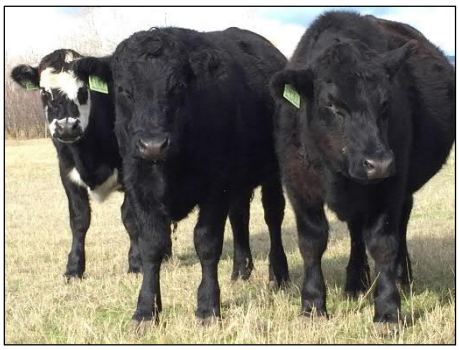
Associated Environmental

REPORT

Regional District of Central Okanagan and Okanagan Sustainability Leadership Council

Okanagan Biomass Inventory



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- Contacts listed in the biomass inventory dataset, submitted separately.

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1 PROJECT PURPOSE

The Regional District of Central Okanagan (RDCO) and the Okanagan Sustainability Leadership Council (OSLC) retained Associated Environmental Consultants Inc. (Associated) to develop a biomass inventory for the Okanagan Region as part of their initiative to improve the management of biomass waste in the region. It is a step towards increased renewable gas content in the natural gas system, using biomass waste as a source of renewable natural gas. The result is a dataset that identifies the information sources, composition, estimated quantity and current management practices of the biomass waste in the north, central, and south Okanagan Valley. A draft biomass feedstock and use matrix is also included. The report is intended to be reviewed in conjunction with the excel dataset.

2 METHODS

The initial step was to create categories of biomass feedstock classes or types, which are based on information obtained from literature, RDCO, OSLC and relevant stakeholders. The next step was to determine information sources, solicit information, analyze datasets, determine current biomass management and future projections, and map the summary of volumes. Prior to this deliverable, we provided a draft of the data collected and information sources, which were revised and expanded based on feedback during a client project team meeting on July 14, 2021.

2.1 Information Collection

While gathering information, the following biomass waste streams or categories of biomass were used:

1. Animal waste - produced from commercial livestock farming, and includes manure mixed with animal bedding.
2. Wastewater residuals - primarily biosolids[1] reclaimed from public wastewater systems.
3. Plant residuals - plants mixed with soil media and agricultural crop residues (different from leaf and yard waste).
4. Food waste - organics from restaurants and households.
5. Paper - processed fibre materials such as cardboard, high-grade commercial paper and mixed paper including newspapers and catalogues.
6. Leaf and yard waste - twigs, leaves and trimmings, both commercial (e.g., landscaping) and residential.
7. White wood - dimensional lumber, painted wood and other wood-based construction and demolition waste.
8. Clean Wood – harvesting roadside residuals and lumbermill waste produced from forestry operations.

To estimate quantity and quality of biomass generated in each biomass category, digital, literature and in-person sources were solicited. This entailed phone calls, emails and follow-up, as well as data requests and dataset mining. The methods used for each biomass sub-category are listed in the following subsections.

2.1.1 Animal Waste

Manure biomass volumes are based on livestock counts from the 2016 Census of Agriculture (Ministry of Agriculture 2016), paired with values of manure production by livestock type taken from literature (The Department of Alberta Agriculture and Rural Development 2013). The volumes include animal bedding based on conversations with local livestock producers.

[1]Biosolids are sludge (i.e. solid, semi-solid or liquid material that is generated during the wastewater treatment process) that has been treated to reduce pathogens and odours, stabilized, and tested to ensure that treatment requirements and quality criteria are met

As a further step to verify data, the 2016 Census of Agriculture results were cross referenced with the Agricultural Land Use Inventory (ALUI) data for livestock in the Okanagan (BC Ministry of Agriculture 2014). However, the ALUI data is limited for accuracy of livestock numbers because the method for data collection is with a "windshield survey method" (BC Ministry of Agriculture 2021). Because livestock are often confined to structures, the surveyor typically can't see the animals, so the ALUI summary does not provide an accurate summary of total livestock. For this reason, the census data were deemed more reliable to determine biomass for animal waste.

2.1.2 Wastewater Residuals

The production of biosolids from wastewater treatment is well tracked. Volumes are based on information obtained from the composting facilities and landfills that accept biosolids throughout the region, as well as review of annual reports produced by wastewater handling facilities (AECOM et al. 2011; City of Kelowna 2021; City of Vernon n.d.; Tetra Tech Canada Inc. 2020; Regional District of Okanagan-Similkameen 2010).

2.1.3 Plant Residuals

Plant residual biomass is derived from a summary of total hectares of orchards and vineyards in the Okanagan taken from the ALUI data (BC Ministry of Agriculture 2014), and typical planting densities taken from literature review and discussion with producers (E. Tonner, personal communication, July 13, 2021; Wines of British Columbia, n.d.). The total hectares multiplied by typical densities gave approximation of biomass produced. Values for tree fruits are based on a blend of young and older orchards, with an average of 0.5 tonnes/ha and 0.6 tonnes/ha (young orchards) to 1.9 tonnes/ha to 5 tonnes/ha (six-year old orchards) (Cichy et al. 2017).

Tree fruit:

- Approximately 3.5 tonnes/ha per year

Vineyards:

- Average of 1.8 kg/vine/year (Cichy et al. 2017)
- Density of 4,000 vines per ha

To cross-reference this approach, the published Agriculture and Agri-Food Canada Biomass Inventory Mapping and Analysis Tool (BIMAT) was analysed. It is a dataset and graphical interface hosted on a website that allows forestry, municipal solid waste, and agricultural data to be mapped using a common spatial framework. Crop residuals in the data set are limited to barley, wheat, flax, oats and corn, so were not applicable. Also, the federal data are not ground truthed and was deemed to be less accurate, so was not used in the results for plant residuals.

2.1.4 Food Waste

Food waste is generated from one of two categories: residential and commercial/industrial (e.g., restaurants and supermarkets). Estimated residential/household volumes are based on information from landfill managers and reviewing landfill waste inventory documents (Regional District of Okanagan-Similkameen 2010; Tetra Tech Canada 2018; City of Kelowna 2021). Commercial/industrial food waste information was sought through the BC Restaurant and Foodservices Association by sending a survey to its Okanagan members, but only one response was received. Further information was sought by contacting a local private compost producer, Spa Hills, that collects restaurant food waste in the north and central Okanagan, composts it, and uses it on farmland. The producer declined to provide volumes that are collected. GreenStep Solutions Inc., based in Kelowna, completed an audit of food waste. The information source used by GreenStep was from the landfill waste inventory documents, the same method we have used (A. Nagy, personal communication, October 14, 2021).

The direct avenues for information about commercial/industrial food waste were not successful, so extrapolation from a federal dataset was used, and applied to the known licensed restaurant establishments in the Okanagan. The federal source is an Environment and Climate Change Canada report (2018), that separates food waste by residential, commercial and institutional, and demolition. It provides the total food waste from commercial and institutional annually by province and lists the number of establishments in BC. The number of licensed establishments in the Okanagan was taken from the BC Liquor and Licensing database (2014). The calculations were as follows:

Tonnes BC commercial and institutional food waste annually / number of establishments in BC
= tonnes / BC establishment

Tonnes/BC establishment x number of licenced establishments in the Okanagan
= tonnes commercial/industrial food waste in the Okanagan

2.1.5 Paper

Volume of paper waste is based on information provided in annual reports from landfills and district collection services (Regional District of Okanagan-Similkameen 2010; Tetra Tech Canada 2018; City of Kelowna 2021).

2.1.6 Leaf and Yard Waste

Leaf and yard waste volumes are well tracked at the landfills and compost facilities where they are managed. Volumes are based on information from landfill managers and reviewing landfill waste inventory documents (Regional District of Okanagan-Similkameen 2010; Tetra Tech Canada 2018; City of Kelowna 2021).

2.1.7 White Wood

Volume of white wood is based on landfill inventories and information obtained from landfill managers (City of Kelowna 2021; Regional District of Okanagan-Similkameen 2010; Tetra Tech Canada Inc. 2018).

2.1.8 Clean Wood

Clean wood for mills and roadside is difficult to quantify through direct contact with forestry and mill managers. We have separated the methods for mill versus roadside, as they would be managed differently.

2.1.8.1 Clean Wood - Mills

Wood biomass from mills is used for pellet production or has an informal market with offsite use or fuel for mill burners for energy production, the latter is not carefully tracked (D. Douillard, personal communication, June 28, 2021). The resulting clean wood biomass volume for mills include all these possible end products, with pellets as the main source.

The Biomass Inventory Mapping and Analysis Tool (BIMAT) dataset was used to review information about location and quantity of mill waste. It is a dataset and graphical interface hosted on a website that allows forestry, municipal solid waste, and agricultural data to be mapped using a common spatial framework. In the BIMAT dataset, the woody biomass data was provided by the Canadian Forestry Service of Natural Resources Canada and estimates average annual production based on forestry activities for the years 2013-2014 based on the following sources:

- Estimates of the hardwood and softwood land base derived from satellite imagery (a land cover dataset developed by the Canadian Forest Service).

- Annual Allowable Cut statistics from the State of the Forest report, produced by the Canadian Forest Service, and the National Forest Database (Annual Allowable Cut measures the amount of wood that is permitted to be harvested within a one-year period to ensure forest sustainability and productivity).
- Mill locations and estimates of mill production and fibre use (inventory dataset developed by the Canadian Forest Service and the Canadian Wood Fibre Centre).
- Population and population growth statistics from the 2011 Census, provided by Statistics Canada.
- Hybrid poplar and willow growth and yield estimates from land suitability modeling (model developed by the Canadian Forest Service and the Canadian Wood Fibre Centre) and statistics from a national network of plantations (a demonstration network developed by the Canadian Forest Service and the Canadian Wood Fibre Centre).

The mill results from BIMAT dataset were contrasted to three additional data sources:

1) The latest Major Timber Processing Facilities dataset, which shows the location and the estimated annual capacity of each operational or presumably operational mill in the province. It is a province-published survey dataset from the GEOBC, DataBC, and the Economic Services Branch (FLNR 2020). While valuable to get perspective on mill capacities, the Major Timber Processing Facilities dataset does not provide any data about *waste* stream volumes.
2) Information obtained from the lumber industry (D. Douillard, personal communication, June 28, 2021; V. McGrath, personal communication, June 21, 2021).
3) The Canadian Biomass 2021 Pellet Mill Map (Canadian Biomass 2021) to understand volumes of material going to pellet plants.

2.1.8.2 Clean Wood - Roadside

The BIMAT dataset was reviewed for roadside wood, as provides a summary of material left at the roadside after harvesting and excess (see section 2.1.8.1 for more information). However, the primary source of values for roadside wood are from the Natural Resources Canada dataset (NRCAN 2018). The NRCAN dataset contains vector data (shapefile) of the post-harvest forest residues in Canada for the bioenergy/bioproducts sector in oven-dry tonnes per year (ODT/yr) over the next 20 years. The shapefile maps were produced using remote sensing products, reported at a 10km x 10km scale for harvest residuals. Nationally, the average biomass of forest residues available after harvest is 26 ± 16 ODT/ha (Natural Resources Canada 2018). This was refined to the three regional district boundaries, north, south and central. The NRCAN data is the most comprehensive for Clean Wood - Roadside and was used as the information source.

A more refined biomass inventory of roadside wood in the Okanagan will be completed in 2022. The Ministry of Forests, Lands, Natural Resource Operations and Rural Development (FLNR) completes a review of the Annual Allowable Cut for Timber Supply Areas (TSA) in the Okanagan. This information is provided to FP Innovations, who completes a biomass inventory analysis, typically once every 10 to 12 years (A. Nussbaum, personal communication, October 29, 2021). FP Innovations uses the FLNR data to estimate available forest-origin biomass for the TSA's. They develop a biomass ratio of recovered biomass to recovered merchantable roundwood, and approximate the cost per oven dry tonne, with the input of road networks and plans for Crowns Land (FP Innovations 2017). The Okanagan annual allowable cut data will be provided to FP Innovations by the end of 2021, for their analysis and reporting in 2022 (A. Nassbaum, personal communication, October 29, 2021).

Wildfire plays a role in roadside wood availability; however, it could either increase or decrease roadside wood availability (L. Ronan, personal communication, August 26, 2021). After a large wildfire occurs in the region, as

happened in summer 2021, licensees review their operating areas to inventory salvage logging efforts, which could lead to harvesting larger areas than the annual allowable cut. If clean wood from roadside is a chosen biomass source, this biomass volumes from this stream could be further refined from working with the FLNR.

2.2 Biomass Management and Future Predictions

A summary of current biomass management is provided, and is based on information from the biomass producer, either published in formal reporting or through discussions.

Future biomass predictions are based on population projections from BC statistics (BCStats, n.d.). The predictions correlate to the projected population growth and assume no change in per capita production.

2.3 Mapping

Maps or visualizations of the biomass inventories were created by category. Total volumes were extrapolated into pie charts if there was more than one source made up a category; for example, animal waste comes from cattle, chicken, and livestock manure. If there is one source, for example wastewater residuals, the data are presented in a single circle. The volume of waste is correlated to the size of the circle on the maps.

For the clean wood waste stream, the NRCAN roadside data is at 10km x 10km scale, which is mapped by colour in ODT/year. The mill biomass from the BIMAT dataset required selecting circular areas based on a single point. For this reason, there is some overlap between districts and under-coverage in outlying regions, with total volumes presented as circles.

3 RESULTS

3.1 Information Sources

The sources for data collection varied by biomass category, and overlapped for some regions (north, south and central), shown in Table 3-1. The complete dataset that shows more detail for data sources, which is available in Excel file submitted with this document. Complete references are provided in the references section of this document.

Table 3-1
Data Source by Category of Biomass

Region	Category of Biomass	Source
North Okanagan	Animal Waste	BC Chicken Growers Association
North, Central and South Okanagan	Animal Waste	2016 Census of Agriculture
North and Central Okanagan	Wastewater Residuals	City of Kelowna
Central Okanagan	Wastewater Residuals	Regional District of Central Okanagan Westside Wastewater Treatment Plant
Central Okanagan	Wastewater Residuals	Lake Country Wastewater Operations
South Okanagan	Wastewater Residuals	Regional District of Okanagan-Similkameen
South Okanagan	Wastewater Residuals	Penticton Wastewater Treatment Plant, CH2MHill 2010 Regional Organic Waste Management Strategy
All Okanagan	Plant Residuals	BC Grape Growers Association
All Okanagan	Plant Residuals	Okanagan Vineyards
North, Central, and South Okanagan	Plant Residuals	2006-2014 Agricultural Land Use Inventories, Okanagan
North, Central, and South Okanagan	Plant Residuals	Agriculture and Agri-Food Canada
North Okanagan	Plant Residuals	Vert Nature
Central Okanagan	Plant Residuals	The Valens Company
Central Okanagan	Plant Residuals	Summerhill Wineries
Central Okanagan	Plant Residuals	Stewart Family Estate Vineyard
North Okanagan	Food Waste	Spa Hills Compost
North Okanagan	Food Waste	Tetra Tech Canada Inc. 2018 RDNO Solid Waste Management Plan
Central Okanagan	Food Waste	Tetra Tech Canada Inc. 2021 RDCO Solid Waste Management Plan
Central Okanagan	Food Waste	City of Kelowna
Central Okanagan	Food Waste	UBCO Sustainability Society
Central Okanagan	Food Waste	Original Joes – West Kelowna
South Okanagan	Food Waste	Regional District of Okanagan-Similkameen, CH2MHill 2010 Regional Organic Waste Management Strategy
All Okanagan	Food Waste	Environment and Climate Change Canada. 2018. National Waste Characterization.
North Okanagan	Paper	Regional District of North Okanagan

Region	Category of Biomass	Source
Central Okanagan	Paper	Tetra Tech Canada Inc. 2018 RDNO Solid Waste Management Plan
Central Okanagan	Paper	City of Kelowna
South Okanagan	Paper	Regional District of Okanagan-Similkameen, CH2MHill 2010 Regional Organic Waste Management Strategy
North Okanagan	Leaf and Yard Waste	Tetra Tech Canada Inc. 2018 RDNO Solid Waste Management Plan
Central Okanagan	Leaf and Yard Waste	Hoekstra, S., City of Kelowna
Central Okanagan	Leaf and Yard Waste	Glenmore Landfill, City of Kelowna
South Okanagan	Leaf and Yard Waste	Regional District of Okanagan-Similkameen Waste Collection Statistics
South Okanagan	Leaf and Yard Waste	Regional District of Okanagan-Similkameen, CH2MHill 2010 Regional Organic Waste Management Strategy
Central Okanagan	White Wood	Hoekstra, S., City of Kelowna
South Okanagan	White Wood	Regional District of Okanagan-Similkameen, CH2MHill 2010 Regional Organic Waste Management Strategy
North, Central and South Okanagan	Clean Wood – Mill	Agriculture and Agri-Food Canada, Biomass Inventory Mapping and Analysis Tool (BIMAT)
North and Central Okanagan	Clean Wood – Mill	Tolko Industries Ltd.
North Okanagan	Clean Wood – Mill	Gorman Brothers Lumber
All Okanagan	Clean Wood – Mill	Canadian Biomass 2021
All Okanagan	Clean Wood – Roadside	Ministry of Forests, Lands, Natural Resource Operations and Rural Development
North, Central, and South Okanagan	Clean Wood – Roadside	Natural Resources Canada
North, Central, and South Okanagan	Clean Wood – Roadside	Agriculture and Agri-Food Canada Biomass Inventory Mapping and Analysis Tool (BIMAT)

3.2 Data Reliability

Data reliability is limited by reliability of sources. The most reliable data are from municipally managed sites, the landfills and wastewater residual treatment facilities, where managing waste has a clear economic cost or return and is required by permitting. It is carefully tracked and available publicly. The data from personal communications with producers are limited by the level of detail that producers capture, and how biomass is measured. We have taken those accounts at face value. The ALUI is conducted using visual interpretation of aerial imagery combined with a drive-by “windshield” survey to capture a snapshot in time of land use and land cover. Therefore, ALUI data are limited by what can be observed from the roadside. The federal datasets (BIMAT and NRCAN) are limited by their method of collection, which is a desktop analytical and modelling process, not verified by ground-truthing. Due to limitations with the on-line viewing BIMAT platform, only an approximation of the boundary to each regional district can be used to

determine biomass produced by regional district area. This allows for a general estimation of the coverage in the Okanagan.

The data reliability has been ranked as poor (1) to reliable (5), based on a specific question to the information provider, or reflective of the dataset limitations listed. The graphic of data reliability is provided in the Excel dataset, shown in Figure 3-1. A statement about seasonal availability is captured under assumptions, which is based on available information from information providers and assumptions based on the waste stream. Level of contamination is also assumed, which is based primarily on available reporting and feedback from biomass producers. Contamination includes anything that is non-organic, items that cannot be composted.

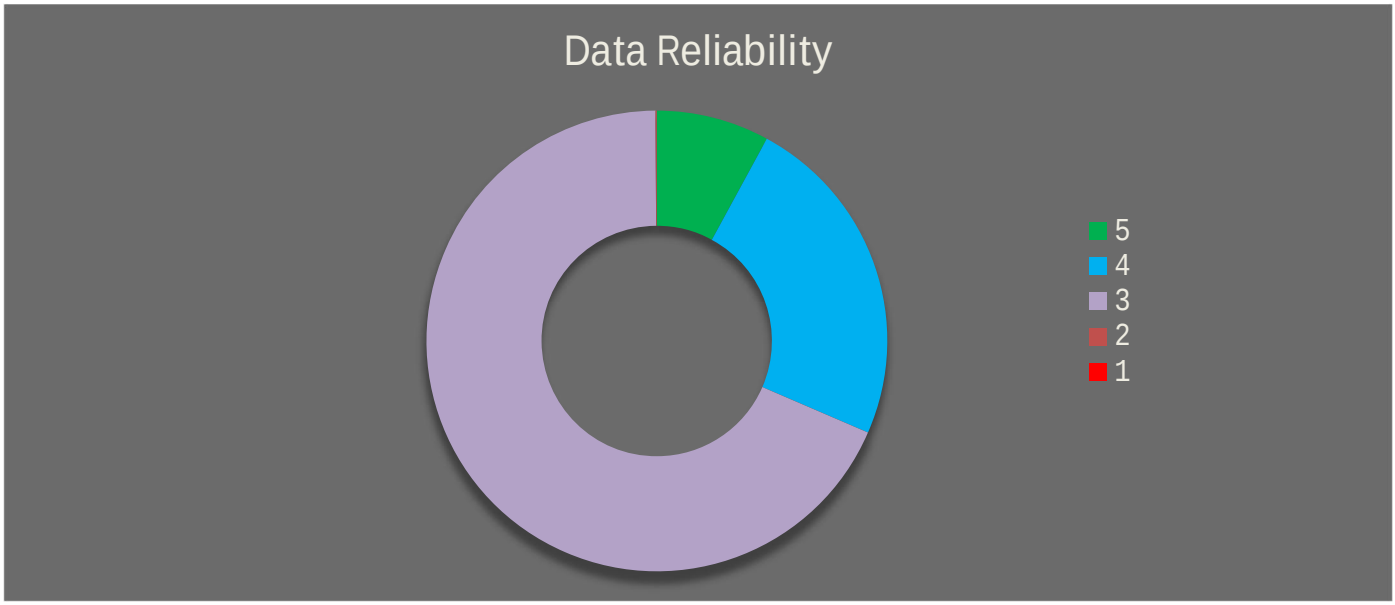

Figure 3-1
Graph Representation of Data Reliability

3.3 Data Assumptions

Data assumptions are required to better estimate volume for each biomass category. Assumptions for each biomass category are summarized as:

- Animal waste - Consistent production year-round and no fluctuation in the number of animals per year.
- Wastewater residuals - Seasonal variations not typical in yearly output. Minimal contamination from possible sources such as white wood and/or metals. The Okanagan has no major sludge sources.
- Plant residuals - Low production during winter months for outdoor producers. No contamination because carefully managed. Composted plant residuals weigh 593.3 kg/m^3 on average (according to Biernbaum 2021). Compost is always labelled as “wet,” as successful compost production requires 30 – 50% moisture.
- Food waste - Consistent production year-round. Some contamination from meat and non-compostable material. Material typically has high moisture content. The list of establishments from the BC Liquor Board is similar to the establishment type captured in the federal dataset used to determine commercial and institutional food waste.

- Paper - Consistent production year-round and limited contamination because carefully managed (e.g., no paper with finishes are accepted).
- Leaf and yard waste - Low production during winter months. Contamination from misplaced articles going into yard waste bins (e.g., garbage, recycling). Material is typically dry with little to no moisture content.
- White wood - Consistent production year-round. Some contamination is always present based on the definition of this category.
- Clean wood - Contamination from inclusion of rocks, soil, and other non-organic materials. Production remains constant year-round for mill waste. Production declines during the winter months for roadside waste.

4 BIOMASS INVENTORY RESULTS

Approximately 1,527,010 tonnes of biomass are produced in the Okanagan annually (Table 4-1). This volume is mostly estimated in wet tonnes (i.e., the volume before oven drying or centrifuge). The largest volume of biomass is from wood waste, both roadside and mill, followed by animal waste. The breakdown of biomass generators is provided in the Excel dataset as a pie chart. The locations of the biomass sources vary, with the majority of animal waste, roadside wood waste and wastewater residuals in the north (Figures 1 through 5, in Appendix A). Current management is listed in Table 4-1 and elaborated in the next section.

Table 4-1
Summary of Biomass Inventory

Category	Estimated Volume (wet tonnes/year)	Current Management
Animal waste	145,900	Composted and used on farm
Wastewater residuals	45,891	Composted and marketed to private users and the public
Plant residuals	57,664	Composted and used on farm
Food waste	63,533	Landfilled or composted at private facility
Paper	33,832	Recycled
White wood	74,445	Landfilled and used in landfill site management
Leaf and yard waste	110,048	Composted and supplied to the public
Clean wood - mill	556,526*	Managed onsite, supplied to other facilities, used in cogeneration or made into pellets
Clean wood – roadside	439,171	Left/managed onsite
Total	1,527,010	

*This is an interpretation of the BIMAT data and where the sawdust is produced. Pellet production is the same biomass product (sawdust) made into pellets. The distribution of pellet production is not the same as BIMAT mill waste distribution, but the volumes align. The Okanagan pellet facilities produce a total of 482,000 tonnes/yr at the following mills (Canadian Biomass 2021):

- Princeton Standard Pellet Corp., Princeton, BC, 70% bulk, 30% bagged, 110,000 tonnes/yr
- Pinnacle Renewable Energy Armstrong, Armstrong, BC, 95% bulk, 5% bagged, 72,000 tonnes/yr
- Lavington Pellet LP - Pinnacle/Tolko Partnership, Lavington, BC, 100% bulk, 300,000 tonnes/yr

4.1 Biomass Management and Future Projections

The current management is listed by category of biomass in Table 4-1. In general, most biomass sources are managed on site, landfilled, go to market or left in place such as roadside wood waste. Only wastewater residuals and leaf and yard waste having a commercial market, for example Ogogrow and Glengrow, respectively, which are marketed as soil amendments for both residential and commercial use. Agricultural material, which includes plant residuals and animal waste, managed on site is typically composted and/or is left stockpiled for long periods until space limitations require that it is removed. Mill clean wood waste often has an informal market with composting facilities or other offsite use or is used to fuel mill burners for energy production (D. Douillard, personal communication, June 28, 2021). Roadside clean wood waste from logging operations it typically left on site and often burned.

Regarding the best use of biomass, ideally it would be diverted from a scenario that produces greenhouses gases, for example landfill disposal or burning. To capture it as a resource and create energy is a step towards increased renewable energy. Reviewing the carbon cycle intensity of biomass use to create energy was not within the scope of this project.

Future biomass projections are provided in the Excel summary as a graph chart. Generally, the biomass production increases incrementally with the population increase. The wood pellet market is strong, and in Canada pellet production grows year over year by approximately 9% (Canadian Biomass 2021). Speculation for increased pellet production in the Okanagan was not found.

4.2 Biomass Use Matrix

A high-level matrix of potential uses for the categories of biomass has been developed. The feasibility matrix is presented as a flow diagram showing the categories of biomass or feedstocks that are in the Okanagan, the conversion technology that is generally commercially available to utilize that feedstock, the type of fuel produced, and the possible end-use of that fuel (Figure 4-1 sourced from Adams et al. 2018).

Biomass can be converted using biological and thermal technologies that rearrange the majority of carbon atoms to a valuable product including energy, fuel and chemical products. Biological utilizes microbial process, is restricted to biodegradable waste, and primarily uses inputs such as food, yard and other organic wastes. Thermal requires an external heat source to transform waste, is restricted to combustible materials, primarily paper, wood, and plant residuals. Conversion technology listed by Adams et al. (2018; Figure 4-1) include the following, each of which have their own limitations:

- Mechanical extraction
- Fermentation
- Anaerobic Digestion
- Liquefaction
- Pyrolysis
- Gasification
- Mechanical Process to chips and/or pellets.

A high-level summary of conversion technologies and their relevance to the Okanagan biomass inventory results is provided here.

Mechanical Extraction

There are many different techniques for mechanical extraction, including (Segneanu et al. 2013): liquid-solid extraction, liquid-liquid extraction, partitioning, acid-based extraction, ultrasound extraction, and microwave assisted extraction. The chosen method depends on nature of material and components that will be isolated, with liquid-liquid extraction and liquid-solid extraction as the main procedures used. This can be used to create bio-diesel with identified plant residual and food waste biomass.

Fermentation and Anaerobic Digestion

Fermentation is a subset of anaerobic digestion, or the first phases of anaerobic digestion. Limitations to fermentation are partially due to poor operational stability, which hinders the technology from being widely adopted and thereby improved. Figure 4-1 shows fermentation into ethanol as a result of alcoholic fermentation, but there are other forms of fermentation that would yield products such as acetic acid. These conversion technologies could be fed with animal waste, wastewater residuals, food waste, and leaf and yard waste (typically once shredded to be used as a bulking agent).

Pyrolysis and Liquefaction

Pyrolysis is the conversion of wood or carbon to charcoal. This product can be further gasified. As taken from Castello et al. (2018), “There are essentially two main classes of thermochemical processes able to produce a liquid fuel directly from solid biomass: fast pyrolysis and hydrothermal liquefaction. The former involves a very fast heating of biomass in the absence of oxygen and it is mostly addressed to biomass feedstock with a reduced moisture content (usually lower than 10%), e.g., wood or straw.” Liquefaction involves the reaction of organic material in the presence of water at very high temperatures and pressure. These conversion technologies could be fed with plant residuals, clean wood and white wood. Pyrolysis has been presented as a technology for converting food waste to energy, but the high moisture content in food waste requires a lot of heat, which may make this process uneconomical. Pyrolysis has also been used to convert wastewater solids, and Metro Vancouver has spent considerable cost to demonstrate hydrothermal liquefaction of wastewater residuals.

Gasification

Gasification is a process that converts the fossil fuel or organic waste into gases including hydrogen, carbon dioxide and carbon monoxide (Ankur Scientific 2019). Limitations are dependant on the type of gasifier. This conversion technology could be fed with plant residuals, food waste, clean wood, white wood and potentially wastewater residuals.

The viability of each resource is influenced by factors beyond simple theoretical or measured total volumes. However, very generally, animal waste has been identified as the third most abundance volume of biomass category, and it is produced at localized areas (on-farm and along major roadways). In this case, anaerobic digestions into biogas could be a viable option. The carefully managed wastewater residuals could be added to that conversion technology (Figure 4-1). Utilizing roadside or mill wood waste to develop a clean, solid fuel would be limited by the effort to collect the material, potential for contaminants, regulatory hurdles and cost-effective technology. These factors would apply to all biomass categories and chosen conversion technology.

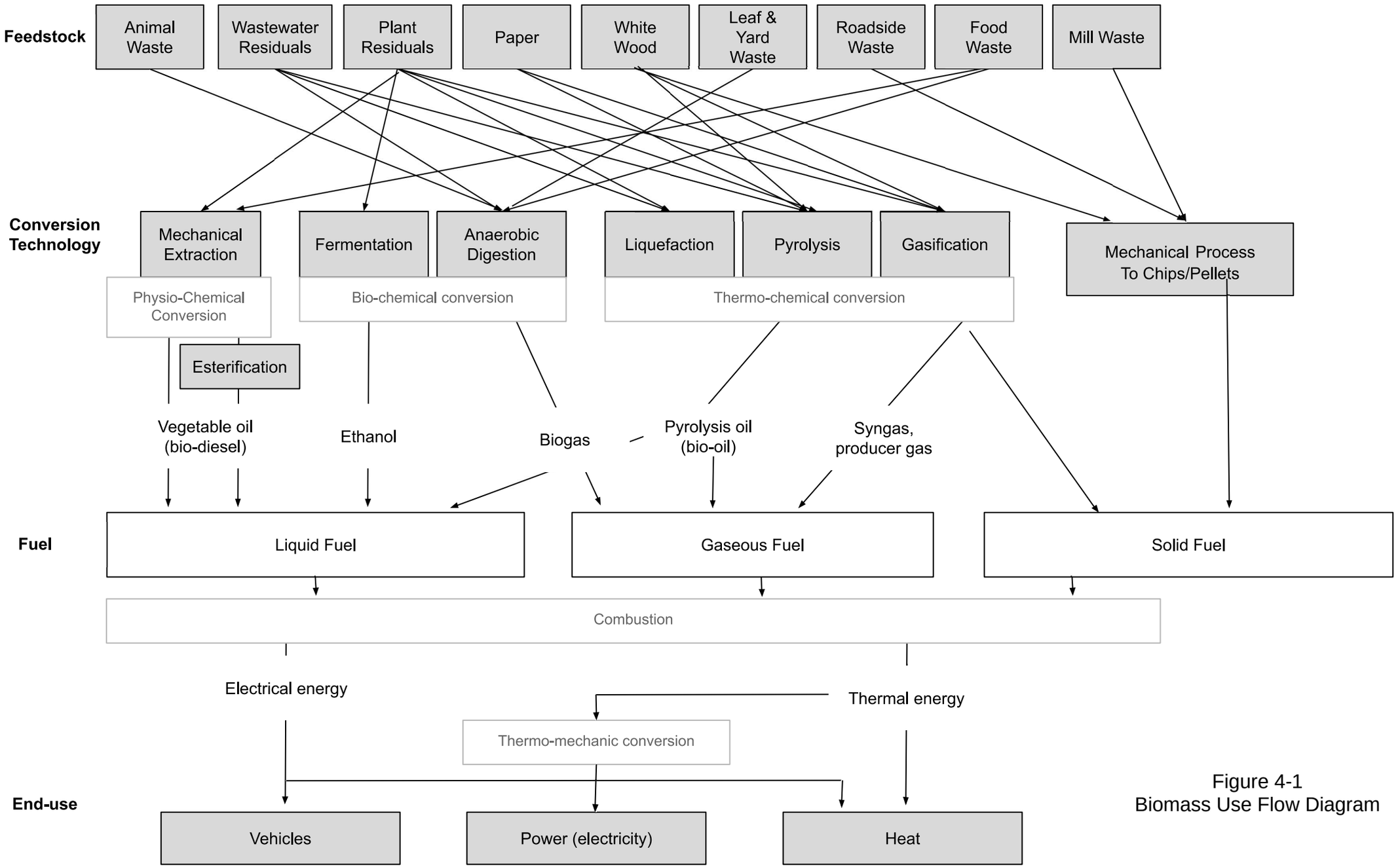

Figure 4-1
Biomass Use Flow Diagram

5 ADDITIONAL WORK

Activities to improve the accuracy of the waste inventory could be completed for the biomass categories. Ideas on how to approach data refinement are listed here:

- Animal waste – Continue to utilize available datasets and monitor the changing agricultural landscape based on market demand for goods.
- Wastewater residuals - Collaboration with the Okanagan municipalities (at a minimum, Vernon, Kelowna and Penticton) could help refine those waste streams and identify joint options for energy creation. Review Metro Vancouver's efforts for wastewater residual conversion to energy.
- Plant residuals – Continue to utilize available datasets and monitor the changing agricultural landscape based on market demand for goods.
- Food waste - Petition other jurisdictions / major cites/regions to see what they have found through their own studies. For example, Metro Vancouver has done a lot of work in this area over the past decades.
- Paper – Continue to collaborate with the Okanagan municipalities (at a minimum, Vernon, Kelowna and Penticton) regarding waste management and monitoring.
- Leaf and yard waste - Continue to collaborate with the Okanagan municipalities (at a minimum, Vernon, Kelowna and Penticton) regarding waste management and monitoring.
- White wood - Continue to collaborate with the Okanagan municipalities (at a minimum, Vernon, Kelowna and Penticton) regarding waste management and monitoring.
- Clean Wood Roadside – Collaboration with FLNR to refine volumes based on agreements with licensees in each operating area.
- Clean Wood Mill and Roadside - Seek results from FP Innovations regarding wood biomass volumes, a study that will begin in late 2021 or early 2022 (A. Nussbaum, personal communication, October 29, 2021)

The cost analysis for capturing these waste streams is unknown at this stage, but it would also be a driver for investment in a biomass to energy project. The viability of each resource is influenced by factors beyond simple theoretical or measured total volumes. The cost to collect, transport, and pre-processing varies by geography, supply logistics, and product type. Each conversion technology has feedstock quantity and quality requirements, which has not been detailed as part of this scope of work. Further work would be needed to determine the requirements and suitability of the inventoried feedstocks as well as conversion from wet to dry tonnes, as relevant.

If a specific biomass category becomes a focus, there are also several risk categories that should be assessed including:

- Supplier Risk,
- Competitor Risk,
- Supply Chain Risk,
- Feedstock Quality Risk,
- Feedstock Scale-Up Risk, and
- Internal Organizational Risk.

To better understand the potential risks in those six categories, the RDCO and OSLC may want to consider an assessment of supply chain risk through the Biomass Supply Chain Risk (BSCR) Standards (EcoStrat Inc. 2021).

6 CONCLUSIONS AND RECOMMENDATIONS

The initial inventory of biomass is promising. The largest volumes are from clean wood, approximately 439,171 tonnes/year for roadside and 556,526 tonnes/year for mill. The wood waste stream is not accurately tracked with estimates based on limited information that are not largely monitored or ground-truthed. It is assumed that mill wood waste already has a market or is converted to biogas, where relevant, and roadside wood would be costly to capture because it would be in remote locations and spread out. FP Innovations is working on an analysis of wood biomass in the Okanagan including the economic and regulatory hurdles. Results of this study could be valuable going forward.

The animal waste stream is the next most abundant source, with the north Okanagan providing the highest volume. Animal waste combined with wastewater residuals could be converted to energy using the same technology. These two feedstocks combined are approximately 191,791 wet tonnes / year.

Additional work to refine volumes of the animal waste and wood waste streams could help direct next steps, as well as a supply chain risk analysis of the chosen waste stream and potential conversion technology.

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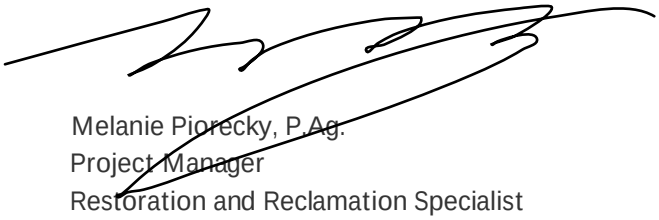
CERTIFICATION PAGE

This report presents our findings of the Okanagan Biomass Inventory for the Regional District of Central Okanagan and Okanagan Sustainability Leadership Council Okanagan Biomass Inventory.

Respectfully submitted,

Prepared by:



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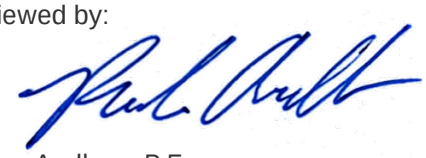
Reviewed by:



Ruben Arellano, P.Eng.
Low Carbon Energy Systems Specialist

APPENDIX A - VISUALIZATIONS

NORTH OKANAGAN REGIONAL DISTRICT

Cattle Manure 64,141 tonnes/yr
Chicken Manure 19,052 tonnes/yr
Livestock Manure (Other) 13,578 tonnes/yr

CENTRAL OKANAGAN REGIONAL DISTRICT

Cattle Manure 6,719 tonnes/yr
Chicken Manure 217 tonnes/yr
Livestock Manure (Other) 6,201 tonnes/yr

OKANAGAN-SIMILKAMEEN REGIONAL DISTRICT

Cattle Manure 28,921 tonnes/yr
Chicken Manure 397 tonnes/yr
Livestock Manure (Other) 6,674 tonnes/yr

Kilometers
0 10 20 30 40 50

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Associated Environmental

Regional District Boundary

Animal Waste

Cattle Manure
Chicken Manure
Livestock Manure (Other)

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DATE: September 2021
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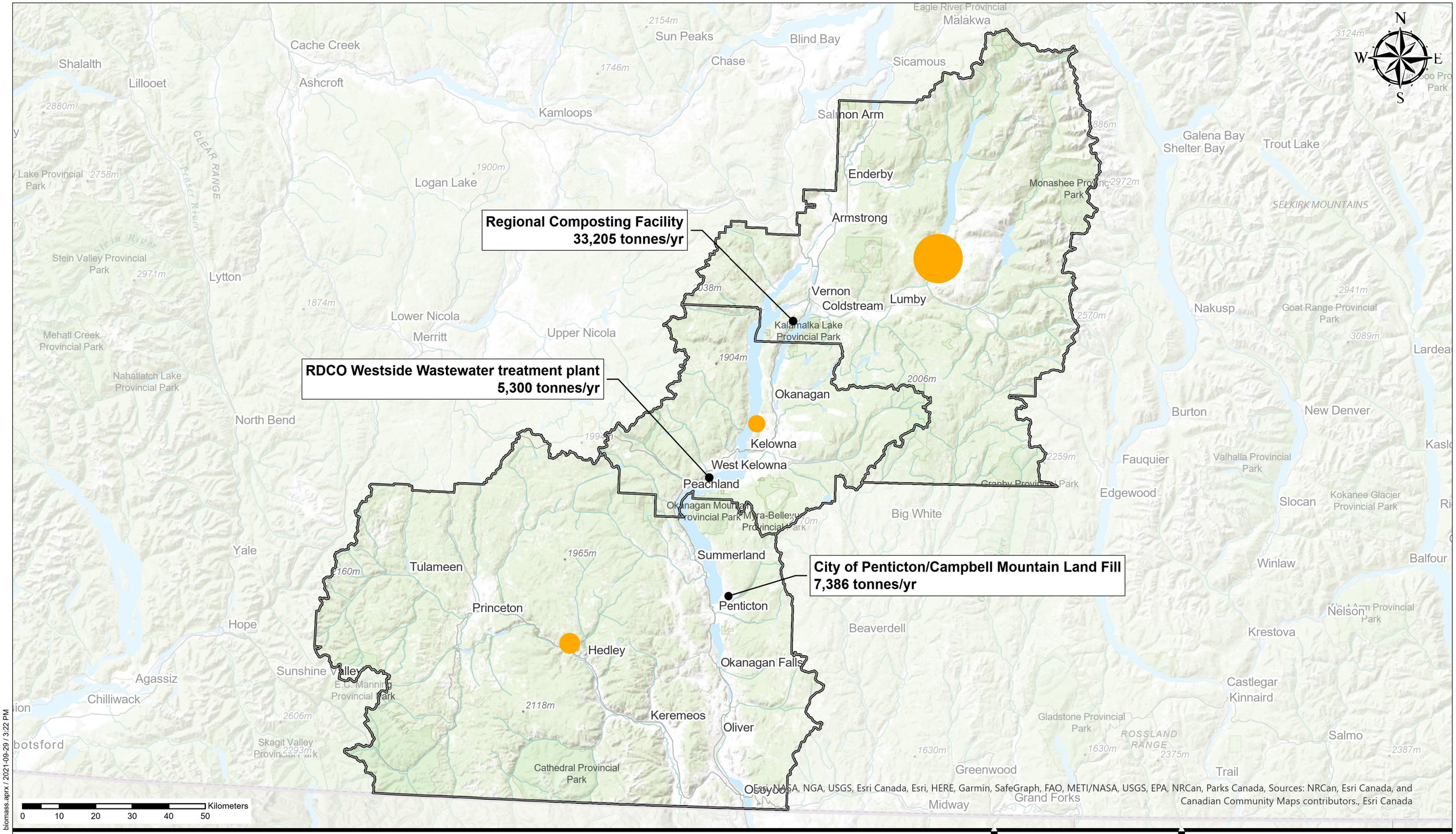
FIGURE 1: ANIMAL WASTE

Regional District Central Okanagan and Okanagan Sustainability Leadership Council

Okanagan Biomass Inventory



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Associated Environmental

Regional District Boundary

Facility Location

Waste Water Residuals

45,891 tonnes/yr

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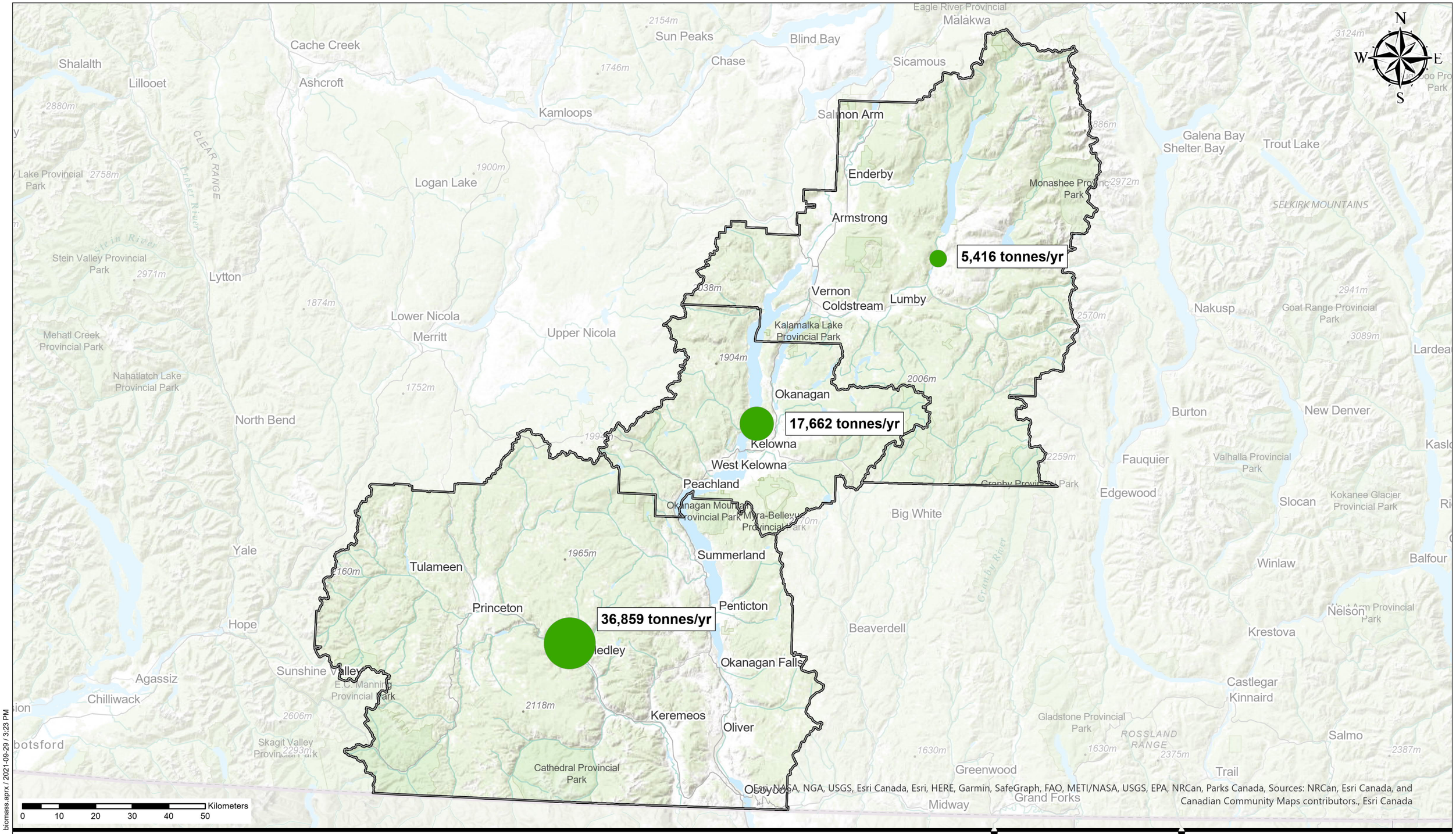
FIGURE 2: WASTE WATER RESIDUALS

Regional District Central Okanagan and Okanagan Sustainability Leadership Council

Okanagan Biomass Inventory



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Associated Environmental

Regional District Boundary

Plant Residuals

59,937 tonnes/yr

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FIGURE 3: PLANT RESIDUALS

Regional District Central Okanagan and Okanagan Sustainability Leadership Council

Okanagan Biomass Inventory

Region	Food Waste	Leaf Yard Waste (tonnes/yr)	Paper Waste	White Wood
Central Okanagan	23,283	41,456	17,994	8,019
North Okanagan	5,212	43,164	6,886	
South Okanagan	10,524	24,321	8,952	66,426
Grand Total	39,019	108,941	33,832	74,445

RDNO Waste Management; Vernon Landfill

Glenmore Landfill

City of Penticton/Campbell Mountain Land Fill

Kilometers
0 10 20 30 40 50

Esri, NASA, NGA, USGS, Esri Canada, Esri, HERE, Garmin, SafeGraph, FAO, METI/NASA, USGS, EPA, NRCan, Parks Canada, Sources: NRCan, Esri Canada, and Canadian Community Maps contributors., Esri Canada

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Associated Environmental

Regional District Boundary

Landfills

Food waste

Leaf yard waste

Paper waste

White wood

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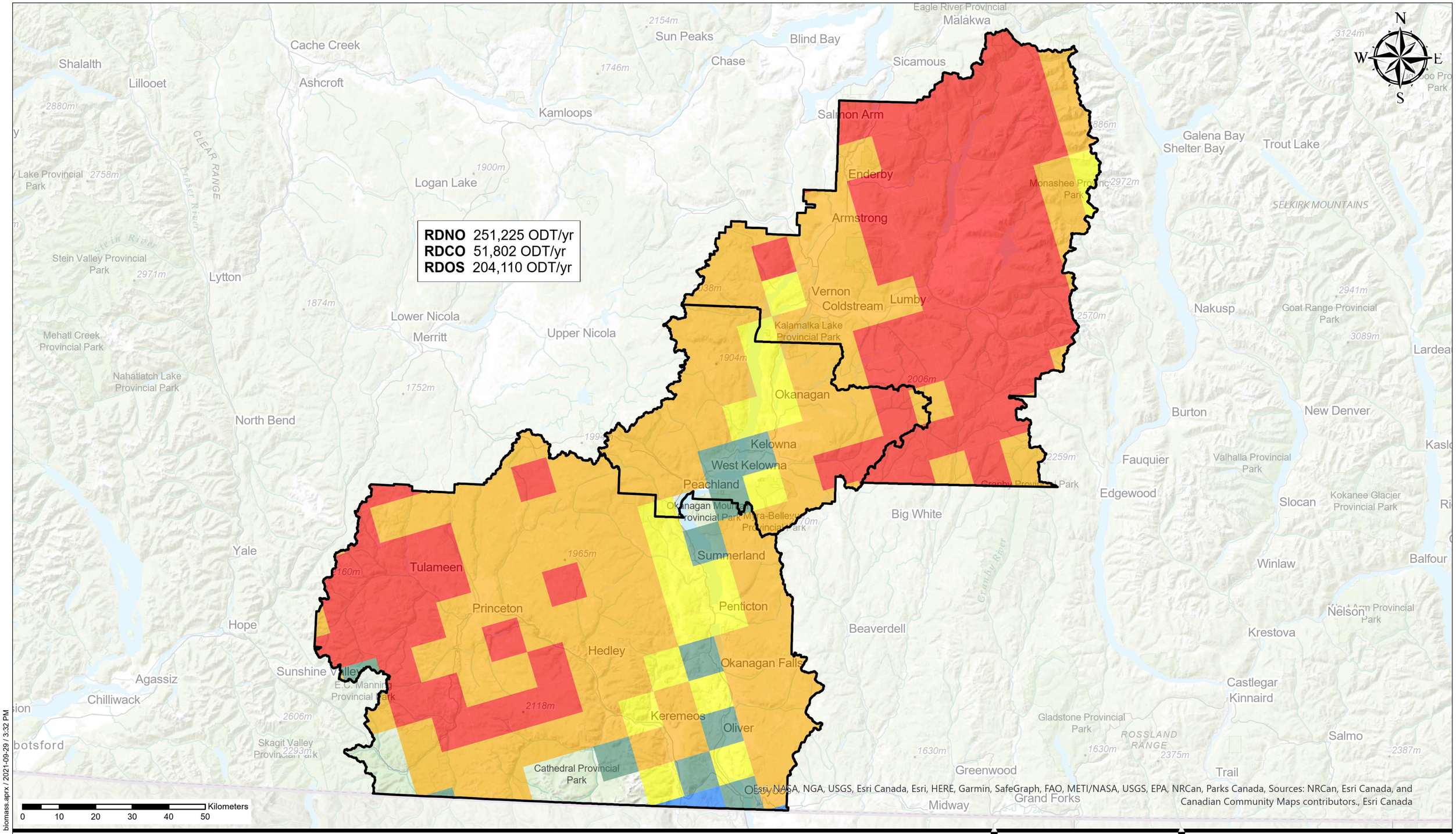
FIGURE 4: LANDFILL LOCATIONS

Regional District Central Okanagan and Okanagan Sustainability Leadership Council

Okanagan Biomass Inventory



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Associated Environmental

Regional District Boundary

Forecasting logging residues in Canada, (ODT/year)

- 0 - 37
- 37 - 178
- 178 - 724
- 724 - 2826
- 2826 - 10,927

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DATE: September 2021
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FIGURE 5: CLEAN WOOD - ROADSIDE

Regional District Central Okanagan and Okanagan Sustainability Leadership Council

Okanagan Biomass Inventory

Distribution of Pellet Production:
Princeton Standard Pellet Corp., Princeton, BC, 70% bulk, 30% bagged, 110,000 tonnes/yr
Pinnacle Renewable Energy Armstrong, Armstrong, BC, 95% bulk, 5% bagged, 72,000 tonnes/yr
Lavington Pellet LP - Pinnacle/Tolko Partnership, Lavington, BC, 100% bulk, 300,000 tonnes/yr

North Enderby Timber Ltd.
Sperlich Log Construction Inc.
Schapol Logging Ltd.
Pinnacle Renewable Energy Inc.
Tolko Industries Ltd.
141,239 tonnes/yr
Rouck Brothers Sawmill Ltd.
Pinnacle Renewable Energy Inc. and Tolko Industries Ltd.
Tolko Industries Ltd.
Gorman Bros. Lumber Ltd.
Tolko Industries Ltd.
277,945 tonnes/yr
Deacoff Bros. Enterprises Ltd.
Gorman Bros. Lumber Ltd.
Princeton Standard Pellet Corporation
Princeton Wood Preservers Ltd.
Weyerhaeuser Company Ltd.
Maurer Construction ltd.
125,382 tonnes/yr
T.L. Timber Ltd.

Malakwa, Sicamous, Eagle River Provincial, Sun Peaks, Blind Bay, Chase, Cache Creek, Shalalth, Lillooet, Ashcroft, Kamloops, Salmon Arm, Logan Lake, Lytton, Lower Nicola, Merritt, Upper Nicola, Mehatl Creek Provincial Park, Nahatlatch Lake Provincial Park, North Bend, Okanagan, Kelowna, Peachland, Okanagan Mountain Provincial Park, Myra-Bellevue Provincial Park, Summerland, Penticton, Tulameen, Hedley, Okanagan Falls, Kerenmeos, Oliver, Cathedral Provincial Park, Osoyoos, Hope, Yale, Agassiz, Chilliwack, Sunshine Valley, E.C. Manning Provincial Park, Skagit Valley Provincial Park, Galena Bay Shelter Bay, Trout Lake, Monashee Provincial Park, SELKIRK MOUNTAINS, Nakusp, Goat Range Provincial Park, Lardeau, Burton, New Denver, Fauquier, Edgewood, Slocan, Kokanee Glacier Provincial Park, Big White, Winlaw, Balfour, Nelson, Krestova, Beaverdell, Castlegar, Kinnaird, Gladstone Provincial Park, ROSSLAND RANGE, Salmo, Greenwood, Trail, Midway, Grand Forks, Valhalla Provincial Park, Cranbrook Provincial Park, Kaslo, Lake Provincial Park, Stein, Mehatl Creek Provincial Park, Nahatlatch Lake Provincial Park, Skagit Valley Provincial Park, botsford, sion

Kilometers
0 10 20 30 40 50

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Associated Environmental

Regional District Boundary
Lumber Mills
Mills producing pellets

Clean Wood - Mills
544,566 tonnes/yr (BIMAT data)

PROJECT NO.: 2021-8880
DATE: November 2021
DRAWN BY: BdJ

FIGURE 6: CLEAN WOOD - MILLS

Regional District Central Okanagan and Okanagan Sustainability Leadership Council

Okanagan Biomass Inventory