Facility: QSS Biosolids, LLC
Facility Address: 135 All American Way, North Kingstown, Rhode Island 02852
Application Rec'd: 25 April 2025
Application For: New sewage sludge pyrolysis facility

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Auth. Signature: Mark DePasquale, Managing Member
Fee: $4,620.00

Reviewer: Ruth Gold – Office of Air Resources (OAR)
Date: October 31, 2025 and January 16, 2026

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BACKGROUND:

Quonset Soil Solutions, LLC was issued Approval Nos. 2552 – 2563 on 15 May 2023 for a pyrolysis facility to convert wood chips to biochar. Located in Quonset Industrial Park, it is also owned and operated by the same corporation that is represented by this application. This application was prepared by Sage Environmental located in Rhode Island and by VOW ASA, an environmental engineering company headquartered in Norway that specializes in solutions that convert biomass and waste into valuable resources.

Please note: *The applicant was provided a draft permit on 11/7/25. Comments received from QSSB to the draft permit revealed some issues that required further discussion and evaluation including revised air dispersion modeling.*

1. *In the application, QSSB specified the manufacturer and model number of each air pollution control equipment presented in this review. In an email from Lacy Reyna of Sage Environmental (QSSB's environmental consultant) to Ruth Gold on 12/2/25, disclosed that the manufacturer for all the equipment has not been finalized by QSSB at this time. It will be required in the permit, that QSSB notify the OAR prior to installation of the selected systems and if the specification of the systems differ, a permit revision may be necessary prior to the installation of the equipment.*

2. *The application presented particulate matter emissions from the Odor Control Stack that would be reduced by 99.95%. After the draft permit was supplied to QSSB with a condition to verify the PM efficiency, QSSB stated that the overall reduction of PM is not solely from the odor air pollution control system but includes the PM removed from the stream by the integral cyclones on the dryers and the integral filters on the dry feedstock silos and the pelletizers. According to the design specifications for the odor control equipment, the PM loading to the odor air pollution control system cannot exceed 20 mg/m^3. As such the control efficiency of the odor air pollution control system in itself cannot be measured for PM. Therefore, QSSB will not take credit for any PM control efficiency from the odor air pollution control system and is proposing to be limited by the hourly emission rate and 20 mg/m^3. See Sage Environmental's 12/8/25, 12/9/25 notification.*

PROPOSAL:

QSS Biosolids, LLC (QSSB) is proposing to build a new facility to be located in Quonset's West Davisville District for treating sewage sludge through a pyrolysis process to produce biochar. Currently in Rhode Island, sewage sludge is incinerated in two facilities: the City of Cranston operates two (2) multiple hearth incinerators; and the City of Woonsocket operates a single fluidized bed combustor.

QSSB is proposing to install two (2) identical pyrolysis reactors (electrically heated), associated process equipment and various air pollution control equipment. The pyrolysis reactors will have the capacity to pyrolyze up to approximately 158.7 tons of sewage sludge per day. Pyrolysis is the thermochemical decomposition of organic material through the application of heat without oxygen. Because no oxygen is present, the feedstock material does not combust but instead the chemical compounds that make up the feedstock material thermally decompose into combustible gases and biochar. The U.S. Environmental Protection Agency has formally recognized that QSS Biosolid's pyrolysis process is not considered incineration.

Major process operations will include an enclosed reception area for delivery of the sewage sludge, storage silos, dryers, and pelletizers, all which will serve to store and prepare the sewage sludge for the pyrolysis reactors. The applicant refers to sewage sludge as Wet Feedstock and Dried Feedstock.

The facility will be equipped with two separate air pollution control systems. An Odor Control Plant is planned for handling any odors produced from the handling, storage, drying and pelletizing of the sewage sludge up to the point of entering the reactors. Another air pollution control system is planned for treating the pyrolysis gas produced from the pyrolysis reactors, referred to as the Emissions Control Plant. The Emissions Control Plant will consist of two thermal oxidizers followed by Catalytic Filters. Therefore, the plant will only have two stacks with emissions to the atmosphere.

The processing equipment and the air pollution control equipment has been designed to be outdoors all year, with a weather shelter to protect it from heavy snowfall and rain. The facility would like to begin construction in spring 2027 and complete construction by spring 2028.

Below is a summary of the major process equipment proposed for the facility. The list follows the path the sewage sludge travels through the process.

Sewage Sludge Handling Process Equipment:

- Two (2) Wet Feedstock Reception Buildings - for receiving sewage sludge trucks
- Four (4) Wet Feedstock Silos - each with a capacity of 800 m^3
- Two (2) disc dryers
- Two (2) Dry Feedstock Silos - each with a capacity of 80 m^3
- Two (2) Pelletizers (followed by a pre-bin to service the pyrolysis systems)

The process equipment above will be able to discharge sewage sludge to either of the next in line device. For example, both of the disc dryers will be able to discharge sewage sludge to either of the two dry feedstock storage silos. This will allow the facility to maximize their equipment but will also allow for maintenance downtime for a single unit while the process is uninterrupted. All the above process equipment will vent to the Odor Control Plant. The pelletizers will discharge dry feedstock to either pyrolysis reactors.

Emissions from the sewage sludge handling process equipment above will discharge to the:

Odor Control Plant:

- One (1) Biotrickling Filter
- Two (2) Chemical Scrubbers in series - acid and caustic stages
- One (1) Carbon Polishing Filter - dual bed activated carbon system

The second part of the facility is the pyrolysis reactors and associated air pollution control systems:

Pyrolysis Process Equipment:

- Two (2) pyrolysis reactors

Each pyrolysis reactor will discharge to a dedicated Emissions Control Plant:

Emissions Control Plant:

- Two (2) Thermal Oxidizers - operate on natural gas and/or pyrolysis gas
- Two (2) Catalytic filters - (contains SCR, dry sorbent injection, and ceramic catalytic filter tubes)

Sewage Sludge

Municipal wastewater, or sewage, refers to water that has been used in urban and suburban area for washing, bathing, and flushing toilets. Municipal wastewater also may include water from industrial sources although industrial sources must pretreat their wastewater before it is discharged into the municipal sewerage system. A municipal wastewater treatment facility processes and treats the wastewater by thickening, digesting, and dewatering to stabilize it, breaking down organic materials, and reducing the volume. Steps are also taken to control pathogens. These steps transform the raw sludge into a more manageable substance, referred to as sewage sludge, or sometimes biosolids. Sewage sludge is the semi-solid material (both organic and inorganic) that settles out during the wastewater treatment.

The applicant has indicated that they will only accept, and process municipal sewage sludge obtained from a municipal wastewater treatment facility and not directly from an industrial wastewater pre-treatment system and has included this language in their draft permit as an operating requirement.

40 CFR Part 503 "Standards for the Use or Disposal of Sewerage Sludge" defines sewage sludge as "a solid, semi-solid, or liquid residue generated during the treatment of domestic sewage in a treatment works. Sewage sludge includes scum or solids removed in primary, secondary, or advanced wastewater treatment processes and any material derived from sewage sludge (e.g., a blended sewage sludge/fertilizer product) but does not include grit and screenings or ash generated by the firing of sewage sludge in an incinerator.

[1]40 CFR Part 60, Subpart LLLL "Standards of Performance for New Sewage Sludge Incineration Units" defines sewage sludge "to include, but is not limited to, domestic septage; scum or solids removed in primary, secondary, or advanced wastewater treatment processes; and a material derived from sewage sludge. Sewage sludge does not include ash generated during the firing of sewage sludge in a sewage sludge incineration unit or grit and screenings generated during preliminary treatment of domestic sewage in a treatment works."

Odorous airstreams from sewage sludge are a common environmental concern where sewage sludge is transported, processed or stored. Types of odorous compounds in sewage sludge have been identified as Hydrogen Sulfide (H_2S), Ammonia (NH_3), Volatile Fatty Acids, methyl mercaptan, dimethyl sulfide, other sulfur compounds, and many other volatile organic compounds that contribute to odors.

The compound H_2S is often the primary odorous compound and smells like rotten eggs. Air with high concentrations of H_2S is harmful to environment and to those exposed to it and can pose corrosion risks to industrial equipment.

DESCRIPTION OF MAJOR OPERATIONS AT THE PLANT

Receiving Station

The Wet Feedstock is transported to the site by trucks. It is expected that the Wet Feedstock will arrive Monday to Friday, in a 12-hour window per day. The plant will accept Wet Feedstock with a moisture content up to 75%.

Each truck will be weighed (weighbridge) upon arrival and when leaving the plant. After weighing, the delivery trucks will enter one of two (2) Wet Feedstock Reception Buildings (WFRBs). Each WFRBs will consist of a truck cleaning zone and a reception discharge bin zone. The WFRBs will enclose the trucks completely when the trucks are in the building. The trucks will enter the WFRB by a door[2] which will open and close immediately before and after the truck has entered the building.

The trucks are equipped with moving floors that will convey the Wet Feedstock out of the truck and into a reception bin. The reception bin will be a push floor container, with a lid which opens when the truck is ready to discharge and will close once the truck has finished. The emptying of the trucks will only happen when the door is closed. The truck will then drive forward into the cleaning zone where the trucks' exterior surfaces will be cleaned to avoid any spill to the environment outside of the WFRBs. Once the truck is cleaned, the door will open, and the truck will drive out and over the weighbridge for weight recording.

The airflow through the building will be designed to keep the building at a slight under pressure to control odors from escaping. Air will be evacuated in separate channels; one channel will draw air from the main building and another channel from the reception bin. The airflow will be towards the back of the WFRB to ensure that the flow of air will be directed away from the entrance gate. The reception buildings will undergo 4 air exchanges per hour while the reception bins will undergo 10 air exchanges per hour. All ventilation air will discharge to the Odor Control Plant.

- **The applicant is proposing to be limited to accepting a combined total of 47,620 lbs/hr (21,600 kg/hr) of sewage sludge at 75% water content through the Reception Buildings.**

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[1] EPA has deemed QSS Biosolids is not subject to 40 CFR Part 60, Subpart LLLL, Subpart O or Subpart CCCC.

[2] The applicant referred to the door as a gate. The permit will specify that the entrance to the building will be a door.

Wet Feedstock Sludge Silos

From the reception bins, the Wet Feedstock will be discharge to the four (4) Wet Feedstock Silos This will be achieved by positive displacement pumps[3], through a closed piping system. The applicant states no air emissions are expected when pumping the Wet Feedstock to the silos as this will be a closed system that will discharge to the Odor Control Plant.

The 4-silos, 800 m^3 total capacity (28252 ft^3) will be able to buffer Wet Feedstock for approximately 4 days of operation and will provide autonomy in the system when performing maintenance on other equipment, as well as serve as a buffer to last over long-weekends. The headspace of the Wet Feedstock Silos will be under negative pressure, and the gases will be extracted from the top and discharged to the Odor Control Plant. The sewage sludge will empty out the bottom of the silos using a water-tight moving floors.

It is my assumption that the silos will be capable of holding approximately 1,939,035 lbs of sewage sludge at 75% MC.

Average density of sludge = 11.68 lbs/gal (1400 kg/m^3)
Average density of water = 8.34 lb/gal (1000 kg/m^3)

(11.68 lb/gal x 25%) + (8.34 lbs/gal x 75%) = 2.92 + 6.255 = 9.175 lbs/gal
28252 ft^3 x 7.4805 gal/ft^3 = 211,339 gallons
211,339 gallons x 9.175 lb/gal = 1,939,035 lbs

Wet Feedstock Dryers

The Wet Feedstock will be pumped by positive displacement pumps through a closed piping system to the dryers. No fugitive air emissions are expected when pumping the Wet Feedstock to the dryers as this will be a closed system.

For optimum operation of the pyrolysis process, the moisture content of the Wet Feedstock needs to be reduced (dried), ideally to approximately 10%.

Two (2) Disc Dryer systems will be installed in parallel. The sludge is slowly moved along through the dryers from the inlet to the outlet end by a paddle system. The discs are mounted on a heavy central shaft with scraper bars to ensure agitation between the discs and aid in evaporation. The disc are designed with a smooth surface that secures maximum heat transfer, increases the level of self-cleaning and reduces fouling problems. The dryers are closed systems and will be operating under a slight vacuum.

The Disc Dryers will be heated via a closed-loop indirect[4] heating by hot oil that is recovered from the pyrolysis gas after treatment in the thermal oxidizers.
The dryers will have a condensate removal system that will continuously remove and collect the moisture evaporated from the product in a high-top vapor dome. The vapor will pass through an internal scrubbing system for heat recovery and removal of the moisture in the exhaust gas. Additionally, the dryers will be equipped with integral cyclone to meet the particulate matter loading requirements for the odor control plant. The scrubber and cyclone are inherent to the disc dryers design for exhaust conditioning to meet the requirements of the Odor Control Plant and are not considered air pollution control devices for permitting purposes under RI Part 9. All exhaust air from the dryers will discharge to the Odor Control Plant for treatment.

- **The applicant is proposing to be limited to a wet feedstock rate of 23,810 lbs/hr at 75% MC (10,800 kg/hr) through each dryer.**

Dried Feedstock Silos

The Dried Feedstock will then be transported out from the dryer by a speed-controlled inclined tubular extraction screw conveyor, discharging to a bucket elevator and into the Dried Feedstock Silos by a horizontal screw conveyor. This will be a dust tight system to ensure that no particulate emissions are discharged directly to the atmosphere.

The Dried Feedstock will be stored in two 80 m^3 (2825 ft^3) silos to ensure an adequate and steady supply for the pyrolysis reactors. The silos are planned to be able to buffer approximately 10 hours of operation. This is to safeguard operational

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[3] Positive displacement pumps provide consistent airflow, reliable pressure and can handle a variety of fluid types while centrifugal systems fluctuate based on resistance.

[4] The sewage sludge within the dryers is not heated directly with combustion gases; therefore, the dryers do not meet the definition of a sewage sludge dryer as defined in 40 CFR 61 Subpart E. (from 3.2.2.1 From 40 cfr 61, page 14/266)

variations in the upstream process, during routine maintenance, and short unplanned downtime does not immediately impact the pyrolysis process.

The Dried Feedstock Silos will have a negative pressure in the headspace at the top of the silos and will exhaust from this point to the Odor Control Plant. To reduce dust in the downstream piping, a top mounted filter will be installed on the gas extraction point at each silo. The filters are inherent to the silos design for exhaust conditioning to meet the requirements of the Odor Control Plant and is not considered an air pollution control device for permitting purposes under RI Part 9. The sliding frame silos will be equipped with level and temperature monitors, explosion relief vents, and connection for inert gas purging. The inert gas will provide an oxygen reduced environment in the silos' headspace.

- ➢ **The applicant is proposing to be limited to a dry feedstock rate of 6614 lbs/hr at 10% MC (3000 kg/hr) to each silo.**

Pelletizer

From each Dried Feedstock Silo the dried feedstock will be transported by screw conveyors to one of two Pelletizers. The applicant states the conveyors are dust tight to ensure no emissions of particulate matter to the atmosphere. The Dried Feedstock Silos can feed either pelletizer. Both pelletizers can feed either of the two Pyrolysis Reactors.

The pellet mill presses the feedstock into pellets to minimize fines in the downstream equipment. To optimize the pelletizing process, a conditioner with water injection mixes the product with water before it enters the pellet mill. This reduces the need for maintenance and increases the lifetime of the downstream Thermal Oxidizers. The Pelletizers will operate continuously under a negative pressure.

The pelletizers have an integral filter for dust control and the filters are inherent to the pelletizers design for exhaust conditioning to meet the requirements of the Odor Control Plant and is not considered an air pollution control device for permitting purposes under RI Part 9. The filtered air will discharge to the Odor Control Plant.

The Pelletizers can also be bypassed, sending un-pelletized Dried Feedstock directly to the Pyrolysis Reactors. This ensures full flexibility and allows for maintenance work without stopping the Pyrolysis Reactors. When feeding un-pelletized Dried Feedstock, slightly more maintenance is most likely required on downstream equipment.

- ➢ **The applicant is proposing to be limited to a dry feedstock rate of 6614 lbs/hr at 10% MC (3000 kg/hr) to each pelletizer.**

ODOR CONTROL PLANT

The Odor Control Plant will consist of the following air pollution control units aligned in series:

1. Biotrickling Filter (BTF)
2. Scrubber
3. Carbon Filter

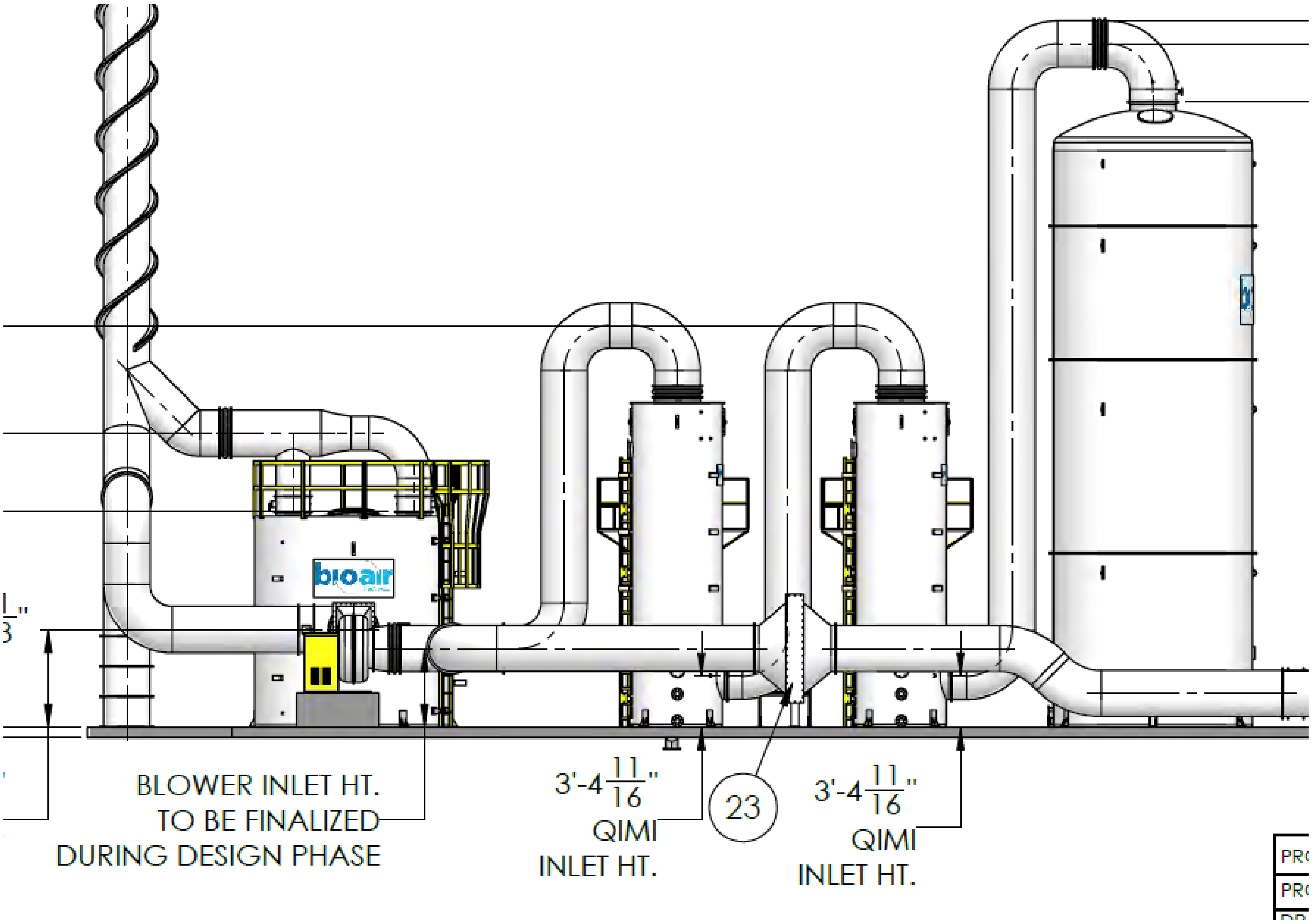
The following sources and their conveyor systems will discharge to the Odor Control Plant:

- Wet Feedstock Reception Buildings
- Wet Feedstock Reception Bins
- Wet Feedstock Silos
- Dryers
- Dried Feedstock silos
- Pelletizers

The Biotrickling Filter, the Chemical Scrubbers and the Carbon Polishing Filter are closed systems with a stack at the outlet of the Carbon Polishing Filter releasing the treated gas to the atmosphere. This will be one of two emission points of air emissions from this facility.

Proposed Efficiency of the Odor Control System	
Ammonia	99% biofilter
Hydrogen Sulfide	99.5% across biofilter, scrubbers and carbon adsorber

The height of the biotrickling filter will be 46.8 feet from ground level to the top of the discharge stack. Both scrubbers will be 26.6 feet in height. The carbon filter will be approximately 14 feet in height. Total length of the air pollution control train will be approximately 88 feet.



From Application page 177/226 – The unit on the left is the Carbon Filter, the two units in the center are the Scrubbers and the tall unit on the right is the Biotrickling Filter. The gas will first travel through the Biotrickling Filter then through the scrubbers and followed by the carbon filter.

BIOTRICKLING FILTER (BTF)

From BioAir – application page 194/226: The performance of the biotrickling filter "**DOES NOT HAVE A SIGNIFICANT OUTCOME ON THE CONCENTRATION OF COMPOUNDS AT THE OUTLET STACK"** because there are three additional downstage treatment processes. The primary purpose of the biotrickling filter is to reduce the concentration of odorous compounds that reach the downstream stages in order to reduce the chemical and water consumption.

Odor Control Plant - Biotrickling Filter Specifications (BTF)	
~~Make:~~	~~BioAir EcoFilter~~
~~Model:~~	~~EF137~~
Maximum Flow Rate:	14054 acfm @75F 13630 scfm
Scrubbing Liquid:	water
Water flow rate:	3.14 gal/min
Make-up rate if recirculated:	Not applicable
Packing type:	EcoBase structured, synthetic
Depth of bed:	29 feet
Volume of media bed:	3946 ft^3
Gas inlet temperature:	88.3°F
Gas outlet temperature:	75°F

Amount collected of liquid waste stream:	4521.6 gal/day
Ultimate disposition of collected material:	Discharged to the municipal sewer system

The proposed biotrickling filter uses biological technology with proprietary structured synthetic filter medium that will grow a colony of microorganisms to metabolize hydrogen sulfide (H_2S), ammonia (NH_3), volatile fatty acids, select VOCs and a wide range of odorous compounds.

The synthetic media features much greater surface area than that of organic media materials like peat moss or wood chips. Higher specific surface area means higher microbial density, which in turn leads to higher odor treatment.

The odorous air will travel upward through the vessel and pass through the microorganism containing media layers. Water containing nutrients for the microorganism, travels downward through the vessel sustaining the microorganism's environment and rinsing the byproducts of metabolized compounds (metabolic sulfate or generated salts) toward a drain in the reactor. The BTF is designed as a once-through, non-recirculating system. Biotrickling filters do not recirculate water. The drained water will pass from the sump in the bottom of the reactor vessel and be piped to a discharge point.

The BTF facilitates the growth of aerobic bacteria, allowing the oxidation and removal of both organic and inorganic odors in a single reactor. The aerobic bacteria can be either **acidophiles** or **neutrophiles.**

> **Acidophilic** bacteria thrive in acidic environments (with a pH of around 2.0 or lower). For example, H_2S oxidation is carried out by acidophilic bacteria that produce acidic by-products. The Thiobacillus bacteria convert H_2S to sulfuric acid in the presence of oxygen, thereby gaining energy for cellular growth and reproduction (metabolism). This is the same bacteria that cause corrosion inside sewer pipes and manholes due to the sulfuric acid (H_2SO_4) that the bacteria produce. The pH is lower near the bottom of a media bed because the sulfuric acid drips downward. At this low pH, acidophilic species of bacteria will thrive. See Figure 9.
>
> **Neutrophilic** bacteria prefer neutral environments and will thrive at the top of the bed due typically around neutral (pH 7.0). Neutrophilic bacteria is primarily responsible for VOC removal.

These bacteria can also be either **autotrophic** or **heterotrophic**.

> **Autotrophic** bacteria use the gaseous CO_2 in the air as their carbon source for cell growth. Examples of odors eliminated in this way are ammonia (NH_3) and hydrogen sulfide (H_2S).
>
> **Heterotrophic** bacteria obtain energy and nutrients from organic compounds produced by other organisms, rather than creating their own food . **Heterotrophs** consume organic odor compounds such as methyl mercaptan (CH_3SH), dimethyl sulfide ($(CH_3)_2S$) and dimethyl disulfide ($(CH_3)_2S_2$). They also consume volatile organic compounds (VOCs).

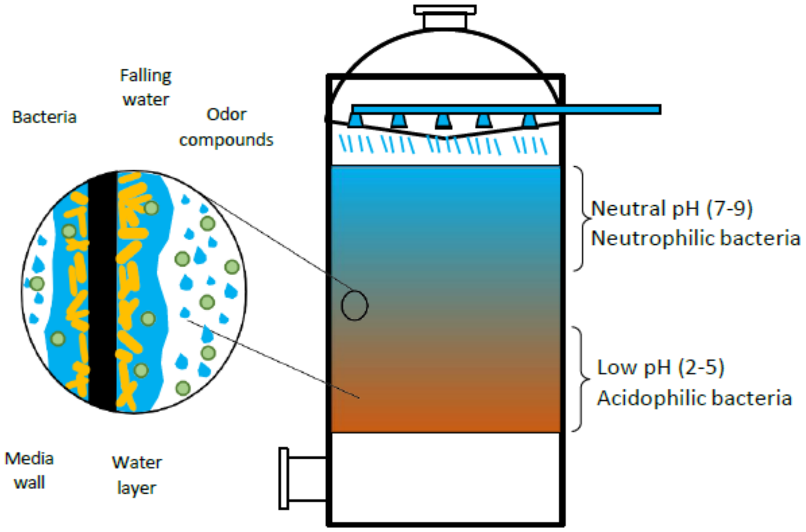


Figure 9: Biotrickling filter with pH zones and an enlargement depicting the dissolution of odor compounds into water at the surface of the media for bacteria to treat.

Temperature of Process Ventilation Air Entering Biotrickling Filter

A question was raised during the preliminary meeting between OAR and QSSB concerning the operating temperature of the Biotrickling Filter due to the system being located outside exposed to the elements. Of concern was the health of the biological organisms that typically require a moderate temperature to sustain life.

> QSSB responded with the following:
> The Wet Feedstock Reception Buildings are the main contributors to the total airflow going to the Odor Control Plant. During cold periods the inlet air to the Wet Feedstock Reception Building will be heated to ensure this airstream is kept above freezing. In addition, the air streams from the dryers and the pelletizers will be warm and contribute to keeping the total flow of process ventilation air within the desired interval. This, together with the tank design will ensure that the Biotrickling filter will have a good working environment for efficient treatment. During detail engineering these details will be re-visited, and the need to insulate ducting etc., will be further explored.

CHEMICAL SCRUBBERS

Following the BioTrickling Filter the airstream is then vented to packed-bed chemical scrubbers, which will further treat the odorous compounds remaining after the BTF. The packed-bed scrubbers will contain polypropylene packing material designed to increase the transfer of the contaminants from the gas phase into the liquid phase. This is mainly possible due to the very high active specific surface area.

The airflow will first travel through acid scrubber, effectively reducing ammonia, amines and other nitrogen-based compounds. The wet scrubbing liquid in the acid scrubber is Sulfuric acid (H_2SO_4).

The airflow will then travel through the caustic scrubber, which will treat any remaining H_2S, methyl mercaptan, dimethyl sulfide, other VOCs, and acidic gases, as well as volatile fatty acids. The caustic scrubber will use both Sodium Hydroxide (NaOH) and Sodium Hypochlorite (NaOCl).

The scrubbing liquid is sprayed down over the media as impacted air is forced upward. The packing media increases the surface area for reaction with the odorous compounds. The scrubbing liquid will be recirculated with the ability to add make-up water if necessary. The liquid waste streams from the scrubbers will drain and discharge to the sewer system. The scrubbed air is released through a vent at the top of the caustic scrubber and discharged to the third unit; a Carbon Polishing Filter.

Odor Control Plant - Scrubber System Specifications		
~~Make:~~	~~BioAir Qimi~~	
~~Model:~~	~~CS67~~	
	Acid Scrubber	Caustic Scrubber
Scrubbing Liquid Composition:	H_2SO_4	NaOH / NaOCl
Scrubbing liquid flow rate:	0.005 gal/min	0.003 / 0.0135 gal/min
Recirculation flow rate:	154 gal/min	220 gal/min
Chemical feed flowrate:	0.32 gal/min	NaOH: 0.18 gal/min (25%) NaOCl: 0.81 gal/min (12%)
Injection rate:	60-100 psi	60-100 psi
Make-up rate if recirculated:	0.09 gal/min	0.07 gal/min
Amount collected of liquid waste stream:	63.137 gal/day	34.34 gal/day
Ultimate disposition of collected material:	Discharged to the municipal sewer system	
~~Packing type:~~	~~BioAir Qimi Media~~	
Depth of bed:	7.1 feet	
Packing surface:	14391 ft^2 (74 ft^2/ft^3)	
Gas inlet temperature:	75°F	
Gas outlet temperature:	75°F	
Gas volume through system:	14054 acfm, 13630 scfm @75F	

CARBON FILTER

Odor Control Plant - Carbon Adsorber Specifications	
~~Make:~~	~~BioAir EcoCarb~~

~~Model:~~	~~EB13D~~
Maximum Flow Rate:	14054 acfm @75F 13630 scfm
Volume of each carbon bed:	398.3 ft^3
Number of beds:	2
Diameter of each bed:	13 feet
Depth of each bed:	3 ft
Adsorption capacity of carbon:	19 lbs H_2S/100 lbs carbon
Gas inlet temperature:	75°F
Gas outlet temperature:	75°F
Stack interior diameter:	3 ft
Stack height above ground:	54 ft
Is stack equipped with rain hat:	No
Distance from discharge to nearest property line:	180 ft

The final stage of treatment will further polish remaining odorous compounds using a vapor phase carbon adsorption system. This is a two vessel carbon bed configuration in series. The air enters the system and flow through the adsorptive media layer before being discharged into the atmosphere. Compounds are adsorbed by the large specific surface area provided by the media.

The types of media selected for this project include:

1. A catalytic activated carbon with high H_2S adsorption. This media is also effective at adsorbing various types of reduced sulfur compounds.
2. Potassium permanganate ($KMNO_4$)-impregnated media which will react chemically with sulfur compounds, volatile fatty acids, and some other VOCs.
3. A general-purpose carbon capable of adsorbing nearly all odorous compounds and VOCs.

The applicant also states that the carbon bed is not designed for ammonia reduction however, ammonia levels are anticipated to be relatively low and are modeled with odor detection in mind. (see page 65/266 letter from VOW) The airstream is then released to the atmosphere via the exhaust stack at the top of the carbon unit.

THE PYROLYSIS REACTORS

The pyrolysis plant will be two independent Pyrolysis Reactors. The two parallel reactors ensure flexibility on the desired flow of the system and redundancy. The Pyrolysis Reactors operate at a slight under-pressure to ensure that any potential minor leaks do not result in the release of process gas to the environment in the production facilities. Electricity will provide the heat source for the reactors.

The Dried & Pelletized Feedstock will be transferred to the Pyrolysis Reactor through an infeed system consisting of:

1. Infeed screw
2. A bucket conveyor to lift the Pelletized Feedstock from the Pelletizer to the Pelletized Feedstock hopper. The hopper is used to ensure small buffering volume for a steady and continuous flow into the Pyrolysis Reactor.
3. An air-lock system to ensure that there will be no air ingress into the Pyrolysis Reactor from the feed-side.
4. Inclined screw with a water lock for fire suppression purposes

Either hopper can feed both pyrolysis reactors. The Feedstock enters the reactor at one end through a screw conveyor. No emissions are expected from the Pyrolysis Infeed System, as this will be a closed system. The Feedstock is conveyed through the reactors by rotation of the drum and remains in continuous contact with the heat source (rotating drum wall). The Feedstock is therefore heated in a uniform manner while passing through the reactor.

During pyrolysis, pyrolysis gas and biochar will be produced. The pyrolysis gas will be transferred in closed piping to the thermal oxidizers (applicant refers to this as Pyrolysis Gas Combustion System), followed by Heat Recovery and the Emission Control Plant.

The Pyrolysis Process is expected to operate in the range **1112-1382°F** (600-750°C). Residence time of the product within the reactor can be controlled by the rotation speed of the drum.

There are three main types of pyrolysis; namely slow, fast, and flash. Slow pyrolysis occurs at temperatures between 572 and 1382°F (300-750°C) with heating rates between 1 and 30 °C/min and residence times on the order of minutes to hours, which ultimately favors char production. Slow pyrolysis produces pyrolysis gas rich in carbon dioxide (CO_2), carbon monoxide (CO), and light hydrocarbons, depending upon the biomass utilized.

At temperatures >1202°F (650°C), hydrocarbon cracking leads to substantial production of pyrolysis gas and the breakdown of oxygen molecules produces CO_2 and CO, while tars and heavy hydrocarbons undergo vapor phase cracking and reforming processes, which produce ethylene (C_2H_4), methane (CH_4), and ethane (C_2H_6).

The high content of nitrogen and sulfur in sewage sludge can result in the formation of large amounts of NO_x and SO_x precursors, such as NH_3, H_2S, hydrogen cyanide (HCN), and carbonyl sulfide (COS), during pyrolysis of sewage sludge. Even small amounts of oxygen in the pyrolysis atmosphere can promote the formation of NOx. These compounds are precursors to NOx. Feedstocks like sewage sludge are high in sulfur and can lead to substantial SOx emissions during pyrolysis. The presence and amount of sulfur dioxide in the emissions depend on the sulfur content of the material being pyrolyzed. Sewage sludge is a known sources of sulfur that can lead to SO_2 emissions. The main sulfur species analyzed in the gas were H_2S (hydrogen sulfide), COS (carbonyl sulfide) and CH_3SH (methanethiol).

Thermal- and fuel-bound mechanisms produce NO_X in thermal processes, with the former being insignificant at temperatures less than 2000°F (1,093°C) when processing sewage sludge. The fuel-bound mechanism requires oxygen in the presence of N in the sludge to produce NO_X. Fuel-bound N primarily converts to N_2 and ammonia. Pyrolysis systems may also sequester some N in the char, limiting NO_X emissions.

The inherent oxygen within the biomass feedstock leads to carbon dioxide (CO_2, a greenhouse gas) formation as a major gaseous product during pyrolysis, although the amount and specific gases emitted depend on factors like the feedstock type, operating temperature, and whether the gas is subsequently combusted.

The majority of the gas from sewage sludge pyrolysis comprises of CO_2, H_2, CO and CH_4. CO_2 content usually decreases and the CH_4 content tends to first increase and then decrease with the rise in temperature.

The Pyrolysis System is designed to minimize the air ingress to the Pyrolysis Reactor. This is ensured by having an airlock on the Pyrolysis Infeed System and a second airlock after the Biochar Cooling Screw.

The gas stream produced by the reactors will discharge to the thermal oxidizers. The pyrolysis process exhaust temperature is approximately 334°C (633.2°F).

- **The applicant is proposing to be limited to a dry feedstock rate of 6614 lbs/hr at 10% MC (3000 kg/hr) to each reactor.**

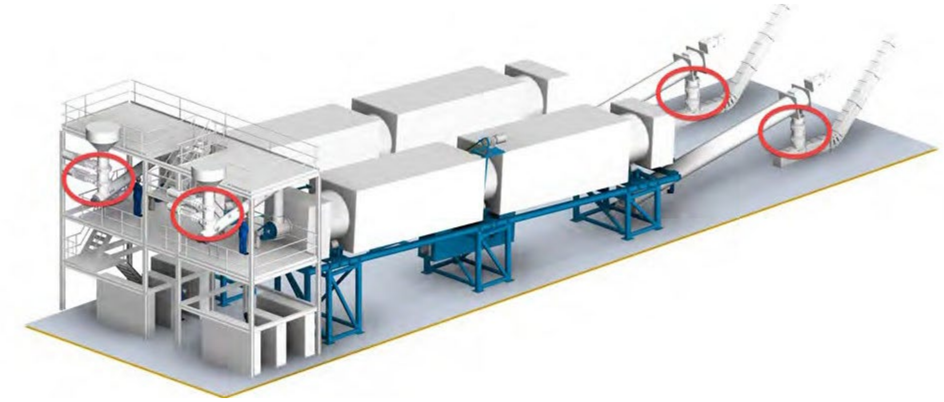


Illustration of feedstock infeed system, pyrolysis reactors and biochar outfeed system. Airlocks indicated by red circles.

THERMAL OXIDIZERS - Pyrolysis Emission Control Plant

Two thermal oxidizers will be installed, each dedicated to one pyrolysis reactor. A thermal oxidizer is an air pollution control device used to treat and remove volatile organic compounds (VOCs), hazardous air pollutants (HAPs), and other compounds. They will operate on Pyrolysis Gas, Natural Gas or any combination of both. During initial system start-up, the thermal oxidizers operate on natural gas until the system has met the temperature requirements and pyrolysis gas can be utilized as the heat source.

Recirculation of treated flue gas from the thermal oxidizer will help to control the temperature and minimize the formation of thermal NOx. After the exhaust travels through the heat recovery unit and the following catalytic filter, the flue gas will be recirculated back to the thermal oxidizers.

After being combusted in the presence of oxygen, NO_x and SO_x precursors from the pyrolysis gas such as NH_3, HCN, H_2S and carbonyl sulfide (COS), could be further converted into NO_x, N_2O, and SO_x. Sulfur is the other element of concern in the gas, mainly due to its oxidation to SO_2 during the combustion process.

The application states the thermal oxidizers are comprised of three (3) zones:

1) a reducing zone operating between 1832°F - 2400°F (1000°C - 1315°C);
2) a conditioning zone;
3) and a final oxidation zone where air is added to bring the products of combustion up to 1832°F (1000°C).

Online sources state "the reducing zone, reduces nitrogen at high temperature to molecular nitrogen without forming NOx. The conditioning zone quenches the gas with recycled flue gas to freeze the equilibrium prior to oxidation of the remaining products with air in the oxidizing zone".

The oxidizers are each equipped with a baffled burner. The burners are rated at 42.2 MMBtu/hr (44.50 GJ/hr) HHV on Pyrolysis Gas, and 38.6 MMBtu/hr (40.75 GJ/hr) HHV on Natural Gas. Information provided from online sources state *"Baffle burners consist of a body, gas nozzle, baffle, and port. Baffle burners recirculate furnace exhaust gases into the combustion envelope to limit peak flame temperatures resulting in reduced* NO_x *formation. Baffle burners can run on many types of gaseous and liquid fuels, and they are often designed for multifuel compatibility to increase flexibility for users. Combustion air enters the burner body and is separated from the fuel, which passes through the body inside a fuel tube, until mixing immediately after the baffle. Because fuel and air are not mixed until they exit the hot side of the baffle, flashback is minimized allowing for high turndown and application to fuels with high flame speeds such as hydrogen. The refractory baffle separates and protects the gas nozzle and burner body from the furnace's thermal radiation, yielding long service life with minimal maintenance."*

The thermal oxidizers will be provided with an emergency vent stack to divert exhaust directly to atmosphere upon loss of plant power/ mechanical failure. The emergency vent is only activated in emergency situations to avoid equipment damage or life-threatening conditions after a multi-point failure.

Thermal Oxidizer Specifications			
~~Manufacturer:~~	~~Process Combustion Corp. (PCC)~~		
~~Model:~~	~~TO-4500-PYR~~		
~~Burner Make:~~	~~Bloom Engineering~~		
~~Burner Model:~~	~~1030-031-DFS~~		
Inlet gas temp:	1382°F		
Heat content of pyrolysis gas:	34.2 Btu/scf		
Halogenated organics:	YES		
	Combustion Chamber		
Chamber Volume:	1,241 ft^3		
Excess Air	10.2%		
Operating Temp:	1832°F		
Gas volume from each pyrolysis:	8,766 scfm		
Maximum gas volume through system:	37,910 acfm @ 1832°F		
Residence Time:	2.0 seconds		
Flame Failure Control	Yes		
Heat		Heat Input Capacity	Firing Rate
	Pyrolysis gas	42.2 MMBtu/hr	2.468 MMcf/hr (@34.2 Btu/cf)
	Natural gas	38.62 MMBtu/hr	0.0379 MMcf/hr (@1020 Btu/cf)

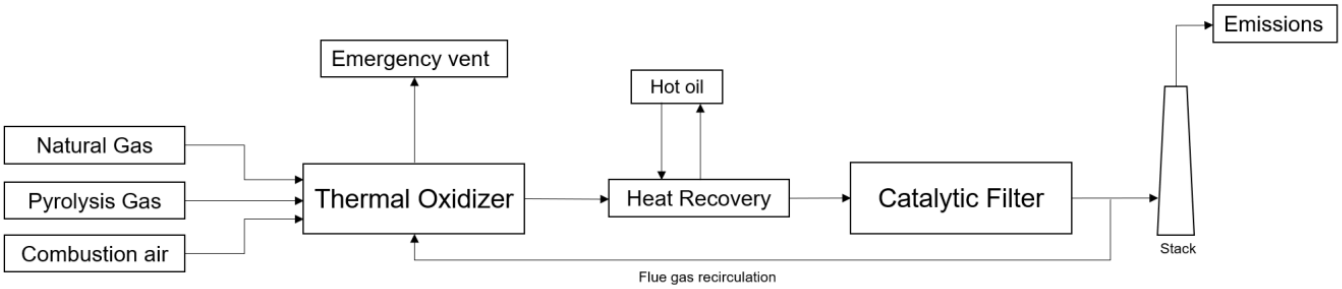
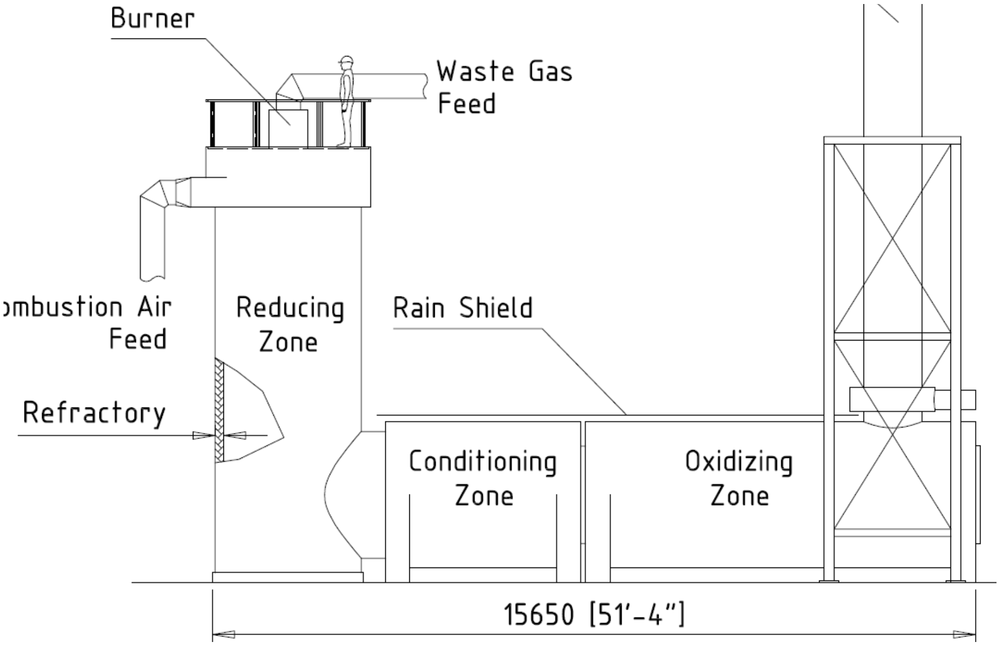


Figure 12 Pyrolysis Gas Combustion System



RESIDENCE TIME

The applicant states the thermal oxidizers will operate with a minimum residence time of 2 seconds.

Volume of combustion chamber x 1/acfm x 60 sec/minute = residence time

1,241 cf x minute/37,910 cf x 60 sec/minute = 1.96 seconds

Note: the chamber volume given in the application form was for both oxidizers. The calculation above is for one oxidizer. The applicant also listed many of the parameters for the equipment on the application forms for multiple devices combined. I have attempted to only record the parameters for a single unit.

Natural Gas

Natural gas will be supplied to the site by local utility on a metered service with the pressure and flow rate to be determined by the utility. If required, a booster station will be installed to maintain the pressure and flow to the plant. Approximately 0.0335 MMcf/hr (950 Nm^3/hr) of natural gas is expected to be used in one thermal oxidizer for approximately 24 hours during cold start-ups of the system. The initial start-up of the system will require 24 hours operation on natural gas. In normal operation no use of natural gas is expected.

CATALYTIC FILTER

Ceramic Filter Specifications	
~~Make:~~	~~Tri-Mer~~
~~Model:~~	~~UCF-HE800~~
Maximum Flow Rate:	19,574 acfm @575F
Acid gas control:	Dry sorbent injection of hydrated lime

Injection rate:	58 lbs/hr
NOx Control:	Ammonia injection
Injection rate:	26.9 lbs/hr
Catalytic filters:	Ceramic filter tubes with embedded catalyst
Number of filters:	800
Method of cleaning:	Automatic: Reverse pulse jet
Gas volume through system:	38,221 acfm
Gas inlet temperature:	620°F
Gas outlet temperature:	575°F
Amount material collected per day:	3,767 lb/day

After the flue gas exits the heat recovery unit, it is passed to the Catalytic Filter for further treatment. The applicant refers to this as the Emission Control Plant in the application.

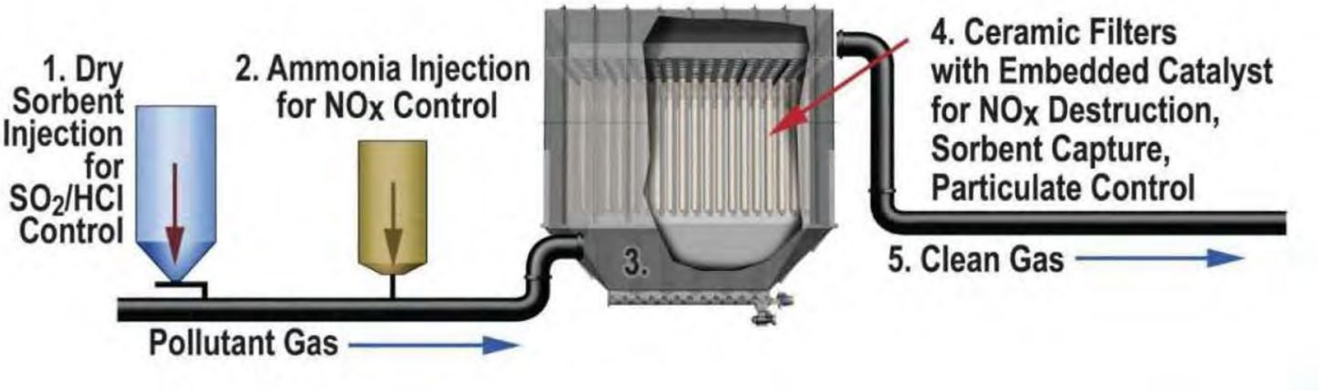
A high temperature ceramic/catalytic filter technology is selected to reduce pollutants such as NOx, SOx, HF and PM in the flue gas. The Catalytic Filter is designed with three modules: a dry sorbent injection system to reduce acid gases, an ammonia injection system for NOx reduction and the ceramic filters embedded with nano-bits of catalyst to reduce PM, NOx, organic HAPs and sorbent capture control. This technology is advantageous for its ability to control multiple pollutants in a single system. Two Catalytic Filters will be installed, each dedicated to a pyrolysis reactor/thermal oxidizer line.

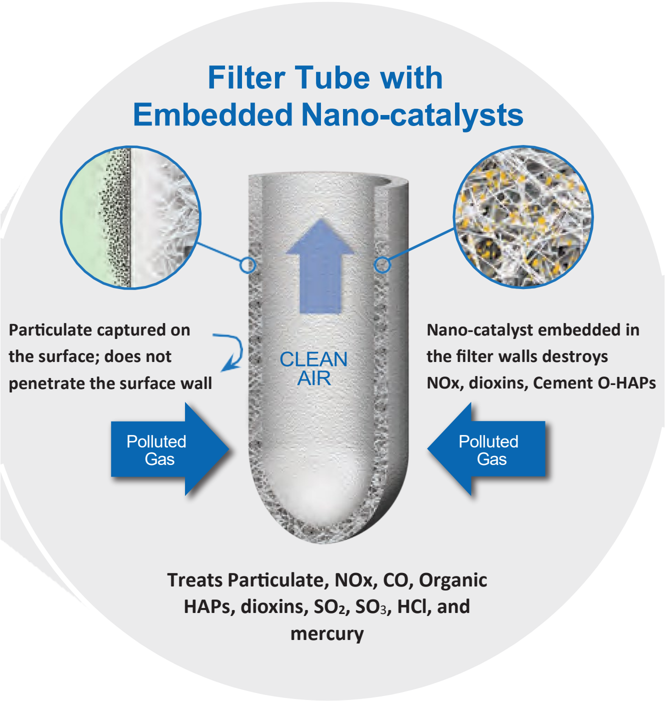
The system includes a bank of 800 self-supporting ¾" thick ceramic filter tubes with embedded catalyst. The unique structure of the filters captures process particulates on its outer surface, keeping it away from the nano-catalyst inside the filter walls. This prevents PM blinding and poisoning of the catalyst and greatly extends the catalyst life.
Filter life is 5-10 years and performs the following duties:

1. Acid Gas Control: The system will have a dry sorbent injection of hydrated lime (calcium hydroxide, $Ca(OH)_2$) to remove SO_2, SO_3, HCl and HF. Powdered hydrated lime will be injected upstream of the filters and the reaction by-products are captured as particulate at the filters. The SO_2 removal reaction occurs within the duct leading to the filters and at the sorbent cake that accumulates on the surface of the filters. The chemical reaction of the sorbent with the acid gas creates a solid particle that is captured on the filters, along with the unreacted sorbent and the process particulate. The temperature range for effective removal is 300°F to 1600°F.

2. NOx Control: NOx will be controlled by injection of ammonia (NH_3) upstream from the catalytic filter. The catalytic filter facilitates the selective catalytic reduction (SCR) of NOx by NH_3. The large reactive surface area of the catalyst produces a NOx removal at temperatures lower than standard SCR and good results start at 450°F (232°C).

3. Particulate Control: The filter removes particulates from gas sources above 302°F (150°C), including PM_{10}, $PM_{2.5}$, and submicron. Heavier loadings require more frequent pulse-jet cleaning of the filters, but outlet levels remain the same as traditional bag filters. The collected dust will be removed by a screw conveyor to a dust collection station. The dust will be deposited in a bag through enclosed piping.





Each Catalytic Filter will have an individual flue gas discharge stack, but both will combine into a single stack exiting the facility. Stack information is provided in modeling analysis section of this review.

The size of the equipment is much larger than usual:

- Each catalytic filter will be approximately 37.5 feet tall with four compartments. Each compartment will have a 3.33 foot diameter circular outlet duct exiting from the top and a 6.83 x 1.95 foot rectangular inlet duct entering at the lower side.
- The dry sorbent injection silo will be 37.6 feet tall, 12 feet wide, and will have a volume of 2,250 ft^3 or 16,831 gallons.

Heat Recovery

The flue gas leaving the Thermal Oxidizers will pass through a heat recovery device, which heats a heat transfer fluid (thermal oil, Therminol 66) for process heating purposes. The main consumers of the recovered heat are the Wet Feedstock dryers. The thermal oil is heated to 500°F (260°C). The thermal oil system is a closed loop, and no air emissions are expected from this stage. The flue gas leaving the heat recovery unit is directed to the Catalytic Filter (Emission Control Plant) for further treatment.

During initial start-up of the system, process derived heat from the pyrolysis process will not be available for the dryers. The thermal oil system will, under these circumstances, be heated by natural gas until the pyrolysis process is reliably supplying heat to the thermal oxidizers.

Biochar

The biochar will exit through a chute in the lower end of the pyrolysis reactors and will enter the Biochar Cooling Screw.

A cooled screw conveyor is used to cool the biochar from the pyrolysis temperature to <140°F (60°C). The cooler is equipped with the possibility for nitrogen purging and a water spray system for moisturizing the biochar to the required humidity for safe storage and handling, and emergency fire-fighting purposes. At the outlet of the cooling screw there is an airlock, ensuring no air ingress into the system. The cooling screw is air and dust tight. The Biochar Cooling Screw is a closed process, **and no air emissions are expected from this stage**.

After cooling and moisturizing, the biochar is transported with closed chain conveyors to the Biochar Logistics Station. The Biochar Transport Screw is considered a closed system **with no air emissions to the surrounding area**.

A big bag packing station will be used for packaging and storing the biochar. A distribution screw will be used between the stations, and automated valves will ensure correct filling of each big bag. The bags will be blanketed with nitrogen and sealed to avoid evaporation of the water and air ingress. The packing station will be in a separate building. The packing station is considered a closed system with no air emissions expected from this stage.

EMISSIONS

The applicant analyzed Criteria Pollutants, all 260 RI Listed Toxic Air Contaminants, and Green House Gases (GHG) for the possibility to emit from the sewage sludge treatment operations and from the pyrolysis/thermal oxidizer operations. Possible sources of their evaluation came from the following; testing of pyrolysis gas from the National Renewable Energy Lab (NREL), various research publications, experimental data conducted by Vow, and feedstock analysis.

All of the Criteria Pollutants and the GHG pollutants, Carbon Dioxide (CO_2), Methane (CH_4) and Nitrous Oxide (N_2O), are expected to be emitted. Out of the 260 Toxic Air Contaminants, 214 pollutants were not expected to be emitted from the facility. Some of the justifications include compounds decomposing under pyrolysis conditions; formation highly unlikely; formation requires special conditions; readily reacts and converts to other compounds under pyrolysis conditions; and miscellaneous other conditions that would preclude that compound being emitted. See Appendix A of this technical review for three tables that summarizes the reasons why they were eliminated as given by the applicant. The spreadsheet provided by the applicant includes much more information per pollutant (in most cases), including links to research articles and reports.

Of the 260 Air Toxic Contaminants, 46 could possibly be emitted. The applicant developed the emission rates from the various sources as noted above. The emission rates was evaluated based on the maximum hourly throughput of each emission source and scaled to 8760 hours/year for comparison to the Minimum Quantities (MQ) of Part 9, Appendix A. Of the 46 pollutants, 25 pollutants exceeded the respective Minimum Quantities (MQs), and air dispersion modeling was required to demonstrate compliance with the Acceptable Ambient Levels (AALs) of Part 22.

Also note that the applicant evaluated Criteria Pollutants as well as HAP emissions from firing natural gas in the oxidizers at 8760 hrs/yr.

EMISSIONS FROM THE ODOR CONTROL PLANT

Below is a table of the emission rates expected from the Odor Control Plant. The applicant based the Dryer emissions on lab analysis conducted by the supplier from a sludge drying plant (digested sludge) in Norway, and used this analysis data, along with some estimations for the RI sludge and process conditions (considering temperature variations and sludge type). The applicant also does not expect any mercury, PCB, or PCDD/F emissions from this low-temperature drying process 212°F (100°C). HAPs were identified by a lab analysis from the dryer supplier.

Although the applicant used a VOC removal efficiency of 75% for the Odor Control Plant, they expect the removal efficiency to be higher and a safety factor of 2 has been used for VOC emissions from dryer to account for sludge variation. (The applicant multiplied styrene and xylene by 0.02; assuming that was a mistake, I multiplied by 2 and used that value going forward. It did not change the outcome of the modeling. QSSB was notified of this error and corrected it in their revised spreadsheet). An exception to the VOC 75% removal efficiency is for Carbon disulfide which is the same as for H_2S at 99.5%.

The emission rates from various processing units are combined below. The applicant provided a breakdown of these emission rates and their assumptions in their spreadsheet. The emission rates for H_2S and NH_3 were given in grams/hour, and were just numerical values, i.e. not source linked in their spreadsheet.

Particulate Matter Issues with the Odor Control Plant

The particulate matter emissions rates from the Odor Control Stack in the applicant's spreadsheet were based on an uncontrolled emission rate of 5 mg/m^3 which resulted in a controlled emission rate of 1.37E-04 lb/hr at 99.95%. The applicant then proposed in their draft permit to be limited to 20 mg/m^3. In an email to QSS on September 22, 2025 I requested additional information as to why the proposed emission rate in their proposed draft permit was 20 mg/m^3 while their application stated 5 mg/m^3. QSS responded in an email on November 3, 2025 that the PM emission rates from the Odor Control Plant were design criteria.

In QSSB initial application the applicant stated that PM would be reduced by 99.95%. a draft permit was supplied to QSS on 11/7/25, which contained an emission rate of 1.37E-04 lb/hr plus stack testing requirement for efficiency at 99.95%. QSSB responded in an email on 12/9/25, that they would not be able to meet the control efficiency in a stack test and that the 99.95% number is an overall efficiency taking into account that the PM loading to the Odor Control Plant is already reduced by the integral control devices to be equipped on the dryers, dry feedstock silos and the pelletizers. To meet the manufacturer's particulate matter loading requirement to the Odor Control Plant, the dryers will be equipped with integral cyclone, and filters will be equipped on the dry feedstock silos and the pelletizers. The cyclone and the filters are considered inherent to the design for exhaust conditioning and are not considered an air pollution control devices for permitting purposes under RI Part 9.

Therefore, QSS withdrew its claim for any reduction efficiency across the Odor Control Plant and the emissions now are considered uncontrolled.

Breakdown of H_2S Emissions from Odor Control Plant - 99.5% reduction						
	Uncontrolled			**Controlled - MQ: 10 lbs/yr**		
Processing Unit:	lb/hr	lb/day	lb/yr	lb/hr	lb/day	lb/yr
Receiving Station Enclosure & Bins	0.092	2.20	804.75	4.59E-04	0.0110	4.02
Wet Sludge Silo	0.747	17.92	6,542	3.73E-03	0.0896	32.71
Dryers & conveyors	0.358	8.60	3,140	1.79E-03	0.0430	15.70
Dried Sludge Silo	2.84E-03	0.068	24.91	1.42E-05	3.41E-04	0.1246
Pelletizer and conveyors	8.20E-03	0.197	71.84	4.10E-05	9.84E-04	0.3592
TOTAL	**1.208**	**29.00**	**10,584**	**6.04E-03**	**0.1450**	**52.92**

Breakdown of NH_3 Emissions from Odor Control Plant – 99% Reduction						
	Uncontrolled			**Controlled - MQ: 300 lbs/yr**		
Processing Unit:	lb/hr	lb/day	lb/yr	lb/hr	lb/day	lb/yr
Receiving Station Enclosure & Bins	0.046	1.11	403.82	4.61E-04	0.011	4.04
Wet Sludge Silo	0.375	9.00	3,284	3.75E-03	0.0900	32.84
Dryers & conveyors	2.39	57.40	20,949	0.0239	0.5740	209.49
Dried Sludge Silo	0.014	0.344	125.53	1.43E-04	3.44E-03	1.26
Pelletizer and conveyors	4.12E-03	0.099	36.11	4.12E-05	9.89E-04	0.3611
TOTAL	**2.83**	**67.94**	**24,799**	**0.0283**	**0.6794**	**247.99**

Emissions from Odor Control Plant					
Pollutant	**Uncontrolled**		**Removal Efficiency**	**Controlled**	
	lb/yr	tpy		lb/yr	tpy
PM, PM10, PM2.5	2400	1.200	0%	--	--
Ammonia (NH_3)	24,799	12.40	For modeling purposes, control efficiency not applied		
Hydrogen sulfide (H_2S)	10,584	5.29	99.5%	52.92	**0.0265**
VOCs					
Carbon disulfide	0.5226	2.61E-04	99.5%	2.61E-03	1.31E-06
2-Butanone (MEK)	4.26	2.13E-03	75.0%	1.06	5.32E-04
Styrene	0.2986	1.49E-04	75.0%	0.0747	3.73E-05
Toluene	0.1493	7.47E-05	75.0%	0.0373	1.87E-05
p-Xylene	0.1493	7.47E-05	75.0%	0.0373	1.87E-05
Controlled VOCs Combined (TPY):					**6.08E-04**

- **QSSB is not taking credit for the control of NH_3 for modeling purposes, therefore the uncontrolled NH_3 emission rates from the Odor Control Plant were used in the modeling analysis, although it is expected that NH_3 will be reduced by 99%.**

EMISSIONS FROM THE ENTIRE FACILITY FOR TOXIC AIR CONTAMINANTS

During the technical review of this application a request was made by Quonset Soil Solutions, a sister company of QSS BioSolids for a problem concerning stack testing at the pyrolysis biochar facility also located in North Kingstown, that was permitted under Approval Nos. 2552-2563 on 15 May 2023. The construction of the pyrolysis and thermal oxidizers at this plant were not built as designed in the permit application and due to several issues, the efficiency of those thermal oxidizers to achieve 99.9 percent control could not be measured. Specifically, the pollutants entering the oxidizer could not be measured therefore the control efficiency could not be determined as required in the permit. The permit only required the VOC control efficiency to be measured. It was therefore decided to not require the VOC control efficiency to be measured and require Quonset Soil Solutions to measure various VOC contaminants to demonstrate compliance with the emission rates proposed in the application using the 99.9 efficiency.

This problem resulted in QSS BioSolids to also state that the control efficiency in the proposed application could not be measured due to the same problems. The VOC control efficiency for this project from the pyrolysis plant was proposed as 99.99%. Because the proposed control efficiency is so high, it was requested that QSSB obtain a performance guarantee in writing from the manufacturer for 99.99%. On December 1, QSS responded in an email that the vendor will only guarantee an efficiency of 99.9%. This changed the potential to emit for various VOCs from the Pyrolysis Control Plant and resulted in increased emission rates. In addition, the emission rates of Acetaldehyde and Phenol now exceeded the Minimum Quantity. An air dispersion modeling analysis was repeated and submitted on December 9, 2025.

Twenty-five pollutants require modeling.

46 POLLUTANTS THAT COULD BE EMITTED BY THE FACILITY

	Pollutant	Notes	Pyrolysis Gas	Pyrolysis Gas ASPEN	Natural Gas Emissions	Odor Control Stack	Facility Combined Total		MQ	Modeling Required?
			tpy	tpy	tpy	tpy	tpy	lb/yr	lb/yr	
1	Acetaldehyde	3	0.0634				0.0634	126.86	50	YES
2	Acetamide	3	1.010				1.010	2,019.90	5	YES
3	Acetone	3	0.0459			6.81E-04	0.0466	93.14	NA	NO
4	Ammonia (NH$_3$)	1		1.211	1.387 (ASPEN)	12.40	14.998	29,995.28	300	YES
5	Aniline	3	0.1150				0.1150	230.04	3	YES
6	Antimony		5.54E-03				5.54E-03	11.07	0.6	YES
7	Arsenic		4.53E-04		6.63E-05		5.19E-04	1.04	0.02	YES
8	Barium		0.0166		1.46E-03		0.0180	36.02	2000	NO
9	Benzene	3	0.0967		6.97E-04		0.0974	194.87	10	YES
10	Beryllium – nat gas				3.98E-06		3.98E-06	7.96E-03	0.04	NO
11	Biphenyl		6.24E-03				6.24E-03	12.49	600	NO
12	Boron and borates		2.12E-03				2.12E-03	4.25	4	YES
13	Cadmium		3.47E-04		3.65E-04		7.12E-04	1.42	0.07	YES
14	Carbon Disulfide – odor					1.31E-06	1.31E-06	2.61E-03	2000	NO
15	Carbonyl sulfide		0.0197				0.0197	39.34	70	NO
16	Chromium III		2.00E-03		4.64E-04		2.47E-03	4.93	20000	NO
17	Cobalt		1.87E-04		2.79E-05		2.14E-04	0.4288	0.1	YES
18	Copper		0.0281		2.82E-04		0.0284	56.78	40	YES
19	Cresols/Cresylic	3	0.2229				0.2229	445.75	20000	NO
20	Ethyl benzene	3	0.0569				0.0569	113.77	9000	NO
21	Fluorides + HF	4	1.197	1.76E-03			1.199	2,397.09	7	YES
22	Formaldehyde – nat gas				0.0249		0.0249	49.76	9	YES
23	Glutaraldehyde		2.60E-03				2.60E-03	5.20	9	NO
24	Hexane	3	0.1435		0.5971		0.7406	1,481.12	20000	NO
25	Hydrochloric acid (HCl)		0.8586				0.8586	1,717.14	700	YES
26	Hydrogen bromide		0.1075				0.1075	214.90	2000	NO
27	Hydrogen cyanide		1.0028				1.0028	2,005.58	100	YES
28	Hydrogen sulfide (H$_2$S)		0.2232			0.0265	0.2496	499.23	10	YES
29	Lead		5.05E-03		1.66E-04		5.21E-03	10.42	0.9	YES
30	Manganese		0.0275		1.26E-04		0.0276	55.20	0.2	YES
31	Mercury		0.0416		8.62E-05		0.0417	83.43	0.7	YES
32	Methyl ethyl ketone	2				5.32E-04	5.32E-04	1.06	4000	NO
33	Molybdenum		6.57E-04		3.65E-04		1.02E-03	2.04	60	NO
34	Naphthalene	3	0.0824		2.02E-04		0.0826	165.19	3	YES
35	Nickel		2.85E-03		6.97E-04		3.54E-03	7.09	0.4	YES
36	PCBs		4.05E-07				4.05E-07	8.10E-04	0.1	NO
37	PCDDs		1.90E-09				1.90E-09	3.80E-06	3.00E-07	YES
38	Phenol	3	0.1127				0.1127	225.30	30	YES
39	Propylene	3	0.6367				0.6367	1,273.48	36500	NO
40	Quinoline	3	0.0102				0.0102	20.38	0.1	YES
41	Selenium		8.95E-04		7.96E-06		9.03E-04	1.81	2000	NO
42	Styrene	3	0.2167			1.87E-05	0.2167	433.47	3000	NO
43	Toluene	3	0.3330		1.13E-03	1.87E-05	0.3342	668.38	1000	NO
44	Vanadium		5.52E-04		7.63E-04		1.32E-03	2.63	0.07	YES
45	Xylene	3	0.0879			3.73E-05	0.0879	175.82	3000	NO
46	Zinc		0.0339		9.62E-03		0.0436	87.12	3000	NO

Notes:

1. Ammonia –The applicant developed the emission rates based on feedstock analysis. The assumption includes that the total NH_3 and HCN produced can reach 80 wt% of raw nitrogen during sewage sludge pyrolysis. The analysis can be found in the applicant's spreadsheet under "Suppl. 2 Metals in gas" excel tab. Although NH3 emissions from the pyrolysis reactors were determined by the applicant under the "Pyrolysis Gas – HAP List" tab in their spreadsheet, NH# emissions were also predicted by ASPEN under the "Stack Emissions (Pyrolysis Gas)" tab. The emissions developed by the ASPEN model are more conservative than the HAP List tab, therefore the ASPEN rates were used for PTE.
2. 2-Butanone (MEK) – a RI Air Toxic Contaminant was not accounted for in the applicant's VOC total (under Odor Control Plant excel tab).
3. The applicant estimated these pollutants based on a stack test performed by the NREL on sewage sludge processed in a pyrolysis reactor (under "Suppl. 3 Pyrolysis Gas Testing" excel tab).
4. ASPEN provided an emission rate for HF from the pyrolysis plant (3.51 lb/yr). That emission rate was not added to the emission rates developed by QSS under the HAP List excel tab to be used in the modeling but if it was it have an insignificant contribution to the predicted impact. (See Stack Emissions (Pyrolysis gas) excel tab.

ADDITIONAL NOTES ON EMISSIONS FROM THE PYROLYSIS CONTROL PLANT

- The chlorine (Cl) present in the sludge will primarily result in HCl emissions from pyrolysis.

- The fate of metals through the process depends on whether they remain with the solid (char) or volatilize. Arsenic (As), Cadmium (Cd), Mercury (Hg), Selenium (Se), and Zinc (Zn) readily volatilize in the pyrolysis reactor. Beryllium (Be), Chromium (Cr), Copper (Cu), and Nickel (Ni) remain in particulate form. Therefore, control of their air emissions is dictated by capturing particulate matter (PM).

- The volatility temperature of lead (Pb) (1161°F in elemental form) may exceed the thermal reactor operating temperature in pyrolysis. The Pyrolysis Process is expected to operate in the range 1112-1382°F. Thus, Pb may remain with the char.

- A thermal oxidizer is used to oxidize products of incomplete combustion (PIC). Emissions of polychlorinated dibenzo-p-dioxins (PCDD) and polychlorinated dibenzofurans (PCDF)—a subset of VOCs—can likewise be expected to be generated. The overall emissions of PCDD/PCDF will, more importantly, be dictated by the thermal oxidizer performance and downstream conditions. It has been noted that PCDD/PCDF occurrence in thermal oxidizers, the formation of these compounds occurs at approximately 750°F (400°C). If these conditions persist downstream of the thermal oxidizer, PCDD/PCDF may reform and should be avoided where practical unless specific APC equipment is included to capture these compounds.

CRITERIA EMISSIONS

The applicant evaluated criterial pollutant emission rates from the facility from all operations. Criteria pollutants from the Odor Control Plant included Particulate Matter from the handling of the dried sludge, and VOC emissions from drying of the sludge. Criteria pollutant emissions from the Emissions Control Stack include emissions from the combustion of the pyrolysis gas and natural gas in the thermal oxidizers. All emission rates were evaluated for 8760 hours per year. None of the combined emissions for criteria pollutants from the facility exceed Major Source Thresholds or RI Modeling Thresholds.

In the table below for the Criteria Pollutants, the emission rates from the pyrolysis reactors were developed by the applicant using the process simulation software Aspen and those values were inserted into their spreadsheet.

Uncontrolled Criteria Pollutant (tpy)					
	PYROLYSIS STACK			ODOR CONTROL STACK	Total Facility Uncontrolled
Pollutant	Pyrolysis	Nat Gas	Total Pyrolysis	Odor Plant	
PM, PM10	707.20	2.519	709.721	1.199	710.918
PM2.5	707.20	2.519	709.721	1.199	710.918
CO	6.065	12.304	18.369	--	18.369
NOx	30.52	6.884	37.403	--	37.403
SO_2	244.28	0.1989	244.480	--	244.480
VOCs	3,216.50	1.823	3,218.325	2.43E-03	3,218.328

Controlled Criteria Pollutant (tpy)						
	PYROLYSIS STACK			**ODOR CONTROL STACK**		
Pollutant	**Uncontrolled**	**Control Efficiency**	**Controlled**	**Uncontrolled**	**Control Efficiency**	**Controlled**
PM, PM10	707.20	99.6	2.829	1.199	--	--
PM2.5	707.20	99.6	2.829	1.199	--	--
CO	6.065	0	6.065	--	--	--
NOx	30.52	80	6.104	--	--	--
SO_2	244.28	85	36.642	--	--	--
VOCs	3,216.50	99.9	3.217	2.43E-03	75	6.08E-04

Criteria Pollutant Summary – Controlled Emissions (tpy)							
	PYROLYSIS STACK		**ODOR CONTROL STACK**	**Combined Facility Total**	**Major Source Threshold**	**Modeling Threshold**	**Over Major Source or Modeling Threshold?**
Pollutant	**Pyrolysis Gas**	**Nat Gas**					
PM, PM10	2.829	2.519	1.199	6.547	250	15	NO
PM2.5	2.829	2.519	1.199	6.547	250	10	NO
CO	6.065	12.304	--	18.369	250	100	NO
NOx	6.104	6.884	--	12.988	50	25	NO
SO_2	36.642	0.1989	--	36.841	250	40	NO
VOC	3.217	1.823	6.08E-04	5.040	50	25	NO

GHG EMISSIONS

GHG emissions were based on combusting both pyrolysis gas and natural gas in the oxidizers. The applicant used Aspen to determining emission rates from the pyrolysis gas for Carbon Dioxide (CO_2). Methane and Nitrous Oxide emissions were calculated based on AP-42 emission factors.

The term tpy CO_2 equivalent emissions (CO_2e) shall be computed by multiplying the mass amount of emissions (tpy) for each of the greenhouse gases, by the gas's associated global warming potential published at 40 C.F.R. § 98, Table A-1, and summing the resultant value for each to compute a tpy CO_2e.

GHG Emissions (tpy)							
Pollutant	Pyrolysis Gas (Aspen)	Nat Gas (Aspen)	Nat Gas AP-42	Total	Global Warming Potential	GHGe Total	Major Source Threshold for Title V
Carbon Dioxide (CO_2)	49,989	37,028		87,018	1	87,018	
Methane (CH_4)			0.7629	0.7629	28	21.36	
Nitrous Oxide (N_2O)			0.7298	0.7298	265	193.39	
					TOTAL:	**87,232**	**100,000**

GHGe calculation:

$$\boldsymbol{Methane\ GHG_e = \frac{0.7629\ tons}{yr}\ x\ 28 = \frac{21.36\ tons}{yr}}$$

Preventative Maintenance for the Odor Control Plant Schedule

The applicant is proposing a planned scheduled preventative maintenance for the three components of the Odor Control Plant.

Routine maintenance stops are planned for the components of the Odor Control Plant and are to be scheduled during the annual shut-down of the plant. The applicant states, before the annual shut-down all Wet Feedstock will be processed, leaving the Wet Feedstock Reception Bin and the Wet Feedstock Silos empty. These are assumed to be the ventilation air streams with the highest concentrations of pollutants. This will minimize the pollutant load to the Odor Control Plant when maintenance is performed.

Carbon Filter Operating Only (Biotrickling Filter and Scrubbers under maintenance)

This is referred to Scenario #1 in the application. The planned maintenance will be scheduled for the Biotrickling Filter and the Scrubbers at the same time to last no more than 24 hours. The Carbon Filter will be the only air pollution control unit operating. According to the application it is primarily designed to treat H_2S. During this bypass scenario there will be reduced treatment for NH_3 compared to normal operation. Although because there will be reduced operations upstream, emissions rates are expected to be lower than normal. This bypass will only be engaged when the Carbon Polishing Filter needs to change the carbon bed. This is anticipated to happen for 1 day every year.

Biotrickling Filter and Scrubbers Operating Only (Carbon Filter under maintenance)

This is referred to Scenario #2 in the application. Planned maintenance will be for the Carbon Filter only while the Biotrickling Filter and the Scrubbers continue operating. During this maintenance both control devices will be bypassed directly to the Carbon Filter. Scheduled maintenance will not be longer than 24 hours in a three year period.

Emissions During Planned Maintenance

	H_2S		NH_3	
	lbs/hour	lbs/day	lbs/hour	lbs/day
Normal operation/Modeled emissions	0.00604 controlled	0.1450 controlled	2.83 uncontrolled	67.94 uncontrolled
Biotrickling Filter & Scrubbers Operating Only	0.006[a]	0.15[a]	0.0028[b]	0.068[b]
Carbon Filter Operating Only (primarily treats H_2S)	0.0012[b]	0.03[b]	3[a]	65[a]

[a] It is assumed that the applicant rounded the assumed emission rates to the emission rates presented in the application.

[b] It is assumed that the lower emission rates are due to lower input emission rates from the planned empty wet feedstock storage silos and the applicant applied the control efficiency to the NH3 emission rates while operating the Biotrickling Filter and Scrubbers only.

The modeled emission rates for NH_3 and H_2S are below the respective AALs for all time periods by the percentages shown in the table below.

Modeled Emission Rates Compared to AALs Percentage

	1-hour	24-hour	Annual
NH_3 (modeled uncontrolled)	13.98	47.73	11.43
H_2S	0.75	0.34	0.18

OPERATION AT CRITICAL FAILURE

The applicant also presented expected emission rates if a critical failure occurs causing a sudden full shut-down of the Odor Control Plant and detailed the steps that will be taken to reduce the impact to the surrounding environment. Also, the applicant detailed the steps to be taken if there is an emergency shutdown of the thermal oxidizers. The oxidizers will be equipped with an emergency vent stack to divert exhaust directly to atmosphere upon loss of plant power/ mechanical failure. These situations are considered a malfunction and will be addressed with our standard language in their permit.

Best Available Control Technology

Best available control technology (BACT) is required by the OAR for issuance of a minor source permit if the change proposed results in an increase in emission per 250-RICR-120-05-9.7.3(A)(1):

> A. *No person shall construct, install or modify or cause the construction, installation or modification of any minor stationary source described in §9.7.1 unless the following conditions are met:*
>
> 1. *A stationary source shall apply BACT for each pollutant it would have the potential to emit. A modification shall apply BACT for each pollutant for which there would be a net emission increase at the stationary source. In no event shall BACT be less stringent than any applicable emission rate contained in the Department's APC Regulations.*

BACT is defined under of 250-RICR-120-05-0.4(A)(8):

> *"Best available control technology" or "BACT" means an emissions limitation (including a visible emissions standard) based on the maximum degree of reduction for each air pollutant which would be emitted from any proposed stationary source or modification which the Director, on a case-by-case basis, taking into account energy, environmental and economic*

> *impacts and other costs, determines is achievable for such stationary source or modification through application of production processes or available methods, systems and techniques, including fuel cleaning, clean fuels, or treatment or innovative fuel combustion techniques for control of such pollutant. In no event shall application of best available control technology result in emissions of any pollutant which would exceed the emissions allowed by any applicable state or federal air pollution control rule or regulation. If the Director determines that technological or economic limitations on the application of measurement methodology to a particular emissions unit would make the imposition of air emissions standards infeasible, a design, equipment, work practice, operational standard or combination thereof, may be prescribed instead to satisfy the requirement of best available control technology. Such standard shall to the degree possible set forth the emission reduction achievable by implementation of such design, equipment, work practice or operation and shall provide for compliance by means which achieve equivalent results.*

The purpose of BACT is to identify all potentially applicable control options from the most stringent to the least stringent, then identifying the technical feasibility of each of the control option. The technically feasible control options are then evaluated on the energy, environmental, and economic impacts of the control option. The most stringent control technology is considered BACT unless technical considerations or energy, environmental or economic impacts, justify elimination of the most stringent technology and results in a selection of a less stringent technology.

The applicant submitted a detailed top-down BACT analysis as this was an expedited permit application.

Proposed BACT for Odor Control Plant		
Pollutant	**Emission Rates**	**Air Pollution Control Systems**
Ammonia	99% reduction	Biotrickling Filter, Two-Stage Wet Scrubber, and Activated Carbon Filter
Hydrogen Sulfide	99.5% reduction	
VOC and VHAPs	75% reduction	
Particulate Matter	~~99.95% reduction, 0.01 grains/dscf~~ *Now 20 mg/m^3*	On 12/9/25, QSS requested the proposed removal efficiency for PM be removed.

Proposed BACT for Pyrolysis Stack		
Pollutant	Technology	Emission Rate or Reduction
Particulate Matter	Catalytic filter	0.005 grains/dscf
VOC and VHAPs	Thermal oxidizer	99.9% reduction
NOx	Ammonia injection (SCR) followed by the catalytic filter	80% reduction, 2.86 lbs/hr
Ammonia	Ammonia injection (SCR)	less than 10 ppmv slip
SOx	Dry sorbent injection followed filtration	85% reduction
CO	Thermal oxidizer	50 ppmv
HCl, HF, HBr	Dry sorbent injection followed by filtration	95% reduction
Metal HAPs	Catalytic filter	0.005 grains/dscf
Mercury	Limiting emissions to less than 0.01 lbs/hr.	

BACT for Ammonia

Odor Control Plant

QSSB is proposing to utilize a biotrickling filter followed by a two-stage wet scrubbing system and a carbon polishing filter to control emissions from the odor control plant. The plant is designed to reduce ammonia emissions by 99% with biotrickling filter and a two-stage wet scrubber system. The biotrickling filter and the two-stage scrubber system are designed to provide 99% control without utilizing the activated carbon filter. As currently designed, the activated carbon filter will not have a significant capability to reduce ammonia. Although the applicant has proposed a control efficiency of 99% for ammonia, they are modeled ammonia emissions at uncontrolled emission rates to be conservative. The potential emission rates modeled are below the AALs (see modeling analysis review below).

Emissions Control Plant

The ammonia slips emissions from the SCR in the catalytic filter designed to control NO_x emissions from the thermal oxidizer are specified by the manufacturer not to exceed 10 ppmv at 3 percent oxygen. The annual ammonia emissions are estimated to be 2.598 tons per year from the Emissions Control Plant. Research was completed to find other sewage sludge pyrolysis facilities with SCR control of the thermal oxidizer exhaust and no sources were identified with this type of control. Therefore, limiting ammonia emissions to less than 0.593 lbs/hr from the Emissions Control Plant are being proposed as BACT.

BACT for Hydrogen Sulfide

Odor Control Plant

The biotrickling filter and the two-stage scrubber system are designed to provide 99.5% control of H_2S without utilizing the carbon filter. Subsequently, the system is also designed to provide 99.5% reduction of H_2S while operating only the carbon filter. The biotrickling filter reduces the chemical consumption in the scrubbers for H_2S removal and together these processes increase the life of the carbon bed.

Based on the redundant design, QSSB is proposing that BACT be accepted as 99.5% reduction of hydrogen sulfide. The intent is to operate all three control units to control hydrogen sulfide but to provide operational flexibility to address maintenance issues, BACT is proposed as 99.5% reduction of hydrogen sulfide and not an operation of specific control equipment.

BACT for VOC and HAP

Odor Control Plant

The potential uncontrolled VOC emissions from the Odor Control Plant is 5.38 lbs/yr. The approximate threshold for cost effective control of VOC emissions is 18 tons per year according to MassDEP's BACT guidance. Therefore, QSSB is proposing that BACT for VOCs from the Odor Control Plant be limited 1.22 lbs/yr which includes the 75% VOC control efficiency provided by odor control plant vendor.

Emissions Control Plant

The VOC and volatile HAP emissions will be controlled using a thermal oxidizer. Thermal oxidizers are commonly considered BACT for sources of VOC and HAP emissions. The applicant originally proposed a control efficiency for VOCs of 99.99% in the application. It was determined that the control efficiency of the thermal oxidizer could not be measured during the course of this review, see the heading above in this review under "EMISSIONS FROM THE ENTIRE FACILITY FOR TOXIC AIR CONTAMINANTS" for the complete discussion.

QSSB has now proposed a VOC control efficiency of 99.9% and will provide a vendor guarantee for the VOC control efficiency after the vendor has been selected and prior to installation of the thermal oxidizers. Based on the specified control and that thermal oxidizers have been considered BACT for other VOC emitting sources, the thermal oxidizer with control of 99.9% of VOC and HAP is being proposed as BACT.

BACT for PM

Odor Control Plant

QSSB proposed in the application that the particulate matter emissions from the Odor Control Stack would be reduced by 99.95%. After the draft permit was supplied to QSSB with a condition to verify the PM efficiency, QSSB stated that the overall reduction of PM is not solely from the control equipment but includes the PM removed from the stream by the integral cyclones on the dryers and the integral filters on the dry feedstock silos and pelletizers. According to the design specifications of the Odor Control Plant, the PM loading to the plant cannot exceed 20 mg/m^3*. As such the control efficiency of the Odor Control Plant in itself cannot be measured for PM or if it would be it would not represent the complete PM removal efficiency of the stream. Therefore, QSSB has not taken any credit for any control efficiency for the Odor Control Plant for PM and is proposing to be limited by the hourly emission rate and 20 mg/m*^{3} *(0.0087 grains/ft*^{3}*). See Sage Environmental's 11/3/25 notification.*

The uncontrolled PM emissions from process steps vented to the odor control plant are approximately 1.199 tons per year.

Emissions Control Plant

The catalytic filter has been designed to control particulate emissions including metal HAPs down to a guarantee of 0.005 grains per dry standard cubic foot. The controlled emissions of particulate emissions from the pyrolysis stack are 5.348 tons per year. The use of the catalytic filter to limit emissions to less than 0.005 grains per dry standard cubic foot is proposed as BACT. The applicant nor the manufacturer specified a control efficiency for PM from the catalytic filters. Additional research did not identify other sewage sludge biochar facilities being permitted with thermal oxidation followed by a catalytic filter.

Under Regulation No. 12, *Incinerators* (250-RICR-120-05-12) emissions are limited to the following rates. Note: although these are for incinerators and the pyrolysis units are found not to be incinerators, the comparison to the emission rates are still displayed here.

	Regulation No. 12 PM Emission Limit	QSS Proposed Limit
Large, Pathological and Special Incinerators	0.08 gr/dscf	0.005 gr/dscf
Sewage Sludge Incinerators	1.30 lb PM/ton dry sludge input	0.3689 lb PM/ton dry sludge input

BACT for NOx

NOx emissions will be generated from the combustion of pyrolysis gases in the thermal oxidizer. QSSB is proposing to utilize ammonia injection with a catalytic filter to reduce NOx emissions by selective catalytic reduction (SCR). In addition, QSSB will utilize flue gas recirculation into the reducing chamber and the conditioning chamber of the oxidizer to control combustion temperatures to reduce NOx production. The flue gas recirculation and SCR in the catalytic filter will control NOx emissions by 80% to a controlled emission rate limit of less than 2.97 pounds per hour. Research of other permitted sewage sludge pyrolysis facilities identified two other such sources, one in Edmonds, WA and one in Redwood, CA. Neither of these facilities proposed control of NOx emissions following the pyrolysis gas combustion due to both the low emissions and the costs of control. QSSB is proposing to utilize SCR control using a catalytic filter and flue gas recirculation to control NOx emissions. These controls are above those required for other permitted facilities of a similar type and are therefore being proposed as BACT.

BACT for SOx

The emissions of both SO_2 or SO_3 will be controlled by dry sorbent injection of dry sorbents upstream of the catalytic filter. The reaction by-products will be captured as particulates in the filter. The reduction of SOx emissions utilizing this technology will be 85% to a controlled emission rate 8.41 lb/hr or 36.84 tons per year. The cost to implement additional controls beyond utilizing the catalytic filter with dry sorbent injection were not evaluated as this technology is also proposed as BACT for NOx, PM, and metal HAP control. QSSB is proposing that utilizing catalytic filter with dry sorbent injection be considered BACT for SOx due to the costs associated with adding additional control.

BACT for CO

The pyrolysis process is already proposed to be controlled by a thermal oxidizer for the destruction of VOC and HAPs contained in the pyrolysis gas. Due to the high level of control specified by the manufacturer for control of VOC and HAPs, and the fact that thermal oxidizers have been demonstrated to control CO emissions at a high level, QSSB is proposing that use of the thermal oxidizer to reduce CO emissions to the manufacturer specified 50 ppmv at 3% O_2 as BACT (4.19 lb/hr) for this pollutant.

BACT for Hydrochloric Acid and Hydrofluoric Acid

The HCl and HF emissions will be controlled by the catalytic filter with dry sorbent injection. The use of the catalytic filter is also being utilized to control PM, NOx, SOx, and metal HAP emissions. The dry sorbent injected into the exhaust stream upstream of the catalytic filter will react with the HCl and HF present in the exhaust stream and the products of reaction will be captured by the filter. QSSB is proposing that use of the catalytic filter to control HCl and HF by 95% be considered BACT.

BACT for Mercury

The RBLC was reviewed to identify control technologies for controlling mercury at other similar sources and other sewage sludge pyrolysis facilities were not identified. Additional review was completed to identify other potentially applicable sources. Below is a table of the potentially applicable sources from the RBLC. QSSB is proposing an emission rate of 0.0095 lbs/hr from the Emissions Control Plant only.

Permit Date	RBLC ID Number	Facility Name	Process Name	Permitted Hg Limit	Control
11/18/12	FL-0336	Pinellas County Res Recovery Facility	Three Municipal Waste Combustors	50 mg/dscm	Activated Carbon Injection
12/23/10	FL-0324	Palm Beach Renewable Energy Park	Three Municipal Solid Waste Combustors	25 µg/dscm, 0.0098 lbs/hr	Activated Carbon Injection
11/3/06	FL-0284	Hillsborough County Resource Recovery	Municipal Waste Combustion	28 µg/dscm	Activated Carbon Injection
3/24/03	VA-0271	Harrisonburg Resource Recovery Facility	Municipal Waste Combustion	0.08 ppmv	Activated Carbon Injection
3/25/03	VA-0277	Harrisonburg Resource Recovery Facility	Municipal Waste Combustion Units (2)	0.08 mg/dscm	No Control
11/21/01	CT-144	Riley Energy Systems of Lisbon	Municipal Waste Combustors (2)	0.165 lbs/hr	Activated Carbon Injection with Fabric Filter

9/20/01	MI-0297	Mineral Detroit, LLC	Sludge Incinerator/Glass Furnace	0.05 mg/dscm, 0.0197 lbs/hr	Quench, Carbon Injection, Baghouse, Testing
7/21/00	FL-0164	Dade County Resource Recovery Facility	Municipal Waste Combustors, 4 units	0.07 mg/dscm, 0.08 tons/yr	Carbon Injection

The control technologies identified during this search are provided below.

- Activated Carbon Injection followed by fabric filtration
- Fabric Filtration
- Electrostatic Precipitator

Activated Carbon Injection Followed by Fabric Filtration

This technology involves injecting carbon into the exhaust stream to allow mercury to adsorbed onto the carbon. After the injected carbon has adsorbed the mercury, the carbon is then filtered out of the exhaust stream using a fabric filter. The pyrolysis process exhaust temperature is approximately 334°C which is above the temperature where it is feasible to inject carbon into the stream. However, this technology was deemed technically feasible and would provide 85% removal of mercury.

The estimated emissions of mercury are 0.0417 tons per year or 83.43 pounds per year. The applicant states the total capital to install the quench system to reduce the temperature of the flue gas, inject the carbon, and then filter the injected carbon out of the flue gas is estimated to be $4,700,000. In addition to high capital cost, the annual cost to purchase the carbon needed to control the mercury would be $260,000. The cost to dispose of the contaminated carbon would be significant as well since the carbon would likely require disposal of hazardous waste. Even without including the carbon disposal cost the estimate annual cost per ton is calculated to be $20,530,000 per ton. This cost is above an acceptable range and is deemed not economically feasible to implement. Therefore, this control option is being eliminated from further consideration.

Fabric Filtration

Again, the exhaust temperature of this process does not allow for the removal of mercury in the catalytic filter. The mercury would be in the vapor phase due to the high exhaust temperatures expected. Since this technology is already being utilized in the catalytic filter but is not expected to remove mercury, the use of additional fabric filters would not provide mercury reduction due to the elevated temperature of exhaust stream. Therefore, fabric filtration is considered technically infeasible and is eliminated as an option for consideration as BACT.

Electrostatic Precipitator

An electrostatic precipitator (ESP) is a device that uses electric fields to remove particulate matter, such as dust, soot, and ash, from industrial gases. However, the removal of non-particulate emissions using this technology is limited. Research indicates that the removal efficiency of vapor phase elemental mercury ranges from 0% to 20%. Improved removal efficiency requires injection of oxidizing additives to increase the content of Hg2+ in the flue gas and typically injection of a sorbent to adsorb the mercury to allow effective removal. The exhaust stream from the pyrolysis process is at an elevated temperature where mercury is expected to be in the vapor phase. Although this technology would provide limited removal without additional injection of oxidizing agents or sorbents, this option is deemed to be technically feasible and will be evaluated further.

An ESP would require implementation of the carbon injection system described above to be effective. Based on the costs associated with the activated carbon system being above the threshold for economic feasibility, the addition of an ESP system would only cause the overall control system costs to increase. Therefore, this control option is deemed to be not economically feasible to implement. Therefore, this control option is being eliminated from further consideration.

Control Technology	Technical Feasibility	Control Efficiency	Economically Feasible
Activate Carbon Injection Followed by Fabric Filtration	Y	85%	No
Fabric Filtration	N	--	--
Electrostatic Precipitator	Y	0 – 20%	No

Based on the above review of control technologies for mercury removal from the pyrolysis exhaust, all the potential control technologies have been eliminated from consideration either due to being technically infeasible or economically infeasible. In addition, QSSB is proposing that limiting the emissions of mercury to 0.00952 pounds per hour be accepted as BACT for this process.

MODELING

As the proposed changes will increase emissions greater than the MQs of 250-RICR-120-05-9.17 for many pollutants- based on the proposed operations, the facility is required to demonstrate compliance with 250-RICR-120-05-22.9, Table I, Acceptable Ambient Levels (AALs) through the use of an air quality dispersion model. Under Regulation 9 and 22 permitting requirements:

Regulation 9 requirements:

9.7.3 Requirements for Approval

A. No person shall construct, install or modify or cause the construction, installation or modification of any minor stationary source described in § 9.7.1 of this Part unless the following conditions are met:

2. Emissions from the stationary source will not cause an impact on the ground level ambient concentration at or beyond the property line in excess of that allowed by "Air Pollution Control Regulation No. 22 - Air Toxics" and any Calculated Acceptable Ambient Levels.

Regulation 22 requirements:

22.6 Requirements for Permits to Construct, Install, or Modify

C. Except as specified in § 22.6(D) of this Part, no permit to construct, install or modify will be issued for a stationary source subject to this regulation unless it can be demonstrated that:

1. The emissions of any listed toxic air contaminant from the proposed facility shall not cause an impact, at or beyond the property line of the facility, which exceeds the Acceptable Ambient Levels for that contaminant specified in § 22.9 of this Part. (A guidance document to assist with compliance can be found in the Rhode Island Guideline for Air Quality Modeling for Air Toxics Sources.

The applicant submitted an air dispersion modeling report on 04-24-2025 and a revision on 12/5/25. The latest revision only was for NH3 and H2S. The model was reviewed by the OAR for compliance with the RI Air Dispersion Modeling Guidelines.

Stack Parameters

Other parameters that are used in a modeling analysis that have an influence on the outcome of the predicted impacts are stack height, stack interior diameter, exit temperature, stack gas flow rate, stack orientation, rain caps, meteorological conditions, and locations. A condition will be included in the permit concerning the stack height and stack interior diameters to reflect what was used in the modeling analysis.

Model Inputs			
	Units	**PGSTACK**	**OCSTACK**
Stack Height	***m***	**36.58**	**16.48**
	ft	120.0	54.1
Exit Temperature	***K***	***607.15***	***297.15***
	°F	633.2	75.2
Stack Diameter	***m***	***0.65***	***0.71127***
	in	25.59	28.0
	ft	2.133	2.334
Exit Velocity	***m/sec***	***20.49***	***16.80***
	ft/sec	67.224	55.117
Area of Stack	ft^2	3.572	4.277
Flow Rate	cfm	14,408	14,145
Distance from discharge to nearest property line:	ft	190	180
Rain hat?		No	No

Items italicized are from the Aermod modeling input files.

NH_3 and H_2S from Odor Control Plant & Emissions Control Plant - Modeling Summary

Modeling for the odor control plant is only required for ammonia (NH_3) and hydrogen sulfide (H_2S). All other pollutants that require modeling are only emitted from the pyrolysis plant. The ammonia emissions from the odor control plant are modeled assuming uncontrolled emissions. Emission rates were determined based on the maximum one hour emission rates. For a 24-hour emission rate the one-hour rate was multiplied by 24 hours/day and for the annual emission rate the one-hour was multiplied by 8760 hours/year. Therefore, if the 1-hr, 24-hr and annual emission rates are converted to g/s they would all be identical.

Aermod's output contains a combined maximum impact labeled "ALL". The "ALL" impact is from an algorithm combining the air dispersion elements from both stacks resulting in a single impact representing all the emissions of that pollutant. QSS will be limited to the emission rates used in the modeling for both the Emissions Control Plant and the Odor Control Plant.

The modeling results have been updated from the latest modeling run of 12/5/25.

Emission Rates for NH_3 & H_2S from Both APC Stacks								
	NH_3				**H_2S**			
	(g/s)	**(lbs/hr)**	**(lbs/day)**	**(lbs/yr)**	**(g/s)**	**(lbs/hr)**	**(lbs/day)**	**(lbs/yr)**
Pyrolysis APCE Stack	0.074717	**0.593**	14.24	5195.95	6.413E-03	**0.0509**	1.223	446.31
Odor APCE Stack	0.35670	**2.83**	67.94	24,799	7.610E-04	**6.04E-03**	0.1450	52.92

NH_3 and H_2S Maximum Predicted Impacts for 2016-2020 ($\mu g/m^3$)						
	NH_3			**H_2S**		
Modeled Year	**1-hr**	**24-hr**	**Annual**	**1-hr**	**24-hr**	**Annual**
2016	**139.82121**	43.33891	7.33077	**0.29832**	0.09691	0.01660
2017	114.68422	46.42199	6.81964	0.24468	0.09904	0.01555
2018	131.03221	44.51799	7.40036	0.27956	0.09652	0.01683
2019	122.76152	**47.73424**	6.45472	0.26191	**0.10184**	0.01459
2020	125.69189	41.31982	**8.0019**	0.26817	0.08931	**0.01813**
Maximum:	**139.82121**	**47.73424**	**8.0019**	**0.29832**	**0.10184**	**0.01813**
AALs	1000	100	70	40	30	10

- **THE MAXIMUM PREDICTED IMPACTS FOR NH_3 AND H_2S ARE LESS THAN THE AALS, THEREFORE COMPLIANCE CAN BE EXPECTED.**

Modeling Summary for Other Pollutants - Emissions Control Plant

Emission rates for pollutants other than NH_3 and H_2S were modeled at **1 lb/hr** (0.1260 g/s) from the Emissions Control Plant. The maximum impacts are then multiplied by the emissions rate to determine the calculated impact for that pollutant. See equations below.

Emissions Control Plant - Other Pollutants - Predicted Impacts at 1 lb/hr ($\mu g/m^3$ / lb/hr)			
Modeled Year	1-hr	24-hr	Annual
2016	1.77263	0.92652	0.05871
2017	***1.87550***	0.87994	0.05727
2018	1.82864	1.01885	0.06332
2019	1.82023	1.03620	***0.06374***
2020	1.77773	***1.09411***	0.06331
Maximum:	**1.87550**	**1.09411**	**0.06374**

Emissions Control Plant – Other Pollutants – Calculated Impact Analysis									
	Emission Rates			**AALs ($\mu g/m^3$)**			**Calculated Impact ($\mu g/m^3$)**		
	(lbs/hr)	**(lbs/day)**	**(lbs/yr)**	**1-hr**	**24-hr**	**Annual**	**1-hr**	**24-hr**	**Annual**
Acetaldehyde	0.0145	0.3476	126.86			0.5			9.23E-04
Acetamide	0.2306	5.534	2019.90			0.05			0.01470
Aniline	0.0263	0.6302	230.04		1	0.6		0.02873	1.67E-03
Antimony	1.26E-03	0.0303	11.07		0.2			1.38E-03	
Arsenic	1.18E-04	2.83E-03	1.04	0.2		0.0002	2.22E-04		7.55E-06
Benzene	0.0222	0.5339	194.87	30	20	0.1	0.04172	0.02434	1.42E-03
Boron and borates	4.85E-04	0.0116	4.25	10			9.09E-04		
Cadmium	1.63E-04	3.90E-03	1.42		0.1	0.0006		1.78E-04	1.04E-05
Cobalt	4.90E-05	1.17E-03	0.4288			0.001			3.12E-06

Copper	6.48E-03	0.1556	56.78	100		2	0.0122		4.13E-04
Fluorides + HF	0.2736	6.57	2397.09	20	3		0.5132	0.2994	
Formaldehyde	5.68E-03	0.1363	49.76	50	40	0.08	0.0107	6.21E-03	3.62E-04
Hydrochloric acid (HCl)	0.1960	4.70	1717.14	2000		9	0.3676		0.01249
Hydrogen cyanide	0.2289	5.49	2005.58	300		3	0.4294		0.01459
Lead	1.19E-03	0.0286	10.42			0.008			7.59E-05
Manganese	6.30E-03	0.1512	55.20		0.05	0.04		6.89E-03	4.02E-04
Mercury	9.52E-03	0.2286	83.43	2	0.3	0.009	0.0179	0.01042	6.07E-04
Naphthalene	0.0189	0.4526	165.19		3	0.03		0.02063	1.20E-03
Nickel	8.09E-04	0.0194	7.09	6	0.2	0.004	1.52E-03	8.85E-04	5.16E-05
PCDDs-OCDD*	4.33E-10	1.04E-08	3.80E-06			3.00E-09			2.76E-11
Phenol	0.0257	0.6173	225.30	80		200	0.0482		1.64E-03
Quinoline	2.33E-03	0.0558	20.38			0.001			1.48E-04
Vanadium	3.00E-04	7.21E-03	2.63	0.2			5.63E-04		

- **THE CALCULATED IMPACTS ARE LESS THAN THE AALS, THEREFORE COMPLIANCE CAN BE EXPECTED.**

$$One\ Hour\ Calculated\ Impact\left(\frac{\mu g}{m^3}\right) = Emission\ rate\ \left(\frac{lb}{hr}\right)\ \text{ x One hour predicted impact }\left(\frac{\frac{\mu g}{m^3}}{\frac{lb}{hr}}\right)$$

$$24\ Hour\ Calculated\ Impact\left(\frac{\mu g}{m^3}\right) = Emission\ rate\ \left(\frac{lb}{day}\right)\ \text{ x 24 hr predicted impact }\left(\frac{\frac{\mu g}{m^3}}{\frac{lb}{hr}}\right)\text{ x }\frac{1\ day}{24\ hr}$$

$$Annual\ Calculated\ Impact\left(\frac{\mu g}{m^3}\right) = Emission\ rate\ \left(\frac{lb}{yr}\right)\ \text{ x annual predicted impact }\left(\frac{\frac{\mu g}{m^3}}{\frac{lb}{hr}}\right)\text{ x }\frac{1\ yr}{8760\ hr}$$

Analysis of Modeling Results							
Pollutant	**Allowable**			**Is PTE less than allowable?**	**Percent PTE to Allowable**		
	(lbs/hr)	**(lbs/day)**	**(lbs/yr)**		**(lbs/hr)**	**(lbs/day)**	**(lbs/yr)**
Acetaldehyde			68,717	YES			0.18
Acetamide			6,872	YES			29.4
Aniline		21.94	82,460	YES		2.87	0.28
Antimony		4.39		YES		0.69	
Arsenic	0.1066		27.49	YES	0.11		3.78
Benzene	16.00	438.71	13,743	YES	0.139	0.12	1.42
Boron and borates	5.33			YES	0.009		
Cadmium		2.19	82.46	YES		0.18	1.73
Cobalt			137.43	YES			0.31
Copper	53.32		274,867	YES	0.012		0.02
Fluorides + HF	10.66	65.81		YES	2.6	10.0	
Formaldehyde	26.66	877.43	10,995	YES	0.02	0.02	0.45
Hydrochloric acid (HCl)	1,066.38		1,236,900	YES	0.02		0.14
Hydrogen cyanide	159.96		412,300	YES	0.14		0.49
Lead			1,099	YES			0.95
Manganese		1.10	5,497	YES		13.8	1.00
Mercury	1.07	6.58	1,237	YES	0.89	3.5	6.74
Naphthalene		65.81	4,123	YES		0.69	4.01
Nickel	3.20	4.39	549.73	YES	0.03	0.44	1.29
PCDDs-OCDD*			4.12E-04	YES			0.92
Phenol	42.66		27,486,665	YES	0.06		0.0008
Quinoline			137.43	YES			14.83
Vanadium	0.1066			YES	0.28		

$$One\ Hour\ Allowable \left(\frac{lb}{yr}\right) = \frac{One\ hour\ AAL \left(\frac{\mu g}{m^3}\right)}{One\ hour\ predicted\ impact \left(\frac{\frac{\mu g}{m^3}}{\frac{lb}{hr}}\right)}$$

$$24\ Hour\ Allowable \left(\frac{lb}{day}\right) = \frac{24\ hour\ AAL \left(\frac{\mu g}{m^3}\right)}{24\ hour\ predicted\ impact \left(\frac{\frac{\mu g}{m^3}}{\frac{lb}{hr}}\right)}\ x\ \frac{24\ hrs}{day}$$

$$Annual\ Allowable \left(\frac{lb}{yr}\right) = \frac{Annual\ AAL \left(\frac{\mu g}{m^3}\right)}{Annual\ predicted\ impact \left(\frac{\frac{\mu g}{m^3}}{\frac{lb}{hr}}\right)}\ x\ \frac{8760\ hrs}{yr}$$

Applicable State Air Pollution Control Parts/Regulations

250-RICR-120-05-1:	Visible Emissions
250-RICR-120-05-3:	Particulate Emissions from Industrial Processes
250-RICR-120-05-7:	Emissions of Air Contaminants Detrimental to Person or Property
250-RICR-120-05-16:	Operation of Air Pollution Control Systems
250-RICR-120-05-17:	Odors
250-RICR-120-05-22:	Air Toxics

Visible Emissions, 250-RICR-120-05-1:

250-RICR-120-05-1 limits the opacity of visible emissions from all sources to less than or equal to 20 percent for a period or periods aggregating more than three minutes in any one hour. Proper operation and maintenance of the facility should not produce visible emissions from the exhaust stack in excess of that allowed under this Part.

Visible emissions in the permit will be limited to zero from the Odor Control Plant, although visible emissions shall not be a violation if it is from the presence of uncombined water. Additionally, the dryers, dry sewage sludge silos, and pelletizer units are equipped with integrated dust controls to meet the particulate matter loading requirements for the exhaust air directed to the odor control plant.

Visible emissions in the permit will be limited to 10% opacity not to exceed a 3-minute period from the Emissions Control Plant. Therefore, compliance is expected.

Particulate Emissions from Industrial Processes, 250-RICR-120-05-3:

The purpose of this regulation is to limit particulate emissions from industrial sources. The regulation contains a table with various process weights and related emission rates. Interpolation of the data in the table for the process weight rates up to 60,000 Lb/Hr shall be accomplished by use of the equation: E = 4.10 $P^{\wedge 0.67}$ where E = rate of emission in Lb/Hr and P = process weight rate in Tons/Hr.

As this is a continuous operation with different loading rates, I evaluated the maximum process weight to be used the equipment exhausting to the Odor Control Plant, which would be the dryers at 23,810 lbs/hr each or a total of 47,620 lbs/hr (23.81 ton/hr).

$$E = 4.10\ x\ 23.81^{0.67} = 34.29\ lb/hr$$

The proposed PM emission rate from the Odor Control Plant is **0.274 lb/hr**.

The maximum process weight to the pyrolysis reactors is 6,614 lbs/hr each or a total of 13,228 lb/hr (6.614 ton/hr).

$$E = 4.10\ x\ 6.614^{0.67} = 14.54\ lb/hr$$

The proposed PM emission rate from the Emissions Control Plant is **1.22 lb/hr**.

Therefore, QSS BioSolids is expected to be in compliance with this regulation.

Emissions of Air Contaminants Detrimental to a Person or Property, 250-RICR-120-05-7:

This regulation prohibits emissions from being injurious to human, plant or animal life, from causing damage to property, or from unreasonably interfering with the enjoyment of life and property. Compliance can be expected with if proper maintenance and operating procedures for the air pollution control systems and process equipment are followed. A condition will be put into the permit that requires the owner/operator to maintain and operate the equipment in a manner consistent with good air pollution control practice for minimizing emissions. Therefore, compliance is expected.

Odors, 250-RICR-120-05-17:

This regulation prohibits the emissions of air contaminants that create objectionable odors at locations beyond the property line of the facility.

Compliance can be expected if proper maintenance and operating procedures for the air pollution control systems and process equipment are followed. The major odor producing contaminants, ammonia and hydrogen sulfide, were modeled, and the proposed emission rates were less than the applicable AALs. A condition will be put into the permit that requires the owner/operator to maintain and operate the equipment in a manner consistent with good air pollution control practice for minimizing emissions. Stack testing will also be required to demonstrate compliance with the modeled rates. Therefore, compliance is expected.

Operation of Air Pollution Control Systems, 250-RICR-120-05-16:

This regulation is applicable to any air pollution control system. It requires the baghouses, thermal oxidizers, and SCR to be operated according to its design specifications whenever the source on which it is installed is operating or emitting air contaminants. The permit will contain conditions which will specify that the control systems are operated and maintained according to the manufacturer's specification. Therefore, compliance with this regulation is expected.

Air Toxics, 250-RICR-120-05-22

This regulation applies to any stationary source emitting a listed air toxic substance greater or equal to the Minimum Quantities (MQ) in Table III of the regulation. To ensure compliance with the Acceptable Ambient Levels (AAL) (Table I) of each listed air toxic emitted from the facility greater than the MQs, a modeling analysis was performed by the applicant. The analysis demonstrated compliance with each AAL. Stack testing will also be required to confirm compliance with the permit limits within 180 days after startup of the facility. Therefore, compliance with this regulation should be expected.

Non-Applicable State Air Pollution Control Regulations

250-RICR-120-05-29: Operating Permits

Operating Permits, 250-RICR-120-05-29

The applicant is not subject to Part 29 at this time but their potential CO_2e is 87,224 tons per year. The CO_2e threshold for being subject to Part 29 is 100,000 tpy. QSS will be required to measure CO2e emissions after startup.

250-RICR-120-05-29, Operating Permits applies to any major source. Major source is defined under 29.5.A.15.

"**Major source**" means any of the following (summary):

- For pollutants other than radionuclides, that emits or has the potential to emit, in the aggregate, ten (10) tpy or more of any HAP or twenty-five (25) tpy or more of any combination of HAPS, or
- That emits or has the potential to emit fifty (50) tpy or more of VOCs or NOx, or
- That emits or **has the potential to emit, 100 tpy or more of any air pollutant subject to regulation**.

29.5.A.28: "**Subject to regulation" means**, for any air pollutant, that the pollutant is subject to either a provision in the Clean Air Act, or a nationally-applicable regulation codified by the EPA in 40 C.F.R. §§ 50 through 99, that requires actual control of the quantity of emissions of that pollutant, and that such a control requirement has taken effect and is operative to control, limit or restrict the quantity of emissions of that pollutant released from the regulated activity. Except that:

a. Greenhouse gases (GHGs), the air pollutant defined in 40 C.F.R. § 86.1818–12(a) as the aggregate group of six (6) greenhouse gases: carbon dioxide, nitrous oxide, methane, hydrofluorocarbons, perfluorocarbons, and sulfur hexafluoride, shall not be subject to regulation **unless, as of July 1, 2011, the GHG emissions are at a stationary source emitting or having the potential to emit one hundred thousand (100,000) tpy CO_2 equivalent emissions.**

b. The term tpy CO_2 equivalent emissions (CO_2e) shall represent an amount of GHGs emitted, and shall be computed by multiplying the mass amount of emissions (tpy), for each of the six (6) greenhouse gases in the pollutant GHGs, by the gas's associated global warming potential published at 40 C.F.R. § 98, Table A-1, and summing the resultant value for each to compute a tpy CO_2e.

Non-Applicable Federal Regulations

NSPS 40 CFR Part 60, Subpart LLLL - "Standards of Performance for New Sewage Sludge Incineration Units"

Applies to Sewage Sludge Incinerators (SSI) for which construction commenced after October 14, 2010, or for which modification commenced after September 21, 2011.

NSPS 40 CFR Part 60, Subpart CCCC - "Standards of Performance for New Stationary Sources: Emissions from Commercial and Industrial Solid Waste Incineration"

Commercial and industrial solid waste incineration (CISWI) units are subject to the requirements of the Standards of Performance for Commercial and Industrial Solid Waste Incineration Units (NSPS Subpart CCCC) if the unit commenced construction after June 4, 2010, or commenced reconstruction or modification after August 7, 2013.

NSPS 40 CFR Part 60, Subpart O - "Standards of Performance for Sewage Treatment Plants"

The provisions of this subpart are applicable to each incinerator that combusts wastes containing more than 10 percent sewage sludge (dry basis) produced by municipal sewage treatment plants, or each incinerator that charges more than 1000 kg (2205 lb) per day municipal sewage sludge (dry basis).

Clean Water Act, 40 CFR Part 503 - "Standards for the Use or Disposal of Sewerage Sludge"

The provisions of this subpart are applicable to sewage sludge that is applied to land, fired in a sewage sludge incinerator or placed on a surface disposal site.

40 CFR Part 61, Subpart E - "National Emissions Standard for Mercury"

The provisions of this subpart are applicable to those stationary sources which process mercury ore to recover mercury, use mercury chlor-alkali cells to produce chlorine gas and alkali metal hydroxide, and incinerate or dry wastewater treatment plant sludge.

Note: the pyrolysis units proposed by QSS are not considered incinerators.

Conclusions/Recommendations

Approve the application as proposed with the attached permit conditions and emission limitations.

137 Pollutants that Decomposes Under Pyrolysis Conditions

	Pollutant	CAS#		Pollutant	CAS#
1	Acetonitrile	75058	70	Ethylene glycol monobutyl ether	111762
2	Acetophenone	98862	71	Ethylene glycol monoethyl ether	110805
3	2-Acetylaminofluorene	53963	72	Ethylene glycol monoethyl ether acetate	111159
4	Acrolein	107028	73	Ethylene glycol monomethyl ether	109864
5	Acrylamide	79061	74	Ethylene glycol monomethyl ether acetate	110496
6	Acrylonitrile	107131	75	Ethylene imine (Aziridine)	151564
7	Allyl chloride	107051	76	Hexachlorocyclohexanes, technical grade & mixed isomers	608731
8	o-Anisidine	90040	77	alpha-Hexachlorocyclohexane	319846
9	Aramite	140578	78	beta-Hexachlorocyclohexane	319857
10	Arsine	7784421	79	gamma-Hexachlorocyclohexane (Lindane)	58899
11	Benzidine	92875	80	Hexachloroethane	67721
12	Benzoic acid	65850	81	Hexamethylphosphoramide	680319
13	Benzotrichloride	98077	82	Isophorone	78591
14	Benzyl chloride	100447	83	Isopropanol	67630
15	Bis (chloromethyl) ether	542881	84	Lead - tetraethyl lead	78002
16	Bis (2-ethylhexyl) phthalate (DEHP)	117817	85	Methoxychlor	72435
17	Bromates (including Potassium bromate)		86	Methyl bromide (Bromomethane)	74839
18	Bromoform	75252	87	Methyl chloroform (1,1,1-Trichloroethane)	71556
19	1,3-Butadiene	106990	88	4,4-Methylene bis (2-chloroaniline)	101144
20	Butyl benzyl phthalate	85687	89	4,4-Methylenedianiline	101779
21	Calcium cyanamide	156627	90	Methyl hydrazine	60344
22	Captan	133062	91	Methyl iodide (Iodomethane)	74884
23	Carbon tetrachloride	56235	92	Methyl isobutyl ketone (Hexanone)	108101
24	Catechol	120809	93	Methyl isocyanate	624839
25	Chloramben	133904	94	Methyl methacrylate	80626
26	Chlordane	57749	95	Methyl tert butyl ether (MTBE)	1634044
27	Chlorine dioxide	10049044	96	Michler's ketone (4,4'-Bis (dimethylamino) benzophenone)	90948
28	Chloroacetic acid	79118	97	Nitrobenzene	98953
29	2-Chloroacetophenone	532274	98	4-Nitrobiphenyl	92933
30	4-Chloroaniline	106478	99	4-Nitrophenol	100027
31	Chlorobenzilate	510156	100	N-Nitrosodiethylamine	55185
32	Chloroform	67663	101	N-Nitrosodimethylamine	62759
33	Chloromethyl methyl ether	107302	102	N-Nitrosodiphenylamine	86306
34	4-Chloro-o-phenylenediamine	95830	103	N-Nitrosdi-n-propylamine	621647
35	Chloropicrin	76062	104	N-Nitroso-n-methylethylamine	10595956
36	Chloroprene	126998	105	N-Nitroso-n-methylurea	684935
37	p-Cresidine	120718	106	N-Nitrosomorpholine	59892
38	Cumene	98828	107	N-Nitrosopiperidine	100754
39	Cyanide[a] (inorganic)[ij], except Hydrogen cyanide		108	N-Nitrosopyrrolidine	930552
40	Cyclohexane	110827	109	Parathion	56382
41	2,4-Diaminoanisole	615054	110	p-Phenylenediamine	106503
42	2,4-Diaminotoluene	95807	111	Phosgene	75445
43	Dibromochloromethane	124481	112	Phosphine	7803512
44	1,2-Dibromo-3-chloropropane	96128	113	PCBs- Aroclor 1254	11097691
45	Dibutylphthalate	84742	114	1,3-Propane sultone	1120714
46	1,2-Dichlorobenzene	95501	115	Propoxur (Baygon)	114261
47	Dichloro diphenyl dichloroethylene (DDE)	3547044	116	Propylene dichloride (1,2-Dichloropropane)	78875
48	cis- 1,2-Dichloroethene	156592	117	1,2-Propylenimine (2-Methyl aziridine)	75558
49	trans- 1,2-Dichloroethene	156605	118	Styrene oxide	96093
50	Dichloroethyl ether (Bis (chloroethyl) ether)	111444	119	1,1,1,2-Tetrachloroethane	630206
51	2,4-Dichlorophenoxyacetic acid, salts & esters (2,4-D)	94757	120	1,1,2,2-Tetrachloroethane	79345
52	1,3-Dichloropropene	542756	121	Tetrachloroethylene (Perchloroethylene)	127184
53	Dichlorvos	62737	122	1,1,1,2-Tetrafluoroethane	811972
54	Diethanolamine	111422	123	Thioacetamide	62555
55	1,1-Difluoroethane (HCFC 152a)	75376	124	Titanium tetrachloride	7550450
56	3,3'-Dimethoxybenzidine	119904	125	2,4-Toluene diamine (2,4-Diaminotoluene)	95807
57	p-Dimethyl aminoazobenzene	60177	126	o-Toluidine	95534
58	Dimethyl carbamoyl chloride	79447	127	Toxaphene (Chlorinated camphene)	8001352
59	Dimethyl formamide	68122	128	Trichloroethylene	79016
60	1,2-Dimethyl hydrazine	540738	129	Trichlorofluoromethane	75694
61	2,4-Dimethylphenol	105679	130	2,4,5-Trichlorophenol	95954
62	Dimethyl phthalate	131113	131	2,4,6-Trichlorophenol	88062
63	Dimethyl sulfate	77781	132	Triethylamine	121448
64	4,6-Dinitro-o-cresol	534521	133	Trifluralin	1582098
65	2,4-Dinitrophenol	51285	134	Vinyl acetate	108054

137 Pollutants that Decomposes Under Pyrolysis Conditions

	Pollutant	CAS#		Pollutant	CAS#
66	2,4-Dinitrotoluene	121142	135	Bromodichloromethane	75274
67	1,2-Epoxybutane	106887	136	Ethyl chloride (Chloroethane)	75003
68	Ethyl carbamate (Urethane)	51796	137	Carbaryl	63252
69	Ethylene dibromide (Dibromoethane)	106934			

24 Pollutants that Formation Is Highly Unlikely or Requires Special Conditions/Catalysts

	Pollutant	CAS#		Pollutant	CAS#
1	Acrylic acid	79107	13	Ethylene dichloride (1,2-Dichloroethane)	107062
2	Aldrin	309002	14	Ethylene thiourea	96457
3	2-Aminoanthraquinone	117793	15	Ethylidene dichloride (1,1-Dichloroethane)	75343
4	4-Aminobiphenyl	92671	16	Heptachlor	76448
5	Azobenzene	103333	17	Hexachlorobenzene	118741
6	3,3'-Dichlorobenzidene	91941	18	Maleic anhydride	108316
7	Dieldrin	60571	19	Methylene diphenyl diisocyanate	101688
8	Diethyl sulfate	64675	20	Pentachloronitrobenzene (Quintozene)	82688
9	n,n-Dimethyl aniline	121697	21	Pentachlorophenol	87865
10	3,3'-Dimethyl benzidine	119937	22	1,2,4-Trichlorobenzene	120821
11	1,1-Dimethyl hydrazine	57147	23	Methanol	67561
12	1,2-Diphenylhydrazine (Hydrazobenzene)	122667	24	Cupferron	135206

53 Pollutants with Various Comments as to Why They Will Not Be Emitted from the Facility

	Pollutant	CAS#	Comments
1	Epichlorohydrin	106898	Intermediate and converts to other compounds
2	Ethyl acrylate	140885	
3	Methylene chloride (Dichloromethane)	75092	
4	Propionaldehyde	123386	
5	n-Propyl bromide (1-Bromopropane)	106945	
6[5]	Coke oven emissions	8007452	N/A for pyrolysis
7	N-Nitrosodi-n-butylamine	924163	
8	2,4-and 2,6-Toluene diisocyanate[h]	26471625	
9	2,2,4-Trimethylpentane	540841	
10	Vinyl bromide	593602	
11	Vinyl chloride	75014	
12	Vinylidene chloride (1,1-Dichloroethylene)	75354	
13	2-Nitropropane	79469	Readily convert to other compounds under pyrolysis conditions
14	Hexachlorocyclopentadiene	77474	
15	Propylene glycol monomethyl ether (PGME)	107982	
16	Propylene oxide	75569	
17	Hexamethylene-1,6-diisocyanate	822060	Unstable under pyrolysis conditions
18	Hydrazine	302012	
19	beta-Propiolactone	57578	
20	Phthalic anhydride	85449	
21	Ethylene oxide	75218	
22	Diazomethane	334883	
23	Methyl chloride (Chloromethane)	74873	no comments given
24	1,1,2-Trichloroethane	79005	
25	Phosphoric acid	7664382	
26	Phosphorus, white	7723140	
27	Fine mineral fibers[c]		
28	Asbestos	1332214	Absence in sewage sludge-Destroyed above 550C
29	Chlorine	7782505	Chloride is released as HCl amd KCl/NaCl - Balance between CH3Cl and HCl-Formation of Cl2 is not favorable
30	Chlorobenzene	108907	Concentration in sewage
31	2-Chlorophenol	95578	Concentration in sewage
32	1,4-Dichlorobenzene (p-Dichlorobenzene)	106467	Concentration in sewage
33	Sodium hydroxide	1310732	Converts to Na_2CO_3 and stay in biochar form
34	1,4-Dioxane (1,4-Diethyleneoxide)	123911	Converts to secondary products above 300C-Feedstock-dependant
35	p-chloro-o-toluidine	95692	Currently banned
36	Nitric acid	7697372	If present, would react with metals and decompose
37	Nickel subsulfide	12035722	If present, would react with oxidizing agents
38	Bromine[a] except Hydrogen bromide & Bromates)[j]		Most of Br-compounds will be converted to HBr, but part of HBr could be converted to Br2 depending of cooling of flue gasses

53 Pollutants with Various Comments as to Why They Will Not Be Emitted from the Facility

	Pollutant	CAS#	Comments
39	Quinone	106514	Oxidizing agent and Readily reacts and converts to other compounds under pyrolysis conditions
40	Hydroquinone	123319	Easily converts to other compounds under pyrolysis conditions/Concentration in almond shells
41	Mercury – Methyl mercury	22967926	Decompose to Hg under pyrolysis conditions
42	Selenium sulfide	7446346	Shampoos, medicine / SeS_2 is bio-reduced to elemental selenium which converts to SeO_2 during pyrolysis
43	Selenium – Hydrogen selenide		Decomposes to elemental Se at about 160°C. If ignited, it burns to give off SeO2
44	Sulfates[f]		N/A sulfate is reduced into sulfide
45	Sulfuric acid and Oleum[g]		N/A Sulfur is released in a form of H_2S, but not sulfuric acid or oleum
46	Tetrachlorophenols	25167833	Not determined in sewage sludge
47	1-Chloro-1,1-difluoroethane (CFC 142B)	75683	Not relevant / feedstock to make PVDF
48	Chlorodifluoromethane (HCFC-22)	75456	Not relevant / used in air conditioning and refrigeration applications (phased out)
49	Chromium VI[a]		Pyrolysis gases, such as CO and CH4, can participate directly in the reduction of Cr(VI) and eventually convert it to Cr(I–III)
50	Polycyclic Organic Matter		Some compounds of POP (PAH and PAH-derivatives) are already included in the HAP list. Each of them have been assessed and determined if they are relevant for the pyrolysis process
51	Ethylene glycol	107211	Thermal degradation under pyrolysis conditions
52	Hexachlorobutadiene	87683	Thermal destruction under incineration conditions
53	Chlorinated paraffins (avg length C12- C13, 60% chlorine)	108171262	Under pyrolysis conditions converts to Cl-PAHs, PCBs and PCNs, which are decomposed

Emission Factors from AP-42 Chapter 1.4

2 lines fuel capacity: 0.0729 MM scf/hr

Natural Gas Air Toxic Emissions

Pollutant	Emission Factor	Emissions	
	(lb/MMscf)	(lbs/hr)	(TPY)
Arsenic	2.00E-04	1.46E-05	6.39E-05
Barium	4.40E-03	3.21E-04	1.41E-03
Benzene	2.10E-03	1.53E-04	6.71E-04
Beryllium	1.20E-05	8.75E-07	3.83E-06
Cadmium	1.10E-03	8.02E-05	3.51E-04
Chromium	1.40E-03	1.02E-04	4.47E-04
Cobalt	8.40E-05	6.12E-06	2.68E-05
Copper	8.50E-04	6.20E-05	2.71E-04
Formaldehyde	0.075	5.47E-03	0.0240
Hexane	1.8	0.1312	0.5749
Lead	0.0005	3.65E-05	1.60E-04
Manganese	3.80E-04	2.77E-05	1.21E-04
Mercury	2.60E-04	1.90E-05	8.30E-05
Molybdenum	1.10E-03	8.02E-05	3.51E-04
Naphthalene	6.10E-04	4.45E-05	1.95E-04
Nickel	2.10E-03	1.53E-04	6.71E-04
Selenium	2.40E-05	1.75E-06	7.66E-06
Toluene	3.40E-03	2.48E-04	1.09E-03
Vanadium	2.30E-03	1.68E-04	7.35E-04
Zinc	0.029	2.11E-03	9.26E-03
GHG Pollutants			
CH_4	2.3	0.1677	0.7346
N_2O	2.2	0.1604	0.7026