Hauled Waste Characterization
City of Salem – Hauled Waste Study for Willow Lake WPCF

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Background, Scope, and Objective

The City of Salem operates a 600-kilowatt (kW) lean burn engine-generator system at the Willow Lake Water Pollution Control Facility (WLWPCF). The system was installed at in the late 1980s and is powered by biogas that is generated from the anaerobic digesters at the WLWPCF. In 2008/2009, the City conducted a study that evaluated the following cogeneration alternatives (Carollo, 2009):

- Current 600-kW cogeneration system (baseline)
- No cogeneration
- Increase the output of the existing internal combustion engine
- Add a 335-kW engine to existing engine to better utilize digester gas
- Add a 300-kW fuel cell to existing engine to better utilize digester gas
- Replace existing engine with a new 848-kW engine
- Replace existing engine with a 1,400-kW fuel cell

The engine provides renewable energy for the plant and heat recovery for the anaerobic digesters. For example, the existing cogeneration system generated 333 kW in 2007/2008 or approximately 28 percent of the average annual power demand at the WLWPCF (Carollo, 2009). The 2009 study was prompted by the City's desire to minimize future energy costs, limit their greenhouse gas emissions, and better utilize the renewable energy available.

Although the study did not identify specific recommendations, the City has since concluded (baring new developments in biogas utilization technologies) that if the existing cogeneration system is upgraded, expanded, or replaced, the internal combustion engine (ICE) technology would continue to be utilized. The specific number and size of engines would be determined during a preliminary/predesign phase when and if the City opted to proceed with a cogeneration upgrade project.

More recently, the City of Salem has begun accepting a variety of hauled wastes at the WLWPCF and would like to explore expanding these practices or alternatives to existing practices to maximize the beneficial use of these waste streams (generation of electricity and heat) and increase the revenue stream associated with accepting these hauled wastes. Additionally, the City would like to evaluate their service area for additional waste streams such as fats, oils, and grease (FOG)/brown grease or other high-strength wastes that could be introduced into their process trains. The WLWPCF has excess capacity in both its liquids and solids train, so an evaluation and categorization of waste streams is required to determine how to realize the greatest beneficial use.

Scope

The scope of this study is divided into the following two phases:

- Phase 1: Characterize Hauled Wastes
- Phase 2: Determine Best Use of Hauled Waste Streams at the WWTP

The work presented in this technical memorandum summarizes only the efforts conducted associated with Phase 1. It is assumed that under the Phase 2 effort (if the city were to proceed with Phase 2), evaluations of cogeneration would assume the use of ICE technology (i.e., other biogas utilization technologies, such as microturbines fuel cells would not be re-evaluated further).

Objectives of Hauled Waste Characterization Memorandum

The objective of this memorandum is to summarize the existing hauled waste sources that are currently accepted at the plant, characterize the quantity of waste streams, such as FOG or other wastes that may be available in the Willow Lake service area, and to recommend a path forward for further evaluation of the beneficial use of these waste streams at the plant. In addition, this memorandum will provide an initial basis for sizing a potential future hauled waste receiving station. After the City has reviewed of this information, the City will then decide if and when to proceed with the second phase of the study.

Existing Hauled Waste Streams

The Willow Lake WPCF currently accepts hauled wastes from various sources, including septage, leachate from municipal solid waste landfills, municipal biosolids from other wastewater utilities in the region, and other industrial waste streams.

Leachate

Leachate from Coffin Butte (Corvallis) and Riverbend (McMinnville) landfills are accepted at WLWPCF via hauled tanker trucks. Leachate is received at the float bays and is either pumped or flows by gravity to the influent pump station downstream of the barscreen sampler intake. The volume of leachate varies significantly based on precipitation rates, with daily discharge rates varying from as high as 80,000 gallons per day (gpd) in wet winter months and down to zero during the summer. The Coffin Butte landfill has historically discharged a base flow of approximately 6,500 gpd or one truck per day, while Riverbend seems to be much more seasonal and weather dependent.

Leachate typically has a fairly high chemical oxidation demand (COD) concentration (approximately 5,000 to 10,000 mg/L) and a low total suspended solids (TSS) concentration (approximately 25 milligrams per liter [mg/L]) with a pH ranging between 7.5 and 8. Table 1 summarizes the existing leachate flow streams that are accepted at the plant.

TABLE 1
Leachate Summary

	Minimum	Average	Maximum
Coffin Butte			
BOD5, mg/L	762	1357	2,490
COD, mg/L	2,670	5,664	13,000
pH, pH units	7.20	7.70	7.98
TSS, mg/L	22	60	140
Riverbend			
BOD5, mg/L	380	1,350	2,320
COD, mg/L	3,870	5,010	6,150

TABLE 1
Leachate Summary

pH, pH units	7.57	7.91	8.25
TSS, mg/L	26	47	67

Notes:

BOD5 = biochemical oxygen demand
COD = chemical oxygen demand

mg/L = milligrams per liter
TSS = total suspended solids

Municipal Biosolids

WLWPCF has historically accepted municipal sludge from other wastewater treatment plants that are constructing new solids processing facilities or are having temporary emergency situations that are preventing regular solids processing. Municipal biosolids are received at the north primary scum pit and pumped directly into the digesters. In 2013, the plant has been accepting sludge from the City of Aurora, Silverton, and Wilsonville WWTPs. Aurora began hauling lagoon-stabilized solids to the plant in March 2013 and is expected to continue indefinitely. The Wilsonville WWTP is currently under construction until the end of 2013, at which point they will resume solids processing and will discontinue hauling thickened waste activated sludge (TWAS) to Willow Lake. Silverton discontinued hauling TWAS to Willow Lake in March 2013. The City has had discussions with both the Cities of Albany and Hubbard about accepting their municipal biosolids, but no hauling has started to date. Table 2 summarizes the flows and loads for the municipal biosolids received at the plant in 2013. While this material has good potential for biogas production, the temporary nature of most of the arrangements does not lend itself to being a reliable digester feed stream.

TABLE 2
Municipal Solids Summary

	Minimum	Average	Maximum
City of Aurora – Waste Sludge			
TS, mg/L	17,400	17,400	17,400
VS, mg/L	14,700	14,700	14,700
Silverton WWTP			
TS, mg/L	1,080	24,075	85,300
VS, mg/L	828	18,585	57,200
Wilsonville WWTP			
TS, mg/L	5,131	43,573	53,500
VS, mg/L	4,153	36,094	49,700

Notes:

mg/L = milligrams per liter
TS = total solids
VS = volatile solids

WWTP = wastewater treatment plant

Industrial Waste Streams

The City of Salem also runs an Industrial Pretreatment Program for approximately 14 industrial dischargers to the Willow Lake collection system (see summary of wastes discharged to the City's sanitary sewer in Table 3). These

industrial users are mostly food processing companies, but also include a solar manufacturer and a biodiesel refinery. Historical discussions with these companies indicate that, for the most part, there is not significant opportunity for additional hauled waste streams or to convert their discharge stream to a hauled waste stream. One exception is Sequential Biofuels, which is currently hauling waste cola from the biodiesel refining process to the WLWPCF, where it is fed into the liquids process stream (similar to the landfill leachate).

TABLE 3
Industrial Waste Summary

Industry	Flow, Avg mgd	Avg BODs, lbs/month	Avg TSS, lbs/month
Kerr	1.548	17,753	7,660
Kettle Foods	2.335	35,216	21,998
Meduri Farms	0.508	27,950	3,378
Norpac	8.378	69,800	20,255
Oregon Cherry	5.146	93,431	2,961
Oregon Fruit	0.518	7,392	394
Rainsweet East	0.886	3,938	2,701
Rainsweet West	0.298	482	219
Sanyo[a]	5.507	7,509	12,694
Sequential Biodiesel	0.028	6,206	2,690
Truitt Brothers	4.860	9,422	8,263
Truitt Special Products	1.408	9,489	4,090
Ventura	0.244	1,004	629
Yamasa	1.315	35,686	10,415
Industrial Totals	**33**[b]	**325,300**[c]	**98,300**[c]

[a]Solar Manufacturer
[b]Rounded to the nearest mgd
[c]Rounded to the nearest hundred

Notes:
mg/L = milligrams per liter
BOD = biochemical oxygen demand
TSS = total suspended solids

Potential Hauled Waste Streams

CH2M HILL evaluated additional waste streams in the WLWPCF service area that could be introduced into either the liquids or solids waste stream to increase biogas production while increasing tipping fee revenue.

Fats, Oils, and Grease

FOG, or brown grease, is collected from restaurant and institutional grease interceptors, collection system cleanouts, and some industrial food production facilities. It has high-energy content and co-digests easily in municipal sludge anaerobic digesters to produce methane, which can be used to fuel cogeneration systems.

According to a survey conducted by the National Renewable Energy Laboratory (NREL) in 1998, in communities requiring grease traps, the average amount of FOG collected is 13.4 pounds per person. Using this per capita FOG generation rate, restaurants within the City of Salem could generate 2.09 million pounds of FOG annually, based

on its population of approximately 156,000. CH2M HILL has found that this NREL estimate often understates the quantity of FOG produced by a community, so determining local information about the availability of FOG is essential.

To estimate the volume of FOG that is actually being collected in Salem, CH2M HILL contacted FOG haulers or pumpers that are part of the Preferred Pumper Program (PPP) formed by municipal wastewater utilities in the Portland metro area. Most of these haulers also operate in the Salem area and throughout Oregon, Washington, and Northern California. Because the WLWPCF is close to the I-5 trucking corridor, it was assumed that many of these haulers might be interested in discharging FOG at the plant to minimize trucking and disposal costs. The 12 FOG pumpers in the PPP were contacted by phone; responses from seven were collected. Table 4 summarizes the results of this phone survey.

TABLE 4
Waste Hauler Survey Summary

Company	Service area	Total FOG (gal/month)	Salem Area FOG (gal/month)	Interest in Salem FOG Receiving Station?
A-Affordable Septic Service	Salem, Amity, Gresham, Grand Ron, Troutdale, St. Paul, Damascus, Forest Grove, as far south as Jefferson.	1300 to 1700	A couple contracts	Cost Dependent
Baker Commodities	Portland metro to the CA border	450,000	Unknown	Yes
Cloudburst Recycling	Portland and surrounding area	Unknown	None	Maybe
Darling International	Longview to Eugene	150,000	Unknown	Yes
Encore Oils	Eugene to Bellingham out to The Dalles and to the coast	50,000 to 100,000	Unknown	Maybe
Liquid Environmental Solutions	OR, WA, Northern CA	50,000 to 75,000	20,000 to 30,000	Yes
River City Environmental	OR, WA, Northern CA	300,000	40,000	Yes
Oregon Oil	Portland metro, north to Olympia, east to The Dalles, west to the coast, south to Eugene	unknown	unknown	Cost Dependent
Total		**1,000,000 – 1,080,000**	**60,000 – 70,000**	
Gresham[a]		-	180,000 – 240,000	
CWS[b]		-	200,000 – 270,000	

[a]Average collection rate of existing system.

[b]Design basis for FOG receiving station. Based on estimates from CWS FOG Study (Kennedy/Jenks Consultants, 2011).

Notes:

BOD = biochemical oxygen demand
CWS = Clean Water Services
mg/L = milligrams per liter
TSS = total suspended solids

Table 4 shows that there is a significant amount of FOG being collected in the Northwest and a fair amount in the Salem service area. Many of the haulers take their loads to Tillamook to a cow manure digester or to the Gresham WWTP, so they were interested in reducing their haul distance and discharging at Willow Lake. The main concern expressed by the haulers was disposal fee, with many agreeing that 6 to 8 cents per gallon was a reasonable

tipping fee. The City of Salem charges 3 cents a gallon for leachate and would intend to charge the same for FOG, unless City Council approves a different rate.

A secondary concern was the flexibility of receiving station operation; many haulers prefer to operate at night or on weekends when traffic is light and odors from pumping out interceptors would not be noticed by the public. They also wanted a consistent disposal site that has enough receiving capacity so that their trucks would not be turned away due to full tanks at the receiving station.

When evaluating whether to implement a FOG receiving station at WLWPCF, the City of Salem should also consider that other municipal wastewater utilities are also looking to collect FOG for biogas production, and the market could become saturated. The City of Gresham is in the process of expanding its receiving facility to address some of the concerns expressed by the FOG haulers. Clean Water Services will begin construction of a large FOG-receiving facility and cogeneration project in August 2013. MWMC is also studying FOG availability in their service area.

Other Investigations/Programs

A brief summary of several of the other wastewater utilities in Oregon who have evaluated or are currently evaluating supplemental waste injection into anaerobic digesters to generate more biogas is presented in this section.

City of Gresham

The City of Gresham completed a FOG study in 2009 (CH2M HILL, 2009) that evaluated the feasibility of injecting FOG and food waste into their digester to boost digester gas production and maximize the output of their cogeneration system. The study evaluated the capacity of the digestion system, performed a market analysis to determine the availability of FOG, food waste, dairy waste and other industrial waste streams. The City used this information to perform a financial analysis that evaluated the revenue and costs of constructing and maintaining these systems, taking potential Business Energy Tax Credit (BETC) and Energy Trust grant incentives into account. The study concluded that the City could reasonably expect to capture 7,000 to 11,000 gpd of the FOG available in their service area and the Portland metropolitan area. The City is implementing a two-phase approach in which a pilot FOG receiving station be constructed to verify the availability, strength, and handling characteristics of the waste streams as well as document the increased biogas production. If this project proved successful, the City would have sufficient information to design and construct a larger cogeneration system.

The City moved forward with the construction of the pilot FOG receiving station and has been operating the system since fall 2012. To secure a base load of FOG for the system, the City issued an RFP to local FOG haulers to deliver their loads to the plant at a contracted price of $0.08/gal. Three haulers; ProPump, Liquid Environmental Services, and River City Environmental, were selected and have been delivering FOG since 2012. On average, the plant has seen an approximate 55 percent increase in biogas production since introducing FOG.

Gresham has had some challenges in operating the receiving station. The FOG receiving station currently has a single 11,000-gallon storage tank, which limits the amount of FOG that can be handled. They have recently completed a design and bid a project to double the capacity of the storage. They have struggled to manage the haulers; there is a high turnover rate of the drivers, which necessitates constant retraining. The station only receives FOG from 6:00 a.m. to 3:00 p.m., about which all three haulers have complained because they often clean grease traps in the early morning and would like to be able to immediately offload their trucks. Gresham is investigating a key card system to help alleviate this problem. Operations staff sample the storage tanks once per day for TS, VS, and pH and, in general, have found that the loads are watered down (2 to 3 percent average TS compared to the anticipated 6 percent) and slightly more acidic than expected. The low pH has caused some corrosion problems on their grinder screen so the manufacturer is replacing screen with stainless steel parts.

On the whole, the City has been fairly pleased with the implementation of a FOG receiving station and the associated increase in biogas production. They are continually looking for new sources of FOG and other liquid food wastes to bring into the plant.

Clean Water Services

Clean Water Services completed a FOG study in 2011 (Kennedy/Jenks Consultants, 2011). This study evaluated the potential FOG generated at food service establishments (FSEs) in Washington County to understand the overall availability in their Durham and Rock Creek service areas. They first developed a database of the FSEs and categorized them as low, medium, high, or very high grease producing facilities based on the experience of the District's source control staff, available pumping records, and annual sales volume. After the preliminary classifications were assigned, a select group of facilities was identified for FOG sampling. These facilities were selected to provide a range of very high, high, medium, and low FOG-producing facilities in the sampling program. Brown grease samples were collected from the inlet bays of commercial grease interceptors at 53 establishments and were analyzed for COD, total solids, and volatile solids in the District's Water Quality Laboratory. Based on the sampling results, the preliminary FSE classification of very high, high, medium, and low producing facilities was adjusted to reflect actual results, and grease production rates for each category were established. By applying these rates to the FSE database, it was estimated that the anticipated level of grease production for all facilities in the service area ranged from 8,200 lbs/day to 19,300 lbs/day, with an average production rate of 13,000 lbs/day. At 97.1 percent volatile solids, this equates to 12,600 lbs/day VS. The average concentration of total solids pumped from interceptors in the District's service area is conservatively estimated at 9.4 percent based on only the contents of the inlet bay, or 7 percent based on the total interceptor volume. Based on 7 percent TS, approximately 22,700 gpd of brown grease is produced in Washington County FSEs.

This study helped CWS decide to proceed with a schematic design of a FOG receiving station and cogeneration project at Durham. As part of the schematic design report, several scenarios were evaluated to estimate the potential biogas production that could be achieved if different percentages of the total available FOG were received at Durham. These scenarios included 25 percent of available FOG, FOG up to digester capacity, and FOG up to engine capacity. In the end, it was determined that the Durham plant could reasonably receive 25 percent of the FOG available, and used that as the basis for the design of the system.

The design of this system has recently been completed and construction will begin in summer 2013. This design includes two 37,500-gallon concrete FOG receiving/storage tanks, two 850-kW cogeneration engines, a 25,000-cubic-foot gas storage bubble, and a variety of other improvements.

MWMC

The Metropolitan Wastewater Management Commission (MWMC) is the wastewater utility for the communities of Eugene and Springfield in Lane County 66 miles south of Salem. They are in the process of conducting a study similar to this study although they have limited their effort to only FOG for direct injection into their digesters and are not assessing the broader hauled waste category.

Industrial/Commercial Streams

The City of Salem evaluated other potential new industrial or commercial waste streams that could be hauled to the plant including local breweries and wineries. It was found that brewery waste streams are currently sold for use as feed for livestock and there was little enthusiasm for paying for disposal. Wineries have high BOD waste streams during harvest and crushing, but this only occurs during September and October, and most wineries already had treatment systems installed for handling this waste stream. Waste solids such as grape skins, stems, and seeds are typically composted onsite and are used for fertilization of vineyards.

In the past, City of Salem staff has had discussions with Kettle Foods about hauling dissolved air floatation (DAF) solids from potato chip processing to WLWPCF, but Kettle Foods officials did not seem to be particularly interested and it was not pursued further. Norpac has also expressed interest in having the City take expired or damaged canned vegetables, but it was determined that removing the organic materials from the cans and then disposing of the empty cans would be a difficult and cost prohibitive process.

The City has also had discussions with BrucePak, a meat packing facility, about receiving emulsified fat from chicken, pork, and beef products that is blended and thickened to 10 percent in gravity float thickeners. Ultimately, due to concerns about odor from putrified meat products, potential pollutants of emerging concern

(steroids and bovine spongiform encephalopathy [BSE], commonly known as mad cow disease), and handling issues of the product, the City decided not to pursue this waste stream further.

In general, it seemed that most industrial or commercial producers already have mechanisms in place for processing, recycling, or disposing of their waste streams. There is limited potential for expansion of hauled waste from these producers; however, the City should remain open for future discussions with these entities as their processes and waste streams evolve.

Preliminary Estimates of Biogas Production and Electrical Power Generation from Identified FOG Sources

Existing Cogeneration System

The City has an existing cogeneration system that uses a 650-kW Wakesha 510GL engine that was installed in 1988. The unit uses approximately 240,000 standard cubic feet per day (scfd) of digester gas and has an average uptime of 75 to 95 percent depending on annual maintenance requirements. The WLWPCP had an average digester gas production rate of 317,000 scfd from the anaerobic digesters (Carollo, 2009).

Potential Biogas Production from FOG

Assuming that the City could capture all of the FOG available in their service area and 10 to 15 percent of the total FOG that is hauled in Oregon, it is estimated that 5,000 to 8,000 gallons per day of FOG could potentially be received at WLWPCF. The plant's location along the I-5 corridor makes it an ideal location to capture a large portion of the FOG being hauled from Northern California and Southern Oregon. The combination of primary sludge and thickened waste activated sludge digested at a typical municipal wastewater treatment facility produces approximately 15 standard cubic feet (scf) of digester gas per pound of volatile solids removed. FOG produces approximately 24 scf of digester gas per pound of volatile solids removed. Table 5 shows that approximately 45,000 to 72,000 scf/day of additional biogas could be produced from this amount of FOG.

TABLE 5
Estimated Biogas Production at WLWPCP

FOG (gal/day)	5,000	8,000
TS (mg/L)	50,000	50,000
VS %	95%	95%
VS (ppd)	1,980	3,169
VSR (FOG)	95%	95%
DG Production (scf/lb VS)	24	24
DG Production (scf/day)	45,000	72,000

Conclusions and Path Forward

A variety of hauled wastes were evaluated as part of this study, but it appears that FOG is the only waste stream that could provide enough value to warrant further examination. Although the City has relationships with various commercial and industrial facilities through their IPP program, most producers already have mechanisms in place for processing, recycling, or disposing of their waste streams. It is estimated that 5,000 to 8,000 gpd of FOG could be received at the plant, boosting the biogas output by up to 72,000 scf/day. Based on lessons learned from Gresham, a FOG receiving station should include storage tanks that are at least twice the volume of the expected daily receiving rate. For WLWPCP this would equate to a 10,000 to 16,000 gallons of storage volume.

To fully understand the impact of receiving FOG at WLWPCP, a process model of the plant should be developed to evaluate the impact of injecting hauled waste streams into the anaerobic digesters and develop an approach for utilization of biogas using internal combustion engines. This would assist the City in understanding capacity limitations of existing equipment and support systems, as well as impact on the operation and maintenance of

these systems. Because the existing cogeneration equipment is nearing the end of its useful life, it may be useful to evaluate cogeneration options to determine the optimal approach in terms of number and size of units based on expected biogas production. Gas cleaning and electrical system upgrade requirements for cogeneration should also be evaluated.

In addition, an economic model should be developed to determine the financial viability of a FOG receiving program. This would include a life cycle return on investment or payback evaluation, including the capital costs of the receiving station, cogeneration upgrades, gas cleaning upgrades, and electrical upgrade; annual operation and maintenance costs; and non-monetary factors. This effort should also include an evaluation of the potential risks of changes or competition for the FOG supply, variability in tipping fees, and opportunities to increase access to FOG through the use of City ordinances regarding the sizing and use of grease traps/interceptors. The implementation of a Preferred Pumper type program should also be considered to better ensure quality of the waste streams and to increase coordination with waste haulers.

Works Cited

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