Memorandum

BURNS McDONNELL

Date: September 23, 2019

To: Mr. Christian Johanningmeier, PE, Columbia, MO

From: Brian Weis, PE, Burns & McDonnell
Scott Martin, PE, Burns & McDonnell

Subject: Preliminary Feasibility Study – Columbia Landfill
Biogas to Renewable Natural Gas Upgrade Project

09/23/19 2:09 PM

Introduction

Columbia Water & Light ("City") operates a Landfill Gas to Electricity Plant at the Columbia, Missouri Sanitary Landfill (Landfill). The purpose of this preliminary study is to determine if using landfill gas (LFG) to produce Renewable Natural Gas (RNG) is economically viable and if further study should be performed to analyze if RNG is a more economical use of LFG, when compared to electricity generation from the current Landfill Gas to Electricity Plant. The RNG would potentially be used as transportation fuel as part of the United States Environmental Protection Agency's (EPA's) Renewable Fuel Standards (RFS) Program, by injection into a local utility pipeline or by an onsite compressed natural gas (CNG) fueling station, or by both methods in a phased program approach. Upgrading LFG to RNG has potential to generate considerable revenue from multiple streams but will require investment in new infrastructure and ongoing operating costs, as described herein. The City's raw LFG consists of approximately 45 to 50% methane and contains many other undesirable constituents (typical of industry LFG quality) whereas pipeline-quality natural gas is approximately 95 to 98% methane and is largely free of impurities.

LFG to RNG Processing

Several process technologies have the potential to upgrade the City's raw LFG to RNG quality. Each technology has varying costs, advantages, and disadvantages. Burns & McDonnell consulted with Greenlane Biogas North America, Ltd. (Greenlane), a provider of biogas to RNG upgrading systems, to obtain pricing for a suitable LFG to RNG processing system. Greenlane has over 100 biogas upgrading system installations around the world using various upgrading technologies. Greenlane's Water Wash RNG processing technology supplemented with additional nitrogen and oxygen removal was specified by Greenlane based on inlet LFG characteristics provided by Burns & McDonnell. One benefit of the Water Wash process is removal of hydrogen sulfide, volatile organic compounds, and siloxanes without supplemental treatment equipment. The processing equipment is designed and delivered to site mounted on a series of skids. The skid sizes and arrangement on the site will be determined in later design development phases. A conceptual process flow diagram of the Water Wash treatment process is provided in Figure 1.

The RNG processing system requires managing a low-methane and high carbon dioxide tail gas stream. Burns & McDonnell assumed that thermal destruction of the tail gas stream would be required by the MDNR, and accordingly included costs for a thermal oxidizer.

Concept Plant Site and Pipeline

The RNG processing facility (Plant) has been conceptually located west of, and in general proximity to, the existing LFG to Electricity Plant to afford efficiencies with interconnecting to the existing LFG collection system and utilities. Figure 2 shows a potential location of the RNG Plant on the Landfill site. The Plant would consist of those process components shown in the Concept RNG Plant Site (dashed) boundary on Figure 1.

After processing, the gas is routed to a compressor station at the Plant which compresses the gas through an electrically driven reciprocating compressor to approximately 900 pounds per square inch (psi). Subsequently, the gas is routed to a metering station, where it is analyzed to ensure compliance with the end user natural gas company specifications. If the gas meets specifications, it is conveyed offsite via pipeline, otherwise it is diverted and recirculated for further processing. The RNG will be conveyed through a new City-owned pipeline to a local transmission or distribution pipeline owned by a natural gas company. Outlet flow of RNG from facility is assumed to be approximately 800 scfm based on upstream raw LFG characteristics, projected LFG flowrates, and typical water wash system performance.

Two preliminary pipeline options, shown in Figure 3, were considered in this study. The preliminary routes were developed to minimize land acquisition, with installation occurring within public roadways and previously established access road right-of-ways, where practicable.

Option 1 Pipeline Route: Downstream of the Plant site, the proposed 4-inch pipeline will be routed west past Route B to complete a tie-in with an existing 6-inch Panhandle Eastern (Panhandle) transmission lateral or an Ameren distribution pipeline branching off the Panhandle lateral, located approximately 3.2 miles west of the RNG processing facility. This pipeline route would involve open trench, auger bore and horizontal directional drilling (HDD) bore techniques for installation and required feature crossings. Approximately two (2) auger bores and two (2) HDD bores are assumed for this pipeline option.

Option 2 Pipeline Route: Downstream of the Plant site, the proposed 4-inch pipeline will be routed west, then north along Route B and other public roads to complete a tie-in with the existing 30-inch Panhandle trunk line approximately 8.4 miles north of the RNG processing facility. This pipeline route would involve open trench, auger bore and horizontal directional drilling (HDD) bore techniques for installation and required feature crossings. Approximately eight (8) auger bores and two (2) HDD bores are assumed for this pipeline option.

Further analysis regarding the best pipeline route and connection option is beyond the scope of this study and will require discussions and negotiations with the respective natural gas pipeline companies. Other pipeline connection options may be determined feasible by further analysis, including an Ameren branch pipeline located at the nearby Columbia Energy Center.

Financial Analysis

The following sections summarize capital costs, annual operational costs, and the annual operating revenue, the primary components of a preliminary 10-year pro forma developed for the project. It should be noted that numerous assumptions and variables were used to develop the financial information presented herein. Given the early stage of the concept development, the financial analysis presented herein should be considered as a preliminary order of magnitude assessment.

Capital Costs

Estimated costs for a typical RNG processing skid were provided by Greenlane. Burns & McDonnell's construction design-build estimators prepared opinions of probable construction costs for the new City pipeline, other components of the system, and the balance of plant construction. Indirect costs were also applied as a percent of the construction costs as shown in Table 1 below. Due to several components of the system that could vary greatly depending on several factors that have yet to be determined, a low-end estimate and a high-end estimate are presented in Table 1. For example, the low estimate assumes pipeline Option 1 while the high estimate assumes pipeline Option 2. The low and high cost values presented should not be viewed as a range but rather two distinct scenarios, both with a +/- 50% cost confidence, as typical for this level of project definition.

Table 1: Capital Cost Opinion

	Low	High
Greenlane Water Wash Biogas Upgrading System	$2,295,000	$2,295,000
Nitrogen Reduction Unit	$1,000,000	$3,650,000
De-Oxygenation Catalyst	$500,000	$995,000
Regenerative Thermal Oxidizer	$195,000	$195,000
Compressor Station, Meter Station & Pipeline	$6,361,000	$11,263,000
Balance of Plant	$1,956,000	$1,956,000
Idle LFGtE Facility	$50,000	$50,000
Estimated Construction Costs	**$12,357,000**	**$20,404,000**
Startup (2.5%)	$308,925	$510,100
Engineering (10%)	$1,235,700	$2,040,400
Construction Management (12%)	$1,482,840	$2,448,480
Contingency (10% Low, 30% High)	$1,235,700	$6,121,200
Estimated Capital Costs	**$16,620,165**	**$31,524,180**

For the purpose of this study, capital costs are assumed to be incurred in the year 2021.

Operating Costs

Operating costs include Plant labor, purchase of raw landfill gas from the City's landfill, utilities, Plant maintenance costs, pipeline tariff, and professional services associated with Renewable Identification Numbers (RINs) accountancy. Operating costs have been estimated at just over $1M per year starting in year 2022 and trends upward approximately with inflation.

Operating Revenue

The City's estimated operating revenue for this project consists of three streams including the sale of the gas commodity itself to the natural gas pipeline owner, the sale of RINs associated with the RNG (as part of the RFS program), and the state-specific credits associated with the use of the RNG as a transportation fuel. In this study the RNG is assumed to be used as a transportation fuel in California with revenue realized through the California Low Carbon Fuel Standard (LCFS). A brief background description of the RFS and LCFS programs are provided below:

- The Renewable Fuel Standard (RFS): The RFS is a federal program administered by the United States Environmental Protection Agency (EPA) that requires a certain volume of renewable fuel to replace or reduce the quantity of petroleum-based transportation fuel. EPA uses Renewable Identification Numbers (RINs) to track renewable transportation fuels. The RIN is attached to the physical gallon of renewable fuel as it is transferred to a fuel blender. Landfill gas is considered a cellulosic biofuel under this program.
- The California low-carbon fuel standard (LCFS): The LCFS is a program administered by the California Air Resources Board (CARB) to reduce greenhouse gas emissions in transportation fuels. Landfill gas produced at the facility qualifies as an eligible source provided it is used as a transportation fuel in California.

The projected annual revenue in year one of operation (assumed to be 2022) is estimated at $5.4M and remains somewhat constant assuming no change in current market prices. The market prices for these revenue streams over the last 2 years are provided in tabular form in Attachment 1. A breakdown of the year one projected amount by revenue stream is given below.

- Sale of Gas: $700K
- Sale of RINs: $2.4M
- LCFS Credits: $2.3M

These revenue projections are directly tied to the LFG quantities produced by the existing landfill and the future landfill that is planned by the City. Estimated gas production data is provided in Attachment 2. Waste reduction policies implemented by the City in the coming years are not likely to significantly reduce the gas produced during the 10-year project analysis period, given the decomposition time of waste in anaerobic conditions.

Preliminary Pro Forma

Using the values described above projected over a 10-year period, Burns & McDonnell developed a simple economic model that allows consideration of various cost and price point variables. Tables 2 and 3 below show the net cash flow for the "Low" Capital Cost Scenario and the "High" Capital Cost Scenario, respectively with RIN and LCFS credit prices at approximately current rates. The current price for RINs is close to the 2-year minimum value, while the LCFS credits are close to the 2-year maximum values. Several other variables are assumed, many of which are shown as input values in the tables (blue text).

Table 2: "Low" Capital Cost Scenario Project Cash Flow

			2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
Capital Cost Opinion			Low / High										
Greenlane Water Wash Biogas Upgrading System			$2,295,000 $2,295,000										
Nitrogen Reduction Unit			$1,000,000 $3,650,000										
De-Oxygenation Catalyst			$500,000 $995,000										
Regenerative Thermal Oxidizer			$195,000 $195,000										
Compressor Station, Meter Station & Pipeline			$6,361,000 $11,263,000										
Balance of Plant			$1,956,000 $1,956,000										
Idle LFGtE Facility			$50,000 $50,000										
Startup (2.5%)			$308,925 $510,100										
Engineering (10%)			$1,235,700 $2,040,400										
Construction Management (12%)			$1,482,840 $2,448,480										
Contingency (10% Low, 30% High)			$1,235,700 $6,121,200										
Total Capital Costs			$16,620,165 $31,524,180										
Operating Costs			(Input Values)										
Utilities:													
Electric				$309,557	$317,296	$325,228	$333,359	$341,693	$350,235	$358,991	$367,966	$377,165	$386,594
Water				$31,065	$31,841	$32,637	$33,453	$34,289	$35,147	$36,025	$36,926	$37,849	$38,795
Sewer	4,000,000	gallons per year		$14,659	$13,636	$13,636	$13,636	$13,636	$13,636	$13,636	$13,636	$13,636	$13,636
Labor - Fully Burdened	$152,000			$152,000	$155,800	$159,695	$163,687	$167,780	$171,974	$176,273	$180,680	$185,197	$189,827
Air Compliance				$15,000	$0		$0	$0	$11,314	$0	$0	$0	$0
Attestations / QAP Services				$48,375	$49,500	$50,625	$51,750	$52,875	$54,000	$55,125	$56,250	$57,375	$58,500
Maintenance / Consumables:				$25,300	$25,933	$26,581	$27,245	$86,539	$28,625	$29,340	$30,074	$30,826	$97,911
Pipeline Tariff	$1.00	$/mcf		$265,838	$269,292	$272,343	$275,038	$277,416	$279,514	$281,365	$282,996	$284,434	$285,699
Landfill Gas Purchase		Based on current cost		$189,953	$194,370	$198,788	$203,205	$207,623	$212,040	$216,458	$220,875	$225,293	$229,710
Total Operating Expenses				$1,051,746	$1,057,668	$1,079,533	$1,101,374	$1,181,851	$1,156,485	$1,167,214	$1,189,404	$1,211,775	$1,300,673
Operating Revenue													
Gas Sale Price (NYMEX Henry Hub Futures Price)	2%	Discount to HH		$2.44	$2.50	$2.59	$2.68	$2.78	$2.91	$3.06	$3.18	$3.29	$3.41
NG Revenue				$696,497	$723,941	$758,077	$790,103	$829,239	$872,912	$923,372	$964,756	$1,005,470	$1,046,619
RINs	Min	$0.65		$2,392,353	$2,423,437	$2,450,895	$2,475,142	$2,496,545	$2,515,430	$2,532,085	$2,546,766	$2,559,701	$2,571,089
	0.0%	Annual Increase											
LCFS Price	Max	$193.80		$2,320,649	$2,277,492	$2,228,560	$2,175,735	$2,119,029	$2,058,354	$1,995,388	$1,929,919	$1,862,290	$1,792,174
	0.0%	Annual Increase											
Total Revenue				$5,409,502	$5,424,872	$5,437,534	$5,440,983	$5,444,816	$5,446,699	$5,450,848	$5,441,444	$5,427,464	$5,409,885
Total Project Cash Flow													
Upfront Capital Costs	Low		($16,620,165)										
Operating Expenses				($1,051,746)	($1,057,668)	($1,079,533)	($1,101,374)	($1,181,851)	($1,156,485)	($1,167,214)	($1,189,404)	($1,211,775)	($1,300,673)
Total Revenues				$5,409,502	$5,424,872	$5,437,534	$5,440,983	$5,444,816	$5,446,699	$5,450,848	$5,441,444	$5,427,464	$5,409,885
Net Cash Flow			($16,620,165)	$4,357,755	$4,367,204	$4,358,001	$4,339,609	$4,262,965	$4,290,214	$4,283,634	$4,252,041	$4,215,690	$4,109,212
Total Net Cash Flow			($16,620,165)	$4,357,755	$4,367,204	$4,358,001	$4,339,609	$4,262,965	$4,290,214	$4,283,634	$4,252,041	$4,215,690	$4,109,212
Discounted Cash Flow	4%		($16,620,165)	$4,190,149	$4,037,726	$3,874,247	$3,709,516	$3,503,847	$3,390,618	$3,255,210	$3,106,925	$2,961,888	$2,776,036
Cumulate Cash Flow (non-discounted)			**($16,620,165)**	**($12,262,410)**	**($7,895,205)**	**($3,537,204)**	**$802,405**	**$5,065,370**	**$9,355,584**	**$13,639,218**	**$17,891,258**	**$22,106,948**	**$26,216,160**

Table 3: "High" Capital Cost Scenario Project Cash Flow

			2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
Capital Cost Opinion			Low / High										
Greenlane Water Wash Biogas Upgrading System			$2,295,000 $2,295,000										
Nitrogen Reduction Unit			$1,000,000 $3,650,000										
De-Oxygenation Catalyst			$500,000 $995,000										
Regenerative Thermal Oxidizer			$195,000 $195,000										
Compressor Station, Meter Station & Pipeline			$6,361,000 $11,263,000										
Balance of Plant			$1,956,000 $1,956,000										
Idle LFGtE Facility			$50,000 $50,000										
Startup (2.5%)			$308,925 $510,100										
Engineering (10%)			$1,235,700 $2,040,400										
Construction Management (12%)			$1,482,840 $2,448,480										
Contingency (10% Low, 30% High)			$1,235,700 $6,121,200										
Total Capital Costs			$16,620,165 $31,524,180										
Operating Costs			(Input Values)										
Utilities:													
Electric				$309,557	$317,296	$325,228	$333,359	$341,693	$350,235	$358,991	$367,966	$377,165	$386,594
Water				$31,065	$31,841	$32,637	$33,453	$34,289	$35,147	$36,025	$36,926	$37,849	$38,795
Sewer	4,000,000	gallons per year		$14,659	$13,636	$13,636	$13,636	$13,636	$13,636	$13,636	$13,636	$13,636	$13,636
Labor - Fully Burdened	$152,000			$152,000	$155,800	$159,695	$163,687	$167,780	$171,974	$176,273	$180,680	$185,197	$189,827
Air Compliance				$15,000	$0		$0	$0	$11,314	$0	$0	$0	$0
Attestations / QAP Services				$48,375	$49,500	$50,625	$51,750	$52,875	$54,000	$55,125	$56,250	$57,375	$58,500
Maintenance / Consumables:				$25,300	$25,933	$26,581	$27,245	$86,539	$28,625	$29,340	$30,074	$30,826	$97,911
Pipeline Tariff	$1.00	$/mcf		$265,838	$269,292	$272,343	$275,038	$277,416	$279,514	$281,365	$282,996	$284,434	$285,699
Landfill Gas Purchase		Based on current cost		$189,953	$194,370	$198,788	$203,205	$207,623	$212,040	$216,458	$220,875	$225,293	$229,710
Total Operating Expenses				$1,051,746	$1,057,668	$1,079,533	$1,101,374	$1,181,851	$1,156,485	$1,167,214	$1,189,404	$1,211,775	$1,300,673
Operating Revenue													
Gas Sale Price (NYMEX Henry Hub Futures Price)	2%	Discount to HH		$2.44	$2.50	$2.59	$2.68	$2.78	$2.91	$3.06	$3.18	$3.29	$3.41
NG Revenue				$696,497	$723,941	$758,077	$790,103	$829,239	$872,912	$923,372	$964,756	$1,005,470	$1,046,619
RINs	Min	$0.65		$2,392,353	$2,423,437	$2,450,895	$2,475,142	$2,496,545	$2,515,430	$2,532,085	$2,546,766	$2,559,701	$2,571,089
	0.0%	Annual Increase											
LCFS Price	Max	$193.80		$2,320,649	$2,277,492	$2,228,560	$2,175,735	$2,119,029	$2,058,354	$1,995,388	$1,929,919	$1,862,290	$1,792,174
	0.0%	Annual Increase											
Total Revenue				$5,409,502	$5,424,872	$5,437,534	$5,440,983	$5,444,816	$5,446,699	$5,450,848	$5,441,444	$5,427,464	$5,409,885
Total Project Cash Flow													
Upfront Capital Costs	High		($31,524,180)										
Operating Expenses				($1,051,746)	($1,057,668)	($1,079,533)	($1,101,374)	($1,181,851)	($1,156,485)	($1,167,214)	($1,189,404)	($1,211,775)	($1,300,673)
Total Revenues				$5,409,502	$5,424,872	$5,437,534	$5,440,983	$5,444,816	$5,446,699	$5,450,848	$5,441,444	$5,427,464	$5,409,885
Net Cash Flow			($31,524,180)	$4,357,755	$4,367,204	$4,358,001	$4,339,609	$4,262,965	$4,290,214	$4,283,634	$4,252,041	$4,215,690	$4,109,212
Total Net Cash Flow			($31,524,180)	$4,357,755	$4,367,204	$4,358,001	$4,339,609	$4,262,965	$4,290,214	$4,283,634	$4,252,041	$4,215,690	$4,109,212
Discounted Cash Flow	4%		($31,524,180)	$4,190,149	$4,037,726	$3,874,247	$3,709,516	$3,503,847	$3,390,618	$3,255,210	$3,106,925	$2,961,888	$2,776,036
Cumulate Cash Flow (non-discounted)			**($31,524,180)**	**($27,166,425)**	**($22,799,220)**	**($18,441,219)**	**($14,101,610)**	**($9,838,645)**	**($5,548,431)**	**($1,264,797)**	**$2,987,243**	**$7,202,933**	**$11,312,145**

Tables 4 and 5 below show a simple payback matrix for the "Low" capital cost scenario and the "High" capital cost scenario, respectively. These tables are intended to demonstrate the degree of sensitivity of the project financial results to RIN values and LCFS credit values, key variables of the model. The maximum, minimum, median, and mean values indicated in the tables are based on the monthly prices over the last 2 years. Scenarios in which payback was not achieved in the 10-year duration of the model reflect a >10 value, indicating greater than 10 years. The shaded cells in Tables 4 and 5 below indicate the scenario shown in Tables 2 and 3 (respectively), with the RIN and LCFS credit price set at approximately current rates.

Table 4: Simple Payback Matrix ("Low" Capital Cost Scenario)

*values shown are in years to payback

		LCFS Credit Values				
		$193.80	$85.00	$170.00	$151.20	$0.00
RIN Values		2-Yr Max.	2-Yr Min.	2-Yr Median	2-Yr Mean	None
$2.70	2-year Max.	1.4	1.6	1.4	1.5	1.7
$0.65	2-year Min.	3.8	5.4	4.1	4.3	7.7
$2.25	2-year Median	1.6	1.8	1.7	1.7	2.1
$2.10	2-year Mean	1.7	2.0	1.8	1.8	2.2
$0.00	None	9.2	>10.0	>10.0	>10.0	>10.0

Table 5: Simple Payback Matrix ("High" Capital Cost Scenario)

*values shown are in years to payback

		LCFS Credit Values				
		$193.80	$85.00	$170.00	$151.20	$0.00
RIN Values		2-Yr Max.	2-Yr Min.	2-Yr Median	2-Yr Mean	None
$2.70	2-year Max.	2.6	2.9	2.7	2.7	3.2
$0.65	2-year Min.	7.3	>10.0	7.8	8.2	>10.0
$2.25	2-year Median	3.1	3.5	3.1	3.2	3.9
$2.10	2-year Mean	3.2	3.7	3.3	3.4	4.2
$0.00	None	>10.0	>10.0	>10.0	>10.0	>10.0

Summary and Recommendations

The preliminary pro forma indicates this project has potential to be financially beneficial for the City. At current rates, the "Low" capital cost scenario payback is less than 4 years and is under 8 years for the "High" capital cost scenario. As such, the project capital cost is a critical factor in the breakeven payback time period. At the current level of study, the concept design is uncertain, and many components require further evaluation. Further development of the design has the potential to reduce the construction capital cost estimates and applied contingency factors.

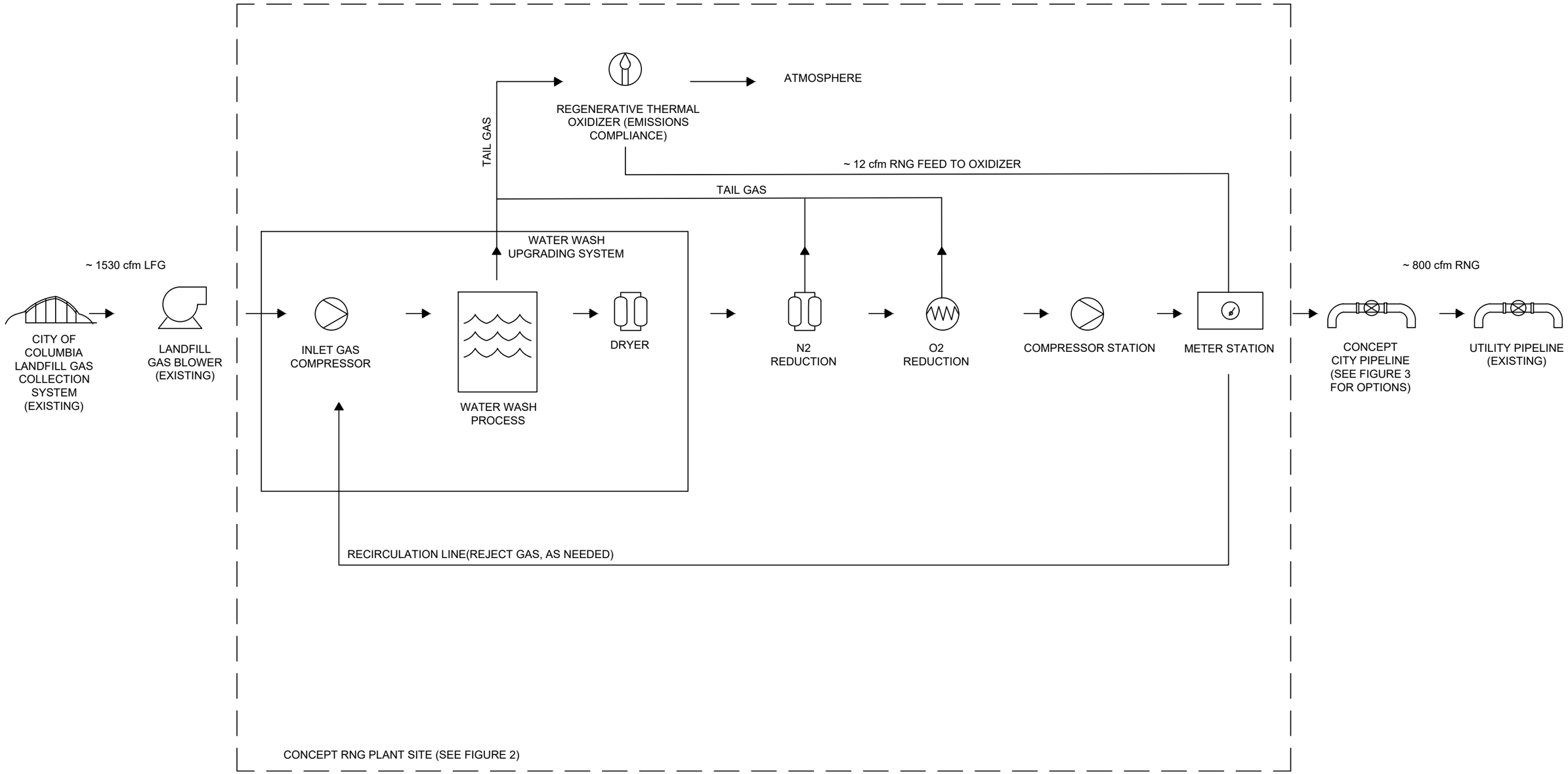
The revenue stream estimates are also critical to the preliminary financial analysis. The RFS administrative decisions made by the EPA have a significant impact on RIN prices. Recent indications are that the RFS program will be extended for several years, however as with most financial markets, RIN price futures remain uncertain. The California LCFS credit prices have been on a steady incline over the last two years and although no indications point to changes for the program, credit prices are likewise susceptible to impact by government policy and market forces. Natural gas is a widely used commodity for which demand appears stable in the near term while supply and pricing are susceptible to variation in market conditions.

It is recommended that the City advance the project with further evaluation. The following is recommended to be considered as part of further study:

- Pipeline routes: Evaluate feasibility of each route and consider other routes to alternate tie-in points. The City has indicated that a potential route along the railroad near the site could be a viable option at a considerably lower cost. Another potential connection point to consider may be at a 600 psi Ameren branch line at the Columbia Energy Center, a much closer tie-in point but unknown whether this is a logistically feasible tie-in location;
- Pipeline alternative: Develop a pro forma variation that examines the alternative of constructing an onsite CNG station. Missouri does not have a transportation fuel incentive program. Using the fuel in Missouri or other states without incentive programs removes the significant LCFS credit (or other potential state credit) revenue stream;
- Critically evaluate the need for ancillary equipment associated with the gas upgrading equipment, including the nitrogen reduction unit and the de-oxygenation catalyst that were specified as part of the water wash system;
- Consideration of gas upgrading technology alternatives to the water wash system;
- Further develop pro forma and evaluate factors driving market prices and market volatility for the various revenue streams;
- Financially compare potential RNG project to operation of the City's existing LFG to Energy Plant;
- The Oregon Department of Energy administers a similar program to the California LCFS program, gather details and evaluate the advantages and disadvantages of each;
- Consider how an Anaerobic Digester might improve gas quality and flow rates, potentially eliminating the need for other ancillary equipment.

*Burns & McDonnell's cost estimates, analyses, and recommendations presented in this study are based on our professional experience and judgment, as well as external sources and assumptions. The low and high cost values presented should not be viewed as a range but rather two distinct scenarios, both with a +/- 50% cost confidence as typical for this level of project definition. Burns & McDonnell does not guarantee that actual values or scenarios will not differ from those presented upon implementation. Further evaluation of certain information, assumptions, and scenarios is recommended.

FIGURES



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BURNS McDONNELL

Figure 1
PROCESS FLOW DIAGRAM
CONCEPT LFG TO RNG
UPGRADE PROJECT
COLUMBIA LANDFILL

RNG PIPELINE, SEE FIGURE 3
FOR CONTINUATION OPTIONS

HINKSON CREEK

CONCEPTUAL RNG
PLANT LOCATION

COLUMBIA LANDFILL

EXISTING LANDFILL GAS
TO ENERGY (LFGtE) PLANT

EXISTING BLOWER AND
FLARE FACILITY

LANDFILL SITE ENTRANCE

FM

840

790

770

LEGEND

- G — CONCEPT LANDFILL GAS
- GAS — CONCEPT PIPELINE
- E — CONCEPT ELECTRICAL LINE
- SS — CONCEPT EXISTING SANITARY SEWER
- W — CONCEPT WATER LINE
- SS — CONCEPT SANITARY SEWER LINE

N

0 100' 200'

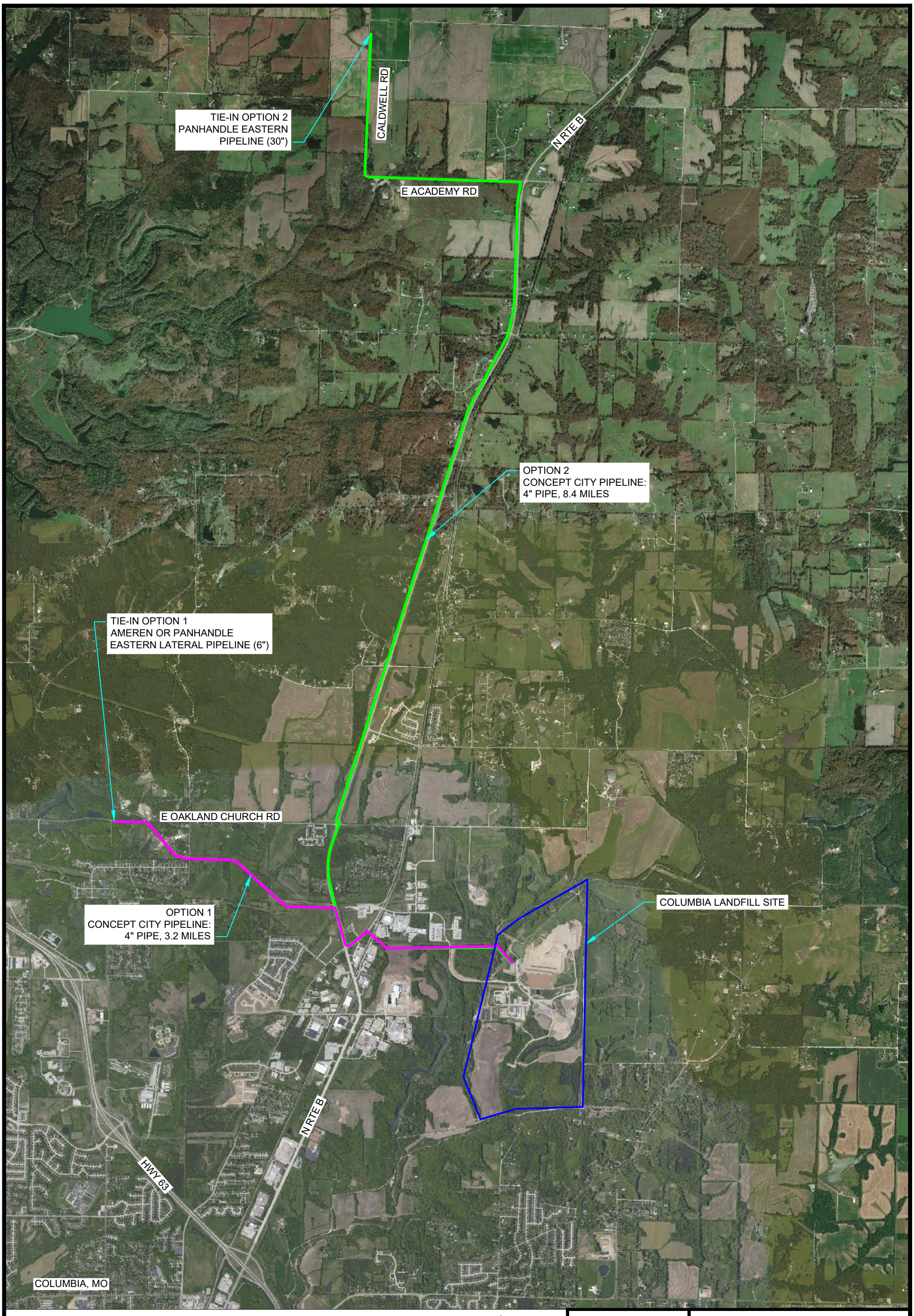
SCALE IN FEET

BURNS McDONNELL

Figure 2

CONCEPTUAL
RNG SITE LAYOUT
COLUMBIA LANDFILL

Z:\CLIENTS\ENS\COLUMBIAMO\116866_RNG-PRELIM-FS\DESIGN\CADD\DWGS\RNG PLANT CONCEPT.DWG 1/16/2019 TMCOLLINS



N

0 3000' 6000'

SCALE IN FEET

BURNS McDONNELL

Figure 3

RNG PIPELINE OPTIONS AND SITE VICINITY MAP COLUMBIA, MO

ATTACHMENT 1

LCFS Price History

Aug-17	$85.00
Sep-17	$88.00
Oct-17	$91.00
Nov-17	$94.00
Dec-17	$101.00
Jan-18	$115.00
Feb-18	$137.00
Mar-18	$122.00
Apr-18	$129.00
May-18	$140.00
Jun-18	$154.00
Jul-18	$169.00
Aug-18	$179.00
Sep-18	$171.00
Oct-18	$181.00
Nov-18	$177.00
Dec-18	$183.00
Jan-19	$190.00
Feb-19	$186.00
Mar-19	$188.00
Apr-19	$180.00
May-19	$185.00
Jun-19	$190.00
Jul-19	$193.80

Max	$193.80
Min	$85.00
Median	$170.00
Mean	$151.20
None	$0.00
Std Deviation	$38.56

RIN Price History

Aug-17	$2.60
Sep-17	$2.70
Oct-17	$2.70
Nov-17	$2.70
Dec-17	$2.60
Jan-18	$2.60
Feb-18	$2.55
Mar-18	$2.50
Apr-18	$2.45
May-18	$2.50
Jun-18	$2.50
Jul-18	$2.25
Aug-18	$2.25
Sep-18	$2.25
Oct-18	$2.10
Nov-18	$2.10
Dec-18	$2.10
Jan-19	$2.05
Feb-19	$1.95
Mar-19	$1.85
Apr-19	$1.85
May-19	$1.50
Jun-19	$1.25
Jul-19	$1.20
*July Low	$0.65

Max	$2.70
Min	$0.65
Median	$2.25
Mean	$2.15
None	$0.00
Std Deviation	$0.44

Natural Gas Price History

Aug-17	$2.90
Sep-17	$2.98
Oct-17	$2.88
Nov-17	$3.01
Dec-17	$2.82
Jan-18	$3.87
Feb-18	$2.67
Mar-18	$2.69
Apr-18	$2.80
May-18	$2.80
Jun-18	$2.97
Jul-18	$2.83
Aug-18	$2.96
Sep-18	$3.00
Oct-18	$3.28
Nov-18	$4.09
Dec-18	$4.04
Jan-19	$3.11
Feb-19	$2.69
Mar-19	$2.95
Apr-19	$2.65
May-19	$2.64
Jun-19	$2.40
Jul-19	$2.37

Max	$4.09
Min	$2.37
Median	$2.89
Mean	$2.98
None	$3.00
Std Deviation	$0.45

ATTACHMENT 2

Combined LFG Generation from LandGEM Modeling
City of Columbia Sanitary Landfill, Installation ID: 019-0091
RNG Study

Year	Annual MSW Tons (US Short Tons)	Non-Bioreactor Tons (US Short Tons)	Bioreactor Tons (US Short Tons)	Bioreactor LFG (SCFM)	Non-Bioreactor LFG (SCFM)	Total LFG Generation (SCFM)	LFG Collection @ 75 Percent Collection Efficiency
1986	89,383.00	89,383.00		-	-	-	-
1987	91,164.00	91,164.00		-	43	43	32
1988	104,082.00	104,082.00		-	85	85	64
1989	83,947.00	83,947.00		-	132	132	99
1990	96,929.00	96,929.00		-	167	167	125
1991	101,094.00	101,094.00		-	207	207	155
1992	96,684.00	96,684.00		-	247	247	185
1993	107,420.00	107,420.00		-	284	284	213
1994	114,594.00	114,594.00		-	324	324	243
1995	120,716.00	120,716.00		-	367	367	275
1996	123,539.00	123,539.00		-	410	410	308
1997	127,902.00	127,902.00		-	453	453	340
1998	127,834.00	127,834.00		-	497	497	373
1999	133,843.00	133,843.00		-	539	539	404
2000	146,273.00	146,273.00		-	582	582	436
2001	156,803.00	156,803.00		-	629	629	472
2002	156,192.00	156,192.00		-	680	680	510
2003	157,970.00	157,970.00		-	728	728	546
2004	162,429.00	162,429.00		-	775	775	582
2005	164,443.00	164,443.00		-	823	823	617
2006	197,272.00	197,272.00		-	870	870	652
2007	175,175.00	175,175.00		-	930	930	698
2008	161,520.00		161,520.00	-	978	978	733
2009	146,304.00	46,817.28	99,486.72	224	940	1,164	873
2010	163,135.00	52,203.20	110,931.80	337	925	1,263	947
2011	162,444.00	51,982.08	110,461.92	453	914	1,367	1,025
2012	162,854.00	52,113.28	110,740.72	556	903	1,459	1,094
2013	169,364.00	53,655.84	115,708.16	647	893	1,539	1,155
2014	167,099.00	66,683.06	100,415.94	734	883	1,618	1,213
2015	173,995.00	69,435.00	104,560.00	791	881	1,672	1,254
2016	175,743.00	70,132.56	105,610.44	847	880	1,726	1,295
2017	185,663.00	74,091.27	111,571.73	898	879	1,777	1,332
2018	173,138.97	69,093.39	104,045.58	951	880	1,831	1,373
2019	173,138.97	69,093.39	104,045.58	988	879	1,867	1,400
2020	173,138.97	69,093.39	104,045.58	1,021	877	1,898	1,424
2021	173,138.97	69,093.39	104,045.58	1,050	876	1,926	1,445
2022	173,138.97	69,093.39	104,045.58	1,076	875	1,951	1,463
2023	173,138.97	69,093.39	104,045.58	1,099	874	1,973	1,480
2024	173,138.97	69,093.39	104,045.58	1,119	873	1,992	1,494
2025	173,138.97	69,093.39	104,045.58	1,137	872	2,009	1,507
2026	173,138.97	69,093.39	104,045.58	1,153	871	2,024	1,518
2027	173,138.97	69,093.39	104,045.58	1,168	870	2,037	1,528
2028	173,138.97	69,093.39	104,045.58	1,180	869	2,049	1,537
2029	173,138.97	69,093.39	104,045.58	1,191	868	2,059	1,544
2030	173,138.97	69,093.39	104,045.58	1,201	867	2,068	1,551
					Max LFG Generation=	**2,068**	**1,551**

1. Based on 2014 Filling Information, 2009 - 2014 Tonnages assume 32% of waste is Routed to Non-Bioreactor Cells.

2. Forward looking tonnages assume landfill expansion beyond Cell 6 will occur. An annualized waste increase of 0% due to anticipated future landfill diversion.

3. Non-bioreactor LFG Modeled with Traditional Inputs (k=0.04, Lo=100). Bioreactor LFG Modeled with "Wet" Inputs Title V / Part 70 Permit Renewal - Bioreactor Cells. Average Bioreactor Landfill k-value calculated as 0.116 from Barlaz (et. al) Performance of North American Bioreactor Landfills. II: Chemical and Biological Characteristics. ASCE Journal of Environmental Engineering, Vol. 136, No. 8, August 1, 2010. Utilized k=0.12/year for the emissions calculations.

4. LFG Collection represents the 75% of LFG Generation per AP-42 - Average Collection.