

**VANCOUVER ISLAND UNIVERSITY (WL 020)
LAND APPLICATION PLAN**

Date: July 15, 2009

Biosolids production facilities:

Regional District of Nanaimo
Greater Nanaimo Pollution Control Centre
4600 Hammond Bay Road
Nanaimo, British Columbia
V9T 5A8

French Creek Pollution Control Centre
957 Lee Road
Parksville, British Columbia
V9P 1Z4

District of North Cowichan
Chemainus STP
9575 Bare Point Road
Chemainus, British Columbia

Contacts for biosolids dischargers:

Regional District of Nanaimo
Attn: Sean De Pol
Manager of Liquid Waste
6300 Hammond Bay Road
Nanaimo, British Columbia
V9T 6N2
Phone: (250) 390-6560
Fax: (250) 390-1542

District of North Cowichan
Attn: Clay Reitsma
Assistant Municipal Engineer
Engineering Department
7030 Trans Canada Hwy
Duncan, British Columbia
V9L 3X4
Phone: (250) 746-3159
Pager: (250) 715-9096

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Owner of proposed application site: TimberWest Forest Corporation
3-4890 Rutherford Road
Nanaimo, B.C.
V9T 4Z4

Attn: Yvonne Deibert
Property Administrator
Phone: (250) 729-3708
Fax: (250) 729-3763

Proposed start of application: August 1, 2009

Time period of application: One year

Location and boundaries of application: Vancouver Island University Forest
WL 020
Nanaimo, BC
Block 505, Nanoose Land District
Block 463, Dunsmuir Land District
Block 355 Dunsmuir Land District

Plan prepared by: Paul Lucas, RPF
Vancouver Island University
900 Fifth Street
V9R 5S5

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Summary

Vancouver Island University Forest (WL020) manages over 1,700 hectares (ha) of forestlands, 12 kilometres (km) northwest of Nanaimo, on the lower slopes of Mt. Benson. As part of an operational fertilization program, Vancouver Island University Forest proposes to use biosolids in a forest fertilization program. Biosolids from the Regional District of Nanaimo's (RDN) Greater Nanaimo Pollution Control Centre (GNPCC) and French Creek Pollution Control Centre (FCPCC) (hereinafter referred to as Greater Nanaimo and French Creek biosolids respectively) are proposed for use in this program. Biosolids from the District of North Cowichan (DNC) Chemainus Sewage Treatment Plant (Chemainus STP) (hereinafter referred to as DNC biosolids) will also be used.

The biosolids will be used in an operational fertilization program on poor and low productivity forest stands. The use of biosolids as fertilizer was done in a 1992 and again from 2003 - 2008 as part of a forest fertilization project. Use of biosolids as a forest fertilizer is a stated objective in Vancouver Island University's Woodlot License Plan 2008-2018. The site vegetation and soils are assessed, and samples of the soil collected and analyzed for fertility and trace element concentrations. Concentrations of nitrogen and phosphorus in the existing soil are very low, and the soils have low organic matter content. Biosolids will be surface applied in 2009 and 2010 to the forest stands by a high-speed side-discharge spreader. The maximum calculated application rate is 20.5 dry tonne per ha (dt/ha), providing 1025 kg N/ha. Special site management considerations have been identified with respect to biosolids stockpiles, transportation and application. Calculation of post-application trace element concentrations in the soil shows that they will not exceed the standards set out in the current Organic Matter Recycling Regulation (OMRR). No post application environmental monitoring program is to be conducted.

Objective

The treatment area is located about 1.1 km west of the Biggs Road/Doumont Road intersection, just off Weigles Road. Stands will be fertilized with an agronomic application rate of biosolids to provide the nitrogen that the trees and understory vegetation require to optimize growth, while ensuring no adverse environmental impacts.

Site Characteristics

Stands in the treatment areas are composed of a mixed Douglas fir/Lodgepole pine stand and is approximately 55 years old. This stand was juvenile spaced in 1989 favouring the largest, best spaced Douglas fir as leave trees. A map of the application area is found in Appendix 1. This management polygon is completely enclosed within other stand management polygons and for the most part, located behind locked gates, thereby restricting public access.

The trees are spaced to a density of 1,074 stems per ha and when combined with roadside pruning provides ease of access to the stand for fertilization. The topography is best described as gently undulating. There is no appreciable slope to the land in any specific direction. The understory vegetation is described in detail below. Previous stand records

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indicate that the stand was fertilized with biosolids in 1992. The reapplication of biosolids in this system is designed to maintain the significant increase in rates of diameter growth that occurred following the 1992 fertilization treatment. The reduced rotation age will see a complimentary reduction in risk of catastrophic loss due to forest fire.

Vegetation

The vegetation of the area is dominated by the overstory of Douglas fir (*Pseudotsuga menziesii*), 24.2 metres (m) in height. Significant components of the understory vegetation include:

Salal (*Gaultheria shallon*): a shade intolerant, evergreen shrub that has been shown to compete for moisture and nutrients, effectively reducing growth of crop (Douglas fir) trees. With an average height of 75 centimeters (cm) salal forms a uniformly continuous dense mat of competitive vegetation throughout the stand. This shrub is indicative of disturbed and early seral or secondary succession. Previous experience gained from the 1992 biosolids fertilization project shows that salal growth is not enhanced as a result of nitrogen input from biosolids. It appears that the increased shade from the crowns of fertilized crop trees is reducing the vigour and growth rate of salal.

Oregon-Grape (*Mahonia aquifolium*): a shade-tolerant to intolerant evergreen shrub that occurs on dry, low to medium productivity soils. This shrub is present throughout the forest stand in scattered associations with salal.

Trailing Blackberry (*Rubus ursinus*): again, a shade-tolerant to intolerant deciduous shrub that occurs on dry, medium productivity soils. This shrub is common on open forests at low elevations.

Other species include the oval leafed mitrewort (*Mitella ovalis*), red huckleberry (*Vaccinium parvifolium*), swordfern (*Polystichum munitum*) and bear berry (*Actostaphylos uva-ursi*)

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Soils

The bedrock within this polygon is of sedimentary origin, varying sequences of conglomerate, shale and sandstone overlying volcanics. A thin, (often less than 1 m) veneer of morainal deposits, including till and lenses of gravel silts exist. Soil type is ortho dystric brunisol having a very thin organic surface layer (less than 2 cm thick) consisting of mostly coniferous leaves and twigs. Soils are of low productivity, being impoverished nutritionally, thin and well drained.

Average nutrient concentrations in the soils in are found in the table below.

Mineral Soil Analysis

Nutrient	Concentration (ug/g)
Ammonium	<.5
Nitrate	<.5
TKN %	0.114
Phosphate	105
Potassium	118
Arsenic	< 10
Cadmium	< 0.5
Chromium	41
Cobalt	16
Copper	38
Lead	14
Mercury	0.08
Molybdenum	< 4
Nickel	26
Selenium	< 2
Zinc	87
pH	5.3

Concentrations of nitrogen in the forms of ammonium and nitrate are very, severely deficient. Soils are also low in organic matter.

Biosolids Information

Biosolids used in this forest fertilization project will originate from the RDN's GNPCC and FCPCC, and the DNC's Chemainus STP. The GNPCC serves a connection population of approximately 79,000, treating an average of 33,000 cubic metres (m³) of wastewater per day. The FCPCC serves a connection population of approximately 24,000, treating an average of 9,000 m³ of wastewater per day. The Chemainus STP serves approximately 3,100 residents, treating an average of 2,140 m³ of wastewater per day.

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Greater Nanaimo biosolids achieve pathogen reduction by mesophilic anaerobic digestion as required for biosolids pathogen reduction in Schedule 1 of the OMRR. The geometric mean of seven discrete samples analyzed for fecal coliform was 221,542 most probable number per gram (MPN/g), below the 2,000,000 MPN/g pathogen reduction limit required for Class B biosolids, as specified in Schedule 3 of the OMRR. Greater Nanaimo biosolids achieve vector attraction reduction (VAR) by mesophilic digestion, reducing the mass of volatile solids by 58%, exceeding the 38% minimum reduction requirement for Class A or Class B biosolids as specified in Schedule 2 of the OMRR.

French Creek biosolids achieve pathogen reduction by digestion in autothermal thermophilic aerobic digesters (ATAD) as required for biosolids pathogen reduction in Schedule 1 of the OMRR. The geometric mean of seven discrete samples analyzed for fecal coliform was 6,295 most probable number per gram (MPN/g), below the 2,000,000 MPN/g pathogen reduction limit required for Class B biosolids, as specified in Schedule 3 of the OMRR. French Creek biosolids are digested in ATAD, resulting in a 45% reduction in the mass of volatile solids, exceeding the 38% minimum reduction requirement for Class A or Class B biosolids as specified in Schedule 2 of the OMRR.

District of North Cowichan (DNC) biosolids achieve pathogen reduction by extended aeration digestion as required for biosolids pathogen reduction in Schedule 1 of the OMRR. The geometric mean of seven discrete samples analyzed for fecal coliform was 428 most probable number per gram (MPN/g), below the 2,000,000 MPN/g pathogen reduction limit required for Class B biosolids, as specified in Schedule 3 of the OMRR. DNC biosolids achieve vector attraction reduction (VAR) by extended aeration digestion, reducing the mass of volatile solids to less than 1.50 mg O₂/hr/g DS as specified in Schedule 2 of the OMRR.

The following tables display trace element and nutrient concentrations, and physicochemical and microbiological characterization of the Greater Nanaimo, French Creek and DNC biosolids.

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Biosolids Trace Element Analysis

Constituent ⁽¹⁾	Greater Nanaimo 6/29/09 ⁽²⁾	French Creek 6/29/09 ⁽²⁾	DNC 6/29/09 ⁽²⁾	OMRR Class A ⁽³⁾	OMRR Class B ⁽⁴⁾	Units
Arsenic	< 10	<10	< 10	75	75	ug/g
Cadmium	1.8	2.1	1.9	20	20	ug/g
Chromium	49	42	42	-	1,060	ug/g
Cobalt	3	4	3	150	150	ug/g
Copper	789	783	965	-	2,200	ug/g
Lead	38	59	54	500	500	ug/g
Mercury	1.9	4.67	3.77	5	15	ug/g
Molybdenum	6	8	8	20	20	ug/g
Nickel	16	21	18	180	180	ug/g
Selenium	<2	<2	<2	14	14	ug/g
Zinc	813	949	825	1,850	1,850	ug/g

⁽¹⁾ Reported on a dry weight basis.

⁽²⁾ Indicates sample collection date.

⁽³⁾ Limits specified in Trade Memorandum T-4-93 (September 1997), Standards for Metals in Fertilizers and Supplements as referenced by the OMRR.

⁽⁴⁾ Limits specified in the OMRR for Class B biosolids, Schedule 4, Column 3.

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Biosolids Physicochemical and Microbiological Analysis

Constituent ⁽¹⁾	Greater Nanaimo 6/29/09 ⁽²⁾	French Creek 6/29/09 ⁽²⁾	DNC 6/29/09 ⁽²⁾	Units
Total Solids (%)	32.1	32	23.85	%
TKN (%)	3.12	3.27	3.56	%
Available Phosphorus	810	1,020	1,380	ppm
Nitrate	7 ⁽⁴⁾	6 ⁽⁴⁾		mg/kg
Ammonia	7,490 ⁽⁴⁾	7,010 ⁽⁴⁾		ppm
Available Potassium	391	729	1,070	ppm
pH	6.1	6.3	6.3	-
Electrical Conductivity	1,800	2,300	1,270	uS/cm
Fecal Coliform	221,542 ⁽³⁾	6295 ⁽³⁾	428 ⁽³⁾	MPN/g

⁽¹⁾ Reported on a dry weight basis.

⁽²⁾ Indicates sample collection

⁽³⁾ Geometric mean of 7 discrete samples. To meet Class B pathogen limit criteria for fecal coliform, the geometric mean of 7 discrete samples must be < 2,000,000 MPN/g.

⁽⁴⁾ Analysis from sample collected on February 19, 2007

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Proposed Application Rate

Design values used in the calculation of the biosolids application rate reflect the nitrogen demand by the crop trees and minor vegetation. The estimated nitrogen uptake and transformations are found in the table below.

Application Rate Data

Nitrogen Uptake - Trees (kg/ha)	115
Nitrogen Uptake - Understory (kg/ha)	40
Volatilization (%)	30
Denitrification (%)	10
Immobilization (kg/ha)	175
Mineralization Rate (%)	30
Total Nitrogen Required (kg/ha)	848
Maximum Application Rate (dt/ha)	20.9
Application Rate (Bulk Tonnes/ha)	71.3

The mineralization rate of the biosolids was determined from research and experience gained in Vancouver Island University Forests' 1992 biosolids project and from the Best Management Practices Guidelines for Land Application Of Managed Organic Material (June 2002).

As a conservative measure, the average nitrogen and total solids values from the three biosolids were used in calculating the application rate. Based on the assumed nitrogen requirements, transformation rates and concentrations in the biosolids, applications to a maximum of 20.9 dt/ha of biosolids are recommended.

Application Method and Timing

Biosolids will be transported and stored on the Vancouver Island University Forest site. Storage sites will be located on high ground a minimum of 400 m from any surface water body. Application of biosolids will take place for short periods throughout the year. Application will utilize a side-discharge aero-spreader. Biosolids will be surface applied and not incorporated, due to the existing root structure of the trees. Biosolids applications will cease under conditions of inclement weather (e.g. intense rainfall events) or at the discretion of the project manager.

The biosolids applications are scheduled to occur throughout the year.

Special Site Management Considerations

The active portion of the root network (i.e. the area of the root biomass that will contribute the most to nutrient uptake) in these coniferous stands occurs around the canopy drip line. As the stand is close to crown closure the application of biosolids will be made in a relatively uniform manner, as the crop tree roots exist throughout the entire stand. If a truck is utilized as the prime mover than the application will be made uniformly for 30 m on either side of roads that bisect the forest stand.

Prior to biosolids applications the area will be surveyed for mountain bike and hiking trails. While no significant adverse environmental impact will occur from the application of biosolids to these areas, best management practices suggest no application be made to these areas. Mountain bike and hiking trails will be identified prior to application and all trails leading into application area will have appropriate signage erected.

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Access to the application area is via Weigles Road. Fisheries and Oceans Canada staff have reviewed facility plans and the Land Application Plan in previous years and they have indicated that they expect no impacts on streams. Transporting and applying biosolids from the storage facility will be done on private roads behind gates. All creeks in the application area will have a 30 m no treatment buffer established prior to application.

Water Resource

The treatment area is located in the Brannen Lake watershed. This watershed is not used as a community water supply under the DRINKING WATER PROTECTION REGULATION[includes amendments up to B.C. Reg. 363/2008, December 4, 2008]

. The nearest residential water well is 1.4 km to the east at 6292 Doumont Road.

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Application Rate Data

Criteria	Units	Value		Calculation	Comments
Initial Ammonia/Ammonium	%	0.75		n/a	Obtained from biosolids analysis
Initial Nitrate Nitrite	%	0.0009		n/a	Obtained from biosolids analysis
Organic Nitrogen	%	3.31		n/a	Obtained from biosolids analysis
Solids	%	29.3		n/a	Obtained from biosolids analysis
Nitrogen Transformations					
Mineralization Rate	%	30		n/a	Obtained from biosolids analysis
Volatilization Losses	%	30		n/a	(Best Management Practices)
Denitrification Losses	%	10		n/a	(Best Management Practices)
Nitrogen Uptake/Storage					
Tree Uptake	kg N ha ⁻¹ yr ⁻¹	115		n/a	Professional knowledge - 1992 project
Understorey Uptake	kg N ha ⁻¹ yr ⁻¹	40		n/a	Professional knowledge - 1992 project
Soil Immobilization	kg N ha ⁻¹ yr ⁻¹	175		n/a	Professional knowledge - 1992 project
Available N required	kg N ha⁻¹		330		Sum of nitrogen uptake and storage
Nitrogen Transformations					
Initial Ammonia/Ammonium	kg dt ⁻¹	7.5		(.75/100)*1000 kg dt ⁻¹	Calculate initial concentration per tonne
Volatilization Losses	kg dt ⁻¹	-2.25		(30/100)*7.5 kg dt ⁻¹	Calculate volatile nitrogen losses
Mineralization Additions	kg dt ⁻¹	9.93		(3.31/100)*(30/100)*1000 kg dt ⁻¹	Calculate mineral additions
Ammonia/Ammonium Total:	kg dt ⁻¹		17.96		Sum of ammonia/ammonium transformations
Denitrification Losses	kg dt ⁻¹	1.8		(10/100)*17.96 kg dt ⁻¹	Calculate volatile nitrogen losses
Net Available N	kg dt⁻¹		15.8		Calculate net N available per tonne applied
Application Rate	dt ha⁻¹		20.9	330/15.8	Tonnes required to meet nitrogen needs
Application Rate	wt ha⁻¹		71.3	20.5/(29.3/100)	Convert dry tonnes to wet tonnes
Application Rate	kg ha⁻¹		848	20.5 dt ha(3.31% +.75%)	Application rate by nitrogen content

Calculation of agronomic application rate for forest fertilization

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The adjacent property owners to the east of Vancouver Island University Forest, Mr. Tom Gibson from Dunsmuir Quarries, Mr. Bryan Gregson owner of Lot 179 and Mr. Eric Heikaala owner of WL 012 have expressed oral/written support for the project.

Post Application Site Monitoring

Flynnfall Creek headwaters and where Flynnfall Creek leaves WL 020 will each be sampled for metals and fecal coliforms once in the fall of 2009 and once in the spring of 2010. Following the biosolids application the polygon boundaries will be walked to ensure the application has not extended into any adjacent polygons. Trees will be measured periodically to ensure optimum growth rates are maintained and to evaluate if forest stand requires additional treatments. Signs will be posted and maintained at key access points informing any visitors of the biosolids fertilization activities.

Estimated Trace Element Concentrations

The following table gives the pre-application concentrations of trace elements in soil and biosolids in mg/kg and kg/ha and estimated post-application soil concentrations. As a conservative measure, the highest trace element concentrations from the three biosolids were used in calculating additions to soil and post-application soil concentrations. Post-application soil trace element concentrations will not exceed standards set out in the OMRR.

Trace Element Data

Trace Element	Concentration in Biosolids	Addition to Soil (kg/ha)	Pre-Application Soil Concentration (ug/kg)	Pre-Application Soil Concentration (kg/ha)	Estimated Post Soil Concentration (kg/ha)	Estimated Post Soil Concentration (ug/kg)	OMRR Max. Threshold (ug/kg)
Arsenic	<10	0.209	< 10	21.0	21.2	10.1	300
Cadmium	2.1	0.04	< 0.5	1.1	1.14	0.54	100
Chromium	42	0.87	41	86.1	86.97	41.4	300
Cobalt	4	0.08	16	33.6	33.68	16.0	300
Copper	965	20.06	38	79.8	99.86	47.6	50,000
Lead	44	0.91	14	29.4	30.31	14.4	1,000
Mercury	4.67	0.09	0.08	0.2	0.29	0.13	40
Molybdenum	6	0.12	< 4	8.4	8.52	4.1	40
Nickel	21	0.44	26	54.6	55.04	26.2	500
Selenium	<2	0.04	< 2	0.4	0.44	0.21	10
Zinc	949	18.81	87	182.7	201.57	96.0	30,000

Biosolids Application Rate: maximum of 20.9 dt/ha

Soil Bulk Density: 1400 kg/m³

Soil Depth: 0.15 m

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The estimated post-application soil concentrations are calculated based on the assumption there is no change in bulk density following application, and that the biosolids are incorporated into the top 15 cm of the soil. In the application proposed in this Land Application Plan, the biosolids will not be incorporated, but remain on the surface.

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