QUALITY ASSURANCE/QUALITY CONTROL (QA/QC) PLAN

FOR

GLOVERSVILLE/JOHNSTOWN JOINT WWT FACILITY EXPANSION GENERATOR & H_2S REMOVAL SYSTEM

Agreement # - 44538

5/24/18 Update

Submitted to:

New York State Energy Research and Development Authority
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Albany, NY 12203-6399

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Submitted by:

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Introduction

The Gloversville/Johnstown Joint Wastewater Treatment Facility (G/J WWTF) is located in Fulton County. The facility treats approximately 13.1 mg/d of domestic sanitary sewage from the two cities as well as industrial wastewater from local manufacturers. The facility originally hosted two Anaerobic Digesters that generate biogas from approximately 200,000 Tons of activated sludge. The gas was used to generate power in two older and smaller engine generators. In 2010, with incentives from NYSERDA (PON2684), G/J WWTF installed two Caterpillar Engine/Generators with a combined capacity of 700 kW (2x 350 kW) to convert 67% of the biogas into electricity.

This QA/QC Plan (ADG PON 2828) is in support of an expansion engine/generator, and a H_2S reduction system. A third Caterpillar G3508 LE engine and SR 4B generator was installed in 2014 with electric interconnection complete in 2015. The new 375 kW generator has a larger capacity than the existing units. This allows G/J WWTF to produce 30% more electricity from the total biogas generated with only 3% requiring to be flared.

Biogas is generated within the anaerobic digester by converting activated sludge that aggregates as sewage/waste is treated throughout the facility. In order to make enough biogas for proper loading of the new engine generator set, the facility needed to convert more waste into activated sludge. Therefore, G/J WWTF installed a high efficiency Contact Adsorption Settling Thickening (CAST) process. Instead of feeding all of the activated sludge into the digester as originally designed, CAST pipes (i.e. seeds) a small percent of activated sludge into the beginning of the treatment process, which engages the bacteria to rapidly generate more sludge.

Alternative methods to generate increased levels of activated sludge require a high consumption of power. Because CAST uses less energy to achieve the same amount of activate sludge, it is eligible for Industrial and Process Efficiency incentives (PON 2456 - IPE project #12273). IPE projects provide incentives for performance energy savings, while the ADG program offers incentives (in part) for performance energy generation.

In addition to the engine/generator, a Unison Solutions (Connelly-GPM, Inc.) H_2S iron sponge removal system was installed as a preventive maintenance measure for all (three) of the engines. H_2S in the biogas is corrosive, which causes wear and tear, downtime, and excessive maintenance when entrained through the system. The Unison Solutions process starts with the biogas in a down flow design, passing through a fixed bed of iron oxide deposits on wood shavings, for which the H_2S chemically reacts to create a stable byproduct of iron pyrite and water. G/J WWTF installed a system that is capable of passing 425 standard cubic feet per minute (scfm) of biogas through the membrane to reduce 300 parts per million (ppm) H_2S to less than 60 ppm prior to entering the engine/generator.

This plan describes the approach to monitor the performance of the new engine/generator and H_2S removal systems. The system will be installed to measure and collect the quantity of both the biogas consumed by the engine and the electricity produced by the generator, as well as the pre & post Unison Solutions H_2S levels. The data will serve as the basis for payment of a capacity incentive to help offset the capital expenses associated with the procurement of the new equipment

as well as performance incentives over a ten (10) year period, which G/J WWTF has applied for under a Standard Performance Contract with NYSERDA.

ADG System Notes

There are two mixed type anaerobic digesters; a primary and secondary with a total capacity of 2.8M gallons. Biogas is stored in a dual membrane gasholder with an approximate volume of 47,000 ft^3. The existing municipal and industrial waste streams generate 165M ft^3/yr of biogas. This represents an operating volume 18,835 ft^3. G/J WWTP planned for an additional industrial wastewater stream that would generate 20M ft^3/yr or 2,283 ft^3 more biogas, which when combined is much less than the total digester capacity. The additional engine generator system installed is a packaged Caterpillar system with a G3508 gas variable fuel engine with a SR4B high efficiency generator operating at a maximum capacity of 375 kW.

Figure 1: Caterpillar 375 kW Engine/Generator

Iron Sponge System Description

Unison Solutions designed the iron sponge H_2S removal system. The sponge is designed for a biogas flow rate of 425 scfm containing up to 300 parts per million (ppm) of H_2S.

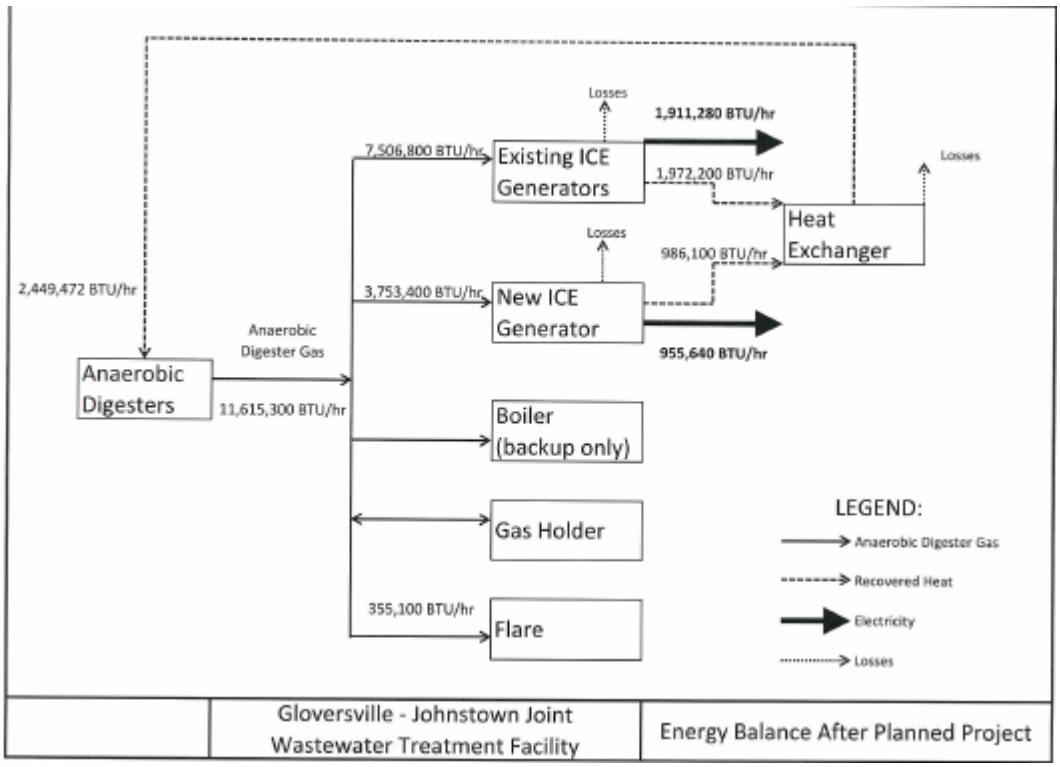
Table 1. Iron Sponge System Design Specifications

Iron Sponge	Unison Solutions
Iron Sponge Design Operation	Temperature: 95 °F PH: 8-10
Designed Biogas Flowrate	425 scfm
Biogas Pressure	Inlet: 8-10" WC Outlet: 1-3" WC
Biogas Composition (est.)	CH4 Inlet: 50-52 % CH4 Outlet: 50-52% RH Inlet: 100% RH Outlet: 100% H_2S Inlet: 300 ppm H_2S Outlet: 0 ppm

The Unison Solutions iron sponge has several components. After the biogas leaves the digester it is filtered through a *Uni-Scrub* moisture/particulate removal system. Then it goes to the iron sponge vessel, which is a vertical cylinder of at least eight (8) feet. The biogas flows through an inlet valve on top of the vessel through the media, which is composed of Iron Oxide (Fe_2O_3) deposited on wood chips. According to the manufacturer both hydrated and dry Iron Oxide is used. The Hydrated form requires 15-18 lb/ft^3 in place, while only 50-65% weight of dry sponge is needed. The chips should have 35-50% of its weight as moisture, with a bulk density of 770-865 kg/M^3. When the H_2S reacts with the iron sponge, water is also created, which needs to be drained to prevent accumulation. After being treated in the iron sponge the biogas is analyzed by a Landtec FAU-TDL gas analyzer, which also measures CH_4, and CO_2 in addition to H_2S. The H2S concentration of biogas before the iron sponge is measured and recorded at least once per week by Draeger Tube or other method approved by NYSERDA. Figures 3 and 3a show schematic diagrams for the three engine generators and for the overall anaerobic digestion system. The location of the Landtec FAU-TDL gas analyzer and the sampling port for the measurements before the iron sponge are shown in Figure 3a. Figure 4 shows the process flow diagram of the Unison Solutions iron sponge system components.

Figure 2: Iron Sponge Vessel

Figure 3 and 3a. Process Flow Diagrams



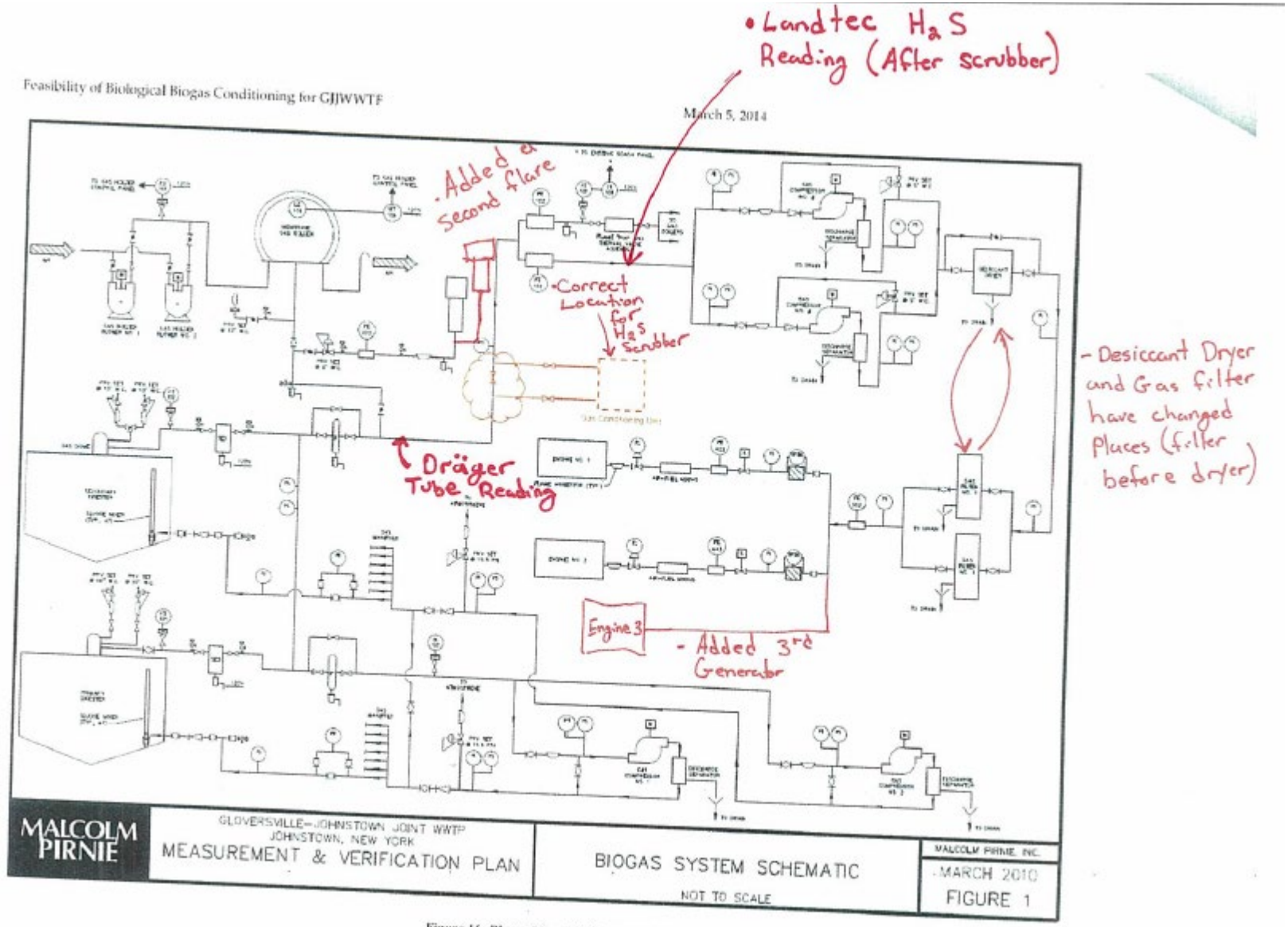
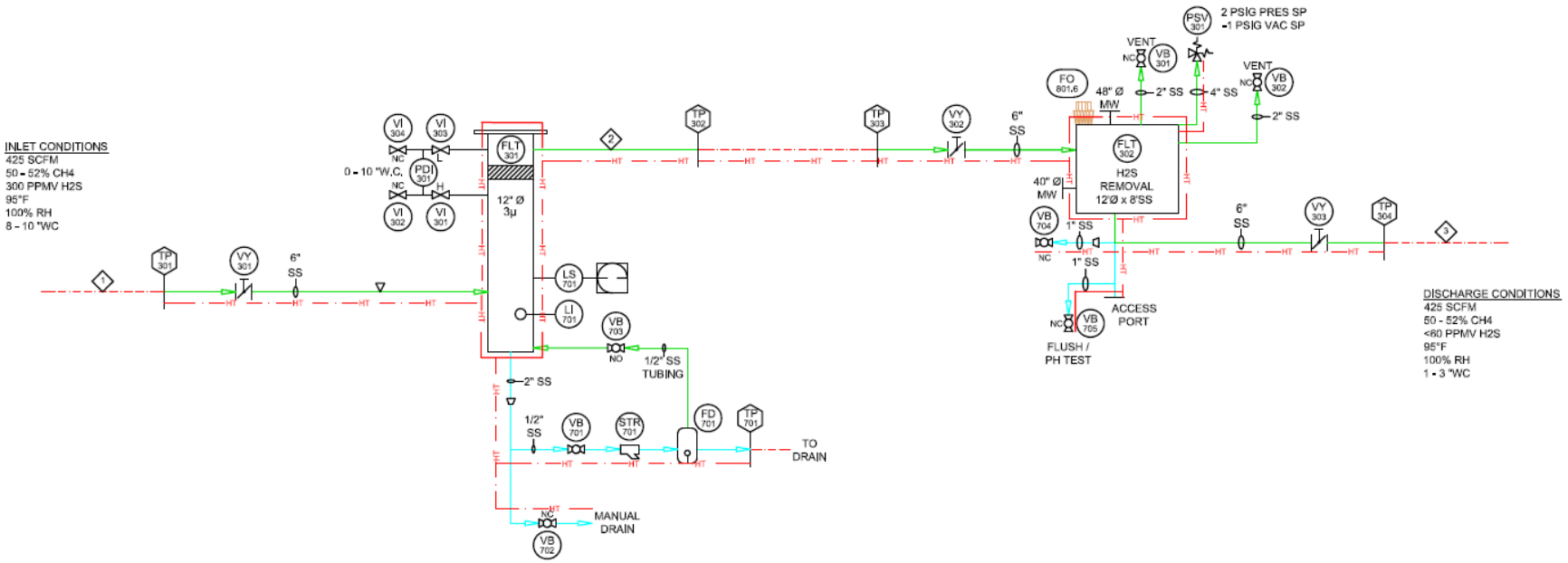


Figure 16: Biogas Plant P&ID with Scrubber

Figure 4: Schematic of H_2S Removal Process



Capacity Payment Descriptions

This Section describes the Capacity Incentive Payments included in the Agreement, the payment milestones to be achieved in order to receive payment, and the deliverables to be provided in achieving these milestones. For this new engine generator system and the H_2S iron sponge, the available Capacity Payments are Capacity Payments 1, 2, 3, 4, 5, and 6, which are presented below.

Capacity Payment #1: Up to 15% of Total Capacity Incentive is payable for reimbursement of project costs once the G/J WWTP provides evidence sufficient to demonstrate payments for major equipment (e.g. power generation system, anaerobic digester system, biogas clean-up and handling systems etc.) and/or engineering design.

Capacity Payment #2: Up to 45% of the Anaerobic Digester component of Total Capacity Incentive is payable for reimbursement once L&S Energy Services has verified that construction/installation/upgrade of the anaerobic digestion system has been completed.

Capacity Payment #3: Up to 45% of the Power Generation component of Total Capacity Incentive is payable once G/J WWTP has provided sufficient documentation to NYSERDA verifying that the power generation system has been delivered to the site (e.g. delivery receipt).

Capacity Payment #4: Up to 45% of the Project Enhancement Component of the Total Capacity Incentive is payable once L&S Energy Services has verified that construction/installation of the Project Enhancement has been completed or the required documentation for the Project Enhancement, according to applicable sections of *Using the Incentive Calculation Tool* of Exhibit D has been submitted to NYSERDA. G/J WWTP may request payment at this time for any Project Enhancements that have been completed and verified. Payment for Project Enhancements completed and verified after the request for Capacity Payment #4 had been made may be requested with the Capacity Payment #6.

Capacity Payment #5: 20% of Total Capacity Incentive is payable once documentation has been provided to NYSERDA that sufficiently verifies successful operation of the newly installed system and completion of interconnection, if applicable (e.g. interconnection acceptance test documentation from the utility). Verification of successful operation for example may include documentation of operation of the equipment with data from meters or hand-held biogas measurement equipment or other methods of documentation satisfactory to NYSERDA.

Capacity Payment #6: Up to 100% of the Total Capacity Incentive is payable once the newly installed system is successfully commissioned. Commissioning includes (a) operating the ADG-fueled energy generation system at a minimum output of 75% average capacity factor (281 kW) over seven (7) consecutive days, during which time the total output of the other two engine generators installed with a prior NYSERDA project total at least an 80% capacity factor average (560 kW), and (b) demonstrating the ability to upload data generated by the system to NYSERDA's CHP website, if applicable. A project Commissioning Report must also be completed detailing the installation and commissioning activities and include design updates and as-built diagrams. Any project Enhancements payments that were not made with the Capacity Payment #4 may be requested with this payment.

Performance Incentive Description

There are 10 Performance Incentive payments. Each payment shall be based on the verified electricity generated and verified H_2S levels that satisfy requirements for the Iron Sponge system during each of the 10 consecutive years during which Performance Incentives are offered, known as the Performance Period.

Performance Incentive payments shall be made after the following:

The Annual Performance Report, prepared by L&S Energy Services, has been approved by NYSERDA. G/J WWTP is responsible for ensuring that data provided in the Annual Performance Reports accurately represent the operation of the ADG-to-Electricity System in accordance with the QA/QC plan.

- An invoice has been submitted to NYSERDA for the previous year's Performance Incentives.
- A statement has been submitted to NYSERDA stating whether or not a Federal Grant via 1603 Treasury Grant, USDA REAP and/or NRCS/EQIP digester funding has been received for one or more components of the project. G/J WWTP may be required and hereby agrees to provide NYSERDA with any necessary authority for NYSERDA to independently verify the existence and amount of any federal grant and to execute any documents necessary for NYSERDA to do so.

In general, 10% of the Power Generation component of the Total Performance Incentive (based on the kWh production times $0.025) will be paid by NYSERDA in each year, not to exceed a cumulative total of 100% of the Power Generation component of the Total Performance Incentive. The Annual Performance Report will include (a) the actual verified electricity produced by the new engine generator and the total of all verified electricity produced by all three engine generators and (b) the biogas input into new engine and the total biogas input into all three. It is anticipated that the total annual electricity output from earlier two generators will continue to reach or exceed the 80% capacity factor included in the NYSERDA Agreement that provided funding for them.

The percentage paid in a given year will be calculated based on the ratio of the actual verified electricity produced compared to the total electrical generation stipulated in the contract agreement. If, in a given year, G/J WWTP is unable to produce 10% of the total electrical generation expected over the 10 year period, that production deficit can be made up in subsequent years provided the cumulative percentage of the total Performance Incentives paid by that year does not exceed the cumulative percentage of years that the system had been in production. For example, a maximum of only 80% of the total Performance Incentives can be paid for production at the end of the 8^{th} year of the Performance Period.

Additionally, the H_2S Reduction Processes component of the annual Performance Incentives payments is based on the hourly outlet H_2S readings (up to a max. of 90% of the hours in a year) that are below the minimum H_2S threshold of 400 ppm for iron sponge. Therefore the H_2S Reduction component of annual Performance Incentive payment is determined by multiplying the Contract Capacity, times the factor 0.83333, times the verified hourly samples below the min H_2S threshold, times the H_2S Performance Incentive variable.

Monitoring System Equipment, Installation, Operation, and Maintenance

Payment for this incentive shall ultimately be based on the ability of the iron sponge to reduce H_2S levels to less than 400 ppm, as supported by collected data. Measurements of biogas that has been treated in the iron sponge will be made with continuous automatic gas sampling and analysis, or by other methods found acceptable to NYSERDA. For this project a Landtec FAU-TDL biogas analyzer will be used to measure the H_2S concentrations, CH_4, and CO_2 percentage of this biogas.

Figure 3a shows the locations of the three (3) new biogas measurements. The gas analyzer measures H_2S levels after the iron sponge (**H2S_OUT**). The H2S levels in the biogas prior to treatment in the iron sponge will be measured by Draeger tubes or other method approved by NYSERDA. Information on these data points is shown in Table 2.

Table 2. Monitored Data Points

Point Name	Description	Instrument	Engineering Units	Expected Range
H2S_IN	H_2S Before Sponge	Draeger Tube 1/week manual	ppm	0 – 500 ppm (± 5% full scale)
H2S_OUT	H_2S After Sponge	Landtec FAU-TDL	ppm	0 – 500 ppm (± 1% full scale)
CH4	CH_4 After Sponge	Landtec FAU-TDL	%	0-100 % (± 1 % full scale)
CO2	CO_2 After Sponge	Landtec FAU-TDL	%	0-100 % (± 1 % full scale)
FG1	Biogas to Engine 1 (Old)	Milton CAT Control Panel	CFM	0-200 CFM (± 1 %)
FG2	Biogas to Engine 2 (Old)	Milton CAT Control Panel	CFM	0-200 CFM (± 1 %)
FG3	Biogas to Engine 3 (New)	Milton CAT Control Panel	CFM	0-200 CFM (± 1 %)
WG1	Generator 1 Power Output (Old)	Milton CAT Control Panel	kW	0-400 kW (± 1 %)
WG2	Generator 2 Power Output (Old)	Milton CAT Control Panel	kW	0-400 kW (± 1 %)
WG3	Generator 3 Power Output (New)	Milton CAT Control Panel	kW	0-400 kW (± 1 %)

Maintenance activities will be performed using the facility SCADA system and will be delivered daily to CDH/NYSERDA database. The SCADA system pulls data from the Milton CAT and Landtec FAU-TDL onto an interface that averages one-minute samples in 15-minute intervals for the daily upload. The upload consists of a CSV file with a timestamp.

The worksheet in Appendix B may be used as a template for documenting the capabilities of the iron sponge system. Biogas flow and H_2S output from the iron sponge will be documented for each hour of the year that samples are taken. The percentage of cumulative outlet H_2S samples (up to a maximum of 90% of the hours in a year - 7,884) with 399 ppm H_2S and below will be submitted to document adequate compliance with the requirement for payment. The summary of samples will show the percentage of cumulative samples with 399 ppm H_2S and below as well as the percentage of cumulative samples with 400 ppm H_2S and above. For the 7 day period at least 3 samples of H2S input will be measured each day, recorded in the worksheet in Appendix B, and analyzed to examine the variability in results.

Incentive calculation methods for the 6th Capacity Incentive Payment and the annual Performance Payments, which are based on H_2S data, are as follows:

- To satisfy H2S reduction requirements for the 6th Capacity Incentive payment 126 hourly H_2S outlet data values (representing 75% of the 168 hours in a week) must be below 400 ppm for a consecutive 7-day period when the following conditions are met for each of the 126 hours, or other documentation must be provided that is satisfactory to NYSERDA:

    1. The kWh output from the three engine generators is greater than 538 kW which is 50% of total capacity of 1075 kW (375 kW from the third engine-generator with the new NYSERDA Agreement and 700 kW from the two engine-generators with the earlier NYSERDA Agreement) or the flow of biogas through the iron sponge is greater than 11,272 cubic feet per hour (50% of the biogas needed to generate 1,075 kW based on an average efficiency of 33% and average methane content of 54% in the biogas), and
    2. The Landtec biogas meter reading for CH4 (or other meter or other parameter acceptable to NYSERDA) is greater than 0 to document that the meter is operating.

- The annual Performance Incentive payment for H_2S reduction is determined by multiplying the total of the Contract Capacity (375kW) and the existing capacity (700kW), times the factor of 75% divided by 90%, times the verified hourly samples (not to exceed 7,884 hours/year) below the minimum H_2S threshold while the conditions 1 and 2 above are met, times the H_2S Performance Incentive variable for an iron sponge ($0.004/kWh). NYSERDA will consider other formulations for calculating the Performance Incentive, in the event that the iron sponge is unable to operate due to reasons outside of the operation of the sponge itself. NYSERDA may direct its technical contractors to sample the biogas, determine H_2S removal efficiency, and compare the results to the data originally provided by the operator. For the annual Performance Incentive payments at least one sample of H2S input will be measured each week and results provided for incorporation on the NYSERDA website. More frequent samples may be needed if the concentration of H2S is found to change significantly.

Max Incentive: 1,075 kW * 0.75 / 0.9 * 7,884 hours/year * $0.004/kWh = $28,251/year

Management of Monitoring System Data

G/J WWTP staff will perform the following quality assurance and quality control measures to ensure the data produced from the monitoring system accurately describes system performance.

On a daily basis, the manager (or other specified employee) will perform inspections of the iron sponge equipment and record findings into the project log.

On a weekly basis, the manager (or other specified employee) will perform inspections of the QA/QC biogas analyzer installations and complete the routine maintenance on the analyzer, noting any abnormalities or unexpected readings.

On a weekly basis, the staff will review the data stored on the NYSERDA Integrated Data System website (chp.nyserda.org) to ensure it is consistent with their observed performance of the ADG system and logged readings. The facility will review the data using the reporting features at the website, including:

- Monitored Data – Plots and Graphs
- Monitored Data – Download (CSV File)

In addition, the facility staff will also setup and use the email reports that are available at the Integrated Data System website to help the track system performance, including:

- A periodic email report summarizing performance and the estimated incentive,
- An email report will be sent out if data are not received at web site or do not pass the quality checks.

The website will automatically evaluate the quality of the collected data using range checks and basic relational checks identified in the website Database Notes. The expected ranges for the sensors (Table 2) will be used for the range checks. For this facility any applicable relational checks will be made by the Technical Consultant during preparation of the Annual Performance Reports for the G/J WWTP invoices. Data that passes the range and relational quality checks can be used in the incentive reports listed above. However, all hourly data are available from the NYSERDA Integrated Data System website using the "Download (CSV file)" reporting option. Further details on range and relational data quality checks, including site specific ranges and relations, can be found in the sites "Database Notes" document on the NYSERDA Integrated Data System website.

In the event of a communications or analyzer failure, the facility personnel will work with L&S Energy Services to resolve the issue.

If unanticipated loss of data occurs, the facility will follow the procedures outlined in Exhibit D of their contract, i.e. using data from similar periods – either just before or after the outage – to replace the lost data. Facility personnel understand that they can use this approach for up to two (2) 36-hour periods within each 12-month performance reporting period. If more than two (2) such data outages occur, facility personnel will provide information from other acceptable data sources (e.g.,

weekly recorded logs) to establish data during the period in question in a manner acceptable to NYSERDA.

Amendment of the QA/QC Plan Provisions

The QA/QC methods and procedures described above have been determined to be appropriate and effective for the current configuration and operating procedures of the anaerobic digestion system at the Gloversville/Johnstown Joint Wastewater Treatment Facility. Amendments to this QA/QC Plan can be proposed and considered at any time should they be found desirable to address such things as changes in the system or in the capabilities of QA/QC equipment. Proposed changes will be considered and approved by NYSERDA when shown to be warranted by acceptable rationale. Approved changes will be incorporated in updated versions of the QA/QC Plan.

Appendix A

Cut sheets and Manuals for:

- **Landtec FAU-TDL**
- **Milton CAT**
- **Drager Tubes**
- **Shark 200 Data Logger**
- **Engine Flow Meter**

Technical Drawings:

- **Biogas Generator Building Interconnection Plan**
- **Digester Building - First Floor Modification Plans and Sections**
- **Digester Building - Second Floor Modification Plan**
- **Iron Sponge - Plan and Sections**

Appendix B

H_2S Reduction Spreadsheet Sample

Worksheet to Document Ability of Biological Scrubber to Produce Measureed H2S Concentrations Less Then 400 ppmv for 75% of Samples								
Data to be Completed by Operator						Analysis which can be done by Technical Consultant		
A	B	C	D	E		F	G	H
Hour	Date of Sample	H2S in Biogas Before Cleanup (ppm)	H2S in Biogas After Cleanup (ppm)	CH4 in Biogas After Cleanup (%)		Total Number of Samples with <400 ppm H2S	Total Number of Samples with ≥ 400 ppm H2s	Total Number of Samples with ≥ 50% CH4
0:00	1	1,500	50	59%		18	6	18
1:00	1	1,600	50	59%				
2:00	1	2,000	250	54%		Total Samples		24
3:00	1	16,000	250	54%		% Under Maximum Range		75%
4:00	1	14,000	400	50%		% CH4 In Range		75%
5:00	1	1,250	150	56%				
6:00	1	1,300	150	56%				
7:00	1	1,500	150	56%				
8:00	1	2,000	200	55%				
9:00	1	1,500	250	54%				
10:00	1	1,500	250	54%				
11:00	1	1,600	150	56%				
12:00	1	800	250	54%				
13:00	1	800	350	51%				
14:00	1	1,200	350	51%				
15:00	1	1,100	450	49%				
16:00	1	1,300	350	51%				
17:00	1	1,400	350	51%				
18:00	1	1,500	350	51%				
19:00	1	1,400	550	46%				
20:00	1	1,300	550	46%				
21:00	1	1,500	350	51%				
22:00	1	2,000	950	36%				
23:00	1	800	550	46%				
Note: This is an example for 1 day's worth of data. This table will need to be extended to 7 days for the 6th Capacity Payment and 365 days for the Annual Performance Payments.								