Co-digestion Options Evaluation

Scope Summary Technical Memorandum

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Project Formulation Program

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Co-digestion Options Evaluation

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Acronyms and Abbreviations

BTP	Brightwater Treatment Plant
County	King County
lb	pound(s)
lb(s) VS	pound(s) volatile solids
lb(s) VS/cf-day	pound(s) volatile solids per cubic foot per day
SRT	solids retention time
STP	South Treatment Plant
SWD	Solid Waste Division
TS	total solids
VS	volatile solids
VSLR	volatile solids loading rate
WTD	Wastewater Treatment Division
WWTP	wastewater treatment plant

1. Introduction and Objective

The King County (the County) Wastewater Treatment Division (WTD) and Solid Waste Division (SWD) are evaluating the feasibility of food waste digestion at the South Treatment Plant (STP) as a means of diverting organics from landfills and increasing revenues from renewable natural gas generation. To implement food waste digestion, source-separated food waste would be processed to remove contaminants and meet material quality criteria suitable for anaerobic digestion. The preprocessed food waste would then be pumped directly into anaerobic digesters at the County's wastewater treatment facility.

The primary objective of this project formulation is to provide decision-makers with information necessary to evaluate a future food waste digestion project. Three food waste digestion options are presented herein to provide a range of possible preprocessing configurations and summarize upgrades to the STP process needed for food waste digestion. Additional elements of this project formulation include constructing a food waste-receiving station, constructing a new digester and digester control building, adding a new struvite recovery process, and upgrading the existing digester gas conditioning system at STP.

2. Facility Background and Summary

SWD strives to achieve zero waste of resources by 2030. Currently, approximately 39 percent of commercial and residential food waste and green waste generated in King County is collected together and processed by privately owned companies at their composting facilities. However, existing regional composting infrastructure is reaching maximum capacity. Approximately 75,600 wet tons per year of commercial food waste is landfilled, while 37,000 wet tons per year of commercial food waste is collected and processed at private compost facilities. SWD is considering options to expand food waste-processing capacity for the area to divert food waste from the landfill and reach their resource zero waste goals.

WTD owns and operates the STP in Renton, Washington. The facility has four anerobic digesters and generally operates three digesters at a time. All digester gas currently produced at STP is classified by the U.S. Environmental Protection Agency as D3 renewable identification numbers because the feedstock is municipal waste. Digester gas produced during anerobic digestion is cleaned via water scrubbing and sold as renewable natural gas to Puget Sound Energy. The gas is sold under the Renewable Fuel Standard, allowing for the sale of the physical and environmental gas properties, thus increasing the value of the gas produced.

Natural gas needed for process or space heating at STP can be provided from either renewable natural gas produced by STP's digesters or purchased from Puget Sound Energy. The County has a goal for STP to generate enough power or fuel to be considered a net zero energy facility.

Initially, the project scope was to consider STP or Brightwater Treatment Plant (BTP) as possible locations to anaerobically digest food waste. The West Point Treatment Plant was not considered due to lack of available footprint and truck traffic limitations. Discussions with the County's engineering and operations staff during formulation kickoff resulted in removing the BTP site from further consideration due to side stream impacts on the membrane bioreactor treatment process, and because digester gas is used only for process heating or flared. The BTP location may be a good candidate in the future (10+ years from now) when significant infrastructure improvements at BTP have been addressed, particularly the infrastructure to use digester gas for more than just process heating (for example, compressed natural gas.

During kickoff meeting discussions, STP was identified as the most logical facility for food waste digestion, because solid-waste generation data collected by the SWD indicate that the southern portion of the service area generates more food waste than other areas, and sufficient digester capacity and renewable gas production capacity are currently available.

3. Option Design Criteria

To make anerobic digestion of food waste feasible at the STP, the food waste needs to be preprocessed before it reaches the STP digesters. This section discusses three operational options for the preprocessing facility, which would be located at Bow Lake. This section also describes the design conditions used for the project formulation.

The following three food waste preprocessing options, which assume infrastructure improvements at STP, were included in this project formulation:

- Option 1 – Preprocessing facility owned and operated by SWD
- Option 2 – Preprocessing facility owned by SWD and operated by a third party
- Option 3 – Preprocessing facility owned and operated by a third party

Different scenarios require different levels of involvement from the SWD and have implications for the cost of facility construction, operation, and revenue.

3.1 Assumptions

Several assumptions were common to all options; these assumptions, listed below, were based on feedback from King County or professional judgement from similar facilities:

- Preprocessing facility at Bow Lake:
  - Equipment will be based on a turnkey waste separation press technology.
  - Food waste solids concentration will be 27 percent total solids (TS).
  - Food waste volatile solids (VS) content will be 85 percent.
- WTD food waste receiving station:
  - Preprocessed food waste solids content will be 12 percent TS.
  - Food waste feed piping will go to each digester.
- Solids handling at STP:
  - New anaerobic digester will be the same volume as the existing digesters (2.75 million gallons).
  - No changes will be made to existing digesters or existing digester heating systems.
  - New digester will be a similar design and operation as existing digesters.
  - Current feed solids concentration for wastewater solids will be 6.25 percent TS.
  - Maximum volatile solids loading rate (VSLR) of new digester will be 0.19 pound VS (lb VS) per cubic foot of digester capacity per day (lb VS/cf-day).
    - Higher organic loadings may be available up to 0.3 lb VS/cf-day. A loading sensitivity is provided
  - Minimum solids retention time (SRT) of new digester will be 18 days.
    - An SRT as low as 15 days may be possible for stable digestion, but 18 days is used in accordance with the County's guidelines. A loading sensitivity is provided.
  - Food waste solids loading to digester will be 70,000 lbs VS per day.
  - Food waste solids content into digester will be 12 percent TS.
  - VS reduction of food waste will be 85 percent.
  - Dewatering polymer dose will be 42 active pounds polymer per dry ton.
  - Dewatered cake solids content from dedicated food waste digester will be 23 percent TS.

  - Struvite treatment will use digested solids struvite recovery.
  - Biosolids will be distributed as Loop® using the existing biosolids program.
- Digester gas conditioning system:
  - Cleaning system will be a water wash system.
  - All digester gas produced will be conditioned to renewable natural gas and injected into the natural gas grid.
    - Higher hydrogen sulfide concentrations and lower siloxane concentrations are expected from the food waste digester gas compared to the existing digester gas stream.
  - Methane yield of digester gas produced from food waste digestion will be 7 standard cubic feet per lb of food waste.
  - Food waste digester gas methane concentration will be 73 percent by volume.
  - Existing conditioning system will remain in service.
  - No changes will be made to existing waste gas burner.

3.2 Solids Processing Modifications at South Treatment Plant

Solids processing at STP would require the following modifications:

- New receiving station to accept the food waste
- New digester to be used for food waste digestion only and possibly a new digester control building
- Separate gas metering for each gas production type
- Expanded gas conditioning system to handle the increased gas production
- Struvite recovery system

Constructing a dedicated food waste digester would allow the existing digesters to continue operating using municipal wastewater solids and maintain the current D3 digester gas classification. Digester gas produced from food waste would be classified as D5 renewable identification numbers and would result in a different value, so it would be metered separately. Nevertheless, the gas could be processed in the same gas conditioning system, and the existing flares and finished gas pipeline to the interconnect could continue to be used.

All digested biosolids likely would be dewatered as a combined stream and distributed as Loop®. Constructing a new struvite recovery system was included in the facility upgrades to address solids-handling challenges associated with increased solids production and possible increased struvite formation.

It may be preferable for King County to blend pre-processed food waste with municipal wastewater solids prior to digestion. In this case, a blend of food waste and municipal wastewater solids would be fed to all active digesters equally. As a result, RINs issued for digester gas produced from municipal wastewater solids would be changed from D3 to D5.

3.2.1 South Treatment Plant Flow and Load Projections

The STP currently has four digesters for wastewater solids. The *Treatment Plant Flows and Loadings Study Summary Report* (King County, 2019) determined the digesters at STP are projected to be limited from the VS loading rate by approximately 2034. Therefore, additional digestion capacity to meet projected needs is required. More analysis on the load projections and implications to digester capacity will be needed as a part of WTD's capital project delivery process.

Digester gas production was calculated for current, 2030, and 2040 loading scenarios to account for a 20-year facility design life. Digester gas production from municipal wastewater solids and food waste are shown on Figure 3-1, with gas production from wastewater solids shown in solid colors, and gas

production from food waste shown as hatched. Because the STP receives municipal waste from different sources throughout the year, which impacts digester gas production, five different feed scenarios were developed:

- Average summer conditions with nitrification
- Average summer conditions without nitrification
- Average winter conditions
- Maximum month conditions without the addition of deicer or flows from BTP
- Maximum month condition, including deicer and BTP flows

The existing gas-scrubber capacity, existing waste gas-burner capacity, and an upgraded scrubbing system capacity are shown based on an analysis performed by WTD. The amount of food waste processed at STP depends on the gas-scrubbing system or the waste gas burner capacity. The existing gas-scrubbing system is the most limiting, but expanding that system with a similarly sized unit would make the waste gas burners the limiting unit process. More analysis on gas capacity will be needed as a part of WTD's capital project delivery process.

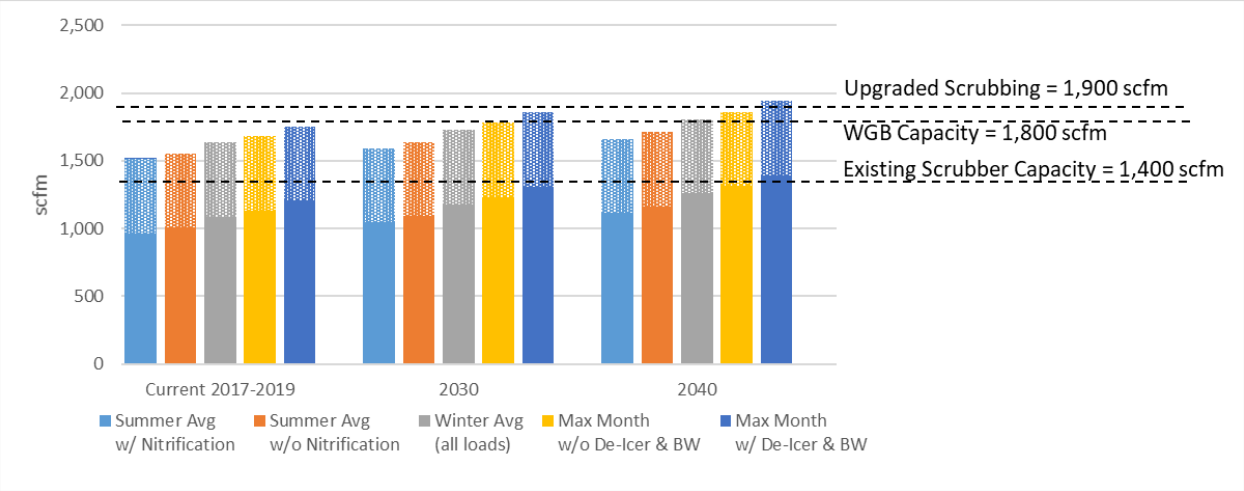

Figure 3-1. Anticipated Digester Gas Production Rates with Municipal Solids and Food Waste Feed Stock

3.2.2 New Digester

A new digester constructed for food waste digestion would match the size and operational protocol of the existing digesters. Depending on the nutrient content of the food waste, supplemental micronutrients such as cobalt, nickel, or others may be required to support the microbiological activity in the food waste digester(s). To maintain a maximum VSLR of 0.19 lb VS/cf-day and a minimum SRT of 18 days, the new food waste digester could receive up to 70,000 lbs VS per day (15,000 tons TS per year or 55,500 wet tons per year). However, the Revenue and Food Waste Analysis prepared by SWD suggests that only 66,500 wet tons per year of food waste will be available in south end region in 2020, increasing by 2 to 5 percent per year thereafter. Food waste from the eastside region (for example, Houghton, Factoria, and Shoreline) was not considered in this analysis due to hauling distances and other considerations. The entire raw food waste tonnage likely would not be available when a food waste digestion program is implemented. Therefore, this analysis assumed that only 50 percent of the raw food waste tonnage produced in the south end could be secured throughout the study period, resulting in a baseline solids loading of 42,000 lbs VS per day (9,000 tons TS per year or 33,300 wet ton per year) in 2020. This food waste loading increases to approximately 53,500 lbs VS per day (11,500 tons TS per year or 42,400 wet ton per year) in 2030. For simplicity, the 2030 loadings were used to calculate the baseline payback periods in the Basis of Estimate. Note that these loadings are significantly less than the capacity of a food waste digester and thus the digester may be under-utilized. Additional capacity in the under-utilized

digester or digesters could be used for wastewater solids loadings that may exceed the projections estimated in this document.

It is likely possible to operate a stable food waste digester with a VSLR as high as 0.3 lb VS/cf-day and a minimum SRT of 15 days. In that case, the food waste digestion system would be capable of receiving up to 110,000 lbs VS per day (10,900 tons TS per year or 40,100 wet tons per year).

Further research should be performed to confirm the food waste loadings available in the region. If the anticipated maximum digester loading rate of 110,000 lbs VS per day of food waste is available, the economic feasibility of this project could be significantly improved.

3.2.3 Expanded Digester Gas Conditioning System

The STP uses a high-pressure water wash system to condition digester gas to pipeline quality for sale and injection. The current water wash system was used as a basis for system capacity expansion. The technology removes hydrogen sulfide, moisture, siloxanes, and carbon dioxide. In the system, gas is compressed prior to entering the bottom of the scrubbing vessel, with water flowing downward through the vessel. Conditioned gas exits the vessel at the top. Water with undesirable constituents exits the bottom of the vessel and can be combined with wastewater for treatment or added to a new stripping column included as part of the gas conditioning system upgrade. The stripping column results in an air stream containing impurities, which is a waste stream from the conditioning system.

3.2.4 Food Waste-Receiving Station

A new food waste-receiving station would require access for haul trucks and allow for metering the accepted waste. Several municipalities use receiving facilities for food waste, additional wastewater solids, the organic fraction of municipal solid waste, or fats, oils, and greases. This evaluation only considered food waste receiving, although receiving other types of wastes could be considered in the future. A food waste receiving station would collect, store, and condition the preprocessed food waste before pumping the material into the anaerobic digester system at STP. The following components were assumed for each food waste receiving station:

- Receiving and pump station, with a quick-connect hose connection, rock/sediment trap, in-line grinder, flow meter, and driver interface control panel
- Sloped wash down area with high-pressure hose discharging to the plant drain system
- Electrical instrumentation and controls to activate the unloading station and provide load tracking information
- Piping connection to the anaerobic digestion system
- Two food waste storage tanks with 1 day of storage each
- Grinder pump-based hydraulic mixing system
- Water connection
- Odor control system from tank vent exhaust
- Digester feed pumps

These components were the minimum per receiving station. Two receiving stations were assumed for this project to ensure 100-percent redundancy. Completely redundant systems were assumed based on guidance from County personnel.

3.2.5 Struvite Recovery System

Struvite is a precipitate of magnesium ammonium phosphate that is common in wastewater treatment facilities and affects the STP. Struvite recovery has been included in this project to address the following concerns: nuisance struvite production in the dewatering side stream, anticipated increases in nutrient

loadings to the secondary treatment system, and phosphorus concentrations in Loop® biosolids. Struvite-recovery technology generally involves adding magnesium to the process stream in the form of magnesium chloride or magnesium hydroxide. Aeration or bases can also be applied to increase the solution pH. These processes create supersaturation conditions for struvite, causing struvite to spontaneously precipitate out of solution. Proprietary technology is often used to separate the struvite from the process stream, where it can be used directly as a soil amendment or sold to fertilizer manufacturers. The struvite can also remain in the solids stream, which helps reduce downstream nuisance struvite formation.

Several struvite recovery systems are available. Most recovery systems are installed on the dewatering side stream, but one manufacturer offers a struvite recovery system for digested biosolids. Installing a struvite recovery system on the digested biosolids line provides additional benefits, such as reduced nuisance struvite formation in the dewatering equipment and reduced phosphorus and nitrogen content in the biosolids. For this project, a struvite recovery system installed on the digested solids line was assumed.

Space has been identified at the STP to accommodate the infrastructure needed, and the layout would include the following:

- A food waste-receiving station sited to allow access from haul trucks
- One new digester and two potential future digesters
- A control building for the new digester (The digester control building would be constructed at full size to allow additional digester expansion in the future and contain all pumps, heat exchangers, controls, and auxiliary equipment needed for a digester.)
- Struvite recovery system
- Additional gas condition system equipment

The food waste receiving station, struvite recovery, and biogas upgrading equipment footprints are based on discussions with equipment suppliers and will depend on the technology chosen during an alternatives analysis. Expansions to the existing digester heating system were not included.

3.3 Food Waste Preprocessing

3.3.1 Option 1 - Preprocessing Facility Owned and Operated by Solid Waste Division

Option 1 has the SWD owning and operating the preprocessing facility. Tipping fees for receiving food waste would be paid to SWD, and SWD may pay a tipping fee to the WTD for taking the preprocessed food waste for digestion. In this scenario, the County would be responsible for all costs associated with the facility, capital, and operations and maintenance. All revenue from the process would be the County's. A process flow diagram of this option is shown on Figure 3-2. SWD infrastructure is shown within the maroon boxed area, and the WTD infrastructure is within the green box. If desired, hauling to and from the preprocessing facility could be done by a third party.

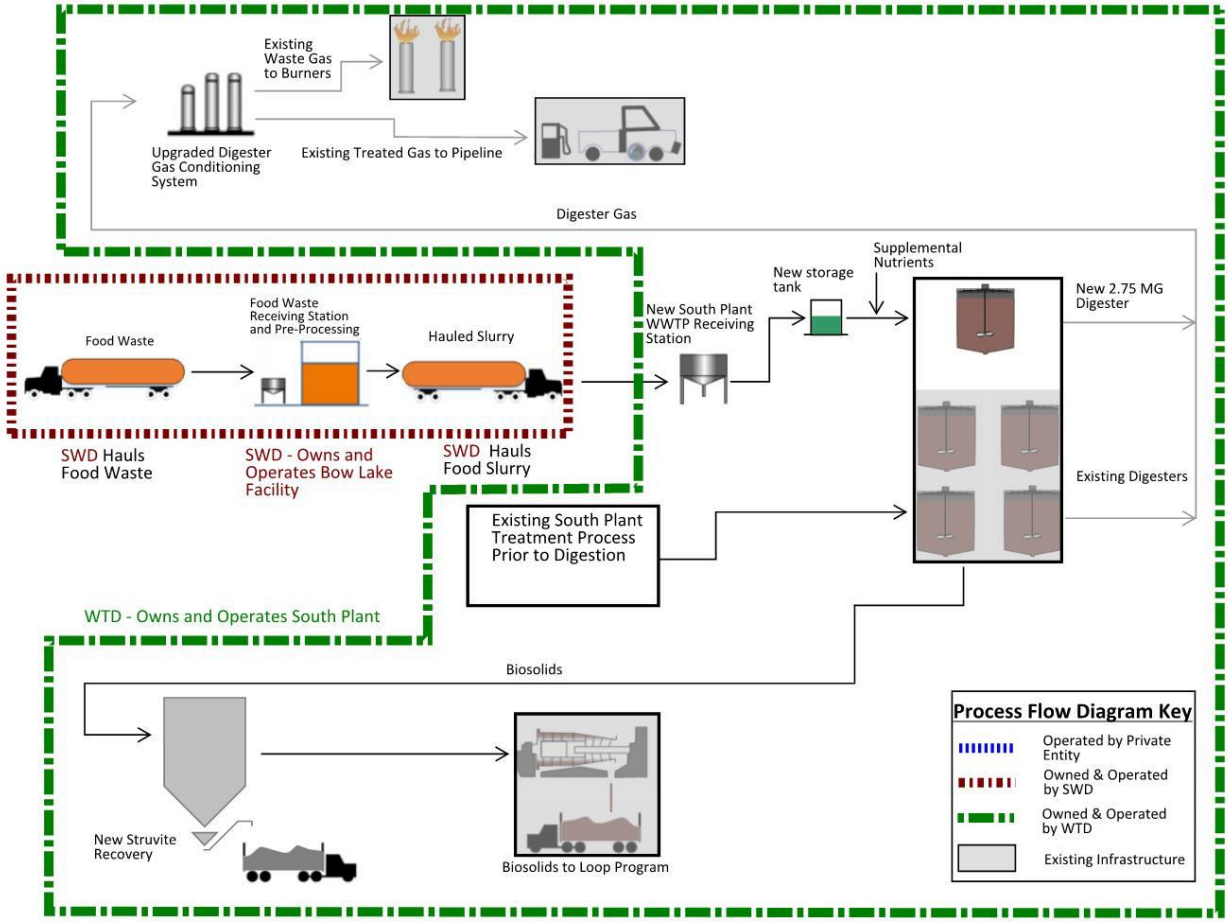

Figure 3-2. Food Waste Digestion Option 1

The County would haul and operate a food waste-processing facility (Bow Lake), and then the County would haul to the STP.

3.3.2 Option 2 - Preprocessing Facility Owned by Solid Waste Division and Operated by a Third Party

Option 2 involves SWD constructing and owning a preprocessing facility, but facility operation would be contracted to a third party. Preprocessed material would be transferred from the preprocessing facility to STP by either the County or the third party. The SWD would receive tipping fees for accepting the food waste, and the WTD would receive a tipping fee for codigesting the slurried food waste. Increased gas production and any revenue associated with the sale of the gas would be paid to WTD. A process flow diagram of this option is shown on Figure 3-3. SWD infrastructure is shown within the maroon boxed area, and the WTD infrastructure is within the green box.

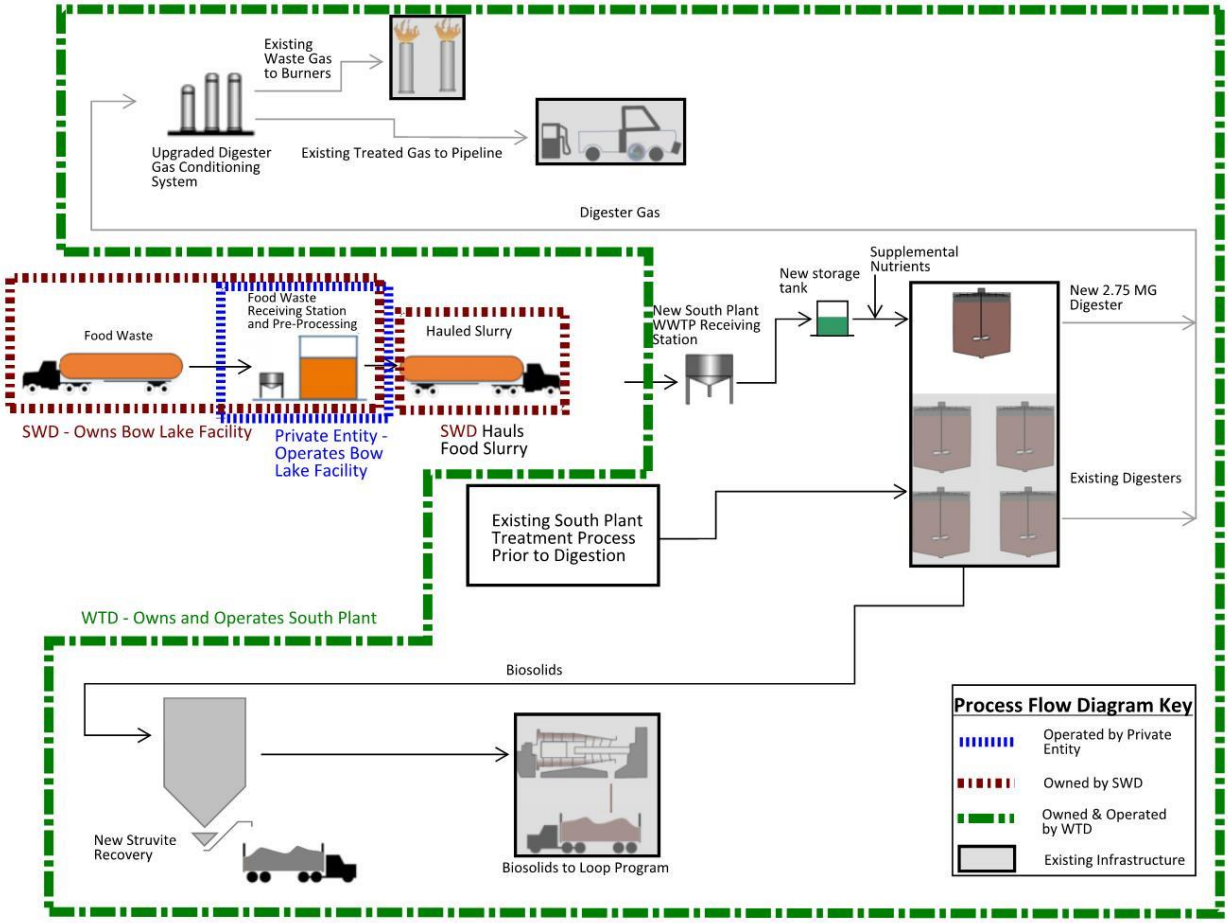

Figure 3-3. Food Waste Digestion Option 2

The County would own food waste-processing facility (Bow Lake), private entity would operate Bow Lake facility with SWD, or a private entity would haul preprocessed food waste to the STP.

3.3.3 Option 3 - Preprocessing Facility Owned and Operated by a Third Party

Option 3 would not include ownership or operation of facilities by SWD. Instead, a private entity would be contracted to build, own, and operate the preprocessing facility. Under this option, the facility could be located at Bow Lake or elsewhere. The WTD or private hauler would pay tipping fees to the third party for accepting the raw food waste, and the third-party would pay tipping fees to WTD to receive the preprocessed food waste. A process flow diagram of this option is included on Figure 3-4.

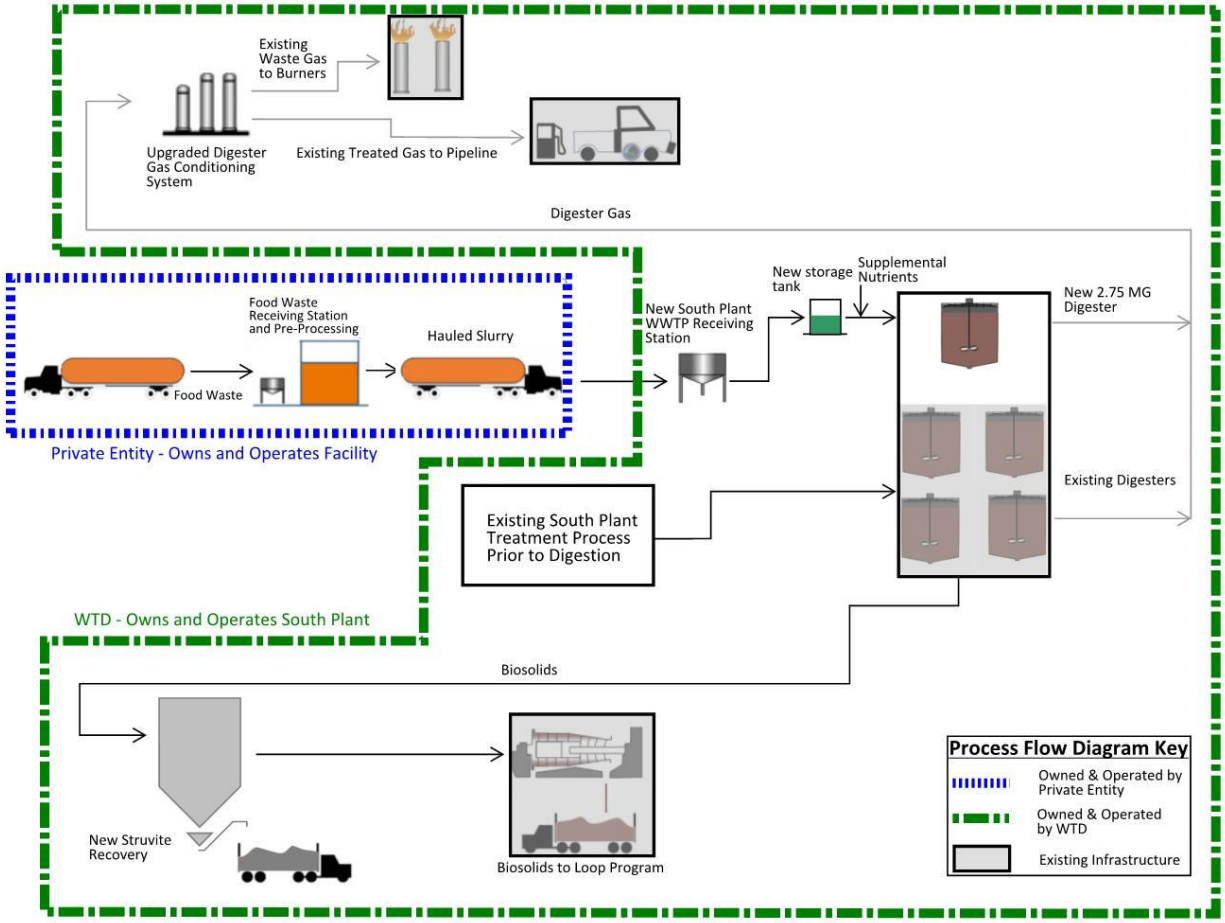

Figure 3-4. Food Waste Digestion Option 3

A private entity would haul and preprocess the food waste at a private facility and haul the preprocessed food waste to the STP.

Options 1 and 2 would include food waste preprocessing at the existing Bow Lake recycling and transfer station. This location was selected at the County's request. Space has been identified at Bow Lake to accommodate the infrastructure needed. The preprocessing facility is expected to require approximately 10,000 square feet to allow for waste truck receiving, processing, odor control, and truck loadout to haul to the food waste digestion facility. Three possible locations were identified to confirm that space is available for the new facility in conjunction with the existing infrastructure. These sites were chosen to allow for ease of truck access while minimizing the impact of additional truck traffic on the existing facility and operation.

4. Nonfinancial Considerations

Evaluation of a potential food waste digestion project should factor in financial (cost and potential revenue) considerations, which are detailed in the Basis of Estimate. In addition, nonfinancial considerations should be included in a holistic project formulation. Environmental, social, and operational considerations were identified as potentially affecting the implementation of food waste digestion by SWD and WTD and are listed in Table 4-1. The considerations do not highly depend on the option chosen and could be applied to all three options.

Table 4-1. Food Waste Digestion Nonfinancial Considerations

	Benefits	Drawbacks
Environmental	Diversion of organics from landfills	Increased nutrient loading to WWTP
	Renewable natural gas production	
	Adaptability to future regulatory changes and risk	
	Smaller footprint and less odor compared with composting	
Social	High local and regional public acceptability – zero waste	Increased truck traffic near STP
	Potential catalyst for other communities to adopt similar practices	
	Job creation (additional operations staff)	
Operational	High process reliability	Increased process complexity
	Redundancy and capacity with additional digester	More frequent digester cleaning may be needed
	Decreased equipment maintenance costs, improved biosolids dewaterability (higher cake solids content) and/or lower polymer demand with struvite recovery could	Increased operations and maintenance expected for both SWD and WTD

STP South Treatment Plant
SWD Solid Waste Division
WTD Wastewater Treatment Division
WWTP Wastewater Treatment Plant

While not a benefit or a drawback, expanding the STP facility and/or Bow Lake would require new permits and permit modifications to be completed by the County. If the preprocessing facility were owned and operated by a third party, then the third party would need to permit the facility independently of the County, but the cost would likely be included in the third-party tipping fee. Food waste-hauling would add trucks on the roadways and accessing the STP could be considered a challenge. These nonfinancial considerations should be more fully established and developed in an alternatives analysis.

5. Limitations

This document was prepared solely for King County Department of Natural Resources and Parks, in accordance with professional standards at the time the services were performed and in accordance with the contract between King County Department of Natural Resources and Parks and CH2M HILL Engineers, Inc. (Jacobs Engineering Group Inc.), dated August 13, 2019. This document is governed by the specific scope of work authorized by King County Department of Natural Resources and Parks; it is not intended to be relied upon by any other party, except for regulatory authorities contemplated in the scope of work. We have relied on information or instructions provided by King County Department of Natural Resources and Parks and other parties and, unless otherwise expressly indicated, have made no independent investigation as to the validity, completeness, or accuracy of such information.

6. References

King County 2014. *South Treatment Plant Flow and Waste Load Projections 2010–2060*. King County Department of Natural Resources and Parks. November.

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