Attachment A

Food Waste Recycling Alternatives Analysis

November 4, 2024

King County

Contents

List of Tables and Figures

Proviso Text

Ordinance 19546 Section 129, Capital Improvement Program, Department of Natural Resource and Parks, P1 [1]

P1 PROVIDED THAT:

Of this appropriation, $1,000,000 for capital project 1143934, South Plant Co-Digestion ("WTD capital project"), and $9,500,00 for capital project 1143795, Solid Waste Co-digestion Pre-processing Facility ("SWD capital project"), shall not be expended or encumbered until the executive transmits a commercial organics co-digestion planning report and a motion that should acknowledge receipt of the report, and a motion acknowledging receipt of the report is passed by the council. The motion should reference the subject matter, the proviso's ordinance number, ordinance section and proviso number in both the title and body of the motion.

A. For the purposes of this proviso, "feedstock" means the organics collected from generators of organic waste materials and is used as an input for a processing facility.

B. The department of natural resources and parks, solid waste division ("SWD") and wastewater treatment division ("WTD"), shall coordinate on the development of the commercial organics co-digestion planning report. The report shall include, but not be limited to, the following:

1. A description of the public engagement process used by SWD that includes a list of the stakeholders approached, how these stakeholders were engaged and a summary of the stakeholder concerns. The public engagement process shall include, but not be limited to, outreach to entities that provide organics collection to commercial customers or that provide organics processing;

2. An analysis from SWD that describes how the SWD capital project is expected to impact existing entities that provide organics collection to commercial customers or that provide organics processing while respecting the open-market system for commercial organics collection currently in place; i.e., rate subsidies should not be considered. The analysis shall include identification of any potential adverse impacts to these entities, including those resulting from competition for feedstock, and recommended strategies to mitigate the adverse impacts identified;

3. A discussion from SWD that provides justification for moving forward with this SWD capital project instead of other potential actions to enhance or expand the regional organics collection and processing system. The discussion shall specifically consider: (1) providing additional supports to existing entities that provide organics collection to commercial customers or that provide organics processing in order to expand regional capacity; or (2) moving forward with the exploratory partnership between the county and the Port of Seattle on sustainable aviation fuel if organics are identified in the ongoing feasibility study as potential aviation fuel feedstock;

4. An analysis from SWD for how it intends to flow control open market organic recyclables for digestion with respect to the current open market system;

5. An analysis from WTD that evaluates whether the utilization of anaerobic digesters at the South Treatment Plant in Renton for the co-digestion of organics with wastewater solids is likely to impact the designation and value of environmental credits referred to as Renewable Information Numbers ("RINS") attached to the sale of South Plant biomethane, and how any such an impact relates to provisions of the agreement for sale of South Plant biomethane and associated environmental credits; and

6. Separate project plans for the WTD and SWD capital projects, or a joint project plan that encompasses both projects. The separate project plans or the joint project plan shall be informed by

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[1] Ordinance 19546 [LINK]

the public outreach process described in subsection B.1. of this proviso and the analyses required by subsection B.2, 3., and 4 of this proviso. The separate project plans or the joint project plan shall include, but not be limited to, the following:

a. the WTD and SWD analyses on the best use of the commercial organics anticipated to be available as RCW 70A.205.545 is implemented;

b. the business case for the county providing justification for the county's investment in the WTD and SWD capital projects;

c. whether the SWD capital project will be operated by a third party or SWD, as well as the justification supporting the selected operator choice;

d. whether land acquisition will be needed to site the SWD capital project or whether existing county-owned land such as the Renton Recycling and Transfer Station will be used;

e. how the feedstock will be secured for the SWD capital project and whether acceptance of organics will be limited to the SWD service area. If acceptance of organics will not be limited to the SWD service area, the separate project plan for the SWD capital project or the joint project plan shall include a plan for mitigating the potential that the SWD capital project would be supported by revenues from county disposal feepayers but used by nonfeepayers;

f. whether all, a portion or none, of the pre-processed organics at the SWD capital project will go to the WTD capital project and a plan for how any pre-processed materials would be transported to the WTD capital project, as well as any supporting analysis;

g. a plan from WTD for mitigating any risks resulting from the impacts identified in the evaluation provided for in subsection B.4. of this proviso related to potential changes in RINS classifications resulting from utilization of WTD's South Plant digesters for co-digesting organics;

h. updated estimated capital and operating costs for both the WTD and SWD capital projects with any assumptions in the cost estimates clearly articulated;

i. a description of any proposed cost recovery or cost sharing arrangements for the WTD capital project and SWD capital project; and

j. next steps for both the WTD and SWD capital projects that include a high-level timeline with significant project actions and milestones.

The executive should electronically file the commercial organics co-digestion report and motion required by this proviso no later than November 1, 2024, with the clerk of the council, who shall retain an electronic copy and provide an electronic copy to all councilmembers, the council chief of staff and the lead staff for the transportation, economy and environment committee or its successor.

Executive Summary

Introduction. King County undertook the 2024 King County Food Waste Recycling Alternative Analysis study in response to a Proviso included in Ordinance 19546. The Proviso required a planning report by the Solid Waste Division (SWD) and Wastewater Treatment Division (WTD) exploring the potential to develop commercial organics co-digestion.

The Department of Natural Resources and Parks (DNRP) project team conducted analyses to better understand how the County can facilitate the diversion of food waste from the landfill; identify and implement the most beneficial use for processed food waste; and determine capacity requirements for co-digesting commercial food waste (CFW) at the South Treatment Plant (STP). [2]

Co-digestion and bio-digestion use the same technical treatment process of anaerobic digestion. For this study, *co-digestion* is the digestion of wastewater solids and CFW slurry in the same (STP) digester. [3] *Bio-digestion* is defined as a standalone digester owned and operated by a third party that digests food waste and possibly other organic feedstocks but does not focus on digesting wastewater solids.

Flow Control. King County does not have authority to require that commercial recyclable materials, including source-separated organics, be disposed of at a King County solid waste facility. Consequently, this lack of authority to flow-control organics limits options for the County to directly engage in organics processing and additional diversion of CFW from the landfill. With that in mind, this report addresses the potential for co-digestion and other approaches to food waste recycling in accordance with the Proviso.

South Treatment Plant Capacity and Renewable Identification Numbers (RINs). The digester capacity assessment found that even without the addition of food waste slurry (FWS), it would be necessary to expand capacity to provide sufficient digestion capability for future wastewater flow and loading projections due to growth. Digester capacity expansion through addition of a fifth and sixth digester or other digester improvement or intensification options would be necessary to provide sufficient digestion capacity even without FWS. It is assumed that 2035 is the earliest STP could accept FWS for co-digestion because the anaerobic digestion expansion project would take approximately 10 years to plan, design, and construct.

The County receives revenues from its conversion of biogas from the STP digesters into renewable natural gas. The currency upon which this revenue is based is called Renewable Identification Numbers, or RINs. Based on historical average RIN trading prices, the addition of CFW to the digestion process could increase total STP RIN revenue by 6 percent in 2030 and 18 percent in 2050.

Potential Risk from PFAS. Per- and polyfluoroalkyl substances (PFAS) are synthetic chemicals with unique properties which are widely used in various industrial and consumer products. PFAS contamination is an emerging concern, and over recent years, states have been preparing guidance values for wastewater effluent and biosolids products. PFAS pose concerns due to their persistence, bioaccumulation potential, and potential adverse health effects. Certain feedstocks, such as those

[2] The project team consisted of project managers and subject-matter experts from SWD and WTD, lead consultant Jacobs, consultant HDR, Cascadia Consulting Group, EcoEngineers, and a University of Washington civil and environmental engineering professor.

[3] A slurry is a mixture of liquids and solids.

containing food packaging, are known to have higher concentrations of PFAS. The risk associated with PFAS contained in CFW could adversely impact the County's Biosolids Program and its Loop product and customers.[4] It is possible that restrictions on the feedstocks used in anaerobic digestion could limit the risk of PFAS contamination in the biosolids produced, but this potential remains uncertain and will require further research.

Outreach to and Potential Impacts to Existing Entities. As part of the analysis, the project team conducted outreach to entities that collect and process organics in the Puget Sound region to understand their perspective on the County's potential participation in food waste diversion, pre-processing, and processing. While some said the County's role should be to enforce the organics law and set policy, there is some interest in entering into a partnership or conducting a pilot project with the County for pre-processing food waste.

Currently, the majority of organics processing in King County is done at composting facilities and requires less pre-processing than co-digestion**.** The long-standing history of private sector composting facilities in the region in an open market would suggest their continued viability and reliability. Some entities, such as Divert, prefer to source-separate food waste and work directly with generators of CFW rather than organics collectors. Currently, these entities are either piloting operations or have not yet started full-scale operations. Development of a SWD pre-processing facility would need to take into consideration the potential impacts to, and opportunities to complement, these developing bio-digestion enterprises. Such a facility could indirectly compete for feedstock (through agreements with existing organics collectors), depending on the supply and demand balance between the amount of CFW and the total regional capacity of bio-digestion and composting facilities.

For existing collectors and haulers (e.g. Waste Management, Recology, Republic Services, and Cedar Grove), a SWD capital project to pre-process commercial food waste would provide market diversity, thereby making the overall organics market more resilient and capable of adapting to changing conditions. However, some of these entities are vertically integrated, providing collection and hauling, pre-processing, and processing through composting or bio-digestion.

Feedstock Availability, Service Area, and Impacts to Feepayers. The alternatives analysis conducted for this report assumed that the County is most interested in the material within its boundaries and that this approach had the highest potential to effect change. King County generates significant quantities of CFW, which is also largely processed in the county. Because organics would be collected and processed in King County, there would be no impacts to feepayers from providing services to non-ratepayers.

Distribution and Transport/Land Acquisition. If SWD were to host a pre-processing facility, the County or a third party could enter into a long-term agreement with a third-party hauler to bring their collected organics to the pre-processing facility, from which all of the pre-processed material would be transported via trailer truck to the STP for co-digestion.

A survey of 10 surplus, County-owned sites did not identify any site suitable for organics pre-processing, due either to size or zoning. However, an analysis of the industrial real estate market in south King

[4] King County's Biosolids Program Loop product is a fertilizer alternative produced by cleaning, recycling, and transforming wastewater into biosolids used for beneficial reuse land application.

County identified multiple property types with existing structures or vacant land that would likely be suitable for a pre-processing facility.

Alternatives of Supporting Existing Entities or Sustainable Aviation Fuel: Per the Proviso, alternative approaches to food waste reduction—through support of existing processing entities or developing a sustainable aviation fuel (SAF) program—were also explored and found not to be viable.

SWD and WTD are both limited in the types of support they can offer to enhance or expand the regional organics collection and processing system. As mentioned previously, the County does not have the authority to control the flow of organics; in accordance with the Proviso, subsidies were not considered and WTD cannot fund processing capacity for purposes other than sewage collection and treatment. However, based on outreach to existing entities, at least two are interested in entering into a partnership or conducting a pilot project with the County for pre-processing food waste.

Prior to the present study and in compliance with Ordinance 19210, Section 107, King County and the Port of Seattle selected a consultant to conduct an evaluation of the feasibility of directing some or all of the municipal solid waste (MSW) received at County solid waste facilities to the Port's SAF project.[5] It was determined that the high moisture content in food waste makes it an undesirable feedstock for conversion to SAF, so this technology would not constitute a food waste diversion alternative.

Food Waste Processing Technologies. The report includes an overview of known food waste processing technologies, highlighting pre-processing, anaerobic digestion technologies, small-scale versus large-scale systems, and composting. There is also an assessment of environmental beneficial use cases, which concludes that compost and anaerobic digestion (AD) rank equally, contingent on the beneficial use of digestate or biosolids from AD through land application. In addition, greenhouse gas emissions were included in the alternative evaluations and found that both alternatives provide a net reduction of greenhouse gas emissions.

Best Use of Organics *and* Operator Choice: For initial analysis of alternatives, the project team developed a list of possible processing and beneficial reuse approaches or technologies and applied a fatal-flaw analysis using three pass-fail criteria: excessive costs, unproven technology, or overly complex technological, regulatory, or policy issues. The top three options (composting, co-digestion, and third-party bio-digestion) were carried forward and more specific alternatives and sub-alternatives were developed for these three options. While not called for in the Proviso, third-party digestion was added as an alternative for best use of organics. Due to several factors, there was insufficient information to fully analyze this alternative for the purposes of this report, so further research and consideration of pursuing options related to this alternative are among the next steps identified in the report.

[5] Municipal Solid Waste-to-Fuels Study Summary [LINK]

Alternatives Advanced for Analysis

Alternative	Pre-processing	Processing	Status
1a	Pre-processing at County-owned site operated by third party	Co-Digestion at South Plant	**Carried forward to business case evaluation**
1b	Pre-processing at third-party owned and operated site	Co-Digestion at South Plant	**Carried forward to business case evaluation**
2a	Pre-processing at County-owned site operated by third party	Composting at third-party centralized location	**Dropped – assumed pre-processing will continue to be conducted by composters**
2b	Pre-processing (for composting) at third-party owned and operated site	Composting at third-party centralized location	**Current approach. Carried forward to business case evaluation and redefined as Alternative 2.**
3a	Pre-processing at County-owned site operated by third party	Digestion at third-party site	**Not included in business case evaluation, but recommended for continued monitoring and further evaluation in the future**
3b	Pre-processing at third-party owned and operated site	Digestion at third-party site	

Business Case. The business case evaluation (BCE) for the selected alternatives, comprised of a monetary and economic assessment and a non-monetary assessment, was applied to the alternatives.

For SWD, Alternative 2, continued and expanded composting, has the highest non-monetary score and no direct capital outlay costs or additional annual operating costs for CFW processing. However, with this approach comes less control and, therefore, higher risk that there will be insufficient CFW processing capacity and insufficient diversion from the landfill. There is also risk of future capacity constraints.

Alternative 1b has the second highest non-monetary score, requires that SWD collect reimbursement monies and distribute to WTD for co-digestion at STP, and has the highest risk. Due to the high degree of risk to SWD, further cost-recovery analysis would be needed to explore the implications of this approach.

Alternative 1a has a non-monetary score slightly lower than Alternative 1b, would directly incur the costs to develop the CFW pre-processing facility site, and must reimburse WTD for co-digestion at STP. However, Alternative 1a has the highest probability to successfully add CFW processing capacity and divert CFW away from the landfill.

Both 1a and 1b have significant price risk because the fee to collect CFW at the pre-processing facility could be more than double the current cost to compost food waste. This makes it difficult to ensure there is enough feedstock for processing.

Alternative 3, third-party bio-digestion—focused on processing CFW as opposed to other feedstocks, such as manure from dairies—is not currently available in the Puget Sound region and therefore no business case evaluation was developed for this approach; however, one of the composting companies is evaluating the addition of a bio-digestion system for the purpose of processing food waste.

It is anticipated that, without flow control or more certainty associated with CFW quantity and quality, the risk of Alternative 3a would be higher than Alternative 2 if the third party is a new entity that is not currently composting in King County; this is due to the lack of certainty of food waste feedstocks and lack of certainty that the system could continue to operate without having a stable source of revenue. However, if the third-party bio-digester is integrated into an existing composting facility, these risks would be somewhat lower because this vertically integrated enterprise would have more flexibility to route received materials to either co-digestion or composting.

For WTD, as for SWD, Alternative 2 has the highest non-monetary score and no direct capital outlay costs or additional annual operating costs. From the perspective of WTD, the non-monetary score and costs would be the same for Alternative 2 and Alternative 3, third-party bio-digestion, if a third party were to successfully implement this solution. Alternative 2 has a much lower risk score relative to Alternatives 1a and 1b, primarily because STP would not be receiving any CFW.

Alternative 1b has the lowest non-monetary score and the highest risk for WTD and does not provide any economic advantage compared with Alternative 1a. However, each of these sub-alternatives was carried forward for further analysis.

If Alternative 1, co-digestion, were to be pursued, the consultant would recommend Alternative 1a, pre-processing at a County-owned site operated by a third party, with co-digestion at STP, over Alternative 1b, pre-processing by third-party site owner-operator, with co-digestion at STP.

Cost Recovery. Capital investments for food waste processing would be expected to include projects that serve both direct food waste processing services (i.e., a receiving station) and investments in sewer treatment plant capacity for food waste processing over and above the capacity being planned and built to serve sewer customers.

WTD could finance capacity investments to the sewer system that include both capacity for wastewater service and marginal capacity for food waste processing (i.e. co-digestion) for SWD. It is likely that SWD would directly fund the facilities required only to serve the selected food waste processing alternative, although these might also be initially financed by WTD and then included in a cost-recovery structure. WTD and SWD will need to prepare a cost-of-service analysis and propose a related cost recovery structure to ensure required reimbursements for facilities, capacity, and ongoing operations dedicated to food waste processing versus wastewater infrastructure.

The following assumptions were used in developing the life-cycle analysis for both SWD and WTD.
For the pre-processing facility:

Alternative 1a and 1b:

- SWD would retain land and facility lease payments or administrative fees collected from a third-party operator of a pre-processing facility, if applicable (Alternative 1a)
- Third party to design and build the equipment portion of the pre-processing to be recovered through utilizing a portion of the raw CFW tipping fees
- Third-party ongoing operating costs would be offset by a portion of the raw CFW tipping fees
- The raw CFW tipping fees would be paid by the cities' haulers to the pre-processor; this revenue would be distributed to attain CFW cost reimbursement

Alternative 1b: Funding the construction and ongoing operating costs for a pre-processing facility developed by others would have to be paid back by the generators of the CFW via tipping fees for receiving the raw CFW.

For STP co-digestion:

- CFW slurry tipping fees: collected by SWD from haulers; SWD would pay a portion of this to WTD to ensure revenue neutrality and cost reimbursement to WTD for costs incurred for accommodating CFW. The remainder retained by SWD to reimburse SWD for CFW pre-processing costs
- CFW tipping fees: WTD would receive and retain tipping fees from haulers contracted by the cities or the operator of the pre-processing facility for receiving the CFW slurry at the STP

Renewable energy credits: If WTD were to receive payment for renewable energy credits, such as additional RIN payments resulting from digesting CFW slurry, this revenue would be retained by WTD and subtracted from the total of the annual debt service for capital investments and annual operating costs incurred for accommodating CFW, resulting in the net cost reimbursement amount.

Next Steps. DNRP concluded that it is not feasible to immediately develop a CFW pre-processing facility or co-digestion at the STP. However, the County should proceed with steps outlined in the report's Conclusion section to help determine the most feasible and effective approach to food waste reduction and diversion, including evaluating third-party organics processing developments and pursuing potential partnerships and other opportunities.

For both SWD and WTD, the fact that the County does not have flow control for organics, and more specifically CFW as the primary feedstock, is too high of an unmitigated risk. Within the current flow-control policy framework, pricing is key to securing feedstock. Unfortunately, the price that would need to be charged to recover costs is more than double current fees for composting.

There may not be enough additional CFW of appropriate quality to justify new processing capacity for some time. For WTD, the unclear risk associated with PFAS loadings from CFW, which could, in turn, adversely impact the County's Biosolids Program and its Loop product and customers, precludes a full commitment to co-digestion until the risks can be mitigated or better understood. Further investigation to mitigate or better define these risks is needed. The consultant team recommends proceeding with specific activities and action items to better quantify these risks and revisit the County's role in organics diversion efforts.

A key takeaway from the analysis was that because there are many outstanding questions regarding new organics processing capacity (e.g., bio-digestion) in the region, SWD should continue to research and evaluate third-party organics processing capacity developments and pursue potential partnerships and other related opportunities.

Background

Department Overview: The King County Department of Natural Resources and Parks (DNRP) works in support of sustainable and livable communities and a clean and healthy natural environment. Its mission is to foster environmental stewardship and strengthen communities by providing regional parks, protecting the region's water, air, land, and natural habitats, and reducing, safely disposing of, and creating resources from wastewater and solid waste.[6]

The Solid Waste Division (SWD) of DNRP provides garbage transfer and disposal as well as recycling services for approximately 1.3 million residents and 660,000 employees in King County. The King County solid waste system serves a large unincorporated area and 37 of the 39 cities in King County.[7]

The Wastewater Treatment Division (WTD) of DNRP protects public health and enhances the environment by collecting and treating wastewater while recycling valuable resources for the Puget Sound region.[8]

Key Historical Context: According to the U.S. Environmental Protection Agency (EPA), more than one-third of the food produced in the U.S. is never eaten, wasting the resources used to produce it and creating numerous environmental impacts. Food waste is the single most common material that goes into landfills, comprising 24 percent of landfilled municipal solid waste (MSW) nationally. [9]

King County's 2020 Strategic Climate Action Plan (SCAP) identifies food-waste reduction as a priority in reducing greenhouse gas emissions. The SCAP commits to achieving zero waste of resources and zero edible food waste by 2030 through actions that include implementation of a regional organics plan and prioritizing food waste reduction strategies.[10]

The garbage collected from the areas served by the County's solid waste system is disposed of at the Cedar Hills Regional Landfill (CHRLF) in Maple Valley. The landfill is currently anticipated to stop receiving waste in 2040, and a long-term plan for disposal after closure of the landfill will be determined through an update to the Solid Waste Comprehensive Management Plan, expected to be completed in 2026.[11]

In November 2022, SWD launched a new program called Re+, aimed at actions to divert as much waste as possible from the landfill and help the county achieve zero waste of resources. One focus of Re+ is to reduce the amount of food waste going to the landfill and increase the capacity to process this waste in

[6] Department of Natural Resources and Parks [LINK]
[7] About the Solid Waste Division [LINK]
[8] About the Wastewater Treatment Division [LINK]
[9] EPA 2024. From Farm to Kitchen: The Environmental Impacts of U.S. Food Waste. [LINK]
[10] Kuharic, M. (ed.) and the Reducing Greenhouse Gas Emissions Team. 2020. Section I: Reducing Greenhouse Gas Emissions. In: King County 2020 Strategic Climate Action Plan. [King County Climate Action Team (eds.)]. King County, Washington. [LINK]
[11] King County Solid Waste Comprehensive Management Plan [LINK]

a beneficial way. A 2022 study found that food waste comprised 17.8 percent of the material being disposed of at the CHRLF.[12]

The current method used to process food waste collected in the King County solid waste system is composting, but there are potential permitting and capacity limits that could be reached in the next few decades, so other processing options are under consideration. Focusing on commercial food waste (CFW), SWD issued a request for information (RFI), completed in mid-2022, that looked at available processing options and processors. Options identified included continued and expanded composting; anaerobic co-digestion of commercial food waste with wastewater solids at an existing WTD treatment plant; and an anaerobic digestion operation owned and operated by entities other than the County. The study discussed in this report includes a comparison of these processing methods to better understand which should be pursued.

Key Current Conditions: Washington State's Organics Management Law of 2022, passed as House Bill (HB) 1799, supports the Washington State Legislature's 2021 Climate Commitment Act (CCA), a sweeping law that sets carbon emissions limits and requires the state to reduce its carbon output by 45 percent by 2030, 70 percent by 2040, and 95 percent by 2050.[13,14] To help meet the state's CCA emissions targets, implementation of the new law will reduce methane by diverting organic materials from municipal landfills towards beneficial uses. By 2025, 20 percent of previously disposed of edible food must be recovered for consumption, relative to 2015 levels. By 2030, 75 percent of previously disposed of organic materials must be diverted from landfills, relative to 2015 levels.

Report Methodology: The King County Food Waste Recycling Alternative Analysis study was undertaken in 2024 to explore ways to reduce the environmental footprint generated by food waste, extend the life of the CHRLF, and increase material recycling and energy recovery.

The project team consisted of project managers and subject-matter experts from SWD and WTD, lead consultant Jacobs, consultant HDR, Cascadia Consulting Group, EcoEngineers, and University of Washington civil and environmental engineering Professor Mari Winkler. The project team focused on conducting analyses to better understand how the County can facilitate the diversion of food waste from the landfill; identify and implement the most beneficial use for processed food waste; and determine capacity requirements for co-digesting CFW at the South Treatment Plant (STP).

In the study, only CFW generated in King County would be considered. The project team developed a list of possible processing and beneficial reuse approaches or technologies and applied a fatal-flaw analysis using three pass-fail criteria: excessive costs, unproven technology, or overly complex technological, regulatory, or policy issues. The technologies included:

- Direct use of food waste for animal feed, also known as sustainable alternative feed enterprise (SAFE)
- Continued and expanded composting
- Anaerobic digestion
    - Co-digestion at the STP

[12] Cascadia 2023. 2022 King County Waste Characterization and Customer Survey Report [LINK]
[13] Organics Management Law, HB 1799 [LINK]
[14] Climate Commitment Act, SB 5126 [LINK]

- Third-party bio-digestion
- Landfill bioreactor[15]

Co-digestion and bio-digestion use the same technical treatment process of anaerobic digestion. For this study, *co-digestion* is the digestion of wastewater solids and CFW slurry in the same (STP) digester. *Bio-digestion* is defined as a standalone digester owned and operated by a third party that digests food waste and possibly other organic feedstocks but does not focus on digesting wastewater solids.

The project team developed preliminary evaluation criteria and used a decision science tool to qualitatively screen these alternatives. The top three options—composting, co-digestion, and third-party bio-digestion—were carried forward through further analysis and the alternatives were refined to:

- **Alternative 1: *Co-Digestion at STP***
  - **1a:** Pre-processing at County-owned site operated by third party; co-digestion at STP
  - **1b:** Pre-processing at third-party owned and operated site; co-digestion at STP
- **Alternative 2: *Composting***
  - **2a:** Pre-processing for composting at County-owned site, operated by third party; composting at third-party centralized location
  - **2b**: Pre-processing for composting at third-party owned and operated site; composting at third-party centralized location
- **Alternative 3: *Third Party Bio-Digester***
  - **3a:** Pre-processing at County-owned site operated by third party; digestion at third-party site
  - **3b:** Pre-processing at third-party owned and operated site; digestion at third-party site

Further analysis of these alternatives is described in section B.6(a), Best Use of Commercial Organics, and other aspects of the project team's analysis are summarized throughout this report in response to specific items in the Proviso.

Report Requirements

This report is organized to align with the requirements of the Proviso and summarizes the consultant's study.

It is relevant to note that King County does not have statutory authority to require that commercial recyclable materials, including source-separated organics, be disposed of at a King County solid waste facility.[16] Consequently, this lack of authority to flow-control organics limits options for the County to directly engage in organics processing and additional diversion of CFW from the landfill. As described below, this factor has implications for several specific elements of this Proviso, including impacts to

[15] Landfill bioreactor is a technology whereby an increase in waste degradation is accomplished through the addition of liquid and air to enhance microbial processes.

[16] The County can require that commercial organics not be deposited as regular municipal solid waste at any County facility; it can also flow control the residual (non-recyclable) material from organics collected from residences and from organics processing facilities within its solid waste jurisdiction.

existing collection and processing entities (B.2.), support to existing entities (B.3(1)), business case (B.6(b)), operator choice (B.6.(c)), and how the feedstock will be secured (B.6.(e)).

B.1 A description of the public engagement process used by SWD that includes a list of the stakeholders approached, how these stakeholders were engaged and a summary of the stakeholder concerns. The public engagement process shall include, but not be limited to, outreach to entities that provide organics collection to commercial customers or that provide organics processing

In accordance with the Proviso, a description of the public and stakeholder engagement process as well as any stakeholder concerns is provided below.

Public Outreach

The project team considered outreach to the public and, in consultation with SWD Communications staff, the team elected not to pursue community engagement while alternatives are still under development. Once the viability of food waste diversion alternatives is better understood, the team intends to implement outreach and engagement to solicit community feedback.

Processing and Collecting Entities

Stakeholder engagement has been ongoing since the initial planning phases of the analysis of potential food waste recycling alternatives, and was under way even before the project began. For example, in 2019 an RFI was solicited by SWD to obtain responses from organizations that might be interested in processing commercial food waste in partnership with King County. The RFI sought input on several food waste processing options, including anaerobic digestion, as well as different ownership models for a co-digestion facility.

SWD has also held ongoing meetings and communications with commercial entities such as Cedar Grove, Waste Management, and Divert over the past several years to develop and maintain relationships with the key commercial organic waste processing entities in the region.

To support public outreach and engagement efforts specifically in response to the Proviso, the consultant team worked with SWD and WTD staff to develop questions for initial interviews with processing and collecting entities. The team began with three entities involved in food waste processing, followed by three entities involved in collection and hauling of food waste in King County. For each of these outreach efforts, the consultant team initiated communication with an introductory phone call and/or email explaining the purpose of the project and the nature of the questions the team wished to discuss with the entity. A few of the entities provided follow-up information via email. Notes from the interviews were prepared and the dates of the communications and other details are provided below.

Cedar Grove

Cedar Grove is a well-established composting operation in the Puget Sound area that has been collecting and processing commercial food waste for decades.[17] It operates two composting facilities, located in Everett and Maple Valley.

[17] Cedar Grove Composting, Inc. [LINK]

On May 23, 2024, a member of the consulting team contacted Cedar Grove's general counsel by phone to introduce the co-digestion project and schedule an interview. On June 4, 2024, three members of the consulting team conducted a video teleconference interview regarding food waste processing with three representatives of the company. On August 19, 2024, two members of the consulting team conducted a video teleconference with the president and general counsel of Cedar Grove regarding food waste collection.

Cedar Grove collects commercial food waste from approximately 3,500 commercial customers. Cedar Grove also states that the company collects the majority of the commercial food waste currently being collected in King County.

Cedar Grove is confident in its ability to handle additional food and yard waste material generated in the region. The company recommended that the County enforce the Organics Management Law rather than become a pre-processor or processor. However, Cedar Grove is receptive to a partnership with the County. There are a few different ways that the County could engage in a partnership with Cedar Grove, either by supporting a new bio-digester project or exploring what type of County-owned pre-processing needs could support the composting operation.

The company plans to continue diversifying its processing capabilities, including by building its own bio-digester at its Maple Valley location, which it expects to be operational in two years with a capacity of 100,000 tons per year.

Divert

Divert has been engaged in food waste diversion and processing across the nation since 2007.[18]On May 23, 2024, a member of the consulting team contacted the Divert Vice President of Public Affairs to introduce the project and schedule an interview. The consultant also emailed questions. On June 5, 2024, two members of the consulting team conducted a video teleconference with the vice presidents of both Public Affairs and Collection Solutions at Divert.

In 2022, Divert announced plans to expand its food-waste-to-renewable natural gas (RNG) operations with the opening of 30 more locations, including Longview, Washington, where one of its next facilities will be built. Divert anticipates opening the Longview bio-digester operation in 2025. Its current business model is focused on specific and clean feedstock with a direct connection to commercial food waste generators, creating a clearer feedback loop. The company believes the County's role is to set policy rather than become actively involved in food waste diversion, pre-processing, or processing.

Waste Management

Waste Management (WM) currently collects about 3,000 tons per year of commercial organic material within King County.[19] Its service areas are divided into WM Northwest (Bothell, Duvall, Kirkland, Redmond, Snoqualmie, Woodinville, and other unincorporated areas within King County), WM South Sound (Algona, Auburn, Federal Way, Normandy Park, Pacific, and other unincorporated areas within King County), and WM Seattle (Newcastle, Tukwila, and other unincorporated areas within King County). The company currently takes its commercial organics to facilities other than Cedar Grove.

[18] Divert, Inc. [LINK]
[19] WM [LINK]

On May 23, 2024, a member of the consulting team contacted WM's Director of Business Development-Organic Recycling to introduce the project and schedule an interview. Questions were sent via email on May 28, 2024. The WM contact sent some initial information to the consulting team via email on May 29, 2024 and on the same date, three members of the consulting team conducted a video teleconference the original contact as well as the company's Organic Project Development Manager. On August 6, 2024, a member of the consulting team contacted WM Director of Business Development-Organic Recycling to gather information about their local involvement in CFW collection. Following several email exchanges in August, the Organic Project Development Manager emailed the requested information on September 13, 2024.

In addition to collection, WM also provides pre-processing through long-term franchise agreements in various North American locations. The company is interested in a partnership with the County and with gaining a better understanding of feedstock volumes and material characteristics of the county's commercial food waste. WM says the fact that SWD and WTD are operated under the same department makes a partnership with the divisions appealing, because this can make decision-making and the design process easier than with jurisdictions that have separate wastewater and solid waste management structures. WM has approached the County regarding a potential pre-processing demonstration project. WM has a range of processing options, depending on need.

Recology

Recology has been providing collection and processing of organics in California and Oregon for many years.[20] In Washington, the company currently provides collection of commercial and residential organics in several locations throughout King County. The company provides commercial organics collection to customers in Bothell, Carnation, Issaquah, Shoreline, Burien, Des Moines, Maple Valley, SeaTac, Mercer Island, Tukwila, and North Bend; Redmond will be added in 2026. This service accounts for about 4,000 tons per year of commercial organics, taken primarily to Cedar Grove.

On August 12, 2024, a member of the consulting team contacted the King County General Manager of Recology by email to introduce the project and ask some questions. Responses were provided via email from the King County General Manager of Recology as well as its Pacific Northwest Regional Manager. The information Recology provided indicated that the company is very interested in participating in and expanding organics diversion for the region, possibly as a third-party processor, through additional commercial accounts, or through other approaches.

Republic Services

Republic Services currently collects about 500 tons per year of commercial organics material from within King County.[21] Its service areas are divided into Republic of Bellevue (Beaux Arts Village, Bellevue, Clyde Hill, Hunts Point, Kenmore, Lake Forest Park, Medina, Mercer Island, North Bend, Sammamish, Sammamish Klahanie, Yarrow Point, and other unincorporated areas within King County) and Republic of Kent (Covington, Kent, Renton, and other unincorporated areas within King County).

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[20] Recology [LINK]
[21] Republic Services [LINK]

On August 6, 2024, a member of the consulting team contacted Republic via email to introduce the project and ask a series of questions. The consultant team member sent a follow-up email on August 23, 2024. No response to either email has been received. The information above is from past research and information routinely collected from haulers by SWD.

Other Processors

Winton Manufacturing Compost Works in Leavenworth, WA, is also in partnership with Cedar Grove and may have potential to offer expanded capacity in the future.

While not part of this study, past outreach conducted by the lead consultant on this project has determined that dairy digesters, which primarily process dairy manure, are not currently interested in receiving CFW feedstocks. The liquid and solid products are typically used on site and may be rendered less suitable by lower-quality feedstock or contaminated CFW. These facilities often lack the pre-processing and receiving capabilities and permitting required for CFW diversion and are generally not interested in providing a disposal pathway for CFW.

Puget Sound Energy

Puget Sound Energy (PSE) is a private energy utility company that provides both natural gas and electricity service to the South Treatment Plant (STP), located in Renton.[22]

On May 24, 2024, the WTD project manager for the co-digestion study contacted a manager at PSE to initiate communication. On June 11, 2024, four members of the consulting team and three staff from SWD and WTD conducted a video teleconference with two managers at PSE to discuss renewable energy generation at the STP.

Renewable Natural Gas (RNG)

There is a 20-inch, high pressure natural gas lateral next to STP where WTD currently injects RNG produced at STP. PSE anticipates that any additional RNG produced from co-digestion could also be injected here. WTD has an agreement in place with PSE for RNG, and future PSE agreements will most likely mirror costs based on this agreement. PSE does not currently offer incentives for RNG production and has no plans to offer such incentives in the future.

Renewable Electricity

If STP were to consider the sale of renewable electricity to the electrical grid by sending conditioned biogas to combined heat and power (CHP) engines, PSE offers Power Purchase Agreements (PPAs) for Qualifying Facilities for interconnection agreements.[23] The fuel source and carbon intensity of the fuel would drive the PPA pricing, as the goal of carbon neutrality is a major driver for PSE. For this alternative to be viable, rework would be required from the County to make the existing substation work for the sale of renewable electricity into the PSE power grid. PSE indicated that it may offer incentives for renewable electricity production around 2030.

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[22] Puget Sound Energy [LINK]

[23] Combined heat and power is a system that converts biogas into electricity and heat using an internal combustion engine. Electricity is used on site or fed into the electricity grid.

B.2 An analysis from SWD that describes how the SWD capital project is expected to impact existing entities that provide organics collection to commercial customers or that provide organics processing while respecting the open-market system for commercial organics collection currently in place; i.e., rate subsidies should not be considered. The analysis shall include identification of any potential adverse impacts to these entities, including those resulting from competition for feedstock, and recommended strategies to mitigate the adverse impacts identified;

The additional CFW that is collected and diverted away from the landfill will require a significant amount of pre-processing to remove contaminants, including food packaging, plastics, glass, and metal, to yield viable feedstock for beneficial reuse such as anaerobic digestion.

CFW collection has been provided as an optional service to businesses throughout the county for many years by entities including WM, Recology, and Republic, discussed above in Section B.1. The businesses that have opted to participate are those with particular interest, and they are generally more attentive to keeping contaminants out of their CFW than those that are required to add the service. The increased CFW will be coming from businesses that have not previously used this service, and some will be organics from a future mixed waste processing (MWP) facility that SWD hopes to incorporate into its system as part of the County's Re+ initiative. (See section B.6(e) for further discussion of MWP and Re+).

Currently, the majority of organics processing in King County is done at composting facilities and requires less pre-processing than co-digestion. There are privately owned composting operations in the region (e.g. Cedar Grove), some of which have been in business for decades and include some of the most technically diverse and operationally advanced compost facilities in the nation The long-standing history of private sector composting facilities in the region in an open market would suggest their continued viability and reliability.

The local industry has developed a range of composting technologies to suit a variety of feedstock materials, land-area constraints, and capital and operating cost variables. Selection of the appropriate composting technology is typically determined by the condition of the feedstock, the available land or site area, and proximity to neighbors or sensitive receptors; it is also influenced by the long-term capacity of the facility to manage the capital and operational costs of processing the quantity and quality of material anticipated to be available to the facility. (Composting technology is discussed further in section B.6 (a), Best Use of Commercial Organics).

Although there are many bio-digestion systems in Washington, most are committed to dedicated feedstocks (e.g., cow manure from dairy farms) and are neither equipped nor permitted to receive CFW or other organic waste.

Some entities, such as Divert, prefer to source-separate food waste and work directly with generators of CFW rather than organics collectors. Currently, these entities are either piloting operations or have not yet started full-scale operations. Development of a SWD pre-processing facility would need to take into consideration the potential impacts to, and opportunities to complement, these developing bio-digestion enterprises. Such a facility could indirectly compete for feedstock (through agreements with existing organics collectors), depending on the supply and demand balance between the amount of CFW and the total regional capacity of bio-digestion and composting facilities.

For existing collectors and haulers WM, Recology, Republic Services, and Cedar Grove, a SWD capital project to pre-process CFW would provide market diversity, thereby making the overall organics market more resilient and capable of adapting to changing conditions. However, it should be noted that some of these entities are vertically integrated, providing collection and hauling, pre-processing, and processing through composting or bio-digestion. For example, Cedar Grove provides collection and composting and is looking into adding digestion, and WM provides collection and pre-processing.

Recommended strategies to mitigate adverse impacts to the operations and growth of other entities include:

- Continuing outreach and engagement with existing collection and processing operators to understand and address their concerns
- Monitoring existing and planned regional organics processing capacity as well as the actual amount of CFW diversion
- Partnering with entities to pilot pre-processing technologies that would expand regional organics capacity

B.3 A discussion from SWD that provides justification for moving forward with this SWD capital project instead of other potential actions to enhance or expand the regional organics collection and processing system. The discussion shall specifically consider: (1) providing additional supports to existing entities that provide organics collection to commercial customers or that provide organics processing in order to expand regional capacity; or (2) moving forward with the exploratory partnership between the county and the Port of Seattle on sustainable aviation fuel if organics are identified in the ongoing feasibility study as potential aviation fuel feedstock;

The project team has determined that the South Treatment Plant (STP) currently lacks capacity to support co-digestion, and thus moving forward with the SWD capital project is not justified at this time. The basis of this determination is outlined below.

The digester capacity assessment found that even without the addition of food waste slurry (FWS), it would be necessary to expand capacity to provide sufficient digestion capability for future wastewater flow and loading projections due to growth. Digester capacity expansion through addition of a fifth and sixth digester or other digester improvement or intensification options would be necessary to provide sufficient digestion capacity, even without FWS. It is assumed that 2035 is the earliest STP could accept FWS for co-digestion because the anaerobic digestion expansion project would take approximately 10 years to plan, design, and construct. Factors leading to this conclusion are outlined in further detail in section B.5, following the discussion of impacts on the STP's Renewable Identification Numbers.

(1) providing additional supports to existing entities that provide organics collection to commercial customers or that provide organics processing in order to expand regional capacity

SWD and WTD are limited in the types of support they can offer to enhance or expand the regional organics collection and processing system. As explained here and below in response to Proviso requirement B.4, King County does not have authority to require that commercial recyclable materials, including source-separated organics, be disposed of at a King County solid waste facility.[24]

In accordance with section B.2 of the Proviso, subsidies should not be considered. WTD also cannot fund processing capacity for purposes other than sewage collection and treatment.[25] However, based on outreach to existing collection and processing entities, two entities have expressed interest in potentially entering into a partnership or conducting a pilot project with the County for pre-processing food waste. SWD could enter into a partnership with a third party by purchasing and leasing land and infrastructure for a pre-processing facility; this would help expand the regional organics processing capacity and increase market diversity. This type of solution applies to Alternatives 1a and 3a, described below in section B.6(a).

In other parts of the U.S., partnerships or feedstock agreements exist between private entities and municipal agencies. In some cases, the municipality has no flow control, but the private entity has collection agreements near the pre-processing facility to ensure the supply of feedstock and reduce the risk of an unused or under-utilized asset.[26]

(2) moving forward with the exploratory partnership between the county and the Port of Seattle on sustainable aviation fuel if organics are identified in the ongoing feasibility study as potential aviation fuel feedstock;

Prior to the present study and in compliance with Ordinance 19210, Section 107, King County and the Port of Seattle selected a consultant to conduct an evaluation of the feasibility of directing some or all of the municipal solid waste (MSW) received at County solid waste facilities to the Port's sustainable aviation fuel (SAF) project.[27,28] The study included analysis of whether the County's waste stream is suitable for conversion to aviation and other fuels. The Ordinance also requested a recommendation as to whether the partnership between the County and the Port should move forward and, if so, identification of next steps.

The study found that the high moisture content in food waste makes it an undesirable feedstock for MSW to SAF conversion, so this technology would not constitute a food waste diversion alternative. Gasification is the first step in converting MSW to SAF, and raw MSW must be sorted, shredded, and dried before it can be fed directly into a gasifier. The processed material consists mainly of materials with high energy content that can be converted to liquid or gaseous fuels, such as paper, wood waste, cardboard, plastics, and textiles. Only small amounts of food waste and yard waste may be included. A community with a high plastics or paper recycling rate, which removes feedstock from the waste stream, produces MSW with lower energy content and therefore requires more waste to produce a given amount of SAF. In 2035, SAF fuel produced from commercial food waste as feedstock would provide an estimated 0.05 percent of the Seattle-Tacoma International Airport’s 2023 jet fuel needs. In

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[24] Flow controls are legal provisions that allow state and local governments to designate where municipal solid waste and/or recoverable materials are taken for disposal.
[25] 230.10.10 King County Charter [LINK]
[26] Water Research Foundation 2019. Food Waste Co-Digestion at Water Resource Recovery Facilities: Business Case Analysis.
[27] Ordinance 19210 [LINK]
[28] Municipal Solid Waste-to-Fuels Study Summary [LINK]

the report on MSW to SAF conversion, submitted in compliance with Ordinance 19210, Section 107, dated December 2023, the Executive recommended not moving forward on the MSF-to-SAF partnership, but identified several actions the County should take to support further exploration of regional SAF production.[29]

B.4 An analysis from SWD for how it intends to flow control open market organic recyclables for digestion with respect to the current open market system

Authority to control the flow of solid waste does not extend to open-market, commercially generated, source-separated recyclable materials. King County does not have statutory authority to require that commercial recyclable materials, including source-separated organics, be disposed of at a King County solid waste facility.[30]

As noted earlier in this report, the County's lack of authority to flow-control organics thus limits options for the County to directly engage in organics processing and additional diversion of CFW from the landfill, which would ensure feedstock availability.

B.5 An analysis from WTD that evaluates whether the utilization of anaerobic digesters at the South Treatment Plant in Renton for the co-digestion of organics with wastewater solids is likely to impact the designation and value of environmental credits referred to as Renewable Information Numbers ("RINS") attached to the sale of South Plant biomethane, and how any such an impact relates to provisions of the agreement for sale of South Plant biomethane and associated environmental credits

Analysis of Revenue from Renewable Identification Numbers (RINs) [31]

The STP receives revenue based on the sale of RIN credits from EPA's Renewable Fuel Standard (RFS) program.[32] RINs are the currency of the RFS program, and the EPA sets limits each year on the number of RINs that may be sold based on renewable fuel volume targets. The various RIN types are assigned different market values based on fuel pathways for that RIN and are directly tied to the heating value of the fuel that is produced. The main fuel pathways for municipal wastewater treatment plants are via cellulosic biofuel, considered under the applicable codes as either a D3 RIN or a D5 RIN.

D3 RINs are generated from converting biogas at municipal wastewater treatment facility digesters into RNG, and D5 RINs are produced from converting biogas from additional feedstock, such as FWS, into RNG through anaerobic digestion or co-digestion. Co-digestion of FWS and municipal wastewater solids can increase biogas production quantity (as compared to wastewater solids only) due to higher volatile solids reduction and digester solids loading rate.

STP currently receives revenue based on the sale of D3 RINs. If STP were to co-digest FWS and thickened sludge (THS), RNG derived from the scrubbed and dried biogas from FWS feedstock would receive the

[29] Municipal Solid Waste-to-Fuels Study Summary [LINK]

[30] The County can require that commercial organics not be deposited as regular municipal solid waste at any County facility; it can also flow control the residual (non-recyclable) material from organics collected from residences and from organics processing facilities within its solid waste jurisdiction.

[31] Information on RIN impact is from Jacobs 2024. Food Waste Recycling Alternatives Analysis Project. South Treatment Plant Capacity and Condition Assessment

[32] EPA Renewable Fuel Standard Program [LINK]

D5 RIN pricing, while STP would continue to receive D3 RIN revenue from the sale of the portion of the RNG produced from digestion of THS. Based on historical weekly trading data from the EPA, RIN values for D3 and D5 RINs have fluctuated since the inception of the RFS Program.

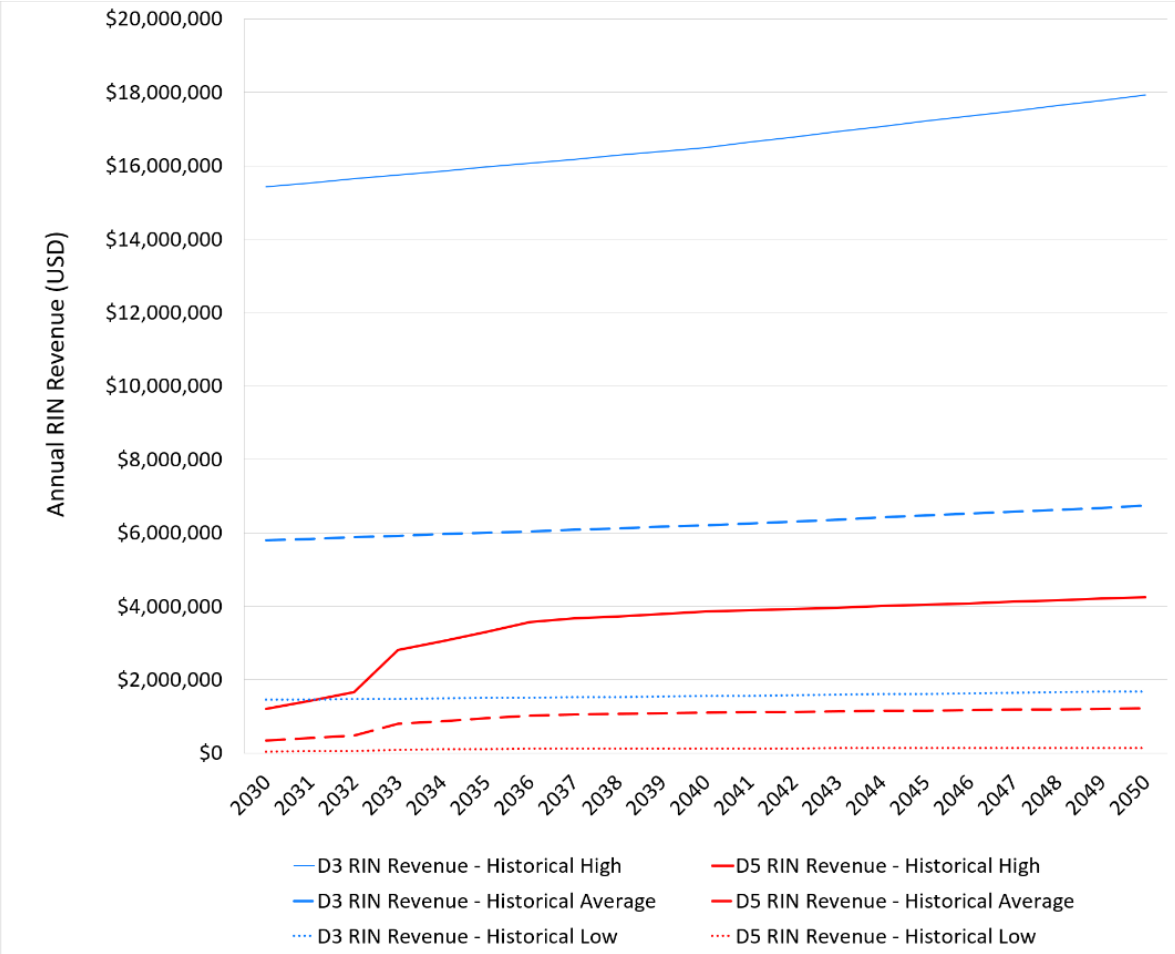
Historical trading data for D5 RINs is available from July 2010 while data for D3 RINs is only available from August 2013. The historical average and current value are as follows:

- D3 RINs (generated from WTD solids):
  - Historical, based on averages from August 26, 2013, to April 22, 2024: $1.88
  - Current, as of August 22, 2024: $3.33

- D5 RINs (would be generated from CFW, if co-digested at STP):
  - Historical, based on averages from July 12, 2010, to April 22, 2024: $0.86.
  - Current, as of August 22, 2024: $0.55

The markets are constantly fluctuating based on many factors, including supply and demand. Projections of annual RIN revenue were developed based on historically low, average, and high RIN values of D3 and D5 RINs and projected annual average STP biogas production, with and without co-digestion of FWS at the STP.

Figure 1. King County STP D3 and D5 RIN Revenue Projections, 2030–2050



Due to the volatility of the RIN trading market, it is important to consider the range of potential revenue for WTD. Probabilistic modeling, a statistical technique used to account for the impact of random events or actions in predicting future outcomes, could be useful to account for the change in various parameters and inputs; these could include seasonality of biogas production, changes in RIN equivalency values, and future changes to the RFS and RIN trading values. Figure 1 displays the range of annual revenue expected based on current RIN equivalency value, as well as each of these historical D3 and D5 RIN values projected over time, with D5 RIN projections showing the range of RIN revenue expected should WTD accept the available FWS for co-digestion at the STP, based on historical trading values. The D3 RIN projections show the range of RIN revenue according to the annual average flow and load projections of THS. D3 RIN revenue is projected to make up the large majority of the revenue; however, based on historical average D3 and D5 RIN trading prices, the D5 RINs have the potential to increase total STP RIN revenue by six percent in 2030 and 18 percent in 2050. Projections are only made to 2050, due to uncertainty of RIN prices and the future of EPA's RFS program.

Limitations on Processing Capacity at South Treatment Plant

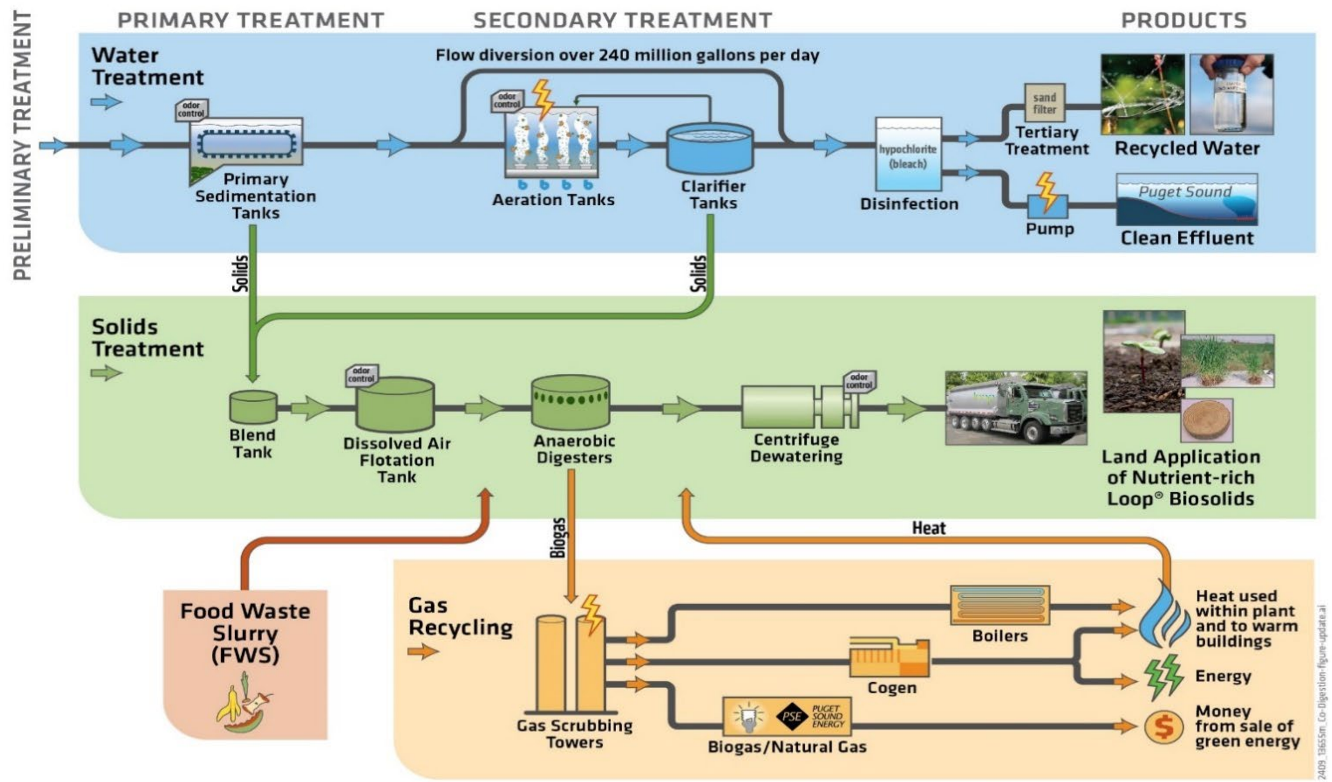
While not specifically requested in the Proviso, the project team evaluated the STP's capability to provide co-digestion by assessing both equipment and capacity. This was necessary because a major basis for the analysis called for in the Proviso is the assumed availability and use of anaerobic digesters at the STP for the co-digestion of organics with wastewater solids.

The STP is designed to treat an average design daily flow rate of 115 million gallons per day (MGD). The plant is rated by the National Pollutant Discharge Elimination System permit to treat maximum monthly flows of up to 144 MGD. From 2014 to 2023, annual average flows at STP were 76.6 MGD and maximum month flows were 124 MGD.[33]

The major treatment processes at STP include preliminary treatment (coarse material screens and grit removal), primary treatment (aerated grit channels and primary sedimentation), secondary treatment (aeration tanks and secondary clarifiers), and sodium hypochlorite (bleach) disinfection. For the solids, treatment includes sludge thickening and blending in separate tanks; four anaerobic digestion tanks with floating covers; one blended-sludge storage tank; three high-solids dewatering centrifuges; and biogas treatment and liquid scrubbing to remove carbon dioxide so the gas can be injected into the natural gas pipeline as RNG.

[33] Information on STP capacity is from Jacobs 2024. Food Waste Recycling Alternatives Analysis Project. South Treatment Plant Capacity and Condition Assessment

Figure 2. STP Process Flow Diagram



The anaerobic digesters utilize gas mixing. The floating covers on the digesters collect gas, gas compressors in the digester control building compress the gas, and the gas is then injected through spargers—a device used to introduce a gas into a liquid medium—to allow for complete mixing. The digesters are heated by hot water to sludge heat exchangers with circulating sludge pumps to maintain temperatures required for mesophilic digestion.[34]

The pre-processed and diluted commercial food waste used as potential feedstock for co-digestion into the anaerobic digesters at STP is referred to as food waste slurry (FWS). Pre-processing consists of screening, de-contaminating, de-packaging, grinding, and blending the food waste to a slurry.

Pre-processing would take place at a facility other than STP due to the lack of available space at STP. Once pre-processed food waste is transported to STP, water would be added to create the FWS. FWS has variable levels of total solids content, volatile solids content, total and soluble chemical oxygen demand, volatile fatty acids, alkalinity, pH, and residual contaminants (glass, plastics, and grit).

Equipment Assessment

The impact on digestion, biogas treatment, and dewatering equipment at STP must be considered when contemplating accepting FWS for co-digestion. Impacts to the King County Biosolids Program and its Loop product must also be considered, including increased biosolids management costs primarily associated with hauling costs for the additional solids generated from the portion of the CFW that is not digested.[35] STP is a large and complex facility with numerous equipment assets of various ages. Co-digestion would place additional stress on existing plant processes and equipment. Critical, aging assets must be identified, replaced, or upgraded to maintain reliable plant operation before implementing co-digestion.

WTD provided asset management reports for digestion, biogas treatment, and dewatering equipment, including useful remaining life. The analysis identified all equipment determined to be nearing the end of its useful life.

The most critical pieces of existing equipment that may require upgrade or replacement within the next several years, regardless of whether co-digestion is implemented, include the following:

- Digestion equipment, including gas compressors, circulation sludge grinders, heat exchangers, sludge withdrawal pumps, and chilled water supply pumps
- Biogas handling equipment, including dryers, water turbines, compressors, final gas delivery dewpoint transmitters, water pumps, and compressor lube oil pumps
- Dewatering equipment, including centrifuge inclined conveyors, four motor control centers, and sludge feed pumps

Capacity Assessment

Digester Capacity

Wastewater treatment plants are designed to treat wastewater based on both the volume of flow conveyed to them and the amount of organic and solids load in the wastewater. The digester capacity

[34] Mesophilic refers to organisms that grow best in moderate temperature; the optimum growth temperature for these organisms is 37 °C.

[35] King County's Biosolids Program Loop product is a fertilizer alternative produced by cleaning, recycling, and transforming wastewater into biosolids used for beneficial reuse land application. The material is transported to several forest and farmland areas in the state.

assessment found that even without the addition of FWS it will be necessary to expand capacity to provide sufficient digestion capability for future influent flow and loading projections attributable to population growth. Digester capacity expansion through addition of a fifth and sixth digester or other digester improvement or intensification options would be necessary to provide sufficient digestion capacity for future flow and loading projections without FWS.

There are approaches other than additional mesophilic digesters that could address capacity constraints, and future planning efforts will determine WTD's plans for digestion capacity. For the purposes of this analysis, it has been assumed that a fifth and sixth mesophilic digester will be constructed by 2035; the fifth tank for capacity and the sixth tank to retain the same level of redundancy capability. If another technology were selected, the timing could differ from that estimate.

Annual food waste tonnages from 2019 to 2023 and food waste projections through 2060 were obtained for this project, but site-specific nutrient content of FWS is not available at this time, so nutrient loading and food waste characterization had to be estimated to calculate the additional amount of nitrogen load on the STP aeration basins that would result from co-digesting FWS.

It is assumed that 2035 is the earliest STP can accept FWS for co-digestion because the anaerobic digestion expansion project would take approximately 10 years to plan, design, and construct. The year 2030 was also considered in the capacity analysis to evaluate impacts to existing infrastructure and processes at STP from the addition of FWS.

The consultant estimated the capacity for the existing digesters plus an assumed digester expansion to accept FWS for co-digestion. For the purposes of this feasibility evaluation, it is assumed that a fifth mesophilic digester would be built to provide solids treatment capacity for future wastewater flows and loads, and for FWS. In addition, to maintain required redundancy (the ability to have one digestion tank off-line in standby mode), a sixth digester would be needed.

Factors that determine digester capacity include the following:

- Volatile solids loading rate (VSLR): The amount of organic material that can be safely and efficiently processed by volume or within a timeframe
- Solids retention time (SRT): the amount of time solids reside in the digester
- Specific energy loading rate (SELR): the ratio of food to microorganisms in the digester. SELR is an important characteristic to check for co-digestion compatibility, as the thickened sludge (concentrated solids from liquid sewage) and FWS have different characteristics.

The capacity of the four and five digesters in operation was evaluated based on the most conservative conditions with regard to VSLR and SRT. SRT, as opposed to VSLR, is the limiting factor for the digestion capacity through the study period of 2055 and is used to determine when additional digesters are needed. Additional considerations for the design of a fifth and sixth digester, and for improvements to increase the capacity of the four existing digesters, include anaerobic digestion enhancement technologies or potential conversion of the existing mesophilic digesters to thermophilic digesters.[36]

[36] Thermophilic refers to organisms that thrive at relatively high temperatures, between 41 and 122 °C.

Biogas Treatment Capacity

The biogas scrubbing system at STP consists of two scrubbing towers, with a combined capacity of two million standard cubic feet per day. Carbon dioxide, water, and impurities are removed from the biogas during the scrubbing process. The scrubbed biogas is then analyzed to confirm quality of the RNG to be sold. Gas that does not meet the RNG specification is flared using one of the three waste gas burners.

The analysis of biogas handling capacity found that, to provide full biogas scrubbing capacity for co-digested, thickened sludge and FWS through at least the design year 2045, and to maximize revenue from RNG, additional biogas scrubbing capacity must be provided or the biogas conditioning system replaced with a new system.

Dewatering Capacity

The three existing dewatering centrifuges were installed in 2005. The digested sludge is injected with polymer, dewatered through centrifuge bowls that rotate at high speeds, and then hauled off site for use in the County's Biosolids Program for beneficial reuse land application. Calculations assume that one centrifuge is maintained on standby at all times (N+1 centrifuges for operational redundancy). To maintain the N+1 redundancy with the increased load from co-digestion with FWS, existing dewatering capacity is sufficient to process annual average flows; however, an additional centrifuge is required to cover peak 14- and 30-day loads to ensure flexible processing capability in design years 2045–2060. STP has the necessary footprint to accommodate the fourth centrifuge. Three existing centrifuges have an expected end-of-life of six to 11 years from 2024, indicating that upgrades to existing equipment will be required before 2045.

Fire Protection Standards

The analysis includes an assessment of existing facilities for compliance with fire protection standards for wastewater treatment and collection facilities issued by the National Fire Protection Association. The digestion facilities, gas handling facilities, and solids handling facilities at STP contain equipment that must be rated for the electrical area classification in accordance these standards. The evaluation describes the existing buildings and structures that will require evaluation and potential upgrades if STP is selected as the site for food waste receiving through co-digestion and waste-to-energy processes.

Potential Risk Posed by PFAS

Per- and polyfluoroalkyl substances (PFAS) are synthetic chemicals with unique properties, which are widely used in various industrial and consumer products. PFAS contamination is an emerging concern and, over recent years, states have been preparing guidance values for wastewater effluent and biosolids products.

For this analysis, the consultant conducted an extensive literature review, including academic papers, articles, and research reports issued over the last 10 years, relating to potential sources of PFAS in digestate resulting from the addition of organic wastes, including PFAS, in food and food waste.[37]

There are more than 12,000 identified chemical varieties of PFAS in production that have been found in the environment since the 1940s. The presence of PFAS in the environment has raised concerns due to

[37] Jacobs 2024. Food Waste Recycling Alternatives Analysis Project. Literature Review of Per- and Polyfluoroalkyl Substances Concentrations in Processed Food Waste Slurry

their persistence, bioaccumulation potential, and potential adverse health effects. Since the 1960s, the U.S. Food and Drug Administration (FDA) has authorized specific types of substances containing PFAS for use in food-contact applications. These substances are valued for their nonstick and grease-, oil-, and water-resistant properties. Authorized uses include nonstick coating applications, sealing gaskets for food processing equipment, and grease-proofers applied to fast-food wrappers, microwave popcorn bags, take-out paperboard containers, and pet food bags.

A recent study by the FDA revealed that over 97 percent of the fresh and processed foods tested did not contain detectable levels of PFAS. However, data indicate that PFAS in U.S. food items purchased from retail stores are primarily found in seafood, followed by meat products.

In a literature review focused on identifying potential sources of PFAS coming into compost sites, food-contact materials and food packaging were reported to have the highest PFAS concentrations across all sources evaluated.

Because the FDA still authorizes certain PFAS for products in contact with food, concentrations in food waste is still a potential concern for source-separated organic feedstock digesting facilities and final biosolids.

Although several individual PFAS can be found in food packaging or food waste, the only compounds under current federal regulation are specific to drinking water. It is anticipated that future regulations could be developed at the federal and state levels for biosolids, soils, wastewater, or receiving waters, but none currently exist at the federal level in the U.S. However, regulations for limiting use and sale of products containing PFAS do exist in some states, including Washington, and are evolving as knowledge of PFAS continues to mature.

The development of effective methods for identification and treatment of PFAS is ongoing. Removing PFAS from biosolids, compost, or soil, or transforming them into benign compounds is anticipated to be complex and involve technologies that have yet to be proven at scale. The only known processes to effectively transform PFAS in biosolids into more benign compounds are pyrolysis and gasification, which are emerging treatment technologies. PFAS air pollution impacts from these technologies are unknown.

PFAS pose concerns due to their persistence, bioaccumulation potential, and potential adverse health effects. Certain feedstocks, such as those containing food packaging, are known to have higher concentrations of PFAS. The risk associated with PFAS contained in CFW could adversely impact the County's Biosolids Program and its Loop product and customers. It is possible that restrictions on the feedstocks used in food packaging, for example, could reduce the amount of PFAS in CFW. However, at this time, due to the lack of site-specific PFAS data and the fact that federal and state guidance and regulation is not yet available, it is not possible to adequately quantify PFAS risk associated with co-digesting CFW at the STP. Recommendations for next steps regarding PFAS risk are provided in the Conclusions section.

B.6. Separate project plans for the WTD and SWD capital projects, or a joint project plan that encompasses both projects. The separate project plans or the joint project plan shall be informed by the public outreach process described in subsection B.1. of this proviso and the analyses required by subsection B.2, 3., and 4 of this proviso. The separate project plans or the joint project plan shall include, but not be limited to, items a-j (below):

As conceived by the project team prior to and during this analysis, project plans for SWD and WTD would be separate. One project from SWD would provide pre-processed CFW to WTD, and the other from WTD would accept and process the food waste for co-digestion with wastewater solids. Due to factors such as the lack of capacity at STP for co-digestion of pre-processed CFW (Section B.5) and the County's lack of flow control authority over commercial recyclable materials, including source-separated organics (Section B.4), there are no project plans included in the Proviso response at this time. As stated in Section B.1, public outreach that would inform a project plan or plans has been deferred while alternative approaches to food waste recycling and beneficial use are still under development.

Proviso items B.6 a-j are addressed in order below under each sub-heading.

B.6 (a) the WTD and SWD analyses on the best use of the commercial organics anticipated to be available as RCW 70A.205.545 is implemented

Under Registered Code of Washington (RCW) 70A.205.545, businesses that generate at least eight cubic yards of organic material waste per week must arrange for organic materials management services.[38] Goals of the law include:

- Reducing the amount of organic materials disposed of in landfills by 75 percent by 2030
- Recovering at least 20 percent of the edible food that was disposed of in 2015 for human consumption by 2025
- Reducing methane emissions, a key strategy to address climate change

The law also supports the compost market and creates opportunities for food waste prevention and recovery. The discussion below covers the consultant's analysis of alternative uses of commercial organics anticipated to be available as the law is implemented.

Initial Alternatives Analysis for Best Use of Commercial Organics

The alternatives analysis was conducted in a series of steps. For initial analysis of alternatives, the project team developed a list of possible processing and beneficial reuse approaches or technologies based on consultation with subject-matter experts in SWD and on the consultant team. The team then applied a fatal-flaw analysis using three pass-fail criteria: excessive costs, unproven technology, or overly complex technological, regulatory, or policy issues. The technologies considered included:

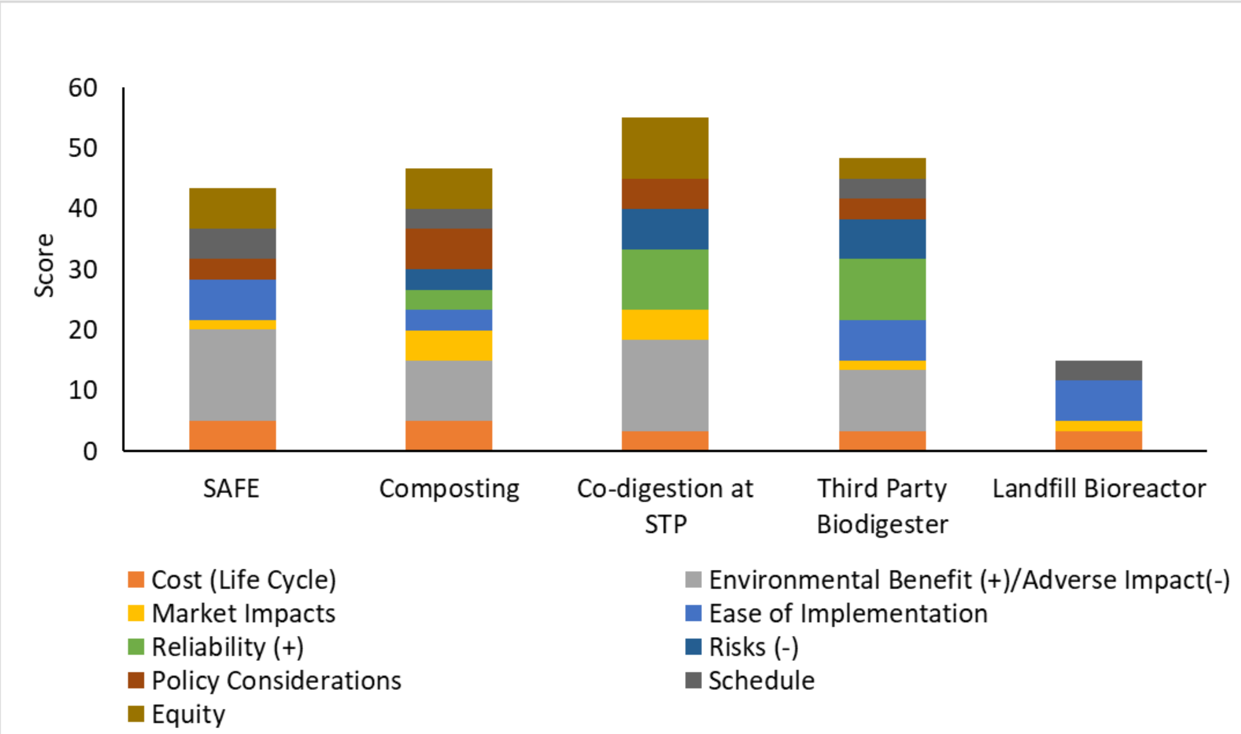
- Direct use of food waste for animal feed, also known as sustainable alternatives feed enterprise (SAFE)

[38] RCW 70A.205.545 [LINK]

- Continued and expanded composting
- Anaerobic Digestion
    - Co-digestion at the STP
    - Third-party bio-digestion
- Landfill bioreactor[39]

The project team developed evaluation criteria and the consultant's expert in decision science created a tool that was used by the team to qualitatively screen these alternatives.

Figure 3. Comparison of Initial Alternatives



The three top-scoring options identified by the project team—composting, co-digestion, and third-party bio-digestion—were carried forward. In addition, the team developed more specific alternatives and sub-alternatives for these three approaches to create more options to consider. The narrative below describes the two types of technology involved in these alternatives—anaerobic digestion and composting—followed by further analysis and identification of detailed sub-alternatives.

Food Waste Processing Technologies

Pre-processing

Selection of the appropriate pre-processing technology remains a key factor in developing any organics treatment process. In general terms, the more nonorganic materials present, the more complicated and expensive the pre-processing system. Conversely, the more pristine the feedstock, the less complicated

[39] A technology whereby an increase in waste degradation is accomplished through the addition of liquid and air to enhance microbial processes.

and expensive the pre-processing system, and the proportionally higher the beneficial use derived from it.[40]

Anaerobic Digestion Technologies

Anaerobic digestion (AD) is the biological decomposition of organic materials in the absence of oxygen under controlled conditions. This is the process employed at the STP and to which co-digestion of food waste could be added. This process reduces the volume of organic materials and produces a biogas (primarily methane and carbon dioxide). The remaining solid material, called biosolids, contains nondigested solids and, depending on the material's moisture content, can be dewatered and land applied, or can be further processed through aerobic composting to produce a soil amendment. AD is commonly used to treat wastewater solids and agricultural sources such as manures; however, it has also been used as a way of treating some portions of the MSW stream.

There are several types of AD technology. Wet systems can be classified further into high- or low-solids systems, based on the percentage of solids in the slurry feedstock. Dry systems process feedstock with solids content high enough to be stacked.

Feedstocks for AD vary according to the type of technology but, in broad terms, they include MSW-derived organics, manure, food waste, and, for some technologies, grass clippings, yard trimmings, brush, and wastewater treatment plant biosolids. Inert materials contained in the digestion feedstock, such as metals, glass, and plastics, are considered contaminants and must be either removed prior to digestion (for wet-type systems) or screened out during or after digestion (for dry-type systems). If the feedstock is below the desired moisture content for the chosen technology type, water is added to the AD system.

As explained above in Digester Capacity (B.3), several factors influence the design and performance of AD. These include the concentration and composition of nutrients in the feedstock, temperature of the AD reactor, retention time of the material in the reactor, volatile solids loading, pH, and volatile acid concentration.

Small-scale Versus Large-scale Systems

Some small-scale AD systems are being tested in agricultural and trial urban settings. [41] These small-scale systems can completely eliminate waste hauling when sited at the generator location. Thus, the single greatest advantage of small-scale systems is the avoidance of expensive collection and transport. Other advantages include local resilience in the form of energy independence, emergency response and disaster preparedness, local food production, and job creation. Beneficial use of the digestate is also usually local and small in scale. Small-scale systems are typically associated with localized circular economies that minimize trucking in and out of a community. The drawbacks of small-scale systems include the relative lack of economies of scale on an individual basis, the requirement for customization of the digestion technology to the specific feedstock, and the requirement for operational staff to support the operations and maintenance of the distributed facilities.

Economies of scale tend to favor large regional or centralized facilities because costs decrease as production increases. There has been a recent increase in the use of AD technologies for regional waste processing at commercial-scale plants in North America, including New York City, Los Angeles, and

[40] Information on technologies is from HDR 2024. Food Waste Processing Technologies and Regional Options
[41] HDR 2024. Food Waste Processing Technologies and Regional Options

Boston, all of which have been co-digesting source-separated organics from centralized pre-processing systems owned and operated by WM. [42] Larger facilities have to incorporate strategies to mitigate odor impact; the odor is typically not from the digestion process itself, but in the waste receiving, pre-processing, and post-processing operations.

Composting

Food waste can be blended into yard waste at certain proportions and managed through composting. Optimal blends of feedstock can result in more rapid decomposition based on the higher nutrient content of the food waste and generate a higher-quality finished product. Several types of composting technologies are available. The main established types of composting technology for CFW can be categorized as either turned windrow or forced aeration. [43]

Odor emissions from the aerobic composting of food waste can be significant, as it can be difficult to keep the windrow consistently aerobic through proper moisture and airflow. Food wastes typically contain proteins at much higher quantities than yard waste. The microbial degradation of proteins can naturally produce vinegars, ammonia, and trace quantities of methane. These emissions are typically more objectionable than the odors associated with yard waste composting. As in yard waste composting, odor emissions are more pronounced when windrow turning occurs because the turning process aerates the material, releasing organic-rich air within the pile. Furthermore, if porosity is not maintained, the blended food waste and yard waste material can more quickly convert to an anaerobic process, resulting in extremely unpleasant odor emissions. Although composting food waste with yard waste can be prone to produce odorous emissions, these odors can be minimized through good operational practices that maintain an aerobic condition throughout the active compost.

Contamination levels in commercial food waste can vary greatly depending on the source and whether the waste is pre-consumer or post-consumer waste. The amount of contamination will affect the pre-processing system chosen for the facility. Pre-processing can be located at the composting facility or at a separate collection or transfer site.

Each of the composting technologies performs well. Selection of the appropriate composting method depends on the condition of the feedstock, the available land, proximity to neighbors or sensitive receptors, and long-term operability for the quantity and quality of material committed to the facility.

Beneficial Use Analysis

In October 2023, the EPA released the Wasted Food Scale, accompanied by a report investigating and ranking the 11 common pathways for wasted food from most to least environmentally preferable.[44] The EPA report ranks composting and AD equally, contingent on the beneficial use of digestate or biosolids from AD through land application.

Both composting and anaerobic digestion produce material that can be applied to land as soil amendments, benefiting soil and plant health. However, the production of biogas, the additional byproduct of AD, places AD slightly above composting due to its potential to reduce the dependence on

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[42] HDR 2024. Food Waste Processing Technologies and Regional Options

[43] Windrows are long, narrow rows of organic material roughly twice as wide as they are high and as long as space allows, which can be turned periodically or have perforated pipes underneath them to allow air flow.

[44] EPA 2023. From Field to Bin: The Environmental Impacts of US Food Waste Pathway [LINK]

fossil fuels for energy. If the digestate and biosolids from anaerobic digestion are not applied to land, composting becomes the preferred pathway.

Refinement of Alternatives

Following the initial alternatives analysis that used the nine screening criteria shown in Figure 3, the analysis conducted by the project team carried forward the composting, co-digestion, and third-party bio-digestion alternatives and more specific alternatives and sub-alternatives were developed. These alternatives are summarized below.

- **Alternative 1: *Co-Digestion at STP***
  - **1a:** Pre-processing at County-owned site operated by third party; co-digestion at STP
  - **1b:** Pre-processing at third-party owned and operated site; co-digestion at STP
- **Alternative 2: *Composting***
  - **2a:** Pre-processing at County-owned site, operated by third party; composting at third-party centralized location
  - **2b**: Pre-processing at third-party owned and operated site composting at third-party centralized location
- **Alternative 3: *Third Party Bio-Digester***
  - **3a:** Pre-processing at County-owned site operated by third party; digestion at third-party site
  - **3b:** Pre-processing at third-party owned and operated site; digestion at third-party site

In July 2024, a workshop was convened among members of the project team and stakeholders from SWD and WTD (Workshop 1) to qualitatively score and rank these alternatives. Based on the results from the workshop and subsequent follow-up discussions, the alternatives were characterized as shown in Table 1.

Table 1. Alternatives Advanced Based on Workshop 1 Input

Alternative	Pre-processing	Processing	Status
1a	Pre-processing at County-owned site operated by third party	Co-Digestion at South Plant	**Carried forward to business case evaluation**
1b	Pre-processing at third-party owned and operated site	Co-Digestion at South Plant	**Carried forward to business case evaluation**
2a	Pre-processing at County-owned site operated by third party	Composting at third-party centralized location	**Dropped – assumed pre-processing will continue to be conducted by composters**
2b	Pre-processing (for composting) at third-party owned and operated site	Composting at third-party centralized location	**Current approach. Carried forward to business case evaluation and redefined as Alternative 2**
3a	Pre-processing at County-owned site operated by third party	Digestion at third-party site	**Not included in business case evaluation, but recommended for continued monitoring and further evaluation in the future**
3b	Pre-processing at third-party owned and operated site	Digestion at third-party site	

Regarding Alternative 3, according to ongoing research and market analysis by the project consultant, digestion at a third-party site is a quickly evolving market. While there was not sufficient information available to the project team for a complete business case evaluation or non-monetary evaluation, this area is evolving quickly and should be continuously monitored. For example, there is currently no commercial-sized, third-party digestion system in the region accepting CFW slurry. However, Cedar Grove is actively working on bringing bio-digestion into its organics processing methods with the addition of a new 100,000 ton-per-year bio-digester mentioned in Section B.1. Unfortunately, Cedar Grove will not be ready to share more information about this until 2025 and, therefore, the project team was not able to fully evaluate it for this study.

As additional information becomes available about the actual future quantity and quality of feedstock available as HB 1799 is implemented, additional investigation into potential partnerships supporting Cedar Grove or other third-party bio-digesters may become more feasible. The project team recommended that SWD continue to monitor the development of third-party bio-digestion systems and pursue potential partnerships or other related opportunities. This recommendation is included in the next steps outlined in Section B.6(j).

B.6 (b) the business case for the county providing justification for the county's investment in the WTD and SWD capital projects

The business case evaluation (BCE) for the selected alternatives is comprised of a monetary assessment and a non-monetary assessment, and is applied to these alternatives:

- **Alternative 1: *Co-Digestion at STP***
    - **1a:** Pre-processing at County-owned site operated by third party; co-digestion at STP
    - **1b:** Pre-processing at site owned and operated by third party; co-digestion at STP
- **Alternative 2: *Composting***
    - **2b**: Pre-processing at third-party owned and operated site; composting at third-party centralized location

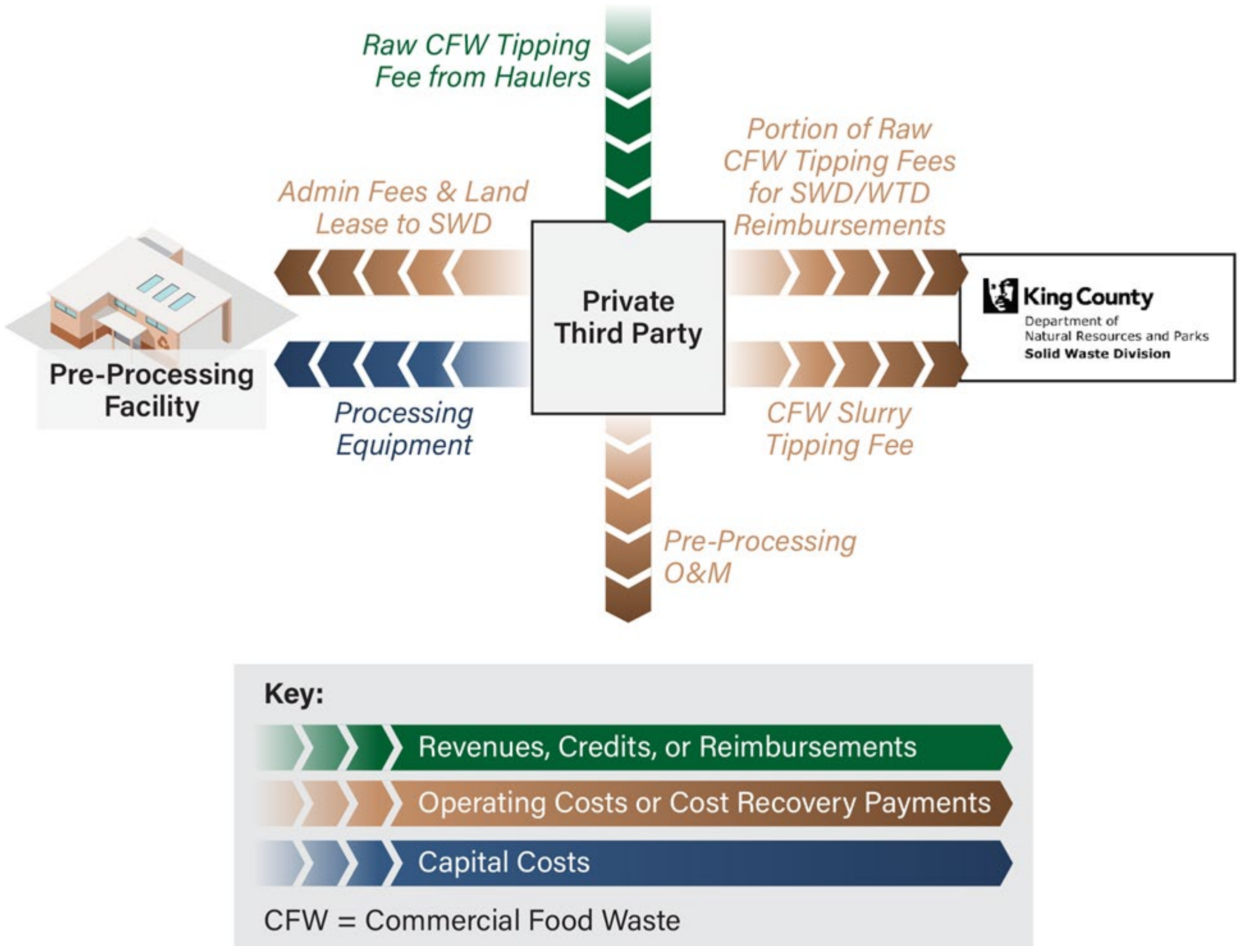
The information below is a conceptual approach used for the purpose of economic assessment. WTD and SWD will need to prepare a cost-of-service analysis and propose a related cost recovery structure to ensure required reimbursements for facilities, capacity, and ongoing operations dedicated to food waste processing versus wastewater infrastructure. This is further discussed in Section B.6(i).

Monetary and Economic Assessment

Third-party Pre-processor under Alternative 1a

The cash flow for third-party operator of the pre-processing facility under Alternative 1a is assumed to be as shown in Figure 4.

Figure 4. Cash Flow, Alternative 1a Pre-processing



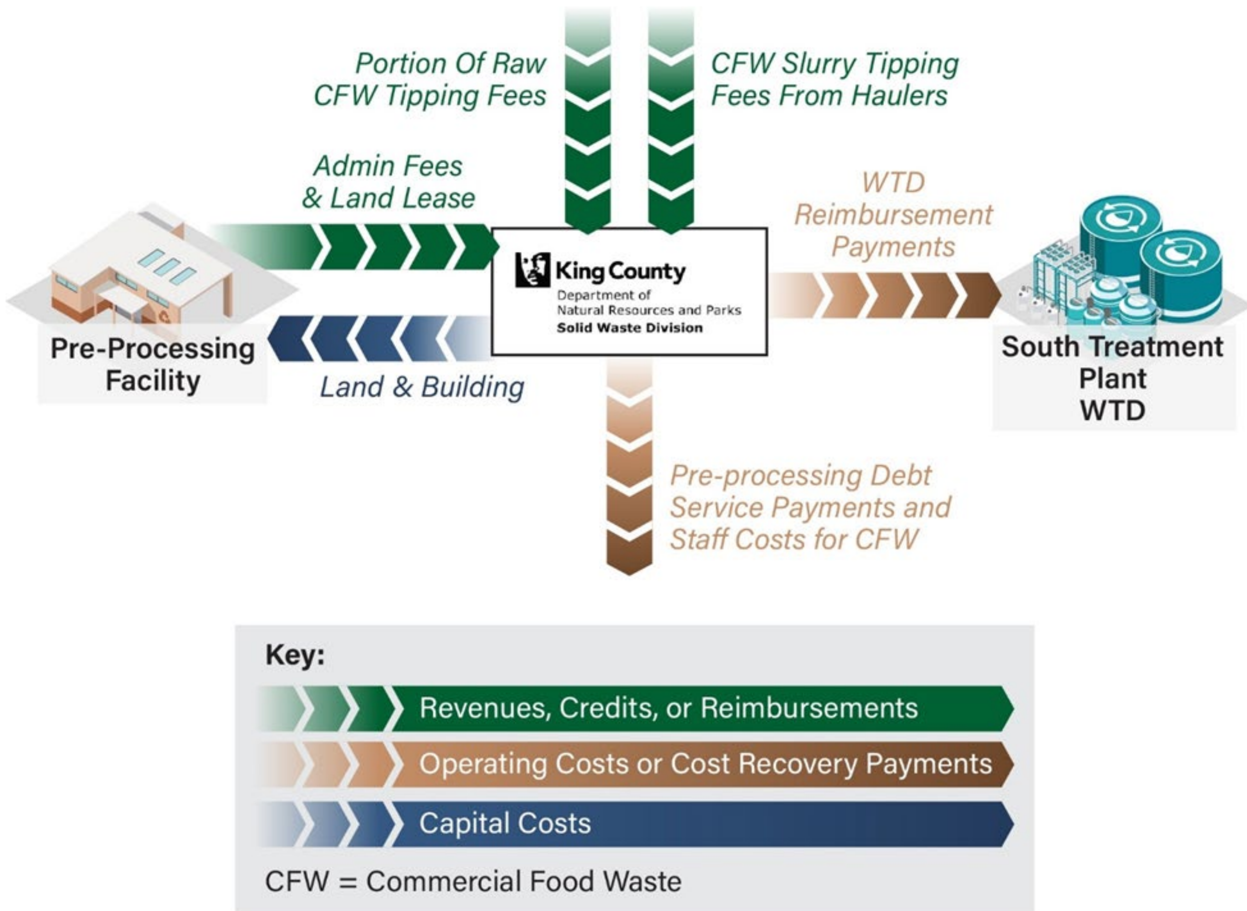
In this economic assessment, it is assumed that raw CFW revenue passes from a hauler to the third-party operator of the pre-processing facility. Costs paid by the third party would be as follows:

- Raw CFW tipping fees: Paid by the haulers and used to pay the following costs and reimbursements.
    - Administration and land fees: paid to SWD for hosting and administering the operating services agreement between the third-party operator and King County
    - Processing equipment: third party's debt service for processing equipment installed into the pre-processing
- CFW slurry tipping fees: paid to SWD for receiving the material at STP
- Pre-processing operations and maintenance (O&M) costs

SWD under Alternative 1a Co-digestion

The cash flow for SWD co-digestion at STP under Alternative 1a is assumed to be as follows:

Figure 5. SWD Cash Flow, Alternative 1a Co-Digestion



SWD would receive revenue as follows:

- Administrative fees and land lease: paid by the third-party pre-processing facility operator to SWD
- CFW slurry tipping fees: paid by the haulers and third-party pre-processing facility operator to SWD

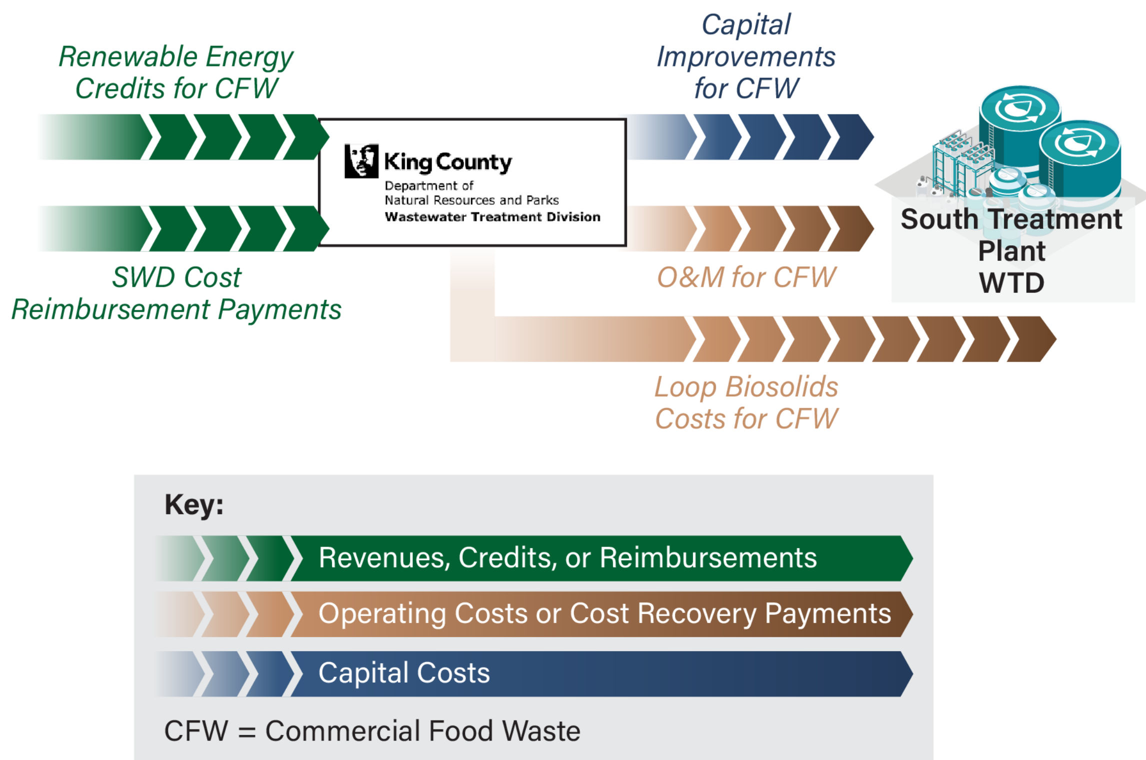
SWD would use these revenues to pay the following costs and reimbursements:

- Pre-processing capital cost: SWD's debt service for the land and building shell for the pre-processing facility
- Pre-processing O&M: SWD's administrative staff costs for hosting the pre-processing facility and managing the contract with the third party.

WTD under Alternatives 1a and 1b Co-digestion

The cash flow for WTD co-digestion at STP under Alternatives 1a and 1b are as follows:

Figure 6. WTD Cash Flow, Alternative 1a and 1b Co-Digestion



The costs for co-digestion incurred by WTD at the STP to accommodate CFW are as follows:

- STP O&M: additional O&M costs incurred by WTD at the STP to receive and digest the CFW slurry, treat the resulting biogas to be utilized for either RNG or CHP, and dewater the additional digested solids generated by the CFW slurry
- King County Biosolids Program: additional costs for land application of the additional solids generated by the CFW slurry (not digested)

Two sub-alternative approaches for use of the biogas resulting under co-digestion were considered in the business case analysis: RNG, which has been utilized by WTD for many years, and combined heat and power (CHP), which is a more speculative approach. The EPA does not currently have an approved pathway for generators of renewable electricity to monetize renewable electricity through the RFS program via electricity RINs (eRINs).

- Monetization of the renewable energy generated from the portion of the biogas (derived from CFW, not STP wastewater solids);
  - RNG (similar to current WTD program for D-3 RINs generated by STP wastewater solids):
    - Gas commodity value: paid by PSE to WTD

        - EPA RFS D-5 RINs: paid to WTD, likely through an off-take agreement similar to the way WTD has received payment for D-3 RINs
        - WA Clean Fuels Standard (CFS): paid to WTD through process similar to federal RFS program
    - CHP (speculative regarding ability to generate revenue from EPA RFS program):
        - Electricity commodity value: paid by PSE to WTD via new net-metering agreement
        - EPA RFS D-5 eRINs: paid to WTD, assuming EPA is able to develop and obtain approval for eRIN pathway before 2035
        - WA CFS: paid to WTD through process similar to federal RFS program
        - Heating value benefit: heat recovered from CHP process is utilized to heat anaerobic digesters and offset PSE natural gas purchases

Based on the assumptions above, the capital costs, annual O&M costs, and annual revenues over the 20-year life cycle of the project (2035 to 2055) are shown in Table 2.

Table 2. CFW Expenditures (2024 dollars)

Description	Alternative 1a - Pre-Processing + CFW Receiving Station + Digestion + Gas Conditioning		Alternative 1b - Pre-Processing + CFW Receiving Station + Digestion + Gas Conditioning	
	RNG	CHP	RNG	CHP
Estimated CFW Costs ($ Millions):				
Capital Investment Cost	**138**	**132**	**138**	**132**
County capital cost	115	109	75	68
Third-party capital cost	23	23	64	64
Annual Net Costs	**-17**	**-17**	**-18**	**-18**
Annual debt service for total capital[a,b]	-9	-9	-10	-10
Annual O&M costs[a]	-8	-8	-8	-8
Annual Revenues Requirement[a]	**17**	**17**	**18**	**18**
Annual renewable energy revenues[a]	2	4	2	4
Revenue requirement recovered from tipping fee[a]	15	13	16	14

Notes:

CFW - Commercial food waste

a. Annual values are the average over the life-cycle analysis study period (2035 to 2055)

b. An interest rate of 5% was used for the County and an interest rate of 7% was used for third party in debt service calculations

All costs correspond to high-diversion scenario for CFW

All costs are rounded to nearest $M

Table 3 below shows the estimated CFW tipping fees needed to recover costs for pre-processing and WTD treatment related to CFW. For purposes of comparison with Alternative 2 (composting): regional composters charge a tipping fee of approximately $75 per ton. Tipping fees for options 1a and 1b are double this amount or more, making it difficult to secure feedstock.

Table 3. Tipping Fees Required to Reimburse County for CFW Expenditures (2024 dollars)

Description	Alternative 1a - Pre-Processing + CFW Receiving Station + Digestion + Gas Conditioning		Alternative 1b - Pre-Processing + CFW Receiving Station + Digestion + Gas Conditioning	
	RNG	CHP	RNG	CHP
Raw CFW tipping fees to recover pre-processing cost, $/wet ton	$101.14	$101.14	$108.40	$108.40
CFW slurry tipping fees to recover WTD cost, $/wet ton[a]	$75.58	$48.11	$75.58	$48.12
All-inclusive, combined CFW tipping fees, $/wet ton	**$176.72**	**$149.25**	**$183.98**	**$156.52**
Notes:				
CFW - Commercial food waste				
All costs correspond to high-diversion scenario for CFW				
a. Equivalent $/gallon is $0.32 for RNG and $0.20 for CHP				

Non-Monetary Assessment

Risk

Detailed risk registers were developed for the short list of alternatives to help guide and score the non-monetary assessment of risk.

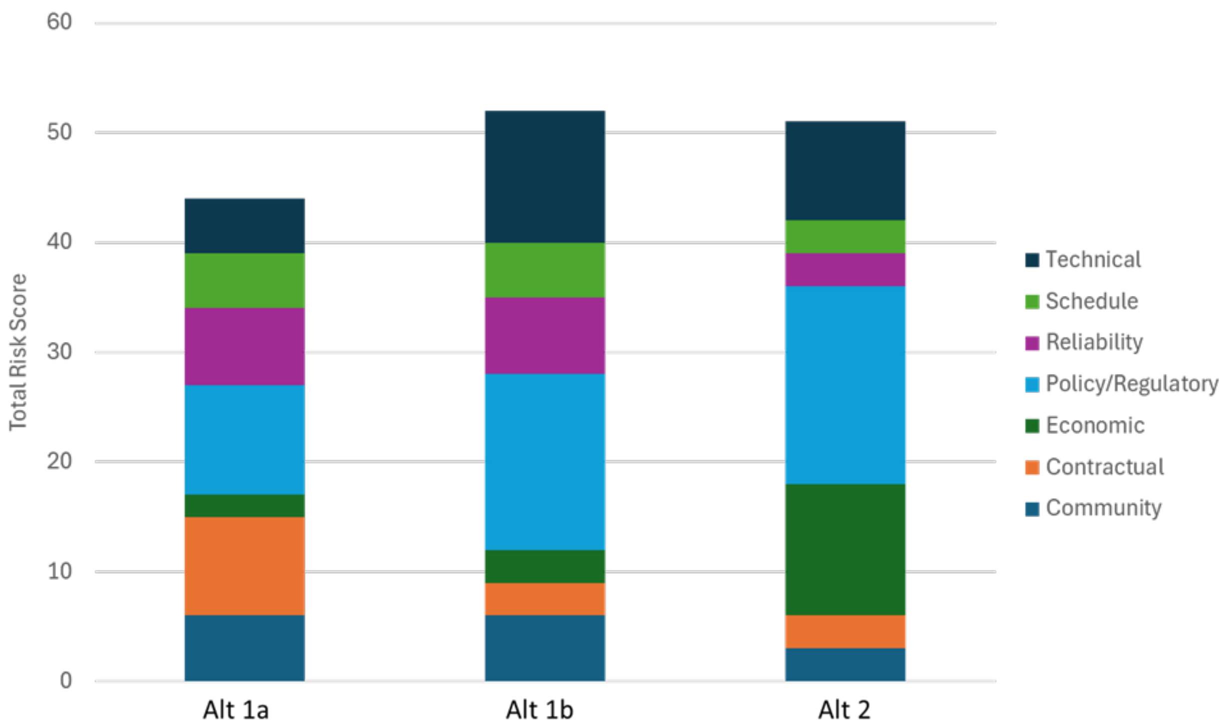
For SWD, examples of risks include:

- quantity and quality of food waste diversion (technical)
- lack of flow control and regulatory enforcement (policy and regulatory)
- agreements with third parties (contractual)
- ability to adapt to changing waste streams (reliability)
- market capacity and competition (economic)
- implementation timing (schedule), and
- community acceptance (community).

Many of these risks, such as quantity and quality of food waste feedstock, also apply to WTD. Other risks considered that are specific to WTD include nutrient removal and future potential PFAS regulations. In this assessment, higher scores indicate higher risks.

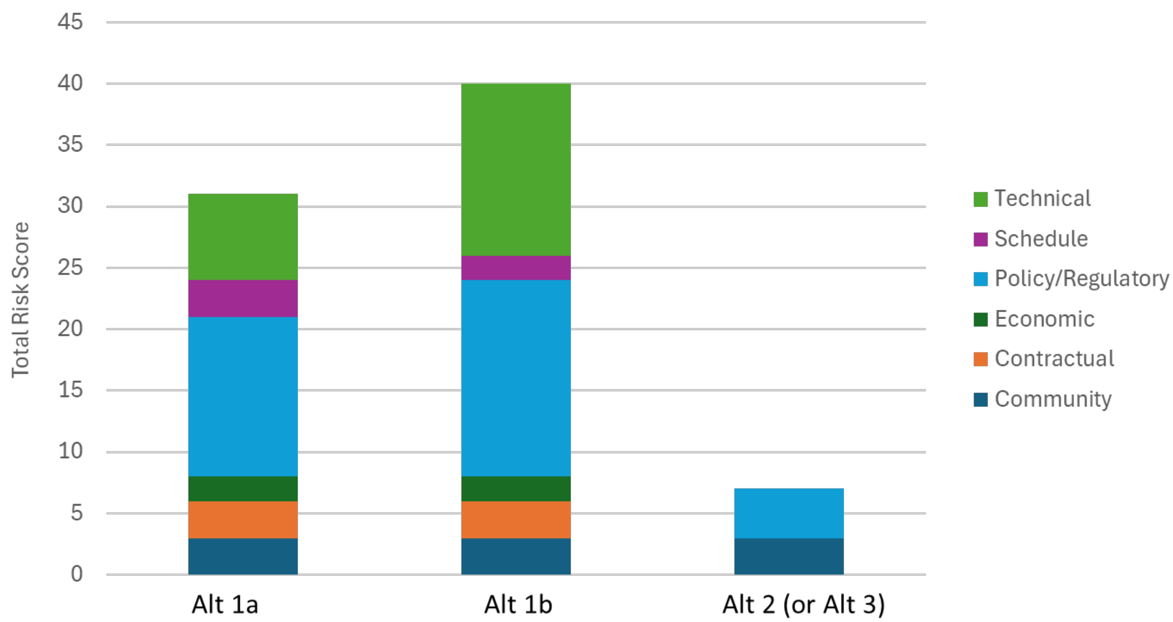
Risk scores for SWD, shown in Figure 7, indicate that Alternative 1b has the highest risk, followed by Alternative 2, and Alternative 1a has the lowest risk. Although not shown, risk for Alternative 3, third-party bio-digester, was estimated to be higher. This is due to the lack of flow control for SWD, and the risk associated with a third party taking on a significant investment without flow control, which has led to the failure of several bio-digester projects across the U.S.

Figure 7. Risk Scores for SWD



Risk scores for WTD, shown in Figure 8, indicate that Alternative 1b has the highest risk, followed by Alternative 1a, and that Alternative 2 has a much lower risk profile than either of the options under Alternative 1. It is assumed that for Alternatives 2 and 3, WTD would have limited involvement and the risk scores for both would be low.

Figure 8. Risk Scores for WTD



Non-Monetary Scores:

Each alternative was evaluated against eight non-monetary criteria specific to SWD and WTD. These included:

- consideration of greenhouse gas emissions and contribution to meeting County energy goals (environmental benefit)
- impacts to existing food waste handling businesses (market impacts)
- complexity of implementation and O&M needs (ease of implementation).

Weights were assigned by the project team to each criterion based on relative importance and then each alternative was scored, with a higher evaluation score representing a comparatively better alternative. The results informed the team's decision on the recommended approach. The non-monetary scores for SWD are shown in Figure 9 and scores for WTD in Figure 10.

Figure 9. Non-Monetary Scores for SWD

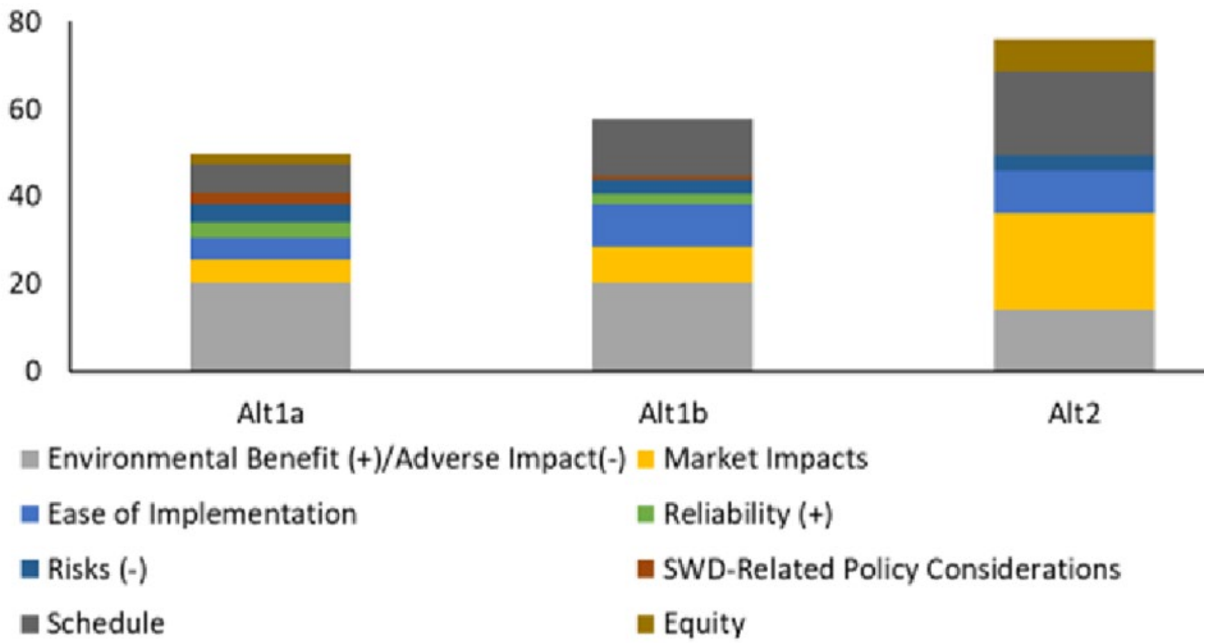
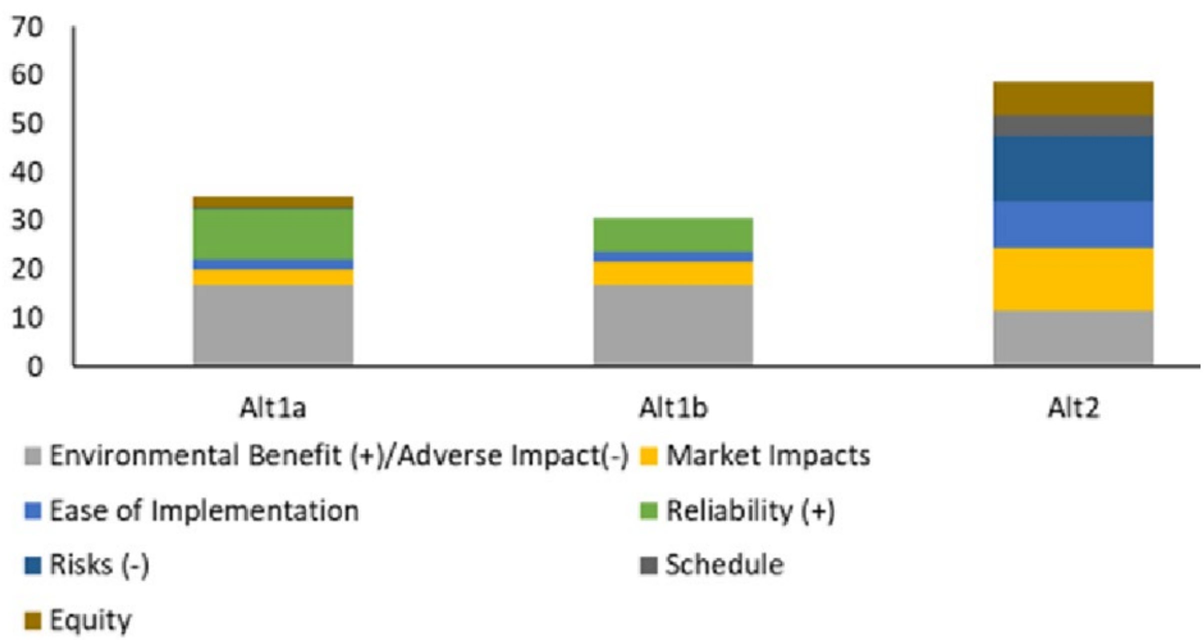


Figure 10. Non-Monetary Scores for WTD



SWD Business Case

For SWD, Alternative 2, continued and expanded composting, has the highest non-monetary score and no direct capital outlay costs or additional annual operating costs for CFW pre-processing. However, with this approach comes less control and, therefore, higher risk that there will be insufficient CFW processing capacity and insufficient diversion from the landfill. There is also risk of future capacity constraints.

Alternative 1b has the second highest non-monetary score, requires that SWD collect reimbursement monies and distribute to WTD for co-digestion at STP (see WTD Business Case, below), and has the highest risk. Due to the high degree of risk to SWD, further cost-recovery analysis would be needed to explore the implications and economic feasibility of this approach.

Alternative 1a has a non-monetary score slightly lower than Alternative 1b, would directly incur the costs to develop the CFW pre-processing facility site, and must reimburse WTD for co-digestion at STP. However, Alternative 1a has the highest probability to successfully add CFW processing capacity and divert CFW away from the landfill.

Both 1a and 1b have significant price risk associated with them because the fee to collect CFW at the pre-processing facility could be more than double the current cost to compost food waste. This makes it difficult to ensure there is enough feedstock for processing.

Alternative 3, third-party bio-digestion—focused on processing CFW as opposed to other feedstocks, such as manure from dairies—is not currently available in the Puget Sound region and therefore no business case evaluation was developed for this approach; however, one of the composting companies is evaluating the addition of a bio-digestion system for the purpose of processing food waste.

It is anticipated that, without flow control of CFW or more certainty associated with CFW quantity and quality, the risk of Alternative 3a would be higher than Alternative 2 if the third party is a new entity that is not currently composting in King County; this is due to the lack of certainty of food waste feedstocks and lack of certainty that the system could continue to operate without having a stable source of revenue. However, if the third-party bio-digester is integrated into an existing composting facility, these risks would be somewhat lower because this vertically integrated enterprise would have more flexibility to route received materials to either co-digestion or composting. SWD should continue to research and evaluate third-party organics processing capacity developments and pursue potential partnerships or other related opportunities.

WTD Business Case

For WTD, as for SWD, Alternative 2 has the highest non-monetary score and no direct capital outlay costs or additional annual operating costs. From the perspective of WTD, the non-monetary score and costs would be the same for Alternative 2 and Alternative 3, third-party bio-digestion, if a third party were to successfully implement this solution. Alternative 2 has a much lower risk score relative to Alternatives 1a and 1b, primarily because STP would not be receiving any CFW.

Alternative 1b has the lowest non-monetary score and the highest risk for WTD and does not provide any economic advantage compared with Alternative 1a. However, each of these sub-alternatives was carried forward for further analysis. WTD would prepare a cost-of-service analysis and propose a related cost-recovery structure to ensure the SWD Enterprise Fund fully reimbursed the Water Quality Enterprise Fund for facilities, capacity, and ongoing operations dedicated to food waste processing, so that WTD could demonstrate compliance with the sewage disposal contracts and eligible costs to recover from the contract agencies through the sewer rate.

A sensitivity analysis concluded that Alternative 1a could potentially be more economically attractive to the County if CHP were pursued over RNG. The potential benefits of CHP at the STP are speculative at this time and both the federal tax credit for renewable electricity projects and the federal renewable energy credits for electricity (eRINs) need to be tracked by the County over the next several years.

B.6 (c) whether the SWD capital project will be operated by a third party or SWD, as well as the justification supporting the selected operator choice

If Alternative 1, co-digestion, were to be pursued, DNRP recommends Alternative 1a, pre-processing at a County-owned site operated by a third party, with co-digestion at STP, over Alternative 1b, pre-processing at third-party owned and operated site, with co-digestion at STP. The pre-processing equipment is complex, unique, and better suited to third-party operation; SWD does not currently have staff expertise to operate a pre-processing facility. Under Alternative 1a, SWD would issue a request for proposals from the market to identify the operator providing the best qualifications and value for the project. More detailed information is provided in section B.6(j), which discusses conclusions and next steps.

B.6 (d) whether land acquisition will be needed to site the SWD capital project or whether existing county-owned land such as the Renton Recycling and Transfer Station will be used

DNRP determined that a site for pre-processing should be zoned for industrial or manufacturing use; comprise a minimum of approximately three to four acres of developable land; allow for siting of a 20,000 square-foot building; have access to water; and be located in an area that accommodates heavy truck traffic. The four options for locating the facility included an existing SWD facility, surplus County-owned land, and properties owned by other entities.

SWD's Bow Lake Recycling and Transfer Station was evaluated and found to be infeasible because there is no space inside the current facility big enough to house the pre-processing facility. Outside the building, potentially available areas are already being used, are planned for other uses, or are not big enough.

Redevelopment of SWD's Renton Recycling and Transfer Station is being analyzed under a separate project. The project team is examining ideas for repurposing the site to help accelerate the County's goals to support healthy, thriving communities in a waste-free King County. Previous internal analysis suggests that a pre-processing facility could be viable at this site, but no decision will be made regarding use of the site while SWD continues to engage with the City of Renton and surrounding communities.

A survey of 10 surplus, County-owned sites did not identify any site suitable for organics pre-processing, due either to size or zoning.

King County Department of Executive Services real property staff conducted an analysis of the industrial real estate market in south King County, which is typically less expensive than other areas of the county, and provided ranges for rent, land, taxes, insurance, and maintenance cost based on current market rates. They identified multiple property types with existing structures or vacant land that would likely be suitable for a pre-processing facility. Based on this information, a placeholder of $2 million was utilized in the business case evaluation for Alternative 1a for SWD to acquire a suitable piece of land to host the facility.

B.6 (e) how the feedstock will be secured for the SWD capital project and whether acceptance of organics will be limited to the SWD service area. If acceptance of organics will not be limited to the SWD service area, the separate project plan for the SWD capital project or the joint project plan shall include a plan for mitigating the potential that the SWD capital project would be supported by revenues from county disposal feepayers but used by nonfeepayers

Securing Feedstock/Food Waste Availability

When discussing food waste availability, it should be noted that, as explained in section B.4, Flow Control in Open Market, King County does not currently have the authority to flow-control disposal of commercial source-separated recycling, including organics.

The following food waste availability analysis is summarized from a technical memorandum provided by the consultant.[45] The amount of commercial food waste generated in King County that is currently being source-separated, picked up by haulers, and diverted from the landfill can be estimated using a combination of hauler data and waste characterization studies. The 2019 to 2023 hauler data were used to calculate the quantity of commercial (nonresidential) organics currently being collected by haulers in King County (excluding Seattle and Milton) and diverted from landfill. The 2019 to 2023 hauler data was specifically sorted for nonresidential (generator type) and organics (tonnage type) to identify commercial food waste tonnage.

A material characterization report was used to calculate the composition of edible food waste, nonedible food waste, compostable packaging, and noncompostable contaminants within commercial food waste in King County.

During the past five years, the total commercial food waste diversion in King County has fluctuated between 6,000 and 8,000 tons annually and has increased approximately 9 percent within that time period. Table 4 shows the top 10 King County jurisdictions currently collecting and diverting commercial food waste.

[45] Jacobs 2024. Food Waste Recycling Alternatives Analysis Project. Food Waste Material Estimates.

Table 4. Top 10 Jurisdictions Recovering Commercial Food Waste

Rank	Jurisdiction	Recovered Commercial Food Waste[a]					
		5-Year Total (tons)	2019 (tons)	2020 (tons)	2021 (tons)	2022 (tons)	2023 (tons)
1	Redmond	5,289	1,584	1,045	876	799	986
2	Issaquah	3,322	860	618	654	489	701
3	Bothell	3,121	630	568	713	574	636
4	Shoreline	2,658	328	541	596	463	729
5	Burien	2,630	439	586	517	493	595
6	Kirkland	2,107	510	358	407	441	392
7	Bellevue	2,033	491	496	404	309	334
8	Mercer Island	1,853	107	449	458	390	449
9	Auburn	1,757	319	313	368	360	398
10	SeaTac	1,411	346	224	264	250	327
11-40	All others[b]	8,664	1,378	1,591	1,914	1,804	1,976
All	**Total**	34,847	6,991	6,789	7,171	6,373	7,523

[a] Commercial food waste tons represent edible food, nonedible food, and compostable packaging as well as an estimated 12 percent non-compostable contaminants

[b] All other jurisdictions and respective commercial food waste recovered

The estimated quantities of commercial food waste currently available and available during the planning horizon are based on waste characterization studies, hauler data, and Re+ forecasts.

Cascadia Consulting Group conducted and documented a commercial food waste analysis in 2022. The study used existing waste characterization studies and available data on employee counts to estimate which industries within King County (excluding Seattle or Milton) generate the most food waste, and how much and of what composition each industry generates. King County generates about 122,182 tons of food waste per year, and, of that amount, the restaurant sector and other services sector are responsible for 36 percent and 26 percent, respectively.

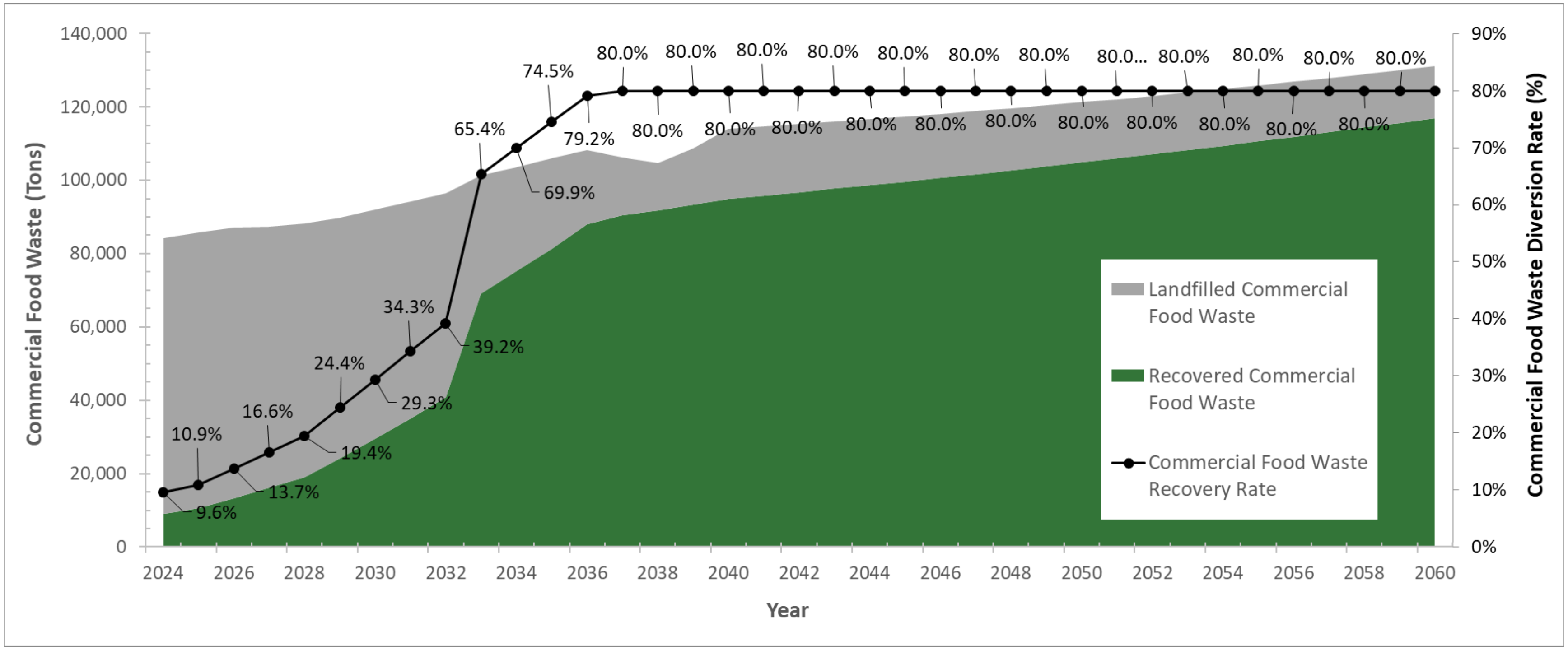
These estimates represent the highest-case scenario of food waste generation within King County, as it assumes all potential food waste generators are producing food waste. A more conservative estimate provided by King County Re+ data was used to calculate the commercial food waste recovery rate. King County has prepared waste projections associated with the Re+ Plan and related programs. Re+ data were evaluated to identify the volume of commercial food waste currently landfilled that would become available for landfill diversion and potential processing as a result of Re+ actions. In this evaluation, commercial, nonresidential data was used along with the material categories of edible food, nonedible food, and compostable packaging to comprise "commercial food waste."

In addition, noncompostable contaminants were estimated to calculate the total commercial food waste tonnage for pre-processing and collection considerations. Noncompostable contaminants represent metal, plastic, glass, noncompostable paper, and other materials that may be present in commercial food waste collection bins and are removed during a pre-processing step prior to co-digestion.

High-, medium-, and low-diversion scenarios for commercial food waste were calculated using Re+ data as a reference and modified, as described below. For the alternatives analysis for this project, design tons are based on the high-diversion-scenario, 2045 commercial food waste estimates.

The high-diversion scenario described below for commercial food waste tonnage and used for this analysis reflects Re+ projections and reaches the established maximum recovery rate of 80 percent in 2037 (Figure 11).

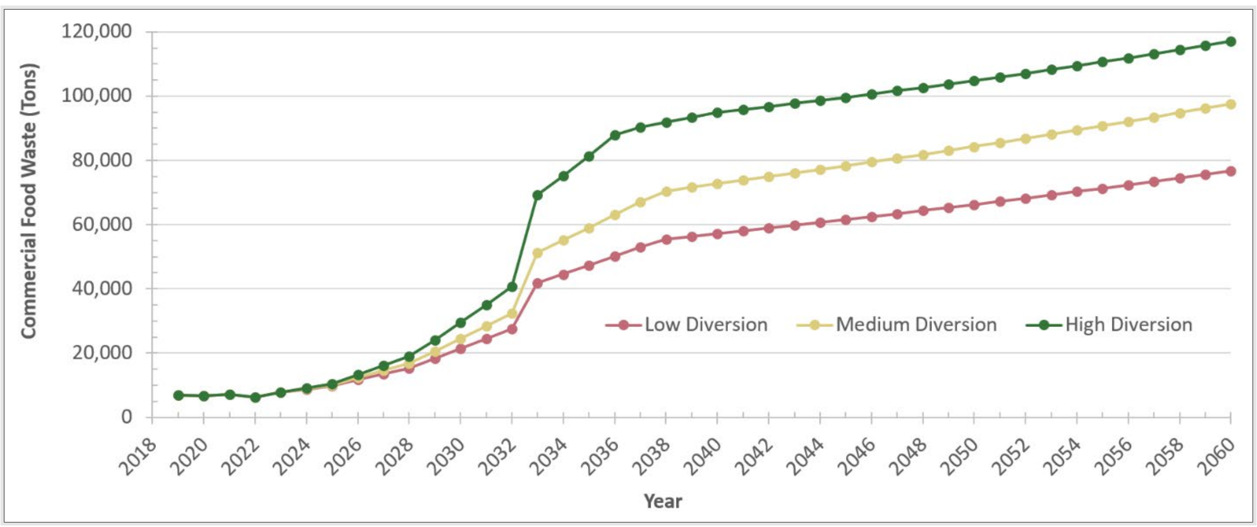
Figure 11. High-Diversion Scenario Project Commercial Food Waste Generation and Recovery Rate



The high-diversion scenario follows Re+ diversion projection and caps commercial food waste diversion at 80 percent of the total generated. In addition, from 2040 to 2060, generation and diversion of commercial food waste would increase by 1.4826 percent each year. In design year 2045 of the high-impact scenario, 100,000 tons of commercial food waste is estimated to be diverted from the landfill (80 percent recovery rate).

To gain the complete picture of the estimated quantity of commercial food waste that could be collected in the future, the projected hauler data for 2019-2023 and projected Re+ data for 2024-2040 were combined and then a 1.4826 percent growth factor was applied for the years 2041-2060 (Figure 12).

Figure 12. High-, Medium-, and Low-Diversion Scenarios for Commercial Food Waste



SWD is currently looking at approaches to incorporate mixed-waste processing (MWP) into its system. The large increase in commercial food waste tonnage occurring between 2032 and 2033 is associated with an MWP facility becoming operational and diverting organic materials for co-digestion or third-party bio-digestion.[46] The feasibility to incorporate MWP facility-diverted organic material into commercial food waste projections will continue to be evaluated. The quantity of organic materials from MWP will depend on the MWP technology used. For example, the GreenWaste Recovery Facility in San Jose, CA, is designed to recover 75 percent of organic material that is received in the MSW stream. This facility is the only High Diversion Organic Waste Processing Facility in California recognized by CalRecycle.[47] The lack of additional recognized facilities is an indication that organic waste sorting technologies are underdeveloped but will likely continue to improve.

[46] Mixed waste processing facilities sort municipal solid waste which has not been separated by the consumer or waste generator.

[47] CalRecycle is a state agency overseeing recycling and waste management initiatives.

Service Area

The alternatives analysis assumed that King County is most interested in the material within its boundaries and that this approach had the highest potential to effect change. The county generates significant quantities of CFW, which is also largely processed within the county. While other locations utilize some of this processing capacity, the analysis focused on understanding the county context. Within the lifetime of this planning horizon there were enough unknowns that looking at organics generated in the county was deemed the most appropriate for this study.

Feepayers versus Nonfeepayers

Because organics would be collected and processed in King County, there would be no impacts to feepayers from providing services to nonfeepayers and thus no need for mitigation.

B.6 (f) whether all, a portion or none, of the pre-processed organics at the SWD capital project will go to the WTD capital project and a plan for how any pre-processed materials would be transported to the WTD capital project, as well as any supporting analysis

If SWD were to host a pre-processing facility, the plan would be for the County or a third party to enter into a long-term agreement with a third-party hauler to bring its collected organics to the pre-processing facility, from which all of the pre-processed material would be transported via trailer truck to the STP for co-digestion.

A review by the project consultant of six co-digestion facilities across the U.S., drawn from a report on food co-digestion, found that CFW haulers are typically also the food waste pre-processing entity. Depending on the market, some co-digestion facilities have long-term agreements for feedstock sourcing. Those facilities that did not were close to multiple food waste or other feedstock generators.[48]

B.6.(g) a plan from WTD for mitigating any risks resulting from the impacts identified in the evaluation provided for in subsection B.4. of this proviso related to potential changes in RINS classifications resulting from utilization of WTD's South Plant digesters for co-digesting organics

Due to recent changes in EPA policy, no risk is anticipated from the potential changes in RINs classifications. RNG produced from *cellulosic* feedstock (municipal biosolids, landfill gas, agricultural waste, and separated MSW) typically qualifies for D3 RINs, while RNG produced from *non-cellulosic* feedstocks (food and other organic waste) can qualify for lower-value D5 RINs. Historically, if D3- and D5-eligible feedstocks were co-digested, the biogas produced was only eligible to generate D5 RINs. However, in June 2023, the EPA approved a methodology allowing for co-digestion of D3 and D5 feedstocks, meaning that King County could add food waste to its digesters currently processing municipal biosolids and generate both D3 and D5 RINs. Therefore, STP could earn the full value of the RNG. No mitigation would be necessary because co-digesting organics would not impact the existing D3 RINS classification for RNG produced by municipal biosolids.

[48] Water Research Foundation 2019. Food Waste Co-Digestion at Water Resource Recovery Facilities: Business Case Analysis.

B.6.(h) updated estimated capital and operating costs for both the WTD and SWD capital projects with any assumptions in the cost estimates clearly articulated;

This section presents the results of the monetary assessment conducted by the consultant. It provides a cost estimate as well as the assumptions on which the estimate is based. This information is also included in Section B.6(b), as part of the basis for the business case.

The assessment was conducted for these alternatives:

- **Alternative 1: *Co-Digestion at STP***
  - **1a:** Pre-processing at County-owned site operated by third party; co-digestion at STP
  - **1b:** Pre-processing at site owned and operated by third party; co-digestion at STP
- **Alternative 2: *Composting***
  - **2b**: Pre-processing at third-party owned and operated site; composting at third-party centralized location

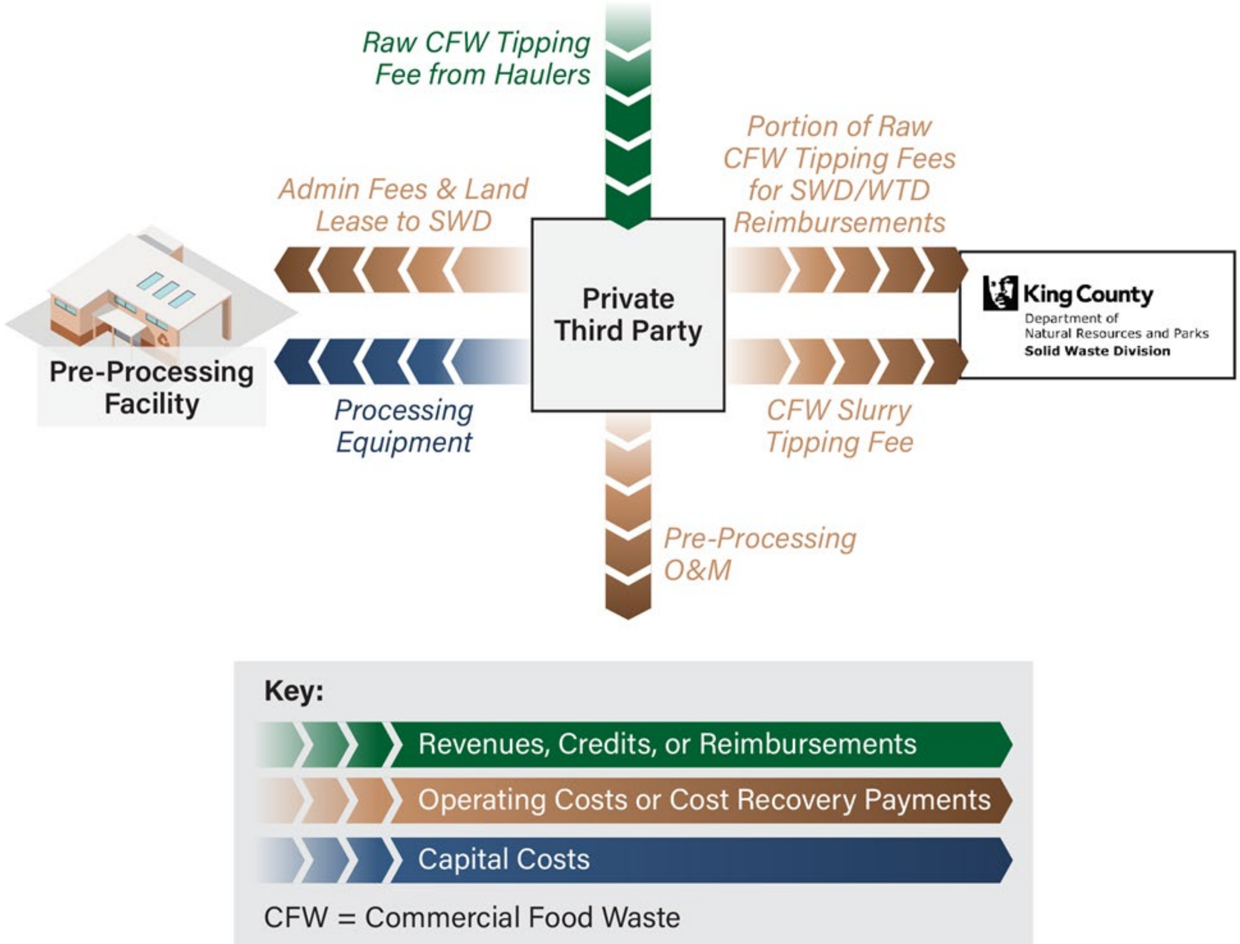
The information below is a conceptual approach used by the project team for the purpose of economic assessment. WTD and SWD will need to prepare a cost-of-service analysis and propose a related cost recovery structure to ensure required reimbursements for facilities, capacity, and ongoing operations dedicated to food waste processing versus wastewater infrastructure. This is further discussed in Section B.6(i).

Monetary and Economic Assessment

Third-party Pre-processor under Alternative 1a

The cash flow for third-party operator of the pre-processing facility under Alternative 1a is assumed to be as shown in Figure 13.

Figure 13. Cash Flow, Alternative 1a Pre-processing



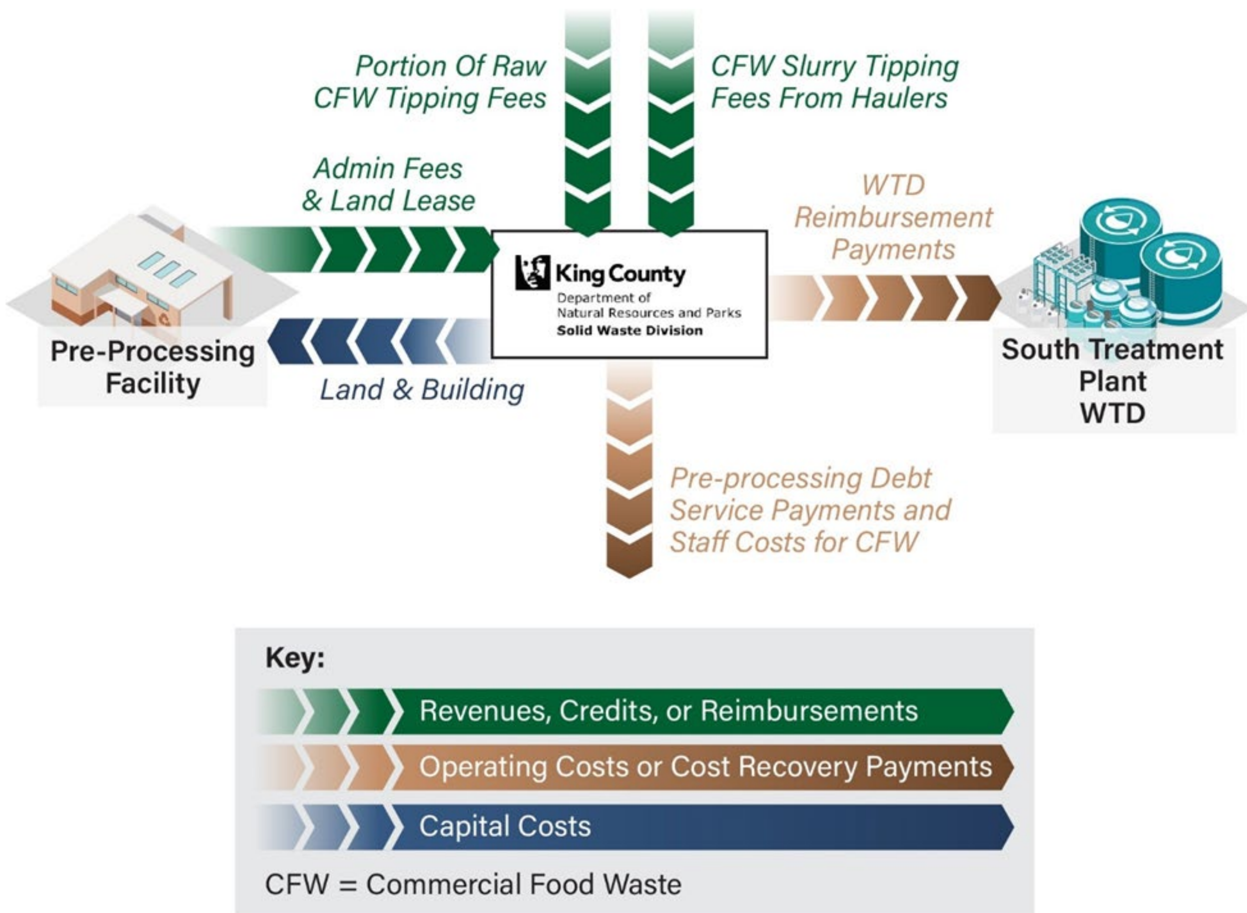
In this economic assessment, it is assumed that raw CFW revenue passes from a hauler to the third-party operator of the pre-processing facility. Costs paid by the third party would be as follows:

- Raw CFW tipping fees: Paid by the haulers and used to pay the following costs and reimbursements.
  - Administration and land fees: paid to SWD for hosting and administering the operating services agreement between the third-party operator and KC
  - Processing equipment: third party's debt service for processing equipment installed into the pre-processing
- CFW slurry tipping fees: paid to SWD for receiving the material at STP
- Pre-processing operations and maintenance (O&M) costs

SWD under Alternative 1a Co-digestion

The cash flow for SWD co-digestion at STP under Alternative 1a is assumed to be as follows:

Figure 14. SWD Cash Flow, Alternative 1a Co-Digestion



SWD would receive revenue as follows:

- Administrative fees and land lease: paid by the third-party pre-processing facility operator to SWD
- CFW slurry tipping fees: paid by the haulers and third-party pre-processing facility operator to SWD

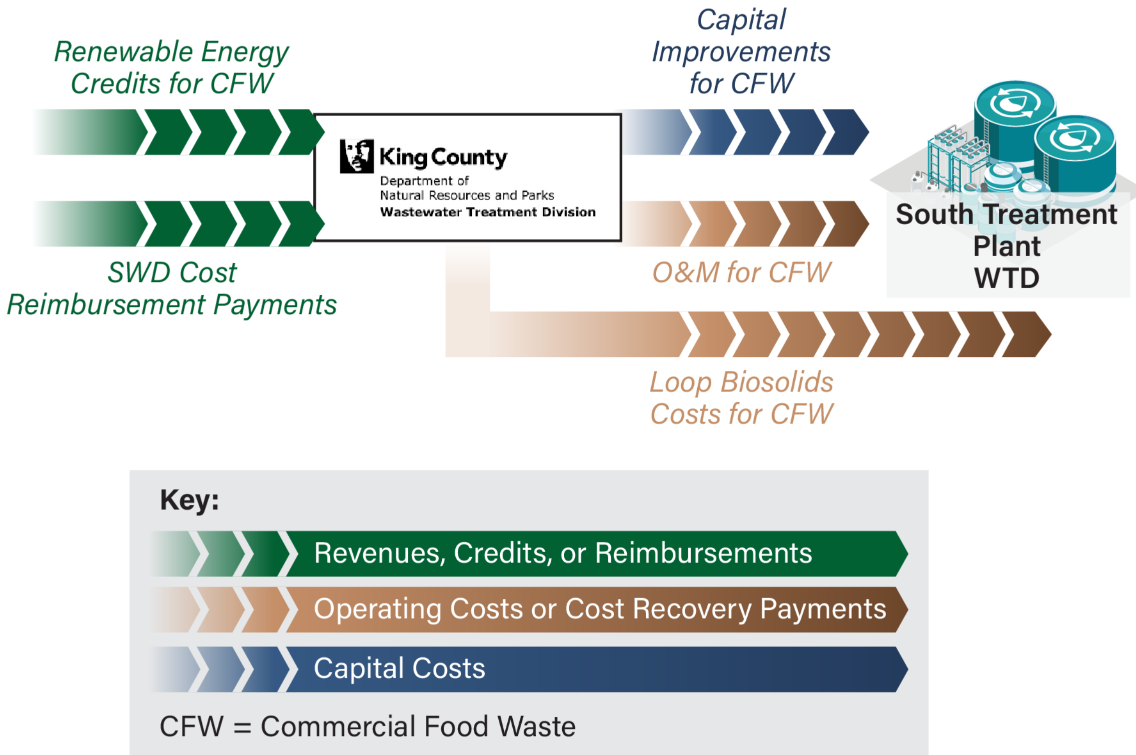
SWD would use these revenues to pay the following costs and reimbursements:

- Pre-processing capital cost: SWD's debt service for the land and building shell for the pre-processing facility
- Pre-processing O&M: SWD's administrative staff costs for hosting the pre-processing facility and managing the contract with the third party.

WTD under Alternatives 1a and 1b Co-digestion

The cash flow for WTD co-digestion at STP under Alternatives 1a and 1b are as follows:

Figure 15. WTD Cash Flow, Alternative 1a and 1b Co-Digestion



The costs for co-digestion incurred by WTD at the STP to accommodate CFW are as follows:

- STP O&M: additional O&M costs incurred by WTD at the STP to receive and digest the CFW slurry, treat the resulting biogas to be utilized for either RNG or CHP, and dewater the additional digested solids generated by the CFW slurry
- King County Biosolids Program: additional costs for land application of the additional solids generated by the CFW slurry (not digested)

Two sub-alternative approaches for use of the biogas resulting under co-digestion were considered in the business case analysis: RNG, which has been utilized by WTD for many years, and combined heat and power (CHP), which is a more speculative approach. The EPA does not currently have an approved pathway for generators of renewable electricity to monetize renewable electricity through the RFS program via electricity RINs (eRINs).

- Monetization of the renewable energy generated from the portion of the biogas (derived from CFW, not STP wastewater solids);
    - RNG (similar to current WTD program for D-3 RINs generated by STP wastewater solids):
        - Gas commodity value: paid by PSE to WTD
        - EPA RFS D-5 RINs: paid to WTD, likely through an off-take agreement similar to the way WTD has received payment for D-3 RINs

        - WA Clean Fuels Standard (CFS): paid to WTD through process similar to federal RFS program
    - CHP (speculative regarding ability to generate revenue from EPA RFS program):
        - Electricity commodity value: paid by PSE to WTD via new net-metering agreement
        - EPA RFS D-5 eRINs: paid to WTD, assuming EPA is able to develop and obtain approval for eRIN pathway before 2035
        - WA CFS: paid to WTD through process similar to federal RFS program
        - Heating value benefit: heat recovered from CHP process is utilized to heat anaerobic digesters and offset PSE natural gas purchases

Based on the assumptions above, the capital costs, annual O&M costs, and annual revenues over the 20-year life cycle of the project (2035 to 2055) are shown in Table 5.

Table 5. CFW Expenditures (2024 dollars)

Description	Alternative 1a - Pre-Processing + CFW Receiving Station + Digestion + Gas Conditioning		Alternative 1b - Pre-Processing + CFW Receiving Station + Digestion + Gas Conditioning	
	RNG	**CHP**	**RNG**	**CHP**
Estimated CFW Costs ($ Millions):				
Capital Investment Cost	**138**	**132**	**138**	**132**
County capital cost	115	109	75	68
Third-party capital cost	23	23	64	64
Annual Net Costs	**-17**	**-17**	**-18**	**-18**
Annual debt service for total capital[a,b]	-9	-9	-10	-10
Annual O&M costs[a]	-8	-8	-8	-8
Annual Revenues Requirement[a]	**17**	**17**	**18**	**18**
Annual renewable energy revenues[a]	2	4	2	4
Revenue requirement recovered from tipping fee[a]	15	13	16	14

Notes:
CFW - Commercial food waste
a. Annual values are the average over the life-cycle analysis study period (2035 to 2055)
b. An interest rate of 5% was used for the County and an interest rate of 7% was used for third party in debt service calculations
All costs correspond to high-diversion scenario for CFW
All costs are rounded to nearest $M

Table 6 below shows the estimated CFW tipping fees needed to recover costs for pre-processing and WTD treatment related to CFW. For purposes of comparison with Alternative 2 (composting): regional composters charge a tipping fee of approximately $75.00 per ton. Tipping fees for options 1a and 1b are double this amount or more, making it difficult to secure feedstock.

Both 1a and 1b have significant price risk associated with them because the fee to collect CFW at the pre-processing facility could be more than double the current cost to compost food waste. This makes it difficult to ensure there is enough feedstock for processing.

Table 6. Tipping Fees Required to Reimburse County for CFW Expenditures (2024 dollars)

Description	Alternative 1a - Pre-Processing + CFW Receiving Station + Digestion + Gas Conditioning		Alternative 1b - Pre-Processing + CFW Receiving Station + Digestion + Gas Conditioning	
	RNG	CHP	RNG	CHP
Raw CFW tipping fees to recover pre-processing cost, $/wet ton	$101.14	$101.14	$108.40	$108.40
CFW slurry tipping fees to recover WTD cost, $/wet ton[a]	$75.58	$48.11	$75.58	$48.12
All-inclusive, combined CFW tipping fees, $/wet ton	**$176.72**	**$149.25**	**$183.98**	**$156.52**

Notes:
CFW - Commercial food waste
All costs correspond to high-diversion scenario for CFW
a. Equivalent $/gallon is $0.32 for RNG and $0.20 for CHP

B.6 (i) a description of any proposed cost recovery or cost sharing arrangements for the WTD capital project and SWD capital project; and

Capital investments for food waste processing would be expected to include projects that serve both direct food waste processing services (i.e., a receiving station) and investments in sewer treatment plant capacity for food waste processing, over and above the capacity being planned and built to serve sewer customers.

WTD could potentially finance capacity investments to the sewer system that would include both capacity for wastewater service and marginal capacity for food waste processing for the SWD. WTD would own the asset and therefore provide the initial financing of the new capacity, contingent upon a cost recovery agreement being in place. This would ensure WTD rate payers do not fund the capacity that will be in use by SWD and that SWD would be responsible for any stranded capacity if the business model were to change.

SWD could directly fund the facilities required only to serve the selected food waste processing alternative, although these might also be initially financed by WTD and then included in the cost-recovery structure. WTD and SWD would prepare a cost-of-service analysis and propose a related cost-recovery structure that takes into account revenues generated from the sales of gas and associated RINs. For example, if financed by WTD, WTD would want to ensure the SWD Enterprise Fund fully reimbursed the Water Quality Enterprise Fund for facilities, capacity, and ongoing operations dedicated to food waste processing after accounting for revenues, so that WTD could demonstrate compliance with the sewage disposal contracts and eligible costs to recover from the contract agencies through the sewer rate.

The following assumptions were used in developing the life-cycle analysis for both SWD and WTD:

For the pre-processing facility:

Alternative 1a and 1b:

- SWD would retain land/facility lease payments or administrative fees collected from a third-party operator of a pre-processing facility, if applicable (Alternative 1a)
- Third party to design and build the equipment portion of the pre-processing to be recovered through utilizing a portion of the raw CFW tipping fees
- Third-party ongoing operating costs would be offset by a portion of the raw CFW tipping fees
- The raw CFW tipping fees would be paid by the cities' haulers to the pre-processor; this revenue would be distributed to attain CFW cost reimbursement (see Section B.6.(b))

Alternative 1b:
Funding/financing the construction and ongoing operating costs for a pre-processing facility developed by others would have to be paid back/supported by the generators of the CFW via tipping fees for receiving the raw CFW.

For STP co-digestion:

- Capital costs to install co-digestion at the STP: converted into debt service and WTD would be reimbursed by SWD via cost reimbursement payments
- CFW slurry tipping fees: collected by SWD from haulers; SWD would pay a portion of this to WTD to ensure revenue neutrality/cost reimbursement to WTD for costs incurred for accommodating CFW. The remainder retained by SWD to reimburse SWD for CFW pre-processing costs
- CFW tipping fees: WTD would receive and retain tipping fees from haulers contracted by the cities and/or the operator of the pre-processing facility for receiving the CFW slurry at the STP

Renewable energy credits: If WTD were to receive payment for renewable energy credits, such as additional RIN payments resulting from digesting CFW slurry, this revenue would be retained by WTD and subtracted from the total of the annual debt service for capital investments and annual operating costs incurred for accommodating CFW resulting in the net cost reimbursement amount.

B.6 (j) next steps for both the WTD and SWD capital projects that include a high-level timeline with significant project actions and milestones

DNRP concluded that it is not feasible to immediately develop a CFW pre-processing facility or co-digestion at the STP. However, DNRP recommends that the County should proceed with next steps outlined in this section to help determine the most feasible and effective approach to food waste reduction and diversion, including evaluating third-party organics processing developments and pursuing potential partnerships and other opportunities.

For SWD and WTD, the fact that the County does not have flow control for commercially generated organics and, more specifically, CFW, poses unmitigated risk. Pricing is a further risk, in that the fee to collect CFW at the pre-processing facility could be more than double the current cost to compost food waste. Moreover, HB 1799 has been slow to implement; there is the potential for the law to be modified or further guidance to come from the state legislature, and details regarding implementation and enforcement have yet to be clarified. There may not be enough additional CFW of appropriate quality to justify new processing capacity for some time. For WTD, the unclear risk associated with PFAS loadings from CFW, which could, in turn, adversely impact the County's Biosolids Program and its Loop product and customers, precludes a full commitment to co-digestion at this time.

Further investigation is needed to mitigate or better define these risks. DNRP recommends proceeding with specific activities and action items to better quantify the risks and revisit the County's role in accelerating organics diversion efforts. Preliminary steps for the pre-processing facility and co-digestion could proceed in parallel with the risk investigation, with "off-ramps" if the risks were better defined and/or deemed to be too high. For the time being, composting is well established in the Puget Sound region and food waste should continue to be composted.

Dairy digesters are not currently interested in receiving CFW feedstocks, and Divert, a company developing a biodigester facility in Longview, prefers to work directly with generators of CFW rather than organics collectors.

One of the major composters does have plans to add a 100,000-ton-per-year bio-digester to its system. This would reduce concerns about reaching composting permitting limits in the future and offer an alternative way to process organics in the future.

The risk of action must be weighed against the risk of a less proactive approach that relies only on existing and expanded composting in the Puget Sound region for the diversion of organics from the landfill.

Findings Pertaining to SWD

- SWD's lack of authority to flow-control commercially generated organics limits options for the County to directly engage in organics processing and additional diversion of CFW from the landfill. Instead, the County must fully explore partnerships with jurisdictions that already have contracted relationships with commercial food waste generators, for example through municipal contracts, and with private entities with access to commercial food waste generators.

- Composting continues to be a viable option with capacity to support the region into the early 2030s. Until new, reliable processing technologies develop, composting will continue to be the primary means of diverting CFW from the landfill. Both Alternatives 1a and 1b have significant price risk because the fee to collect CFW at the pre-processing facility could be more than double the current cost to compost food waste.

- The region will need more processing capacity in the 2030s or earlier if feedstock currently hauled out of the county returns to be processed within the county, or if the material coming from outside the county that is being processed in-county grows.

Findings Pertaining to WTD

- The STP cannot currently accept CFW slurry for co-digestion nor commit to accepting CFW slurry in future years due to inadequate anaerobic digestion and RNG processing capacity and lack of a

CFW receiving station at the STP; these facilities may not be available at the STP until 2035. There is also uncertainty regarding potential risk from PFAS contamination in CFW.

- Development of a co-digestion facility would involve a lengthy planning and development schedule and is not a decision that could be implemented quickly. Preliminary steps to further this alternative should continue, with "off-ramps," so that there is enough time to implement a project if additional information collected during the next steps determines that this a viable pathway.

Next Steps

The next steps and approximate timelines outlined below are recommended by DNRP to King County based on this alternatives analysis study.

Next Steps for SWD

- Continue efforts to prevent and divert food waste – *ongoing*
  - Maximize Re+ actions related to food waste diversion and contamination reduction in the collected CFW stream
  - Increase efforts to promote food waste prevention and food donation
- Continue to coordinate with WTD staff to track their progress on next steps discussed below – *ongoing*
- Continue to research and evaluate third-party organics processing capacity developments and pursue potential partnerships or other related opportunities
- Continue assessment of options for securing feedstock, which is critical both for the viability of co-digestion at the STP and to attract any additional third parties that might develop a bio-digester system focused on processing CFW in the region – *assess every year, with next assessment in 2025*
- Proceed with developing a pre-processing project with "off-ramps," depending on flow control developments, the outcomes of third-party composting and bio-digester expansion and development in the region, cost-of-service findings, and PFAS risk findings – *estimated eight-year effort, initiate planning in 2025*
  - If "off-ramps" above not taken by either SWD or WTD, proceed with land acquisition for pre-processing site – *2026-2027*
- Consider and pursue a pilot project to explore whether a third party can consistently produce a CFW slurry that could be co-digested at the STP or processed in a third-party bio-digestion system- *2025- 2026*
- Consider a pilot project to explore the quality and quantity of organics that may be produced in a mixed waste processing facility – *2025-2026*
- Continue to track organics diversion; if actual quantities differ from projections, the strategy will require reassessment and adjustment – *ongoing*
- Conduct cost of service study and gain more in-depth understanding of the financing expectations and preferred processes for SWD and WTD - *estimated two-year effort beginning in 2025*
- Partner with cities and haulers to develop a CFW PFAS data baseline – *estimated three-year effort beginning now through 2027*

- Pursue funding opportunities (e.g., Sustainable Food Management Priorities, HB 2301, Waste Material Management)[49]– *ongoing, annual effort until or unless "off-ramps" are taken by SWD and/or WTD*
- Explore King County's role in the current policy framework, e.g., how updating local or state codes could help to secure feed stock

Next Steps for WTD

- Include co-digestion as potential additive alternate in digestion expansion planning, with "off-ramps" – *Planning for STP digester capacity expansion set to begin in 2027*
- Continue to coordinate with SWD staff to track its progress on next steps - *ongoing*
- Prepare a cost-of-service analysis and propose a related cost-recovery structure, in coordination with SWD, if co-digestion were to be implemented at STP. Consider other mechanisms that may be feasible for funding this project- *estimated two-year effort beginning in 2025*
- Defining PFAS Risk:
    - Continue to track state and federal PFAS regulatory progress - *ongoing*
    - Develop PFAS data baseline (influent, effluent, biosolids, and landfill leachate) – *ongoing with baseline established in 2027 (in coordination with SWD PFAS data baseline effort)*
    - Take co-digestion "off-ramp" if PFAS risk is manifested – *Approximately 2028, as part of alternatives analysis for STP digester capacity expansion project*
- Continue to track capital funding opportunities and renewable energy credit programs (e.g., WA Clean Fuel Standard and EPA RFS eRIN status) – *ongoing, annual effort*

Appendices

Appendix A: South Treatment Plant Capacity and Condition Assessment
Appendix B: Literature Review of Per- and Polyfluoroalkyl Substances Concentrations in Processed Food Waste Slurry
Appendix C: Food Waste Processing Technologies and Regional Options
Appendix D: Food Waste Material Estimates

[49] Among other provisions, HB 2301 establishes new grant programs related to food waste reduction and organic material management policy implementation. [LINK]

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From:	Matt Noesen, Project Manager, Jacobs Natalie Gustafson, Wastewater Process Engineer, Jacobs Shruti Jagini, Wastewater Process Engineer, Jacobs
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CC:	Melissa Wu, Deputy Project Manager, Jacobs
Date:	July 18, 2024
Task Name:	200.02 Capacity and Condition Assessment, and portions of 300.02, Preliminary Basis of Design Report
Subject:	**South Treatment Plant Capacity and Condition Assessment** **Food Waste Recycling Alternatives Analysis Project**

Jacobs prepared this technical memorandum (TM) for the Food Waste Recycling Alternatives Analysis Project (Project) for the King County Department of Natural Resources and Parks, Wastewater Treatment Division (WTD) and Solid Waste Division (SWD). This TM documents the capacity and condition assessment of King County's South Treatment Plant (STP), in Renton, Washington, specifically regarding the STP's capacity to accept food waste for co-digestion. The assessment will be used to inform a planning-level evaluation of alternatives to process food waste, including the option to co-digest food waste at STP. Detailed impacts to other WTD wastewater treatment planning efforts, such as long-term wastewater system planning and nutrient reduction, will be further evaluated and coordinated, as appropriate, after the County selects a preferred alternative for the Project. This TM summarizes the following:

1. Condition of existing digestion system, biogas treatment equipment, and dewatering equipment.
2. Projections of the hydraulic, solids, and organic loading on STP's solids system through 2060 based on the raw influent wastewater projections presented in the *South Treatment Plant Peak Flow and Wasteload Projections* (King County, 2019) both with and without the addition of food waste.
3. Projections of additional recycle nutrient loads within the STP from the co-digestion of food waste.
4. Code assessment of existing facilities, regarding the 2024 edition of the National Fire Protection Association 820, the *Standard for Fire Protection in Wastewater Treatment and Collection Facilities* (NFPA 820).

5. Projections of revenue generated from Renewable Identification Numbers (RINs) sales related to the addition of food waste.

BACKGROUND

STP uses an anaerobic-selector activated sludge secondary treatment process designed to treat an average design daily flow rate of 115 million gallons per day (MGD). The STP is rated by the National Pollutant Discharge Elimination System (NPDES) permit to treat maximum monthly flows of up to 144 MGD. From 2014 to 2023, annual average flows at STP were 76.6 MGD and maximum month flows were 124 MGD.

The major treatment processes at STP include preliminary treatment (bar screens and grit removal), primary treatment (aerated grit channels and primary sedimentation), secondary treatment (aeration tanks and secondary clarifiers), and sodium hypochlorite disinfection. On the solids side, treatment includes waste-activated sludge and primary sludge co-thickening through dissolved air flotation (DAF) thickening tanks; one thickened-sludge blend tank; four parallel, single-stage, mesophilic, anaerobic digestion tanks with floating covers; one blended-sludge storage tank; three high-solids dewatering centrifuges; and biogas treatment (moisture, hydrogen sulfide and siloxane removal), and liquid scrubbing to remove carbon dioxide so the gas can be injected into the natural gas pipeline as renewable natural gas (RNG). The plant also has a waste gas flare and a gas turbine for cogeneration of electrical and heat, although that system is not currently utilized. This TM focuses on STP's solids and gas processing capacities, but also considers the additional return streams from co-digestion that must ultimately be handled by the liquids treatment process.

The anaerobic digesters utilize gas mixing. The floating covers on the digesters collect gas, gas compressors in the digester control building compress the gas, and the gas is then injected through spargers located at the bottom of the tanks to allow for complete mixing. The digesters are heated by hot water to sludge heat exchangers with circulating sludge pumps to maintain temperatures required for mesophilic digestion.

Recovered commercial food waste is defined for this Project as the portion of edible and non-edible food waste, and biodegradable packaging materials from businesses (i.e. restaurants, hotels, grocery stores), that is diverted from the landfill and is available for co-digestion. Food waste slurry (FWS) is defined as the preprocessed and diluted recovered commercial food waste feedstock as the potential feedstock into the anaerobic digesters at STP for co-digestion. Preprocessing is defined as the contaminant removal/screening/de-packaging step to remove contaminants, packaging, and non-biodegradable material followed by a grinding and blending step that converts the food waste to a slurry. Preprocessing would take place at a different facility than STP due to the lack of available footprint at STP. Once preprocessed food waste is transported to STP, process water would be added to create the FWS. FWS has variable levels of total solids content, volatile solids content, total and soluble chemical oxygen demand (COD), volatile fatty acids, alkalinity, pH, and residual contaminants (glass, plastics, and grit).

Annual food waste tonnages from 2019 to 2023 and food waste projections through 2060 were obtained from the Project's Food Waste Material Estimates TM (Jacobs 2024). Site-specific nutrient content of FWS are not available at this time, and food waste characterization assumptions described in the Nutrient Loading Estimates section of this TM were used to estimate the additional amount of nitrogen in the centrate recycle and hence the load on the STP aeration basins as a result of co-digesting FWS.

EQUIPMENT CONDITION ASSESSMENT

The impact on digestion, biogas treatment, and dewatering equipment must be considered when accepting FWS for co-digestion at STP. Impacts to the LOOP biosolids management program must also be considered including increase in truck trips and land application rates, if applicable. STP is a large and complex facility with numerous equipment assets of various ages. Co-digestion will place additional stress on existing plant processes and equipment. Critical, aging assets must be identified, replaced and/or upgraded to maintain reliable plant operation, before implementing co-digestion.

WTD provided Jacobs with asset management reports for these three main process areas; Tables 1 through 3 summarize the major digestion, biogas treatment, and dewatering equipment, respectively, including useful remaining life. Jacobs calculated the useful life remaining based on equipment service life, except where useful life is indicated in the WTD asset list for specific pieces of equipment. The minimum useful life remaining is assumed to be between three and five years, as zero to two years is reserved only for equipment that has failed and requires immediate replacement. Related assets, such as motors, ancillary valves, variable frequency drives, and individual motor control center (MCC) buckets, are not included in the summary tables.

Table 1. Digestion Equipment Condition Summary

Equipment	Asset Number	Years in Service to 2024, if Available	Useful Life Remaining (Years)
Digester gas compressors 1 through 10	CPR222001/21/41/61/81/101/121/141/161/181	4 to 33	3 to 21
Digester circulation sludge grinders 1 through 8	GDR221038/41/42/43/46/49/64/72	28	**3 to 5**
Heat exchangers 1 through 6	HEX221003/13/23/33, HEX233001, HEX232028	37	**3 to 5**
Digester tanks 1 through 4 and sludge storage tank	T223001/11/21/31/41	37	13[a]
Digester floating covers 1 through 4	ME223001/11/21/31	37	See note[b]
Digester circulation pumps 1 through 8	P221001/04/08/11/18/21/28/31, P220002	28 to 37	**3 to 5**
Digester feed pumps 1 through 5	P232001/02/03/04/	5 to 28	7 to 15

Equipment	Asset Number	Years in Service to 2024, if Available	Useful Life Remaining (Years)
	03SPR		
Solids MCC air handling unit circulation pumps 1 and 2	P237003/003SPR	4	16 to 21
Digester transformers 1 through 4	TFR221001/02, TFR221111/13	No information	No information
Odor control units 1 and 2	OCU233001/02	No information	No information
Chilled water supply pumps 1 through 3	P211102, P221102/03	28	**3 to 5**
Digested sludge withdrawal pumps 1 through 6	P221111/13/39/40, P221100SPR, P221140SPR	4 to 29	**3** to 21

[a] Based on assumed useful life of a concrete anaerobic digester tank (50 years). Digester useful life will vary depending on multiple factors including digester operating conditions and frequency of tank inspection and maintenance. STP staff performs occasional digester cleaning, and as a part of this process, perform structural and mechanical inspections.

[b] The digester covers were fabricated and installed in 1987 (Thompson 2024). From 2014 to 2018, the covers went through extensive rehabilitation, which included recoating, replacing piping and related equipment on the cover, making improvements that reduced moisture accumulation within the cover and vertical travel, and changing the arc of the hoses to prevent kinking.

Bold red text = Equipment identified as having useful life remaining of five years or less.

Table 2. Biogas Handling Equipment Condition Summary

Equipment	Asset Number	Years in Service to 2024, if Available	Useful Life Remaining (Years)
Gas scrubbing system	ME222265	No information	No information
Scrub gas dryers 1 through 3	ME222270 TO ME222272	29	**3 to 5**
Scrub water turbine 1 through 3	TBN222212/22/27	37	**3 to 5**
Scrub gas compressor, first and second stage	CPR222230/30A/30B CPR222240/40A/40B CPR222245/45A/45B	32 to 37	**3** to 6
Gas dryer final discharge filter	FLT222965A FLT222965B FLT222965C	No information	No information
Gas system final custody specification gas filter	FLT222506	11	14
Final gas delivery dewpoint transmitter	FLT222294/B	37	**3 to 5**
MCC - scrub water 1 and 2	MCC222210/20	21	19
Scrub water pump 1 through 3	P222210/20/25	37	**3**
Gas compressors lube oil pumps	Various	28 to 29	**3 to 5**
Gas compressors cooling water Pumps	Various	No information	No information
Waste gas burners 1 through 3	ME222440/50/60	14	6

Bold red text = Equipment identified as having useful life remaining of five years or less.

Table 3. Dewatering Equipment Condition Summary

Equipment	Asset Number	Years in Service to 2024, if Available	Useful Life Remaining (Years)
Centrifuge 1 through 3	CFG211011/12/13	9 to 19	6 to 11
Blended sludge grinder 1 through 2	GDR210001/02	1 to 20	**5** to 19
Sludge feed pump 1 through 3	P210013/14/15	19	**3** to 6
Truck conveyors 1 through 3	CON211009/25/26	19	6
Centrifuge inclined conveyors 1 through 3	CON211291/92/93	20	**5**
Centrifuge screw conveyor 1 through 3	CON211011/12/13	19	6
MCC 1 through 4	MCC211253/54A/54B/55	37	**3 to 5**
MCC – variable frequency drive room	MCC211904	19	6
Solids MCC air handling unit	AHU237001	37	**3 to 5**
BFP washwater pump[a]	P210058	37	**3 to 5**
BFP conveyor[a]	CON211009	19	6
Dewatering odor pumps 1 through 6	P210710/20/30/40/50/60	6	9

[a] Belt filter presses (BFP) were the main type of dewatering equipment at STP before centrifuges were installed in 2005. Ancillary BFP equipment remains onsite, and the remaining BFP is used only during digester cleanings.
Bold red text = Equipment identified as having useful life remaining of five years or less.

The most critical pieces of existing equipment that require upgrade or replacement within the next 5 years prior to implementing co-digestion include the following:

- Digestion equipment, including gas compressors, circulation sludge grinders, heat exchangers, sludge withdrawal pumps, and chilled water supply pumps.
- Biogas handling equipment, including dryers, water turbines, compressors, final gas delivery dewpoint transmitters, water pumps, and compressor lube oil pumps.
- Dewatering equipment, including centrifuge inclined conveyors, MCCs 1 through 4, and sludge feed pumps.

NUTRIENT LOADING ESTIMATES

The Washington State Department of Ecology final Puget Sound Nutrient General Permit (PSNGP) became effective on January 1, 2022, and the second permit term is anticipated to begin on January 1, 2027. The current PSNGP limits total inorganic nitrogen (TIN) loadings from point source wastewater treatment plants (WWTPs) to Puget Sound at current levels. The PSNGP applies to 58 domestic WWTPs discharging to Puget Sound, including the STP. The current PSNGP regulates only nitrogen and is in addition to the WWTPs existing NPDES individual discharge permits.

The PSNGP identifies individual TIN action levels for WTD’s three regional treatment plants; i.e., for West Point WWTP, Brightwater WWTP, and STP along with the option to combine the individual effluent TIN action levels into a single “bubbled” action level. The County selected the bubbled action level of 15,820,000 lb/yr. Total effluent TIN from the three plants was below the bubbled action level in 2022 and 2023. The addition of FWS would increase nitrogen loads in the plant and may impact the County’s ability to stay below the PSNGP bubbled action level. This section summarizes an evaluation of FWS nutrient loading on STP so WTD can factor this information into their planning and compliance approach with the PSNGP.

Jacobs developed a full STP model using Jacobs’ Replica Parametric Design (RPD) process modeling software and calibrated this model using process parameters in the existing GPS-X simulation model for STP most recently calibrated by HDR, as well as using historical process data from 2014 to 2023, provided by WTD. Jacobs and HDR team members met on February 29, 2024, to discuss the recent updates HDR made to the GPS-X model and to gain an understanding of the modeling approach.

The influent TKN and influent ammonia mass loadings to the aeration basins are within a margin of error of less than 7 percent of the historical STP data. Similar to the GPS-X model, the RPD model was calibrated to indicate a conservative TKN and ammonia concentration in the plant effluent to represent lower nitrification through secondary treatment.

The limited scope of this modeling exercise provides insight into the fate of nutrients with the addition of FWS for co-digestion, based on literature related to co-digestion of food waste regarding nutrients in source-separated organic food waste. Jacobs ran RPD models with and without the addition of FWS to identify the relative nutrient impacts on STP effluent between 2030 and 2060. It is assumed 2035 is the earliest STP can accept FWS for co-digestion because any large solids treatment expansion project would take approximately 10 years to plan, design, and construct. The year 2030 was also considered in the capacity analysis to evaluate impacts to existing infrastructure and processes at STP from the addition of FWS.

Figure 1 shows a simplified process flow diagram, displaying the location of the FWS input in the RPD model and the relationship of the input to downstream, affected processes.

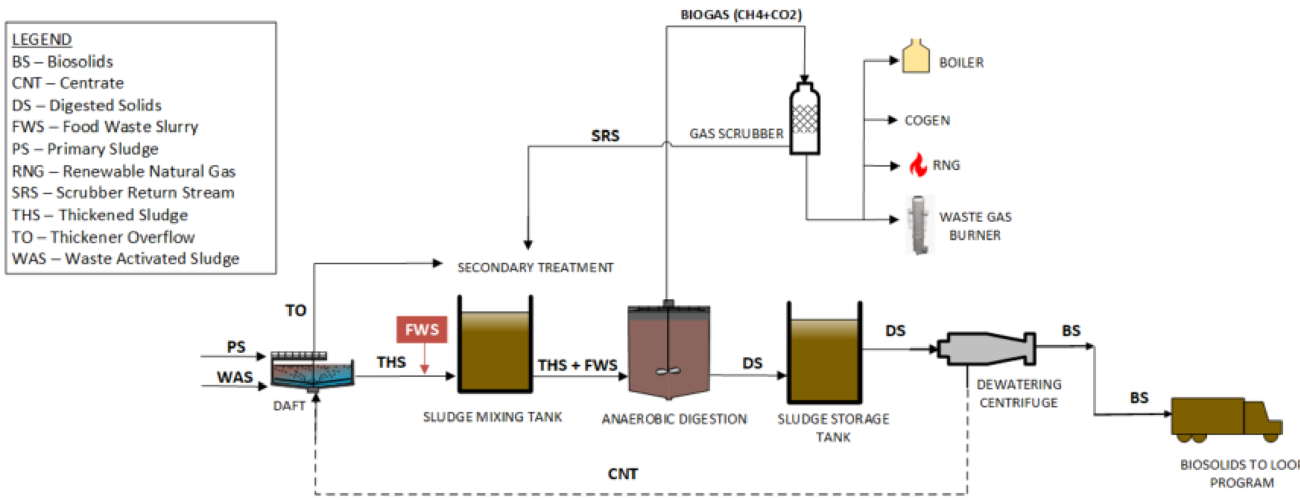

Figure 1. STP Simplified Process Flow Diagram of Solids and Gas Processing with Food Waste Co-Digestion

Site-specific FWS characteristics are not available at this time and there is limited industry data available on the nutrient content of FWS. The assumptions of the FWS characteristics were made based on Waste Management's Engineered BioSlurry Quality Criteria (2017) as well as the Water Research Foundation's *Characterization of Source Separated Food Waste for Co-Digestion in Water Resource Recovery Facilities* (2023). Table 4 summarizes the FWS characteristics and the source for each assumption. In the future, regional food waste sampling and characterization could be performed, considering that using non-site-specific data for characterization could lead to overestimating or underestimating of the nutrient loads and other parameters of the FWS.

Table 4. Commercial Food Waste Characterization

Parameter	Range	Assumed Value[c]	Range Source
Total solids[a]	13% to 16%	16%[d]	Waste Management 2017
COD (mg/L)	160,000 to 230,000	195,000	Waste Management 2017
Volatile suspended solids	88% to 92%	90%	Waste Management 2017
TKN[b] (mg/L)	2,500 to 5,000	3,750	Waste Management 2017
Ammonia (mg/L)	150 to 300	225	Waste Management 2017
Total Phosphorus (% dry weight)	0.03% to 1.8%	1.60%[e]	Water Research Foundation 2023
Alkalinity (% dry weight)	0.1% to 2.44%	1.20%	Water Research Foundation 2023
Volatile acids (mg/L)	6,000 to 12,000	9,000	Waste Management 2017

[a] Total solids in preprocessed, commercial food waste.
[b] TKN = the sum of ammonia nitrogen and organic nitrogen.
[c] Mid-range values are assumed, except where noted.
[d] Upper range value for total solids is assumed to account for variability in feedstock.
[e] Due to the large variability in feedstocks represented in the literature for the range of total phosphorus, a conservative upper end of the range is assumed.

Based on available literature on pretreatment of source separated organic feedstock, a contamination of less than 25% of materials such as plastics, glass, inerts, and other rejectable materials, was reported across nine different water resource recovery facilities throughout the United States that either preprocess or receive preprocessed organic material for co-digestion (Water Research Foundation 2023). Commercial food waste typically contains approximately 12 percent of noncompostable contaminants, as identified by Cascadia Consulting Group (Cascadia 2019) in a 2019 waste composition study. In addition, based on the Project's Food Waste Material Estimates TM (Jacobs 2024), approximately 25% of the material considered to be recovered for co-digestion is categorized as 'compostable packaging,' and the assumption is that a portion of this packaging may not be readily digestible, such as wood and fiber-based materials, and will need to be removed, either at the preprocessing facility or at the food waste receiving station at STP. Based on the contamination levels and portion of compostable waste in the commercial food waste stream, Jacobs assumes preprocessing the food waste will result in a total of 75 percent recovery rate of what is considered the available commercial food waste (edible and non-edible food waste, as well as compostable packaging) that is recovered for co-digestion in the STP digesters. The final FWS is assumed to be diluted with process water to 12 percent total solids prior to mixing with thickened sludge (THS) upstream of digestion at STP. This dilution is important in creating a more pumpable slurry.

The preprocessed, recovered food waste flow and loads available for co-digestion are provided in Table 5; projected STP influent flows and loads are listed in Table 6.

Table 5. Projected Recovered Available Food Waste for Co-Digestion at STP, 2030-2060

Year	Annual Recovered Food Waste Available for Co-Digestion - High Impact Scenario (wet tons/year)	FWS to Co-Digestion - High Impact Scenario (gallons per day)	Year	Annual Recovered Food Waste Available for Co-Digestion - High Impact Scenario (wet tons/year)	FWS to Co-Digestion - High Impact Scenario (gallons per day)
2030	25,925	17,033	2046	88,360	58,053
2031	30,802	20,237	2047	89,256	58,642
2032	35,848	23,552	2048	90,172	59,244
2033	60,756	39,917	2049	91,107	59,858
2034	66,034	43,385	2050	92,062	60,486
2035	71,473	46,958	2051	93,038	61,127
2036	77,252	50,755	2052	94,033	61,780
2037	79,361	52,141	2053	95,049	62,448
2038	80,678	53,006	2054	96,085	63,129
2039	82,017	53,886	2055	97,143	63,824
2040	83,379	54,781	2056	98,221	64,532
2041	84,163	55,296	2057	99,321	65,255
2042	84,965	55,823	2058	100,443	65,992
2043	85,786	56,362	2059	101,586	66,743
2044	86,625	56,913	2060	102,751	67,508
2045	87,483	57,477			

[a] Assumes 75% recovery of available food waste through preprocessing for co-digestion and dilution of 16 percent total solids preprocessed food waste to 12 percent total solids FWS.

Table 6. Projected Influent Flows and Loads at STP, 2030-2060

Condition	2030	2040	2050	2060
Flow (MGD) [a]				
Annual Average	82	86	94	102
Peak 30-Days	134	141	151	162
Influent BOD loading (lb/d) [a]				
Annual Average	196,000	209,600	227,700	246,400
Peak 30-Days	250,300	266,700	288,400	310,800
Peak Week	302,500	321,900	347,500	374,100
Influent TSS loading (lb/d) [a]				
Annual Average	195,800	208,600	227,300	246,600
Peak 30-Days	244,700	260,800	284,100	308,200
Peak Week	307,400	327,600	356,800	387,100
THS Total Solids (lb/d) [b]				
Annual Average	193,984	207,444	225,358	243,866
Peak 30-Days	323,919	345,143	373,225	402,214
Peak 14-Days	364,143	387,725	418,883	451,161
Ammonia (lb/d) [c]				
Annual Average	21,887	23,406	25,427	27,515
Peak 30-Days	27,951	29,782	32,206	34,707
TKN (lb/d) [c]				
Annual Average	37,024	39,593	43,013	46,545
Peak 30-Days	47,282	50,380	54,479	58,710
FWS Total Solids (lb/d)[d]				
High-Impact Scenario	17,047	54,825	60,534	67,562

[a] Source: Brown and Caldwell 2019.

[b] THS total solids calculated based on BOD to TSS ratios at annual average and peak 30-Days conditions based on STP influent data from 2014 to 2022. Peak 14-days BOD to TSS ratios interpolated from peak 30-Days and peak week conditions from Brown and Caldwell 2019 to calculate THS total solids.

[c] Estimated NH3, TKN based on NH_3/BOD, and TKN/BOD ratios. Ratios calculated based on 5-year average plant data (January 2019-December 2023).

[d] Based on High-Impact Scenario food waste loading (Jacobs 2024) and 75% recovery of available food waste through preprocessing for co-digestion.

Jacobs developed Figures 3 through 6 from the RPD model results. A process flow diagram from the RPD model is shown under Figure 2. The results display the effects on nutrient loading at STP, in particular the levels of TKN in various locations, including dewatered sludge (Figure 3), dewatered centrate, (Figure 4), aeration basin influent TIN (Figure 5), as well as ammonia (NH_3-N) loads in centrate recycle (Figure 6).

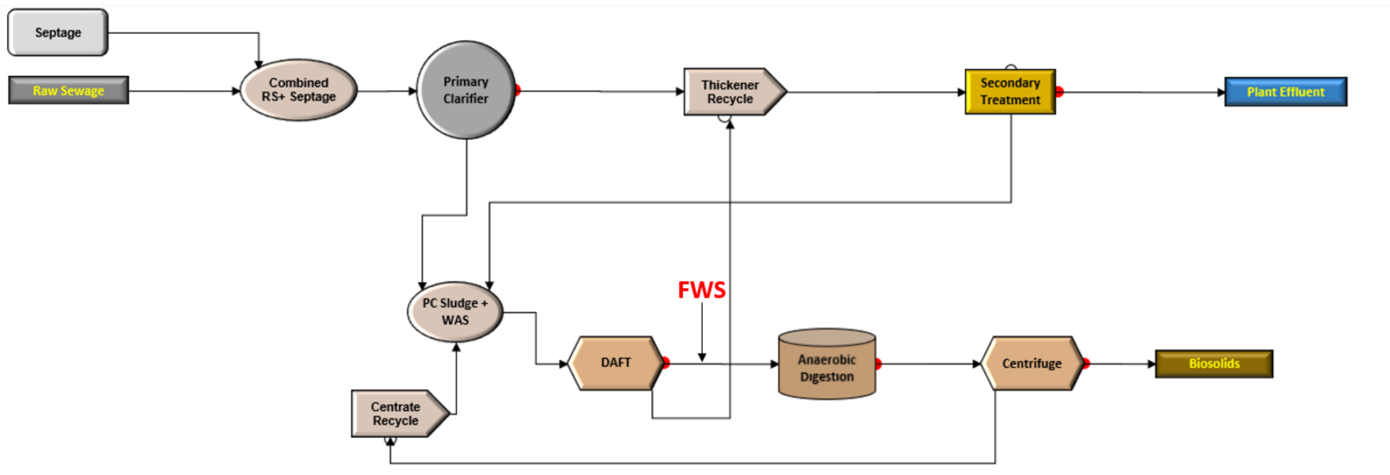

Figure 2. Process Flow Diagram from RPD Model

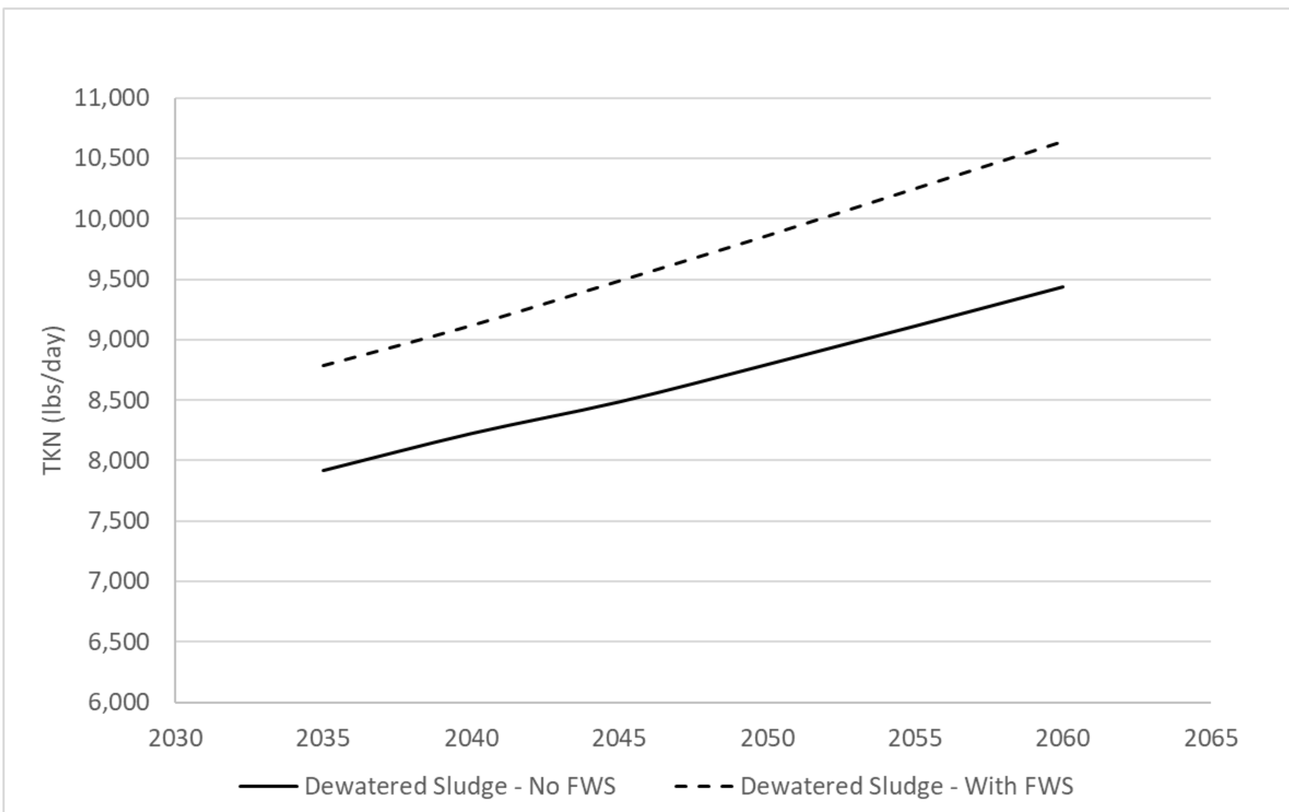

Figure 3. Dewatered Sludge TKN Load Projections, Annual Average Conditions, 2035–2060

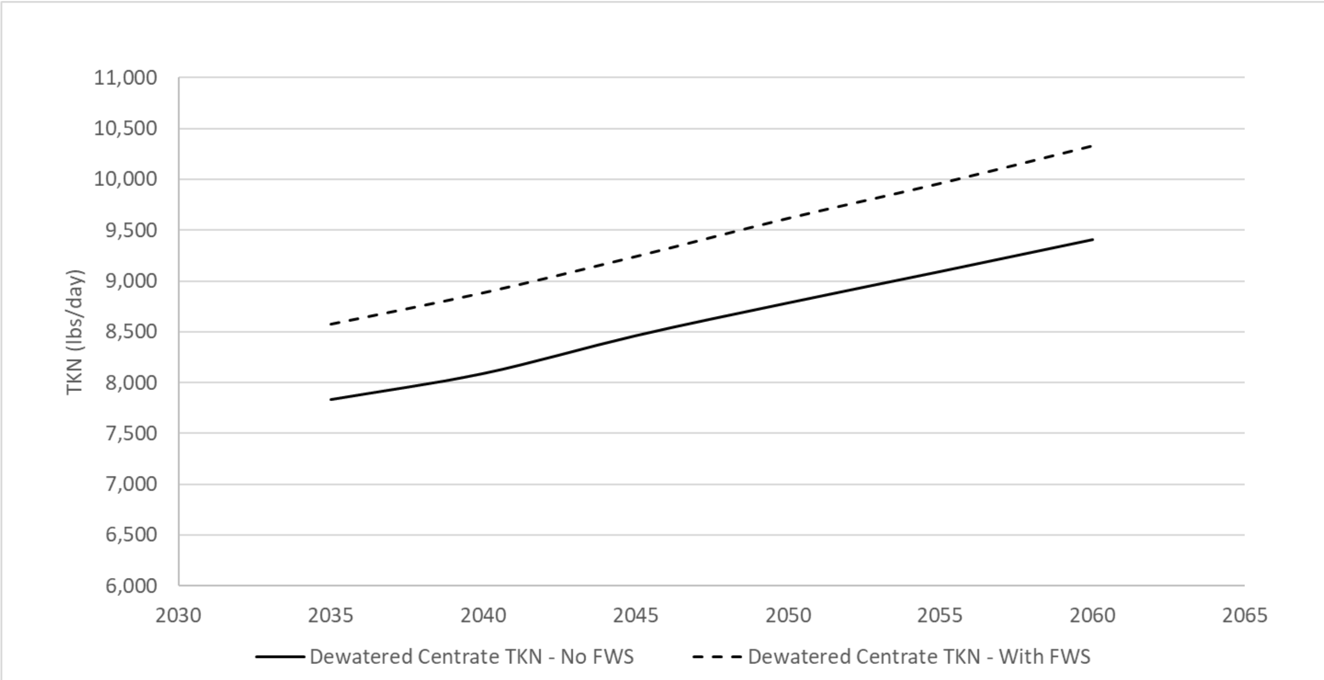

Figure 4. Dewatered Centrate TKN Concentration Projections, Annual Average Conditions, 2035–2060

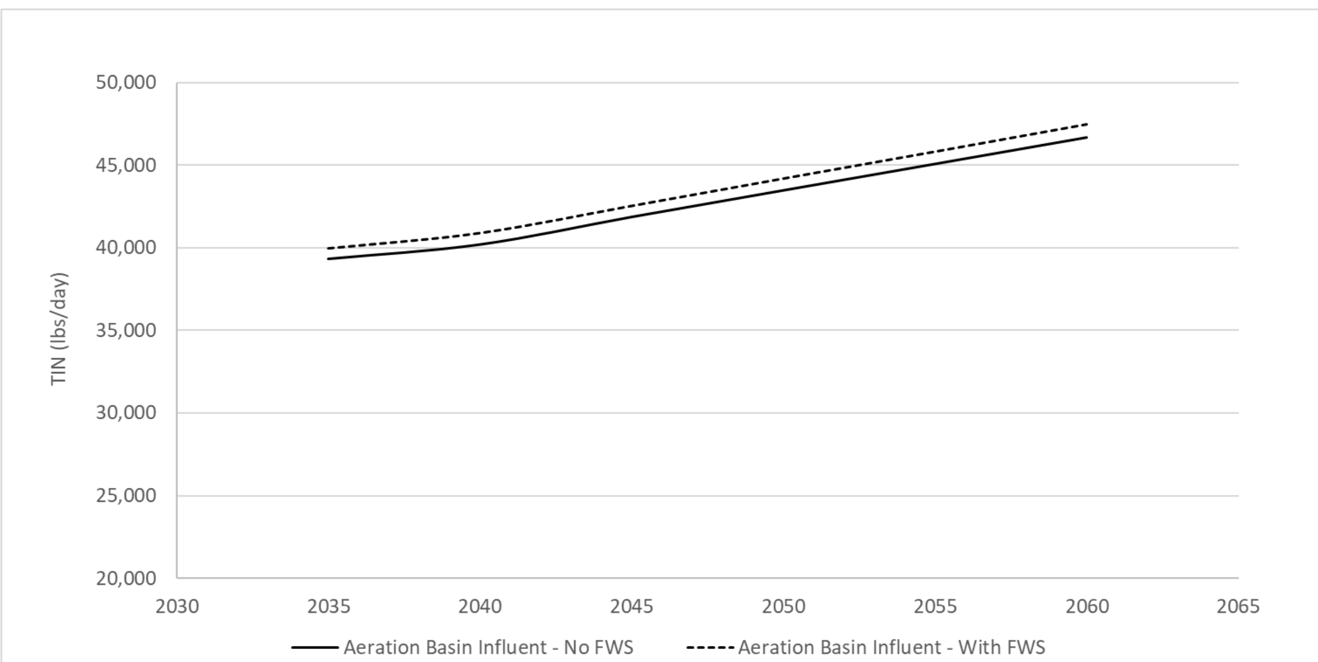

Figure 5. Aeration Basin Influent TIN Load Projections, Annual Average Conditions, 2035–2060

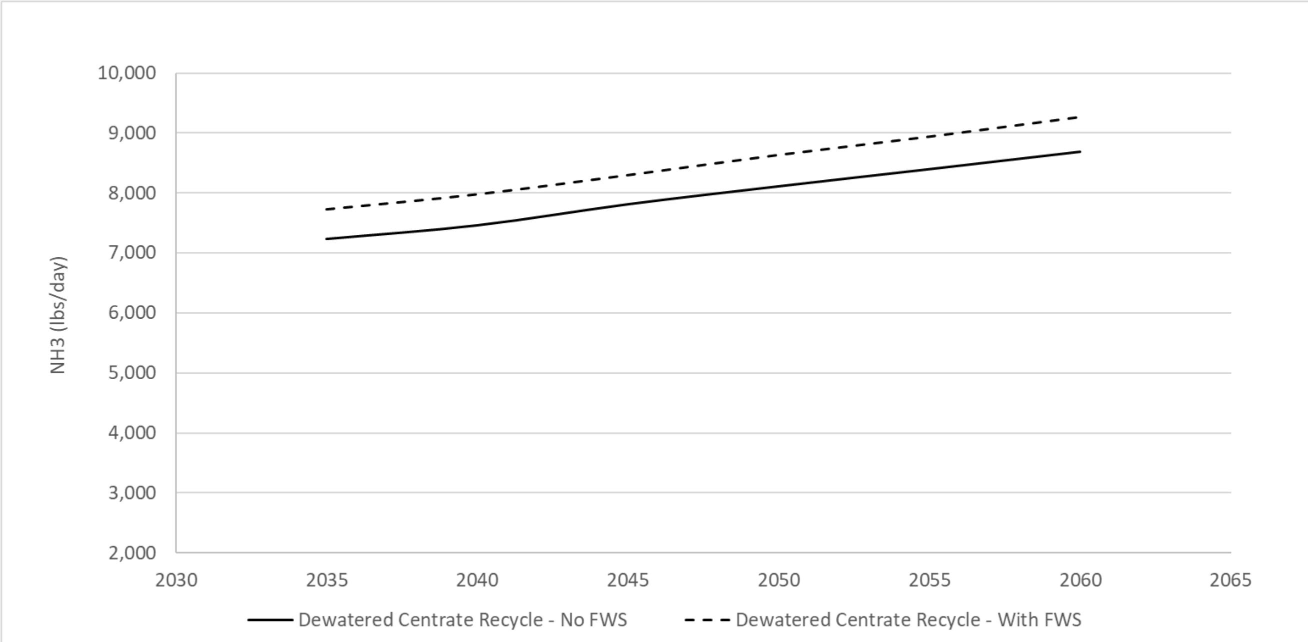

Figure 6. Centrate Recycle NH_3 Load Projections, Annual Average Conditions, 2035–2060

Table 7 provides a summary of percentage increase in aeration basin influent TIN loads from 2035 through 2060 with the addition of FWS. An increase in the range of 1.5% was projected with addition of FWS.

Table 7. Summary of Percent Increase in Aeration Basin Influent TIN with FWS, 2035 – 2060

Year	Increase in STP Aeration Basin Influent TIN load with FWS Co-Digestion Compared to Baseline THS Digestion, Annual Average Conditions	Increase in STP Centrate TIN load with FWS Co-Digestion Compared to Baseline THS Digestion, Annual Average Conditions
2035	1.4%	6.3%
2040	1.5%	6.4%
2045	1.4%	5.7%
2050	1.4%	6.0%
2055	1.4%	6.0%
2060	1.4%	6.0%

Based on Figures 3 through 6 and the results of this modeling exercise, co-digestion with FWS will most notably increase the TKN concentration in the digested sludge and the TKN mass loading of the dewatered sludge centrate that is recycled back to the DAF thickeners. A portion of the nitrogen loading that is recycled to the DAF thickeners is also sent to the aeration basins for secondary treatment, along with the wash water recycle from the biogas scrubbing equipment. Digester effluent TKN concentration with FWS co-digestion are higher than the digester effluent without FWS co-digestion.

TKN mass loading of the dewatered centrate is projected to increase between 1.4 and 9 percent over time, as more FWS becomes available for co-digestion. The increase in TIN load into the aeration basins as a result of the FWS co-digestion range from 1.4 to 1.5 percent between 2035 and 2060.

CAPACITY ASSESSMENTS

Digestion

The four existing digesters at STP each have a working volume of 2.75 million gallons (MG). From the design criteria listed in Table 8, Jacobs estimated the capacity for the existing digesters, and an assumed digester expansion, to accept FWS for co-digestion. For the purposes of this feasibility evaluation, it is assumed that a fifth 2.75-MG mesophilic digester with a beam type cover is built to provide solids treatment capacity for future wastewater flows and loads, and for FWS. A separate, future project (County project REQ-2177) would evaluate and determine WTD's desired approach to expanding solids treatment capacity at STP to meet future needs.

Table 8. STP Design Criteria for Co-Digestion

Criteria	Value	Units	Basis
Minimum SRT at 30-day peak loading conditions	18.0	Days	WTD maintains a minimum 18-day SRT for mesophilic digestion at STP
Digester volume, each	2.75	Million gallons	Full digester volume with floating cover at 1-ft level (Butler 2019)
Maximum recommended SELR	0.30	lb inf COD/lb dig VS-day	Amador et al. 2012
Maximum VSLR	0.25	lb VS / cf-day	Amador et al. 2012[a]
THS COD to VS ratio	1.25	lb COD / lb VS	Jacobs' RPD standard value for digester influent.
FWS COD to VS ratio	1.70	lb COD / lb VS	Water Environment & Reuse Foundation 2017
THS VS	88	Percent	Butler 2019
THS total solids	6	Percent	Average STP digester total solids feed, Jan. 2019 to Dec. 2023.
FWS VS	90	Percent	Waste Management 2017
FWS total solids	12	Percent	Total solids limit of pumpable slurry based on viscosity of resulting FWS.
VS Removal – digested THS	58	Percent	Butler 2019
VS Removal – digested FWS	83	Percent	Water Environment & Reuse Foundation 2017
Specific digester gas production	16.7	scf/lb VS destroyed	Butler 2019
Methane content in biogas	61	Percent	Butler 2019

Criteria	Value	Units	Basis
Biogas lower heating value	550	BTU/scf	Based on 61 percent methane content in biogas.
Methane slip during biogas scrubbing	6.5	Percent	Butler 2019

BTU = British thermal unit; cf = cubic foot; dig = digester; inf = influent; scf = standard cubic foot; SELR = specific energy loading rate; SRT = solids retention time; VS = volatile solid; VSLR = volatile solids loading rate

[a] Applied SELR increases with increase in VS and COD loads as well as increased total solids in influent digester feed, which allow for a VSLR of up to 0.25 lb VS / cf-day while maintaining the recommended maximum SELR as described in Amador et al. 2012 and as shown in Figure 8.

Digester capacity is limited most notably by VSLR as well as SRT. Under current operating conditions, WTD staff prefer to operate STP at a maximum VSLR of approximately 0.19 lb VS/cf-day; however, a higher VSLR of 0.25 lb VS/cf-day can be achieved, assuming SELR remains below the recommended maximum level of 0.30 lb inf COD/lb dig VS-day. SELR is an important characteristic to check for co-digestion compatibility, as the THS and FWS have varying total solids, as well as COD to VS ratios. SELR considers the strength of feed (measured by COD) and the active biomass in the digesters (measured by VS inventory). SELR is a food to microorganism ratio for digesters.

The SELR remains under the maximum recommended digester SELR under all listed operating conditions, indicating the digesters can operate at the higher VSLR of 0.25 lb VS/cf-day. The capacity of the four and five digesters in operation was evaluated based on the most conservative of these two conditions: maximum digester VSLR of 0.25 lb VS/cf-day and minimum SRT under peak 30-day conditions of 18.0 days. Figure 7 displays this capacity. A summary of calculations for capacity of STP digesters to accept FWS is shown under Table 9.

Table 9: Summary of Calculations for Capacity of STP Digesters to Accept FWS

Year	4 Digesters in Service				5 Digesters in Service			
	THS (Dig Feed) TS, lb/d [a]	Projected Raw FW lb/d [b]	Projected FW VS, lb/d [c]	Food Waste Capacity, lb/d [d]	THS (Dig Feed) TS, lb/d [a]	Projected Raw FW lb/d [b]	Projected FW VS, lb/d [c]	Food Waste Capacity, lb/d [d]
2030	323,919	142,055	15,342	No Capacity	-	-	-	-
2035	334,531	391,633	42,296	No Capacity	334,531	391,633	42,296	79,500
2045	359,184	479,359	51,771	No Capacity	359,184	479,359	51,771	38,400
2050	373,225	504,449	54,481	No Capacity	373,225	504,449	54,481	15,000
2060	402,214	563,019	60,806	No Capacity	402,214	563,019	60,806	No Capacity

Analysis assumes digester upgrades are available starting 2035

[a] Based on 2030–2060 peak 30-day flows (Brown and Caldwell 2019).

[b] Projected Recovered Available Food Waste for Co-Digestion

[c] Assumes 75% recovery of available food waste through preprocessing for co-digestion and dilution of 16 percent total solids preprocessed food waste to 12 percent total solids FWS.

[d] Based on a minimum SRT of 18 days

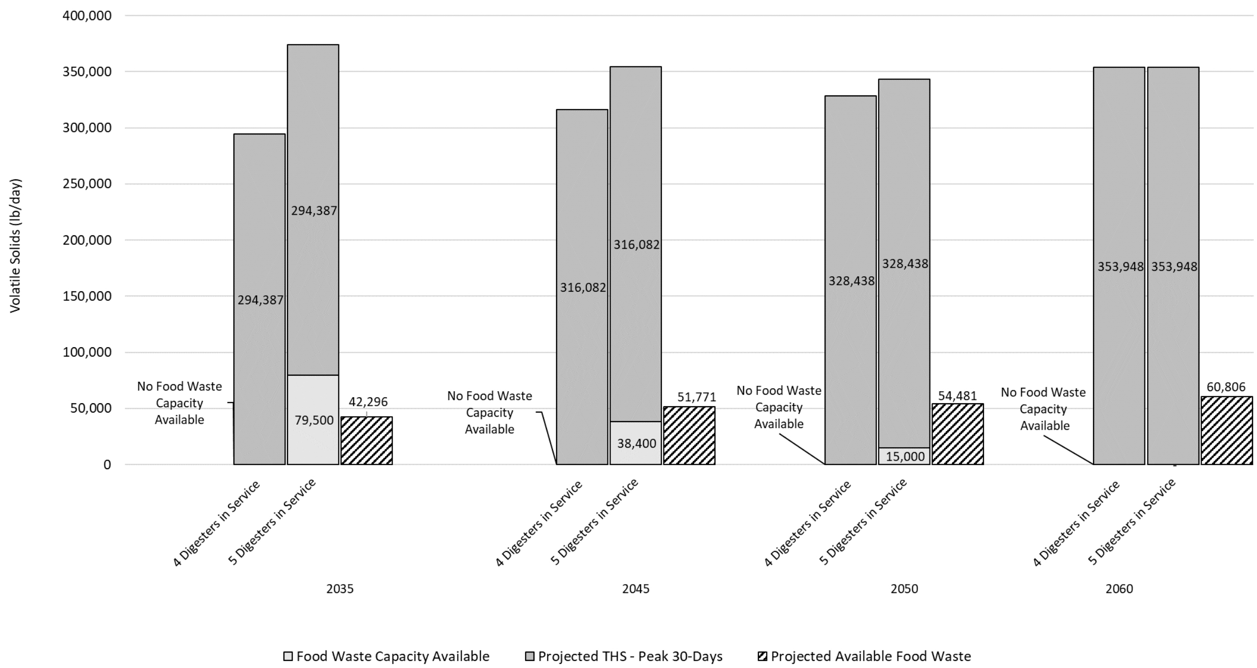

Figure 7. Capacity of STP Digesters to Accept FWS for Co-Digestion, 2035–2060

Beginning in 2030, STP does not have capacity to accept food waste for co-digestion with all four existing digesters are in operation. The digestion capacity at STP is limited even without the addition of FWS. Digester capacity expansion, such as by adding a fifth digester, or other to be determined digester improvement or intensification options, is required to provide sufficient digestion capacity for future flow and loading projections without FWS.

As shown in Table 10, SRT is the limiting factor for the digestion capacity as opposed to VSLR. Additional considerations for the design of a fifth digester, as well as improvements to increase the capacity of the four existing digesters, include anaerobic digestion enhancement technologies (such as thermal hydrolysis and microbial hydrolysis processes), conversion of the existing mesophilic digesters to thermophilic digesters and recuperative thickening.

Table 10. STP Digester SRT and VSLR, with and without FWS Co-digestion, 2030–2060

Condition	Year	4 Digesters in Service		5 Digesters in Service	
		SRT (days)[b]	VSLR (lb VS/cf-d)[c]	SRT (days)[b]	VSLR (lb VS/cf-d)[c]
THS (no FWS)[a]	2030	17.0	0.19	-	-
	2045	15.3	0.21	19.2	0.17
	2050	14.7	0.22	18.4	0.18
	2060	13.7	0.24	17.1	0.19
THS + FWS co-digestion[d]	2030	17.0	0.19	18.0	0.21
	2045	15.3	0.21	18.0	0.19
	2050	14.7	0.22	18.0	0.19
	2060	13.7	0.24	17.1	0.19

Analysis assumes digester upgrades are available starting 2035.
[a] Based on 2030–2060 peak 30-day flows (Brown and Caldwell 2019).
[b] Minimum SRT at peak 30-day conditions assumed to be 18.0 days. Under this condition, with four digesters in operation, there is no capacity to accept food waste after 2030.
[c] Maximum VSLR assumed to be 0.25 lb VS/cf-d.
[d] Based on 2030–2060 peak 30-day flows (Brown and Caldwell 2019) and includes the capacity of the digesters at STP to accept preprocessed food waste, assuming 16 percent total solids and 90 percent VS in raw food waste, 75 percent food waste recovery through preprocessing, and 12 percent total solids in FWS to digestion.
[e] SRT at peak 30-day loading conditions is the limiting factor with five digesters under mesophilic conditions. VSLR is shown at the limited FWS loading rates required to maintain 18.0 days SRT at 30-day peak conditions.

As noted, the four existing digesters do not have available capacity to accept FWS beginning after 2030, with SRT being the limiting factor. Per Chapter 173-308 of the Washington Administrative Code (WAC), biosolids must be treated at a minimum SRT of 15-days when operating between 95 degrees F and 131 degrees F to meet requirements of Class B pathogen reduction. This regulation is violated with and without FWS addition starting in 2050 with four digesters in service. In addition, WTD maintains a minimum 18-day SRT for mesophilic digestion at STP, which would not be maintained starting in 2030 for 4-digester operation, and in 2060 for 5-digester operation. SELR was calculated only for the scenario with five digesters in service operating under peak 14- and 30-day THS and FWS loading conditions, assuming all available FWS is co-digested; these SELRs, along with VSLR and total solids in digester feed, are displayed on Figure 8 and assume a maximum VSLR of 0.25 lb VS/cf-day.

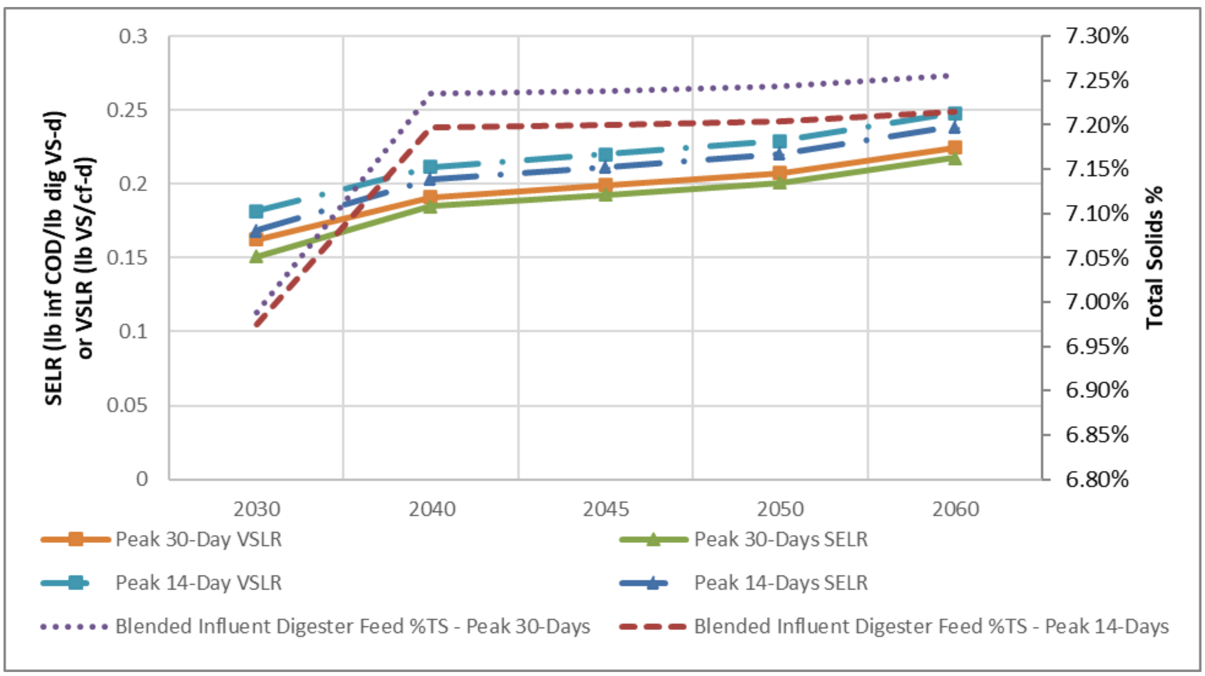

Figure 8. Digester VSLR, SELR and Influent Total Solids with FWS Co-Digestion, 5 Digesters in Service, 2030-2060

Biogas Treatment

According to the STP digestion operations and maintenance manual (WTD, 2013), the biogas scrubbing system at STP consists of two scrubbing towers, with a combined capacity of 2.0

million standard cubic feet per day. The biogas scrubbing system consists of biogas compressors, scrubbing water pumps/turbines, scrubbing towers, gas dryers, and gas analyzers. Carbon dioxide, water, and impurities are removed from the biogas during the scrubbing process. The scrubbed biogas is then analyzed to confirm quality of the renewable natural gas (RNG) to be sold. Gas that does not meet the RNG specification is flared using one of the three waste gas burners, with each burner having a capacity of 600 standard cubic feet per minute.

WTD staff retain the flexibility to send scrubbed biogas to cogeneration engines or boilers in the STP; however, this is not standard procedure due to the financial value of the RNG that is sold. Discussion of the RIN revenue from the sale of RNG is presented later in this TM.

The capacity of the biogas scrubbing system compared to projected THS and co-digested THS and FWS is displayed on Figure 9 for design year 2045 with projections out to 2060, under annual average and peak 14- and 30-day loads.

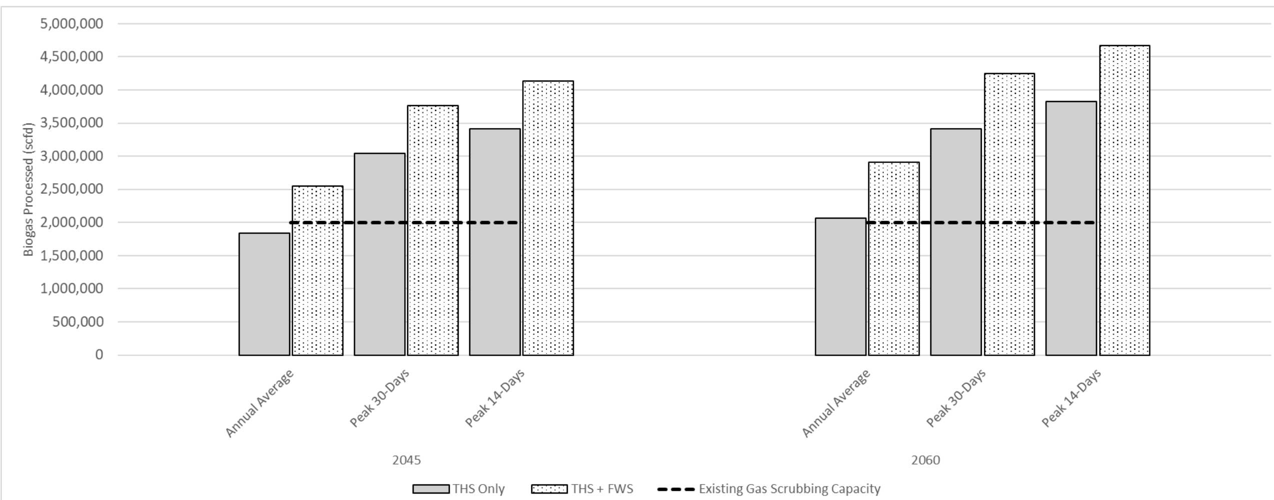

Figure 9. STP Biogas Handling Capacity with and without FWS Co-Digestion

As shown on Figure 9, the capacity of the existing gas scrubbing system at STP is limited under all conditions except annual average conditions of digestion, with only THS for 2045 and 2060. To allow full biogas scrubbing capacity for co-digested THS and FWS through at least the design year 2045 and to maintain the ability to maximize revenue from RIN sales, additional biogas scrubbing capacity must be provided, or the biogas conditioning system may be replaced entirely with a new system, such as a membrane separation system or pressure swing adsorption system.

Dewatering

The three existing dewatering centrifuges were installed in 2005. The digested sludge is injected with polymer, dewatered through centrifuge bowls that rotate at high speeds of 2,500 rpm (rotations per minute), and the dewatered sludge from STP is hauled offsite for use with the WTD Loop program for beneficial reuse land application. The current centrifuge capacity, excluding food waste, was estimated by Brown and Caldwell (2019). Brown and Caldwell identified two operating centrifuges, plus one standby (2+1), with an operating hydraulic loading rate of 225 gallons per minute per centrifuge, to achieve a cake dryness between 22 and 23 percent total solids.

Table 11 details the number of centrifuges required to operate STP with the new FWS load, and outlines utilization with the number of operating centrifuges indicated until 2060. The key years in Table 11 reflect conditions of the 2045 design year and projections out to 2060 (Brown and Caldwell 2019). These calculations utilize post-digestion total hydraulic mass flow data, including annual averages and peak 14- and 30-day loads.

Table 11. STP Dewatering Centrifuge Requirements for N+1 Operation with FWS Co-Digestion

Loading	2045		2060	
	Number of Operating Centrifuges[a,b]	% Utilization of Operating Centrifuges	Number of Operating Centrifuges[a,b]	% Utilization of Operating Centrifuges
Annual average	2 + 1 Standby	71%	2 + 1 Standby	80%
Peak 30-days	3 + 1 Standby	75%	3 + 1 Standby	84%
Peak 14-days[c]	3 + 1 Standby	83%	3 + 1 Standby	93%

[a] All calculations assume that one centrifuge is maintained on standby at all times (N+1 centrifuges for operational redundancy).
[b] The dewatering process is assumed to operate continuously, 24 hours a day, 7 days a week, with one unit out of service.
[c] Peak 14- day values were calculated through interpolation of peak 30-day loads and peak 7-day loads from Brown and Caldwell data (2019).

To maintain the N+1 redundancy with the increased load from co-digestion with FWS, existing dewatering capacity is sufficient to process annual average flows; however, an additional centrifuge is required to cover peak 14- and 30-day loads to ensure flexible processing capability in design years 2045–2060. STP has the necessary footprint to accommodate the fourth centrifuge. It is noted that the three currently installed centrifuges have an expected EOL in 6-11 years from 2024 (Table 3), which indicates that upgrades to existing equipment will be required before 2045.

NFPA 820 CODE COMPLIANCE EVALUATION

The digestion facilities, gas handling facilities, and solids handling facilities at STP contain equipment that must be rated for the electrical area classification in accordance with NFPA 820 (2024). This evaluation describes the existing buildings and structures that will require evaluation and/or upgrades if STP is selected as the site for food waste receiving, through co-digestion and waste-to-energy processes. Existing buildings were evaluated based on 1993 as-built drawings (Brown and Caldwell). Attachment 1 contains markups of the areas identified in this section, for digesters, sludge pump room, gas equipment room, and dewatering building, and airflow schematics for the dewatering building and tunnels.

This evaluation focuses on the definitions, requirements, space ventilation and building classification requirements as set forth in Chapter 6 of NFPA 820 (2024), which applies to solids treatment processes.

Location Classification Definitions (NFPA 820, 2024):

Classified Location. A space where flammable gas, flammable liquid-produced vapor, combustible liquid-produced vapors, combustible dusts, or combustible fibers/flyings could be present, and the likelihood that a flammable or combustible concentration or quantity is present. Each room, section, or area is considered individually in evaluating its classification.

Unclassified Location. A space that does not meet the definition of a classified location.

Ventilation Types (NFPA 820, 2024):

- No ventilation, or ventilated at less than 12 air changes per hour (ACH)
- Continuously ventilated at 12 ACH
- Continuously ventilated at 6 ACH
- No ventilation, or ventilated at less than 6 ACH

Note that in order to comply with Chapter 9 of NFPA 820 (2024), if a space classification is being decreased via ventilation, it must be push/pull ventilation and the HVAC system must be monitored for failure.

Fire Protection Measures (NFPA 820, 2024):

- Combustible gas detection system
- Fire alarm system
- Hydrant protection
- Portable fire extinguishers installed, located, and maintained in accordance with NFPA 10 (2022)

Electrical Equipment Requirements

Class I, Division 1, Group D: National Electrical Manufacturers Association (NEMA) 7-rated, intrinsically safe, electrical panels and motors, and cables and conduits specifically rated for the hazard classification. NEMA 7 is often referred to as explosion-proof. Conduits must be sealed per the National Electrical Code.

Class I, Division 2, Group D: NEMA 7-rated, intrinsically safe, explosion proof electrical panels and motors are required in these spaces, as well and cables and conduits specifically rated for the hazard classification. Conduits must be sealed per the National Electrical Code.

Unclassified: Typically, NEMA 4, 4x, or 12 rated electrical panels may be installed in an unclassified space. NEMA 4 and 4x panels may be installed indoors or outdoors and provides protection against foreign objects as well as splashing from the elements, the difference being NEMA 4x panels provide an additional degree of protection against corrosion. NEMA 12 panels are reserved for indoor use only and provide a lesser degree of protection from foreign objects and ingress of water.

Digesters 1 through 4

The STP currently has four digesters with floating covers and one stored sludge tank with a fixed cover. The NFPA 820 (2024) classifications of these digester tanks are based off Table 6.6.2, Row 16, which describes the classification for anaerobic digesters with either a fixed or floating cover. The digesters are Class I Division 1, Group D spaces. This classification extends 10 feet above the highest point of the cover and 5 feet from the wall. A Class I Division 2, Group D space extends 15 feet above the Division 1 area above the cover and 5 feet beyond the Division 1 area around the wall. These two classifications require hydrant protection as well as portable fire extinguishers. A fifth digester will have the same area classification.

Digester Control Building and Gas Scrubber Area

The digester control building, located central to Digesters 1 through 4, consists of three main rooms, including the digester gas equipment room, gas scrubber area, north pit area, sludge pump room, and drain pump room. The NFPA 820 (2024) classifications of these rooms are based on Table 6.6.2, Row 17 and Row 18.

Based on as-built drawings (Brown and Caldwell 1993), the gas equipment room is classified as a Class I, Division 2, Group D space. According to the Digestion Operation and Maintenance Manual (King County 2013), a study performed by Brown and Caldwell describes the gas room as being declassified. For the purposes of this TM, the gas equipment room is considered as classified per the 1993 as-built drawings.

If there is existing space in the digester gas equipment room to accommodate additional digester gas handling equipment, such as compressors, this equipment must be rated to meet the space classification of a Class I Division 1, Group D area at the equipment and within 5 feet of the equipment, based on NFPA 820 (2024) Table 6.6.2, Row 18. Beyond 5 feet from the gas handling equipment, the room is Class I, Division 2, Group D. This room must contain a combustible gas detection system, hydrant protection, and portable fire extinguishers.

The gas scrubber area is located outside and also includes areas with additional enclosed scrubbing equipment. All equipment within 5 feet of the gas scrubbing equipment and enclosures is classified as Class I, Division 1, Group D.

Additional sludge pumping equipment, such as digester transfer pumps, digester feed pumps, heat extractors, and digester circulation pumps, would be located in the sludge pump room, assuming there is space in the existing room to accommodate the new equipment. The sludge pump room is generally an unclassified area as it is ventilated at a minimum of 6 ACH and is physically separated from the gas handling equipment, except in the locations 5 feet from the digester, which is a Class I, Division 1 space, and 5 feet beyond the Division 1 space, which is a designated Class I, Division 2 space, per Table 6.6.2, Row 16 (NFPA 2024). In addition, the locations surrounding gas conveyance valves and appurtenances are treated as a classified space within 10 feet of the valves and appurtenances.

Based on as-built drawings, the drain pump room shares ventilation with the sludge pump room, is ventilated at a minimum of 6 ACH and is designated as an unclassified area.

Sludge Dewatering Building

The sludge dewatering building is located directly east of the digester control building. The NFPA 820 (2024) classifications of the rooms in this building are based off Table 6.6.2, Row 12, line a, which requires 6 ACH for the rooms in the dewatering building to be unclassified.

The main equipment in the basement of the building are centrifuge sludge transfers pumps, dry polymer feeders for DAF thickeners and centrifuges, polymer mixing tanks for DAF thickeners and centrifuges, polymer day tanks, and polymer day tank transfer pumps. Main equipment located on the ground floor of the building are centrifuges, bulk polymer storage tanks and polymer dilution units. Along with the main dewatering building, the bulk chemical storage areas are ventilated at 6 ACH and are designated as unclassified. Additional dewatering equipment in this building must meet classification requirements in Row 12. Hydrant protection, portable fire extinguishers and fire alarm systems are required throughout the dewatering building based on this classification.

Tunnels

There are a series of underground tunnels at STP that connect buildings. In particular, the tunnels that contain sludge gas piping and natural gas piping fall under the NFPA 820 (2024) classification based off Table 6.6.2, Row 22, which requires a minimum of 6 ACH for the tunnels to be unclassified.

Based on tunnel airflow diagrams and tunnel dimensions from as-built drawings, the STP tunnels are generally ventilated at a minimum of 6 ACH and are considered unclassified, except the areas within 10 feet of gas valves and appurtenances, which are classified as Class I Division 2, Group D. The tunnels are required to contain a combustible gas detection system, hydrant protection, and portable fire extinguishers.

FUTURE RIN REVENUE ESTIMATES

STP receives revenue based on the sale of RIN credits, from the U.S. Environmental Protection Agency (EPA) Renewable Fuel Standard (RFS) program. RINs are the currency of the RFS program, and the EPA sets limits each year on the number of RINs that can be sold based on renewable fuel volume targets. The various RIN types are assigned different market values based on fuel pathways for that RIN, and RINs are directly tied to the heating value of the fuel that is produced. The main fuel pathways for municipal wastewater treatment plants are via cellulosic biofuel, considered under the Applicable D Codes for Each Fuel Pathway for Use in Generating RINs (U.S. Code of Federal Regulations, 2024) as either a D3 RIN or a D5 RIN. D3 RINs are generated from converting biogas at municipal wastewater treatment facility digesters into RNG, and D5 RINs are produced from converting biogas from additional feedstock such as FWS, into RNG through anaerobic digestion or co-digestion.

STP currently receives revenue based on the sale of D3 RINs. If STP were to co-digest FWS and THS, RNG derived from the scrubbed and dried biogas from FWS feedstock would receive the D5 RIN pricing, whereas STP would continue to receive D3 RIN revenue from the sale of the portion of the RNG produced from digestion of THS.

Based on historical weekly trading data from the EPA, RIN values for D3 and D5 RINs have fluctuated since the RFS Program inception. Figure 10 displays historical RIN sale prices and shows the relative value between the D3 and D5 RINs over time.

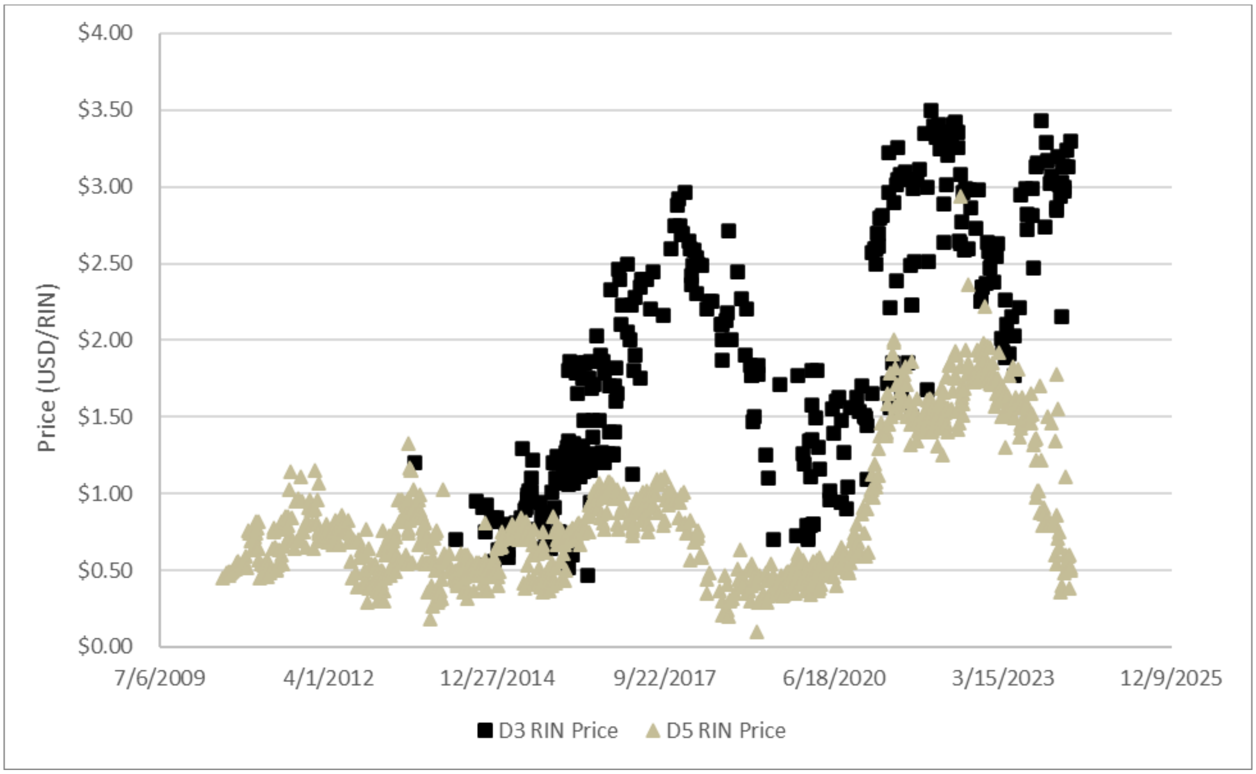

Figure 10. Historical D3 and D5 RIN Prices, 2010–2024 (U.S. EPA 2024)

Historical trading data for D5 RINs is available from July 2010; however, historical trading data for D3 RINs is only available from August 2013. Historical average RIN trading costs are listed below:

- D3 RINs (based on averages from August 26, 2013, to April 22, 2024): $1.88.
- D5 RINs (based on averages from July 12, 2010, to April 22, 2024): $0.86.

As of May 2024, D5 RINs are trading near historic lows at $0.43/RIN and D3 RINs are trading near historic highs at $3.20/RIN; however, the markets are constantly fluctuating based on many factors, including supply and demand.

Projections of annual RIN revenue were developed based on historically low, average, and high RIN values of D3 and D5 RINs and projected annual average STP biogas production with and without co-digestion of FWS. The RIN equivalency value as of May 2024 is 11.693 RINs/MMBtu, and it is assumed that 95 percent of the scrubbed, dried biogas from STP meets RNG specifications and is sold as part of the RIN program. In addition, the current third-party offtake agreement was provided to Jacobs, which states that 10 percent of the RIN revenue earned is shared with the third party that administers the RIN program on behalf of King County.

Due to the volatility of the RIN trading market, it is important to consider the range of potential revenue, and a tool such as a Monte Carlo simulation could be useful in the future to account for the change in various parameters and inputs, such as seasonality of biogas production, changes in RIN equivalency values, and future changes to the RFS and RIN trading values. Figure 11 displays the range of annual revenue expected based on current RIN equivalency value, as well as each of these historical D3 and D5 RIN values projected over time, with D5 RIN projections showing the range of RIN revenue expected should WTD accept the available FWS for co-digestion at the STP, based on historical trading values. The D3 RIN projections show the range of RIN revenue according to the annual average flow and load projections of THS described earlier in this TM.

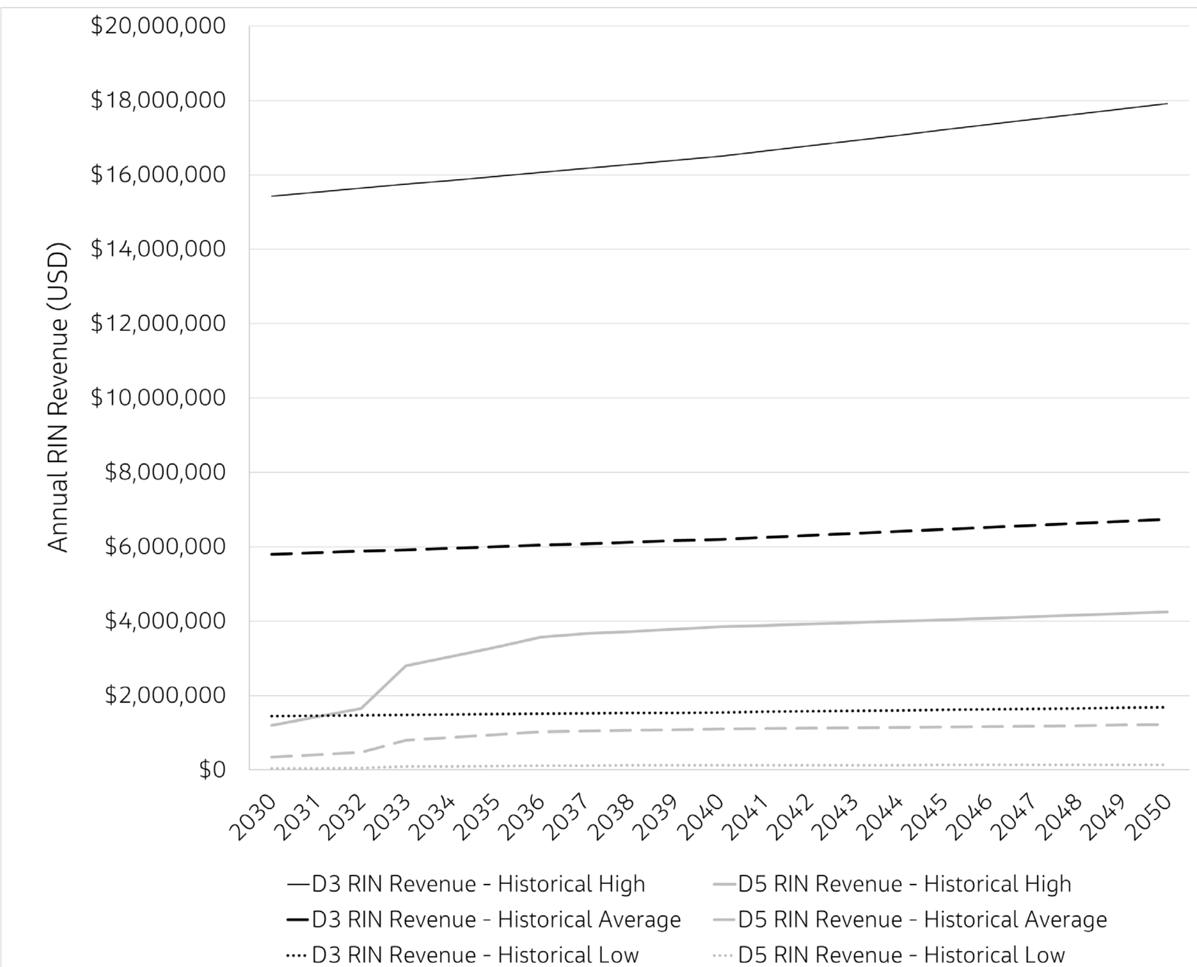

Figure 11. King County STP D3 and D5 RIN Revenue Projections, 2030–2050

D3 RIN revenue is projected to make up the large majority of the revenue; however, based on historical average D3 and D5 RIN trading prices, the D5 RINs have the potential to increase total STP RIN revenue by between 6 percent in 2030 and 18 percent in 2050. Projections are only made to 2050, due to uncertainty of RIN prices and the future of EPA's RFS program.

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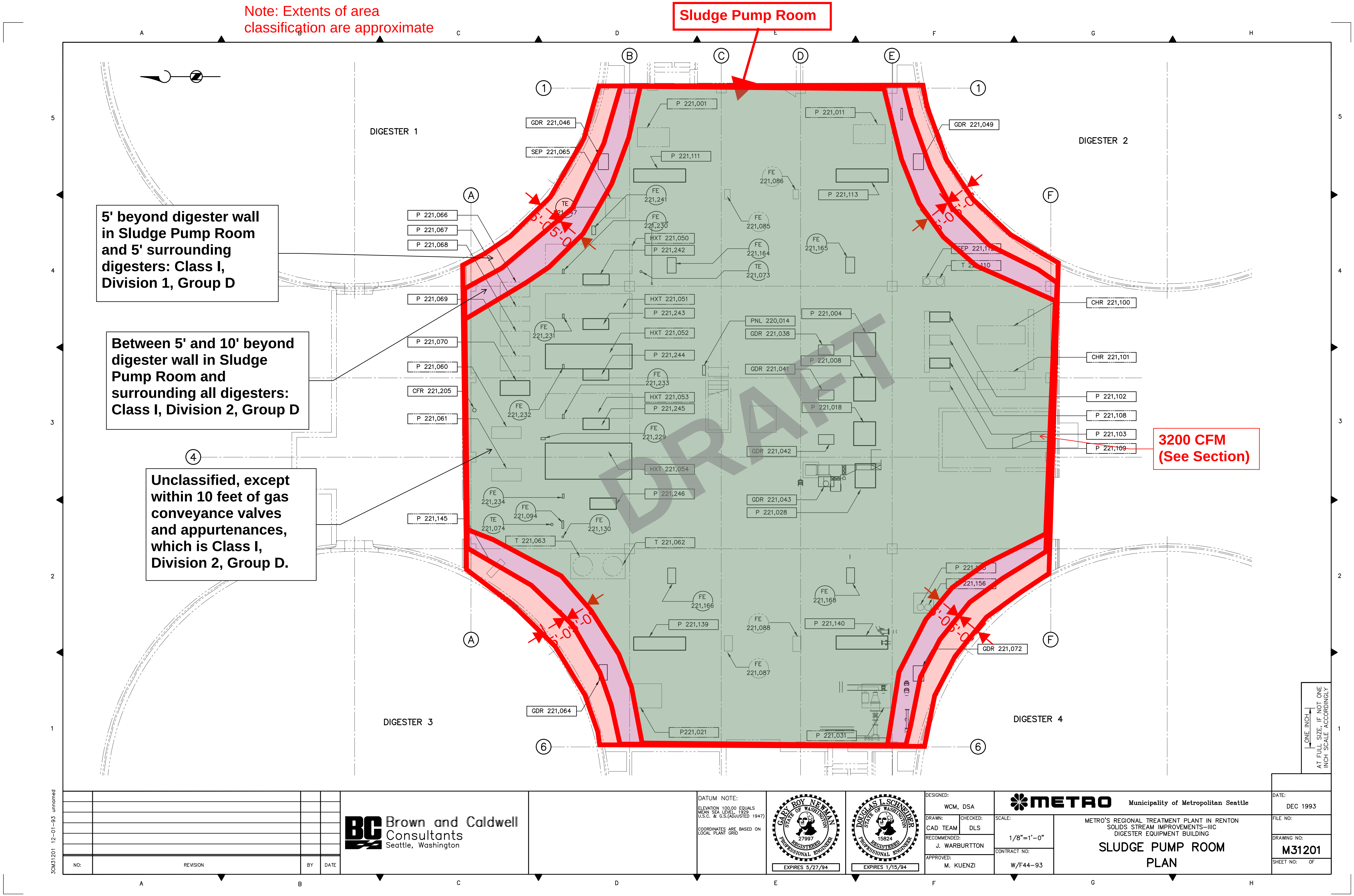
ATTACHMENT 1

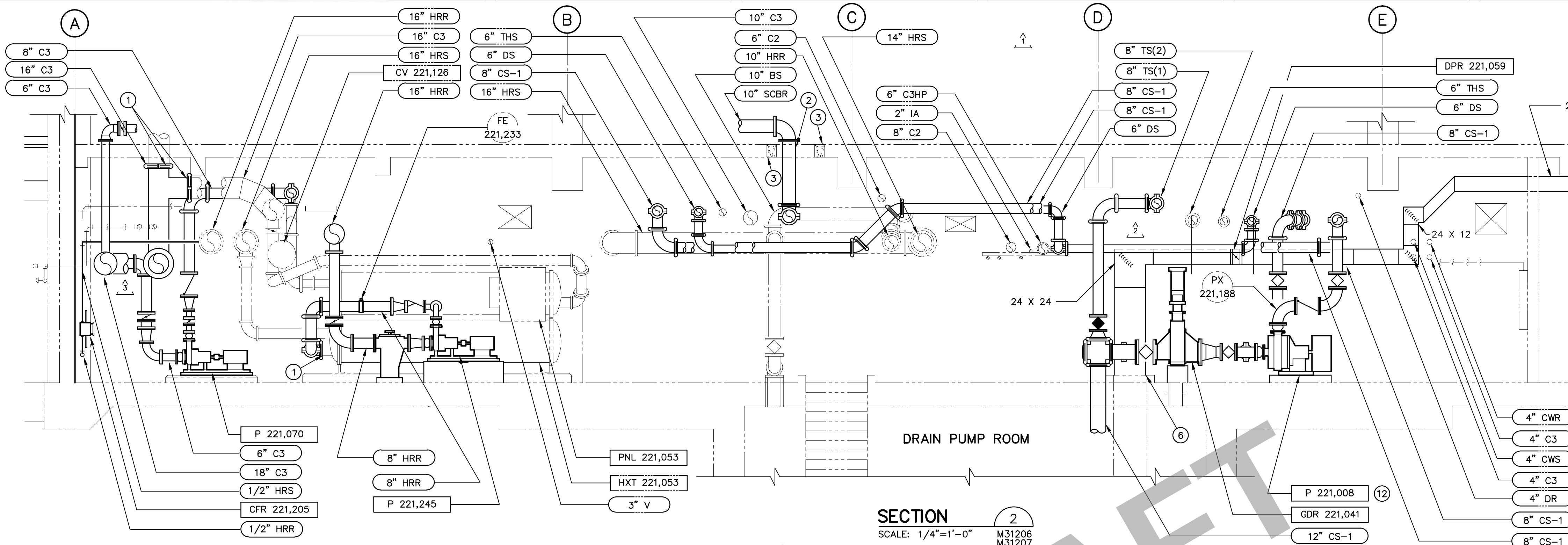
STP AS-BUILT DRAWING MARKUPS

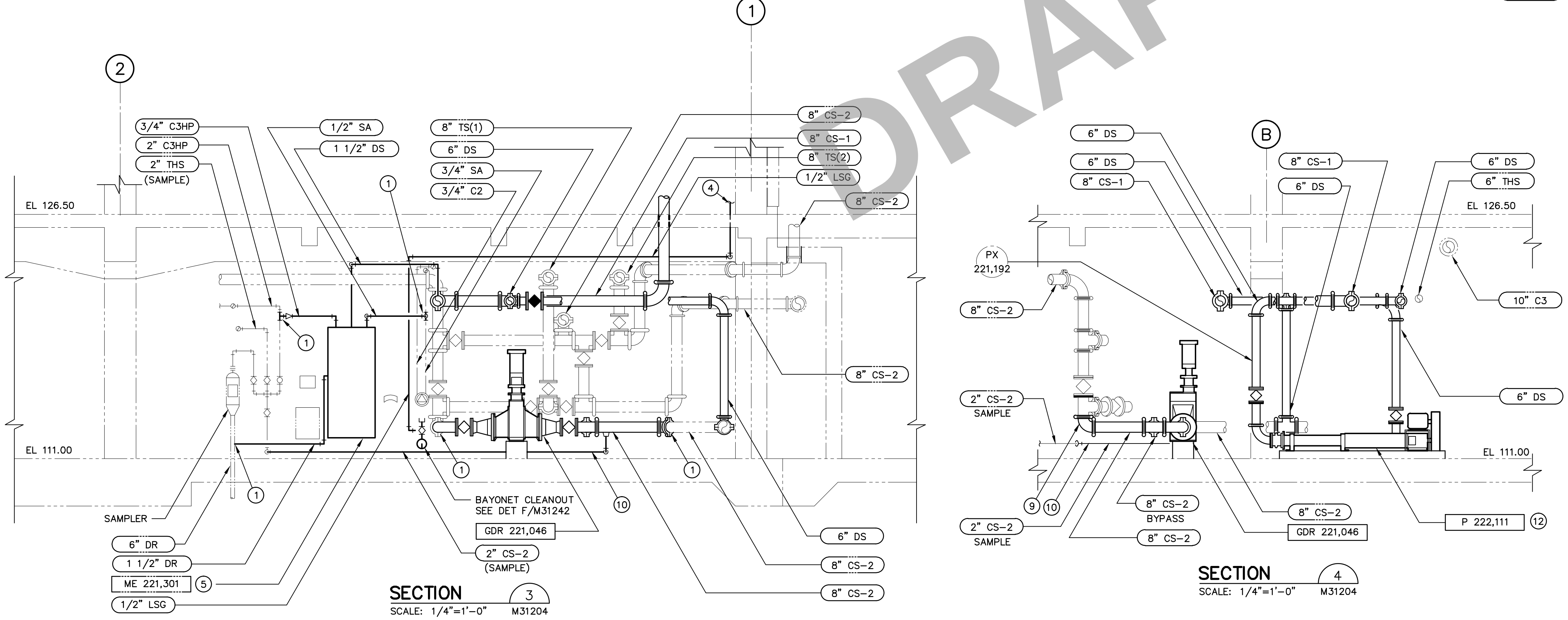
FOR NFPA 820 EVALUATION



Note: Extents of area classification are approximate
Sludge Pump Room
DIGESTER 1
DIGESTER 2
DIGESTER 3
DIGESTER 4
5' beyond digester wall in Sludge Pump Room and 5' surrounding digesters: Class I, Division 1, Group D
Between 5' and 10' beyond digester wall in Sludge Pump Room and surrounding all digesters: Class I, Division 2, Group D
Unclassified, except within 10 feet of gas conveyance valves and appurtenances, which is Class I, Division 2, Group D.
3200 CFM (See Section)
DRAFT
Brown and Caldwell Consultants
Seattle, Washington
DATUM NOTE:
ELEVATION 100.00 EQUALS MEAN SEA LEVEL 1929 U.S.C. & G.S.(ADJUSTED 1947)
COORDINATES ARE BASED ON LOCAL PLANT GRID
EXPIRES 5/27/94
EXPIRES 1/15/94
DESIGNED: WCM, DSA
DRAWN: CAD TEAM
CHECKED: DLS
RECOMMENDED: J. WARBURTTON
APPROVED: M. KUENZI
SCALE: 1/8"=1'-0"
CONTRACT NO: W/F44-93
METRO Municipality of Metropolitan Seattle
METRO'S REGIONAL TREATMENT PLANT IN RENTON
SOLIDS STREAM IMPROVEMENTS-IIIC
DIGESTER EQUIPMENT BUILDING
SLUDGE PUMP ROOM
PLAN
DATE: DEC 1993
DRAWING NO: M31201
NO:
REVISION
BY
DATE
ONE INCH
AT FULL SIZE, IF NOT ONE INCH SCALE ACCORDINGLY

Sludge Pump Room - Sections - Airflow





KEY NOTES:

1. CONNECT NEW PIPING TO EXISTING PIPING.
2. PROVIDE TYPE H PENETRATION.
3. REMOVE PIPING PENETRATION. REINFORCE AND GROUT FILL OPENING
4. FOR CONTINUATION SEE DRAWING M31242.
5. EXISTING SAMPLER RELOCATED AS SHOWN. PIPING CONNECTIONS SIMILAR FOR RELOCATED SAMPLERS AT DIGESTERS 2, 3 AND 4. SEE DETAIL J/M30013.
6. CONNECT NEW 24 X 24 DUCT TO EXISTING 26 X 26 DUCT.
7. PROVIDE NEW 24W X36 X 44 FREE AREA STATIONARY LOUVER PLENUM.
8. PROVIDE 24"W X 36"H STATIONARY LOUVER.
9. ROTATE EXISTING 8" 90° FITTING AND CONNECT NEW 8" CS-2 LINE AS SHOWN.
10. EXTEND EXISTING 2" CS-2 SAMPLE LINE AS REQUIRED AND CONNECT TO NEW 8" CS-2 LINE DOWNSTREAM OF GDR 221,046. SEE SECTION 3/M31222.
11. RELOCATE EXISTING ELECTRICAL CONDUITS AS REQUIRED TO AVOID CONFLICT WITH NEW PLENUM.
12. PROVIDE FLUSHING CONNECTIONS AS SHOWN IN DETAIL K/M30013.

ONE INCH AT FULL SIZE, IF NOT ONE INCH SCALE ACCORDINGLY

NO:	REVISION	BY	DATE
3	RFIM728	TMB	11/95
2	RFIM550	TMB	8/95
1	RFIM415/PWC83	TMB	6/95

3CM31222 12-01-93 unnamed

Brown and Caldwell Consultants
Seattle, Washington

DATUM NOTE:
ELEVATION 100.00 EQUALS MEAN SEA LEVEL 1929 U.S.C. & G.S.(ADJUSTED 1947)
COORDINATES ARE BASED ON LOCAL PLANT GRID

GARY ROY NEWMAN, STATE OF WASHINGTON, 27997, REGISTERED PROFESSIONAL ENGINEER — EXPIRES 5/27/94

DOUGLAS L. SCHNEIDER, STATE OF WASHINGTON, 15824, REGISTERED PROFESSIONAL ENGINEER — EXPIRES 1/15/94

DESIGNED: WCM, DSA
DRAWN: CAD TEAM — CHECKED: DLS
RECOMMENDED: J. WARBURTON
APPROVED: M. KUENZI
SCALE: 1/4"=1'-0"
CONTRACT NO: W/F44-93

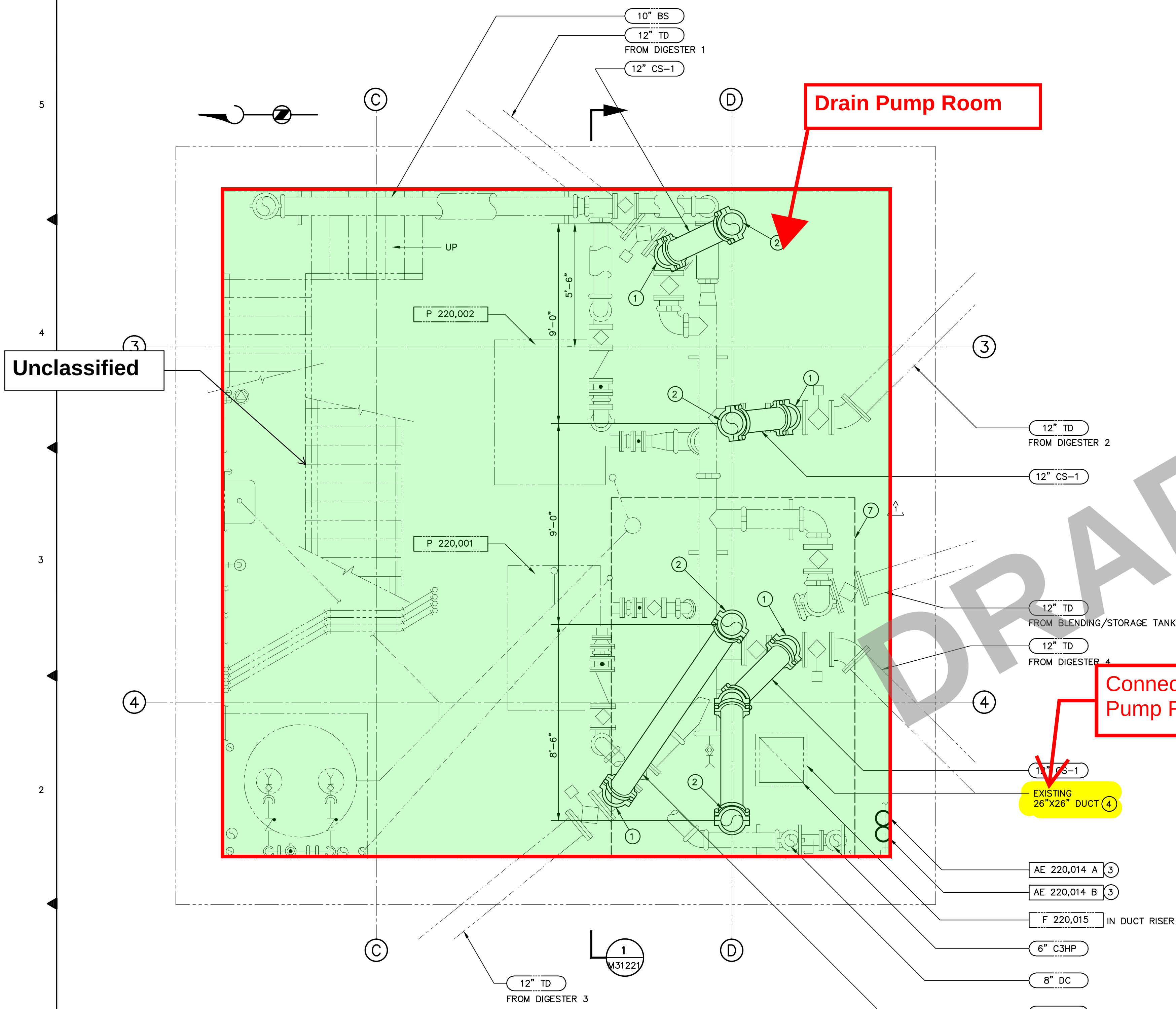
METRO — Municipality of Metropolitan Seattle

METRO'S REGIONAL TREATMENT PLANT IN RENTON
SOLID STREAM IMPROVEMENTS—IIIC
DIGESTER EQUIPMENT BUILDING

SLUDGE PUMP ROOM
SECTIONS 1

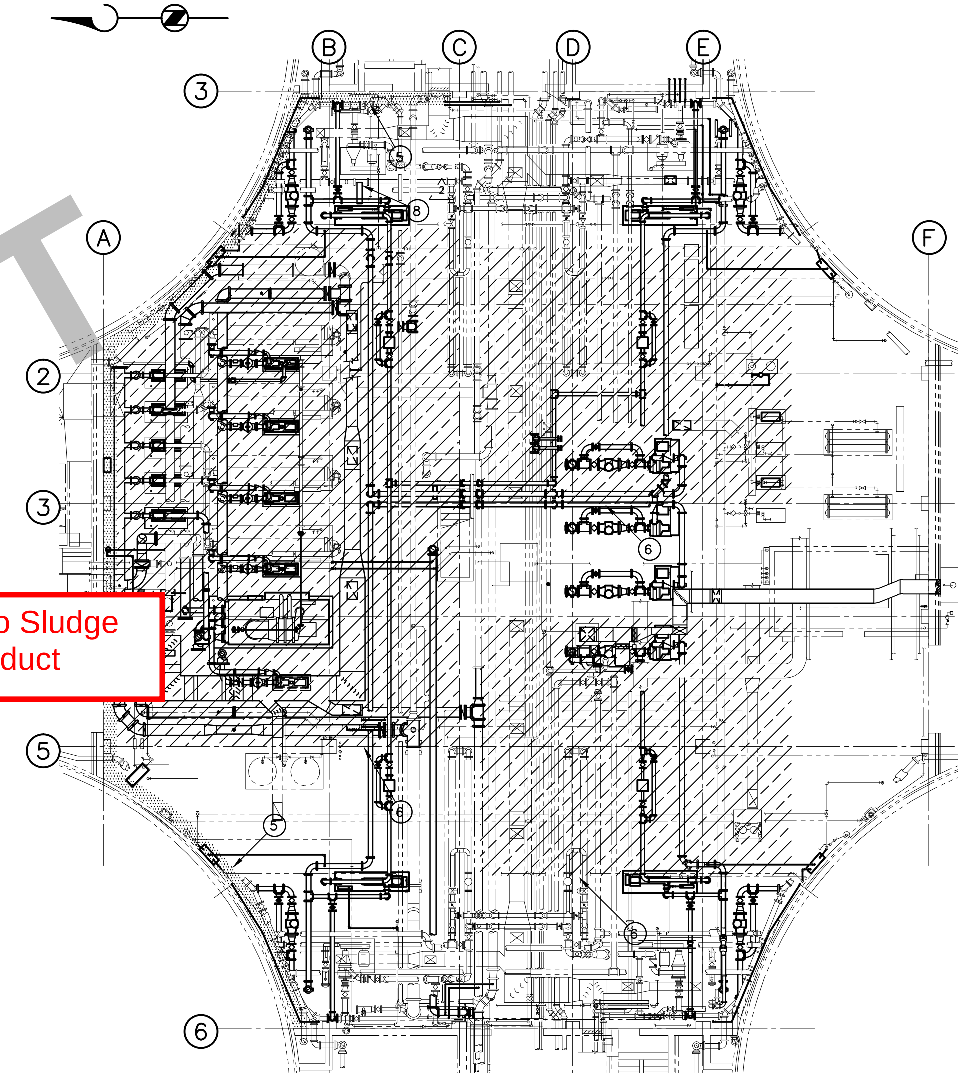
DATE: DEC 1993
FILE NO:
DRAWING NO: M31222
SHEET NO: OF

Note: Extents of area classification are approximate



KEY NOTES

1. REMOVE EXISTING 12" X 6" REDUCER, 6" PLUG VALVE AND 6" DS LINE. CONNECT NEW 12" CS-1 LINE WITH NEW 12" PLUG VALVE TO EXISTING 12" TEE.
2. ROUTE NEW 12" CS-1 TO NEW SLAB PENETRATION.
3. MOUNT SENSORS ON WALL 18" ABOVE FINISHED FLOOR.
4. PROVIDE NEW DUCT SECTION AS REQUIRED TO RELOCATE EXISTING INTAKE GRILLE TO 2" ABOVE FLOOR. SEE DRAWING M31221.
5. WALL MOUNTED ACOUSTICAL PANELS. SEE SECTION 09500.
6. CEILING MOUNTED ACOUSTICAL PANELS. SEE SECTION 09500.
7. RELOCATE LIGHTS AND CONDUIT IN THIS AREA
8. RAISE LIGHT A2C (ABOVE DIGESTER WITHDRAWAL PUMP 1)



SLUDGE PUMP ROOM

ACOUSTICAL PANEL LAYOUT PLAN

SCALE: NO SCALE

ONE INCH — AT FULL SIZE, IF NOT ONE INCH SCALE ACCORDINGLY

NO:	REVISION	BY	DATE
2	RFI882/PWC244	BJ	4/96
1	RFI895/PWC244	BJ	4/96

3CM31203 12/14/93 GAC

Brown and Caldwell Consultants, Seattle, Washington

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GARY ROY NEWMAN, STATE OF WASHINGTON, 27997, REGISTERED PROFESSIONAL ENGINEER, EXPIRES 5/27/94

DOUGLAS L. SCHNEIDER, STATE OF WASHINGTON, 15824, REGISTERED PROFESSIONAL ENGINEER, EXPIRES 1/15/94

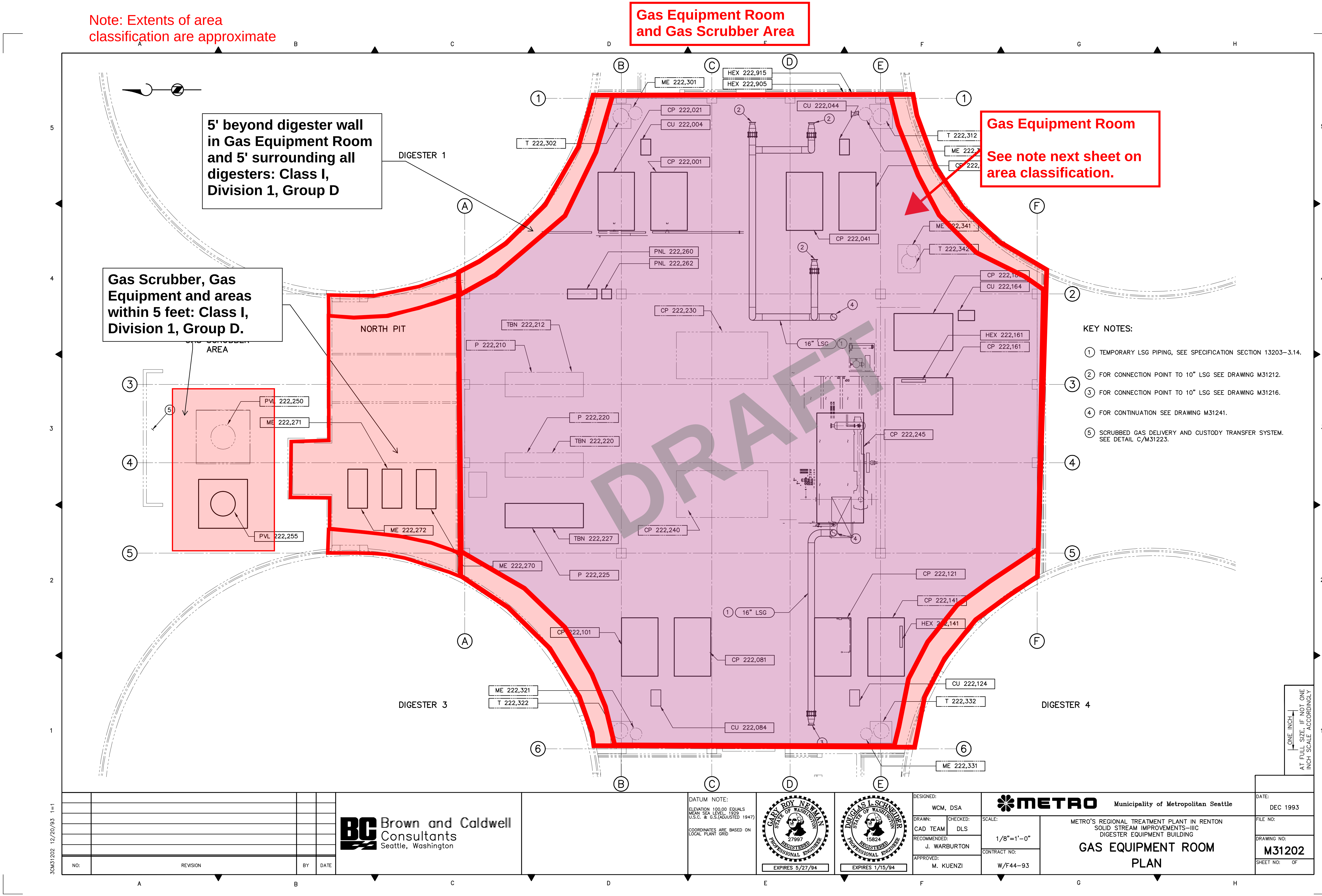
DESIGNED: WCM, DSA
DRAWN: CAD TEAM — CHECKED: DLS
RECOMMENDED: J. WARBURTON
APPROVED: M. KUENZI
SCALE: 3/8"=1'-0"
CONTRACT NO: W/F44-93

METRO Municipality of Metropolitan Seattle

METRO'S REGIONAL TREATMENT PLANT IN RENTON
SOLID STREAM IMPROVEMENTS—IIIC
DIGESTER EQUIPMENT BUILDING

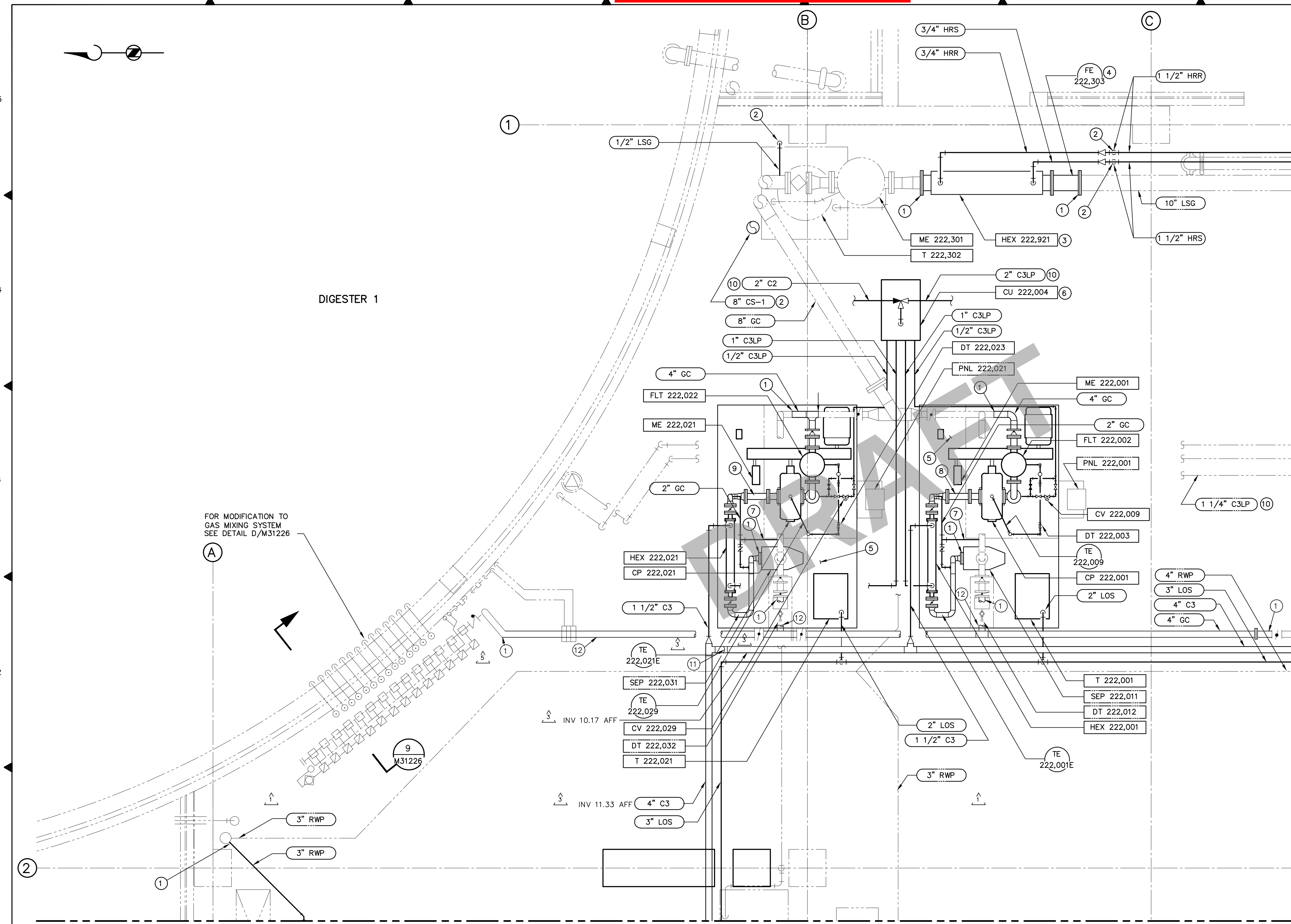
DRAIN PUMP ROOM PLAN

DATE: DEC 1993
FILE NO:
DRAWING NO: M31203
SHEET NO: OF



Note: Extents of area classification are approximate
Gas Equipment Room and Gas Scrubber Area
Gas Equipment Room
See note next sheet on area classification.
5' beyond digester wall in Gas Equipment Room and 5' surrounding all digesters: Class I, Division 1, Group D
Gas Scrubber, Gas Equipment and areas within 5 feet: Class I, Division 1, Group D.
DIGESTER 1
DIGESTER 3
DIGESTER 4
NORTH PIT
AREA
DRAFT
KEY NOTES:
1 TEMPORARY LSG PIPING, SEE SPECIFICATION SECTION 13203-3.14.
2 FOR CONNECTION POINT TO 10" LSG SEE DRAWING M31212.
3 FOR CONNECTION POINT TO 10" LSG SEE DRAWING M31216.
4 FOR CONTINUATION SEE DRAWING M31241.
5 SCRUBBED GAS DELIVERY AND CUSTODY TRANSFER SYSTEM. SEE DETAIL C/M31223.
ME 222,301
HEX 222,915
HEX 222,905
CP 222,021
CU 222,004
CU 222,044
T 222,302
T 222,312
CP 222,001
CP 222,041
PNL 222,260
PNL 222,262
T 222,342
CP 222,230
CU 222,164
TBN 222,212
P 222,210
HEX 222,161
CP 222,161
16" LSG
PVL 222,250
ME 222,271
P 222,220
TBN 222,220
CP 222,245
PVL 222,255
ME 222,272
TBN 222,227
CP 222,240
ME 222,270
P 222,225
CP 222,121
CP 222,141
CP 222,101
CP 222,081
ME 222,321
T 222,322
CU 222,124
T 222,332
CU 222,084
ME 222,331
AT FULL SIZE, IF NOT ONE INCH SCALE ACCORDINGLY
ONE INCH
Brown and Caldwell Consultants Seattle, Washington
DATUM NOTE: ELEVATION 100.00 EQUALS MEAN SEA LEVEL 1929 U.S.C. & G.S.(ADJUSTED 1947) COORDINATES ARE BASED ON LOCAL PLANT GRID
GARY ROY NEWMAN STATE OF WASHINGTON 27997 REGISTERED PROFESSIONAL ENGINEER EXPIRES 5/27/94
DOUGLAS L. SCHNEIDER STATE OF WASHINGTON 15824 REGISTERED PROFESSIONAL ENGINEER EXPIRES 1/15/94
DESIGNED: WCM, DSA
DRAWN: CAD TEAM
CHECKED: DLS
RECOMMENDED: J. WARBURTON
APPROVED: M. KUENZI
SCALE: 1/8"=1'-0"
CONTRACT NO: W/F44-93
METRO Municipality of Metropolitan Seattle
METRO'S REGIONAL TREATMENT PLANT IN RENTON SOLID STREAM IMPROVEMENTS-IIIC DIGESTER EQUIPMENT BUILDING
GAS EQUIPMENT ROOM PLAN
DATE: DEC 1993
FILE NO:
DRAWING NO: M31202
SHEET NO: OF
NO: REVISION BY DATE
3CM31202 12/20/93 1=1

Gas Equipment Room Space Classification Note

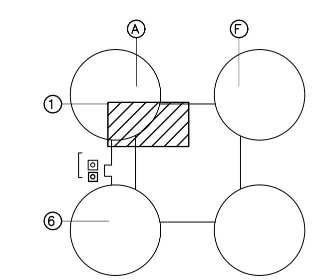


KEY NOTES:

1. CONNECT NEW PIPING TO EXISTING PIPING.
2. PROVIDE TYPE H PENETRATION.
3. FOR LSG PREHEATER SEE DETAIL B/M31223.
4. FOR LSG FLOWMETER SEE DETAIL I4C/I01106
5. NEW EQUIPMENT PAD, SEE DET N/S49 AND SPECIFICATION SECTION 13203 – 3.16.
6. TYPE A CONTROL UNIT. SEE DWG M30012. PROVIDE VALVED STRAINER BLOWOFF ON WATER SUPPLY.
7. CONNECT NEW 2 1/2" GC TO EXISTING PRV.
8. TW 222,001A; TW 222,010; PE 222,007
9. TW 222,021A; TW 222,030; PE 222,027
10. CONNECT 2" C3LP AND 2" C2 TO CONTROL UNIT WATER SUPPLY FROM LOCAL SOURCE PIPING. SEE CONNECTION TO 3–WAY VALVE ON P31221.
11. INSTALL 45° BEND.
12. REMOVE EXIST. 4" GC STEEL PIPE & INSTALL NEW 4" SS TYPE 304, SCHEDULE 40 PIPE. REUSE EXIST. VALVES.

GENERAL NOTES:

1. THE DIGESTER GAS EQUIPMENT ROOM IS A CLASS 1 DIVISION 2 GROUP D AREA AND SHALL REMAIN IN OPERATION THROUGHOUT THE CONSTRUCTION PERIOD. ALL CONSTRUCTION PRACTICES IN THE GAS EQUIPMENT ROOM SHALL BE IN ACCORDANCE WITH THE RESTRICTIONS OF THE HAZARDOUS AREA CLASSIFICATION. ADDITIONAL VENTILATION, FIRE PROTECTION REQUIREMENTS AND ALIKE, WHICH ARE REQUIRED TO PERFORM THE MODIFICATIONS IN THIS AREA, SHALL BE PROVIDED BY THE CONTRACTOR AND COORDINATED WITH THE PLANT STAFF.
2. FOR EQUIPMENT DRAIN AND FLOOR DRAIN MODIFICATIONS SEE DRAWING M31231.



KEY PLAN
NO SCALE

ONE INCH AT FULL SIZE, IF NOT ONE INCH SCALE ACCORDINGLY

NO:	REVISION	BY	DATE
5	PWC198	TMB	1/96
4	RFIM458	TMB	6/95
3	RFI225A/PWC77	TMB	6/95
2	RFIM377	TMB	5/95
1	AB1	TMB	3/95

3CM31211 12/17/93 GAC

Brown and Caldwell Consultants
Seattle, Washington

DATUM NOTE:
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COORDINATES ARE BASED ON LOCAL PLANT GRID

GARY ROY NEWMAN — STATE OF WASHINGTON — 27997 — REGISTERED PROFESSIONAL ENGINEER — EXPIRES 5/27/94

DOUGLAS L. SCHNEIDER — STATE OF WASHINGTON — 15824 — REGISTERED PROFESSIONAL ENGINEER — EXPIRES 1/15/94

DESIGNED: CJC, DSA
DRAWN: CAD TEAM
CHECKED: DLS
RECOMMENDED: J. WARBURTON
APPROVED: M. KUENZI
SCALE: 3/8"=1'–0"
CONTRACT NO: W/F44–93

METRO Municipality of Metropolitan Seattle

METRO'S REGIONAL TREATMENT PLANT IN RENTON
SOLID STREAM IMPROVEMENTS—IIIC
DIGESTER EQUIPMENT BUILDING

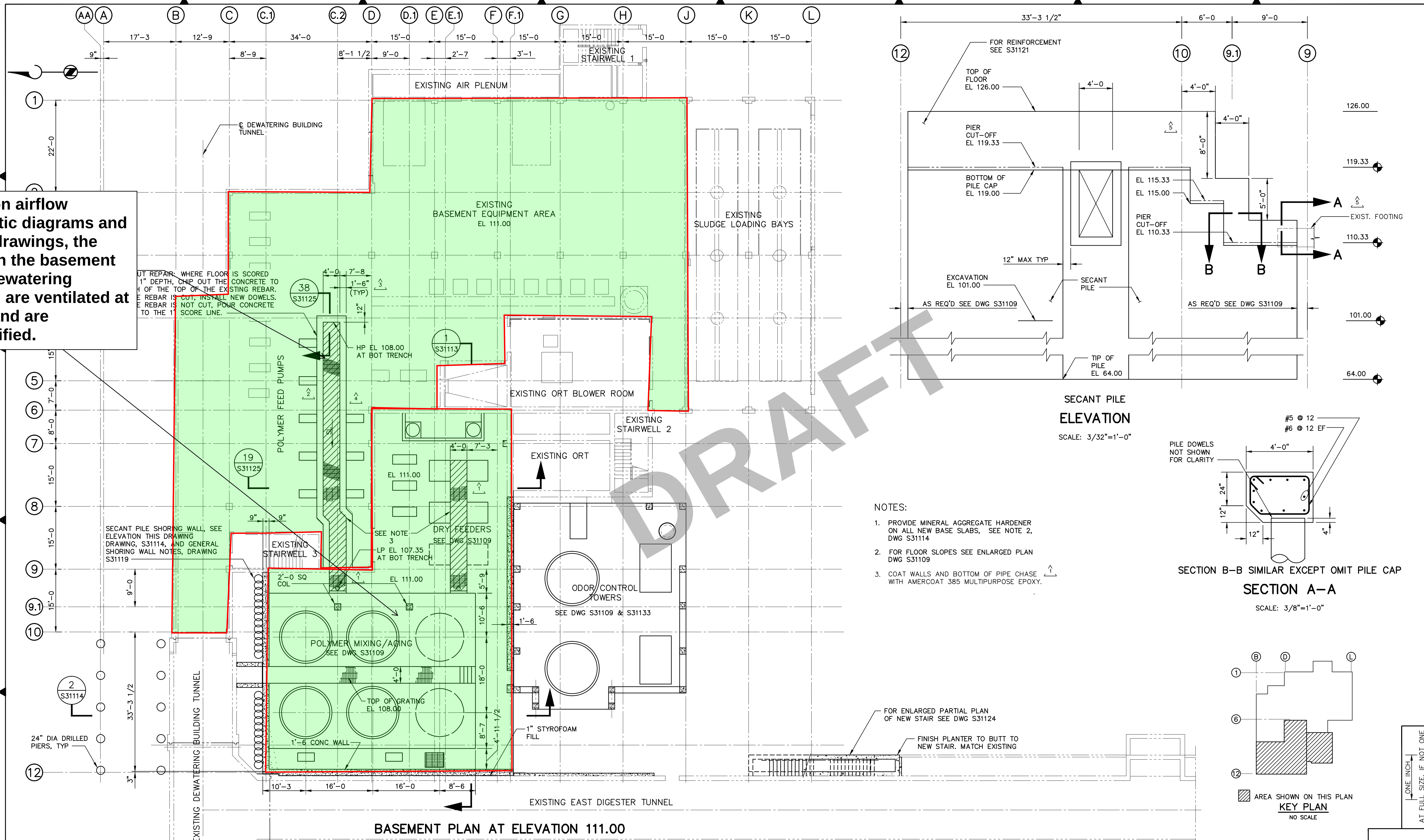
GAS EQUIPMENT ROOM PLAN 1

DATE: DEC 1993
FILE NO:
DRAWING NO: M31211
SHEET NO: OF

Note: Extents of area classification are approximate

Dewatering Building - Basement Floor Plan

Based on airflow schematic diagrams and record drawings, the rooms in the basement of the dewatering building are ventilated at 6 ACH and are unclassified.



NO:	REVISION	BY	DATE
5	AB1	TMB	10/95
4	RFIM144	BGS	4/95
3	RFIM188	MAG	4/95
2	RFIM254	TMB	3/95
1	PWC21	BGS	12/94

Brown and Caldwell Consultants, Seattle, Washington

DATUM NOTE: ELEVATION 100.00 EQUALS MEAN SEA LEVEL 1929 U.S.C. & G.S.(ADJUSTED 1947). COORDINATES ARE BASED ON LOCAL PLANT GRID

DESIGNED: S. SZETO | DRAWN: CT | CHECKED: CYC | RECOMMENDED: J. WARBURTON | APPROVED: M. KUENZI

SCALE: 3/32"=1'-0" | CONTRACT NO: W/F44-93

METRO Municipality of Metropolitan Seattle

METRO'S REGIONAL TREATMENT PLANT IN RENTON SOLIDS STREAM IMPROVEMENTS-IIIC SLUDGE DEWATERING BUILDING

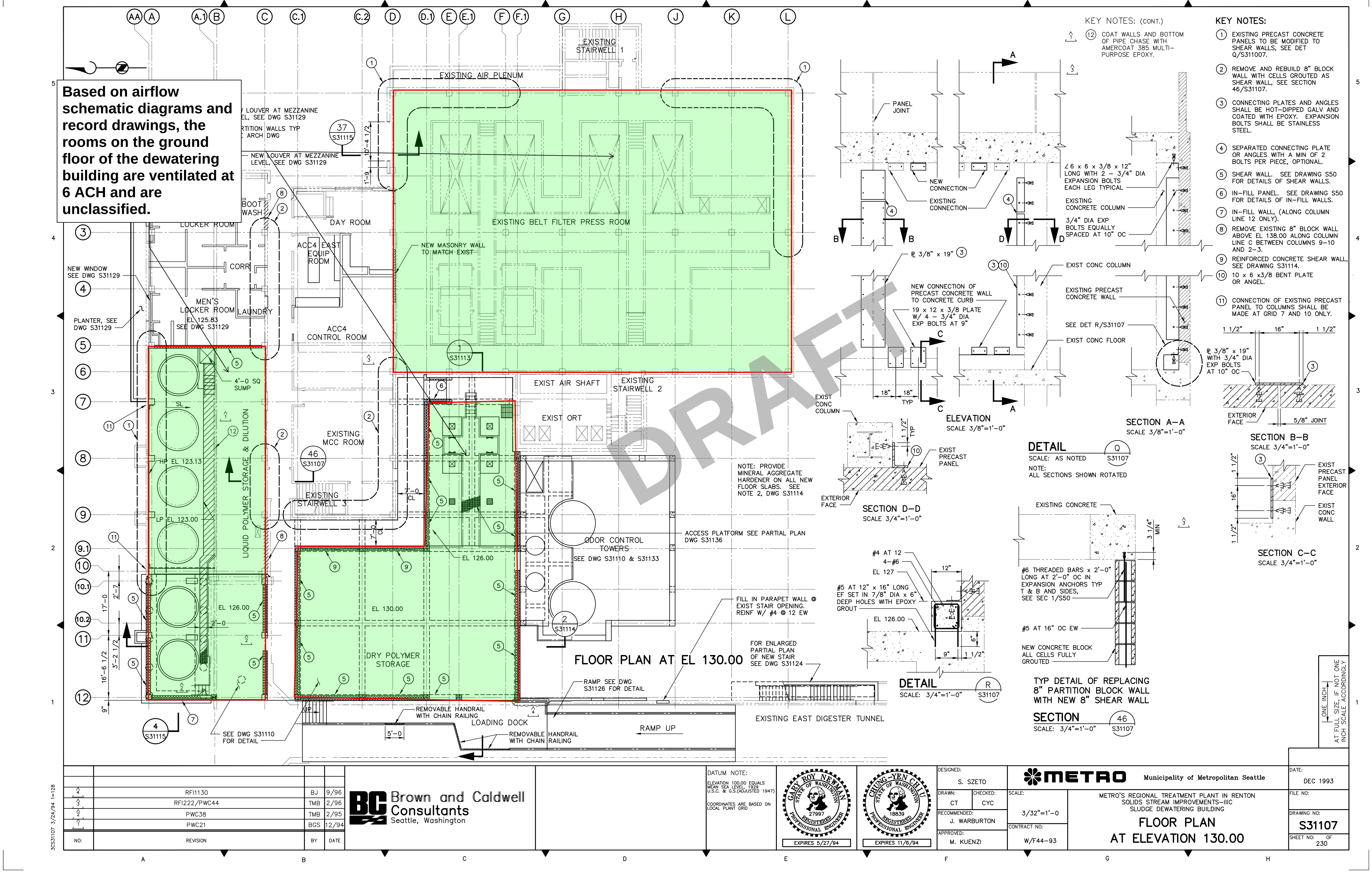
BASEMENT PLAN AT ELEVATION 111.00

DATE: DEC 1993 | DRAWING NO: S31106

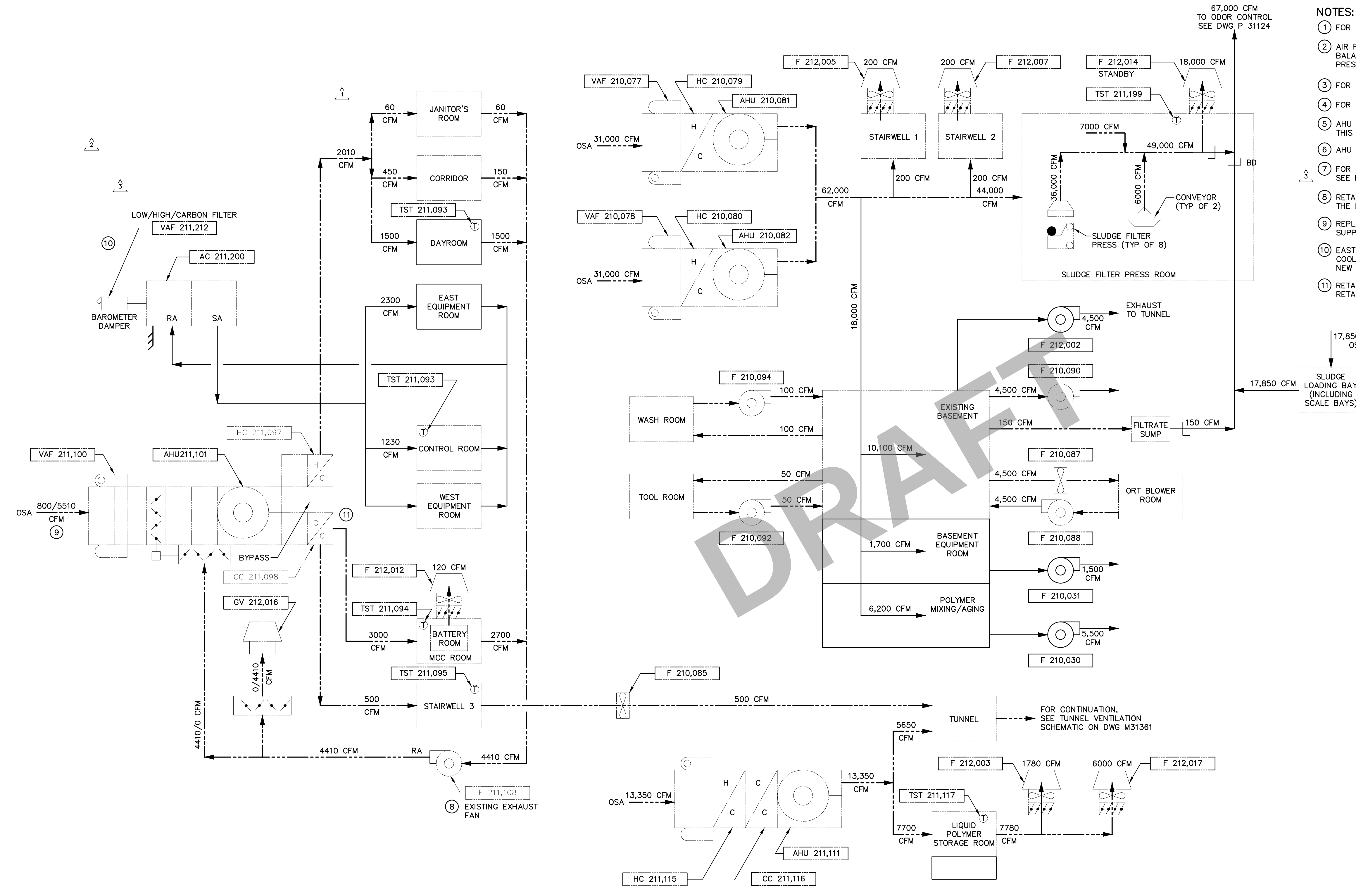
Note: Extents of area classification are approximate

Dewatering Building - Ground Floor Plan

Based on airflow schematic diagrams and record drawings, the rooms on the ground floor of the dewatering building are ventilated at 6 ACH and are unclassified.



Dewatering Building - Airflow Schematic



NOTES:

1. FOR DOWNSTREAM FOUL AIR SCHEMATIC SEE P DWGS.
2. AIR FLOW QUANTITIES SHOWN ON SCHEMATICS MAY NOT ALWAYS BALANCE. THIS IS TO PROVIDE A POSITIVE OR NEGATIVE AIR PRESSURE WITHIN THESE AREAS.
3. FOR LOCKER ROOM AIR FLOW SCHEMATIC SEE DRAWING M31164.
4. FOR DRY POLYMER AREA AIR FLOW SCHEMATIC SEE DRAWING M31157.
5. AHU 210,081 AND AHU 210,082 ARE INCREASED IN CAPACITY UNDER THIS CONTRACT.
6. AHU 211,101 IS INCREASED IN CAPACITY UNDER THIS CONTRACT.
7. FOR EXISTING, DEMOLISHED, REPLACED DUCTWORK AND REGISTERS SEE MECHANICAL DWGS.
8. RETAIN EXISTING RETURN AIR FAN F211108. REPLACE OR READJUST THE EXISTING SHEAVES FOR 4410 CFM RETURN AIR.
9. REPLACE OR READJUST THE EXISTING SHEAVES OF AHU 211101 TO SUPPLY TOTAL AIR OF 5510 CFM.
10. EAST EQUIPMENT ROOM, WEST EQUIPMENT ROOM AND CONTROL ROOM COOLING AND HEATING WILL BE DISCONNECTED FROM AHU 211101. NEW ROOF TOP PACKAGE UNIT WILL BE INSTALLED BY OWNER.
11. RETAIN EXISTING COOLING COIL CC 211098 OF AHU 211101. RETAIN EXISTING HEATING COIL HC 211097 OF AHU 211101.

AT FULL SIZE, IF NOT ONE INCH SCALE ACCORDINGLY — ONE INCH

NO:	REVISION	BY	DATE
3	PWC433	MRW	7/97
2	AB2	MRW	7/96
1	AB1	MRW	7/96

3CM31156 12/21/93 1=1

Brown and Caldwell Consultants
Seattle, Washington

DATUM NOTE:
ELEVATION 100.00 EQUALS MEAN SEA LEVEL 1929 U.S.C. & G.S.(ADJUSTED 1947)
COORDINATES ARE BASED ON LOCAL PLANT GRID

GARY ROY NEWMAN — STATE OF WASHINGTON — 27997 — REGISTERED PROFESSIONAL ENGINEER — EXPIRES 5/27/94
DAVID L. CLARK — STATE OF WASHINGTON — 21798 — REGISTERED PROFESSIONAL ENGINEER — EXPIRES 4/3/94

DESIGNED: P. WOLSTENHOLME
DRAWN: CAD TEAM — CHECKED: DLC
RECOMMENDED: J. WARBURTON
APPROVED: M KUENZI
SCALE: NO SCALE
CONTRACT NO: W/F44-93

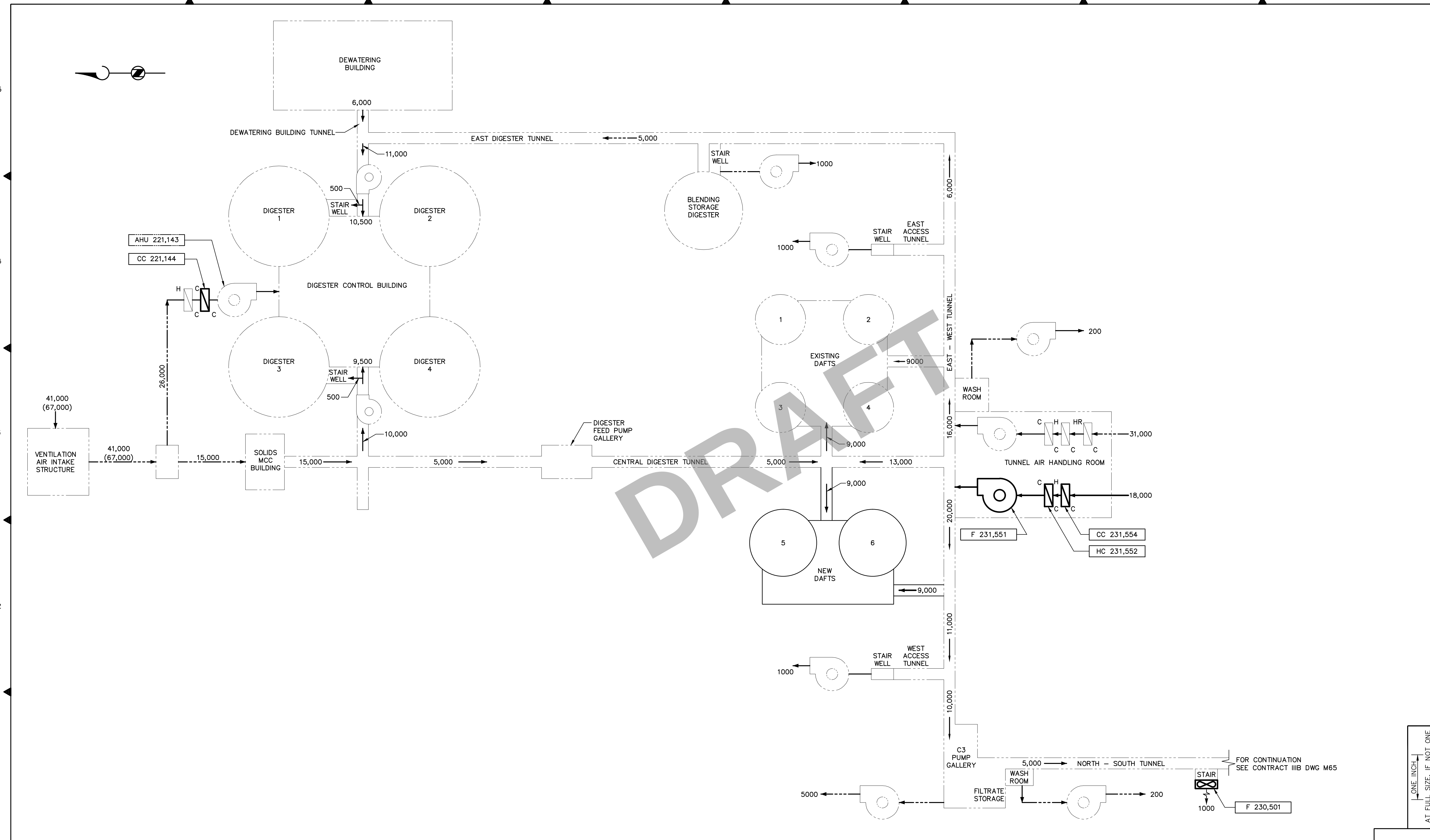
METRO Municipality of Metropolitan Seattle

METRO'S REGIONAL TREATMENT PLANT IN RENTON
SOLIDS STREAM IMPROVEMENTS—IIIC
SLUDGE DEWATERING BUILDING

AIR FLOW SCHEMATICS

DATE: DEC 1993
FILE NO:
DRAWING NO: M31156
SHEET NO: OF

Tunnels - Airflow Schematic



ONE INCH — AT FULL SIZE, IF NOT ONE INCH SCALE ACCORDINGLY

NO:	REVISION	BY	DATE

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Seattle, Washington

DATUM NOTE:
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DAVID L. CLARK — STATE OF WASHINGTON — 21798 — REGISTERED PROFESSIONAL ENGINEER — EXPIRES 4/3/94

DESIGNED: P. WOLSTENHOLME
DRAWN: CAD TEAM
CHECKED: DLC
RECOMMENDED: J. WARBURTON
APPROVED: M. KUENZI
SCALE: NO SCALE
CONTRACT NO: W/F44-93

METRO Municipality of Metropolitan Seattle

METRO'S REGIONAL TREATMENT PLANT IN RENTON
SOLIDS STREAM IMPROVEMENTS—IIIC

SOLIDS AREA TUNNELS AIRFLOW SCHEMATIC

DATE: DEC 1993
FILE NO:
DRAWING NO: M31361
SHEET NO: OF

3CM31361.DWG 12/21/93 1=1 GAC

\\spcad\R\RIII\R3C WF44-93\MECH\3CM31361.dwg, 11/27/2013 8:46:09 AM, Jeff

Technical Memorandum

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Bellevue, Washington 98004
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To:	Drew Thompson, WTD, and Andrew Fitzpatrick, SWD/King County
From:	Carlin Coleman, Grace Hadinata, and Matt Noesen/Jacobs
Reviewed:	Lyndsey Lopez, Matt Noesen, Scott Grieco, and Corey Klibert/Jacobs
Cc:	Shelby Smith/HDR
Date:	August 6, 2024
Task Name:	200.03 Market Evaluation
Subject:	**Literature Review of Per- and Polyfluoroalkyl Substances Concentrations in Processed Food Waste Slurry** **Food Waste Recycling Alternatives Analysis Project**

INTRODUCTION

King County is evaluating options for diverting food waste from landfill disposal. When food waste is added to wastewater anaerobic digesters that have extra capacity, it can effectively utilize the existing infrastructure to divert food waste from landfills. Currently, there is an abundance of data on anaerobic digester performance and operation based on measurements appropriate for wastewater solids digestion. However, there is far less data available to estimate digester performance with the addition of other organic wastes (WRF, 2018). Moreover, there is limited available data regarding negative impacts, such as elevated concentrations of contaminants from digestate (the residual material after anaerobic digestion). Per- and polyfluoroalkyl substances (PFAS) are a group of contaminants (see Attachment 1 for definition of terms) of emerging concern, and over recent years, states have been preparing guidance values for wastewater effluent and biosolids products (WRF, 2022). This literature review includes a summary of recent (within last 10 years) academic papers, articles, and research reports, as it relates to potential sources of PFAS in digestate resulting from addition of organic wastes, including PFAS in food, food waste, and digestate.

LITERATURE REVIEW

Per- and Polyfluoroalkyl Substances

PFAS are a group of synthetic chemicals widely used in various industrial and consumer products due to their unique properties. There are over 12,000 identified chemical varieties in production and found in the environment since the 1940s. For the purpose of this Memo, the abbreviation PFAS will be used generally to represent this family of per- and polyfluoroalkyl substances.

The presence of PFAS in the environment has raised concerns due to their persistence, bioaccumulation potential, and potential adverse health effects. Since the 1960s, the FDA has authorized specific types of substances containing PFAS for use in food contact applications.

These substances are valued for their non-stick and grease, oil, and water-resistant properties. The most commonly studied PFAS are perfluorooctanoic acid (PFOA) and perfluorooctane sulfonate (PFOS) (Barr, 2020). However, previous studies have revealed the presence of a wider range of PFAS in food packaging such as perfluoroalkylcarboxylic acids (PFCAs), perfluoroalkanesulfonic acids (PFSAs), fluorotelomer alcohols (FTOHs) and phosphate esters (PAPs and diPAPs) which can be transferred to food (Minet 2022, Begley 2008). Although several individual PFAS can be found in food packaging or food waste, the only compounds under current federal regulation are PFOA, PFOS, perfluorobutane sulfonic acid (PFBS), perfluorononanoic acid (PFNA), and hexafluoropropylene oxide dimer acid (HFPO-DA), and those regulations are specific to drinking water. HFPO-DA is commonly referred to as GenX when present in drinking water. Although it is anticipated that future regulations could be developed at the federal and state level for biosolids, soils, wastewater, or receiving waters, none currently exist in the United States. Also, regulations for limiting use and sale of products containing PFAS do exist in some states, including Washington State, and continue to evolve as technical and policy understanding of PFAS continues to mature.

Removing or transforming PFAS into benign compounds from a water, biosolids or soil medium is challenging, and developing effective methods for identification and treatment is ongoing.

PFAS Concentrations in Food

Limited available data indicate that PFAS in U.S. food items purchased from retail stores are primarily found in seafood, followed by meat products, with concentrations varying across different studies (USEPA, 2021). A recent study by the FDA employs the Total Diet Study (TDS) to assess PFAS exposure through food consumption. The study has revealed that over 97% of the fresh and processed foods tested from the TDS did not contain detectable levels of PFAS. However, 44% of seafood samples from the TDS and 74% of samples from a targeted seafood survey conducted in 2022 showed the presence of at least one type of PFAS (USFDA, 2022). The results of the seafood survey indicate that clams had the highest concentrations of PFAS among all the tested seafood types. The primary route of PFAS exposure for fish and shellfish is through water uptake via the gills and filter-feeding for bivalves and crustaceans. These organisms can accumulate PFAS from the aquatic environment through water, suspended solids, and sediment.

PFAS compounds also remain prominent in food contact materials (FCMs) and food packaging, which could result in migration of PFAS to food. Food contact materials cover a very expansive list of potential products, from industrial food production equipment and machinery. In a literature review focused on identifying potential sources of PFAS coming into compost sites, FCMs were reported to have the highest PFAS concentrations across all sources evaluated. PFAS sources considered in this review included FCMs, potentially contaminated food sources, and pesticides contained within yard waste (Wood, 2021).

Historically, long chain perfluoroalkyl acids (PFAAs) were most frequently detected in FCMs, but short chain PFAAs started appearing in 2011 (Phelps 2024). Interestingly, the research by Phelps et al illustrate that long-chain PFAAs are now found alongside short-chain PFAAs, rather than being completely replaced by them (Phelps 2024). It is unclear whether long-chain PFAAs are still intentionally present substances, unintentionally formed degradation products of, e.g., fluorotelomers or fluorinated polymers, or created as byproducts in the manufacture of other PFAS used for food packaging (Phelps 2024). Current as of February 2024, the FDA has authorized certain PFAS for use in specific food contact applications (USFDA, 2024a). The following is a summary of FDA's authorized uses of food contact substances that contain PFAS and migration potential:

- **Nonstick coating applications:** PFAS molecules are polymerized, forming large molecules that are then applied to the surface of cookware at high temperatures. This process tightly binds the polymer coating to the cookware, and studies have shown negligible migration of PFAS from the coating to food (USFDA, 2024a). However, PFAS is used as an emulsifier in the production of polytetrafluoroethylene (PTFE), commonly known by its trade name, Teflon®. Residual PFAS may leach into material contacted with these PTFE coatings. Historically, this has been PFOA, but more recently use of replacement chemicals such as ammonium 4,8-dioxa-3H-perfluorononanoate ADONA are being used (Schlummer 2015).
- **Sealing gaskets for food processing equipment:** PFAS molecules are polymerized and the resultant large molecules are further joined together to create a resin used in parts like sealing gaskets and O-rings for food processing equipment. This manufacturing process removes virtually all the smaller (i.e., migratable) PFAS molecules, resulting in negligible amounts of PFAS capable of migrating to food (USFDA, 2024a).
- **Manufacturing aids:** PFAS molecules, whether polymerized or not, are used as aids in the manufacture of other food contact polymers. The quantities of PFAS used as manufacturing aids are so small that migration to food is negligible. The amount of PFAS used as aids in the manufacture of other food contact polymers is so small that only negligible amounts can migrate to food from this use (USFDA, 2024a).
- **Grease-proofers applied to fast-food wrappers, microwave popcorn bags, take-out paperboard containers, and pet food bags**: PFAS are attached as "sidechains" to non-PFAS polymerized molecules, forming the final grease-proofing agent applied to paper packaging. The application process occurs at lower temperatures, which are insufficient to remove smaller migratable PFAS molecules. Under certain conditions, these smaller PFAS sidechains can detach and potentially migrate to food at levels

that may raise safety concerns. Manufacturers have voluntarily discontinued the sale of remaining PFAS-containing grease-proofers authorized for food contact use. As a result, PFAS-containing (long-chain PFAS and 6:2 FTOH) substances are no longer sold for use as grease-proof coatings on paper food packaging, (USFDA, 2024a). It is anticipated that it may take until June 2025 to exhaust existing stocks of products containing these food contact substances (USFDA, 2024b).

PFAS Concentrations in Food Waste

The term food waste can include a wide range of materials and is dependent on how the specific jurisdiction or program defines it and type of generator or source. For example, some programs that include the collection of food waste allow customers to include some compostable packaging or paper products, while others are food-only. Additionally, residential curbside programs often commingle food waste with yard debris; whereas commercial curbside programs (from businesses) do not typically do that. These distinctions are important to understand because they impact the applicability of PFAS related data from food waste.

Food waste, properly collected and processed, is a potential feedstock for co-digestion at wastewater treatment plants (WWTPs), however, other organic components of municipal solid waste such as paper and cardboard or grass and woody material, are not suitable for WWTP anaerobic digesters because of their poor digestibility (Carollo, 2019). Preprocessing feedstock offsite is helpful and often performed at solid waste management facilities. Preprocessing requires grinding and blending materials, removing contaminates, and producing a high quality, consistent slurry (WRF, 2018).

While data on PFAS in food waste is limited, multiple studies cited in a USEPA paper (2021) reported the presence of PFAS in food from areas with no known sources of PFAS releases (non-contaminated areas). The limited data show that food contact materials may contribute more to overall PFAS levels in food waste streams (USEPA, 2021).

PFAS in food waste streams can vary based on several factors. These factors include the specific food groups present in the feedstock, the origin of the food, and the types of food contact materials used. PFAS concentrations in source-separated organic (SSO) food waste are anticipated to be very low but could be of concern in case of significant PFAS-containing plastic contamination, leaching of PFAS from packaging into food, or bioaccumulation (WRF, 2023). According to a 2021 USEPA paper, comparison of composts made with and without food waste reported that food waste compost had higher PFAS levels than yard waste compost. Additionally, data showed that PFAS concentrations were higher in composts with compostable food packaging and that compostable food contact materials have higher PFAS concentrations that non-compostable samples. Total PFAS loads ranged from 31 to 75 μg/kg dry weight (dw) in composts with compostable food packaging and from 2.3 to 7.4 μg/kg dw in composts without compostable food packaging. Of the composts with compostable food packaging, PFHxA was the PFAS with the highest concentration, with levels ranging from 10.52 to 49.84 μg/kg dw, as compared to concentrations of 0.38–1.07 μg/kg dw in the three composts without compostable food packaging (USEPA, 2021). PFAS soil concentrations protective of potable groundwater under Washington state's Model Toxics Control Act Cleanup Regulations lists a concentration of 35 μg/kg for PFHxA in vadose zone (Washington State Department of Ecology, 2023). Note that the Washington state regulations also include values for other PFAS compounds.

Quantifying PFAS in Food Waste Anaerobic Digestion

There are a lack of studies specifically measuring PFAS levels in anaerobic digestates produced solely from 100 percent food waste. Existing studies on digestates were conducted using mixtures of various feedstocks, such as yard waste, kitchen waste, and industrial waste, making it challenging to draw conclusions about PFAS concentrations specifically in food waste digestates. In a study examining five PFAS (PFOS, PFHxS, PFBS, PFOA, and PFNA) in sewage sludge from three WWTPs, concentrations before and after anaerobic digestion reported varying results; PFAS concentrations in the primary sludge (feedstock) were found to be either greater, similar, or lower compared to the anaerobic digested sludge, depending on factors such as hydraulic residence time and digestion duration (USEPA, 2021). PFOS and perfluorononanoic acid (PFNA) concentrations were found to increase in the digestate, possibly due to the degradation of precursors present in the sewage sludge (USEPA, 2021).

While some PFAS compounds have been phased out from production of grease-proofers authorized for food contact in the United States, the FDA still authorizes certain PFAS for products in contact with food (nonstick coating, sealing gaskets, and manufacturing aids). Therefore, PFAS concentrations in food waste is still a potential concern for SSO feedstock digesting facilities and final biosolids (WRF, 2022). More recent studies found generally lower PFOA and PFOS concentrations in biosolids from municipal WWTPs compared to earlier studies in which mean biosolids PFAS concentrations were often dominated by a few industrially impacted outliers, indicating industrial phaseouts in the 2000s are having positive impacts (Young et al, 2024).

In 2020, the California State Water Board required Wastewater Resource Recovery Facilities (WRRFs) treating over 1 MGD to measure PFAS in their influent, effluent, biosolids. California's GeoTracker PFAS Map reports at least one type of PFAS has been detected in solids at 94% of the 156 WRRFs sampled. The majority of California WRRF biosolids results were equal to or below their reporting limits for PFOA and PFOS (Young et al, 2024).

However, in April 2024, the USEPA announced final National Primary Drinking Water Regulation (NPDWR) for six PFAS, establishing legally enforceable Maximum Contaminant Levels (MCLs) (see Table 1). Although these regulatory thresholds are for drinking water, these low thresholds may pose challenges to land application of biosolids (Young et al, 2024, and NEBRA, 2023) and should be considered in assessments of land application of biosolids. The presence of PFAS in municipal biosolids has led to concern over the potential impacts of land application of biosolids to human health and the environment. To evaluate the potential for exposure, several factors must be considered, including whether groundwater is impacted, and if so, if the impacted groundwater is used for potable water or for other uses that lead to human exposure. The risk of significant PFAS contamination of groundwater from land application of biosolids depends on various factors including soil texture, depth to groundwater, biosolid source (industrial vs. municipal) and PFAS chain length (Pepper et al, 2023). Overall, the risk of significant PFAS contamination of groundwater from land application of biosolids would be most likely in a scenario where industrially-impacted biosolids are applied to a coarse textured soil with a shallow depth to groundwater and high rainfall or irrigation. Less significant risk would occur when municipal biosolids are applied to finer textured soils with large depth to groundwater (Pepper et al, 2023).

Additionally, if biosolids are applied to land, PFAS can accumulate in soils and groundwater, and may be absorbed into food or fodder crops (De Silva et al, 2020) and lead to subsequent uptake of contamination into cattle and dairy products (Jha, 2021). There are reported examples of detectable levels of PFAS in soils, hay, and milk from dairy farms in the US (Jha, 2021). The scientific evaluations of crop uptake and accumulation in beef/tissue of cattle is still a growing field of research. The EPA is currently conducting a biosolids risk assessment for PFAS in biosolids which is expected to be published by the end of 2024 (USEPA, 2024b). In addition, the Washington State Department of Ecology (Ecology) Water Quality division is undertaking a monitoring effort to test for PFAS in biosolids at selected municipal wastewater treatment facilities in Washington. As NPDES permits are renewed for these facilities, PFAS monitoring of the influent, effluent and biosolids is being required.

Table 1. USEPA Maximum Contaminant Levels (MCLs) for six PFAS in drinking water[1].

Compound	Final MCL Goal	Final MCL (enforceable levels)
PFOA	0	4.0 parts per trillion (ppt) (also expressed as ng/L)
PFOS	0	4.0 ppt
PFHxS	10 ppt	10 ppt
PFNA	10 ppt	10 ppt
HFPO-DA (commonly know as GenX chemicals)	10 ppt	10 ppt

[1] Hazard Index Calculation described in USEPA Proposed PFAS National Primary Drinking Water Regulation FAQs for Drinking Water Primacy Agencies https://www.epa.gov/system/files/documents/2023-03/FAQs_PFAS_States_NPDWR_Final_3.14.23_0.pdf.

Mixtures containing two or more of PFHxS, PFNA, HFPO-DA, and PFBS	1 (unitless) Hazard Index	1 (unitless) Hazard Index

Source: USEPA, 2024a

The calculation for the hazard index (HI) is:

$$HI\ MCL = \left(\frac{[HFPO\!-\!DA_{water}]}{[10\ ppt]}\right) + \left(\frac{[PFBS_{water}]}{[2000\ ppt]}\right) + \left(\frac{[PFNA_{water}]}{[10\ ppt]}\right) + \left(\frac{[PFHxS_{water}]}{[10\ ppt]}\right) = 1$$

CONCLUSIONS

In conclusion, generally PFAS pose concerns due to their persistence, bioaccumulation potential, and potential adverse health effects. While the majority of fresh and processed foods tested in the FDA's Total Diet Study did not contain detectable levels of PFAS, seafood samples, particularly clams, showed the presence of PFAS in a significant percentage of samples. While the FDA has authorized specific PFAS-containing substances for use in food contact applications, steps have been taken to minimize their migration into food, such as discontinuing the use of PFAS-containing substances in paper food packaging production that exceeded a negligible amount. Although specific studies on PFAS levels in anaerobic digestates from 100 percent food waste are limited, research using various feedstocks suggests that PFAS concentrations can vary.

Based on the literature, certain feedstocks are known to have higher concentrations of PFAS. With this understanding, it is possible to implement restrictions on the feedstocks used in anaerobic digestion, and this limits the risk of PFAS contamination in the biosolids produced. Overall, further research and development of effective methods are crucial to understanding and addressing the challenges posed by PFAS contamination.

The Washington Pollution Control Hearings Board (PCHB) has ordered Ecology to include additional discussion and analysis of PFAS, Polybrominated diphenyl ethers (PBDEs), and microplastics in the reissuance of the General Permit for Biosolids Management (Ecology, 2024). The extent to which PFAS, as well as microplastics and PBDE, are observed in biosolids could factor into consideration of food waste co-digestion (or at a minimum, not be overlooked). It is uncertain what to expect from Ecology's further evaluation of PFAS in biosolids land application. King County should monitor Ecology's progress and continue dialogue with Ecology staff to determine whether they are willing to share any information about plans that would impact the County and other wastewater utilities.

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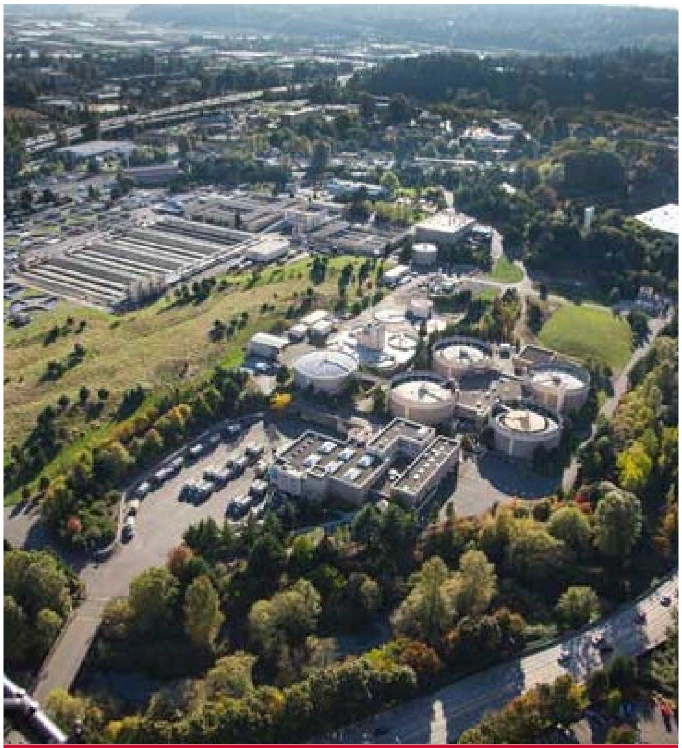
ATTACHMENT 1
DEFINITION OF TERMS

HFPO-DA	hexafluoropropylene oxide dimer acid
PFAS	per- and polyfluoroalkyl substances
PFHxS	perfluorohexane sulfonate
PFNA	perfluorononanoic acid
PFOA	perfluorooctanoic acid
PFOS	perfluorooctane sulfonate



Final Food Waste Processing Technologies and Regional Options

Prepared for Jacobs under Task 200.03 – Market Evaluation, Food Waste Recycling Alternative Analysis

King County, Washington

September 6, 2024

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Contents

Figures

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Abbreviations

°F	degree(s) Fahrenheit
AD	anaerobic digestion
ASP	aerated static pile
BGE	Baltimore Gas and Electric Company
Btu	British thermal unit(s)
CAR	Climate Action Reserve
CG	Cedar Grove
CHP	combined heat and power
CFW	commercial food waste
CMSA	Central Marin Sanitation Agency
CO_2	carbon dioxide
CORe	Centralized Organic Recycling equipment
County	King County
CSB	community-supported biocycling
EBMUD	East Bay Municipal Utility District
EBS	engineered bioslurry
EU	European Union
F2E	Food to Energy
FOG	fats, oils, and grease
GC	gas chromatograph
GLSD	Greater Lawrence Sanitary District
H_2S	hydrogen sulfide
HDR	HDR Engineering, Inc.
HZ-SLO	Hitachi Zosen–San Luis Obispo
ICI	industrial, commercial, and institutional
JC Biomethane	Junction City Biomethane
LACSD	Los Angeles County Sanitary District
Lenz	Lenz Enterprises
MRF	materials recovery facility
MSW	municipal solid waste
MW	megawatt(s)
NYC	New York City
NYCDEP	New York City Department of Environmental Protection
OWS	Organic Waste Solutions
PacifiClean	PacifiClean Environmental
PFRP	process to further reduce pathogens
POTW	publicly owned treatment works
PSE	Puget Sound Energy
PUD	Public Utility District
RIN	Renewable Identification Number
RNG	renewable natural gas
scf	standard cubic foot/feet
STP	South Treatment Plant
SSO	source-separated organics
SWD	Solid Waste Division
tCO_2e	ton(s) of carbon dioxide equivalents
tpd	ton(s) per day
VOC	volatile organic compound
WM	Waste Management
WSDA	Washington State Department of Agriculture
WTD	(King County) Wastewater Treatment Division
WWTP	wastewater treatment plant
ZWED	Zero Waste Energy Development

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1 Introduction

King County, Washington (County) has a long-standing history of relying on composting as the primary method of managing its organic wastes. Composters in the region have been collecting and processing yard waste materials mixed with commercial food waste (CFW) materials for decades.

HDR Engineering, Inc. (HDR) prepared this report to inform the King County Wastewater Treatment Division (WTD) and Solid Waste Division (SWD) of the wide variety of available methods for managing organic waste. This report focuses on methods of managing increasing quantities of CFW in a way that diverts the materials from disposal at the Cedar Hills Regional Landfill, but also as a way of meeting the Washington State organics diversion mandate of House Bill 1799 (Wash. House Bill 1799, 2022) and Senate Bill 2301 (Wash. Senate Bill 2301, 2024).

The methods discussed generally are currently available in the United States at commercial scale. A few small-scale, or package, types of devices being developed can also be viewed as commercially viable, in that they would not be classified as an "emerging technology." This report covers biological processes but does not explore thermal, chemical, or biochemical processes due to their relatively higher capital and operating costs in addition to their adverse social optics, being seen as akin to incineration/waste-to-energy types of technologies. Conversely, biological processes are relatively plentiful, readily available, and relatively inexpensive compared to the other types of processes and are more likely to be supported by both regulatory agencies and the public.

Generally, the treatment of organic material using biological processes can be categorized into the following two groups:

- **Anaerobic,** which is the degradation of organic matter using an oxygen-deprived environment. Generally, this process is referred to as anaerobic digestion (AD). It employs the use of bacteria that thrive in oxygen-deprived environments, known as anaerobes. When consuming organic material, anaerobes emit methane, carbon dioxide (CO_2), various alcohols and volatile organic compounds (VOCs), and water as moisture.
- **Aerobic,** which is the degradation of organic matter using an oxygen-rich environment. Generally, this process is referred to as composting. It employs the use of bacteria that thrive in oxygen-rich environments, known as aerobes. When consuming organic material, aerobes emit heat, CO_2, and water as moisture. The process is rarely purely oxygen-rich, so it also typically includes some pockets of oxygen-deprived materials. These pockets contain anaerobic bacteria and can generate variable quantities of the anaerobic emissions discussed above.

The primary interests of this study began with a focus of exploring AD using the South Treatment Plant [STP]) in Renton, Washington, for its potential to serve as a co-digestion facility for a portion of the County's CFW. However, this report has been expanded to inform the reader of the growing organics management industry, and now serves to provide a broad overview of the types of preprocessing systems, AD technologies, and composting technologies currently available. The expanded sections are meant to familiarize the reader with the broad array of systems in the marketplace. Although not all of these technologies are applicable to King County's interests, they are included for the reader's general understanding and appreciation of the innovative ways organic material can be managed.

The report clarifies the functional differences between AD and composting process technologies, and how pretreatment systems are needed to bridge the gap between the condition of organic waste as set out by the waste generator and the quality of feedstock required for the biological processing technology to receive/process the material. Finally, the report provides a summary of the known operators, both for AD and composting, in the greater King County area and the surrounding region.

2 Preprocessing Technologies

Preprocessing technologies can generally be categorized according to the different types of feedstock material streams they process, namely:

- **Mixed or municipal solid waste (MSW) streams,** which include high quantities of non-putrescible materials such as metals, glass, ceramics, cardboard, paper, and plastic contamination. Examples of this include CFW co-collected with other MSW materials which are not compostable nor digestible, resulting in a somewhat elevated composition of organic material, but which is still predominantly MSW. These types of waste streams generally require the use of a press-type technology.
- **Source-separated organics (SSO) streams,** which include small amounts of non-putrescible materials and may require the organic matter to be de-packaged. Examples of this include grocery store food wastes where out-of-date vegetables may be packaged in plastic bags, or post-consumer food waste that may contain packaging materials, film plastic, plastic packaging and metallic utensils. This waste stream can be processed using a de-packaging type of preprocessing system or a mechanical/removal type of system.

Each of these types of technologies is described in more detail below.

2.1 Press-Type Technologies

The use of a press to extract the organic fraction from mixed waste is becoming increasingly popular where the organic content of mixed waste is high, or where jurisdictions prefer to avoid implementing a source separated collection system. Several forms of waste presses have been developed and employed, primarily in Europe, to process a variety of feedstock materials, mostly from mixed waste streams. The process, referred to as bio-squeeze, extrusion, or press, can include a variety of ancillary systems to remove contaminants that are extruded along with the liquid organic content of the feedstock. The press system can be designed to function on SSO or on mixed waste. These systems employ a similar process whereby the feedstock material is compressed into a sieve that allows the wet fraction to release through the holes in the sieve.

A combined yard trimmings and food waste SSO stream (Figure 2-1) is run through the Fitec BioSqueeze unit shown in Figure 2-2, extruding organic-rich cake as shown in Figure 2-3. Similar to other organic processes developed in Europe, if mixed waste is the feedstock, the remaining solid fraction following this process is typically landfilled or incinerated in energy-from-waste facilities.

Figure 2-4 and Figure 2-5 show the Anaergia OREX press extruding an organic-rich cake from a wet mixed municipal waste stream.

The cake from these systems typically contains relatively high quantities of grit, glass, ceramics, and fragments of metal. It requires downstream degritting prior to sending the resulting slurry to a low solids-type AD facility. Alternatively, the cake would be suitable for use in a dry-type AD facility, which has the ability to accommodate grit and contamination. These types of AD technologies are discussed further in Section 2.5.

Figure 2-1. Rothmuhle biogas plant in Germany: incoming organic material stream (SSO)

Source: HDR.

Figure 2-2. Fitec, Rothmuhle biogas plant in Germany: BioSqueeze unit

Source: HDR.

Figure 2-3. Fitec, Rothmuhle biogas plant in Germany: extruded solid fraction from BioSqueeze unit

Source: HDR.

Figure 2-4. Anaergia, OREX, Kaiserslautern: feed hopper (right), OREX press (bottom left)

Source: HDR.

Figure 2-5. Anaergia, OREX, Kaiserslautern: organics polishing system

Source: HDR.

Depending on the feedstock material, the wet fraction typically consists of a cake-like material containing between 30 and 45 percent solids. If SSO is processed (and if the SSO does not contain higher quantities of these contaminants), the pressed cake can be either diluted for a variety of wet digestion processes or blended with woody biomass/yard trimmings and digested in a dry digestion process. If mixed wastes are processed, the press cake contains fragments of contaminants (film plastic, glass, ceramic, grit, and metals). Although this contaminated material can be blended with biomass and digested in a dry digestion system, there are also processes that allow this material to be processed further for use in liquid digestion systems. Several municipal wastewater treatment plants (WWTPs) are exploring the use of the press on mixed waste and wet mixed waste (industrial, commercial, and institutional [ICI] sources). These systems employ further processes including diluting the press-cake (to the range of 8 to 10 percent solids content) for grit removal and hydra-cyclone processes to remove solids and floatable materials. After dilution, the slurry is passed through a cyclone to remove light (floating) contaminants and heavy (sinking) contaminants. The “clean” slurry can then be ready for a low-solids type digester. The contaminants removed require hauling and disposal as solid waste.

These facilities have been employed in standalone locations such as transfer stations where the separation process can occur prior to transport to remote digestion or disposal locations.

2.2 De-Packaging Technologies

De-packaging systems, such as hammermill-, grinder-, shredder-, or flail-type systems, are designed to process packaged organics and have become increasingly popular where commercial organic waste consists of grocery-type packaged material. The unit is not intended for mixed waste. This type of preprocessing system is ideal where the digestion process requires either a high- or low-solids slurry. Several forms of de-packaging systems have been developed and employed, including the Thor from the Scott Food Company (Figure 2-6) and the Tiger by Ecoverse (Figure 2-7) (2024, *Turbo Separator Food Waste Depackaging System*) (2024, *Tiger Depack*). The process is referred to in different terms including a de-packager or turbo-separator.

Figure 2-6. Scott Thor organics de-packager (aka turbo separator)

Source: Olympic Equipment.

Figure 2-7. Tiger Depack by Ecoverse

Source: Ecoverse.

Various other de-packaging systems are readily available, including the Twister manufactured by Dry Cake, the Doda BioSeparator, the Doppstat screw press, the Haarslev Industries rendering-type grinder, the Gemidan Ecogi pulping-type grinder/blender, the Dupps/Mavitec shredding and screw press type device, and others (2024, *Twister Food Waste and MSW Depackager Organic Separator*).

2.3 Mechanical Removal Technologies

The use of mechanical screens combined with manual sorting is one method of preprocessing in practice at existing AD facilities. Mechanical sorting involves the use of a bag-breaker or “reducer” to liberate the contents of bagged waste materials. Following bag-opening, manual and/or mechanical screening is used. Mechanical screening consists of the use of a disc screen or rotating trommel screen, typically separating out materials less than 2 inches in diameter as the “organic-rich” material. Manual sorting can consist of either extracting organics from the material stream or extracting contamination from the material stream, leaving the organic materials for processing. The photographs in Figure 2-8 and Figure 2-9 of the 2-inch-minus disc screen, also referred to as materials recovery facility (MRF) fines, and manual sorting were taken of the Newby Island Resource Recovery Park organics preprocessing line that prepares organic feedstock for the Zero Waste Energy Development (ZWED) Company dry fermentation digester in San Jose, California.

MRF fines from a mechanical system typically contain relatively high quantities of grit, glass, ceramics, and fragments of metal. The resulting MRF fines would require downstream degritting prior to sending the slurry product to a low solids-type digestion facility. Alternatively, the cake would be suitable for use in a dry-type digestion facility that has the ability to accommodate grit and contamination, such as the aforementioned ZWED AD facility.

Figure 2-8. BHS mechanical screening equipment

Source: BHS.

Figure 2-9. Manual sorting of organics

Source: HDR (2015).

2.4 Other Types of Preprocessing Technologies

Other systems are currently successfully deployed in the United States on a full-scale basis in major metropolitan areas using a combination of mechanical sorting and particle size reduction to produce a bio-slurry product.

WM CORe

One such system is Waste Management's (WM's) proprietary Centralized Organic Recycling equipment (CORe) process, a centralized organics recycling system that produces an engineered bioslurry (EBS). The CORe system is typically located at a transfer station where haulers can transport and offload SSO for inert decontamination and processing into a consistent and fully characterized high-quality EBS product. The EBS product is then transferred by sealed tanker to a receiving station located at the WWTP for introduction into the AD system, conversion into biogas, and production of renewal fuel or energy. The CORe system produces an EBS product that typically ranges from 14 to 18 percent solids that is pumped and mixed in wet AD systems.

WM currently has several full-scale CORe systems employed in the United States, one of which is located in New York City (NYC). Working in conjunction with the New York City Department of Environmental Protection (NYCDEP), this public-private project converts SSO into renewable fuel for pipeline injection. Figure 2-10 shows a 250-ton per day (tpd) CORe system processing SSO from commercial haulers as well as schools, residences, and institutional locations throughout NYC.

This approach has become increasingly popular because all preprocessing steps occur off site at an existing solid-waste transfer location and quality standards for EBS are established and monitored prior to product delivery into municipal AD systems.

Figure 2-10. 250 tpd CORe system in New York City

Source: WM.

After production of the EBS is complete, the product is transported by sealed tanker to the WM receiving station located at the NYCDEP Newtown Creek WWTP for co-digestion. Figure 2-11 shows the CORe system EBS holding tank. Figure 2-12 shows the company's EBS receiving and feed-in station tank in the foreground, located adjacent to the NYCDEP WWTP anaerobic digesters.

Figure 2-11. Receiving and feed-in station tank located adjacent to the NYCDEP WWTP anaerobic digesters

Source: WM.

Figure 2-12. NYCDEP WWTP anaerobic digesters

Source: WM.

2.5 Summary of Preprocessing Technologies

The industry has developed a variety of preprocessing technologies to suit many of the challenges associated with managing organic wastes. The technologies perform well within their intended purpose and design. Selection of the appropriate preprocessing technology remains a key decision in developing any organics treatment process. In general terms, the more heterogenous (mixed with other, non-organic materials), the more complicated and expensive the preprocessing system. Or, in reverse, the more pristine, homogenous (non-mixed), the feedstock can be sourced, the less complicated and less expensive the preprocessing system.

This is a difficult issue for the County due to the fact the County prefers to not implement flow control policies which also equates to not implementing source separation of the CFW at the source. Given the County’s position on this issue, it is recommended the County seek or encourage the development of private sector involvement in the system wherein the private sector can assume the risk and performance expectations of the system, rather than the County.

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3 Anaerobic Digestion Technologies

As previously discussed, AD is the biological decomposition of organic materials in the absence of oxygen under controlled conditions. This process reduces the volume of organic materials and produces a biogas (primarily methane and CO_2). The remaining solid material (digestate) contains non-digested solids and, depending on the material's moisture content, can be dewatered to reduce its water content and land applied as "cake" or further processed through aerobic composting to produce a soil amendment. Dewatering yields a semi-liquid/semi-solids cake that can be land applied or the cake can be dried and converted into a pelletized material.

AD is commonly used to treat wastewater solids and agricultural sources such as manures; however, it has also been used as a way of treating some portions of the MSW stream. Early versions of these processes were initially developed in Europe and began being employed in the United States in the 1980s for portions of the MSW stream. Several types of digestion technology continued to be developed and used in Europe, with advancements in technology in North America focused primarily on agricultural applications. Developments in technology advancement included combining digestion with aerobic composting to bio-stabilize the process residue in the food and beverage and municipal waste industries. AD facilities are successfully operating in Europe in large part because of European Union (EU) policies that banned landfilling of unprocessed waste, but also because of high tipping fees and high prices paid for energy.

There are several types of AD technology. Wet systems can be classified further into high- or low-solids systems, based on the percentage of solids in the slurry feedstock. Dry systems process feedstock with a high enough solids content to be stacked.

Feedstocks for AD vary according to the type of technology, but in broad terms, they include MSW-derived organics, manure, food waste, and, for some technologies, grass clippings, yard trimmings, brush, and WWTP biosolids. Biologically inert materials that might be contained in the digestion feedstock, such as metals, glass, and plastics, are undesirable and considered contaminants and must be either removed prior to digestion (for wet-type systems) or screened out during or after digestion (for dry-type systems). If feedstock is below the desired moisture content for the chosen technology type, water is added to the AD system.

Several factors influence the design and performance of AD. These factors include the concentration and composition of nutrients in the feedstock, temperature of the AD reactor, retention time of the material in the reactor, volatile solids loading, pH, and volatile acid concentration.

3.1 AD Process Overview

Prior to digestion, the organic materials need to be prepared to meet certain specifications, which vary for each of the types of digestion technology. After preprocessing, the remaining organic material is typically reduced to a smaller and more consistent size with a shredding machine. In general, wet systems require more preprocessing to remove contaminants because these contaminants can cause AD operational problems and damage mechanical equipment.

The resulting AD feedstock is then typically mixed with water or other liquid food waste organics, but not necessarily before entering a digester vessel. Dry systems do not require additional water. The lack of oxygen in the vessel allows specific microorganisms (anaerobic) to grow, reproduce, and break down the organic fraction of the waste. Conditions within the vessel are kept optimal for process efficiency, but the process occurs naturally. The material remains in the sealed vessel until the organic fraction has been substantially degraded. The resulting products are digestate, liquid (if the digestate is dewatered), and biogas.

The biogas typically has an energy value of approximately 600 British thermal units (Btu) per standard cubic foot (scf) and can be used in a reciprocating engine or gas turbine to produce electricity and heat. It can also be cleaned and injected into the natural-gas network, or it can be compressed into a vehicle fuel.

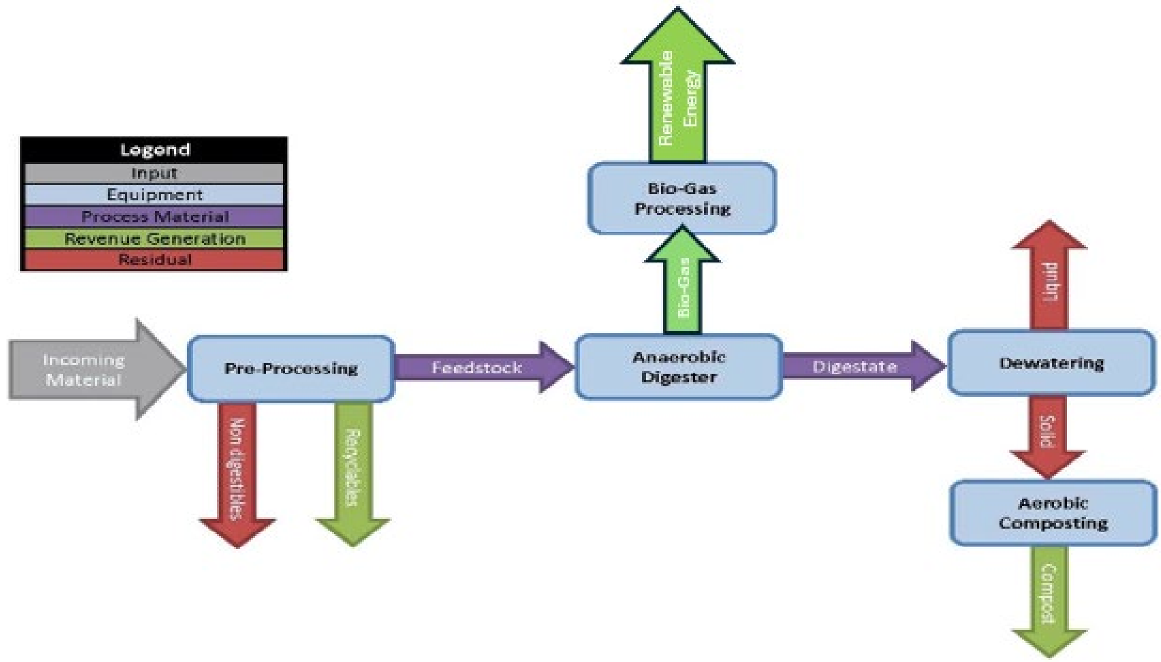
The solid and liquid fraction may then enter a dewatering device (also referred to as a separator), depending on the liquid content, where the liquid fraction is pressed out of the solid fraction. The requirements for separation depend on the moisture content required for the process and the type of solid/liquid product that is generated.

As noted earlier, the digestate can be dewatered to achieve a higher solids content desired for composting or other uses such as land application or fertilizer production. If dewatered, the liquid from the dewatering process is used in the process again, marketed as a fertilizer depending on the quality, or disposed of in a sanitary sewer.

The remaining digestate can be treated further with aerobic composting to produce compost that can be marketed as a soil amendment. Before marketing the soil amendment, additional screening is often required to remove contaminants such as small bits of plastic and other impurities.

Figure 3-1 below provides a flow diagram of a generic AD system.

Figure 3-1. Flow diagram for generic anaerobic digestion process



3.2 Anaerobic Digestion Technologies

AD is widely used on a commercial scale for industrial and agricultural wastes, as well as municipal wastewater solids. AD technology has been applied on a larger scale in Europe on mixed MSW and SSO, but until recently there has been limited commercial-scale application in North America. The City of Toronto, Ontario operates two commercial-scale plants that are designed specifically for processing SSO: the Dufferin Organic Processing Facility and the Newmarket AD Facility. More recently, new full-scale co-digestion projects are now in operation in Southern California, NYC, and Boston. The Los Angeles County Sanitary District (LACSD) WWTP (Carson, California); NYCDEP Newtown Creek WWTP (NYC, New York), and Greater Lawrence Sanitary District (GLSD) (North Andover, Massachusetts) all receive an EBS from WM for co-digesting with wastewater sludge for renewable energy production. Several smaller facilities in the United States are operating on either mixed MSW, SSO, or in some cases, co-digestion with wastewater sludge.

AD can be categorized into two types of technologies or systems:

- **Wet systems,** which require the feedstock to be prepared into a liquid slurry. The slurry undergoes the AD process in a tank or similar type of container. Wet systems can be treated in either of the following levels of solids:
  - **Low-solids:** typically less than 5 percent solids; processing systems include typical WWTP or publicly owned treatment works (POTW) types of digestion systems.
  - **High-solids:** between 10 and 25 percent solids in a liquid slurry or paste, a thick or viscous pumpable material, typically called “plug-flow”.

- **Dry systems,** often referred to as dry fermentation or “bunker-type” systems, do not require preprocessing of the feedstock to the extent practiced for wet systems; instead, the feedstock is retained in a stacked pile as a stationary solid matrix. Consequently, inorganic materials (contamination such as glass, grit, metal fragments, etc.) can remain in the organic mixture through the AD phase and be removed later in the stabilization (composting) phase of the process. Bacteria-rich liquid is applied to the top of the pile to maintain moisture, absorb organic material in the pile, and allow anaerobic bacteria to consume the organics to produce biogas. Dry systems process the feedstock as a solid, and typically operate as a batch-type process in bunkers or garage-type containers.

A further clarification of these technologies is the terms of their use.

The wet-low solids digestion systems are generally only used when feedstock conveyance is used to deliver the organic material to the digester (as is the case for sewage systems throughout the nation). The advantage of wet-low solids digestion is its relative simplicity as evidenced by its universal acceptance and employment in the sewage/WWTP industry nationwide. The disadvantages for these systems are their relatively large tankage and process water requirements which, for the most part, private sector/non-WWTP type users cannot afford.

Conversely, wet-high solids systems are generally used in agricultural settings where the combination of wet feedstocks and relatively low contamination (non-organic materials described below) are present. This technology has been extended to the solid waste industry and specifically, to food waste digestion systems. The advantages of this system are its relatively low tankage and process water requirements, added to its relatively short digestion time and its applicability to a highly putrescible, low-contamination feedstock. Its main disadvantage is its inability to accept highly contaminated feedstocks.

The dry digestion systems are also generally used in agriculture settings in the EU but with many applications in the solid waste industry in the US. This technology has several advantages, including the ability to use a co-collection program whereby food wastes can be added to an existing green/yard waste collection program, saving the cost of an added collection program. The dry system advantages also include the ability to accept non-organic materials, allowing these materials to be removed after the AD process. However, there can be unintended consequences from this feature. For example, the disadvantages of dry systems include reinforcing potentially negative societal behaviors wherein waste generators are oblivious to the effects of contamination in the organics bin, resulting in what is essentially an MSW type feedstock. This condition can result in producing digestate that is unusable by the agricultural industry.

The high solids and dry systems are generally developed for specific feedstocks, hence are referred to as ‘dedicated digestion’ systems insomuch as they are not used for ‘co-digestion’ of sewage.

The following discussions explore each of these systems in more detail.

3.2.1 Wet Digestion, Low-Solids

One option for digesting organic materials is the use of digester capacity at WWTPs such as the South Treatment Plant (STP) in Renton, Washington. Sources of appropriate organic materials could include fats, oils, and grease (FOG) from restaurant grease traps, food waste, and other forms of municipal organics. The use of WWTP AD facilities to process organic materials has been considered by agencies, such as the East Bay Municipal Utility District (EBMUD) in California, NYCDEP Newtown Creek, GLSD in Massachusetts, and LACSD in Southern California. For more than a decade, EBMUD has been refining its food waste digestion program to generate renewable energy. EBMUD employed a pilot facility to convert 20 to 40 tpd of restaurant food scraps to electrical power. Based on the success of the pilot project, EBMUD plans to grow this recycling program. Recycling food scraps at EBMUD supports local zero-waste and landfill reduction goals and mandates. EBMUD uses AD to convert these food scraps into renewable energy. NYCDEP Newtown Creek WWTP currently uses AD to convert approximately 80 to 90 tpd of SSO into renewable energy. In Carson, California, LACSD currently uses AD to convert approximately 85 to 95 tpd of SSO into renewable energy. In North Andover, Massachusetts, GLSD currently uses AD to convert 45 tpd of SSO into renewable energy. Each of these systems employs the WM CORe system to produce an EBS product that is prepared off site and transported to the WWTP for co-digestion.

Numerous other WWTPs have explored these concepts under net-zero energy goals, climate-action goals, or other related goals. Similar concepts could be viable for STP if there is surplus digestion capacity. Alternatively, AD systems for digesting solely food waste and other organics could potentially be collocated at a local WWTP.

Figure 3-2. Food waste delivery at EBMUD WWTP

Source: EBMUD.

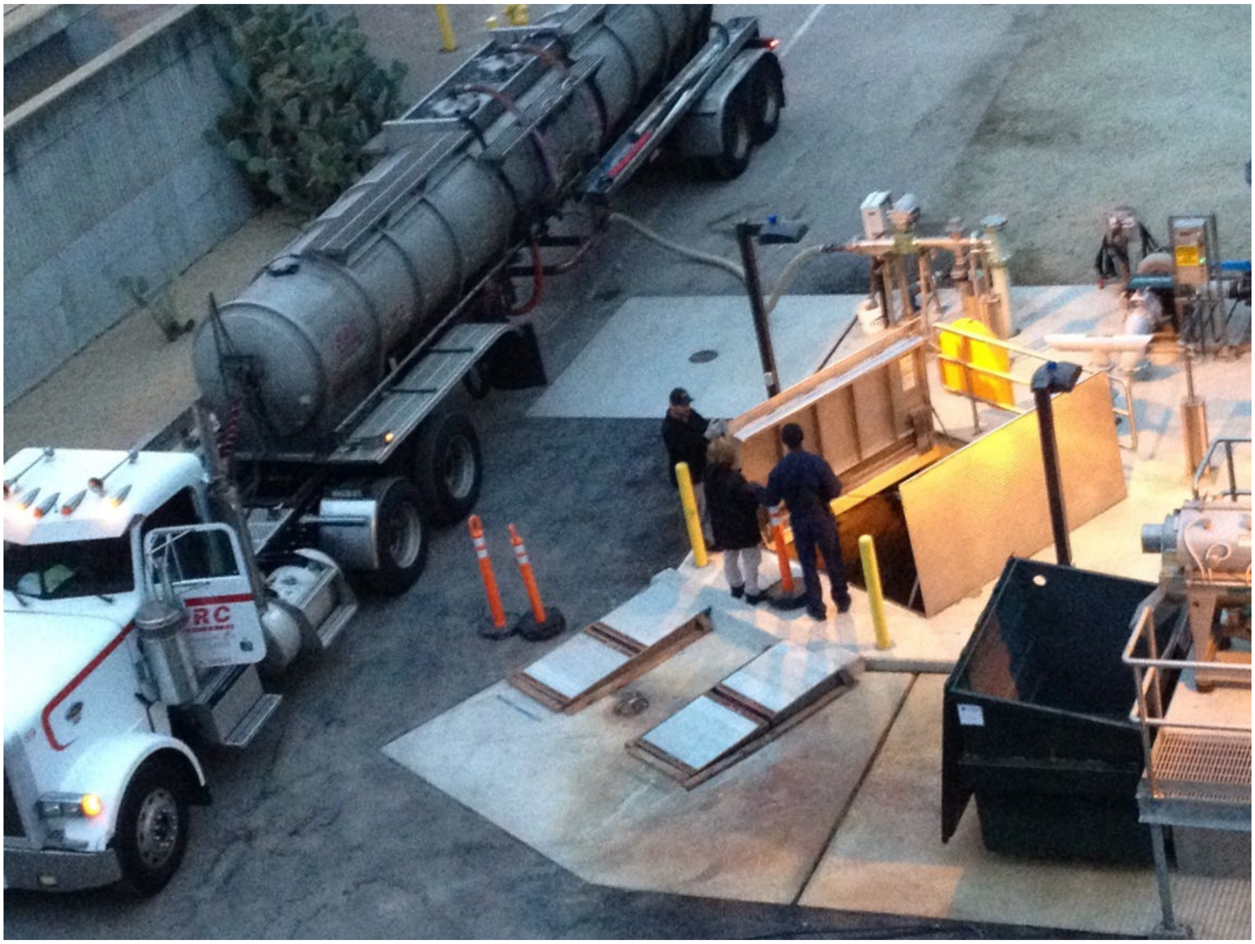
Another example of a WWTP's digestion of food waste is the Central Marin Sanitation Agency (CMSA) commercial Food to Energy (F2E) program. This program uses the digester capacity at WWTPs for digesting municipal organic waste and FOG. However, unlike the EBMUD example above, the F2E program processes a clean food waste feedstock, nearly completely free of contamination. CMSA and the local waste hauler, Marin Sanitary Service, have developed a unique approach to the digestion of municipal organics by placing the obligation of feedstock cleanliness on the waste generator. Marin Sanitary Service employs a rigorous screening, education, and training program on the waste generators that has resulted in nearly contaminant-free food waste. Figure 3-3 below illustrates the feedstock that Marin Sanitary Service collects. Because the food waste contains so little contamination, the processes to prepare the food waste are simple and low-cost.

Figure 3-3. Food waste at Marin Sanitary Service

Source: CMSA.

Once collected, food wastes are delivered to the Marin Sanitary Service where they are unloaded, visually checked for contamination (typically film plastics), and ground to 1 inch minus before being transported to the CMSA WWTP. CMSA has been equipped with a below-grade receiving tank into which the ground food waste is unloaded. The receiving tank also receives FOG. Figure 3-4 shows the food waste and FOG receiving facility.

Figure 3-4. Food waste and FOG receiving facility at CMSA



Source: CMSA.

The food waste and FOG are blended in a below-grade tank, processed through a simple paddle wheel to remove large solids, and injected into the digester. CMSA improved its biogas upgrade and boiler system to accommodate the increased biogas. CMSA reports that the incased biogas production has allowed it to significantly reduce its use of natural gas for cogeneration and digester heat.

The limitation of this program is the requirement of a relatively pristine feedstock that requires both an educated/supportive generator and a diligent waste collector. Because of these limitations, the quantity of material available in a community is restricted by the number of generators that are willing to separate their organic wastes to such high levels of cleanliness. However, the program has a very low cost.

3.2.2 Wet Digestion: Stirred Tank

This section presents a description of the wet digestion: stirred tank AD technology.

Bioenergy Devco

Bioenergy Devco operates a 110,000-ton per year (approximately 400 tpd) CFW AD facility for Baltimore Gas and Electric Company (BGE) in Jessup, Maryland (Figure 3-5). The facility processes organic (food) waste, principally from the adjacent food processing authority/fish market located across the street from the facility, in addition to the grocery processing facility and other food manufacturing/processing facilities nearby, as well as to spot loads of spoiled/expired food generators in the region.

Figure 3-5. Receiving Building at Bioenergy Devco AD facility

Source: HDR (2023).

The facility employs a low-solids continuously stirred tank digestion method. A flexible (rubber) bladder roof is attached to each of the digesters. These bladders are designed to capture biogas that rises up from the digesting fluids in the tank (Figure 3-6). The bladder roof assembly is attached to the rim of the digester and associated ports/mixing device assemblies.

Figure 3-6. Bioenergy Devco low-solids AD tank, Jessup, Maryland

Source: HDR (2023).

Biogas extracted from bladders above the digesters is directed to a condensate removal tank adjacent to the digestion tank. The biogas continues through a series of cooling/water removal processes before being directed to a hydrogen sulfide (H_2S) removal and subsequent CO_2 removal (pressure swing absorption) system. The CO_2 system (which includes trace methane) is processed through a thermal oxidizer before being discharged to atmosphere. The resulting methane is run through a continuous gas chromatograph (GC), testing its methane content, oxygen levels, etc. After passing through the GC, the gas is pumped to the utility site where the gas passes through a second GC (owned by BGE). The system is described to enable continuous gas sampling for injection into the public utility grid. If the two GCs are not in agreement with the gas quality, a valve between the two closes, terminating the BGE receipt of the gas and ceasing its injection into the grid. Figure 3-7 below shows the biogas cleanup treatment system. Figure 3-8 shows the BGE (utility) gas testing and GC system (enclosed in the fencing).

Figure 3-7. Biogas cleanup system at Bioenergy Devco AD facility

Source: HDR (2023).

Figure 3-8. Gas testing and GC system at Bioenergy Devco AD facility

Source: HDR (2023).

A combined heat and power (CHP) internal-combustion gas generator (approximately 1 megawatt [MW]) is located at the site. The CHP generator extracts methane from the BGE gas main located in the street (immediately adjacent to the injection point). Here, methane (natural gas) is drawn from the utility to fuel the CHP generator, providing the site with power and hot water needed for heating the two digester tanks. Figure 3-9 shows the CHP unit.

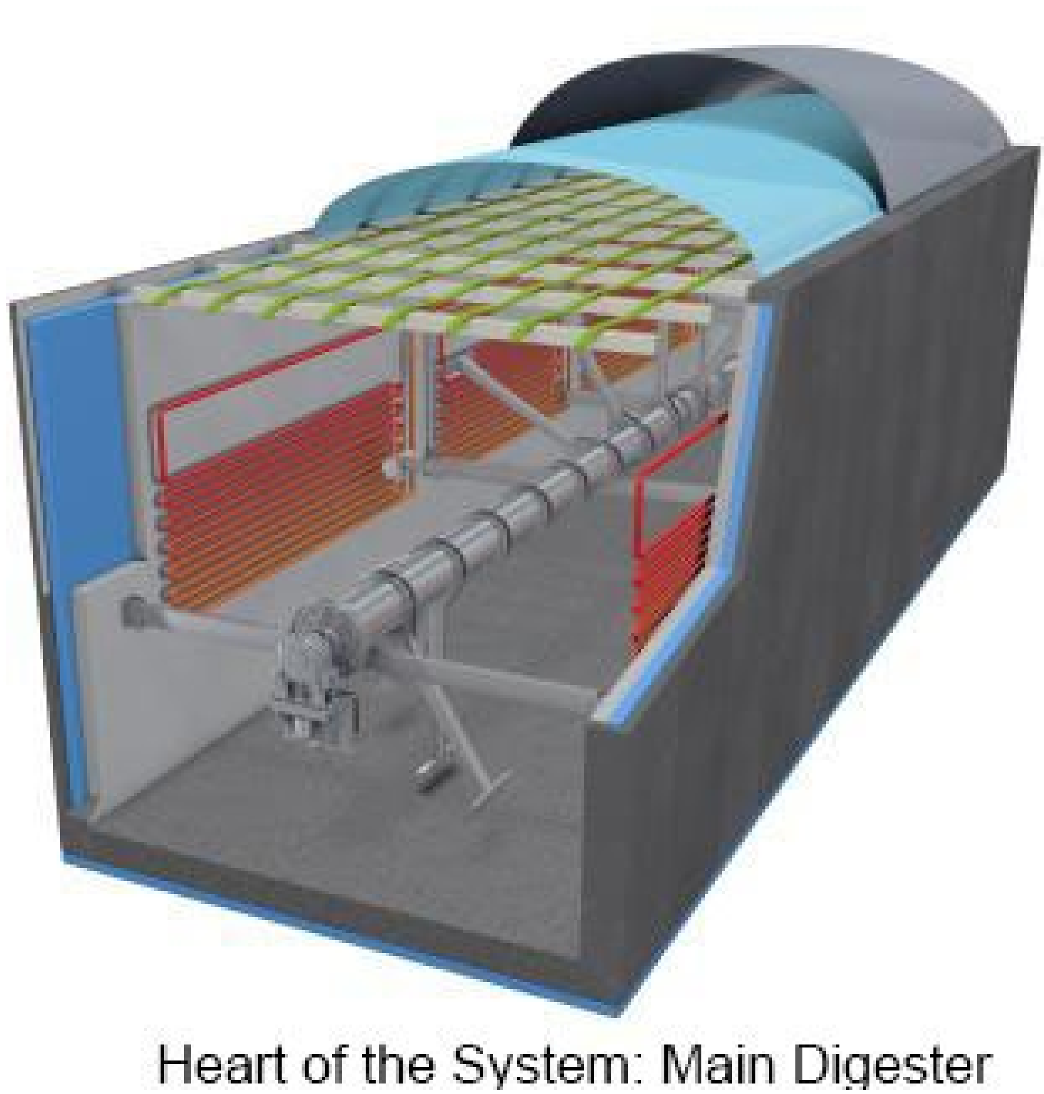
Figure 3-9. Combined heat and power unit at Bioenergy Devco AD facility

Source: HDR.

3.2.3 Wet Digestion: Plug Flow

High solids, wet digestion (plug flow) is a common practice in agricultural manures and industrial digestion systems where feedstock sources are relatively homogenous and where the availability or cost of dilution water makes it a limiting factor. Plug flow digestion is typically performed using high solids ratios above 20 percent solids. As such, the material is too viscous for mixing and behaves more as a solid than a liquid. Displacement pumps that have the ability to pass solids are typically used to inject the feedstock into the digester. Because of the lack of mixing, the feedstock passes through the digester as a plug, hence the name “plug flow.” The digestion unit can be vertical to take advantage of gravity to pass the contents through the digestion process. The unit may also be horizontal and employ a slow-rotating agitator along its axis to move the contents from the entry to the exit. Retention times vary according to manufacturer but range between 1 and 3 weeks. Figure 3-10 through Figure 3-13 present examples of plug flow digesters.

Figure 3-10. Illustration of a horizontal plug flow digester



Source: Eisenmann Corporation.

Hitachi Zosen: Horizontal Plug Flow

One example of a horizontal plug flow AD is the Hitachi Zosen facility located in San Luis Obispo, California (HZ-SLO). The HZ-SLO facility was constructed in 2017 to process food and yard waste from the neighboring community. The facility, shown in Figure 3-11 and Figure 3-12, was designed to process 36,000 tons per year. It includes a reception facility, shredding, a horizontal plug flow digester, in-vessel compost stabilization phase, biogas collection, and co-generation facility (employing electrical generation).

Figure 3-11. High-solids anaerobic digestion facility, San Luis Obispo, California

Source: Hitachi Zosen.

Figure 3-12. Interior of horizontal plug flow digester

Source: Hitachi Zosen.

Normec-OWS: Vertical Plug Flow

Another example of a high solids wet AD system is the vertical plug flow system developed by Organic Waste Solutions (OWS), now Normec-OWS. The vertical plug flow system uses gravity to move the feedstock through the digestion unit. A displacement-type pump lifts the thick slurry material to the top of the tank where the material proceeds downward through the digestion unit over several days. A slurry is released from the bottom of the tank, blended with new feedstock, and returned to the top of the tank to repeat the process and to enable the digestion process to occur. Figure 3-13 below shows an OWS system in operation.

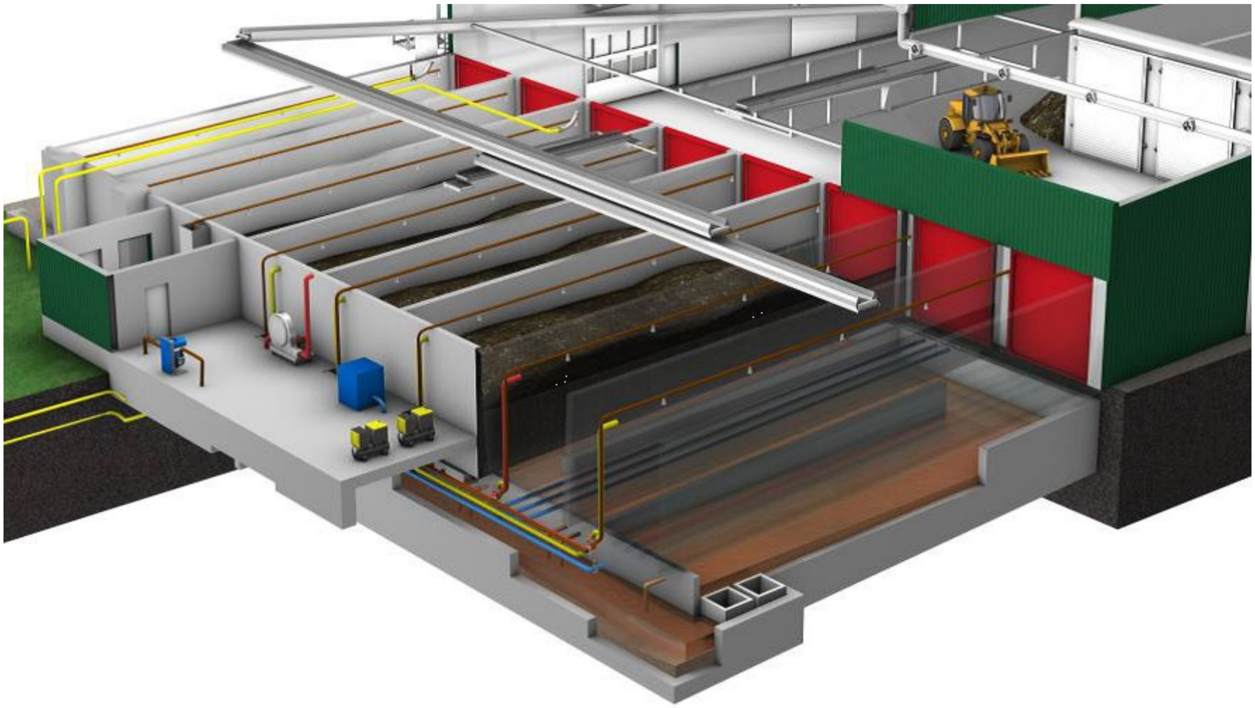
Figure 3-13. Vertical plug flow digester

Source: OWS.

3.2.4 Dry Fermentation

Dry fermentation is a form of AD that employs a high-solids, stacking technology. Dry digestion typically employs a bunker-or garage-style container rather than a liquid-filled tank type of digester. Bunker-type dry fermentation facilities consist of a series of concrete or steel bunkers equipped with airtight ceilings and doors, as shown in Figure 3-14. Waste material, typically in the form of a blend of yard trimmings/garden waste blended with food waste, similar to that of compost feedstock material, is placed (stacked) in the bunker and sprayed with a bacteria-rich inoculant to begin the digestion process. The organic materials remain stacked in the bunker for the entire digestion process (between 3 and 4 weeks), during which time liquids are circulated through the media and biogas is extracted from the bunker.

Figure 3-14. Example of bunker-type dry fermentation process



Source: Kompoferm.

Mechanical type preprocessing systems are typically used for this type of technology. This includes the use of an aggressive mechanical preprocessing system that could remove most of the contaminants present in the feedstock. The preprocessing system may include hand sorting and some mechanical sorting to remove contaminants prior to digestion. These types of preprocessing systems generally remove a small portion of the organics along with the contaminants. Although some of the biogas potential will be lost with this loss of organics, this method allows for a smaller AD footprint because it will not be accommodating as much inert material mixed in with the organics.

Alternatively, dry digestion systems can tolerate digesting a mixture of MSW with minimal or no preprocessing (apart from removal of large items and bag opening). As no pumping of the feedstock is required, the dry AD system is not in danger of damage from contamination like glass and other inert materials. The downside of this approach is that it would result in a larger digester requirement, but it would produce slightly more biogas, as no organics would be lost in preprocessing. Also, the resulting digestate requires extensive post-digestion processing to separate the organic materials from the waste/contamination materials before the organic fraction could be considered an acceptable compost product. Composting is the typical digestate post process, so this approach requires a MSW composting system downstream of the AD process. Compost from MSW-composting systems has no value in the agricultural industry. Of note, dry AD systems are somewhat common in the EU due to its ‘pretreatment’ requirements and most of the digestate is either incinerated or landfilled.

Some facilities use a balance of the two approaches. The ZWED dry fermentation facility in San Jose, California (see Figure 3-15 and Figure 3-16) accepts wet commercial waste that goes through preprocessing intended to bring the contamination levels to 30 percent or lower. The digestate produced from the facility is then composted and is further processed to remove remaining contamination.

Figure 3-15. ZWED dry fermentation facility in San Jose, California (aerial view)

Source: ZWED.

Figure 3-16. ZWED dry fermentation facility bunkers in San Jose, California (interior view)

Source: HDR.

3.2.5 Combination Systems

This section presents a description of combination AD systems.

Surrey Organics to Biofuel Facility

The City of Surrey, British Columbia, developed a combination food/yard waste organics-to-biofuel facility that employs both a dry fermentation system and a side-stream wet-low solids digestion process (Figure 3-17). The project is part of a regional goal that is aimed at reaching elevated diversion from landfilling as a part of a comprehensive strategy to have municipalities and private waste haulers separate organic materials (food, yard waste, and soiled paper) from the landfill waste stream. The City had a yard-waste collection service for its residences and added food waste as an acceptable material in the yard waste cart. To add energy value to the digestion process, the developer was commissioned to secure CFW and organic-rich materials from the ICI sectors. The 121,254-ton per year system fuels the City's waste collection fleet through the local utility provider where the biofuel facility injects renewable natural gas (RNG) into the gas grid and the City extracts the gas for its compressed natural gas–powered waste collection fleet.

Figure 3-17. City of Surrey biofuel facility

Source: City of Surrey.

3.3 Large-Scale Versus Small-Scale Systems

This section presents a comparison between large-scale and small-scale AD systems.

3.3.1 Small-Scale: Distributed Systems

In theory, small-scale distributed systems could be attractive in terms of environmental impacts. Small-scale distributed AD systems are somewhat common for agricultural applications in Europe. These systems produce a distributed source of biogas used for industry as an offset to utility natural gas. As interest in AD is growing in the United States, some small-scale systems are being tested in a variety of agricultural locations as well as some trial urban settings. The single largest advantage of small-scale systems is the avoidance of expensive collection and transport. These systems can completely eliminate waste hauling when sited on site at the generator location. Other advantages are local resilience in the form of energy independence, emergency response and disaster preparedness, local food production, and job creation. Odor control on small units usually includes multiple systems in series because many locations are urban with close neighbors (biofilters, carbon filters, neutralizer-atomizers). Beneficial use of the digestate is usually also local and small scale. Small-scale systems are typically associated with localized circular economies that minimize trucking in and out of a community. The drawbacks of small-scale systems include the relative lack of economies of scale on an individual basis, the requirement for customization of the digestion technology to the specific feedstock, and the requirement for operational staff to support the operations and maintenance of the distributed facilities.

However, except for ultra-small, container-sized units, most of the technologies discussed in this report can be scaled up or down to fit the throughput conditions. An example of the containerized type of units is the Chomp product line, discussed in more detail below. The Chomp product lines range from a low of 25 tons per year to a high of 4,500 tons per year. This range represents about 5 percent of the quantity of waste material that the County envisions needing processing. So, while the concept of a small-scale distributed system has its advantages, economies of scale tend to favor large, regional or centralized facilities.

3.3.2 Large-Scale: Centralized Systems

There has been a recent increase in the use of AD technologies for regional waste processing at commercial-scale plants in North America. Economies of scale tend to favor large, regional or centralized facilities, which is one of the key drivers of employing these systems. Two facilities that process commercial organics and/or co-collected green/food wastes using a dry digestion technology and operating in the 100 to 300 tpd range have been recently developed in the San Francisco Bay Area in California. Two facilities that process post-consumer SSO are operating in the greater Toronto area: the Dufferin Organic Processing Facility in Toronto and the CCI Energy Facility in Newmarket, Ontario.

NYC, Los Angeles, and Boston have all taken leadership positions in the implementation of large, full-scale systems for the conversion of food wastes into renewable energy. As previously discussed, NYCDEP, LACSD, and GLSD have been co-digesting SSO from centralized preprocessing systems owned and operated by WM. WM has employed its proprietary CORe process to produce and deliver a high-quality EBS product for co-digestion under long-term commitments to these municipally operated AD WWTPs. These facilities are all targeted to manage 250 to 500 tpd inbound SSO equivalent.

The CR&R Waste Services facility in Perris, California, was developed because of the many jurisdictions in the region that committed to the facility. Since its construction and implementation, other cities that did not initially commit to the project have expressed interest, resulting in CR&R Waste Services having to expand its facility.

Larger facilities have to incorporate strategies to mitigate odor impact. The odor is typically not from the digestion process itself but rather in the waste receiving, preprocessing, and post-processing operations. Strategies can include rapid-roll doors for trucks entering and exiting the facility, shortening the time between offloading of the material and preprocessing, covering the digestate that is staged for transfer, and installing odorous air treatment systems such as biofilters

3.4 Anaerobic Digestion Technologies Summary

Like preprocessing technologies, the industry has developed a variety of AD technologies to suit a variety of feedstock materials. The fundamental purpose of employing AD is to produce and capture methane as a renewable energy source while keeping within the requirements of the regulatory framework in terms of capacity, effluent discharges, etc. As such, the report has not addressed the unique conditions of King County's WWTP discharge requirements, focusing instead on an overview of the types of AD systems, their attributes and functional differences.

Each of the technologies perform well within their intended purpose and design. Selection of the appropriate digestion technology is typically a default of the condition of the feedstock and its method of conveyance.

Sewage collection and conveyance systems, using water as the method of conveyance, are appropriate for a feedstock that favors low solids wet digestion systems, which is true for WWTP's employing digestion across the United States. In contrast, driven by necessity, digestion systems developed for a specific feedstock or dedicated purpose have been developed. Industrial food producers often have feedstock materials containing high solids content and therefore employ high-solids types of digestion systems. Similarly, dry digestion systems were borne out of the need to use a stackable method of managing the feedstock.

Given the County's position on avoiding solid waste flow control, combined with the added interest in use of the County's WWTPs for co-digestion, it is advisable that the County seek or encourage a partnering with the private sector to navigate the nexus of feedstock preparation for co-digestion.

Similarly, due to the unique and proprietary nature of high solids wet digestion and dry digestion, it is also advisable that the County seek or encourage a partnering with the private sector for the development of these dedicated types of digestion systems.

The rationale for these recommendations is to move the risk profile of the system from the public sector, whose familiarity and appetite for risk is low, to the private sector who are more equipped to assume the risk and performance expectations of the system.

4 Composting Technologies

Food waste can be blended into yard waste at certain proportions and managed through composting. Optimal blends of feedstock can result in more rapid decomposition based on the higher nutrient content of the food waste and generate a higher-quality finished product.

Odor emissions from the aerobic composting of food waste can be significant, as it can be difficult to keep the windrow consistently aerobic through proper moisture and airflow. Food wastes typically contain proteins at much higher quantities than yard waste. The microbial degradation of proteins can naturally produce vinegars, ammonia, and trace quantities of methane. These emissions are typically more objectionable than the odors associated with yard waste composting. As in yard waste composting, odor emissions are more pronounced when windrow turning occurs because the turning process aerates the material, releasing organic-rich air within the pile. Furthermore, if porosity is not maintained, the blended food waste and yard waste material can more quickly convert to an anaerobic process, resulting in extremely unpleasant odorous emissions. Although composting food waste with yard waste can be prone to produce odorous emissions, these odors can be minimized through good operational practices that maintain an aerobic condition throughout the active compost.

Contamination levels in CFW can vary greatly depending on the source and whether the waste is pre-consumer or post-consumer. The amount of contamination will affect the preprocessing system chosen for the facility. The types of preprocessing systems appropriate for CFW going to a dry fermentation AD facility are generally also appropriate for composting facilities. Preprocessing can be located at the composting facility or at a separate collection or transfer site.

Several types of composting technologies are available. The main established types of composting technology for CFW can be categorized as either turned windrow or forced aeration.

4.1 Turned Windrow

The turned windrow process, also known as the open windrow process, involves creating long piles of organic materials, called windrows, and frequently turning these windrows to facilitate the biological breakdown of the organics by adding oxygen. Variables include windrow width, height, mix design, frequency of turning, duration in active compost, and others. Of the established composting technologies, turned windrow requires the greatest amount of land, due primarily to the additional time that a turned windrow system requires to convert the raw materials into finished compost, as compared to the mechanically aerated systems. However, turned windrow composting is the predominant method of composting green/yard waste in the nation. While this method is satisfactory for relatively low putrescible feedstocks (such as green/yard wastes), there are several disadvantages, including the lack of control of oxygen which could result in anaerobic pockets within the mass, relatively longer composting periods to reach a mature product, and the resulting larger land/area requirement as these systems require additional time and include necessary aisleways to function.

4.2 Aerated Static Pile/Turned Aerated Pile

Similar to turned windrow composting, the aerated static pile (ASP) and turned aerated pile composting processes involve organizing organic materials and allowing biological activity to break down those organics into compost. This “technology” simply uses large piles instead of long rows typical of the turned windrow technology. There are several key components of ASP, each of which can have variations to the process as described below. ASP composting methods have been developed specifically for feedstocks containing elevated levels of putrescible material (such as biosolids and food waste). The advantages of ASP systems include their control of air levels within the piles, which can result in better controlled aerobe microbial activity (and avoiding or reducing anaerobic, or anaerobe microbial activity), accelerating the compost process to result in a mature product in relatively less time, and reducing the level of labor and equipment required to turn/manage the compost process. The disadvantage of the ASP system is the initial capital cost of the infrastructure and its relative inflexibility for expansion. Consequently, ASP systems are ideally suited for specific feedstock quantity and quality parameters and less suited to open-market fluctuations in these metrics.

4.2.1 Compost Bed

The compost bed refers to the method used to manage the material, both in terms of its configuration but also in terms of the aeration method. The following list offers the reader information regarding the variable types of compost beds that could be employed using an ASP type system. All of these systems can be operated in large- or small-scale facilities. Of these three methods, windrow beds require more land area than mass bed or bunker-type composting systems, due to the use of aisles between windrows, yielding less quantity of material being composted per acre.

- **Windrow:** Windrows are elongated piles 8 to 10 feet high, 14 to 25 feet wide, one hundred to several hundred feet long. Each windrow is separated from adjacent windrows with an aisle that allows for a straddle-type mechanical windrow turner to aerate the windrow. This is essentially the same process as turned windrow composting described above.
- **Mass bed:** This variation uses a method of consolidating the organic materials where each day’s new compost is piled adjacent to the prior day’s compost. The mass bed process is combined with an aerated floor system to pull air through the material to facilitate biological activity, which allows the pile to remain without being turned for several weeks.
- **Bunker composting:** As the name implies, this process is essentially the mass bed process that uses a three-sided bunker to allow for larger piles. Typically, 1 or 2 days’ compost is placed into a bunker and each bunker is equipped with an aerated floor system to pull air through the bunker. This system allows the compost to remain in the bunker, undisturbed, until the biological process is complete, typically several weeks.

4.2.2 Aeration Method

Aeration method refers to the way air is introduced into the compost pile. The aeration method also indicates if air will be either pulled into or pushed through the materials depending on the operation selected. All of the aeration methods discussed below can be operated in large- or small-scale facilities. These types of aeration systems are relatively similar in terms of their land area requirements. Typically, the pipe-on-grade method is used in windrow-type bed composting, so associated with requiring more land as compared to sparger or low friction floor systems that are more common in mass bed or bunker systems (which generally require less land area).

- **Pipe on grade:** This variation uses a perforated aeration pipe installed on a thin layer (1 to 2 feet) of cured finished compost upon which new, raw organic feedstock can be placed. This is typically used in a windrow-type arrangement. The pipe is then extracted (pulled) from beneath the windrow just before the material is turned onto a second pipe that will continue to pull air through the windrow. This process requires an open windrow to allow for moving the air pipe and the turning of each windrow. The downside of this method is that it requires approximately the same additional area as the compost area to extract/pull from beneath each windrow.
- **Aerated floor:** This variation is similar to the pipe-on-grade method, except it uses a subsurface trench or pipe beneath a concrete floor for aeration, which allows the windrow/pipe to be turned without the need to extract the pipe. The advantage of an aerated floor is the operational efficiency of managing the compost on a durable surface with the aeration system infrastructure beneath the surface, and the added ability to use various configurations of systems (e.g., extended bed, windrow) freely. The main disadvantage is the added capital cost of the installation of the infrastructure.
- **Trench-type, low-friction floor:** This variation uses a trench equipped with a grate-type cover for aeration. The grate prevents the compost material from falling into the trench and blocking the air. Water that drains into the trench is typically directed to an on-site pretreatment plant prior to being discharged to the local sewer system. The trench-type floor can be operated in both positive and negative air systems. The benefits and downsides are similar to those described in the aerated floor text above.
- **Sparger floor:** This variation uses an aerated floor fitted with a nozzle that forces high-pressure air through the windrow/pile. The nozzle creates enough pressure to lift and pushes the compost through the process. This variation can operate only under positive pressure. The advantages and disadvantages are similar to those described in the aerated floor text above.

4.2.3 Aeration System

All of the aforementioned variations utilize some type of aeration system. The aeriation system describes if the compost pile is receiving air beneath it, or drawing air down through it, or both. There are no significant differences in terms of the requirement of land area for these three types of aeration systems. Several types of aeration systems are available, including the following:

- **Positive pressure or positive air:** These systems push air through the materials/compost. These are typically lower-cost systems but can make odor control challenging.
- **Negative pressure or negative air:** These systems pull air through the materials/compost. These systems are typically more expensive because the manifold and blowers need to be stainless steel. However, there is better odor control, as a biofilter can be more easily fitted to treat the extracted air prior to being released.
- **Reversing or respiration:** This term describes systems where air can be either pushed or pulled through the material/compost.

4.2.4 Covered Method

Compost may be covered during the active phase as part of a required or recommended best management practice, particularly where air pollution emissions or odor are of primary concern. There are several methods employed for this.

- **Enclosed:** This variation of an active compost system is typically used in an enclosed building equipped with positive aeration and air collection and treatment, typically through a biofilter.
- **Fabric cover (e.g., GORE):** This variation uses a fabric or tarp to cover the windrow. The cover is secured at the base to control air from escaping and to prevent the tarp from lifting, particularly if the system is used outdoors.
- **Organic cover:** This variation uses cured compost to cover the windrow/pile in lieu of a fabric cover. The advantage is that the cured compost functions as a mini-biofilter, treating the odors in the positive pressure system air.

4.2.5 Turning Method

Several methods are available to turn compost windrows and piles as described below:

- **Automated mechanical turning:** This method uses a machine to turn the compost materials. Typically, the drum-type turning device rides along a rail system that allows for automated operation. This type of turner is typically used in facilities that use a narrow bunker-type bed. The advantage of this system is the very low labor requirement to operate the facility. The disadvantage is the relatively high capital cost, combined with the on-going maintenance of the equipment.
- **Straddle-type windrow turner:** This is a self-propelled vehicle (wheels or track) with an auger- or drum-type rotating mechanism that straddles the windrow, turning the windrow in place as it proceeds. This is the most common type of system used at most of the compost facilities throughout the nation. Its advantages and disadvantages are the same as mentioned in the windrow compost system above.
- **Stacker type (e.g., Vermeer).** This machine can be used in both windrow and mass bed operation. The stacker vehicle cuts through the composting material, cutting a swath and stacking the material on one side as it cuts through the pile on the other side. This type of turner is used in a pipe-on-grade aeration system. The advantage

of this type of system is the relatively high quantity of compost that can be processed in the relatively small space (same as described in extended bed and bunker systems above).

- **Front-end loader:** This is the simplest system where a front-end loader fit with a bucket is used to move/turn the pile from one pile to another. The biggest benefit is flexibility as the loader may be used for other on-site operations. The disadvantage is the relatively high cost of operations. For these reasons, larger facilities tend to migrate into using straddle type windrow turners for the majority of turning and rely on front-end loader for ancillary functions.

4.3 In-Vessel/Container Composting

As the name implies, in-vessel and container composting and/or pre-composting involves composting within a controlled container. In terms of land area requirements, the agitated tunnel/trench type of in-vessel composting typically requires the least land area, primarily due to its ability to produce a finished product in the least amount of time. There are several different types of systems as follows:

- **Static/aerated vessel/silo:** This system uses an enclosed vessel equipped with a positive aeration system. Variations on this type of system include vessels that agitate or rotate/turn their contents. These systems accelerate the composting process but are also constrained by the limited quantity they can accept/process. For the most part, these devices are better suited to small-volume operations (less than 20 tpd) or are associated with a digestion facility and are used to stabilize the organic material from the digester (previously anaerobic) into an aerobic phase. In the latter case, static aerated vessels have a relatively short retention time as their purpose is to evacuate the remaining anaerobic conditions of the organic matter and to convert the mass to an aerobic condition, This can typically be accomplished in a few days.
- **Rotating drum (e.g., Bedminster):** This system uses a large-diameter solid drum (10 to 12 feet in diameter) approximately 100 to 150 feet long installed on a slight angle. The drum is equipped with a turning mechanism that slowly rotates the drum. The rotation enables the contents (compost) to aerate and propel/tumble from one end to the other. The process typically takes 2 to 3 days. When completed, the material is not finished compost and it still requires additional composting or a curing process. Depending on the temperature and residence time in the drum, pathogen reduction requirements may or may not be achieved. Consequently, these drums are typically coupled with an adjacent compost and/or curing facility and are used to blend and prepare the material for subsequent digestion or composting activities.
- **Agitated tunnel/trench:** This system uses a mechanized bunker, tunnel, or trench that is equipped with a mechanized turner. The mechanized turner consists of a machine that turns the compost by riding along a rail system resting on the bunker/tunnel/trench walls. This is similar to the turned aerated pile method described previously. These systems can accommodate a relatively high quantity of compost in a relatively small footprint because of the use of bunkers and the agitation/turning systems that accelerate the compost process. These systems are more commonly used in composting biosolids but can also be used in composting

food waste/green waste materials. They can operate at small scales or very large scales.

4.4 Vermicomposting

Vermicomposting is not composting using bacteria as the mechanism of biological reduction; rather, it is a compost-like process that uses worms to consume the organic matter. Using worms to consume organic material is actually significantly different from composting. The worms eat the organic material and digest and discard the material. However, one of the most critical differences is that worms reside at ambient temperatures (below 110 degrees Fahrenheit [°F]) compared to bacterial composting, which can reach temperatures of above 150°F. According to the U.S. Environmental Protection Agency, one of the required methods for killing pathogens is reaching 155°F for a period of 3 days. Consequently, vermicomposting is not an approved process to meet federal requirements for the process to further reduce pathogens (PFRP). Also, vermicomposting requires the most amount of land of all the compost systems, including non-aerated turned windrow. The reason is the requirements of maintaining the health of the worm population necessitate a relatively shallow bed of organic matter for them to consume, while maintaining their temperature and moisture requirements. This results in the least amount of feedstock applied to the largest amount of area, per unit quantity of feedstock. For these and PFRP requirements, vermicomposting is not considered relevant to King County's CFW system, except perhaps as a demonstration or educational element.

4.5 Static Bin

The static bin system is a process typically used in farming applications for on-farm carcass composting or for dedicated on-farm management such as an equestrian center, poultry or hatchery, etc. This method employs a positively aerated bin where the carcasses are layered with a porous compost mixture. The bins are not turned to avoid exposure of the meat/protein contents until a predetermined duration has passed. These systems are constrained by the use of the bins and are typically intended for small volumes. As such, static bin composting is not considered relevant to King County's CFW system.

4.6 Composting Summary

Like the preprocessing and AD technologies above, the industry has developed a variety of composting technologies to suit a variety of feedstock materials, land-area constraints, capital and operating costs variables and related factors.

Each of the technologies perform well within their intended purpose and design. Selection of the appropriate composting technology is typically a default of the condition of the feedstock, the available land/site area, its proximity to neighbors/sensitive receptors, and long term vision of the facility to afford the capital and operational costs needed for the quantity and quality of material committed to the facility.

Given the long-standing history of private sector composting companies/facilities in the region and the County's preference to maintain an open, non-flow-controlled waste program, continued reliance on private sector composting is an appropriate method of use of this technology

Similar to the preprocessing and digestion sections above, the rationale for continued reliance on the private sector for composting is that they are more equipped to assume the risk and performance expectations of the system, rather than the County.

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5 Technologies near King County

Identifying where existing projects are operating and understanding what those facilities are employing would inform the County as to the types of systems that should be compatible with the County's SWD and WTD infrastructure. The following sections provide insights for this strategy. The locations of the projects highlighted below are shown on Figure 5-1.

Figure 5-1. Food Waste Processing Technologies

5.1 Junction City Biomethane

Junction City Biomethane (JC Biomethane) operates a wet-type AD facility. Previously (2013–2017) JC Biomethane offered services for its 100 tpd AD facility located in Junction City, Oregon. This facility, shown in Figure 5-2, uses a mixed reactor design for digestion. Although the facility has the capability to accept commercial organics, such as food waste and agricultural residues, challenges can occur because of contamination of the arriving materials. To date, JC Biomethane has not secured long-term food waste contracts and continues to operate using manure as the primary feedstock. The facility focuses on locally sourced cow manure and excess agricultural residues. An apparent change of ownership to the Shell New Energies company has also occurred. The facility claims to process biogas into RNG, which is injected to the grid.

Figure 5-2. JC Biomethane's anaerobic digestion facility in Junction City, Oregon

Source: Shell New Energies Junction City.

5.2 Divert

Divert is a CFW diversion service company that is securing service contracts from commercial food generators and directing those wastes to facilities for processing. It seeks commercial food sources that tend to be homogenous and with little contamination. Divert claims to have nearly 7,000 grocery stores under contract nationwide. Its preference in terms of treatment technologies is anaerobic digestion. In conversations with Divert, the company expressed that it prefers source-separated food sources and avoids mixed waste systems, MRF fines, or other highly contaminated feedstocks. Divert claims that its process produces a slurry that is then anaerobically digested with crop silage. It purports that the biogas from its facility is converted to renewable electricity.

In September 2023, Divert announced the groundbreaking on a new diversion and energy facility in Longview, Washington. Figure 5-3 shows a computer rendering of the future Divert facility. Divert was unclear about specifics in terms of serving the greater King County region. The company was also unclear about the specifics of its de-packaging system, offering that its system is proprietary, and its preference is to prevent contamination at the source.

Figure 5-3. Rendering of future integrated diversion and energy facility in Longview, Washington

Source: Divert, Inc.

5.3 Chomp

Chomp, formerly Impact Bioenergy, produces a series of container-type AD devices or units. The units, described as “miniaturized large-scale anaerobic digestion technology,” range in their annual throughput capacity from 25 to 4,500 tons per year. The product lines begin with the “Mini,” which offers the capability to process between 25 and 175 tons per year. The next product line is the “Core.” The range of energy output and capital cost is provided in Figure 5-4, taken from the Chomp website.

Figure 5-4. Chomp energy output and capital cost by product line

	Waste Recovery	Typical Energy Output *	Base Capital Cost
Core	185–4,500 tons/year	583–14,200 MMBTU/year	$600,000–$5,300,000
Mini	25–175 tons/year	79–552 MMBTU/year	$209,000–$580,000

Source: Chomp website.

The Chomp containerized unit has been deployed at a variety of locations in the King County region including the Vashon Island Distributed Bioenergy Feasibility and Possible Demonstration. Impact Bioenergy received a $30,000 grant (2016–2018) to demonstrate feasibility and viability of a community digester operating system for Vashon Island, which can also serve as a template for others.

The project provided a mechanism for Vashon Island to develop community-supported biocycling (CSB)—an alternative, locally based economic model of production and distribution. CSB is designed to close the loop on the community-supported agriculture movement by integrating co-products and services into the hyper-local food system, such as low-carbon fuel vehicle sharing and a liquid organic fertilizer co-product of the food waste AD process.

Chomp/Impact Bioenergy also participated in other grant-funded efforts in the region including the City of Auburn (exploring CFW outreach) and AD field testing.

5.4 Cedar Grove

Cedar Grove (CG) composting owns and operates two compost facilities in the region: one in Maple Valley and another in Everett. CG employs a fabric-covered ASP composting technology using the GORE technology at both Washington facilities. The facilities process green/yard, food, and commercial organic waste materials. CG processes the majority of the City of Seattle's SSO that was contracted to PacifiClean Environmental (PacifiClean) but is processed locally because of the apple maggot quarantine limitations of the PacifiClean facility.

As a precursor to exploring CG's interest in implementing AD, the following discussion provides an overview of CG's recent attempt to implement an AD facility and its current plans resulting from that experience.

CG has explored ways to improve its operations. In 2010, it announced a collaboration to build an AD facility at its Everett facility (Figure 5-5) and integrate it with its composting processes. The project was to have received and processed mixed food/yard trimmings that would be compatible with the CG composting facility program. The goal of the AD project was to anaerobically digest the more putrescible materials (food waste, vegetables, meats, dairy products, etc.) in the enclosed AD facility where the beneficial biogas by-product could be captured and converted to renewable energy. However, because of concerns from the neighboring community (about odor and impacts), the project was unable to proceed.

Figure 5-5. Cedar Grove Everett facility

Source: HDR (2012).

CG is currently exploring the development of a pilot high-solids plug flow-type digester at the Maple Valley site, where it hopes to demonstrate that the digestion process can occur without concern for fugitive odors. The facility would be equipped with a preprocessing system to screen/shred the material into pulp-like thickened slurry prior to digestion. The digester would be a horizontal digester equipped with paddle-like mixers that would both mix and convey the contents of the digester from beginning to end. The digester would have a retention time of several weeks. After the digester has been demonstrated at CG's Maple Valley facility site, CG hopes to replicate the use of this type of digester at the locations of some of its larger-volume customers. CG would service the digesters and also provide its customers with implementation assistance, maintenance, and related support. CG will offer to collect the digestate (post-digestion), which would be transferred to its composting facilities for post-digestion blending and subsequent composting. Biogas generated by the digestion unit would be used by the customer in whatever form it prefers. CG believes that this model (decentralized/distributed digestion) will have a greater chance of success than a centralized digestion unit like the one it previously attempted to develop.

5.5 Recology Cleanscapes

Recology Cleanscapes provides waste collection services in the greater Puget Sound region, specifically holding the current organics collection contract with the City of Seattle. Recology owns and operates the Cleanscapes waste and recycling facilities. Recology does not operate a composting or digestion facility in the region but has composting capabilities in Oregon and California. City residents have combined yard and food waste collection every week. Approximately half of the collected material is sent to the contracted processing facility, Lenz Enterprises (Lenz). Recology is open to assisting the County in support of its goal of diverting recoverable materials from landfilling and securing the highest/best use of resources.

Currently, all single-family customers in Seattle must subscribe to the weekly organics collection service. Residents can elect to backyard-compost their yard trimmings and food wastes. Customers may choose from three sizes of wheeled carts. The cost of service is set to increase with an increasing container size to encourage on-site backyard composting. Customers set out their organics carts at the curb or alley on the same collection day as garbage. Extra organics, properly contained, may be set out for a fee.

Multifamily residential organics services have been mandatory since 2011. The building manager determines container size and collection frequency according to the needs of the building.

Commercial customers with organics have several options for collection of these voluntarily separated materials. They may use one of the two City-contracted collection services or a private collection service. Typically, the collected organics are taken directly to the compost facility instead of to a transfer facility. If customers subscribe to the City-contract cart-based organics (residential-type) service, the materials are taken to a City transfer facility before going to the processor.

5.6 WM

WM serves the region with waste collection services and has invested in technologies to convert organic materials to energy, including its CORe process which was described previously in this report. WM reports that the technology is modular and could be implemented at any of the three WM-owned properties in the region. Where it employs the CORe system, WM's intentions are to deliver the bioslurry to municipal WWTPs, where it is anaerobically digested to increase the production of biogas. WM reports that adding approximately 7 percent organic material by weight in the form of bioslurry to the WWTPs' anaerobic digesters increases energy output by more than 70 percent.

In recent conversations (2024), WM states that it has repeatedly offered to partner with the County to assist the County in reaching its organics diversion goals. WM staff (2024) indicate that they remain open and technology-agnostic. .

5.7 PacifiClean in Quincy, Washington

PacifiClean was awarded the contract to process yard/green/food waste from the City of Seattle. However, prior to initiating this program, the Washington State Department of Agriculture (WSDA) implemented emergency rules under its pest program that specifies methods to prevent the introduction, escape, or spread of apple maggots beyond the quarantine area in 2015. Under these emergency rules, "municipal green waste" generated in the quarantine area is defined as a "regulated commodity" and subject to strict controls. The emergency rules prohibit the transportation of collected organics from western Washington to the PacifiClean facility, which is located outside the quarantine area. To comply with these conditions, the City's organic materials are being delivered to CG for composting as an interim measure until further notice.

5.8 Lenz Enterprises in Stanwood, Washington

Lenz currently processes SSO and yard trimmings from cities in King County, including the majority of Seattle's SSO. The Lenz facility employs a low friction aerated floor, bunker-type bed ASP system with a reversing manifold to a biofilter. Figure 5-6 below depicts an ASP air manifold at the Lenz facility. The smaller portion of Seattle's SSO goes to CG.

Lenz sells the compost as GreenBlenz and Certified Organic GreenBlenz compost products at its facility. The majority of Seattle's residential organic materials (60 percent) are delivered and processed by Lenz. The facility also sells various other landscaping products and services.

Lenz researched AD for more than a decade and, while it has not found a profitable business model in which an AD project has been successfully developed through to sustained operations, Lenz remains interested in the County's AD initiative and wishes to remain informed and involved in the developments as they happen.

Figure 5-6. ASP air manifold, Lenz facility

Source: HDR.

5.9 Silver Springs Organics in Rainier, Washington

Silver Springs Organics (owned by Waste Connections, Inc.) is a commercial composting facility in Rainier in Thurston County. Silver Springs accepts yard trimmings and garden, wood, food, and farm wastes. Silver Springs employs a covered sparger floor, extended bed -type ASP system with a reversing manifold feeding a biofilter. The use of fabric covered comp-dog (inflatable pipe on grade) methods were being used as a trial method at the time, driven primarily by challenges of high maintenance cost of their compost turners required to cut/turn the mass beds. Figure 5-7 below depicts the ASP composting facility in Rainier.

Figure 5-7. Silver Springs ASP composting

Source: HDR.

5.10 Sawdust Supply Company and GroCo Compost

The Sawdust Supply Company, located in Seattle, began in 1912 by taking scrap materials from local sawmills. It now also offers blower truck services, soil amendments, mulch, and other landscaping materials. It offers three soil amendment products that are produced through composting operations. The GroCo soil conditioner product is produced from composting a blend of sawdust and biosolids from WWTPs. The SteerCo compost is produced by composting cattle manure, fir-hemlock sawdust, and nitrogen, for up to 1 year. The BeautiMulch compost is produced by composting clean green yard trimmings.

5.11 Decentralized On-site Composting

Decentralized on-site composting occurs as a typically small-quantity process and sites of varying sizes are located at single-family homes, farms, and institutions. They may also be found at businesses or industrial facilities.

Seattle uses surveys to estimate the amount of organics management occurring in Seattle households. The surveys are conducted every 5 years and results are used to generate estimates for backyard food and yard trimmings composting and for estimating the amount of grass-cycling undertaken in the city.

Several programs have been provided by or supported financially in part by the City of Seattle, with the purpose of encouraging residential backyard composting of food and yard trimmings:

- The Natural Lawn and Garden Hotline, operated by the Seattle Tilth Association.
- Discount compost bins.
- Education and hands-on training programs for residents and landscape professionals.
- Collection of home gas mowers for recycling, as part of the Mayor’s Climate Change Initiative.

Seattle and the County partnered with retailers for the Northwest Natural Yard Days program, which provided discounts or rebates on items to encourage home composting and grass-cycling, like mulching mowers and soaker hoses. The Northwest Natural Yard Days program ran for 12 years before ending in 2009.

Backyard composting in Seattle peaked between 2000 and 2005. After vegetative food waste was allowed in yard trimmings carts in 2005, backyard composting began to decline. With the 2009 change to allow all food waste and requiring all single-family accounts to have organics carts, Seattle increasingly encouraged residents to use the curbside service, and the decline in backyard composting continued. In 2000, 46 percent of Seattle households did backyard composting of yard trimmings. That declined to 40 percent in 2005 and then to 30 percent in 2010. Backyard composting of food waste showed a similar decline during the same period, from 31 percent down to 20 percent of households. These declines led the City of Seattle to stop subsidizing programs for backyard compost bins and green cone composters in 2011.

5.12 South Treatment Plant (County Wastewater Treatment Division)

This topic is addressed in the Task 200.02 South Treatment Plant Capacity and Condition Assessment technical memorandum (provided under separate cover by Jacobs).

5.13 Dairy Digesters

This section describes dairy digesters in the vicinity of King County.

5.13.1 Rainier Biogas: Enumclaw Plateau

The Rainier Biogas, LLC digester and manure management operation is located in Enumclaw, Washington. It was designed with a capacity of 35,274 wet tons, to serve three local family farms with a total of 1,200 cows. The project was projected to avoid 4,400 tons of greenhouse gas emissions annually.

The sealed, heated concrete digester was designed as a plug flow digester that would collect the methane biogas from the decomposing manure and feed it into a 1 MW electric generator, which would generate renewable energy that could be sold to PSE. The project was initially financed by Native Energy through the sale of Help Build carbon offsets. Native Energy provides carbon offsets, renewable energy credits, and carbon accounting software to its customers. The project also received a $492,000 U.S. Department of Energy grant through King County.

The project, which commenced in December 2012, underwent its first project verification process through the Climate Action Reserve (CAR) for the period from December 1, 2012, to April 30, 2014. The verification process showed that the project began receiving manure from four dairies beginning in October 2012. A fifth dairy began delivering manure in December 2013. The digester operates one Guascor engine and a Martin Machinery generator. Excess gas is burned in an auxiliary flare. The solid portion of the effluent stream is used as bedding material for cows at the participating dairies. The liquid fraction is also returned to the participating dairies to be stored for land application. The biogas control system and combustion devices are operated by Farm Power. The verification report cited two notices of violation for exceeding permitted levels of H_2S emissions—June 12, 2013, and October 3 through 14, 2013. The project was found not to have achieved any emission reductions for December 2012. It was found to have achieved a reduction of 2,189 tons of carbon dioxide equivalents (tCO_2e) in 2013, and an additional reduction of 912 tCO_2e in the first 4 months of 2014. The project has reportedly been in operation since 2014.

5.13.2 Werkhoven Dairy/QualcoEnergy Dairy Manure Digester (Snohomish County)

This dairy manure digester is located on the Werkhoven Farm in Monroe, Washington. Initial funding for this manure digester was provided by the U.S. Department of Energy and the U.S. Department of Agriculture. The digester now generates $25,000 per month from electricity sales to Snohomish County Public Utility District (PUD).

The project was a partnership between Qualco Energy, the Werkhoven family, the Tulalip Tribes, and Snohomish County PUD. Qualco Energy allows researchers from Washington State University to study manure and nutrient management at the facility.

Dairy manure is collected by washing down the cow barn floor and collecting wash water, via underground pipe, into a lagoon where mixing begins. In addition to dairy manure, the digester accepts leftovers and expired foods and drinks from restaurants, wastes from food processing plants, and animal blood. The lagoon mixture is pumped underground to the digester, which is made up of five underground chambers. The digester is generally kept about three-quarters full. The entire digester system is underground, which virtually eliminates odors. The digester itself is at a depth of 20 feet, and maintains a temperature of 100°F.

The biogas is sent to the generator building next to the digester, which houses the 450-kilowatt generator. The amount of power generated can power 300 homes. The digester currently produces twice as much gas as the generator can use. Excess gas is flared and is being evaluated for potential uses such as heating greenhouses. A second generator is being considered. The solid portion of the digester effluent is used as compost, which is currently given away to local farmers. Liquid effluent is sprayed on fields.

5.14 Nearby Technologies Summary

There are many privately owned compost companies in the region that include some of the most technically diverse and operationally advanced compost facilities in the nation. The County has benefited from presence of these capable, longstanding compost companies. As noted in the Compost Summary above, continued reliance on these companies is advisable for the County's compost needs.

Although there appears to be many digestion systems in the region, for the most part, these units are committed to dedicated feedstocks and not necessarily well equipped to receive CFW.

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Technical Memorandum

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Date:	July 29, 2024
Task Name:	200.3 Preliminary Architectural Alternatives Assessment
Subject:	**Food Waste Material Estimates** **Food Waste Recycling Alternatives Analysis Project**

INTRODUCTION

King County is evaluating options for processing commercial food waste that is diverted from landfill disposal. The consultant team prepared this memorandum for King County to describe commercial food waste projection estimates, which will be utilized for the alternatives analysis phase of the Food Waste Recycling Alternatives Analysis Project (Project). The projections are based on information reviewed as part of Task 200.01: Review of Existing Information and therefore align with previous King County projections. Once finalized, these estimates will be used in the alternatives analysis for this Project under Task 300.02, where the additional infrastructure needs at the South Treatment Plant in Renton, Washington, and other locations, will be determined for various pre-processing and processing alternatives.

The term "commercial food waste" in this memorandum refers to the edible food, nonedible food, and compostable packaging portions of compostable material, as defined in the *2022 King County Waste Characterization and Customer Survey Report* (Cascadia 2023). Commercial food waste typically contains approximately 12 percent of noncompostable contaminants, as identified by Cascadia Consulting Group (Cascadia) in a 2019 waste composition study.

CURRENT SOURCE-SEPARATED COMMERCIAL FOOD WASTE LANDFILL DIVERSION

The amount of commercial food waste (that is generated in King County) that is currently being source separated, picked up by haulers, and diverted from landfill can be estimated using a combination of hauler data and waste characterization studies. The consultant team utilized the 2019 to 2023 hauler data (Pastore 2024a) to calculate the quantity of commercial (nonresidential) organics that are currently being collected by haulers in King County except Seattle and Milton and diverted from landfill. The 2019 to 2023 hauler data was specifically sorted for non-residential (generator type) and organics (tonnage type) to identify commercial food waste tons.

The consultant team refined this data to estimate the amount and composition of commercial food waste that is present in currently collected commercial organic material in King County using results from Cascadia's 2019 *Commercial Organic Material Characterization* report. The report was used to calculate the composition of edible food waste, non-edible food waste, compostable packaging, and non-compostable contaminants within commercial food waste. The 2019 to 2023 hauler data (Pastore 2024a) also provides some insight into what portions of King County are currently collecting the most commercial food waste (Figure 1).

During the past 5 years, the total commercial food waste diversion in King County has fluctuated between 6,000 and 8,000 tons annually and has increased approximately 9 percent within that time period. Table 1 shows the top 10 King County jurisdictions that are currently collecting and diverting commercial food waste. Attachment 1 provides a complete list of jurisdictions in King County with respective commercial food waste volumes.

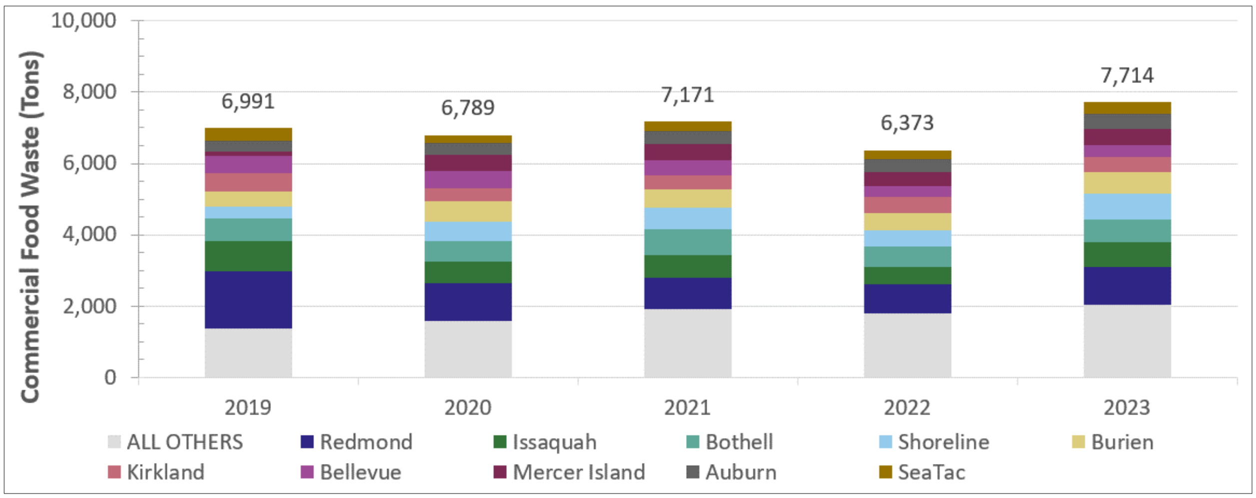

Figure 1. King County Commercial Food Waste Collected and Diverted by Jurisdiction

Table 1. Top 10 Jurisdictions Recovering Commercial Food Waste

Rank	Jurisdiction	Recovered Commercial Food Waste[a]					
		5-Year Total (tons)	2019 (tons)	2020 (tons)	2021 (tons)	2022 (tons)	2023 (tons)
1	Redmond	5,362	1,584	1,045	876	799	1,059
2	Issaquah	3,322	860	618	654	489	701
3	Bothell	3,131	630	568	713	574	646
4	Shoreline	2,658	328	541	596	463	729
5	Burien	2,630	439	586	517	493	595
6	Kirkland	2,140	510	358	407	441	424
7	Bellevue	2,033	491	496	404	309	334
8	Mercer Island	1,853	107	449	458	390	449
9	Auburn	1,778	319	313	368	360	419
10	SeaTac	1,411	346	224	264	250	327
11-40	All Others[b]	8,718	1,378	1,591	1,914	1,804	2,030

Rank	Jurisdiction	Recovered Commercial Food Waste[a]					
		5-Year Total (tons)	2019 (tons)	2020 (tons)	2021 (tons)	2022 (tons)	2023 (tons)
All	**Total**	**35,038**	**6,991**	**6,789**	**7,171**	**6,373**	**7,714**

[a] Commercial food waste tons represent edible food, nonedible food, and compostable packaging as well as an estimated 12 percent noncompostable contaminants (Cascadia 2023).

[b] All Other jurisdictions and respective commercial food waste recovered identified in Attachment 1.

Currently, north King County is responsible for approximately 60 percent of the commercial food waste and south King County is responsible for approximately 40 percent of the commercial food waste that is being diverted from landfill (Table 2). This indicates commercial food waste collection programs are more active in north King County compared to south King County. South King County would have more opportunities for future growth closer to a processing facility. In general, anything south of Bellevue is considered south King County with the exception of Mercer Island included in north King County. Bellevue is included in north King County.

Table 2. North King County Versus South King County Commercial Food Waste Diversion

County	5-Year Total (tons)	2019 (tons)	2020 (tons)	2021 (tons)	2022 (tons)	2023 (tons)
North	19,383	4,223	3,951	3,820	3,274	4,115
South	11,385	1,916	2,010	2,477	2,323	2,659
Total	**30,767**	**6,139**	**5,961**	**6,297**	**5,596**	**6,774**

EXISTING AND FUTURE ESTIMATED COMMERCIAL FOOD WASTE QUANTITIES

The commercial food waste estimated quantity that is currently available and that will be available during the planning horizon for this Project are based on the following datasets and studies:

- Waste Characterization Studies: King County has conducted several waste characterization studies and waste analyses that provide insight into the composition of material that is currently generated, source separated for processing, or disposed.
- *King County Commercial Organics Materials Characterization* (Cascadia 2019)
- *King County Commercial Food Waste Analysis* (Cascadia 2022)
- *King County Waste Characterization and Customer Survey Report* (Cascadia 2023)
- Hauler Data (Pastore 2024a)
- Re+ Forecast (Pastore 2024b)

Existing Commercial Food Waste Generation Estimate

Cascadia conducted and documented a commercial food waste analysis in 2022. The study utilized existing waste characterization studies and available data on employee counts to estimate which industries within King County (not including Seattle or Milton) generate the most food waste, and how much/what composition each industry generates. Using the methodology from the Cascadia study, Table 3 shows that, based on 2022 employee counts, King County generates about 122,182 tons of food waste per year and the restaurant sector and other services sector are responsible for 36 percent and 26 percent, respectively, of total food waste generated in King County.

These estimates represent the highest-case scenario of food waste generation within King County as it assumes all potential food waste generators are producing food waste. A more conservative estimate provided by King County Re+ data (Pastore 2024b) was used to calculate commercial food waste recovery rate.

Table 3. 2022 Cascadia Commercial Food Waste Estimate

Industry Group	Food Waste Generation (tons/year)	% of Total Food Waste
Restaurants	43,636	35.7
Other Services	31,880	26.1
Professional Services	12,317	10.1
Education	7,776	6.4
Lodging and Recreation	7,128	5.8
Medical/Health	6,038	4.9
Supermarkets and Grocery	5,387	4.4
Food Manufacturing and Wholesale	3,920	3.2
Retail and All Other	3,002	2.5
Durable Wholesale and Trucking	851	0.7
Manufacturing	247	0.2
Overall	**122,182**	**100%**

Source: Cascadia 2022.

Future Commercial Food Waste Available for Diversion from Re+ Actions

King County has prepared waste projections that are associated with the King County Re+ Plan and associated programs. King County provided the 2024 Re+ waste generation forecast associated with organics waste (Pastore 2024b). The consultant team evaluated the Re+ data (Pastore 2024) to identify the volume of commercial food waste that is currently landfilled but would become available for landfill diversion and potential processing as a result of Re+ actions. In this evaluation, commercial, nonresidential data was used along with the material categories of edible food, nonedible food, and compostable packaging to determine what we are referring to as "commercial food waste."

Additionally, noncompostable contaminants were estimated to calculate the total commercial food waste tonnage for preprocessing and collection considerations. Noncompostable contaminants represent metal, plastic, glass, noncompostable paper, and other materials that may be present in commercial food waste collection bins and are removed during a preprocessing step prior to co-digestion.

High-, medium-, and low-diversion scenarios for commercial food waste were calculated using Re+ data as a reference and modified, as described below. For the alternatives analysis under Task 300.02 of this Project, design tons are based on the high-diversion scenario 2045 commercial food waste estimates.

Low-Diversion Scenario: The low-diversion scenario assumes annual additional Re+ diversion is decreased by 25 percent each year from 2024 to 2040. Additionally, from 2040 to 2060, generation and diversion of commercial food waste would increase by 1.4826 percent each year. In design year 2045 of the low-impact scenario, 62,000 tons of commercial food waste is estimated to be diverted from landfill (49 percent recovery rate).

Medium-Diversion Scenario: The medium-diversion scenario assumes annual additional Re+ diversion is decreased by 15 percent each year from 2024 to 2040. Additionally, from 2040 to 2060, generation and diversion of commercial food waste would increase by 1.4826 percent each year. In design year 2045 of the medium-impact scenario, 78,000 tons of commercial food waste is estimated to be diverted from landfill (63 percent recovery rate).

High-Diversion Scenario: The high-diversion scenario follows Re+ diversion projection and caps commercial food waste diversion at 80 percent of the generated total. Additionally, from 2040 to 2060, generation and diversion of commercial food waste would increase by 1.4826 percent each year. In design year 2045 of the high-impact scenario, 100,000 tons of commercial food waste is estimated to be diverted from landfill (80 percent recovery rate).

To gain the complete picture of the estimated quantity of commercial food waste that could be collected in the future, the projected hauler data (for 2019–2023) and Re+ projected data (2024–2040) were combined and then a 1.4826 percent growth factor was applied for the years 2041–2060 (Figure 2).

The abnormally large increase in commercial food waste tonnage occurring between 2032 and 2033 is due to a planned mixed-waste processing (MWP) facility[1] becoming operational and diverting residual materials for co-digestion. The exact composition of the proposed MWP facility residual fines is unknown. Although not a perfect comparison, for reference, existing King County material recovery facilities'[2] (MRF) residual materials consist of paper (40 percent), contaminants (23 percent), plastic (23 percent), glass (6 percent), metal (4 percent), and organics (4 percent) (Cascadia 2020). The feasibility to incorporate MWP facility residual material in commercial food waste projections will continue to be evaluated. Inclusion of MWP residual will depend on the composition of residual material and commercial food waste processing technology. Attachment 2 provides a tabular breakdown of estimated commercial food waste diverted tonnage per year for each diversion scenario.

[1] Mixed waste processing facilities sort municipal solid waste which has not been separated by the consumer or waste generator. Mixed waste processing facilities sometimes referred as "dirty MRFs".
[2] Material recovery facilities sort recyclable materials which have already been preliminary separated by the consumer or waste generator.

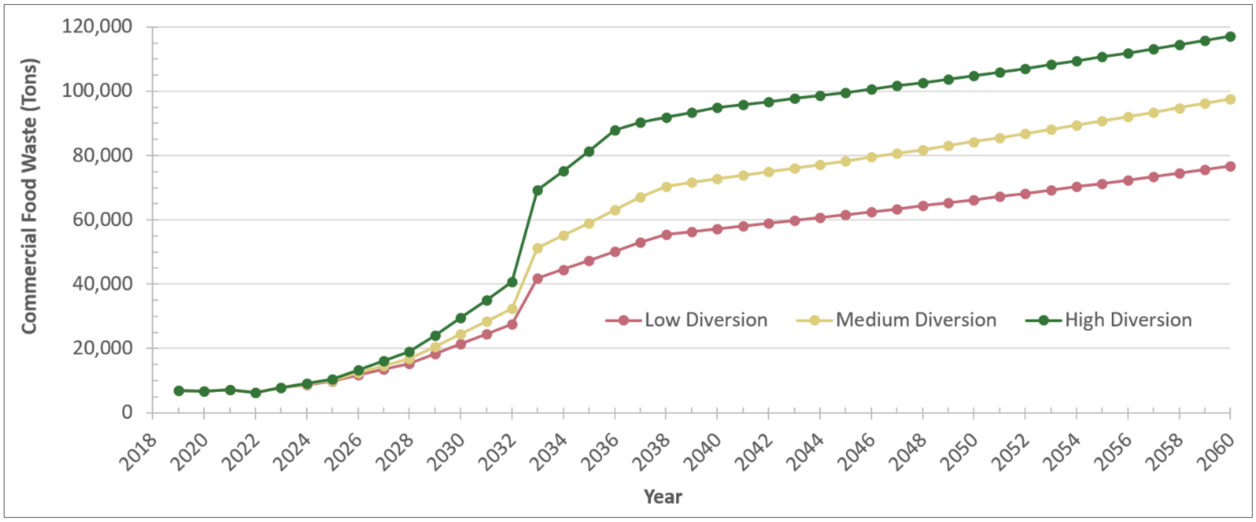

Figure 2. High-, Medium-, and Low-Diversion Scenarios for Commercial Food Waste

High-Diversion Scenario Design Values for Alternatives Analysis

The high-diversion scenario commercial food waste tonnage will be used as design values in the alternatives analysis of Task 300.02 of this Project. This scenario reflects Re+ projections and reaches the established maximum recovery rate of 80 percent in 2037 (Figure 3).

Values shown in Figure 3 include noncompostable contaminants present in commercial food waste collection streams. Noncompostable contaminants are removed by a preprocessing system prior to co-digestion. Projected values for preprocessing are greater than those for post-processing (e.g. co-digestion) due to the removal of noncompostable contaminants in the preprocessing stage (Figure 4).

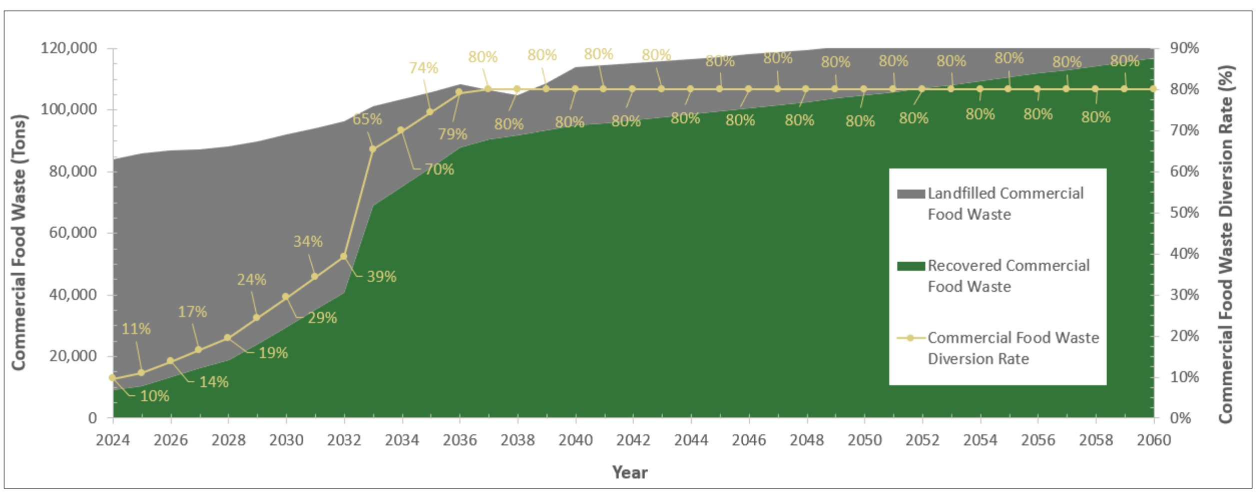

Figure 3. High-Impact Scenario Project Commercial Food Waste Generation and Recovery Rate

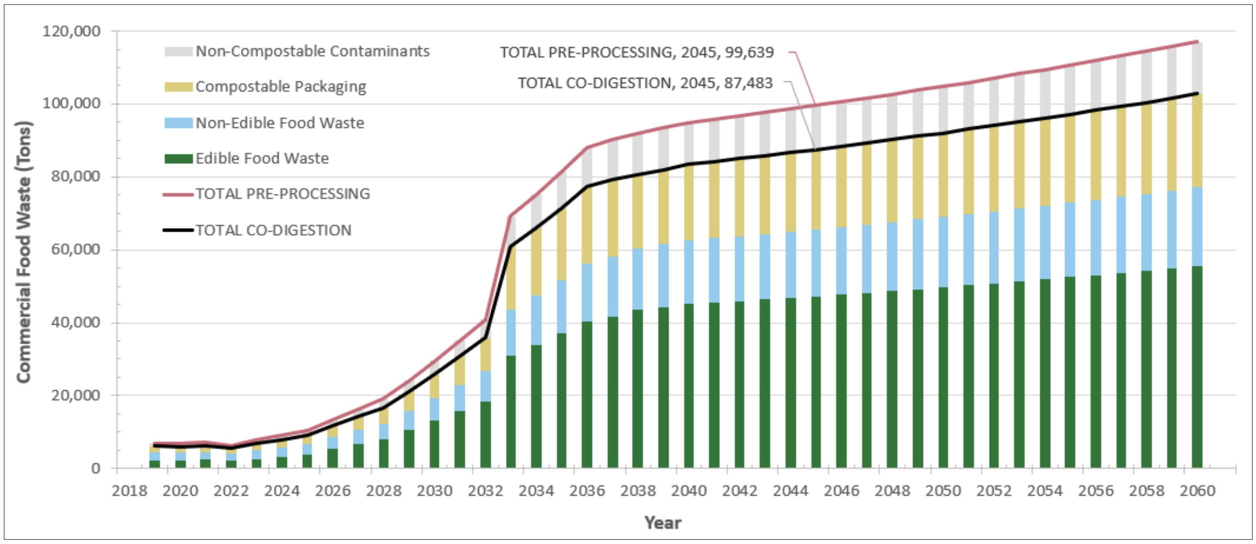

Figure 4. Total Recovered Commercial Food Waste Projection

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ATTACHMENT 1

JURISDICTIONS RECOVERING COMMERCIAL FOOD WASTE

Jurisdictions in King County with respective commercial food waste volumes

Rank[a]	Jurisdiction	5-Year Total	2019 (tons)	2020 (tons)	2021 (tons)	2022 (tons)	2023 (tons)
1	Redmond	4,709	1,391	917	769	702	930
2	Issaquah	2,917	755	542	574	430	616
3	Bothell	2,750	554	499	626	504	567
4	Shoreline	2,334	288	475	524	406	640
5	Burien	2,309	385	514	454	433	522
6	Kirkland	1,879	448	314	357	387	373
7	Bellevue	1,786	431	435	354	272	293
8	Mercer Island	1,627	94	394	402	343	394
9	Auburn	1,561	280	275	323	316	368
10	SeaTac	1,239	304	197	231	220	287
11	Tukwila	1,162	110	131	333	340	248
12	Maple Valley	1,140	192	272	211	145	320
13	Federal Way	1,067	112	143	256	278	278
14	Des Moines	1,012	184	190	202	190	246
15	Unincorporated - South	953	132	88	288	231	214
16	Normandy Park	611	156	131	118	98	108
17	Unincorporated - North	512	142	147	62	90	70
18	Duvall	211	17	75	35	36	49
19	Woodinville	185	28	17	16	23	100
20	Kent	166	28	36	34	34	34
21	Snoqualmie	135	14	65	19	19	18
22	Renton	126	25	24	22	31	24
23	North Bend	94	13	14	24	21	21
24	Kenmore	66	12	11	18	11	14
25	Carnation	48	12	13	12	8	4
26	Lake Forest Park	36	7	8	7	7	8
27	Sammamish	30	6	6	7	5	7
28	Medina	21	4	5	4	3	4
29	Clyde Hill	21	5	5	4	3	3
30	Pacific	14	2	2	2	2	6
31	Covington	11	2	3	2	3	2
32	Newcastle	10	3	3	1	1	2
33	Sammamish Klahanie	6	1	1	2	1	1
34	Yarrow Point	6	2	2	1	0	1
35	Hunts Point	5	1	2	2	1	0
36	Beaux Arts	3	1	1	0	0	1
37	Algona	2	0	2	0	0	0
38	Out-of-Area	0	0	0	0	0	0
39	Black Diamond	0	0	0	0	0	0
40	Enumclaw	0	0	0	0	0	0

[a] Rank based on 5-year total.

ATTACHMENT 2

ESTIMATED COMMERCIAL FOOD WASTE DIVERTED TONNAGE PER YEAR FOR EACH DIVERSION SCENARIO

Low Impact Scenario										
		Total Recovered Commercial Food Waste (Tons)					Total Recovery Rate of Commercial Food Waste	Total Generated Commercial Food Waste (Tons)	Co-Digestion Commercial Food Waste Tons
	Year	Edible Food Waste	Non-Edible Food Waste	Compostable Packaging	Non-Compostable Contaminants	Total Tons Received			
Actual	2019	2,333	2,144	1,662	852	6,991	Unknown	Unknown	**6,139**
	2020	2,265	2,082	1,614	827	6,789	Unknown	Unknown	**5,961**
	2021	2,393	2,199	1,705	874	7,171	Unknown	Unknown	**6,297**
	2022	2,126	1,955	1,515	777	6,373	6.5%	98,213	**5,596**
	2023	2,574	2,366	1,834	940	7,714	8.0%	96,377	**6,774**
Ajusted Re+ Forcast	2024	3,065	2,543	2,062	1,065	8,735	9.2%	94,549	**7,670**
	2025	3,551	2,723	2,291	1,189	9,754	10.1%	96,297	**8,565**
	2026	4,481	3,075	2,736	1,431	11,723	12.1%	97,279	**10,292**
	2027	5,344	3,412	3,154	1,657	13,567	13.9%	97,349	**11,910**
	2028	6,183	3,747	3,563	1,879	15,372	15.7%	97,929	**13,493**
	2029	7,599	4,319	4,261	2,256	18,436	18.6%	98,875	**16,179**
	2030	9,015	4,902	4,962	2,635	21,514	21.4%	100,708	**18,878**
	2031	10,398	5,477	5,651	3,007	24,533	24.0%	102,375	**21,526**
	2032	11,767	6,053	6,335	3,376	27,532	26.5%	104,069	**24,156**
	2033	17,698	8,562	10,447	5,136	41,843	39.6%	105,793	**36,707**
	2034	18,966	9,105	11,018	5,471	44,560	41.4%	107,546	**39,090**
	2035	20,249	9,656	11,592	5,809	47,305	43.3%	109,328	**41,496**
	2036	21,627	10,249	12,126	6,161	50,164	45.1%	111,141	**44,003**
	2037	23,023	10,850	12,676	6,519	53,067	47.0%	112,985	**46,549**
	2038	24,435	11,432	12,661	6,799	55,327	48.2%	114,860	**48,528**
	2039	24,974	11,685	12,666	6,912	56,237	48.2%	116,767	**49,325**
	2040	25,344	11,858	12,946	7,027	57,174	48.2%	118,707	**50,147**
Growth Rate Forecasted	2041	25,719	12,034	13,138	7,131	58,022	48.4%	119,822	**50,891**
	2042	26,101	12,212	13,332	7,237	58,882	48.7%	120,964	**51,645**
	2043	26,488	12,393	13,530	7,344	59,755	48.9%	122,132	**52,411**
	2044	26,880	12,577	13,731	7,453	60,641	49.2%	123,327	**53,188**
	2045	**27,279**	**12,763**	**13,934**	**7,563**	**61,540**	**49.4%**	**124,548**	**53,977**
	2046	27,683	12,953	14,141	7,676	62,452	49.6%	125,797	**54,777**
	2047	28,094	13,145	14,351	7,789	63,378	49.9%	127,073	**55,589**
	2048	28,510	13,340	14,563	7,905	64,318	50.1%	128,377	**56,413**
	2049	28,933	13,537	14,779	8,022	65,272	50.3%	129,708	**57,250**
	2050	29,362	13,738	14,998	8,141	66,239	50.5%	131,068	**58,098**
	2051	29,797	13,942	15,221	8,262	67,221	50.7%	132,457	**58,960**
	2052	30,239	14,148	15,446	8,384	68,218	51.0%	133,874	**59,834**
	2053	30,687	14,358	15,675	8,508	69,229	51.2%	135,320	**60,721**
	2054	31,142	14,571	15,908	8,635	70,256	51.4%	136,796	**61,621**
	2055	31,604	14,787	16,144	8,763	71,297	51.6%	138,301	**62,535**
	2056	32,073	15,006	16,383	8,893	72,354	51.7%	139,837	**63,462**
	2057	32,548	15,229	16,626	9,024	73,427	51.9%	141,403	**64,403**
	2058	33,031	15,455	16,872	9,158	74,516	52.1%	142,999	**65,358**
	2059	33,520	15,684	17,122	9,294	75,621	52.3%	144,627	**66,327**
	2060	34,017	15,916	17,376	9,432	76,742	52.5%	146,286	**67,310**

Medium Impact Scenario										
		Total Recovered Commercial Food Waste (Tons)					Total Recovery Rate of Commercial Food Waste	Total Generated Commercial Food Waste (Tons)	Co-Digestion Commercial Food Waste Tons
	Year	Edible Food Waste	Non-Edible Food Waste	Compostable Packaging	Non-Compostable Contaminants	Total Tons Received			
Actual	2019	2,333	2,144	1,662	852	6,991	Unknown	Unknown	**6,139**
	2020	2,265	2,082	1,614	827	6,789	Unknown	Unknown	**5,961**
	2021	2,393	2,199	1,705	874	7,171	Unknown	Unknown	**6,297**
	2022	2,126	1,955	1,515	777	6,373	6.5%	98,213	**5,596**
	2023	2,574	2,366	1,834	940	7,714	8.0%	96,377	**6,774**
Ajusted Re+ Forcast	2024	3,131	2,566	2,093	1,081	8,871	9.4%	94,549	**7,790**
	2025	3,693	2,772	2,356	1,225	10,045	10.4%	96,297	**8,821**
	2026	4,789	3,179	2,874	1,506	12,349	12.7%	97,279	**10,842**
	2027	5,834	3,574	3,371	1,777	14,557	15.0%	97,349	**12,780**
	2028	6,872	3,971	3,868	2,046	16,757	17.1%	97,929	**14,711**
	2029	8,657	4,659	4,726	2,512	20,553	20.8%	98,875	**18,041**
	2030	10,484	5,370	5,608	2,990	24,452	24.3%	100,708	**21,462**
	2031	12,307	6,085	6,490	3,468	28,350	27.7%	102,375	**24,882**
	2032	14,145	6,810	7,381	3,951	32,286	31.0%	104,069	**28,335**
	2033	22,224	10,009	12,809	6,284	51,327	48.5%	105,793	**45,042**
	2034	24,029	10,729	13,604	6,748	55,110	51.2%	107,546	**48,361**
	2035	25,870	11,464	14,406	7,221	58,961	53.9%	109,328	**51,740**
	2036	27,866	12,263	15,159	7,717	63,005	56.7%	111,141	**55,288**
	2037	29,904	13,078	15,937	8,225	67,144	59.4%	112,985	**58,919**
	2038	31,983	13,872	15,917	8,626	70,398	61.3%	114,860	**61,772**
	2039	32,689	14,179	15,922	8,770	71,560	61.3%	116,767	**62,790**
	2040	33,172	14,389	16,274	8,915	72,751	61.3%	118,707	**63,835**
Growth Rate Forecasted	2041	33,664	14,603	16,515	9,048	73,829	61.6%	119,822	**64,782**
	2042	34,163	14,819	16,760	9,182	74,924	61.9%	120,964	**65,742**
	2043	34,670	15,039	17,009	9,318	76,035	62.3%	122,132	**66,717**
	2044	35,184	15,262	17,261	9,456	77,162	62.6%	123,327	**67,706**
	2045	**35,705**	**15,488**	**17,517**	**9,596**	**78,306**	**62.9%**	**124,548**	**68,710**
	2046	36,235	15,718	17,777	9,738	79,467	63.2%	125,797	**69,729**
	2047	36,772	15,951	18,040	9,883	80,645	63.5%	127,073	**70,763**
	2048	37,317	16,187	18,308	10,029	81,841	63.8%	128,377	**71,812**
	2049	37,870	16,427	18,579	10,178	83,054	64.0%	129,708	**72,876**
	2050	38,432	16,671	18,854	10,329	84,286	64.3%	131,068	**73,957**
	2051	39,001	16,918	19,134	10,482	85,535	64.6%	132,457	**75,053**
	2052	39,580	17,169	19,418	10,637	86,803	64.8%	133,874	**76,166**
	2053	40,167	17,423	19,706	10,795	88,090	65.1%	135,320	**77,295**
	2054	40,762	17,682	19,998	10,955	89,396	65.4%	136,796	**78,441**
	2055	41,366	17,944	20,294	11,118	90,722	65.6%	138,301	**79,604**
	2056	41,980	18,210	20,595	11,282	92,067	65.8%	139,837	**80,784**
	2057	42,602	18,480	20,900	11,450	93,432	66.1%	141,403	**81,982**
	2058	43,234	18,754	21,210	11,619	94,817	66.3%	142,999	**83,198**
	2059	43,875	19,032	21,525	11,792	96,223	66.5%	144,627	**84,431**
	2060	44,525	19,314	21,844	11,967	97,649	66.8%	146,286	**85,683**

High Impact Scenario									
		Total Recovered Commercial Food Waste (Tons)					Total Recovery Rate of Commercial Food Waste	Total Generated Commercial Food Waste (Tons)	Co-Digestion Commercial Food Waste Tons
	Year	Edible Food Waste	Non-Edible Food Waste	Compostable Packaging	Non-Compostable Contaminants	Total Tons Received			
Actual	2019	2,333	2,144	1,662	852	6,991	Unknown	Unknown	**6,139**
	2020	2,265	2,082	1,614	827	6,789	Unknown	Unknown	**5,961**
	2021	2,393	2,199	1,705	874	7,171	Unknown	Unknown	**6,297**
	2022	2,126	1,955	1,515	777	6,373	6.5%	98,213	**5,596**
	2023	2,574	2,366	1,834	940	7,714	8.0%	96,377	**6,774**
Re+ Forcasted	2024	3,229	2,602	2,138	1,107	9,077	9.6%	94,549	**7,969**
	2025	3,911	2,847	2,455	1,280	10,493	10.9%	96,297	**9,213**
	2026	5,277	3,339	3,090	1,627	13,333	13.7%	97,279	**11,706**
	2027	6,632	3,827	3,719	1,970	16,148	16.6%	97,349	**14,178**
	2028	8,020	4,326	4,364	2,322	19,032	19.4%	97,929	**16,710**
	2029	10,470	5,209	5,502	2,943	24,124	24.4%	98,875	**21,181**
	2030	13,071	6,145	6,710	3,602	29,527	29.3%	100,708	**25,925**
	2031	15,744	7,107	7,951	4,280	35,082	34.3%	102,375	**30,802**
	2032	18,509	8,103	9,236	4,981	40,829	39.2%	104,069	**35,848**
	2033	30,947	12,581	17,228	8,442	69,198	65.4%	105,793	**60,756**
	2034	33,904	13,645	18,484	9,176	75,209	69.9%	107,546	**66,034**
	2035	36,960	14,745	19,768	9,931	81,405	74.5%	109,328	**71,473**
	2036	40,316	15,953	20,982	10,734	87,986	79.2%	111,141	**77,252**
	2037	41,746	16,401	21,214	11,027	90,388	80.0%	112,985	**79,361**
	2038	43,418	16,895	20,365	11,210	91,888	80.0%	114,860	**80,678**
	2039	44,377	17,269	20,372	11,396	93,414	80.0%	116,767	**82,017**
	2040	45,033	17,524	20,822	11,586	94,965	80.0%	118,707	**83,379**
Growth Rate Forecasted	2041	45,456	17,689	21,018	11,695	95,858	80.0%	119,822	**84,163**
	2042	45,889	17,858	21,218	11,806	96,771	80.0%	120,964	**84,965**
	2043	46,332	18,030	21,423	11,920	97,706	80.0%	122,132	**85,786**
	2044	46,786	18,207	21,633	12,037	98,661	80.0%	123,327	**86,625**
	2045	**47,249**	**18,387**	**21,847**	**12,156**	**99,639**	**80.0%**	**124,548**	**87,483**
	2046	47,723	18,571	22,066	12,278	100,638	80.0%	125,797	**88,360**
	2047	48,207	18,760	22,290	12,402	101,658	80.0%	127,073	**89,256**
	2048	48,701	18,952	22,518	12,530	102,701	80.0%	128,377	**90,172**
	2049	49,207	19,149	22,752	12,660	103,767	80.0%	129,708	**91,107**
	2050	49,723	19,349	22,990	12,792	104,855	80.0%	131,068	**92,062**
	2051	50,249	19,554	23,234	12,928	105,965	80.0%	132,457	**93,038**
	2052	50,787	19,764	23,483	13,066	107,099	80.0%	133,874	**94,033**
	2053	51,336	19,977	23,736	13,207	108,256	80.0%	135,320	**95,049**
	2054	51,895	20,195	23,995	13,351	109,437	80.0%	136,796	**96,085**
	2055	52,466	20,417	24,259	13,498	110,641	80.0%	138,301	**97,143**
	2056	53,049	20,644	24,529	13,648	111,869	80.0%	139,837	**98,221**
	2057	53,643	20,875	24,803	13,801	113,122	80.0%	141,403	**99,321**
	2058	54,249	21,111	25,083	13,957	114,399	80.0%	142,999	**100,443**
	2059	54,866	21,351	25,369	14,116	115,702	80.0%	144,627	**101,586**
	2060	55,496	21,596	25,660	14,278	117,029	80.0%	146,286	**102,751**