Iowa DNR New Wastewater Technology Assessment No. 11-1

December 2016 Update

The DNR has evaluated a number of potential modifications to the assessment document originally issued in December 2011. Based on additional data from full scale operational facilities within the State of Iowa as well as reevaluation of the original Steinbach pilot data and manufacturer's supporting information, the following alternative design criteria may be accepted on a case-by-case basis for proposed facilities:

1. Pretreatment: In general aerated lagoon systems preceding the SAGR process will be required to meet the standards set forth in Ch. 18C of the Iowa Wastewater Facilities Design Standards (IWFDS). Aerated lagoon systems with detention times less than those provided for in 18C.6.1.1 may be allowed subject to a calculated maximum BOD_5 lagoon effluent/SAGR influent concentration of 30 mg/L under the ADW, AWW and IWFDS 18C.4.1.2 design flows. Lagoon effluent/SAGR influent BOD_5 mass loading shall be calculated for the AWW design flow using the first-order reaction formula presented in Appendix 18C-A of the IWFDS under the conditions described for ice cover, sludge accumulation, temperature and reaction rates in Section 18C.6.1.

2. BOD loading (flux): A maximum 30-day average BOD flux rate of up to 3.75 $lbs/100ft^2$•d with the largest SAGR cell offline at a design load capacity of at least 75% of the total design loading to a zone.

3. HRT: A minimum SAGR HRT of 12 hours based on SAGR pore volume and the AWW design flow.

For proposals based on the above alternate pretreatment and/or HRT criteria, additional monitoring requirements described later in this assessment document will apply. Where lagoon and/or SAGR sizing is not based on the alternate criteria, or where only the alternate BOD loading (flux) criterion is used, additional monitoring requirements will not apply.

In addition, where proposed lagoon or SAGR sizing is based on the alternate criteria, a contingency plan shall be submitted explaining what corrective measures will be taken if the system fails to meet expected performance.

Other modifications included in this update include:

- Removal of language pertaining to a tracer study where the width to length or length to depth ratio exceeded 4:1.

- Addition of a 1½" maximum media size.

- Removal of media sphericity and uniformity coefficient criteria.

- Addition of sample calculations for the alternative criteria.

Process Description: Lagoon Based ammonia removal – OPTAER™ Submerged Attached Growth Reactor (SAGR™)

STATEMENT

Small scale, affordable treatment facilities capable of nitrification of wastes enabling effluent to meet low ammonia levels is a challenge for small communities faced with NPDES permit limits of low single digit values. End-of-pipe limits in the range of 1 mg/l (summer) and 5-10 mg/l (winter) are common results of current water quality standards in Iowa.

Aerated lagoon systems show the capability to provide some ammonia removal in warmer months but are generally incapable of meeting ammonia limits during periods of low water temperatures. The Submerged Attached Growth Reactor (SAGR) is proposed to address this issue and has been presented and evaluated as a retrofit to existing aerated lagoons, and the SAGR system may be applicable to new facilities that meet the study criteria (designed in accordance with Chapter 18C of the Iowa Wastewater Facilities Design Standards). Nelson Environmental, Inc. has provided results from test studies that demonstrated consistent performance at low ammonia effluent levels. Based on these studies, the following guidance is provided for design criteria for SAGR systems to provide year-round nitrification in Iowa wastewater treatment systems.

Iowa's Wastewater Facilities Design Standards did not adequately address the SAGR type process specifically, therefore approvals are done as provided in Section 14.4.3 "Required Engineering Data for New Process Evaluation". This assessment in addition to applicable design standards will provide guidance to designers for DNR approval based on current empirical information relative to capabilities of the SAGR process following aerated lagoons. This document is not a design standard but is an indication of what may be considered acceptable for DNR approval. Future information may result in modification of this assessment. Further, modification to individual systems may be required based on monitoring data collected over the first two years.

The DNR recognized the importance of feasible alternatives. This process was evaluated for technical capability for compliance rather than affordability.

EVALUATION

Nelson, Environmental, Inc. has submitted a data presentation to support the proposal that would provide a system to accomplish the low ammonia values (less than 5 mg/l). This is based on data from a large-scale pilot project at Steinbach, Manitoba, Canada. The SAGR pilot system that was studied followed an existing aerated lagoon treatment system which provided effluent containing ammonia concentrations over an acceptable period of time to demonstrate cold weather operation.

The SAGR process is an insulated below-grade gravel bed with a distribution chamber at the front end that distributes secondary wastewater across the width of the cell, and a collection system at the back end. An aeration system throughout the floor provides aerobic conditions in the bed. Performance test results are attached. Consistent effluent ammonia concentrations below 1 mg/l were demonstrated in both warm and cold months. The Iowa DNR accepts the piloting information and data from Nelson Environmental, Inc. The method of study of the system was reasonable and important criteria were addressed.

REFERENCES

Nelson, Environmental, Inc. submittals for the pilot project and their resulting design guidance include:

1. August 22, 2008, Lagoon Based Cold Climate Ammonia Removal – OPTAER SAGR Pilot System, Steinbach, Manitoba, Year 1 Data Summary.
2. Design Guidance and Criteria for Submerged Attached Growth Reactor (SAGR) provided by Nelson Environmental, Inc.
3. June 8, 2009, Lagoon Based Cold Climate Ammonia Removal - OPTAER SAGR Demonstration System, Steinbach, Manitoba, Year 2 Data Summary.
4. August 7, 2009 email transmitting latest data summary and SAGR bed design criteria to provide bed sizing detail based on the pilot project.
5. July 16, 2010 Lagoon Based Cold Climate Ammonia Removal – OPTAER SAGR Demonstration System, Steinbach Manitoba, Year 3 Data Summary.
6. August 23, 2010 Volumetric Design Criteria for Stienbach and Lloydminster's Demonstration Submerged Attached Growth Reactors (SAGR); submitted by Nelson Environmental to the Iowa DNR
7. November 2, 2011 Statistical probability analysis of TAN effluent data from the SAGR at the Steinbach MB site; submitted by Nelson Environmental to the Iowa DNR.
8. September 12, 2016 Sylvan Lake SD Data.
9. September 12, 2016 Perth Data Summary.

ADDITIONAL REFERENCES

Due diligence conducted by the DNR included independent research into the SAGR process. The references used as part of that research include the following:

1. Missouri Construction Permit Number CP 0000807 – SAGR installation in Lamar, Missouri
2. Wyoming Construction Permit Number 10-334R – SAGR installation in Mountain View, Wyoming
3. Indiana Construction Permit Number 19722 – SAGR installation in Mentone, Indiana
4. Metcalf and Eddy, 4th ed. (2003). Attached Growth and Combined Biological Processes. *Wastewater Engineering Treatment and Reuse*. Boston, McGraw Hill.
5. Metcalf and Eddy, 5th ed. (2014). Attached Growth and Combined Biological Treatment Processes. *Wastewater Engineering Treatment and Reuse*. Boston, McGraw Hill.

QUALIFICATIONS

Similar conditions to the piloted system are necessary to assure replication of results similar to the pilot effluent; this system has been evaluated strictly as a nitrification unit following lagoon treatment. Optimal $CBOD_5$ influent concentrations to the SAGR are 50 mg/L or less. Influent ammonia concentrations is expected to fall in the range from 10 to 25 mg-N/L consistently. It should be noted that the pilot experienced ammonia concentrations in this range consistently year-round, including warmer months, however, stress tests were conducted using zero flow conditions.

RELIABILITY AND REDUNDANCY

A minimum dual train system is required. Each train in the system must have two feed zones; one at the head of the system and one at the midpoint of the system. The system shall be designed to treat 75 percent of the design volume and waste loading rates with the largest zone out of service with all zones designed to operate fully independently.

The power supply for the system is essential to maintaining aeration. Redundancy to ensure adequate aeration shall be provided by following the requirements of IDNR Wastewater Design

Standard 14.5.3 – Power Source Reliability such that adequate power capacity is provided to power maximum wet weather pumping and to power aeration system requirements based on maximum month loading by either:

a. Dedicated standby generator.
b. Alternative power feed from a separate utility substation.

DESIGN CRITERIA

Hydraulic Retention Time:
The minimum design hydraulic retention time (HRT) for the system shall be 24 hours. The design HRT for the SAGR shall be calculated as follows:

$HRT = V_p/Q_{AWW} = (V \cdot \eta)/Q_{AWW}$

V_p = Pore Volume, MG
V = Effective System Volume, MG
η = Porosity of aggregate (ratio of volume of voids to total volume)
Q_{AWW} = Flow, MGD (design flow based on the projected average wet weather flow rate)

Depth Requirements:
The depth of the system shall meet aeration system requirements. A minimum media depth of four (4) feet excluding cover and liner is required.

System Loading:
The total suspended solids (TSS) concentration for flow feeding into the SAGR system shall be less than 50 mg/L (Developed based on 95% confidence interval for mean of TSS from Steinbach and Lloydminster Projects Data). To maintain a sufficiently low TSS concentration for the SAGR influent, treatment to reduce TSS from lagoon effluent may be needed. Approval of SAGR systems may require modification to the existing system or a stand-alone or dedicated process for TSS removal.

The system shall be designed based on a $CBOD_5$ concentration of 25 mg/L and based on a maximum month design loading for TKN loading criteria as follows:

$CBOD_5$ Loading:
$CBOD_5$ Loading = $Q_{AWW} \cdot 25$ mg/L$\cdot 8.34 \cdot 100/(A_x) \leq 2.5$ lb-$CBOD_5$/(100ft$^2 \cdot$d)

Q_{AWW} = Average Wet Weather Flow, MGD
A_x = SAGR cross-sectional area based on depth by width

Notes: $CBOD_5$ loading is based on lagoon effluent $CBOD_5$, $CBOD_5$ loading is per 100 ft^2 cross-sectional area (depth by width)

Total Kjeldahl Nitrogen (TKN) Loading:
TKN Loading $\leq$ 0.40 lb-TKN/(1,000ft$^3 \cdot$d)

Note: TKN loading is per 1,000 ft^3 total system volume based on lagoon influent TKN concentration

Wastewater Distribution:
Wastewater distribution shall be designed with a system to provide even distribution across the entire cross-sectional area with appropriate measures to minimize short-circuiting through the system.

Aeration Requirements:
The aeration system shall be designed to provide a minimum dissolved oxygen concentration of 3.0 mg/L. The system shall incorporate monitoring locations with probes to verify that a minimum 3.0 mg/L is provided. At least two blowers, each sized to handle and treat design TKN loading, shall be installed to support the SAGR process. Diffusers shall be designed to be directly buried in gravel.

Engineered Media:
Aggregate media shall meet the following requirements:

Table 1. Sieve Analysis

Sieve Size	Percent Passing
1½”	100
1”	80-100
¾”	30-80
½”	10-30
⅜”	0-2
¼”	0-1

Table 2. Aggregate Mechanical Requirements

Test	Maximum Value	ASTM Reference
Abrasion	35% Loss	C 131
Soundness	8% Loss	C 88
Micro-Deval	25% Loss	D 6928

The aggregate shall have a minimum porosity of 38%.

Liner:

A 60 mil HDPE liner, or equivalent barrier, shall be installed between the treatment system and the native soils.

Insulation:

An insulating mulch layer shall be provided not less than eight (8) inches thick using dried peat mulch defined in accordance with ASTM D4427-92 or approved compost material. Peat mulch shall meet the following conditions

Table 3. Allowable Peat Composition

Parameter	Value	Reference
Moisture Content	25-75%	ASTM D2974
Ash Content	≤25%	ASTM D2974
pH	3.5-7.5	ASTM D2976
Fiber Content	≥33%	ASTM D1997-91

Compost materials shall comply with IAC Chapter 567-105 and shall meet the following:

Table 4. Allowable Compost Composition

Parameter	Value	Reference
pH	5.0-8.5	ASTM D2976
Soluble Salts	< 5 mS/cm	ASTM D2973-71
Nutrient Content	N – 0.50-2% P – 0.20-2% K – 0.30-1.5%	
Bulk Density	700-1,200 lb/yd^3	ASTM D4531-86
Moisture Content	30-60%	ASTM D2974
Organic Matter Content	25-65%	ASTM D2974
Particle Size	3 inch (100% passing) 1 inch (90-100% passing)	
Heavy Metals	Arsenic < 41 mg/kg Cadmium < 39 mg/kg Copper < 1,500 mg/kg Lead < 300 mg/kg Mercury < 17 mg/kg Nickel < 420 mg/kg Selenium < 36 mg/kg Zinc < 2,800 mg/kg	EPA Part 503
Growth Screening (Plant Growth Test)	80-100%	ASTM D5975
Stability	Stable to Very Stable	

Wood chips may be considered an acceptable alternative but must also meet the requirements for pH, soluble salts, nutrient content, and heavy metals shown in Table 4.

CONSTRUCTION DETAILS

The construction details from the Iowa Wastewater Facilities Design Standards listed below are incorporated by reference into this technology assessment.

- 18C.7.2.1 Material
- 18C.7.2.2 Top Width
- 18C.10 Miscellaneous

ADDITIONAL MONITORING REQUIREMENTS FOR THE SAGR UNIT PROCESS

Monitoring and sampling:

Figure 1 depicts an example of a four-zone system used to identify sample collection points. The system shall be designed to allow for water depth measurement and sample collection from the head of the system at the midpoint (between zones) of the system , and at the end of the system near the effluent.

The monitoring plan outlined in Table 5 shall be followed for a period of two years. All trains may be composited or measured independently, but all trains, if operational, shall be represented;

provide a description of the sample to identify it as Zone 1, Zone 2, Zone 3, Zone 4, or a composite therof. As a condition of facility plan approval, a Memorandum of Agreement (see attached sample) shall be signed by the owner that commits the owner to additional monitoring in accordance with this section for not less than two years. Based on the results shown by the monitoring data, additional modification to individual systems may be required.

Table 5. Monitoring Plan

Parameter	Units	Sampling Frequency	Location		
			Influent	Midpoint	Effluent
Total Kjeldahl Nitrogen	mg-N/L	Once monthly	X	X	X
Ammonia	mg-N/L	Once every two weeks	X	X	X
Nitrite plus Nitrate	mg-N/L	Once every two weeks with ammonia	X	X	X
pH[A]	S.U.	Daily	X	X	X
Alkalinity	$mgCaCO_3/L$	Once every two weeks with ammonia	X		X
Dissolved Oxygen[A]	mgO_2/L	Daily		X	X
Water Temperature[A]	°F	Daily	X	X	X
TSS	mg/L	Once every two weeks	X		
$CBOD_5$	mg/L	Once every two weeks	X		
Flow Volume[A,B]	MGD	Daily	X		X
Water Depth	feet	Once every two weeks	X	X	X

[A]Autologging is acceptable for pH, D.O., and temperature, and flow volume provided calibration is performed in accordance with the manufacturer's recommendations.
[B]The volumetric flow rate may be measured in the influent or effluent, but flow must be measured for each train independently.

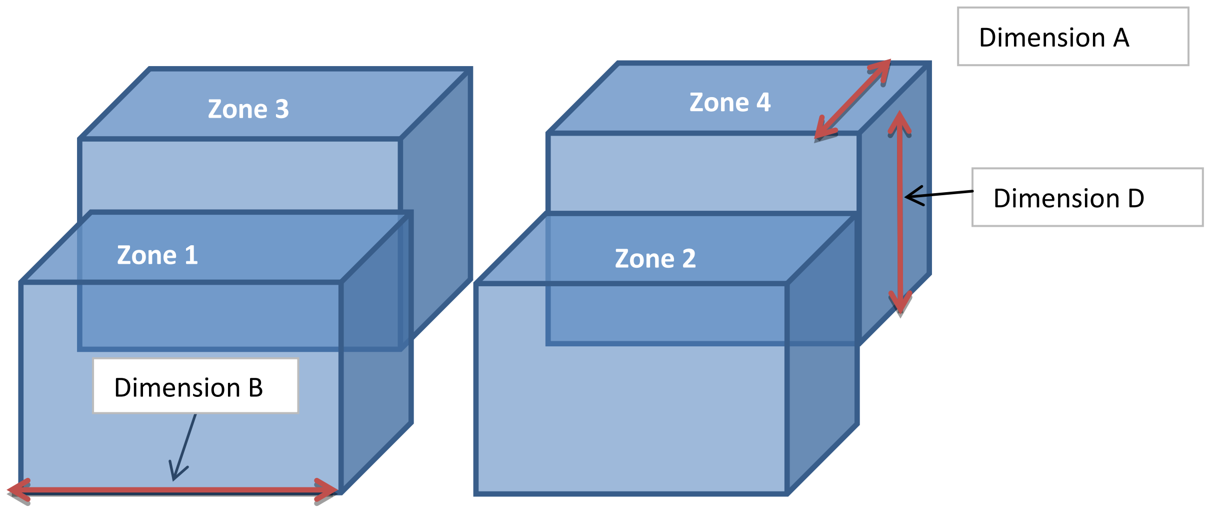


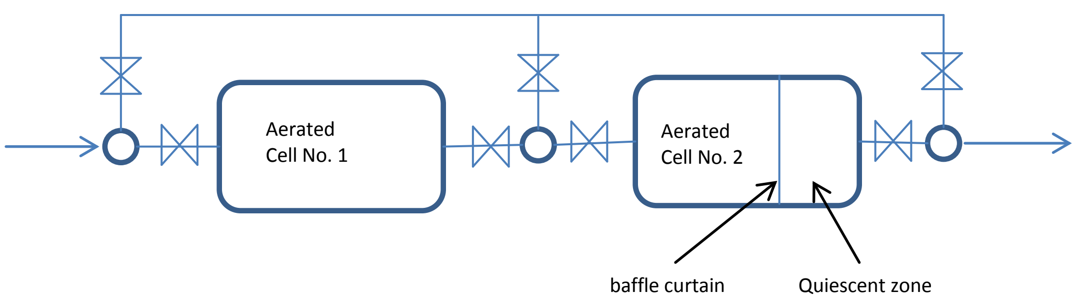
Figure 1. Representation of a four zone SAGR System

CONCLUSION The Iowa DNR accepts the design criteria for the SAGR process for application to similar situations and loading conditions. Iowa DNR will accept for approval proposed projects that utilize the design procedure presented by this technology analysis. Specific project details will depend on the loadings for individual applications and are subject to further review by Iowa DNR.

ALTERNATE CRITERIA EXAMPLE CALCULATIONS

A. Lagoon Calculations

- Two-Cell Aerated Lagoon Facility Layout



- Cell Volumes

Aerated Cell No. 1	2.00 MG
Aerated Cell No. 2	1.63 MG
Quiescent Zone	0.38 MG

- Proposed Design Basis (Raw Influent)

Flows (MGD)		Loads (lbs/day)		
ADW	0.075		Max. 30-day	Max. Day
AWW_{30}	0.450	BOD_5	170	280
MWW	1.100	TSS	200	330
PHWW	2	TKN	36	51

- IWFDS Ch. 18C Aerated Lagoon Design Flow and Calculated Cell Hydraulic Residence Times for BOD Removal Efficiency Calculations

18C.4.1.2“a”: 0.075 + 0.3[0.450-0.075] = 0.188 MGD

Design Population Equivalent: 170/0.17 = 1,000

Cell	Gross Volume (MG)	Ice Cover* Volume (MG)	Sludge** Accumulation Volume (MG)	Net Volume (MG)	AWW_{30} Net HRT (days)	ADW Net HRT (days)	Q_{18C} Net HRT (days)
# 1	2.00	0.38	0.20	1.41	3.1	18.9	7.5
# 2	1.63	0.32	0.17	1.15	2.6	15.3	6.1
Quiescent	0.38	N/A	N/A	0.38	0.8	5.1	2.0

*Estimated volume of 12” average ice thickness at lagoon HWL.
**Estimated at 18.5 gallons per population equivalent per year for a 20-year accumulation.
Sludge distribution per aerated cell assumed proportional to cell volume.

- Calculated BOD_5 Values*

Flow Condition	AWW		ADW		Q_{18C}	
Cell #	1	2	1	2	1	2
Cell Influent, mg/L (lbs/d)	45.3 (170)	31.6 (119)	272 (170)	75.3 (47.1)	109 (170)	53.2 (83.2)
Cell Effluent, mg/L (lbs/d)	31.6 (119)	23.4 (87.7)	75.3 (47.1)	24.3 (15.2)	53.2 (83.2)	28.9 (45.2)

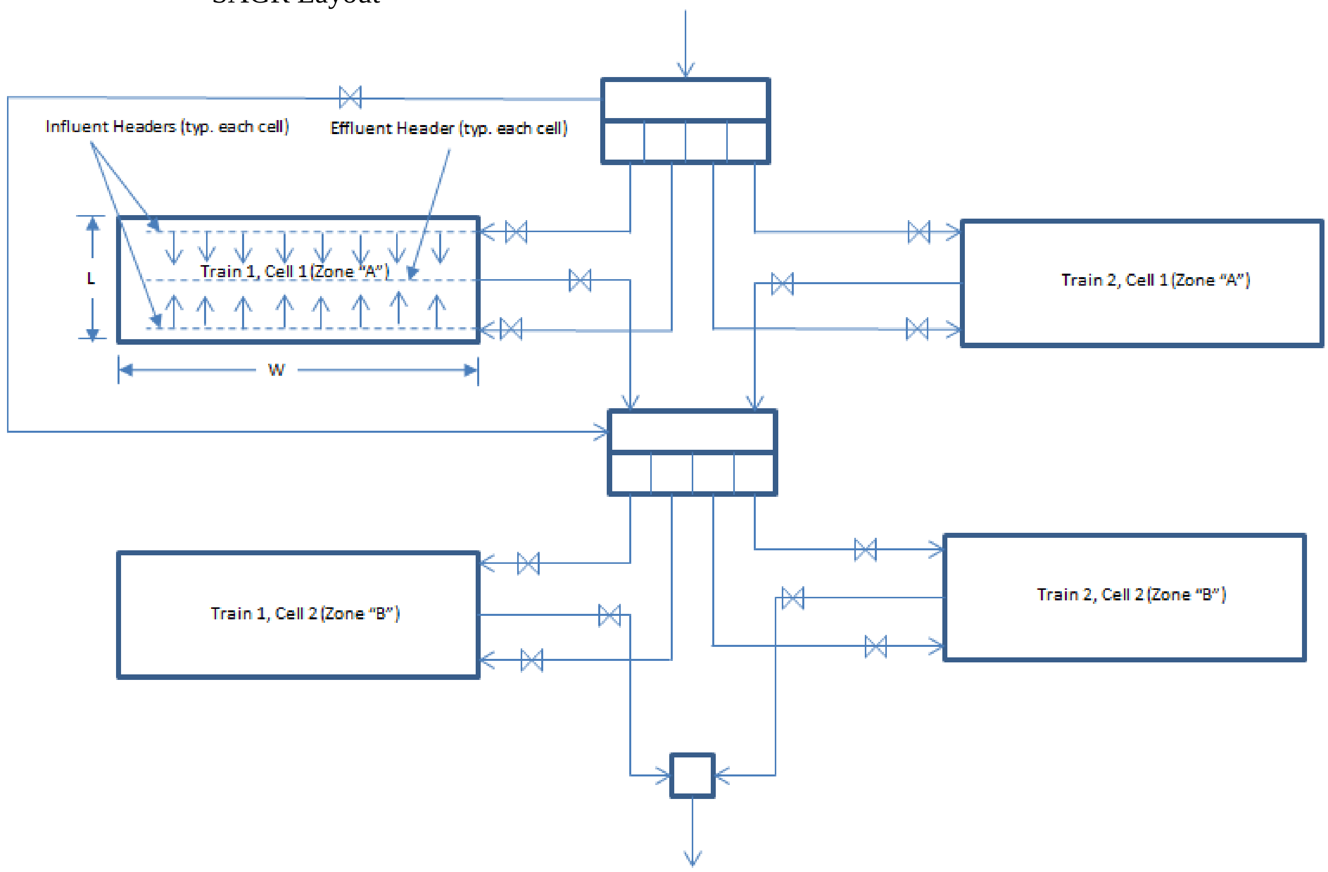
*See IWFDS Ch. 18C Section 18C.6.1 and Appendix 18C-A. $K1_{20} = 0.12$, T = 1° C, $\Theta = 1.037$

Maximum design 30-day average lagoon effluent concentration = 28.9 mg/L<30 mg/L ✓

Lagoon effluent/SAGR influent design BOD_5 Loading = 87.7 lbs/d

B. SAGR Calculations

- SAGR Layout



- HRT, BOD_5 flux, and TKN Volumetric Loading

Minimum BOD_5 Flux Area Required per Cell = $\frac{0.75 \times 87.7\ \text{lbs/d}}{3.75 \frac{\text{lbs}}{100\ \text{sq.ft} \cdot \text{d}}} = 1{,}754\ \text{sq.ft.}$ (75% reliability)

Minimum TKN Loading Volume Required = $\frac{36\ \text{lbs/d}}{0.4 \frac{\text{lbs}}{1{,}000\ \text{cu.ft} \cdot \text{d}}} = 90{,}000\ \text{cu.ft.}$

Media Porosity = 40% (38% minimum)

Minimum HRT Volume Required = 12 hours @ AWW design flow = 12/24 x 0.45/0.4 = 0.563 MG (75,200 cu. ft.)

Minimum Total Volume Required = Max.(TKN, HRT) = 90,000 cu. ft.

Contact: Larry Bryant (515-725-8426; larry.bryant@dnr.iowa.gov)

Last updated: December 2016

SAMPLE MEMORANDUM OF AGREEMENT
Additional Wastewater Treatment System Monitoring

POTW OWNER **City – Sewage File**

The Iowa Department of Natural Resources is in agreement the proposed wastewater treatment process concept for the City and the Department is currently reviewing the submitted facility plans. However, as the proposed system is considered to be innovative, documentation of the performance of the treatment units will be required. The following table outlines the monitoring and sampling plan for the proposed SAGR wastewater treatment system:

			Location		
Parameter	Units	Sampling Frequency	Influent	Midpoint	Effluent
Total Kjeldahl Nitrogen	mg-N/L	Once monthly	X	X	X
Ammonia	mg-N/L	Once every two weeks	X	X	X
Nitrite plus Nitrate	mg-N/L	Once every two weeks with ammonia	X	X	X
pH[A]	S.U.	Daily	X	X	X
Alkalinity	$mgCaCO_3/L$	Once every two weeks with ammonia	X		X
Dissolved Oxygen[A]	mgO_2/L	Daily		X	X
Water Temperature[A]	°F	Daily	X	X	X
TSS	mg/L	Once every two weeks	X		
$CBOD_5$	mg/L	Once every two weeks	X		
Flow Volume[A,B]	MGD	Daily	X		X
Water Depth	feet	Once every two weeks	X	X	X

[A]Autologging is acceptable for pH, D.O., and temperature, and flow volume provided calibration is performed in accordance with the manufacturer's recommendations.
[B]The volumetric flow rate may be measured in the influent or effluent, but flow must be measured for each train independently.

Monitoring and sampling shall be initiated within one month of the startup of the treatment system.

The monitoring and sampling program shown above shall be conducted **for a period of two years** from the date of the first sampling event. This monitoring and sampling are to be performed in addition to the sampling and reporting required by the National Pollution Discharge Elimination System (NPDES) Permit for the facility. Samples with the same sampling points and parameters as those in the NPDES Permit may not need to be duplicated. The monitoring described in this agreement is subject to the same signatory and laboratory certification requirements as described in the NPDES Permit and shall be included in the NPDES monitoring report.

Memo.

Contact XXXX at (515) 725-XXXX with any questions or comments.

FOR THE DEPARTMENT OF NATURAL RESOURCES

CHUCK GIPP, DIRECTOR

By ______________________________

ENVIRONMENTAL SERVICES DIVISION

Date: XXXX

The undersigned agrees to perform the monitoring described above as a condition of the Facility Plan and Construction Permit approval for the above referenced project.

FOR POTW

By ______________________________

Date: ______________________________

cc: