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Technical Memorandum

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Prepared for: City of Bellingham Public Works Department

Project Title: Post Point Resource Recovery Plant Biosolids Project Phase 3 – Biosolids Facility Plan and Nitrogen Removal Impact Study and Phase 4 – Preliminary Design

Project No.: 154154.330.335

Technical Memorandum No. 18

Subject: Product Quantity Projections

Date: October 4, 2021

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List of Abbreviations

City	City of Bellingham
cy	cubic yard(s)
cf	cubic feet
EQ	Exceptional Quality
ha	hectare(s)
kg	kilogram(s)
lb	pound(s)
mg	milligram(s)
Part 503	Title 40, Code of Federal Regulations Part 503
Project	Post Point Biosolids Project
Post Point	Post Point Resource Recovery Plant
TM	technical memorandum
TPAD	temperature-phased anaerobic digestion
TS	total solids
WAS	waste activated sludge
WT	wet ton
WTPD	wet tons per day

Section 1: Introduction

The City of Bellingham (City) is in the planning process to evaluate options for long-term biosolids management and beneficial reuse opportunities for the wastewater residual solids and energy recovered from the Post Point Resource Recovery Plant (Post Point). The Post Point Biosolids Project (Project) is being conducted in phases from alternative screening and evaluation through design and construction.

Phase 1 of the Project included the initial identification of all potential biosolids and energy alternatives, screening to identify viable alternatives for further evaluation, and the selection of a preferred conceptual alternative. In February 2019, the results of Phase 1 were summarized in *Technical Memorandum (TM) No. 1 (TM 1) – Preferred Conceptual Alternative Selection*. Phase 2 further developed the preferred conceptual alternative and evaluated specific processes for biosolids treatment, biogas end uses, and other processes. In May 2019, *TM 2 – Final Alternative Selection* summarized the results of Project planning Phase 2. The Project is currently in Phase 3, which further defines the selected alternative technical requirements and documents the planning effort within the *Biosolids Facility Planning Report* (Biosolids Facility Plan), which is an update to the City's existing, comprehensive *2011 Wastewater Facility Planning Report* (Carollo, 2011).

This *TM 18 – Product Quantity Projections (TM 18)* was prepared as part of Project planning Phase 3 and documents the biosolids product quantities for the Project. This includes defining the types of products, the quantities, and their uses by the City Park and Public Works Department.

1.1 Background

The City would like to recover biosolids as a local resource that can benefit the community as part of their Legacies and Strategic Commitments and based on feedback from community workshops. The Class A biosolids produced from the proposed temperature-phased anaerobic digestion (TPAD) process would not have any regulatory-based restrictions on its use or application. However, this form of biosolids (referred to as a dewatered "cake"), largely due to its aesthetic properties, is more conducive to large-scale agricultural land application than for residential applications. Biosolids cake tends to have high water holding capacity, organic matter, and nutrient content. The varying particle sizes, lower porosity, and permeability make it more applicable to large-scale agriculture, revegetation, or City projects that require site work where there is less specificity for a product.

Further processing of biosolids into amended products such as soil blends and composts can create a more consumer-friendly product that has fewer odors and is easier to handle, making them similar to the soil amendments found in retail stores and nurseries. Amended products are typically mixed with organic and inorganic material to improve soil characteristics such as soil texture, permeability, porosity, drainage, water retention, nutrient balance, carbon-to-nitrogen ratio, appearance, and electric conductivity. These changes typically allow amended products to be more versatile in applications from gardens to lawn care.

Section 2: Class A Dewatered Cake

This section details information on the Class A dewatered cake that will be produced from Post Point.

2.1 Class A Dewatered Cake Flows and Loads

The average annual production of Class A biosolids that will be generated from the TPAD process and subsequently dewatered to 20 percent total solids (TS) are estimated to be 33 wet tons per day (WTPD) in 2025 and 55 WTPD in 2045. A detailed summary of the solids treatment process mass balance can be found in *TM 16 – Solids Mass Balance and Greenhouse Gas*. Table 2-1 summarizes the quantities of dewatered cake generated from Post Point.

Table 2-1. Solids Loadout and Hauling Flows and Loads

Parameter	Flows and Loads 2025		Flows and Loads 2045, Digestion with Tertiary Nitrogen Treatment						
	Min Week	Average Annual/wk	Min Week	Average Annual/wk	Max 30-Day	Max 14-Day	Max 7-Day	Max 3-Day	Max Day
Solids Loadout									
Dewatered Cake, (lb-TS/day)	9,951	12,982	15,613	22,229	28,775	32,255	36,068	44,593	61,478
Solids Concentration, (%)	20%	20%	20%	20%	20%	20%	20%	20%	20%
Dewatered Cake, (wet lb-TS/day)	49,753	64,908	78,063	111,144	143,876	161,276	180,338	222,967	307,390
Dewatered Cake, (WT-TS/day)	25	33	39	56	72	81	90	111	154
Bulk Density, (lb/cf)	59.3								
Dewatered Cake, (cf/day)	840	1,095	1,317	1,876	2,428	2,722	3,043	3,763	5,187
Hauling and Transportation									
Truck Option 1 Capacity, (WT/truck)[1]	16								
Number of Trucks	1.6	2.0	2.4	3.5	4.5	5.0	5.6	7.0	9.6
Truck Option 2 Capacity, (WT/truck)[2]	28								
Number of Trucks	0.9	1.2	1.4	2.0	2.6	2.9	3.2	4.0	5.5

Notes:

1. *Solo dump truck capacity, 28-feet long.*
2. *Single trailer truck capacity, 60 – 65-feet long (common WA biosolids transportation vehicle).*
3. *Abbreviations: TS = total solids, WT = wet ton, lb = pound(s), cf = cubic feet*

2.1.1 Heavy Metals and Pollutant Concentrations

Heavy metals data from Post Point's existing dewatered cake from May 1, 2017, to April 3, 2018, indicate that the pollutants regulated under Title 40, Code of Federal Regulations Part 503 (Part 503) are well below the most stringent requirements contained within that regulation and that the biosolids would likely meet the Exceptional Quality (EQ) standards. Because digestion reduces volatile solids, the concentrations presented in Table 2-2 would be expected to increase once digestion is implemented, however, the addition of organic and inorganic amendments has the potential to decrease concentrations. Table 2-2 summarizes the regulations and average pollutant concentrations from Post Point's existing dewatered cake. Note that not all the monitored pollutants are subject to Part 503, but certain end users may have unique interests or concerns regarding these heavy metals.

Table 2-2. Post Point Existing Dewatered Cake Pollutant Concentrations

Pollutant	Column 1[2] Ceiling Concentration Limits (mg/kg, dry weight)	Column 2 Cumulative Pollutant Loading Rate (kg/ha, dry weight)	Column 3[3] Limit Monthly Average (mg/kg, dry weight)	Post Point Average Solids Sample Test (5/1/17 - 4/3/18) (mg/kg, dry weight)
Arsenic	75	41	41	**1.0**
Cadmium	85	39	39	**1.2**
Chromium[1]	-	-	-	**16.0**
Copper	4,300	1,500	1,500	**158**
Cyanide[1]	-	-	-	**8.3**
Lead	840	300	300	**11.0**
Mercury	57	17	17	**0.2**
Molybdenum	75	-	-	**1.4**
Nickel	420	420	420	**8.6**
Selenium	100	100	100	**3.7**
Silver[1]	-	-	-	**1.5**
Zinc	7,500	2,800	2,800	**278**

Notes:

1. *Pollutant not subject to Part 503 regulation.*
2. *Class B Pollutant requirement.*
3. *Exceptional Quality (EQ) pollutant requirement.*
4. *Abbreviations: mg = milligram(s), kg = kilogram(s), ha = hectare(s)*

2.1.2 Nutrients Profile

The nutrient content of the future dewatered cake will be an important property that will help to determine its value as a soil amendment and fertilizer. The nutrient content will also impact the requirements for final processing. Depending on the desired product characteristics, the soil blending could change feedstock quantities needed for composting or soil blending. Estimations of the nutrient content of the biosolids were derived from the BioWin process model. Table 2-3 summarizes the estimated nutrient content for the Class A dewatered cake.

Table 2-3. Class A Dewatered Cake Nutrients Profile		
Parameter	Flows and Loads 2025	Flows and Loads 2045, Digestion with Tertiary Nitrogen Treatment
	Average Annual	Average Annual
Class A Dewatered Cake		
Total Organic Carbon Content, (%)[1]	33%	33%
Total Nitrogen Content, (%)	3.4%	3.2%
Carbon:Nitrogen Ratio	9.7	10.3
Total Phosphorus Content, (%)	3.9%	3.4%
Potassium [2]	-	-

Notes:

1. *Total organic carbon content was assumed to be 50-percent of the volatile solids.*
2. *Potassium has not been sampled.*

Section 3: Biosolids Final Processing

A consumer-friendly biosolids product requires further processing to improve marketability. The two processing steps that have been considered, due to their high market potential, are composting and soil blending. These processes and the associated estimated quantities of product are summarized in this section.

3.1 Biosolids Composting

Class A dewatered cake can be composted with organic waste or other feedstocks to create soil amendments with greater ranges of use than dewatered biosolids alone. Composting biosolids can further reduce odors, decrease particle size, increase the bioavailability of micro- and macronutrients, and improve soil characteristics. Compost is widely used for applications such as gardening and landscaping. They can improve soil aeration and drainage in areas where the soil is compacted and limit the growth of weeds. Compost as a potting mix can replace potting soil. Some waste materials that can be composted with biosolids include sawdust, wood chips, yard clippings, food waste, manure or crop residues, or food processing wastes. While these materials have traditionally been viewed as waste, they can play a valuable role in returning carbon to the soil while restoring soil health in the local community. Many landscapers and gardeners use composted biosolids for their superior and more sustainable properties. Additionally, composted biosolids products can not only provide nutrients and organic matter but sequester carbon, thereby conserving resources and combating climate change.

3.1.1 Biosolids Composting Process

For the City, Class A dewatered cake would be trucked to an off-site composting facility where mixing equipment would be used to combine the biosolids with bulking agents to generate a feedstock material that is conducive to composting. The feedstocks will be mixed at a ratio of 1:1 to 1:2 biosolids to bulking agent by mass. This material will then feed into the composting process. Various composting technologies are commercially available with the two most common systems being windrow and aerated static pile composting systems. The first phase of the composting process is typically a high-rate process where the compost piles are passively or actively aerated to encourage aerobic decomposition. The decomposition process is exothermic increasing the pile temperatures to thermophilic conditions which destroy pathogenic microorganisms and seeds. This is often done by using perforated floors with blowers or by using specialized machines to turn the compost piles and can last between several days to one or two months. At the end of this phase, most of the readily biodegradable material is consumed resulting in the reduction of water and volatile solids (i.e., processing of the Class A dewatered cake).

The next phase is the curing process where the piles shift from thermophilic back to mesophilic conditions. The bulk of the remaining organic compounds are lignins and other cellulosic materials that are more resistant to degradation. This stage is often used to stabilize and slowly break down the remaining organic materials. The curing phase can take anywhere from 1 to 12 months and is a vital step in balancing moisture, pH, nutrients, and reducing odors to create a high-quality compost product. Screening typically occurs after this phase and is used to homogenize the compost and remove large organic materials (called "overs") that have not fully degraded. These overs are then recycled back into the process as a microbial inoculate and as a bulking agent. The screened compost will then be stored in large piles until distribution and allowed to further mature.

3.1.2 Biosolids Composting Mass Balance

A mass balance was performed to estimate the amount of feedstock required for the composting process and the final biosolids compost generated. Assumptions for the composting mass balance are summarized in Table 3-1.

Table 3-1. Composting Mass Balance Assumptions

Parameter	2025/2045 Flows and Loads	
	Range	Selected/Calculated Values
Feedstock Mixture		
Bulk to Biosolids Ratio (V:V)	2.6 – 4.4	4.0
Bulk to Biosolids Ratio (M:M)	1.0 – 2.0	1.4
Compost Mixture Solids Concentration, (%)	38 – 42%	40%
Carbon:Nitrogen Ratio	25 – 35	35
Active Composting Process		
Volatile Solids Reduction, (%)	10 – 20%	13%
Volume Reduction, (%)	20 – 50%	36%
Target Solids Concentration, (%)	50 – 60%	50%
Screening Process		
Screening Recycled	5 – 30%	10%

Note:

1. *Abbreviations: M:M = mass:mass (ratio) , V:V = volume:volume (ratio)*

Based on the assumptions above, Table 3-2 provides a summary of the feedstocks and finished product for the composting process.

Table 3-2. Composting Feedstock Flows and Loads		
Parameter	Flows and Loads 2025, Digestion with SST	Flows and Loads 2045, Digestion with Tertiary Nitrogen Treatment
	Average Annual	
Feedstock – Dewatered Cake		
Wet Solids, (WT-TS/year)	11,800	20,300
Wet Solids, (wet lb-TS/day)	64,900	111,100
Solids Concentration, (%)	20%	20%
Bulk Density, (lb/cy)	1600	1600
Volume, (cy/year)	14,800	25,400
Feedstock – Bulking Agent		
Wet Solids, (WT-TS/year)	14,500	24,800
Wet Solids, (wet lb-TS/day)	79,200	135,600
Solids Concentration, (%)	55%	55%
Bulk Density, (lb/cy)	550	550
Volume, (cy/year)	52,300	90,000
Feedstock – Screened Overs		
Wet Solids, (WT-TS/year)	2,000	3,400
Wet Solids, (wet lb-TS/day)	11,000	18,900
Solids Concentration, (%)	50%	50%
Bulk Density, (lb/cy)	550	550
Volume, (cy/year)	7,300	12,500
Feedstock - Mixture		
Wet Solids, (wet ton-TS/year)	28,300	48,500
Wet Solids, (wet lb-TS/day)	155,100	265,600
Solids Concentration, (%)	40%	40%
Bulk Density, (lb/cy)	850	850
Volume, (cy/year)	66, 600	114,000
Finished Compost		
Wet Solids, (WT-TS/year)	18,100	31,000
Wet Solids, (wet lb-TS/day)	99,100	169,700
Solids Concentration, (%)	50%	50%
Bulk Density, (lb/cy)	900	900
Volume, (CY/year)	40,200	68,800

Note:

1. *Abbreviations: WT = wet ton, TS = total solids, lb = pound(s), cy = cubic yard(s)*

Figure 3-1 and Figure 3-2 provide a diagram and mass balance of the composting process for 2025 and 2045 average annual flows and loads.

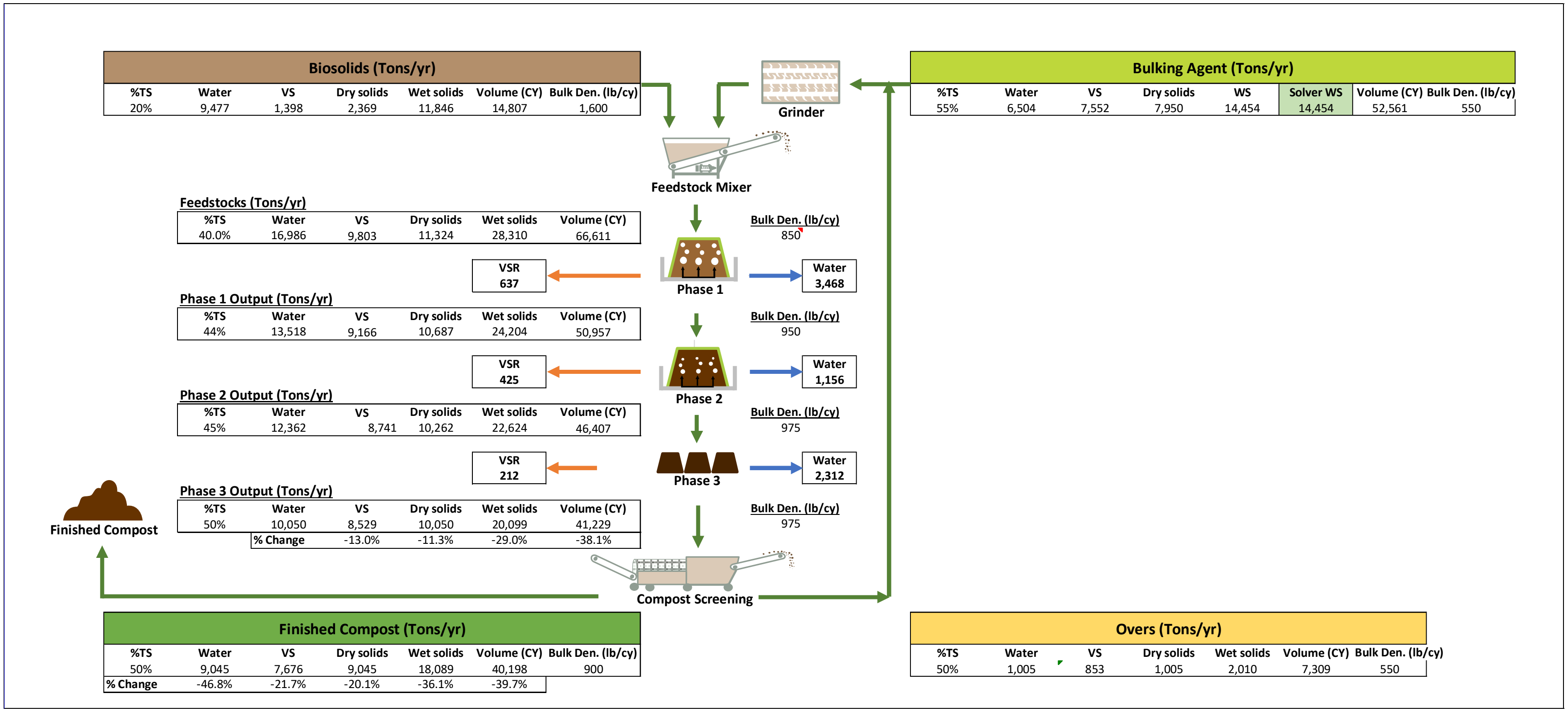

Figure 3-1. Composting Mass Balance, Average Annual 2025 Flows and Loads, 100 Percent Biosolids to Final Processing in Tons per Year

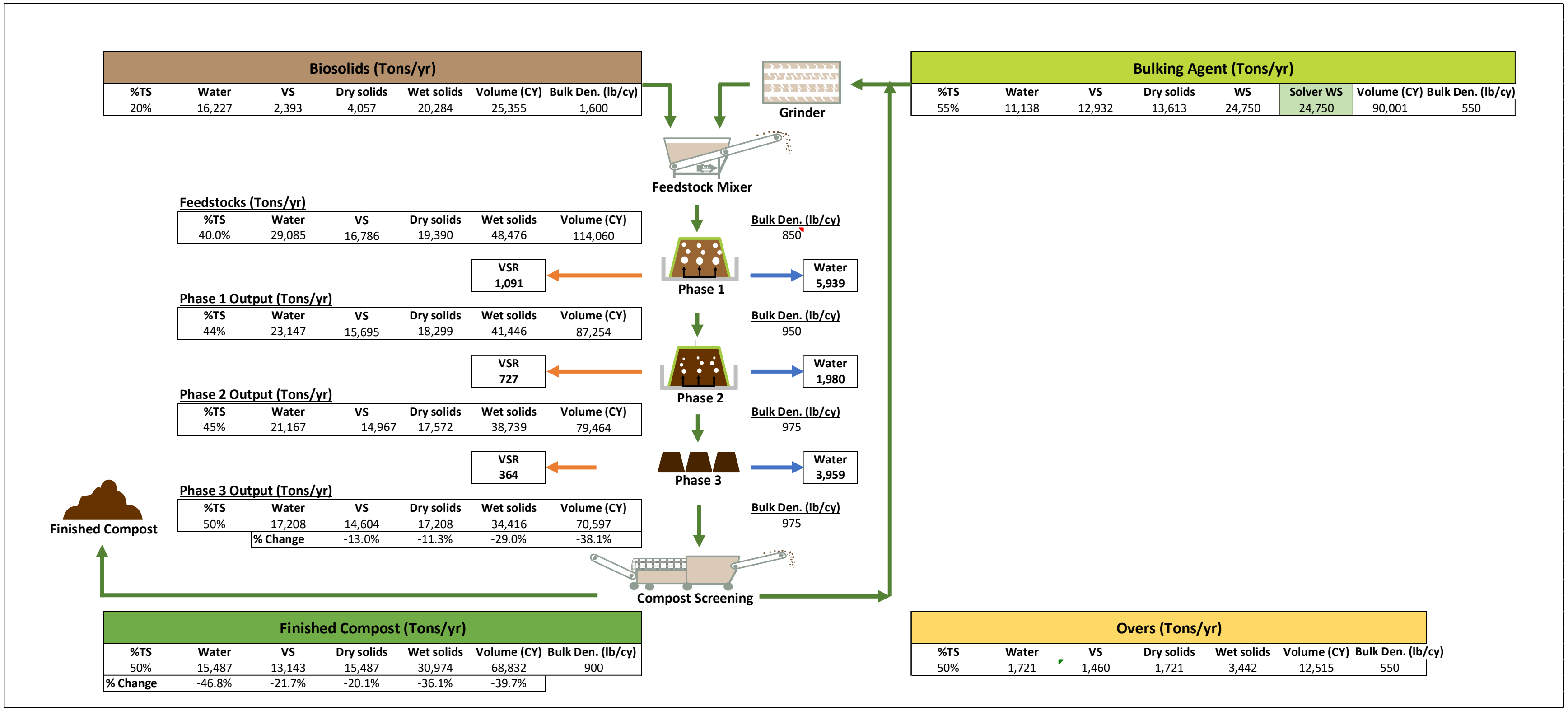

Figure 3-2. Composting Mass Balance, Average Annual 2045 Flows and Loads, 100 Percent Biosolids to Final Processing in Tons per Year

3.2 Soil Blending

While Class B biosolids may be composted to produce a Class A material with certain technologies, producing manufactured soils is a specialized class of biosolids product development. Manufactured soils require processing Class A biosolids cake with clean or sterilized amendments to generate a stable end product to prevent contamination. Class A biosolids are blended with organic or inorganic amendments to adjust the characteristics for a product that can be publicly distributed in bag or bulk form. Soil blending is different than composting because there is no active processing of the material that allows for a high-rate stabilization or maturation of the product. Manufactured soils can be custom-tailored to meet certain applications such as gardening, landscaping, agriculture, golf, or turf. For example, the City of Tacoma produces a range of products under their TAGRO brand which includes potting soil, green roof blend, and classic topsoil blend.

3.2.1 Soil Blending Process

In this scenario, Class A dewatered cake would be trucked to an off-site soil blending facility where mixing equipment would be used to combine the biosolids with different amendments to generate desired or engineered blends. The types of amendments and ratios of mixing will widely vary depending on the desired properties. Depending on the quality of the amendments, a screener or grinder may be needed. The soil blends will then be stored and distributed as bulk or in bags. Soil blends may be cured or aged for an additional time period to further stabilize and mature the product. This step could impact the total solids, volatile solids, nutrients, and bulk density of the product.

3.2.2 Soil Blending Mass Balance

A mass balance was performed to estimate the amount of feedstock required for the soil blending process and the final biosolids soil blend generated. The soil blending mass balance was based on the City of Tacoma’s TAGRO product recipe which is one of the most well-established biosolids soil blending programs and is intended to be a representative mixture. The soil blending program for the City may utilize different feedstocks and ratios. Assumptions for the soil blending mass balance are summarized in Table 3-3.

Table 3-3. Soil Blending Mass Balance Assumptions

Parameter	2025/2045 Flows and Loads	
	Range	Selected/Calculated Values
Finished Soil Blend		
Biosolids to Sawdust to Sand (V:V:V)[1]	-	1:1:0.5
Carbon:Nitrogen Ratio	-	17.5

Note:

1. *V:V:V = volume:volume:volume (ratio)*

Based on the assumptions above, Table 3-4 provides a summary of the feedstocks and finished product for the soil blending process.

Table 3-4. Soil Blending Feedstock Flows and Loads		
Parameter	Flows and Loads 2025, Digestion with SST	Flows and Loads 2045, Digestion with Tertiary Nitrogen Treatment
	Average Annual	
Feedstock – Dewatered Cake		
Wet Solids, (WT-TS/year)	11,800	20,300
Wet Solids, (wet lb-TS/day)	64,900	111,100
Solids Concentration, (%)	20%	20%
Bulk Density, (lb/cy)	1600	1600
Volume, (cy/year)	14,800	25,400
Feedstock – Sawdust		
Wet Solids, (WT-TS/year)	2,600	4,400
Wet Solids, (wet lb-TS/day)	14,200	24,300
Solids Concentration, (%)	60%	60%
Bulk Density, (lb/cy)	350	350
Volume, (cy/year)	14,800	25,400
Feedstock – Sand		
Wet Solids, (WT-TS/year)	9,000	15,400
Wet Solids, (wet lb-TS/day)	49,300	84,400
Solids Concentration, (%)	90%	90%
Bulk Density, (lb/cy)	2,430	2,430
Volume, (cy/year)	7,400	12,700
Finished Soil Blend		
Wet Solids, (WT-TS/year)	23,400	40,100
Wet Solids, (wet lb-TS/day)	128,400	219,900
Solids Concentration, (%)	51%	51%
Bulk Density, (lb/cy)	1,300	1,300
Volume, (cy/year)	36,100	61,700

Note:

1. Abbreviations: WT = wet ton, TS = total solids, lb = pound(s), cy = cubic yard

Figure 3-3 and Figure 3-4 provides diagrams and mass balances of the soil blending process for 2025 and 2045 average annual flows and loads, respectively.

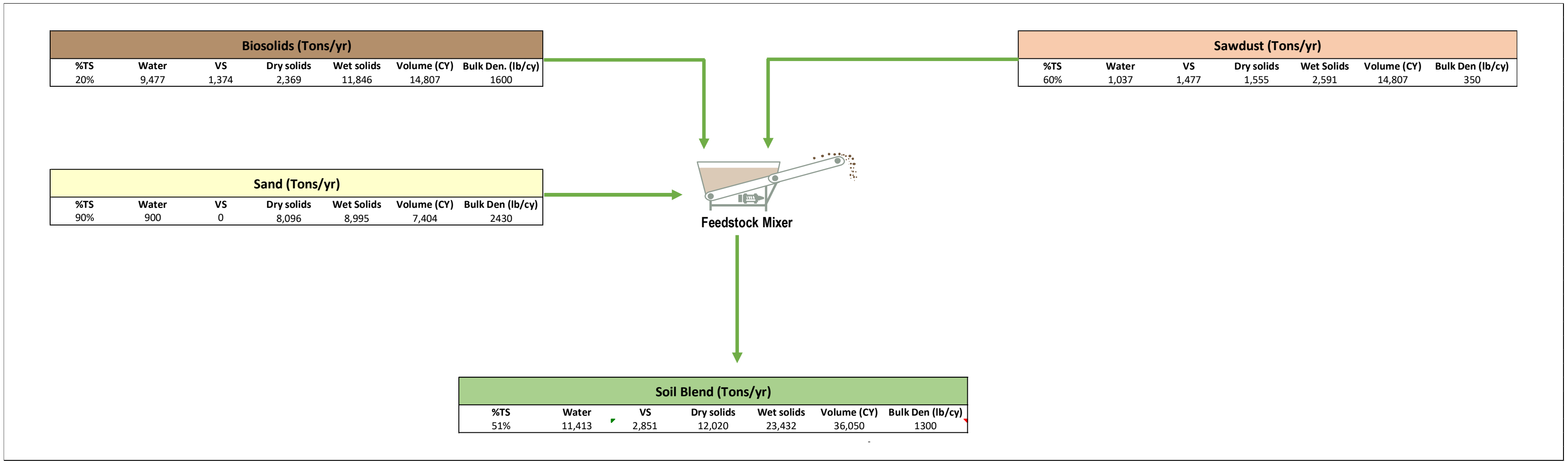

Figure 3-3. Soil Blending Mass Balance, Average Annual 2025 Flows and Loads, 100 percent Biosolids to Final Processing in Tons per Year

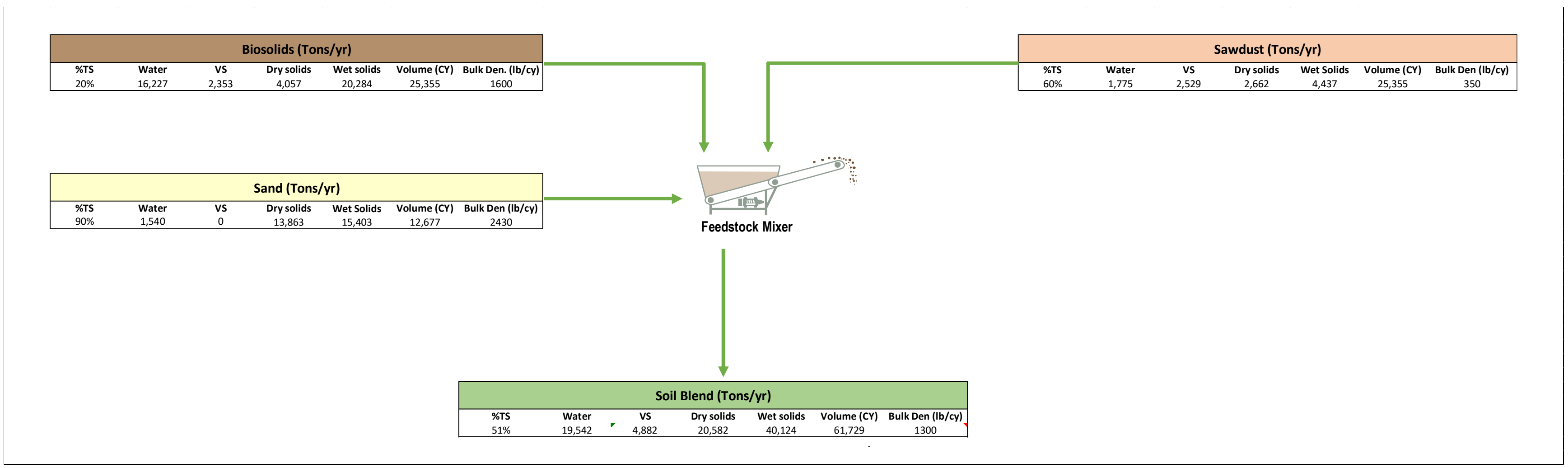

Figure 3-4. Soil Blending Mass Balance, Average Annual 2045 Flows and Loads, 100 percent Biosolids to Final Processing in Tons per Year

Section 4: Biosolids Product Quantities

This section details the quantity of each of the biosolids products that will be generated by the City's biosolids management program and the quantities that are anticipated to be used by the City.

The City will have the potential opportunity to generate a diverse number of biosolids products for both suburban (i.e., landscaping) use and rural/agricultural use. Given the space limitations at Post Point, the City decided to pursue further processing with third-party entities. This effort, known as the Off-Site Facilities Delivery Evaluation, will use an open procurement process to allow the vendor community to propose options for further processing of biosolids from Post Point. Prior market research performed in Phase 3 led the City to conclude that strong market potential exists for soil blenders and composters to accept and process biosolids, however, the procurement process will be open to alternative strategies, so long as they provide beneficial use of the biosolids. Based upon the responses to this initial, more open-ended procurement phase, the City's strategy will be further refined to reflect a more detailed understanding of the vendor community's delivery strategies, as well as the number and variety of vendors who could provide this final processing service. The City will then issue a Request for Proposal to award processing services to one or more qualified vendors.

The City can use biosolids products for various needs including municipal applications in landscaping, parks and recreation, civil and site work, athletic fields, land rehabilitation, and revegetation/reforestation as well as for public distribution. The different biosolids products can serve different needs for the City. However, the use of an amended product will require further processing which will result in increased cost to the biosolids management program. The City can benefit from identifying uses for the Class A dewatered cake which would reduce the amount of material that needs to be further processed. Defining the quantities of biosolids products including Class A dewatered cake, compost, and soil blend products will require coordination with the different City departments including the City Parks and Public Works. This coordination will be performed and documented in this section once completed, and final TM is submitted.

Attachment A: Additional Information