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December 3, 2009

Honorable Judge Daniel P. Jordan, III
United States District Court
Southern District of Mississippi
245 East Capitol, Suite 110
Jackson, Mississippi 39201

Subject: Greenbriar Digging Service Limited Partnership v. South Central Water Association, Inc., Civil Action No. 3:07cv601 DPJ-JCS

Dear Judge Jordan:

This letter report provides my advice to the Court in the case listed above as instructed in your letter via e-mail of July 9, 2009.

BACKGROUND

The information in this section provides a description of ozone systems, equipment and components and ozone process design parameters used in the body of the report.

Ozone system

Virtually all ozone systems have four primary sub-systems:

1. Feed gas system
2. Ozone generating system
3. Ozone contacting system
4. Ozone destruct system

The design of each is critical in achieving desired results from the complete ozone system. Below is a basic description of each system.

Feed Gas System

The purpose of the feed gas system is to provide a steady supply of very clean and very dry oxygen to the ozone generators. Contaminants, such as moisture, hydrocarbons, and particulates can foul or damage the ozone generators. Pressures should be regulated to a very narrow band, typically ±0.25 pounds per square inch (PSI). The feed gas can be air (~21% oxygen) or high purity oxygen (≥ 90% oxygen). Currently air is used in on very small systems or systems originally installed more than 15 years ago. High purity oxygen is widely used in municipal applications; the most common forms

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Exhibit "A"

include (1) on-site generation using pressure swing adsorption (PSA) or vacuum/pressure swing adsorption (VPSA), or (2) on-site bulk storage of liquid oxygen (LOX) delivered by tanker truck from an industrial gas supplier.

Ozone Generating System

The ozone generators convert a small percentage of the oxygen in the feed gas to ozone using energy to split oxygen molecules, from which some oxygen atoms recombine into an ozone molecule. There are three types of ozone generating cells used in ozone production: electrolytic, ultraviolet, and corona discharge. Of these three, corona discharge is exclusively used in commercial ozone generation at any municipal scale treatment of water.

The major components of this system include the ozone generator(s), the power supply units (PSU) dedicated to each generator, and the cooling water system.

The production of ozone generates a lot of heat; 85 – 90% of the electrical power used by a generator is lost as heat. Heat, however, destroys ozone and leads to inefficient production. Thus, the design of the commercial generator vessel is based on a shell and tube heat exchanger, with a cooling water system to circulate cooling water and continuously remove heat from the generating system and discharge into the environment.

Ozone Dissolution and Contacting System

There are three main purposes of the ozone contacting system: (1) dissolve ozone gas from the generators into water, (2) allow reaction (or contact) time for the ozone to oxidize contaminants in the water, and (3) collect off-gas containing undissolved ozone. The two most common forms of dissolving ozone gas into water are bubble diffusion and sidestream injection.

The main component of a bubble diffusion system is a grid supporting a matrix of ozone-resistant porous ceraminc diffusers installed at the bottom of the contactor, usually in the first chamber or two chambers of a baffled contact tank. Bubble diffusion relies upon the energy produced by the feed gas system, which forces gas through the ozone generators, piping and diffusers at the bottom of the contactor. The ozone gas is released into the water in fine bubbles, which migrate to the free water surface at the top of the tank. Ozone gas dissolves into the water as the bubbles migrate upward through the water within the contact tank.

Sidestream injection systems typically employ venturi injectors. One or multiple sidestreams of the bulk flow of water is diverted and pumped through a venturi injector, which develops low pressure at the narrow throat of venturi, pulling gas through ports at the throat. The gas is vigorously and rapidly mixed and dissolved in the turbulent flow.

Ozone Destruct System

Not all of the ozone gas is dissolved into water in the ozone contacting process, whether by bubble diffusion, injection, or other methods of gas/liquid mass transfer. The undissolved gas in the contactor headspace must be converted back to oxygen prior to discharge to the atmosphere. The ozone destruct unit performs this function. Typically this is a thermal catalytic process where the off-gas from the headspace of the ozone contactor is heated to prevent condensation on the catalyst and to speed the conversion to oxygen. The major components include a heater, a catalytic chamber supporting a bed of catalyst, and a blower to pull gas from the contactor headspace through the ozone destruct unit, plus instrumentation and typically a low concentration ozone analyzer to confirm the vented gas meets any permitted discharge limit.

Ozone Process Design Parameters

Ozone Dose
The effectiveness of ozone, as with most chemicals used in water treatment, is assumed to be relative to its concentration in water, that is the amount of ozone per unit of water. Usually, ozone dose is expressed in units of milligrams per liter (mg/L).

Applied Ozone Dose
The applied ozone dose is the amount of ozone produced by the generators and conveyed to the contactor relative to the amount of water passing through the contactor. Since ozone begins to react with contaminants immediately and rapidly upon contact with water, and is consumed in these reactions, applied ozone dose cannot be measured. It is strictly a calculated parameter. Ozone generators are sized based on applied ozone dose.

Transferred Ozone Dose
The transferred ozone dose is the amount of ozone that is physically dissolved in the water that passes through the contactor. The transferred ozone dose is amount of ozone that actually treats water. Similar to the applied ozone dose, the transferred ozone dose cannot be measured. It is strictly a calculated parameter.

Transfer Efficiency
Transfer efficiency is a measure of the difference between the amount of ozone dissolved in water versus the amount of ozone produced and conveyed to the contactor, usually expressed as a percentage. Transfer efficiency links the applied ozone dose, upon which the generator is sized, to the transferred ozone dose, which is the amount of ozone that actually treats water.

Ozone Production Capacity
The ozone production capacity is the amount of ozone produced per unit of time. It is usually expressed in units of pounds per day (lb/d) or kilograms per hour (kg/h). The required ozone production capacity is calculated from the maximum flow rate of water that requires treatment and the applied ozone dose using the following equation:

$$\text{Ozone Production Capacity [lb/d]} = \text{Flow rate [mgd]} \times \text{Dose [mg/L]} \times 8.34$$

Ozone Concentration
Ozone concentration is the amount of ozone produced by the ozone generator relative to the amount of feed gas. It is usually expressed in terms of a percentage based on weight (lb/lb or kg/kg). Ozone concentration links the size of the feed gas system to the size of the ozone generating system.

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OZONE SYSTEM PROCESS DESIGN CONSIDERATIONS AND OPINIONS

Below are several considerations and opinions on the basic design parameters and the major sub-systems and components of the ozone system identified in the trial transcript and trial exhibits.

Basic Ozone Process Design Parameters

Ozone Dose

- Based on the sample data contained in Exhibit D-3, *Ozonation Water Treatment System Evaluation*, and testimony provided by Wayne Wolf of Ozone Technologies, Inc. (OTI), a nominal transferred ozone dose of 18 mg/L is assumed to achieve the desired color removal to 20 True Color Units (TCU). This ozone dose is comparatively high when examining data on ozone installations maintained by the Municipal Task Force of the International Ozone Association (IOA) Pan American Group (PAG). Bench-scale and pilot-scale tests are recommended to confirm this dose. Precision is not required, as there are other design techniques to boost ozone production and the ozone dose (e.g. see the Design Ozone Concentration and Feed Gas Flow Rate sub-sections under the section titled Recommendations below).

Ozone Production Capacity

- Installing ozone generating capacity greater than 280 lb/d is not necessary if (1) bench-scale tests are performed to confirm the design transferred ozone dose, (2) the ozone generators are factory and field tested to confirm the units achieve the rated ozone capacity, and (3) the ozone dissolution system is improved to achieve consistent, high transfer efficiency. Other design techniques allow a boost in ozone production beyond the rated capacity (e.g. see the Design Ozone Concentration and Feed Gas Flow Rate sub-sections under the section titled Recommendations below).

Transfer Efficiency

- The transfer efficiency of 85 – 88%, as reported on page 5 of Exhibit D-3, *Ozonation Water Treatment System Evaluation*, is at the low end of the range expected for bubble diffusion systems used in drinking water applications. The transfer efficiency of 78%, also reported on page 5, is lower than expected. Improving the transfer efficiency to 90% or higher would utilize the ozone generating capacity more effectively.

Ozone Generators

- A single ozone generator, as suggested in Option 1 of Exhibit P-6, *Ozone System Report for South Central Water Association*, is not recommended. Ozone generators require periodic maintenance and have periodic shutdowns due to a variety of events. Annual or biennial cleaning of the generator vessel interior can take up to one week. Multiple generators would insure some ozone production in the event of a planned or unplanned shutdown of a single generator. Planned maintenance can occur during periods of low water demand, accommodating the lengthy shutdown required for cleaning while still meeting treatment goals.

- The existing Hankin Model PH 58 ozone generator has a relatively high energy consumption of 7.0 kWh/lb ozone using the rated power consumption of 29 kW for the 100lb/d unit (as found on the Ozocan website www.ozocan.com). Typical values for modern medium or high frequency corona discharge generators are in the range of 4 – 6 kWh/lb ozone.

- According to the two tests conducted by OTI between August 14 – 18, 2008 and listed on page 4 of Exhibit D-3, *Ozonation Water Treatment System Evaluation*, at 100% power, the maximum ozone production of the existing Hankin Model PH 58 ozone generator is about 78 lb/d, a variance of 22% from the rated capacity of 100 lb/d, recognizing that the cooling water temperature during these tests is 76°F, slightly but significantly higher than the design cooling water temperature of 70°F. If accurate (e.g. if the power consumption was about 29 kW during these tests), this indicates a higher energy consumption of about 9 kWh/lb ozone.

- Replacement of the Hankin Model PH 58 generator, as suggested in Option 1 of Exhibit P-6, *Ozone System Report for South Central Water Association*, will result in a power consumption about three times the specified total power consumption of 30 kW. Typically, the electrical systems at ozone facilities are not sufficiently oversized to accommodate several multiple increases in power without significant modifications to the electrical gear.

- A vacuum ozone generating system is not required. To my knowledge, Ozone Technologies, Inc. (OTI) is the only manufacturer using a vacuum system. The vast majority of ozone applications larger than 2 lb/d use pressurized ozone generator vessels.

- If a vacuum system is selected to increase ozone production from the existing system's capacity of 100 lb/d to 280 lb/d, then a complete system designed and supplied by the OTI is strongly recommended to insure that the system functions properly over the full range of operating conditions.

Ozone Dissolution System

- The transfer efficiency of 85 – 88%, as reported on page 5 of Exhibit D-3, *Ozonation Water Treatment System Evaluation*, is consistent with the ozone generator configuration: minimal submergence of about 17 ft over the diffusers. Ideally, a submergence is 20 – 24 ft,is recommended for bubble diffusion systems, which translates to a side water depth (SWD) of 21 – 25 ft.

- The transfer efficiency of 78% coupled with the visual observations (e.g. coarse bubbles emanating from the base of the diffusers) described in Exhibit D-3, *Ozonation Water Treatment System Evaluation*, particularly over a very short period, indicates a serious problem with the ozone diffusion system.

Ozone Contactor

- Achieving high transfer efficiency with bubble diffusion probably requires increasing the water depth in the tank, in addition to baffling the tank and installing a more compact bubble diffuser grid.

- Breakthrough of ozone from the contactor (ozone leaving the stainless steel vessel), may result in dissolved ozone coming in contact with PVC pipe, significantly reducing the useful life of the pipe. PVC has limited resistance to ozone. Due to the limited available ozone production, the background ozone dose may not be satisfied at this time and the dissolved ozone residual leaving the contactor may currently be low. However, when the ozone production capacity is increased to 280 lb/d, the impact on the PVC pipe may increase dramatically. Feeding ozone at the front end of the contactor and baffling the reactor reduces the dissolved ozone concentration at the contactor outlet.

- The unbaffled ozone contactor with a low length to width ratio probably has significant short-circuiting, and an effective detention time less than 5 minutes, and probably around 3 minutes, rather than the specified 10 minutes. A tracer test would confirm the effective detention time. Increasing the effective detention time would utilize the ozone generating capacity more effectively and reduce the residual dissolved ozone concentration at the contactor outlet.

Ozone Destruct Unit

- Modifying the existing ozone destruct unit as suggested in Option 2 Phase 2 of Exhibit P-6, *Ozone System Report for South Central Water Association*, and as implied in Option 1 of same (a new and larger destruct unit is not listed with other modifications) may not be feasible. Typically, the catalyst bed is designed for a particular maximum gas flow rate, and substantially increasing the gas flow into the contactor and thus through the ozone destruct unit usually results in substantial increases in headloss. The existing system may not be able to operate with the pressure drop caused by the additional headloss. A completely new ozone destruct unit may be required.

- The single ozone destruct unit provides no redundancy in the event of a shutdown or failure, or for periodic maintenance and replacement of the catalyst. These events would force the entire ozone system to be shut down until repairs can be made to avoid discharging ozone gas to the atmosphere.

RECOMMENDATIONS

The following recommendations are made to reliably achieve the treatment goal of 20 TCU.

Basic Ozone Process Design Parameters

The ozone process design parameters discussed in this sub-section are listed in Table 1 below.

Design flow rate

- The design flow rate should remain 1,200 gpm in the event that the well is redeveloped and regains its original capacity.

Transferred Ozone Dose

- The recommended nominal transferred ozone dose is 18 mg/L.

Applied Ozone Dose

- The recommended applied ozone dose is 19.4 mg/L, nominally 19 mg/L.

Transfer Efficiency

- The recommended design transfer efficiency is 93% assuming a sidestream injection system is installed to replace the existing bubble diffusion system.

Design Ozone Production Capacity

- The recommended design ozone production capacity is 280 lb/d based on a flow rate of 1,200 gpm and a nominal applied ozone dose of 19 mg/L.

Design Ozone Concentration

- The recommended design ozone concentration at the 280 lb/d ozone production capacity is 10%. If the design applied ozone dose is insufficient due to a reduction in transfer efficiency, occasional water quality extremes, or other reasons, then the high design ozone concentration of 10% allows the operator to boost ozone production above the design ozone production capacity of 280 lb/d by operating at 100% power while reducing the ozone concentration to 8% by increasing the feed gas flow rate.

Number of Generators

- Two generators are recommended to provide partial redundancy when one generator is taken out of service for annual or biennial cleaning and inspection. With a design ozone concentration of 10% at the design ozone production rate of 280 lb/d (both generators in service), a single generator can produce significantly more than 140 lb/d by operating at 100% power while reducing the ozone concentration to 8% by increasing the feed gas flow rate.

Feed Gas Flow Rate

- The design feed gas flow rate is 1,800 scfh and is based on the gas flow required to achieve the design ozone production rate of 280 lb/d but at 8% ozone concentration. At 280 lb/d and 10% ozone concentration, the required feed gas flow rate is 1,400 scfh. The additional gas flow enables the ozone generators to exceed their individual capacity and produce more than a combined 280 lb/d by operating at 100% power while reducing the ozone concentration to 8% by increasing the feed gas flow rate to the 1,800 scfh maximum.

Cooling Water Temperature

- The design cooling water temperature is a critical parameter. Ozone production declines as the cooling water temperature increases. The rated ozone generator capacity of standard units is usually modified (typically reduced) based on the maximum cooling water temperature at the specific installation site. The maximum cooling water temperature, assumed to be 76°F based on the values recorded by OTI between August 14 – 18, 2008 and listed on page 4 of Exhibit D-3, *Ozonation Water Treatment System Evaluation*, should be used in the selection of new ozone generators to insure that the design ozone production of 280 lb/d can be achieved.

Table 1. Recommended ozone process design parameters

Parameter	Units	Value
Flow rate	gpm	1,200
Applied ozone dose	mg/L	19.4
Transfer efficiency	%	93
Transferred ozone dose	mg/L	18
Ozone production capacity	lb/d	280
Number of ozone generators		2
Ozone generator capacity, ea.	lb/d	140
Ozone concentration[1]	%	10
Feed gas flow rate[2]	scfh	1,800
Cooling water temperature[1]	°F	76

Notes:

1. Design concentration at the ozone production capacity of 280 lb/d and individual generator capacity of 140 lb/d.
2. Based on the ozone production capacity of 280 lb/d assuming 8% ozone concentration.

Ozone System Modifications

<u>Feed gas system</u>

- Replace the existing feed gas system with a new system sized for the design ozone production of 280 lb/d, including two new oil-free rotary screw compressors, two new refrigerant dryers, a new air receiver, a new oxygen generator, and a new oxygen tank, plus ancillary equipment (filters, valves, gauges, etc.).

<u>Ozone Generating System</u>

- Include the following manufacturers in any ozone equipment selection process (in alphabetical order):

1. Fuji Electric Corporation of America,
2. ITT/Wedeco
3. Mitsubishi Electric Power Products, Inc.
4. Ozonia North America

Listing these manufacturers for consideration in no way precludes evaluation of any other manufacturer, including Ozocan and OTI; equipment from these two manufacturers is discussed in trial transcript and/or exhibits. The manufacturers listed above routinely bid, design and install ozone systems similar to the system installed at the South Central Water Association Ozone Treatment Plant and will provide a good comparison in the evaluation of new equipment.

- The manufacturers should be evaluated based in part on ozone production efficiency, successful installations (including overseas installations), and the number of existing installations that are of a similar size (i.e. ozone production capacity) and type (e.g. power supply unit operating voltage and frequency, dielectric design, and feed gas type). Multiple references should be requested from each manufacturer and the references contacted. Dielectric failures at existing installations should be closely examined.

- Consider ozone production efficiency and its effect on electrical modifications when increasing the ozone production capacity from 100 lb/d to 280 lb/d. A manufacturer whose generators produce at high efficiency in power consumption (e.g. 4 – 5 kWh/lb ozone) may significantly reduce the cost of electrical modifications required to increase the ozone production capacity to 280 lb/d.

Ozone dissolution system

- Replace the existing ozone diffusion system with a sidestream injection system to achieve high transfer efficiency, reduce maintenance, and avoid extensive modifications to the existing bubble diffusion system. The recommended injection system consists of two parallel sidestreams, each with an injection pump, venturi injector, both feeding into a 12-inch stainless steel flash mix reactor installed in-line in the contactor inlet pipe.

- The ozone injection system alternative requires that the PVC pipe between the flash mix reactor and the contactor be replaced with 316L stainless steel pipe.

Contactor

- Install over/under baffles dividing the contactor into three chambers in a downflow/upflow/downflow configuration, nearly doubling the effective length-to-width ratio of the contactor, similar to the baffling described in Option 2 Phase 1 in Exhibit P-6 *Ozone System Report for South Central Water Association.*

Ozone Destruct

- Provide a redundant ozone destruct unit to provide duty/standby configuration to avoid full ozone system shutdown in the event of ozone destruct unit failure or maintenance

Additional engineering and testing

The additional engineering work described below is strongly recommended to insure that equipment procured to expand the ozone production capacity to 280 lb/d achieves the desired treatment goal of 20 TCU.

- Run a performance test on the existing ozone generator to confirm existing ozone production capacity.
- Perform a tracer test on the existing contactor before and after baffling to determine the effective detention time.
- Perform laboratory bench-scale ozone demand and decay test and laboratory pilot test to independently confirm the required transferred ozone dose.
- Perform a life cycle cost analysis to determine the most cost-effective feed gas system (on-site oxygen generation vs. on-site storage of LOX) and the optimal operating range of design ozone concentration. The results of the analysis, if previously calculated, may be different considering the substantial increase in feed gas consumption.
- Perform a thorough life cycle cost analysis to determine if replacing the existing Hankin Model PH 58 ozone generator with a more efficient ozone generator has a lower life cycle cost.
- Require a factory acceptance test (FAT) and field performance test of any new ozone generating equipment, the former confirming ozone production capacity and turndown prior to shipment, and the latter confirming ozone production capacity and power consumption in the field after installation.

OPINIONS OF PROBABLE EQUIPMENT COST

Opinions of probable equipment cost are provided for two options:

1. A new ozone system typical of municipal installations designed to meet the initial performance requirements.
2. Expand the existing system to meet the initial performance requirements.

The costs are not total project costs, but major equipment costs. Additional costs for installation, removal of existing equipment, demolition, piping modifications, electrical modifications, structural modifications, and site work is not included. Typically, estimating these costs is performed by engineers practicing in the respective engineering disciplines. The costs above are intended to be used for a comparison with or relate to equipment costs provided in the trial transcript and trial exhibits.

Description of Alternatives

Option 1 – New ozone system

This option is a new and complete ozone system procured through a major ozone manufacturer as the sole ozone system supplier. Option 2 is consistent with a system designed to meet the original performance requirements of treating 1,200 gpm to 20 TCU with redundancy, instrumentation, monitoring and control providing a robust ozone system typical of a municipal installations requiring limited operator attention.

Option 1 is based on two 140 lb/d corona discharge ozone generators operating at 15 – 20 psig pressure on the inlet side of the generator vessel. Included is removal and salvage of the existing equipment. The new feed gas system, ozone generators and ozone destruct unit(s) could fit within the existing structure, but the injection system would likely have to be installed on a concrete pad adjacent to both the contactor and the building. The estimated equipment cost for Option 1 is provided in Table 2 below.

Table 2. List of major equipment items – Option 1

Quantity	Item	Cost
2	Oil-free rotary screw compressors	Package: $ 965,000
2	Refrigerant dryers	
2	Air receivers	
2	PSA Oxygen generator set	
2	Oxygen receiver	
1	Filters, gauges, valves, lump sum	
2	Ozone Generator, 140 lb/d each, w/PSU	
1	Master ozone system control panel	
2	Ozone destruct unit	
1	Field instrumentation package	
2	Skid-mounted injection skids	35,000
1	12-inch flash mix reactor	
1	Contactor modifications, lump sum	20,000
1	Equipment removal, lump sum	40,000
1	Equipment salvage value, lump sum	(70,000)
	Total	$ 990,000

Only minor structural modifications are necessary. Each new skid-mounted unit can fit through the existing 4 ft x 8 ft double door on the front face of the building. The new system would fit within the existing structure with the exception of the sidestream diffusion system. Installation of the sidestream diffusion system may require an exterior concrete pad roughly 8 ft x 8 ft between the building and the contactor.

Electrical gear modifications are expected to be moderate with the installation of the new equipment. Two 140 lb/d generators consume just 26 kW, less than the specified 30 kW maximum power consumption listed in the original contract documents.

Option 2 - Expand the existing system

This option involves expanding the existing system to 280 lb/d, including one new generator with a capacity exceeding 180 lb/d. The estimated equipment cost for Option 2 is provided in Table 3 below.

Table 3. List of major equipment items – Option 2

Quantity	Item	Cost
2	Oil-free rotary screw compressors	$ 50,000
2	Refrigerant dryers	10,000
1	Air receiver	7,000
1	PSA Oxygen generator set	45,000
1	Oxygen receiver	10,000
1	Filters, gauges, valves, lump sum	3,000
1	PHX-126-5601 Ozone Generator, 215 lb/d	190,000
1	Master ozone system control panel	125,000
2	Skid-mounted injection skids	35,000
1	12-inch flash mix reactor	
1	Ozone destruct unit	30,000
1	Contactor modifications, lump sum	20,000
	Total	$ 525,000

Only minor structural modifications are necessary. The expanded system would fit within the existing structure with the exception of the sidestream diffusion system. Installation of the sidestream diffusion system may require an exterior concrete pad roughly 8 ft x 8 ft between the building and the contactor.

The power consumption is more than tripling, from 29 kW to over 90 kW. Substantial electrical improvements are probable.

Option 2 is only feasible using an experienced ozone system supplier and servicer who provides engineering and maintenance services over a broad range of equipment manufacturers, and is able through that experience to integrate components not originally included in the full system design. Since the number of ozone applications is very small, very few companies specialize in ozone systems. I am familiar with only one company with the staff and experience that can successfully implement Option 2: Ozone Water Systems, Inc (OWS). If this option is pursued, I strongly recommend contacting OWS or a firm with a similar record of experience.

Comparison of Alternatives

The difference in cost between Options 1 and 2 are presented in Table 4. Option 1 has a higher capital cost than Option 2, but a substantially lower annual operating cost due to (1) more efficient ozone production – 4.4 kWh/lb ozone, and (2) higher ozone concentration and lower gas flow rate. Assuming an interest rate of 5.0% and a period of 20 years, the Net Present Value (NPV) of Options 1 and 2 are similar in overall cost for the life of the project. Unknown and not considered in this analysis are all of the operating costs and maintenance costs affected by the differences between the products supplied by different manufacturers.

Table 4. Comparison of Cost between Alternatives

Cost Type	Option 1 New Ozone System	Option 2 Expand Existing System
Capital Cost Opinion (equipment only)	$ 990,000	$ 525,000
Annual Operating Cost Estimate[1]	35,000	57,000
Net Present Value[2]	$ 1,427,000	$ 1,236,000

Notes:

1. Consists of power consumption for the feed gas system, ozone generators, and ozone destruct unit at annual average ozone production of 210 lb/d, assuming a power cost of $0.05/kWh.
2. Based on an interest rate of 5.0% and a period of 20 years.

Option 2 does not provide the redundancy of Option 1. If the new large generator is off-line for maintenance or due to a shutdown, the existing generator with a nominal 100 lb/d capacity cannot approach the 280 lb/d capacity because there is a practical limit to the amount of gas which can pass through a single generator before the pressure drop due to headloss becomes too great for the system to operate. The design ozone concentration is already at 6%, limiting the reduction in ozone concentration by increasing the feed gas flow rate at 100% power.

Recommended Alternative

The recommended alternative is Option 1 – New Ozone System. Option 1 provides a reliable and robust system typical of municipal potable water applications. The brief cost analysis indicates, considering ozone equipment and operating costs, a significantly higher capital cost with Option 1, but similar costs between the two options over the life of the project. The potential costs of upgrading the electrical gear to accommodate 90 kW in Option 2 may be substantial. Also, the high energy consumption of the Hankin ozone generators, coupled with an apparent inability to achieve the 100 lb/d ozone production capacity with the existing installed unit, are significant concerns.

DISCLOSURE AND QUALIFICATION

Disclosure

To the best of my recollection, I have not met anyone working for or representing Ozocan or Hankin, and have not visited an installation with Ozocan or Hankin equipment, and am completely unfamiliar with their equipment. I do know John Overby of Ozone Water Systems through collaboration during IOA activities. Ozone Water Systems is formerly a distributor of Hankin Ozone equipment; however, I only learned of this within the past week. To the best of my recollection, I have only met one employee and/or representative of Ozone Technology Inc. (OTI) and only on one occasion: I met Jerry Clark, then Executive Vice President, in 2005 at the banquet during IOA-PAG regional conference at Lake Lanier, GA. We traded business cards and a few kind words, and discovered a common acquaintance: Jon Strand, an engineer employed by SEH in Eau Claire, WI. To the best of my recollection, I have not visited an installation with OTI equipment and am completely unfamiliar with their equipment.

Qualification

The opinions stated in this letter report are based on the original contract documents, trial transcript, trial Exhibit P-6, *Ozone System Report for South Central Water Association*, and Exhibit D-3, *Water Treatment System Evaluation*, combined with personal experience in advanced water treatment process design and in particular ozone systems. The opinions are based on limited information and developed within a limited budget without the benefit of examining, operating or testing the installed equipment. Retrofitting an existing ozone system is a time-consuming, challenging endeavor which typically contains many unknowns at the outset of the retrofit. The opinions stated here form my best estimate given these limitations. The opinions expressed in this letter should be re-evaluated prior to executing any modifications or procuring any equipment.

SUMMARY

The advice summarized below is provided to the Court for consideration.

The equipment cost of salvaging the existing ozone system equipment and installing a new ozone system is $990,000. This does not include installation, the cost of piping, electrical, or structural modifications, and the cost of engineering and project management. For this option, structural and site modifications are minimal. Piping and electrical modifications are moderate.

The equipment cost of retrofitting the existing Hankin ozone system to achieve a total ozone production of 280 lb/d (Option 2, above) is estimated at $510,000. This does not include installation, the cost of piping electrical, or structural modifications, and the cost of engineering and project management. For this option, structural and site modifications are minimal, piping modifications are moderate, but electrical modifications may be substantial.

Due to efficient ozone production, the annual operating cost of Option 1 is estimated to be $22,000 less than Option 2, assuming constant production at an assumed annual average flowrate of 900 gpm and an average ozone production of 210 lb/d.

For reliable, robust operation typical of municipal potable water applications, Option 1 is recommended. Option 1 represents, with the benefit of new information, the ozone system designed to achieve the original treatment goal of reducing color to 20 TCU at a flow rate of 1,200 gpm.

If you have any questions or comments relating to the information provided in this report, please call me at (414) 615-1965. I appreciate the opportunity to be of service to the Court.

Respectfully,

MWH Americas, Inc.

Michael A. Oneby
Supervising Engineer

cc: File