, trapping tenures, and grazing tenures.

Turf and Landscaping Management –Under the OMRR, land application of less than 5 m^3 of Class A biosolids does not require the preparation of a LAP. Fertilizers and supplements sold in Canada are subject to the Canadian Food Inspection Agency T-4-93 – Standards for Metals in Fertilizers and Supplements, Maximum Acceptable Metal Concentration in sewage-based-products.

Benefits

Biosolids land application programs have the following environmental benefits:

- Reduction in the use of non-renewable chemical fertilizers;
- Soil carbon sequestration through soil and plant establishment;
- Improved soil fertility, health, and physical properties;
- Improved vegetation establishment;
- Accelerated soil formation and development where topsoil is absent (mine reclamation);
- Sustainable alternative to the importation of non-renewable topsoil (mine reclamation);
- Increased timber production through improved growth and reduced rotation (forestry);
- Improved growth of understory vegetation which enhances aesthetics and provides forage and habitat for wildlife (forestry); and
- Consistent turf performance due to nutrient slow release (turf and landscaping).

Biosolids land application programs have the following economic benefits:

- Potential to establish a new economy (mine reclamation);
- Reduction in reclamation costs (mine reclamation); and
- Increase in log value through increased forest productivity (forestry).

Risks

Biosolids management is understood through regulation and experience to be a process where potential risks to the environment and public health are well managed and mitigated. Heat-dried biosolids have no biological activity, and thus do not represent a public health risk in the form of a vector for pathogenic bacteria, viruses or other illnesses. With respect to modern biosolids management in the regulated era, there are no recorded incidences where public health has been demonstrated to be harmed through beneficial use. The major environmental risks and associated risk management are:

- Nutrients – Managed by the LAP and Qualified Professional.
- Pathogens, Odours and Aerosols – Odour concerns are the trigger for many public concerns and questions. The reduced odour profile for heat-dried biosolids may reduce some of the negative perceptions typically associated with the more odorous dewatered biosolids use.
- Trace Elements – Trace elements are regulated through OMRR and their regulation is harmonized with the British Columbia Contaminated Sites Regulation (CSR).
- Emerging Substances of Concern (ESOCs) – ESOCs are indirectly managed through the management of trace elements and nutrients. There are few, if any causal linkages between application of these constituents through biosolids and any concrete evidence of environmental impact.

In terms of project risk, the potential size of selected target markets, proximity, and effort required to market and promote adoption should all be rigorously evaluated with a full market analysis.

Track Record

Forest Fertilization – There are several long-term forest and biomass fertilization projects ongoing in the Pacific Northwest that use Class B biosolids. These project provide a track record of clearly demonstrated environmental benefit and no environmental harm or public health issues.

Mine Reclamation and Ecosystem Restoration – There are numerous one-time and long-term reclamation projects ongoing in the Pacific Northwest that use Class A or B biosolids. These projects provide a track record of clearly demonstrated environmental benefit and carbon sequestration; there is no track record of environmental harm or public health issues.

Turf and Landscaping – Milorganite has been used since 1926 and provides the best example of the adoption of heat-dried biosolids within landscaping and turf applications. Use has been both normalized and standardized within professional applications such as golf turf management. An increasing number of wastewater facilities in the United States produce and distribute heat-dried biosolids products for private or commercial use.

Turn-Key Management Costs

Biosolids turn-key projects are typically managed on a bulk tonne basis and vary depending on the management option, transportation fees and regulatory costs. Typical cost ranges based on management options are as follows:

- Forest Fertilization – $50 to $120 per bulk tonne of material managed
- Mine Reclamation – $40 to $120 per bulk tonne of material managed
- Turf and Landscaping – Highly variable, may be a cost centre or a profit centre depending on the case study.

The following is an example of recent turn-key management costs for a 7,000 bulk tonne material managed forest fertilization program on Vancouver Island.

Task Name	Fee Component
Turn Key Biosolids Management: • Regulatory Compliance and Reporting • Access management • Site Management • Environmental Sampling and Monitoring • Biosolids Application • Public Engagement • Reporting back to generator •	$90/bulk tonne
Biosolids Transportation and Management	$30-45/bulk tonne
Turnkey management – 7,000 tonne program	$630,000
Transportation – 7,000 tonne program	$210,000 - $315,000
Total	$840,000 - $945,000

Note that these costs are provided as an estimate based on the variability of transportation and site selection.

TECHNICAL MEMORANDUM

Biosolids as a Tool in Forest Fertilization

Presented to:	Josh Frederick, Capital Regional District
Presented by:	John Lavery, SYLVIS Environmental
Presentation date:	September 12, 2019

Background: Forest Fertilization Using Biosolids

Most North American forest soils, particularly forests that are managed for wood products, are deficient in the nutrients required for optimal tree growth. Through the harvesting process, large amounts of nutrients, organic matter, and soil productivity are removed or lost to disturbance. (Berch et al. 2019 and Johnson 1994). Forest fertilization is a silvicultural practice that has been conducted in British Columbia on an operational scale since 1978 (British Columbia Ministry of Forests and Range, 2006). 99% of forest fertilization in British Columbia utilizes non-renewable sources of chemical fertilizer, which take a heavy toll on our global environment and energy cycles. As an example, the global demand for nitrogen fertilizer uses approximately 2% of the world's energy production to capture nitrogen from the atmosphere to produce urea through the energy-intensive Haber-Bosch Process; this same process also releases significant CO_2 to the atmosphere (Smil 2004).

Renewable sources of nutrients and organic matter represent an alternative to chemical fertilization that is both renewable and less carbon intensive, improving growth, tree nutrition, and overall ecosystem health and productivity. Biosolids applied to forest stands as a fertilizer and/or soil amendment provide a source of macro and micronutrients for vegetation establishment and growth and augment the soil organic matter content. Biosolids fertilization of forest stands has a 40-year history throughout the Pacific Northwest.

This Technical Memo will briefly describe the processes by which biosolids are currently used in forest fertilization in the Pacific Northwest, followed by a section describing the regulatory requirements that are necessary to ensure a compliant program, and recommended additional stakeholder engagement. The next section describes both the benefits conferred on the forest and the environment through that process, and the potential and considered risks to the forest and the environment through that process, including how they are mitigated. The final section will identify known costs and operational considerations for the implementation of such a program in the Capital Regional District context and provides examples of similar projects in the Pacific Northwest.

For the purposes of this technical memorandum, only traditional forestry is included. It is worthwhile to know, however, that biosolids fertilization of woody biomass crops for the production of energy of cellulosic feedstock is also undertaken successfully in Western Canada.

Process

The following images show different biosolids application techniques used for forest fertilization. In the Pacific Northwest, these processes have primarily been used for dewatered biosolids or chemical fertilizers, however, similar equipment and application methodologies would apply for heat-dried biosolids. Transportation costs would be lower for heat-dried biosolids compared to dewatered biosolids.

The processes, whether dewatered or dried material is used, require the following components:

- A landowner or land manager project partner
- A detailed land application plan written by a qualified professional, which identifies:
    - Application site characteristics
    - Images and identifiable features
    - Minimum buffer distances to all regulated features (such as surface water, property boundaries, schools, dwellings, roads, etc.)
    - Soil samples and determination of agronomic rate
    - Application method
    - Limitations on application
- A project design, including (at a minimum):
    - Transportation of the material to on-site short-term storage/staging facilities
    - Storage and staging facilities
    - Complete mapping and visual flagging of the site;
    - Skid trails or semi-permanent trails within the forest block to facilitate application;
    - Application equipment suited to the terrain and challenges of the location. This may be a blower, an aerospreader, a helicopter delivery system, or other process
    - A health and safety program that complies with the legislative requirements
    - A knowledgeable and skilled operating team or trusted contractor

Biosolids are applied using an aerospreader into forest stands if there is adequate spacing between rows of trees. The aerospreader can apply the material 30 meters into the stands.

Photo Credit: SYLVIS

Traditional forest fertilization is conducted using helicopters with a pilot-controlled spreader that distributes the pelletized fertilizer.

Photo Credit: Lakelse Air

Regulatory Requirements and Stakeholder Engagement

The Ministry of Environment and Climate Change Strategy (ENV) strictly regulates the production and application of biosolids through the Organic Matter Recycling Regulation (OMRR); land application of biosolids requires the preparation of a Land Application Plan by a Qualified Professional. This is the minimum regulatory requirement for biosolids forest fertilization and applies to privately held land.

Fertilization of crown land requires partnership with a landowner or land manager, as well as notification of multiple parties, including the Ministry of Forests, Lands, Natural Resource Operations & Rural Development (FLNRORD), First Nations recognized to have overlapping traditional rights and/or title to the landbase, and any overlapping tenure holders, such as mineral resource tenures, trapping tenures, and grazing tenures.

It is worthwhile to point out that the OMRR is currently under comprehensive review by ENV. While ENV has indicated that land application of biosolids will continue to the be the foundation of beneficial use in British Columbia, some aspects of stakeholder engagement and process may change with the review and subsequent amendments.

A well conceived biosolids fertilization program engages numerous additional stakeholders. It is often recommended that all stakeholders, neighbours, and interested parties are kept apprised of the project and given the initial opportunity to understand the project as proposed, and an ongoing opportunity to receive regular updates on project progress and activity. This process ensures a high level of awareness of the project and improves overall understanding of the goals of forest fertilization.

Benefits

There are multiple benefits to using biosolids as a tool in forest fertilization programs. These benefits have been rigorously studied and quantified through 40 years of forest fertilization undertaken in the Pacific Northwest. Biosolids application to forest stands has been evaluated and studied through numerous academic institutions in the region, including the University of British Columbia, Vancouver Island University, Royal Roads University, University of Washington, Washington State University, and the University of Victoria.

Benefits of biosolids fertilization are reasonably specific to each potential application site and that site's particular strengths and weaknesses, but generally may include:

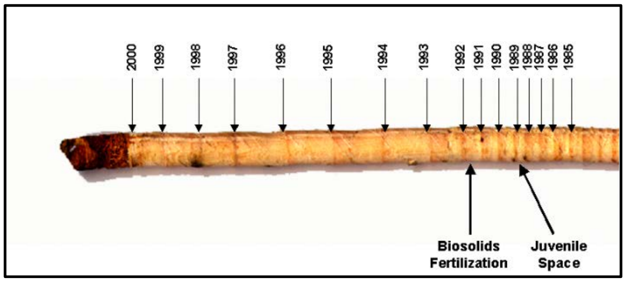
- Increased timber production through improved growth and reduced rotation
- Improved environmental stewardship over chemical fertilizers through numerous processes:
    - Significantly increased carbon sequestration within the forest ecosystem, resulting in climate change mitigation, and greater long-term storage of carbon
    - Soil conditioning improving overall soil structure, water-holding capacity and bulk density to reduce soil erosion
    - Improved water holding capacity within the forest ecosystem, resulting in improved resiliency to drought and improved growth in dry conditions
    - Enhanced ecosystem development through the creation and improvement of wildlife habitat
    - Protection and improvement of water quality, through improved growth of both overstorey and understorey plant, moss and fungal communities
    - Improved soil health, through greater support for mycorrhizal and biological communities
- Economic development through employment opportunities related to the development of a sustainable, long-term beneficial use program

<u>Increased Timber Production</u>

Increased growth rates and foliage production have been observed in trees growing in biosolids-amended soil compared to those which have not received biosolids applications. Not only is there an increase, but there is a sustained growth response. Increased growth rates following biosolids application results in increased width of tree growth rings.

Accelerated tree growth has the potential to affect wood quality. Biosolids fertilization significantly increases growth and may reduce wood density by up to 15 percent. This reduction is similar to the density of wood grown on highly productive sites or growth with chemical fertilizer. In the British Columbia context, wood quality remains well within acceptable ranges for dimensional lumber.

Application of biosolids may increase forest productivity to between 150% to 400% of baseline stand productivity. The magnitude of the impact depends on the existing stand characteristics, climate, and species. This productivity boost is related to the interaction between increased log value and a shortened rotation length.



A 60% increase in tree basal area was observed as compared to unfertilized trees.

Tree response to biosolids fertilization is evident in the larger, greener needles in the fertilized (lower) as compared to not fertilized (upper) branch.

Environmental Stewardship and Climate Change Mitigation

The use of biosolids in forest fertilization provides an alternative to non-renewable fertilizers, which require a significant amount of energy to produce. Biosolids contain slow-release nutrients which minimize the potential for nutrient leaching and runoff to sensitive waterways. When forest fertilization using biosolids is conducted in accordance to the Land Application Plan, there are no harmful impacts to the surrounding groundwater and surface water; increased soil organic matter may improve soil water infiltration and holding capacity with benefits to the watershed.

Additional benefits of biosolids application to forests include improved growth of understory vegetation which enhances aesthetics and provides forage and habitat for a variety of wildlife species.

Accelerated carbon sequestration occurs in a forest that grows more rapidly through fertilization. The addition of carbon from biosolids also accelerates this process, enabling that organic matter to be integrated into forest soils. By fertilizing forest stands the tree's biomass increases, resulting in an increased amount of carbon dioxide that the trees can remove from the air and store in the soil. Forest fertilization is a significant carbon sequestration mechanism. Calculations using the Biosolids Emissions Assessment Model (BEAM) suggest that forest fertilization with biosolids has significant potential for climate change mitigation through carbon sequestration (SYLVIS 2009).

Soil health and the resilience of soil microbial and mycorrhizal communities are greatly enhanced through the application of organic matter-based nutrients. With improved biological communities and increased biological density, fertilized forests also improve their ability to resist erosion and improve surface water quality. Decades of surface water quality data from forest fertilization projects in Washington state have demonstrated that surface waters in catchments fertilized with biosolids are not impaired (King County Department of Natural Resources and Parks 2012) and may have cooler and cleaner water due to the improved soil quality and vegetative cover that enhance water infiltration.

Risk and Risk Management

Biosolids management is understood through regulation and experience to be a process where potential risks to the environment and public health are well managed and mitigated. Dried biosolids have no biological activity, and thus do not represent a public health risk in the form of a vector for pathogenic bacteria, viruses or other illnesses. It is worth noting that with respect to modern biosolids management in the regulated era, there are no recorded incidences where public health has been demonstrated to be harmed through beneficial use.

There is significant misunderstanding, miscommunication, and misinformation about biosolids in the public domain, which has resulted in significant confusion about the risks involved with the production and beneficial use of biosolids. Much of the perceived risk in regards to biosolids is incorrectly understood, and mitigation measures are also poorly understood.

The following risk elements are addressed in individual sections below:

- Nutrients
- Pathogens, Odours and Aerosols
- Trace Elements
- Emerging Substances of Concern

Track Record

An important component of risk management is to understand any real risk as exemplified through the existing track record of forest fertilization projects within the Pacific Northwest. While there are no projects using Class A dried biosolids products in extensive forest fertilization, there are several long-term forest and biomass fertilization projects ongoing in the Pacific Northwest that use Class B biosolids. These projects include the following long-term projects:

- King County, Washington Forest Fertilization – applications and research continuously since the 1980’s
- Regional District of Nanaimo – applications in the 1990’s, continuous applications since 2005
- Sechelt Aggregate Mine reclamation to poplar plantation – continuous applications from 1995 – 2015

From these projects we can take the following risk management information (SYLVIS 2018, King County Department of Natural Resources and Parks 2012):

- Environmental benefit has been clearly demonstrated
- No track record of environmental harm
- No track record of contamination of surface or ground waters
- No adverse impact due to pathogens – no public health issues or illnesses
- No issues in regard to trace elements
- No forest health issues – no toxicities or deficiencies observed
- In the case of King County – cleaner surface waters in the biosolids amended catchments
- Improved wildlife habitat and higher anecdotal presence of a more diverse cross section of native wildlife

- No health issues in wildlife
- No regulatory non-compliance issues

Nutrients

The application of biosolids is overseen by a Qualified Professional. A Qualified Professional is responsible for authoring a biosolids Land Application Plan, characterizing the biosolids and soil quality at the land application site, and determining the application rate based on the site conditions and requirements. This is completed to ensure that the environment is protected, and that the nutrient application meets the needs of the forest stand.

Nutrients are the most abundant chemical constituent in biosolids, and are considered to have the greatest risk potential for environmental harm. Excess applications of nutrients, specifically nitrogen and phosphorus, have reasonable potential to impact the environment through nutrient surpluses which could leach to groundwater or runoff in excess quantities into surface waters, resulting in reduced potability or algal blooms.

Nutrients risks are well managed in biosolids through the OMRR land application planning process. Qualified Professionals calculate application rates taking into consideration the plant requirements; biosolids soil quality; maximum post application elemental concentrations as prescribed by the OMRR, and the existing site conditions, and any other factors deemed important.

Currently there are no heat-dried biosolids (90% solids) being land applied in forest fertilization in the Pacific Northwest. Dried pelletized biosolids are produced and used for agricultural fertilization and turf fertilization (golf courses and turf farms) in Washington state. The following discussions related to the recognition and mitigation of environmental risks are drawn from experience using 20 – 25% dewatered material.

Pathogens, Odours and Aerosols

The acceptance of biosolids use by stakeholders is an integral component in the implementation of a successful biosolids forest fertilization program. Successful stakeholder consultation is achieved by accurate and comprehensive identification of all stakeholders, identifying stakeholder concerns, and selecting effective approaches to address stakeholder concerns.

Odour concerns are the trigger for many public concerns and questions. The reduced odour profile for heat-dried biosolids may reduce some of the negative perceptions typically associated with the more odorous dewatered biosolids use. Several heat dried products are known to emit odours upon rewetting, and this factor should be taken into account when describing the potential odour profile of a biosolids project.

During the wastewater treatment process, the solids undergo processing to significantly reduce pathogenic organisms. The biosolids produced must meet the pathogen limits specified in the OMRR. Granulite, a heat-dried biosolids product produced by Synagro, is free from E coli, fecal coliform, and salmonella. Risks of human exposure to pathogens from land applied 95% solid biosolids are negligible.

From a risk management perspective, odours are understood to be solely a nuisance characteristic in biosolids. The potential for aerosolizes pathogens or viruses from dried biosolids is negligible, due to the absence of detectable microbial pathogens in Class A material (dried or dewatered). By contrast, daily risks from pathogens to personnel working with animal manures range from 1 infection per 2 exposures to 1 infection to 10,000 exposures.

Trace Elements

The biosolids produced must meet the trace element limits specified in the OMRR, which also sets standards for trace element soil concentrations after land application. The regulated limits are risk-based and protective of human and environmental health as appropriate for the land use.

Trace elements are regulated through OMRR and their regulation is harmonized with the British Columbia Contaminated Sites Regulation (CSR). Trace elements are a regulated aspect of biosolids, and their risk is one of non-compliance with the regulation. To date there has been no record of non-compliance related to trace elements in forest fertilization projects in British Columbia.

Emerging Substances of Concern

Emerging substances of concern (ESOCs) are a group of substances which originate from daily domestic, commercial, and industrial activities in minute quantities, and are emergent, therefore a determination on the need for their regulation has not yet been made by the regulator.

The term, ESOCs, refers to an extremely wide variety of substances and is understood to include all constituents not specifically regulated or mentioned in either the OMRR or the CSR. Canadian scientists have recently undertaken a significant risk review to categorize and define many of the emerging substances that modern analytical techniques have been able to quantify (McCarthy and Loyo, 2015). This work recommended future research, but also noted that studies generally conclude that most of the emerging compounds have no detectible effect on the environment after land application, and concentrations of these substances in drainage, runoff or groundwater tend to be much lower than typical concentrations in treated effluent. Similarly, while science has demonstrated uptake by plants and some invertebrates, this presence has not translated into demonstration of negative impact. The researchers stress that presence is not indicative of risk, that dose is a critical component in understanding toxicity, and that dose is not demonstrated to be achieved (McCarthy and Loyo, 2015).

It is important to convey that biosolids are not a source of substances of concern. Biosolids are an intermediary or temporary receiving environment. The concentration of substances in biosolids reflects societal consumption, utilization and ultimately discharge of these substances to the sewer system. In the broadest context, organic matter and nutrients will always represent the greatest components of biosolids as they are the materials which the sewer system was intended to collect. The minute fractions of other substances represent ubiquity of compounds in our society, and their unintended discharge to the sewer, resulting in presence in biosolids.

Over time there has been specific interest in several ESOCs or constituent groups. To date no additional regulation has been recommended. There are few, if any causal linkages between application of these constituents through biosolids and any concrete evidence of environmental impact. One of the challenges in assessing ESOCs is understanding that presence of ubiquitous compounds in an intermediary like biosolids does not infer risk. An understanding of dose-response relationships and cumulative effects is required to form a basis of risk. In some cases, there is a lack of dose-response understanding. In many cases, however, the dose required to elicit a toxicologically relevant reaction is several orders of magnitude higher than the ultimate environmental concentration of the substance. This dose must also be considered in the context of the speed at which a substance degrades within the environment, and its ability to be rendered ineffectual within the environment by being sorbed to soil particles, or otherwise denatured through environmental processes.

ESOCs are currently not regulated under the OMRR. They are however indirectly managed through the management of trace elements and nutrients. When trace elements and nutrients are being managed according to a risk-based approach, the risk of ESOCs which are present in quantities which are orders of magnitude lower are also being managed.

Recent ecotoxicological studies have examined a variety of biosolids products and their impacts on targeted plants, animals, fish, aquatic invertebrates, and terrestrial invertebrates, in order to assess the potential for toxicological response. To date, this work has indicated no adverse toxicological impacts on any organisms studied in the context of agronomic rates of biosolids (McCarthy and Loyo, 2016).

Toxicologically, these studies make sense. The water resource recovery facility (wastewater treatment plant) is fundamentally a bioreactor. Meaningful biological toxicity of compounds in the influent would result in bioreactor upset through a die-off of the treatment media. Through the successful operation of the wastewater treatment plant, we recognize that influent, and biosolids (also biologically active) are not inherently toxic at the bacteriological scale.

Costs and Examples of Forest Fertilization Using Biosolids

Biosolids management in forest fertilization have traditionally been managed on a bulk tonne basis. These costs vary, depending on the distance from the generation point (transportation costs) regulatory burden (regulatory costs) and variation in the simplicity or complexity of the application site and its access restrictions (application or management costs). Other variable costs include stakeholder engagement and reporting requirements back to the generator from the contractor.

Costs from known programs appear to vary between $50 per bulk tonne of material managed to $100 per bulk tonne of material managed. These values do not include transportation, which is a variable costs based on distance and transport challenges (loading/unloading, and terrain challenges.

Biosolids have successfully been used in forest fertilization. Examples of municipal biosolids forest fertilization programs in the Pacific Northwest include:

Woodlot 020, Nanaimo, British Columbia

Snoqualmie Forest, Washington

Photo Credit: King County

Poplar Biomass Plantation, Sechelt

Patterson Road Juvenile Forests, Prince Geroge

Poplar Biomass Planation, Herrling Island

Poplar Biomass Plantation, Carey Island

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TECHNICAL MEMORANDUM

Biosolids as a Tool in Turf and Landscaping Management

Presented to:	Josh Frederick, Capital Regional District
Presented by:	John Lavery, SYLVIS Environmental
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Background: Biosolids in Turf and Landscaping Management

There are several types of turf and landscaping applications that can be considered for biosolids application. They include the following:

1. High performance turf includes golf courses and athletic fields. This turf is intensively managed for specific performance requirements; plant nutrition and soil health are key to ongoing turf health. Human interaction and contact with the soil and turf is extensive.
2. New turf establishment includes the seeding of new turf areas and placement of new sod. Additional nutrients are required for establishment; the opportunity to cultivate the soil and incorporate additional organic matter exists.
3. Sod production is the agricultural production of turf as a crop. Sod harvest removes both soil and nutrients from the site with a requirement to rebuild soils after each harvest for continued site productivity. As with new turf establishment, each crop presents the opportunity to incorporate organic matter and nutrients into the soil.
4. Public landscaping includes grass and garden areas in parks and around buildings. Aesthetics, perception, and safety are important in this application; human interaction and contact with the soil and plants may be extensive.
5. Residential landscaping includes grass and garden areas around private residences. Safety is important in this application; human and pet interaction and contact with the soil and plants may be extensive.
6. Marginal landscaping areas include publicly managed greenways and roadside buffers. These areas may be less intensively managed than the first two and generally have less direct human contact.

Where not further specified, “turf” includes high performance and new establishment applications and “landscaping” includes public, residential, and marginal applications. Sod is an agricultural application, but due to agronomic similarities with new turf establishment can be considered under the same umbrella. While agronomic requirements may be similar across many of these applications, the pathways to use, market size, and public perception can vary.

Direct application of dewatered biosolids (20-25% moisture) is not appropriate for turf and landscaping due to product handling, application characteristics, and odour. Class A biosolids compost or soil products are appropriate for public and residential gardens, marginal landscaping, new turf establishment, and sod production.

Heat-dried biosolids products are ideal for turf and landscaping applications due to minimized biological risks and reduced odour concerns. Heat-dried biosolids are generally marketed as a slow-release fertilizer that is comparable to the handling and application of traditional inorganic fertilizers. Heat-dried biosolids may be used as a sole replacement for other fertilization or as one component of the fertilization program. Milorganite, a granulated heat-dried biosolids product produced by the Milwaukee Metropolitan Sewerage District, is established as a slow-release fertilizer for turf and landscaping; it has been used on lawns and gardens for over 90 years and is marketed for both professional and home use. Granulite is a similar product produced and branded by Synagro; an increasing number of wastewater facilities in the United States produce and distribute heat-dried biosolids products for private or commercial use. The closest local generator producing a dried biosolids product is Pierce County, Washington, which markets and distributes SoundGRO. In British Columbia, the regulatory requirements may impose some additionally limiting factors on distribution and application of similar products.

This Technical Memo will briefly describe the processes by which biosolids are currently used in turf and landscaping, followed by a section describing the regulatory requirements that are necessary to ensure a compliant program, and recommended additional stakeholder engagement. The next section describes both the benefits conferred on the landscape and the environment through that process, and the potential and considered risks to the landscape and the environment through that process, including how they are mitigated. The final section will identify known costs and operational considerations for the implementation of such a program in the Capital Regional District context.

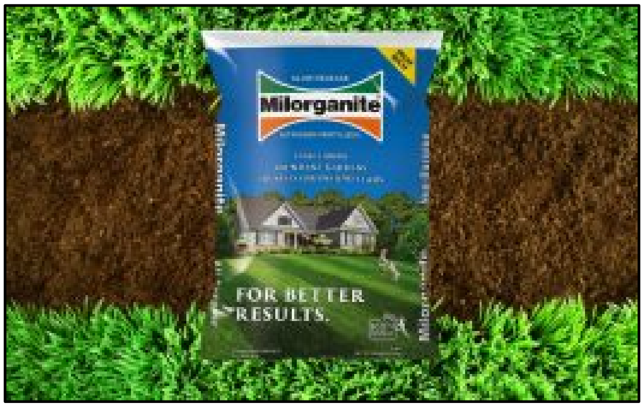
Process

The processes to undertake a land application program in British Columbia, whether dewatered or dried material is used, requires the following components:

- A landowner or land manager project partner;
- A detailed Land Application Plan written by a qualified professional, which identifies:
    - Application site characteristics;
    - Images and identifiable features;
    - Minimum buffer distances to all regulated features (such as surface water, property boundaries, schools, dwellings, roads, etc.);
    - Soil samples and determination of agronomic rate;
    - Application method; and
    - Limitations on application.
- A project design, including (at a minimum):
    - Transportation of the material to on-site storage facilities;
    - Complete mapping and visual flagging of the site;
    - Application equipment suited to the location;
    - A health and safety program that complies with the legislative requirements; and,
    - A knowledgeable and skilled operating team or trusted contractor.

For turf applications and residential landscaping, distribution would likely require bagging or totes. Bulk deliveries may be appropriate for public and marginal landscaping and sod production, which have the capacity for larger volumes.

Heat-dried biosolids can be applied using traditional fertilizer equipment if the material is free-flowing, strong, and a uniform particle size. The following images show different biosolids application techniques relevant for turf and landscaping applications. For established turf, topdressing fertilizer (surface application) is appropriate. For new turf establishment and sod development, a higher application rate may be desirable and incorporation into the soil surface can benefit soil quality and nutrient release.



Heat-dried biosolids can be distributed in totes and bags.

Photo Credit: Milorganite

Milorganite provides spreader settings and application rates. A standard hand-pushed broadcast spreader can be used for top dressing. Similar spreaders can be used for high performance turf management and residentially.

Photo Credit: Milorganite

Heat-dried biosolids can be incorporated into the soil surface when seeding or sodding new lawn.

Photo Credit: Milorganite

Heat-dried biosolids being spread using agricultural equipment for sod production.

Photo credit: NEBRA

Granulite is marketed as a fertilizer for agricultural, nursery, home garden and landscaping. Depending on the size of the area, home garden applications may be spread by hand or sprinkled with a scoop.

Photo credit: Synagro

Regulatory Requirements and Stakeholder Engagement

In British Columbia, the Ministry of Environment and Climate Change Strategy (ENV) strictly regulates the production and application of biosolids through the Organic Matter Recycling Regulation (OMRR). Land application of more than 5 m^3 of Class A biosolids requires the preparation of a Land Application Plan by a Qualified Professional. Depending on the nutrient requirements and application rate, an individual sports area or small landscaping area (less than 1 hectare) may utilize less than 5 m^3.

If sold within Canada as a fertilizer or supplement, the head-dried biosolids are subject to the Canadian Food Inspection Agency T-4-93 – Standards for Metals in Fertilizers and Supplements, Maximum Acceptable Metal Concentration in sewage-based-products.

It is worthwhile to point out that the OMRR is currently under comprehensive review by ENV. While ENV has indicated that land application of biosolids will continue to the be the foundation of beneficial use in British Columbia, some aspects of stakeholder engagement and process may change with the review and subsequent amendments.

A well conceived biosolids fertilization program engages numerous additional stakeholders. It is often recommended that all stakeholders, neighbours, and interested parties are kept apprised of the project and given the initial opportunity to understand the project as proposed, and an ongoing opportunity to receive regular updates on project progress and activity. This process ensures a high level of awareness of the project and improves overall understanding of the goals of the fertilization programs.

Benefits

There are multiple benefits to using biosolids for turf and landscaping management. These benefits have been proven by over 90 years of heat-dried biosolids use within these industries. In general, the benefits of biosolids fertilization may include:

- Improved soil quality through the addition of organic matter
- Consistent performance due to the slow release of nutrients over the growing season
- Improved environmental stewardship over chemical fertilizers through numerous processes:
  - Increased carbon sequestration within the landscape, and displacement of chemical fertilizer use
  - Soil conditioning improving overall soil structure, water-holding capacity and bulk density to reduce soil erosion
  - Improved soil health, through greater support for mycorrhizal and biological communities
- Cost savings through synergistic relationships and inter-departmental cooperation. For example, fertilizer savings in parks and recreation departments within the CRD through the use of dried biosolids as an alternative to chemical fertilizer, through the sharing of this beneficial fertilizer resource. The provision of a low cost, high quality fertilizer product can reduce costs for fertilization of turf and landscaping areas or increase the feasibility of fertilization in areas with budget limitations.

<u>Environmental Stewardship and Climate Change Mitigation</u>

The use of biosolids in turf and landscaping management provides an alternative to non-renewable fertilizers, which require a significant amount of energy to produce. Biosolids contain slow-release nutrients which minimize the potential for nutrient leaching and runoff to sensitive waterways. When fertilization using biosolids is conducted in accordance with best management practices and/or a Land Application Plan, there are no harmful impacts to the surrounding groundwater and surface water; increased soil organic matter may improve soil water infiltration and holding capacity with benefits to the watershed.

Risk and Risk Management

Biosolids management is understood through regulation and experience to be a process where potential risks to the environment and public health are well managed and mitigated. Dried biosolids have no biological activity, and thus do not represent a public health risk in the form of a vector for pathogenic bacteria, viruses or other illnesses. It is worth noting that with respect to modern biosolids management in the regulated era, there are no recorded incidences where public health has been demonstrated to be harmed through beneficial use.

Currently there are no heat-dried biosolids (90% solids) being land applied in the Pacific Northwest. Dried pelletized biosolids are produced and used for agricultural fertilization and turf fertilization (golf courses and turf farms) in Washington state. The following discussions related to the recognition and mitigation of environmental risks are drawn from experience using 20 – 25% dewatered material as well as the use of heat-dried biosolids in other regions.

<u>Public Perception and Health</u>

The acceptance of biosolids use by stakeholders is an integral component in the implementation of a successful biosolids program. Successful stakeholder consultation is achieved by accurate and comprehensive identification of all stakeholders, identifying stakeholder concerns, and selecting effective approaches to address stakeholder concerns. Concerns could be heightened if application areas are used regularly by children or pets for play.

Odour concerns are the trigger for many public concerns and questions. The reduced odour profile for heat-dried biosolids may reduce some of the negative perceptions typically associated with the more odorous dewatered biosolids use.

Many turf and landscaped areas are extensively used by adults, children, and pets who may be in close contact with the grass and garden areas. The microbiological risk associated with direct consumption of biosolids is minimized through the heat-drying process. It warrants restating that dried biosolids have no biological activity, and thus do not represent a public health risk in the form of a vector for pathogenic bacteria, viruses or other illnesses.

Fertilizers, including Milorganite, have Material Safety Data Sheets and fertilizer labels as a requirement in Canada. In comparison to chemical fertilizer MSDS sheets, dried biosolids have a similar hazard classification matrix to chemical fertilizers developed for the same purpose. Use of dried biosolids as a turf fertilizer is not anticipated to have any greater or lesser adverse impact on public health than a chemical fertilizer.

Environmental

The application of biosolids is overseen by a Qualified Professional. A Qualified Professional is responsible for authoring a biosolids Land Application Plan, characterizing the biosolids and soil quality at the land application site, and determine the application rate based on the site conditions and requirements. This is completed to ensure that the environment is protected. The nutrients in heat-dried biosolids are slow release, which imparts certain beneficial properties to the fertilizer, considered to add value to the use of the product.

Trace Elements

The biosolids produced must meet the trace element limits specified in the Organic Matter Recycling Regulation, which also sets standards for trace element soil concentrations after land application. The regulated limits are risk-based and protective of human and environmental health as appropriate for the land use. The Milorganite SDS sheet provides an excellent overview of the value and impacts of trace elements.

Emerging Substances of Concern

Emerging substances of concern (ESOCs) are a group of substances which originate from daily domestic, commercial, and industrial activities. This group is comprised of a wide variety of substances and while many substances impact on human health is generally well understood, many other substances have not been fully characterized in terms of their occurrence in biosolids, their ecological impact within the environment, and their persistence in the environment following biosolids land application. Currently, for ESOCs known in biosolids, risk assessments of specific substances have tended to conclude that there is low risk to human health and the environment through land application.

ESOCs are currently not regulated under the OMRR. They are however indirectly managed through the management of trace elements and nutrients. When trace elements and nutrients are being managed according to a risk-based approach, the risk of ESOCs which are present in quantities which are orders of magnitude lower are also being managed.

Market Size and Access

The potential size of selected target markets, proximity, and effort required to market and promote adoption should all be rigorously evaluated with a full market analysis. In selecting target applications, it is important to balance the effort and expense associated with regulatory requirements and a Land Application Plan with the end use volumes to be consumed by a given application and site. This is particularly true for turf and landscaping applications where the individual application sites may be a small land area compared to a forestry or mine site.

Project

Heat-dried biosolids would compete with traditional fertilizers and compost use within the well established and highly competitive turf and landscaping fertilizer industry. High performance turf has high sensitivity to nutrition program performance and aesthetics. To address these markets, extensive branding, marketing and sales efforts would likely be required to spur adoption, especially outside of use beyond collaborating local government departments. In addition, independent agronomic research may be required to prove product performance and safety compared to standard practices within the industry, if this information cannot be shared from other generators marketing dried biosolids products.

In an economic downturn, the turf and landscaping markets my be subject to budget constraints, which is a detriment if selling the biosolids, but a potential benefit if the biosolids provide a low or no cost, high performance alternative.

Costs and Examples of Biosolids Use in Turf and Landscaping Management

Biosolids management for turf and landscaping applications could be approached through the product sales lens driven by the generator (whether revenue generating or not), or a traditional biosolids management framework of contracting management on a bulk tonne basis. Costs on a bulk tonne basis vary depending on the distance from the generation point (transportation costs), regulatory burden (regulatory costs), and variation in the simplicity or complexity of the application site and its access restrictions (application or management costs). Other variable costs include stakeholder engagement and reporting requirements back to the generator from the contractor.

Milorganite provides the best example of the adoption of heat-dried biosolids within landscaping and turf applications. Milorganite has been used since 1926, likely representing the longest continuous example of biosolids beneficial use. Extensive customer testimonials can be found and use has been both normalized and standardized within professional applications such as golf turf management. Over time, the brand has been built and supporting resources and application guides developed for various application types.

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TECHNICAL MEMORANDUM

Biosolids as a Tool in Mine Reclamation and Ecosystem Restoration

Presented to:	Josh Frederick, Capital Regional District
Presented by:	John Lavery, SYLVIS Environmental
Presentation date:	September 12, 2019

Background: Mine Reclamation Using Biosolids

Mineral and aggregate extraction dramatically impact the topography and ecology of the landscape. Activities such as pit development, operations expansion, and placement of wastes and tailings result in the disturbance and degradation of the existing soil on the site. The remaining soils are often poorly developed, lacking the physiochemical and biological characteristics to support vegetation, and are susceptible to erosion from wind and water.

Likewise, degraded ecosystems, such as forested areas devastated by fire, or agricultural areas that have experienced poor stewardship, may experience significant setbacks in the quality of their soils and productive capability. Lacking the key elements to support biological communities, these lands remain unproductive, marginal, or continue along a pathway of degradation.

Mine reclamation is the process through which mined land is returned to productivity following mineral or aggregate extraction. It generally involves re-contouring, re-establishing hydrologic pathways, and the placement of productive cover on the final topographic layout to enable the successful revegetation of the landscape, and the commencement of pedogenic (soil formation and development) processes.

Ecosystem restoration is a component of mine reclamation, but it is not exclusive to mines. The re-establishment of self-sustaining ecosystem processes to achieve equivalent land capability to adjacent native ecosystems that have not been subject to degradation is the principle objective in restoration. A recent theme that is encompassed here is fire restoration, where ecosystem capability following wildfire is severely diminished, as organic matter, nutrients, and critical biology are traumatically lost from the ecosystem. Recovery can only be accelerated through the acceleration of the recovery of these ecosystem elements.

Many mineral and aggregate mines are challenged by a shortage in total volumes of productive topsoil required to reclaim mined lands to reclamation standards. Mining practices typically require the stripping, salvage, and redistribution of significant volumes of topsoil and subsoil to access mine resources. The shortage of the total volumes is a result of many variables, most notably the natural decomposition of organic matter and soil organic carbon in the soil, degrading both the quality, and the quantity of salvaged soil. In order to address the challenge associated with topsoil quality degradation and quantity reduction, many mines must import material to overcome both quantity and quality deficits. The most common practice to achieve this outcome is the importation of stripped topsoil from other areas on the landscape – an expensive and carbon-intensive process.

Biosolids have proven to be an effective tool in mine reclamation to achieve their reclamation standards. With its unique characteristics, biosolids can be used as a fertilizer, a soil amendment, as a feedstock. As a fertilizer, biosolids increase the nutrient content of the soil. As an amendment, biosolids improve soil physical properties that promote water retention and efficient transport of nutrients, water, and air throughout the soil system. Additionally, biosolids can be used as a feedstock in the fabrication of topsoil for reclamation.

The use of biosolids as a tool for wildfire restoration has frequently been hypothesized, but rarely tested. There are currently demonstration plots seeking to address this potential in California, with these plots based on successful research undertaken in the 1990's in Colorado (McFarland et al 2009, Meyer et al 2004). The principles of restoration are the same as mine reclamation, with the purpose being to improve soil properties, water retention, and tilth to enable the efficient exchange of nutrients water and air at the soil plant interface, and the rapid development of soil biology to buffer these transactions. For the purposes of the remainder of this white paper, the common themes of reclamation and restoration will be covered as one topic, referred to as reclamation/restoration (R/R).

Biosolids can be applied in both one-time and progressive R/R strategies. One-time R/R projects involve conducting all activities once the mine site is no longer active. Progressive R/R efforts seek to minimize the disturbed area on the landscape by systematically reclaiming areas where mining is complete, as mining progresses across to new areas of the mine. Biosolids can provide the following benefits for R/R:

- Gains in soil tilth, fertility, and water holding capacity that improve vegetation establishment success and enable improved root system growth, resulting in vegetation resilience;
- Acceleration in pedogensis (soil formation and development) from regular organic matter inputs enable long-term ecosystem recovery and may be used even in the absence of topsoil placement, directly on subsoils; and
- Fabrication of topsoil from biosolids, mineral subsoil or spoil, and woody organic matter, for direct replacement of imported topsoil throughout the site.

These approaches all address the universal purpose of achieving ultimate R/R certification and equivalent capability soils.

This technical memorandum will briefly describe the processes by which biosolids are currently used in R/R in British Columbia (predominantly mine reclamation), followed by a section describing the regulatory requirements that are necessary to ensure a compliant program, and recommended additional stakeholder engagement. The next section describes both the benefits conferred to the ecosystem and greater environment through R/R and the potential and considered risks to the ecosystem and how these are reduced, mitigated or eliminated. The final section will identify known costs and operational considerations for the implementation of R/R programs in the Capital Regional District, context and provides examples of similar projects in British Columbia.

Process

Different biosolids application techniques are used in R/R as show in Appendix One. In British Columbia, these processes have primarily been used for dewatered biosolids, however, similar equipment and application methodologies would apply for heat-dried biosolids. It is noteworthy that dried biosolids are not prevalent in British Columbia, and modifications to current beneficial use strategies would be required to achieve programs of similar structure.

The process, whether dewatered or dried material is used, require the following components:

- A land manager project partner;
- Amendments to a mine permit (if required), or amendments to forest tenure permits or prescriptions;
- A detailed Land Application Plan written by a Qualified Professional, which identifies:
  - Application site characteristics;
  - Images and identifiable features;
  - Minimum buffer distances to all regulated features (such as surface water, property boundaries, dwellings, roads, etc.);
  - Soil samples and determination of agronomic rate;
  - Application method; and
  - Limitations on application.
- A project design, including (at a minimum):
  - Transportation of the material to on-site short-term storage/staging facilities;
  - Storage and staging facilities;
  - Complete mapping and visual flagging of the site;
  - Application equipment suited to the project design. This may be a rear-discharge manure spreader, or a set of soil mixing equipment;
  - A health and safety program that complies with the legislative requirements; and
  - A knowledgeable and skilled operating team or trusted contractor.

Regulatory Requirements

The Ministry of Environment and Climate Change Strategy (ENV) strictly regulates the production and application of biosolids through the Organic Matter Recycling Regulation (OMRR); land application of biosolids requires the preparation of a Land Application Plan by a Qualified Professional.

The Ministry of Energy, Mines and Petroleum Resources (MEMPR) also requires a closure plan as per the mine permit, in conjunction with Mine reclamation systems.

While the most common regulatory route for biosolids application in mine reclamation is through the development of a Land Application Plan, there are instances where biosolids can be applied in accordance to a Permit issued through the ENV. ENV reporting requirements include annual Operations Plans, annual Operations Reports, and an Environmental Impact Report every three years. A report is also submitted annually to the Ministry of Energy, Mines and Petroleum Resources comprising a summary of disturbed areas and ongoing reclamation.

Benefits

There are multiple benefits to using biosolids as a tool in R/R. These benefits have been rigorously studied and quantified over 50 years of mine reclamation undertaken in North America. Biosolids use in R/R has been evaluated and studied through numerous academic institutions, including Pennsylvania State University, Ohio State University, University of British Columbia, Thompson Rivers University, University of Alberta, Ryerson University, and several other institutions.

Environmental Stewardship and Climate Change Mitigation

The use of biosolids in reclamation provides a more sustainable alternative to the importation of non-renewable topsoils from the surrounding landscape and the use of non-renewable chemical fertilizers for the establishment and maintenance of vegetation.

The topsoil originally removed from a mine site as overburden degrades steadily over time through disturbance, removal to a stockpile, and then ongoing stasis in a stockpile devoid of oxygen, soil biota, or fungal communities to support plant life. Soil disturbance leads to decay, depleting organic matter, reducing tilth and the productive capacity of the soils. Productivity, quality, volume, and water holding capacity of soils are all augmented through biosolids amendment, which is organic matter that will rapidly establish biological activity to provide a better soil environment for the development of vegetation, as well as soil biology. This ultimately improves the overall reclamation outcomes.

Non-renewable chemical fertilizers are used in traditional mine reclamation to aid in the development of vegetation. When traditional chemical fertilizers are exclusively used, application is often required on a regular basis post seeding in order to achieve equivalent land capability to pre-disturbance conditions as required by reclamation policy. This is not the case with the use of biosolids due to the slow-release of nutrients properties.

Mine reclamation provides an opportunity to contribute to climate change mitigation. Soil carbon sequestration is a process in which carbon dioxide is removed from the atmosphere and sequestered in the soil. This process is primarily mediated by plants through photosynthesis. Through reclamation, the soil and plant establishment are able to sequester carbon. Studies have shown that areas reclaimed with biosolids store more carbon than areas without biosoilds, resulting in a net carbon sequestration and climate change mitigation through soil carbon storage (Trlica and Brown 2013).

Economic Growth

The use of biosolids in mine reclamation offers the opportunity to reconsider reclamation through the lens of economic growth. There is an opportunity to create a new economy from the reclamation, growing on top of a previous mining economy that is nearing end-of-life.

Reclamation Cost Savings

There is an opportunity for cost savings to the reclamation program by using biosolids as compared to a more conventional program which makes use of chemical fertilizers and purchased commercial soil products. The mutual benefits to a residuals producer and the landowners responsible for reclamation can result in a strong, synergistic relationship.

Project scale is often a relevant consideration in reclamation costs and biosolids project costs. Reclamation related to large mine projects may require organic matter and nutrients for progressive mine reclamation over a timeline of decades. This scale enables the development of a long-term, highly efficient R/R process, that ultimately assists in the generator's ability to manage long-term costs.

Risk and Risk Management

Currently there are no 90% heat-dried biosolids used in the Pacific Northwest. The following discussion is drawn from experience using 20 – 25% dewatered material. In general, Class A heat-dried biosolids (90% solids) have a lower risk profile than dewatered biosolids.

Biosolids management is understood through regulation and experience to be a process where potential risks to the environment and public health are well managed and mitigated. Dried biosolids have no biological activity, and thus do not represent a public health risk in the form of a vector for pathogenic bacteria, viruses or other illnesses. It is worth noting that with respect to modern biosolids management in the regulated era, there are no recorded incidences where public health has been demonstrated to be harmed through beneficial use.

There is significant misunderstanding, miscommunication, and misinformation about biosolids in the public domain, which has resulted in significant confusion about the risks involved with the production and beneficial use of biosolids. Much of the perceived risk in regards to biosolids is incorrectly understood, and mitigation measures are also poorly understood.

The following risk elements are addressed in individual sections below:

- Nutrients
- Pathogens, Odours and Aerosols
- Trace Elements
- Emerging Substances of Concern

Track Record

An important component of risk management is to understand any real risk as exemplified through the existing track record of R/R projects within the Pacific Northwest. While there are no projects using Class A dried biosolids products in extensive R/R, there are numerous one-time and long-term reclamation projects ongoing in the Pacific Northwest that use Class A or B biosolids. These projects include the following projects:

- Sechelt Aggregate Mine reclamation to poplar plantation – continuous applications from 1995 – 2015
- Watt's Point Aggregate Mine Reclamation mid 2000's

- Similco Mine Reclamation early 2000's
- Copper Mountain Mine Reclamation - ongoing
- Mount Polley Mine Reclamation 2000's through to 2016
- Highland Valley Copper Mine Reclamation 2000's through to 2013 (on hold)
- Producer's Pit Reclamation (2000's, now part of the Royal Bay and Meadow Park neighbourhoods in Metchosin)
- Ministry of Transportation and Infrastructure Aggregate Pit reclamations, including:
    - Pennask Pit (applied in 1996, reapplied in 2011)
    - Bob's Lake Pit (2010-2013)
    - Clark Creek Pit (2013)
    - Timber Lake Pit (2013)

From these projects we can take the following risk management information:

- Environmental benefit has been clearly demonstrated;
- Carbon sequestration has been demonstrated, mitigating climate change;
- No track record of environmental harm;
- No track record of contamination of surface or ground waters;
- No adverse impact due to pathogens – no public health issues or illnesses;
- No issues in regards to trace elements;
- No ecosystem health issues – no toxicities or deficiencies observed;
- No limitations on the ecosystem – areas are grazed by cattle, and trees are reclaiming the areas;
- Anecdotal increased presence of wildlife;
- No health issues in wildlife; and
- No regulatory non-compliance issues.

Nutrients

The application of biosolids is overseen by a Qualified Professional. A Qualified Professional is responsible for authoring a biosolids Land Application Plan, characterizing the biosolids and soil quality at the land application site, and determining the application rate based on the site conditions and requirements. This is completed to ensure that the environment is protected, and that the nutrient application

Nutrients are the most abundant chemical constituent in biosolids and are considered to have the greatest risk potential for environmental harm. Excess applications of nutrients, specifically nitrogen and phosphorus, have reasonable potential to impact the environment through nutrient surpluses which could leach to groundwater or runoff in excess quantities into surface waters, resulting in reduced potability or algal blooms. This is particularly relevant in R/R contexts, where vegetation is non-existent and juvenile – the ecosystem must recover before it can effectively cycle nutrients.

Nutrients risks are well managed in biosolids through the OMRR land application planning process. Qualified Professionals calculate application rates taking into consideration the plant requirements; biosolids soil quality; maximum post application elemental concentrations as prescribed by the OMRR, the existing site conditions, and any other factors deemed important. Where required, additional organic matters may be added to sequester or immobilize nutrients.

Currently there are no heat-dried biosolids (90% solids) being land applied in R/R in the Pacific Northwest. Dried pelletized biosolids are produced and used for agricultural fertilization and turf fertilization (golf courses and turf farms) in Washington state. The following discussions related to the recognition and mitigation of environmental risks are drawn from experience using 20 – 25% dewatered material.

Pathogens, Odours and Aerosols

The acceptance of biosolids use by stakeholders is an integral component in the implementation of a successful biosolids R/R program. Successful stakeholder consultation is achieved by accurate and comprehensive identification of all stakeholders, identifying stakeholder concerns, and selecting effective approaches to address stakeholder concerns.

Odour concerns are the trigger for many public concerns and questions. The reduced odour profile for heat-dried biosolids may reduce some of the negative perceptions typically associated with the more odorous dewatered biosolids use. Several heat dried products are known to emit odours upon rewetting, and this factor should be taken into account when describing the potential odour profile of a biosolids project. In R/R processes that require soil mixing, the co-management of biosolids with a wood waste product generally has the desired result of odour mitigation.

During the wastewater treatment process, the solids undergo processing to eliminate pathogenic organisms. The biosolids produced must meet the pathogen limits specified in the OMRR. Granulite, a heat-dried biosolids product produced by Synagro, is free from E coli, fecal coliform, and salmonella. Risks of human exposure to pathogens from land applied 95% solid biosolids are negligible.

From a risk management perspective, odours are understood to be solely a nuisance characteristic in biosolids. The potential for aerosolizes pathogens or viruses from dried biosolids is negligible, due to the absence of detectable microbial pathogens in Class A material (dried or dewatered). By contrast, daily risks from pathogens to personnel working with animal manures range from 1 infection per 2 exposures to 1 infection to 10,000 exposures.

Trace Elements

The biosolids produced must meet the trace element limits specified in the OMRR, which also sets standards for trace element soil concentrations after land application. The regulated limits are risk-based and protective of human and environmental health as appropriate for the land use.

Trace elements are regulated through OMRR and their regulation is harmonized with the British Columbia Contaminated Sites Regulation (CSR). Trace elements are a regulated aspect of biosolids, and their risk is one of non-compliance with the regulation. To date there has been no record of non-compliance related to trace elements in R/R projects in British Columbia.

Trace element exceedances are often a pre-existing condition at mineral mines. Biosolids R/R projects have a track record of assisting in the management and mitigation of trace element excesses, through the addition of organic matter and a full suite of macro and micronutrients.

Biosolids have also played a role in addressing significant environmental issues that have arisen at mines, including acid rock drainage, high carbonates and alkalinity, molybdenum, copper, lead and arsenic pollution, returning sites with these challenges to productive ecosystems.

Emerging Substances of Concern

Emerging substances of concern (ESOCs) are a group of substances which originate from daily domestic, commercial, and industrial activities in minute quantities, and are emergent, therefore a determination on the need for their regulation has not yet been made by the regulator.

The term, ESOC, refers to an extremely wide variety of substances and is understood to include all constituents not specifically regulated or mentioned in either the OMRR or the CSR. Canadian scientists have recently undertaken a significant risk review to categorize and define many of the emerging substances that modern analytical techniques have been able to quantify (McCarthy and Loyo, 2015). This work recommended future research, but also noted that studies generally conclude that most of the emerging compounds have no detectible effect on the environment after land application, and concentrations of these substances in drainage, runoff or groundwater tend to be much lower than typical concentrations in treated effluent. Similarly, while science has demonstrated uptake by plants and some invertebrates, this presence has not translated into demonstration of negative impact. The researchers stress that presence is not indicative of risk, that dose is a critical component in understanding toxicity, and that dose is not demonstrated to be achieved (McCarthy and Loyo, 2015).

It is important to convey that biosolids are not a source of substances of concern. Biosolids are an intermediary or temporary receiving environment. The concentration of substances in biosolids reflects societal consumption, utilization and ultimately discharge of these substances to the sewer system. In the broadest context, organic matter and nutrients will always represent the greatest components of biosolids as they are the materials which the sewer system was intended to collect. The minute fractions of other substances represent ubiquity of compounds in our society, and their unintended discharge to the sewer, resulting in presence in biosolids.

Over time there has been specific interest in several ESOCs or constituent groups. To date no additional regulation has been recommended. There are few, if any causal linkages between application of these constituents through biosolids and any concrete evidence of environmental impact. One of the challenges in assessing ESOCs is understanding that presence of ubiquitous compounds in an intermediary like biosolids does not infer risk. An understanding of dose-response relationships and cumulative effects is required to form a basis of risk. In some cases, there is a lack of dose-response understanding. In many cases, however, the dose required to elicit a toxicologically relevant reaction is several orders of magnitude higher than the ultimate environmental concentration of the substance. This dose must also be considered in the context of the speed at which a substance degrades within the environment, and its ability to be rendered ineffectual within the environment by being sorbed to soil particles, or otherwise denatured through environmental processes.

ESOCs are currently not regulated under the OMRR. They are however indirectly managed through the management of trace elements and nutrients. When trace elements and nutrients are being managed according to a risk-based approach, the risk of ESOCs which are present in quantities which are orders of magnitude lower are also being managed.

Recent ecotoxicological studies have examined a variety of biosolids products and their impacts on targeted plants, animals, fish, aquatic invertebrates, and terrestrial invertebrates, in order to assess the potential for toxicological response. To date, this work has indicated no adverse toxicological impacts on any organisms studied in the context of agronomic rates of biosolids (McCarthy and Loyo, 2016).

Toxicologically, these studies make sense. The water resource recovery facility (wastewater treatment plant) is fundamentally a bioreactor. Meaningful biological toxicity of compounds in the influent would result in bioreactor upset through a die-off of the treatment media. Through the successful operation of the wastewater treatment plant, we recognize that influent, and biosolids (also biologically active) are not inherently toxic at the bacteriological scale.

Costs and Examples of Mine Reclamation and Restoration Using Biosolids

Biosolids management in R/R have traditionally been managed on a bulk tonne basis. These costs vary, depending on the distance from the generation point (transportation costs) regulatory burden (regulatory costs) and variation in the simplicity or complexity of the reclamation or restoration required to achieve equivalent land capability, and access restrictions (application or management costs). Other variable costs include stakeholder engagement and reporting requirements back to the generator and regulators from the contractor.

Costs from known programs appear to vary between $40 per bulk tonne of material managed to over $100 per bulk tonne of material managed. These values do not include transportation, which is a variable costs based on distance and transport challenges (loading/unloading, and terrain challenges.

Biosolids have successfully been used in both Mine Reclamation and Ecosystem Restoration. Examples of programs in British Columbia are included in the section below.

References

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APPENDIX ONE - IMAGES

Process

The following images show different biosolids application techniques used in R/R.

Heat-dried biosolids, like dewatered biosolids, can be land applied using a rear-discharge manure spreader.

Photo Credit: SYLVIS

Following application, agricultural disks are used to incorporate biosolids into the existing substrate.

Photo Credit: SYLVIS

Biosolids can be used as a feedstock in the fabrication of topsoil. The topsoil can then be applied to areas prior to vegetating.

Photo Credit: SYLVIS

Vegetation is completed based on the prescribed reclamation end-use. For example, an area may be hydroseeded with grasses. Vegetation establishment is observed on the biosolids fabricated soil plot (left) compared to none biosolids fabricated soil plot (right) following hydroseeding.

Photo Credit: SYLVIS

Examples of Mine Reclamation Using Biosolids

Biosolids have successfully been used in mineral and aggregate mine reclamation for over 20 years. The following includes examples of municipal biosolids reclamation programs in British Columbia.

Lehigh Sand and Gravel Mine, Sechelt

Bob's Lake Pit, Merritt

Pennask Pit, West Kelowna

Producer's Pit, Victoria

Clark Creek Pit, Merritt

Highland Valley Copper, Spences Bridge

Mount Polley Mine, Quesnel Lake

Copper Mountain Mine (Similco), Princeton