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Submerged attached-growth reactors as lagoon retrofits for cold-weather ammonia removal

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SUBMERGED ATTACHED-GROWTH REACTORS AS LAGOON RETROFITS FOR COLD-WEATHER AMMONIA REMOVAL

by

Rebecca Ruth Mattson

A thesis submitted in partial fulfillment
of the requirements for the Master of Science
degree in Civil and Environmental Engineering in the
Graduate College of
The University of Iowa

May 2018

Thesis Supervisor: Assistant Professor Craig L. Just

Graduate College
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Iowa City, Iowa

CERTIFICATE OF APPROVAL

MASTER'S THESIS

This is to certify that the Master's thesis of

Rebecca Ruth Mattson

has been approved by the Examining Committee for
the thesis requirement for the Master of Science degree
in Civil and Environmental Engineering at the May 2018 graduation.

Thesis Committee:

Craig L. Just, Thesis Supervisor

Patrick O’Shaughnessy

Jerald L. Schnoor

To my parents, for always believing in me.

“Anything else you’re interested in is not going to happen if you can’t breathe the air and drink the water. Don’t sit this one out. Do something. You are by accident of fate alive at an absolutely critical moment in the history of our planet.”

Carl Sagan

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ABSTRACT

Small towns that operate wastewater treatment lagoons struggle to meet ammonia limits in cold weather. Here we report the performance of a lagoon, retrofitted with submerged attached-growth reactors (SAGRs^{TM}), to provide insight on ammonia effluent compliance and optimal SAGR sizing as functions of water temperature. The lagoon-SAGR water resource recovery facility (WRRF) removed 95% of incoming ammonia with 94% attributable to the SAGRs. The high treatment capacity of the two primary SAGRs, evidenced by nearly continuous dissolved oxygen saturation and exceedingly high ammonia removals, suggested the two secondary SAGRs were essentially unnecessary and that all four SAGRs should be reduced in size. Furthermore, without the secondary SAGRs, the primary SAGR effluent would have exceeded the permitted ammonia discharge limit only four times in the 2.5 year study. At its current size, the lagoon-SAGR WRRF never exceeded permitted ammonia limits, but size reductions should be used for future retrofits.

To further understand cold-weather ammonia removal in the lagoon-SAGR WRRF, we investigated the effect of increased ammonia loading on biomass and the effect of biofilms on microbial abundance. When ammonia loading to the SAGRs was increased in the fall, the lagoon-SAGR WRRF never exceeded its ammonia permit limit, the kinetic coefficients were maintained (0.5-0.8 d^{-1}) and the NH_3 removal rates improved (0.25 kg d^{-1} in baseline loading to 0.45 kg d^{-1}) despite a large temperature decrease (25 °C to <16 °C). In the biofilm, ammonia-oxidizing archaea abundance was 10 times greater than the ammonia-oxidizing bacteria abundance suggesting the potential importance of ammonia oxidizing archaea in biofilm mediated systems. Additionally, the ammonia and nitrite transforming microbes in the SAGRs had a diverse range of dissolved oxygen affinities and were more abundant in the biofilm in comparison to the wastewater. Anaerobic ammonium-oxidizing bacteria were abundant in the biofilm even though the film constantly interacted with high dissolved oxygen. We found that two components of a successful lagoon-SAGR WRRF were increased biomass in the SAGRs before cold-weather due to elevated ammonia loading and diverse oxygen affinities in the microbes related to ammonia removal.

PUBLIC ABSTRACT

Ammonia is one component of wastewater that needs to be removed before releasing the treated water to lakes and rivers due to its toxicity to aquatic organisms. Regulation agencies have started to pass more stringent limits on the allowable amount of ammonia released to natural waters in an effort to protect recreation and aquatic life. Large scale wastewater treatment facilities use a variety of biological methods to meet permitted ammonia limits. However, these methods typically cannot be applied in small wastewater systems, many of which operate lagoons. Additionally, biological ammonia removal is severely limited by cold-temperature which further hinders ammonia removal in lagoons. There is a need for lagoon retrofits for cold-weather ammonia removal. To support small scale wastewater treatment we investigated one lagoon retrofitted with submerged attached-growth reactors (SAGRs^{TM}), reactors that contain attachment media submerged in wastewater and are continuously aerated. This study used historical data to analyze SAGR effectiveness and sizing. We found that SAGRs were an effective lagoon retrofit but should be reduced in size in future systems to minimize construction and maintenance costs while still effectively removing ammonia. We also collected wastewater and biofilm samples from a SAGR to investigate what process contributed to the system success. We found that increasing the amount of ammonia entering the SAGR before winter helped stimulate ammonia removal during limiting temperature conditions and that the attached-growth system selected for a diverse microbial community. This work suggests that SAGRs be used to retrofit lagoons struggling to meet cold-weather ammonia permit limits.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER I: INTRODUCTION AND LITERATURE REVIEW

1.1 Organization

This thesis is organized into four chapters, including this introduction (Chapter 1), and followed by references and an appendix. Each chapter contains the relevant written information followed by cited tables and figures. The second chapter is a submitted manuscript, modified for this thesis format, discussing the first two objectives and hypotheses (1&2) laid out in this introduction. The third chapter has also been submitted as a manuscript and addresses the remaining two objectives and hypothesis (3&4). The fourth chapter concludes the thesis, discusses implications, and suggests ideas for future research. All citations are included in the references section. The appendix contains all of the raw data used in preparation of the figures and conclusions, as well as additional data not used in the thesis body (Appendix A) and selected photos of the research (Appendix B).

1.2 Objectives and Hypothesis

The objectives were to:

1. Validate submerged attached-growth reactors as a full-scale lagoon water resource recovery facility retrofit for cold-weather ammonia removal.
2. Inform future submerged attached-growth reactor sizing decisions.
3. Understand the effect of step-feeding on ammonia loading and biomass production.
4. Identify what microbial community contributes to nitrification in the submerged-attached growth reactors.

We hypothesized that:

1. Retrofitting a lagoon with submerged attached-growth reactors produces ammonia discharge compliant with the permitted ammonia limit >99% of the time.
2. The primary submerged attached-growth reactors alone, half the treatment volume, produces permittable ammonia discharge >95% of the time.
3. Step-feeding increases biomass in submerged attached-growth reactors.
4. Ammonia-oxidizing bacteria are the dominant microorganisms in the submerged attached-growth reactors.

1.3 Literature Review

1.3.1 Ammonia Toxicity

Ammonia[1] must be removed from wastewater discharge because it is a known neurotoxin and is more toxic than nitrate (NO_3^-) and nitrite (NO_2^-), the oxidized forms of nitrogen (Luo et al., 2015). Free ammonia (free-NH_3), in particular, is toxic to aquatic organisms because of its ability to diffuse across cell membranes (Luo et al., 2015). The toxicity is pH- and temperature-dependent as a result of speciation. The un-ionized form, free-NH_3, is in equilibrium with ammonium (NH_4^+), the ionized form:

$$NH_3 + H_2O \leftrightarrow NH_4{}^+ + OH^- \tag{1.1}$$

where NH_3 is free-ammonia (moles), H_2O is water (moles), $NH_4{}^+$ is ammonium (moles), and OH^- is hydroxide (moles). More alkaline pH conditions shift the equilibrium to high free-NH_3 concentrations. At pH 8, five percent of the NH_3 present in water is free-NH_3. Above pH 9.2, free-NH_3 is the dominant species (Figure 1.1) (Middlebrooks & Pano, 1983). As the temperature decreases, the equilibrium constant controlling the speciation increases according to Van't Hoff's equation:

$$\ln\left(\frac{K_2}{K_1}\right) = \frac{-\Delta H°}{R}\left(\frac{1}{T_2} - \frac{1}{T_1}\right) \tag{1.2}$$

where K_1 is the equilibrium constant at temperature T_1 (298K) (unitless), K_2 is the equilibrium constant at temperature T_2 (unitless), T is the absolute temperature (K), $\Delta H°$ is the reaction enthalpy (kJ mol^{-1}), and R is the ideal gas constant in (kJ mol^{-1} K^{-1}). At 25 °C and pH 9.2, the two species are equal in concentration; however, at 0 °C the equilibrium pH shifts to 10.1. At lower pH values and lower temperatures, less free-NH_3 is present (Figure 1.1).

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[1] The use of ammonia (NH_3) in this thesis refers to total ammonia, the sum of free-ammonia and ammonium. Free-ammonia will be referred to as "free-NH_3" and ammonium will be referred to as NH_4^+.

In addition to its toxic effects, NH_3 also exerts an oxygen (O_2) demand. Biodegradation of NH_3 by aerobic microorganisms depletes dissolved oxygen (DO) levels. The amount of DO available for other aquatic organisms in natural water bodies or designed aquatic systems is thus reduced. Because of its toxicity and associated O_2 demand, NH_3 must be removed from wastewater discharges to natural water bodies.

1.3.2 Nitrification

Water resource recovery facilities (WRRFs)[2] take advantage of microbial degradation of NH_3 to treat high levels derived from protein waste (Rittmann & McCarty, 2001). Ammonification quickly converts urea and some organic nitrogen present in urine to NH_4^+ in the anaerobic environment of wastewater collection systems (EPA, 2015). Once wastewater reaches the WRRF, typical domestic influent contains 60% NH_4^+-N, 40% organic nitrogen, and 0% NO_3^--N/NO_2^--N (EPA, 1993). Most WRRFs use biological methods to decrease the NH_4^+-N concentration in the wastewater and prevent the adverse effects of NH_3 discharge in natural waters.

Nitrification is the biological method used in WRRFs to microbially convert NH_3 to NO_3^- (Crittenden et al., 2012). The mechanism can be completed in a two-step process through the cooperation of ammonia-oxidizing bacteria (AOB) or ammonia-oxidizing archaea (AOA) and nitrite-oxidizing bacteria (NOB). Nitrification can also occur via a one-step process by complete ammonia-oxidizing bacteria (COMAMMOX) (Daims et al., 2015). In the rate-limiting step, AOB convert NH_4^+ to NO_2^- (Equation 1.3), followed by NOB converting NO_2^- to NO_3^- (Equation 1.4) (EPA, 1993). Complete ammonia-oxidizing bacteria convert NH_4^+ directly to NO_3^-, which is equivalent to the overall

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[2] Water resource recovery facility (WRRF) is a term suggested by the Water Environment Federation instead of wastewater treatment plant to promote the public opinion that wastewater is a valuable water resource and will be used throughout this thesis.

nitrification equation for the combined AOB and NOB mechanism (Equation 1.5) (van Kessel et al., 2015). Although nitrification equations have been historically written in terms of NH_4^+, free-NH_3 is generally accepted as the substrate utilized by NH_3 oxidizers (Kowalchuk & Stephen, 2001):

$$NH_4{}^+ + 1.5O_2 \rightarrow NO_2{}^- + H_2O + 2H^+ \quad (\Delta G^\circ = -274.7\ kJ \cdot mol^{-1}) \tag{1.3}$$

$$NO_2{}^- + 0.5O_2 \rightarrow NO_3{}^- \quad (\Delta G^\circ = -74.1\ kJ \cdot mol^{-1}) \tag{1.4}$$

$$NH_4{}^+ + 2O_2 \rightarrow NO_3{}^- + H_2O + 2H^+ \quad (\Delta G^\circ = -348.9\ kJ \cdot mol^{-1}) \tag{1.5}$$

where $NH_4{}^+$ is ammonium (moles), O_2 is oxygen (moles), $NO_2{}^-$ is nitrite (moles), H_2O is water (moles), H^+ is hydrogen (moles), $NO_3{}^-$ is nitrate (moles) and ΔG° is Gibbs energy.

This study focuses on two-step nitrification, which involves nitrifying bacteria that are chemolithotrophic and belong to the phyla Gammaproteobacteria and Betaproteobacteria (Madigan et al., 2015). Together, AOB and NOB carry out an eight electron transfer (Madigan et al., 2015). The electron donors utilized by nitrifying bacteria are not particularly strong. The values are E_0’=+0.34 V and E_0’=+0.43 V for the NO_2^-/free-NH_3 and NO_3^-/NO_2^- couples, respectively (where $E_0{}'$ is the potential). Nitrifying microbes rely on O_2 as a high potential terminal electron acceptor to complete the oxidation (Madigan et al., 2015; Wallace & Nicholas, 1969). The microbes obtain energy in the form of ATP from nitrogen compound reduction (Madigan et al., 2015).

The carbon source for nitrifying bacteria is generated by carbon dioxide (CO_2) fixation via the Calvin cycle (Madigan et al., 2015). This process of autotrophic growth is energetically intensive and manifests in slow growth and low yields (EPA, 2015). In comparison to heterotrophic bacteria, nitrifiers yield about one hundredth the biomass

(Wallace & Nicholas, 1969). To overcome the energy requirements of the Calvin Cycle, NOB can grow chemoorganotrophically, using organic substances instead of CO_2 (Madigan et al., 2015). In contrast, AOB cannot grow chemoorganotrophically and are either obligate chemolithotrophs or mixotrophs capable of using alternate energy sources when NH_3 is not present (Madigan et al., 2015). In the case of nitrification, when NH_3 and NO_2^- are used as substrates, both AOB and NOB are obligate aerobes (Sharma & Ahlert, 1977).

Ammonia-oxidizing bacteria are present throughout the environment and are especially abundant in locations exhibiting high protein decomposition, such as WRRFs (Madigan et al., 2015). Ammonia-oxidizing bacteria in wastewater environments are generally of the genera *Nitrosospira* and *Nitrosomonas* (Siripong & Rittmann, 2007). In *Nitrosomonas*, NH_3 is oxidized using the ammonia monooxygenase enzyme to produce hydroxylamine (NH_2OH) and water (H_2O). Ammonia monooxygenase is an integral membrane protein that uses two electrons and two protons to reduce O_2 to H_2O. The periplasmic enzyme, hydroxylamine oxidoreductase, then oxidizes NH_2OH to NO_2^- (Madigan et al., 2015). The ammonia monooxygenase gene is also encoded in AOA, which belong to the phyla Thaumarchaeota, and are known to oxidize NH_3 at low levels (Madigan et al., 2015). Although both AOB and AOA encode for the ammonia monooxygenase gene, the genes are distinct homologs (Francis et al., 2005). After processing by AOB and AOA, NOB consume the nitrite and are typically found as *Nitrobacter* and *Nitrospira* in wastewater systems (Siripong & Rittmann, 2007). The enzyme, nitrite oxidoreductase, oxidizes NO_2^- to NO_3^- (Madigan et al., 2015). There are no known nitrite-oxidizing archaea (Madigan et al., 2015). Nitrifying metabolisms converts NH_3 to NO_3^- and can be harnessed to treat NH_3 in WRRFs.

1.3.3 Ideal Nitrification Conditions

Effective use of nitrifying microbes in wastewater treatment is dependent on water characteristics. The critical characteristics are substrate, pH, DO, and temperature (Middlebrooks & Pano, 1983). The nitrification rate is dependent on active biomass which is sustained through consumption of primary substrate, NH_3 (Rittmann & McCarty, 2001).Nitrification follows zero order kinetics in high NH_3 concentrations and gradually shifts to half and first order kinetics at lower NH_3 concentrations (Choi et al., 2008; Sharma & Ahlert, 1977). Under high NH_3 concentrations, AOB and NOB abundances increase (Shu et al., 2015). However, high enough concentrations can cause substrate inhibition and adversely impact nitrification, especially at high pH values due to toxic levels of free-NH_3 (Rittmann & McCarty, 2001). Periods of extreme NH_3 loading also impact the nitrifying community distribution, but the original nitrifying population can recover after normal conditions return (Prinčič et al., 1998). Accumulation of NO_2^- can also inhibit nitrification due to inhibition by free nitrous acid (Burton et al., 2014). *Nitrosomonas* and *Nitrobacter* are both inhibited by high levels of their respective substrate but are more inhibited by the substrate of the other (Painter, 1970). Typically, domestic wastewaters do not have high enough free-NH_3 and NO_2^- ion concentrations to cause inhibition (Sharma & Ahlert, 1977).

In addition to sufficient electron donor, nitrifying bacteria require sufficient DO as their electron acceptor. Ammonia-oxidizing bacteria and NOB respectively need 3.43 mg and 1.14 mg of O_2 per mg of NH_3-N and NO_2-N oxidized (Sharma & Ahlert, 1977). Decreased DO levels limit AOB and NOB (Huang et al., 2013). AOB have a lower DO half-saturation constant than NOB, leading to AOB enrichment over NOB at low DO concentrations (Ge et al., 2015). Both groups of nitrifying bacteria have higher DO half-saturation coefficients than heterotrophs, putting them at a competitive disadvantage for DO when heterotrophs are present (Rittmann & McCarty, 2001). Increased concentrations of organic matter contribute to DO limitations due to heightened competition with heterotrophs capable of faster kinetics in comparison to nitrifers (Sharma & Ahlert, 1977). Overall, 0.3 mg L^{-1} is the lowest concentration at which nitrification has been shown to occur (Stenstrom & Poduska, 1980).

The pH is another parameter known to control the microbial community (Prinčič et al., 1998). Inhibition by free-NH_3 is considered the most important pH effect (Villaverde et al., 1997). However, the production of two acid equivalents for each mole of NH_4^+ removed in nitrification prevents wastewater from becoming alkaline and therefore prevents inhibition due to free-NH_3. The pH does need to be high enough for some free-NH_3 to be present to act as the substrate used by AOB and AOA (Kowalchuk & Stephen, 2001). Acidic wastewater with zero to little free-NH_3 has shown adverse effects to nitrification (Shammas, 1986). Decreasing pH from 7.5 to 6.5 resulted in a 91% decrease in the nitrification rate (Geets et al., 2007). The observed decrease could also be due to deactivation or insufficient access to alkalinity in the form of bicarbonate. In low pH conditions, the bicarbonate equilibrium is dominated by CO_2, which can be stripped and made inaccessible to the microbes (Villaverde et al., 1997). Extreme pH changes relating to inhibition and changes in available nutrition can also cause large shifts in the microbial community diversity, but the resulting changes have not been shown to impact the overall nitrification rate (Prinčič et al., 1998). Although dependent on temperature, the ideal pH range for nitrification is 8-9 but is expected to vary for suspended versus attached-growth systems (Shammas, 1986).

Temperature also plays a role in nitrification performance by influencing NH_3 speciation and microbial kinetics. Nitrification can successfully continue between 15 °C and 30 °C (Shammas, 1986). Above 15 °C , AOB have significantly higher growth rates than NOB (Ge et al., 2015). Both AOB and NOB are sensitive to colder conditions, and nitrification rates drop off after 15 °C (Shammas, 1986). At temperatures below 10 °C, nitrification is severely limited (Kim et al., 2006). In these colder conditions, NOB phyla increase in diversity and the AOB *Nitrosopira* is up-regulated (Siripong & Rittmann, 2007). Heterotrophs living in low temperatures can become psychophic and have generation times only slightly less than in ideal conditions. Nitrifying organisms cannot make this population shift resulting in much longer generation times (Wijffels et al., 1995). Slow kinetics in cold-temperatures make it difficult to maintain a population, especially if washout occurs (Choi et al., 2008). However, slower growth rates influenced by cold-temperatures can be compensated by increasing the minimum solids retention time (EPA, 2015). Increased retention time requires less DO for nitrification (Stenstrom & Poduska, 1980), and cold-temperatures improve DO solubility, which can somewhat offset the lower kinetics (Choi et al., 2008). For optimal nitrification to continue, NH_3, DO, pH and temperature need to be maintained within ideal conditions.

1.3.4 Nitrification in Biofilms

Constantly providing ideal nitrification conditions can be challenging for wastewater facilities operating passive systems or operating systems with few personnel. This challenge can be mitigated by promoting an attached-growth environment. Biofilm processes are stable, retain biomass for long periods, handle hydraulic and loading shocks, and are less sensitive to decreased temperatures (Eddy, 2014; Schlegel & Koeser, 2007; Wijffels et al., 1995). Biofilms also protect microbes from losses due to flushing and shear stresses (Franco-Rivera et al., 2007). The benefits of biofilm processes stem from the provision of inert support media with high surface-area-to-volume-ratios (Hamoda & Al-Ghusain, 1998). More biomass per unit volume is observed due to greater surface density and increased void space to support high mass and O_2 transfer to the biofilm (Schlegel & Koeser, 2007). The surface area also provides an attachment surface for diverse microbial populations.

Biofilms provide microenvironments, resulting in spatial distributions within the film that affect the mass transfer and system stability (Fdz-Polanco et al., 2000). The substrate level within the biofilm varies with depth and is substantially lower than the bulk fluid, as described by basic biofilm theory (Figure 1.2) (EPA, 1993):

$$J = A \cdot D(\Delta S/\Delta L) \tag{1.6}$$

where J is the flux (mass time^{-1}), A is the biofilm surface area (length^2), D is the diffusion coefficient of the component of interest (length time^{-1}), ΔS is the difference in substrate concentration between the bulk liquid and the liquid film at the biofilm surface (mass length^{-3}), and ΔL is the thickness of the stagnant film (length). The mass transfer or diffusion resistance proportional to the flux negates the conversion of NH_4^+ to NO_2^- as the rate limiting step (EPA, 1993). As a result, nitrifying bacteria stratify or cluster based on substrate availability. When the bulk fluid has high substrate concentrations, biofilms are dominated by *Nitrosomonas* and *Nitrobacter*, with much lower abundances of *Nitrosopira* and an absence of *Nitrospira* (Schramm et al., 2000). *Nitrospira* are observed at the oxic-anoxic interface (Schramm et al., 2000). This observation is consistent with the theory that an NH_4^+ oxidizing zone occurs on the outside of the biofilm, with the NO_2^- oxidizing zone just on the inside or clustered around active AOB (Okabe et al., 1999). Almost no nitrifiers are observed in the anoxic part of the biofilm (Schramm et al., 2000). The nitrifying community is most abundant on the outside of the biofilm due to the need for oxygen.

In comparison to suspended growth systems, biofilm systems have exhibited higher concentrations of nitrifiers (Fatihah & Donnelly, 2009). Long mean solids retention times allow nitrifiers to establish a population and increase cell counts in biofilms (Fatihah & Donnelly, 2009). Immobilization of the bacteria ensure the population is not washed out and can improve nitrification performance, especially in cold-conditions when the growth rate is so low it could not recover (Wijffels et al., 1995). When temperature was decreased from 30 °C to 12 °C, nitrification in an immobilized system and suspended growth system decreased by 20% and 90%, respectively (Wijffels et al., 1995). The ability of a biofilm to withstand adverse environmental conditions, like temperature, is due to the time it takes for environmental conditions to effect the biofilm because of the associated flux (EPA, 1993; Wijffels et al., 1995). In addition to the diffusion limitation, substrate affinity increases at low temperatures, reducing the effects of temperature sensitivity (Wijffels et al., 1995).

The biofilm flux model provides insight into idealized biofilm reactions. However, designing attached-growth systems for nutrient removal is typically not based on theoretical equations. Mass transfer design associated with biofilm systems is much more complicated than designs for suspended growth where mass transfer can be neglected. Mass transfer models can become so complex that they cannot be solved, so reactor design is typically based on experimental results (EPA, 1993).

Experimental results have provided clues as to the ideal growth conditions for nitrifiers in biofilm systems. Biofilm activity consumes 7.1 mg of calcium carbonate ($CaCO_3$) per mg of NH_4^+ oxidized (Villaverde et al., 1997). This is more alkalinity than is consumed in suspended growth systems due to the accumulation of low soluble carbonates within the biofilm (Villaverde et al., 1997). Optimum growth for biofilms has been shown at pH 8 (Villaverde et al., 1997). The DO concentration in the bulk fluid needs to be 2.7 times the NH_4^+ concentration to prevent DO transfer from limiting the nitrification rate (EPA, 1993). Without sufficient DO, NO_2^- builds up due to AOB's affinity for DO over NOB, allowing for NH_4^+ oxidation but not NO_2^- oxidation (Pedros et al., 2008). Ideal conditions suggested by previous studies are a good starting point for new systems but some variation in ideal conditions should be expected for any unit operation. In general, biofilm processes allow for minimized operator attention to wastewater characteristics because the biofilm protects nitrifiers from adverse environmental conditions.

1.3.5 Other Mechanisms for Removing Ammonia

Besides nitrification, NH_3 can be removed from a system by two other mechanisms: free-NH_3 stripping and biomass assimilation (Middlebrooks & Pano, 1983). Total nitrogen (TN) can also be reduced via denitrification and sedimentation of insoluble organic nitrogen (Middlebrooks & Pano, 1983). All microbes assimilate NH_3 due to the universal need for nitrogen in biological cells for synthesis of proteins, amino acids, purines, pyrimidines, nucleic acids, and enzymes (Aleem, 1970). As these microbes die, their nitrogen is recycled back into the system, resulting in little removal. Volatilization, however, can significantly impact NH_3 removal in high pH and abundant NH_3 conditions (Rockne & Brezonik, 2006).

1.3.6 Lagoons

Biological systems for NH_3 removal have been widely implemented at WRRFs. However, many small facilities lack this technology. Wastewater treatment in small towns is frequently accomplished with lagoon systems. The use of pond treatment in the U.S. was first recorded in 1901 but has been used as a wastewater technology for 3000 years (EPA, 2011). Lagoons are simple and relatively inexpensive, as long as land is widely available (EPA, 2015; Reed, 1984; Surampalli et al., 1999). In comparison to other treatment methods, lagoons require less energy input, have reduced operation and maintenance costs, and can better handle organic and hydraulic loading (EPA, 2011; Surampalli et al., 1999). Wastewater ponds have therefore been implemented in many rural locations (EPA, 2015). There are 8000 lagoons in operation in the U.S., totaling about half of the WRRFs in the country (EPA, 2011).

As NH_3 discharge becomes increasingly permitted to protect recreation and aquatic life in natural waters (EPA, 2015; Reed, 1984), there is a need for efficient and low cost NH_3 removal from lagoons (Shannon et al., 2015) or facility replacement. However, lagoons were not originally designed for nutrient removal because treatment was focused on organics and total suspended solids (EPA, 2015). Although not a part of the design, depending on pH, temperature, and detention time, nutrient removal can occur in a pond system (Reed, 1984). Under ideal conditions, allowing for nitrification and free-NH_3 volatilization, lagoons can remove as much as 80-90% of the TN present (EPA, 2015; Reed, 1984). Aerated lagoons can provide some nitrification in warm months but typically cannot meet NH_3 limits in the winter (IDNR, 2016). Studied lagoons have shown high NH_3 concentrations during cold-conditions when ponds become ice covered (Reed, 1984). A lagoon studied in the Midwest showed reduced NH_3 levels in the late spring, summer, and fall, with values ranging from 0.3 to 4.3 mg L^{-1}. In winter, the lagoon effluent increased (8.8 to 23 mg L^{-1}), which corresponded to a decrease in the nitrifying microorganism abundance (Surampalli et al., 1999). In addition to nitrification inhibition in cold-temperatures, another barrier to lagoon success is the lack of system flexibly due to a desired passive design, which is typically operated by one person.

It is a challenge for municipalities treating less than one million gallons per day (MGD) to afford effective treatment systems capable of meeting more stringent NH_3 effluent requirements, especially in cold-temperatures (Shannon et al., 2015). One of the barriers to improving lagoon nutrient removal is the high cost of upgrading or retrofitting systems (EPA, 2015). Retrofitting lagoons is recommend by the EPA as a method for improving NH_3 removal. One suggestion is to modify the discharging schedule to coincide with low nutrient effluent concentrations (EPA, 2015). Retrofitting lagoons with attached-growth systems is also suggested as a way to maintain biological populations while still obtaining desired treatment. Examples of common fixed-film systems include rotating biological contactors and trickling filters (Schlegel & Koeser, 2007). However, the EPA states in its design guidance on lagoon systems that it is not clear that fixed-film systems can overcome cold-temperature limitations (EPA, 2011). Low cost and effective retrofit options need to be available for lagoon wastewater treatment plants to be able to meet NH_3 compliance limits.

1.3.7 Submerged Attached-Growth Reactors as a Lagoon Retrofit

Cold-temperature NH_3 removal from lagoons is of particular concern in Iowa, where a majority of small towns (<10,000 people), 70.4%, treat their wastewater with either aerated or waste stabilization lagoons (IDNR, 2017). The Iowa Department of Natural Resources (IDNR) understands that “affordable treatment facilities that can nitrify wastes in order to meet low NH_3 levels is a challenge for small communities faced with low [National Pollution Discharge Elimination System] NPDES permit values in the single digits,” (IDNR, 2016). In acknowledgement of the challenge for small towns, the IDNR approved the submerged attached-growth reactor (SAGR^{TM}) as a retrofit for aerated lagoons that already meet IDNR facility design standards (IDNR, 2016). Submerged attached growth reactor, SAGR^{TM}, is a trademarked term by Nelson Environmental used to describe a fixed-film reactor that is termed submerged attached growth bioreactor (SAGB) by the rest of the wastewater industry. A system based on Nelson Environmental’s design was approved for use in Iowa, investigated in our study, and will be referred to as SAGR without the trademark for the remainder of this thesis for conciseness.

The SAGRs approved for lagoon retrofits in Iowa are below grade reactors (Figure 1.3). The reactors are filled with an attachment media for biofilm growth which is continually submerged in wastewater. The biofilms are supplied with DO by continuously operating aerators below the fixed media. The aerated biofilm in the reactor is designed to enhance nitrification and is below grade to maintain gravity flow from the lagoons to the SAGRs and provide insulation. Above the wastewater inundated attachment media, there is a 0.2 m attachment media freeboard. Above the dry attachment media, the reactor is covered with 0.3 m of mulch for additional insulation. The SAGRs are operated as two primary SAGRs in parallel followed in series by two identical secondary SAGRs which are also operated in parallel.

Design guidance published by the IDNR on SAGRs is based on compliance with typical Iowa NH_3 limits of 1 mg L^{-1} in the summer and 5-10 mg L^{-1} in the winter, and not on affordability. Conservative safety factors were used in the guidelines due to cold-weather nitrification concerns. Following the mandated standards, the first SAGRs in Iowa were implemented in 2012. Since the first implementation, the IDNR accepted some design modifications that could reduce SAGR sizing on a case-by-case basis.

Based on the SAGR design guidelines:

- Design loading must be 25 mg L^{-1} $cBOD_5$, 50 mg L^{-1} TSS, and a monthly loading of TKN less than 0.4 lb ($1000ft^3$ d^{-1}).
- SAGRs must operate as a dual train system with influent evenly distributed in such a way as to prevent short circuiting.
- The required minimum media depth is 4 ft.
- At least 3 mg L^{-1} DO must be provided by the aeration system.
- The minimum system design retention time should be 24 h, although 12 h is acceptable with additional system monitoring based on (IDNR, 2016):

$$HRT = \frac{V_p}{Q_{AWW}} = (V \cdot \eta)/Q_{AWW} \tag{1.7}$$

  where HRT is hydraulic retention time (d), V_p is pore volume (MG), V is effective system volume (MG), η is porosity of aggregate (ratio of volume to voids of total volume), and Q_{AWW} is flow (MGD) (design flow based on the projected average wet weather flow rate).

- The aggregate should have a minimum porosity of 38%.
- 75% of the design volume and waste loading rate must be treated with the largest zone out of service.
- An insulating layer of mulch should be provided.
- The SAGR should be lined with a 60 mil HDPE liner.

1.3.8 Previous Work on SAGRs

The ease of operation and robustness of SAGRs have made them attractive for facilities treating less than 1 MGD (Shannon et al., 2015). Fixed-film reactors similar to SAGRs, SAGBs, have been studied and well documented at the pilot and bench scale in many different forms. Previously studied SAGBs have been shown to be effective at removing NH_3. At the lab scale, a continuously aerated vertical flow SAGB with plants removed 65-87% of the influent NH_4^+, depending on the loading rate, at an ambient temperature of 19 °C ± 7 °C (Dong et al., 2012). In a similar system, 96-99% of the NH_4^+ from synthetic domestic wastewater was removed at an average temperature of 14.7 °C (Fan et al., 2013). Other SAGBs have successfully removed NH_3 at the bench scale from high strength wastewater (Çeçen, 1996; Chui et al., 2001) and effluent from an up-flow anaerobic-sludge-blanket reactor (de Sousa et al., 2008).

On the pilot scale, studies found similar nitrification rates as on the lab scale. A multi-media SAGB treating high strength centrate was able to achieve 91% nitrification (Onnis-Hayden et al., 2007). In subsequent studies, in the same pilot scale system used by Onnis-Hayden et al., 97% and 98% nitrification efficiency was observed (Pedros et al., 2008; Pedros et al., 2007). Previously published work has shown promising NH_3 removal ranging from 65-99%, depending on influent, environmental conditions, and design. Another pilot-scale lagoon system retrofitted with SAGBs, operated in environmentally relevant temperatures, demonstrated NH_3 reduction from 25 mg L^{-1} to essentially zero at 6 °C (Choi et al., 2008). The average NH_3 removal from 7 batch studies was 94% (Choi et al., 2008). Success was attributed to growth stimulation of, and enhanced DO transfer to, the bacteria (Choi et al., 2008). The Choi et al. system efficiency suggests that a lagoon retrofitted with a biofilm system can enhance lagoon NH_3 removal in cold-temperatures.

Another benefit of SAGBs is that they provide the operator more flexibility to control the substrate load than a lagoon system, which is critical to prevent permit violations. Changing the flow scheme in lab scale SAGBs has been shown to improve nitrification performance. This process has been commonly referred to as step-feeding and generally aims to increase loading, but can be implemented in many forms. Applying a second dosage of substrate to a constructed wetland, a planted SAGB, resulted in the best NH_4^+-N removal. This reactor was intermittently aerated, and it was suggested that even better performance could have occurred if the reactor was continuously aerated (Fan et al., 2013). Two other studies used step-feeding, increased loading, by adding wastewater to points other than the inlet. Influent substrate loads at multiple points, which exposed multiple places in the reactor to full strength wastewater, increased the NH_4^+-N removal (X. Wang et al., 2010) and better utilized the reactor volume (Stefanakis et al., 2011). These studies suggest that increasing the substrate loading in attached-growth systems could improve nitrification performance.

Submerged attached growth bioreactors are ideal for small systems where nitrification is required but denitrification is not (Schlegel & Koeser, 2007). Although combined nitrification and denitrification is possible in certain SAGB designs (Onnis-Hayden et al., 2007; Shannon et al., 2015), denitrification is not necessary in systems operating less than 1 MGD and could increase system cost and complexity for small WRRFs. Many systems are incorporating SAGBs as a low cost option for nitrification, as a final polishing step, because of their flexibility to combine with existing systems (Chui et al., 2001). Using a SAGB in combination with a lagoon for improved nitrification was suggested after it was shown that SAGBs are robust in combination with sedimentation and clarification (Schlegel & Koeser, 2007). Especially in locations with regulatory approval, such as Iowa, SAGBs may be a robust solution to cold-weather NH_3 removal from lagoons.

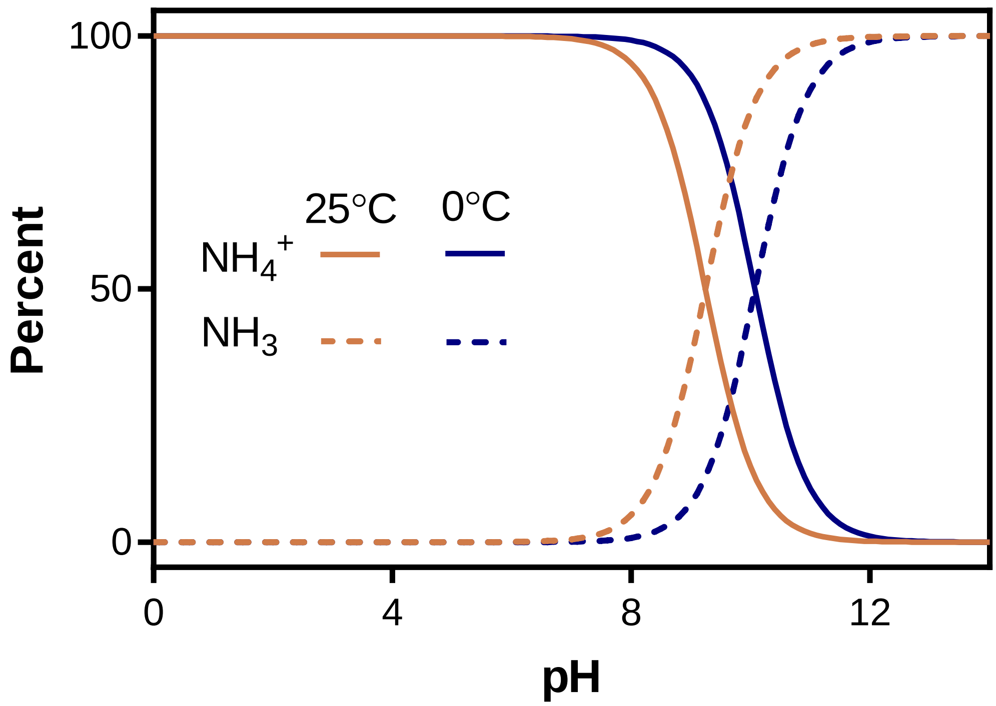

Figure 1.1 Ammonia speciation as a function of pH and the effect of temperature on the pH equilibrium value. Here NH_3 is free-NH_3.

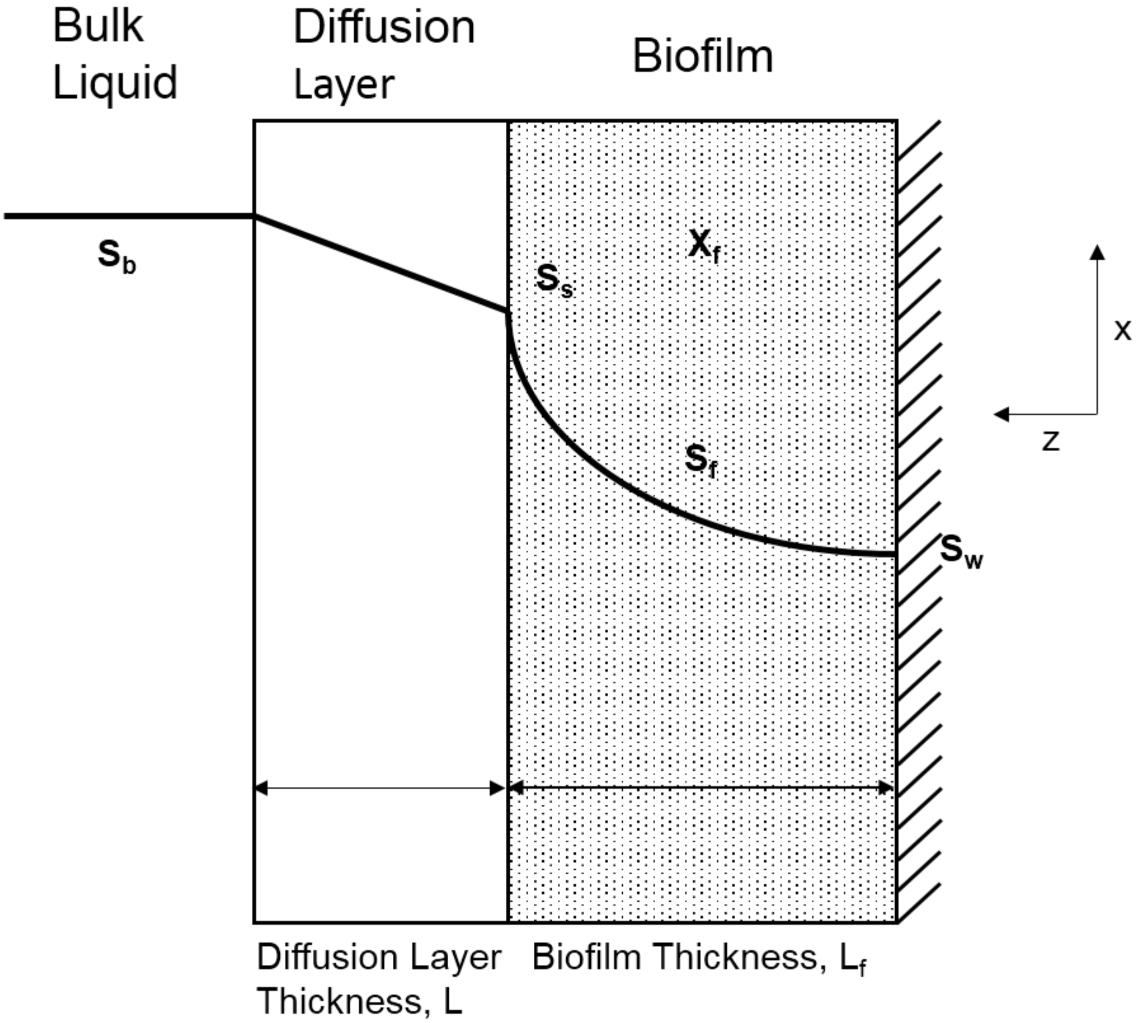

Figure 1.2 Conceptual biofilm model. S represents substrate concentration in the bulk liquid (b), at the outer biofilm surface (s), within the biofilm (f), and at the surface attachment (w). X_f is the microbial density. Figure modified from EPA's *Process Design Manual: Nitrogen Control.*

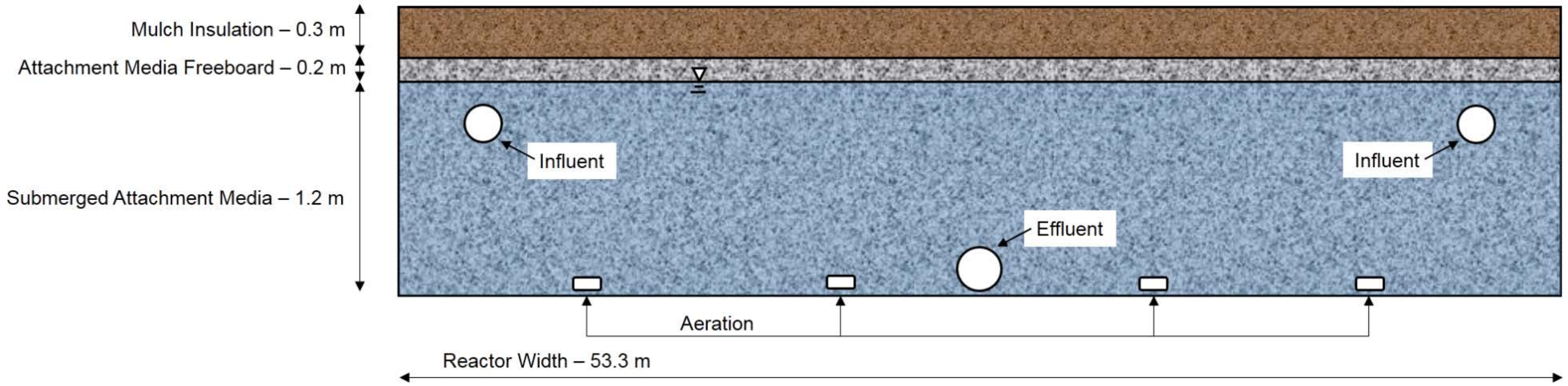

Figure 1.3 Section view of a submerged attached growth reactor, not drawn to scale. The section view was adapted from the Walker, IA Wastewater Treatment Plant Improvements design documents provided by Matthew Wildman.

CHAPTER 2: PERFORMANCE AND SIZING

Submerged attached-growth reactors as lagoon retrofits for cold-weather ammonia removal: performance and sizing

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2.1 Abstract

Small towns that operate wastewater treatment lagoons struggle to meet ammonia limits in cold weather. Here we report the performance of a lagoon, retrofitted with submerged attached growth reactors (SAGRs^{TM}), to provide insight on ammonia effluent compliance and optimal SAGR sizing as functions of water temperature. The lagoon-SAGR water resource recovery facility (WRRF) removed 95% of incoming ammonia with 94% attributed to the SAGRs. The high treatment capacity of the two primary SAGRs, evidenced by nearly continuous dissolved oxygen saturation and exceedingly high ammonia removals, suggested the two secondary SAGRs were essentially unnecessary and that all four SAGRs should be reduced in size. Furthermore, without the secondary SAGRs, the primary SAGR effluent would have exceeded the permitted ammonia discharge limit only four times in the 2.5 year study. At its current size, the lagoon-SAGR WRRF never exceeded permitted ammonia limits, but size reductions should be used for future retrofits.

2.2 Key Words

Submerged attached-growth reactor, SAGRs^{TM}, nitrification, lagoon retrofit, wastewater, ammonia

2.3 Introduction

Ammonia (NH_3) released to natural waters can devastate fish populations making effective wastewater treatment critical (Luo et al., 2015). To reduce NH_3 discharge loads, water resource recovery facilities (WRRFs) typically induce nitrifying conditions which requires additional process control when water temperature (typically less than 10°C) severely limits microbial transformation rates (Kim et al., 2006). Lagoon WRRFs usually have passive hydraulics, which reduces process control and decreases NH_3 removal predictability under cold-conditions. This treatment uncertainty is significant because many of the 8,000 operating lagoons in the United States are in cold-climates (EPA, 2011). Therefore, robust retrofits are needed for cold-climate lagoon WRRFs to reduce NH_3 discharges to natural waters.

One promising lagoon WRRF retrofit which has been previously suggested in the literature (Schlegel & Koeser, 2007) is the addition of submerged attached growth bioreactors (SAGBs) for tertiary treatment. More broadly, SAGBs effectively reduce NH_3 loads, at relatively short hydraulic residence times (HRTs), by maintaining high biomass concentrations (Pedros et al., 2008). Pilot-scale, stand-alone SAGBs have successfully removed NH_3 from high strength wastewater (Çeçen, 1996; Chui et al., 2001; de Sousa et al., 2008; Pedros et al., 2008) and domestic wastewater (Fan et al., 2013). A pilot-scale lagoon WRRF, retrofitted with SAGBs (Choi et al., 2008), reduced NH_3 from 25 mg L^{-1} to effectively zero at 6 °C. Success was attributed to growth stimulation of, and enhanced oxygen transfer to, the bacteria (Choi et al., 2008). These studies suggest SAGBs are a viable retrofit option, but this study provides the needed peer-reviewed NH_3 removal data to inform *full-scale*, lagoon-SAGB WRRF design.

This study focused on the first full-scale, lagoon-SAGB WRRF retrofit in Iowa using submerged attached growth reactors (SAGRs^{TM}, the name of a SAGB type trademarked by Nelson Environmental). Iowa is situated as an ideal test case because of low winter temperatures and 548 permitted lagoons potentially requiring tertiary NH_3 treatment (IDNR, 2017). In 2012, the Iowa Department of Natural Resources (IDNR) approved SAGRs for lagoon-WRRF retrofits and published design guidance with conservative, cold-weather nitrification safety factors (IDNR, 2016). Three years of NH_3 discharge data from a lagoon-SAGR WRRF has led the IDNR to consider design modifications that would reduce SAGR sizing for future retrofits (IDNR, 2016). To inform future SAGR sizing decisions, we undertook a large sample curation and analysis effort to assess NH_3 removal by SAGRs within a full-scale lagoon-SAGR WRRF.

2.4 System Layout and Discharge Criteria

Walker, a small town of 791 people (Bureau, 2010) in eastern Iowa, retrofitted an existing facultative lagoon into three smaller lagoons and four SAGRs (Figure 2.1). Wastewater passed through two, aerated lagoons in series to remove biochemical oxygen demand (BOD) and total suspended solids (TSS), before entering a third lagoon for quiescent gravity settling. Lagoon effluent was divided equally into two primary SAGRs. Primary SAGR effluent was recombined and divided equally into two secondary SAGRs. Both the primary and secondary SAGRs were continuously aerated to enhance biofilm mediated nitrification. Secondary SAGR effluent was ultraviolet disinfected and discharged to a nearby stream (Figure 2.1). On September 1st of each year, lagoon 2 was bypassed to provide additional substrate to the primary SAGRs to stimulate biomass growth. On October 1st of each year, the secondary SAGRs received all substrate for biomass stimulation by bypassing the primary SAGRs. The system was returned to normal operation on December 1st of each year.

Each SAGR was 1.7 (with 0.5 m freeboard) by 9.6 by 53.3 m with a 13.5 h HRT based on a 9.7 L s^{-1} (0.1 MGD) average wet weather (AWW) flow and minimum porosity of 38%. The SAGRs were filled with 1.4 m of aggregate (0.04 m diameter) and covered by 0.3 m of insulating mulch. Dosing occurred along the top outer edges and wastewater gravity flowed to an effluent pipe at the bottom in the center (Figure 2.2). Aerators were spaced along the bottom of the reactor to continuously provide at least 3 mg L^{-1} of dissolved oxygen (DO). The National Pollution Discharge Elimination System (NPDES) permit corresponding with the upgraded WRRF took effect in April, 2014 (Table 2.1).

2.5 Methods

2.5.1 Data Curation and Analysis

Staff from the City of Walker, in partnership with the IDNR from 04/01/2014 to 12/29/2016, generated the data utilized in this study. Several physical, chemical, and biological parameters were reported with certain analyses performed by the facility operator in an uncertified laboratory and others by a certified laboratory (TestAmerica Laboratoriies, Inc., Cedar Falls, IA) (Table 2.2). The data (27,159 individual points) were curated at the University of Iowa, analyzed for statistical significance and plotted graphically using GraphPad Prism 7.00 (GraphPad Software Inc., LaJolla, CA). Non-parametric tests were used to check for statistical significance because the data was not normally distributed (graphical and D'Agostino & Pearson tests). The Sign test was used to compare data sets while incorporating censored data (Helsel, 2005). The Sign test was also used to compare paired sets because the data was not symmetrical. Therefore, the median of the differences for paired sets was compared to zero (no difference). This median was evaluated for DO, alkalinity, and TN, as saturated DO minus measured DO, measured alkalinity minus calculated alkalinity demand, and lagoon effluent TN minus discharge TN, respectively. Statistics were run in Minitab 17 (Minitab Inc., State College, PA) and statistical significance was based on the observed significance level (p) in comparison to a declared significance level of $\alpha = 0.05$.

Ammonia and nitrate/nitrite (NO_3^-/NO_2^-) data below the detection limit were censored to certified lab detection limits, 0.5 and 2.5 mg-N L^{-1} respectively, based on nonparametric methods for comparing two groups (Helsel, 2005). The NH_3 and TN percent removals sets were not normally distributed. Therefore, the median of the NH_3 percent removal in the lagoon-SAGR WRRF and the medians of the NH_3 and TN percent removals in the SAGRs were calculated, although the arithmetic mean was also reported.

2.5.2 Calculations for Unmeasured Parameters

To evaluate the overall NH_3 removal, the facility influent NH_3 concentration was estimated by assuming that NO_3^-/NO_2^- in the lagoon effluent was derived from WRRF influent NH_3 via nitrification. We viewed this assumption to be reasonable since typical influent wastewater contains 60% ammonium-nitrogen (NH_4^+-N), 40% organic nitrogen, and 0% NO_3^-/NO_2^- (EPA, 1993) and that very little ammonification would occur in aerated lagoons.

The DO saturation was calculated using the Benson/Krause equation without correction for salinity or pressure (Meyers, 2011) given by:

$$DO_o = \exp\left[-139.34411 + \frac{1.575701 * 10^5}{T} + \frac{6.642308 * 10^7}{T^2} + \frac{1.243800 * 10^{10}}{T^3} + \frac{8.621949 * 10^{11}}{T^4}\right] \tag{2.1}$$

where DO_o is the dissolved oxygen saturation (mg L^{-1}) and T is the temperature (°C).

The alkalinity demand, 7.05 mg as calcium carbonate ($CaCO_3$) consumed per mg of NH_4^+-N nitrified (Rittmann & McCarty, 2001), was calculated using classic stoichiometry:

$$NH_4{}^+ + 1.815O_2 + 0.1304CO_2 = 0.0261C_5H_7O_2N + 0.973NO_3{}^- + 0.921H_2O + 1.973H^+ \tag{2.2}$$

where $NH_4{}^+$ is ammonium (moles), O_2 is oxygen (moles), CO_2 is carbon dioxide (moles), $C_5H_7O_2N$ is glucose (moles), $NO_3{}^-$ is nitrate (moles), H_2O is water (moles), and H^+ is hydrogen ion (moles). The NH_3 speciation was temperature (using the Van't Hoff equation) and pH corrected and the average temperature was used in cases when pH data was available and temperature was not.

Lagoon effluent and secondary SAGR effluent TN concentrations were calculated from operator data without organic nitrogen because it was not measured:

$$TN = NO_3{}^- + NO_2{}^- + NH_3 \tag{2.3}$$

where TN is total nitrogen (mg-N L^{-1}), $NO_3{}^-$ is nitrate (mg-N L^{-1}), $NO_2{}^-$ is nitrite (mg-N L^{-1}), and NH_3 is total ammonia (mg-N L^{-1}).

2.6 Results

2.6.1 Operator and Certified Lab Data Statistical Comparison

Certified lab and operator NH_3, NO_3^-/NO_2^- and pH data were compared to determine how best to use uncertified operator data to assess SAGR performance (Table C.1). The median NH_3 values obtained from the operator (medin=0.5) and certified lab (median=0.5) (n=104 matched pairs) were not significantly different (p=0.5078) (Figure 2.3A). The NO_3^-/NO_2^- data (n=92 matched pairs) were significantly different (p<0.0001) with the operator data biased low (median=4.2) relative to the certified lab (median=8.9) (Figure 2.3B). For pH, the certified lab data (median=8.3) and operator data (median=8.4) (n=140 matched pairs) were also significantly different (p=0.0002) (Figure 2.3C).

2.6.2 Lagoon-SAGR WRRF Performance

After the retrofit, the lagoon-SAGR WRRF removed 95% (mean=93%) of the incoming NH_3 (Figure 2.4) (Table C.2). During the highest NH_3 concentration (19.7 mg-N L^{-1} in March, 2015) the lagoon-SAGR WRRF removed 97% of the NH_3. In terms of compliance, neither the NH_3 30-day average nor the NH_3 daily maximum limits were exceeded from April, 2014 to December, 2016 (Figure 2.5). Without the SAGRs, the lagoon effluent would have exceeded the daily maximum 69% of the time (n=532). During the same time period, the 5-day carbonaceous biochemical oxygen demand ($cBOD_5$) limit, TN limits, and pH was always within the permitted range (Table C.3 and Figure C.1). The TSS 7-day average was exceeded once in July, 2016, and the DO was below the required minimum (5 mg L^{-1}) once in February, 2015 (Table C.3 and Figure C.1).

2.6.3 SAGR Performance

The SAGRs themselves removed 94% of the NH_3 (mean=77%). The primary SAGRs removed 78% of the NH_3 (mean=70%) and the secondary SAGRs removed 0% (mean=12%)[3] (Table C.2). Primary and secondary SAGR DO concentrations remained above 1 mg L^{-1} (as required for nitrification) and the secondary SAGR DO concentrations remained above the 5 mg L^{-1} permitted limit (Figure 2.6). The saturated DO level was

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[3] The primary and secondary SAGR percent removal medians and mean do not add up to the overall SAGR percent removal because the data is not normally distributed and each respective distribution is unique.

significantly greater than the measured DO in the primary SAGRs (median of differences=1.0, n=388, sign test, $p<0.0001$) (Figure 2.6A). In the secondary SAGRs, the saturated DO level was also significantly greater than the measured DO (median of differences=0.75, n=442, sign test, $p<0.0001$) (Figure 2.6B) (Table C.4). The average monthly measured alkalinity was statistically greater than the average monthly available alkalinity (median of differences=199, n=16, sign test, $p<0.0001$) (Figure 2.7) (Table C.5 and Table C.6). The SAGRs also significantly reduced TN between the lagoon effluent and the discharge (median of differences=5.1, n=450, sign test, $p<0.0001$) (Figure 2.8). From April, 2014 to the end of 2016, the SAGRs removed 46% (mean=43%) of the lagoon effluent TN. The TN removal improved over time and in 2016, the SAGRs removed 74% (mean=72%) of the lagoon effluent TN (Table C.7).

2.7 Discussion

Operator measurements of NH_3 were not statistically different from measurements made by the certified lab and were, therefore, used to evaluate NH_3 removal. The operator pH and NO_3^-/NO_2^- data likely added error to percent removal and alkalinity demand calculations. The operator-measured NO_3^-/NO_2^- values were biased low, which likely decreased the calculated NH_3 influent and the calculated percent removal. The operator-measured pH was frequently biased high from April, 2014 to 2016, and biased low after 2016. But, since the maximum primary SAGR alkalinity demand was no more than half of the available alkalinity, the pH data bias had no impact on our conclusions.

In cold-weather, NH_3 decreased from 19.7 mg-N L^{-1} to 0.5 mg-N L^{-1} (the detection limit) in March of 2015 resulting in a 97% removal for the lagoon-SAGR WRRF. The lagoon-SAGR WRRF showed high NH_3 removal even though the total influent NH_3 often fell below the typical minima, 14 mg-N L^{-1}, for domestic wastewater (Burton et al., 2014). This high NH_3 removal suggests the operational changes in September and October provided the substrate needed for additional biomass growth to support effective, cold-temperature nitrification in the SAGRs. Overall, the SAGRs-alone achieved 94% nitrification which was comparable to the 88-99% shown by SAGBs in controlled environments (de Sousa et al., 2008; Fan et al., 2013; Onnis-Hayden et al., 2007; Pedros et al., 2008) and similar to cold-temperature removal (94%) shown in a pilot-scale SAGB (Choi et al., 2008). Our data confirms the Schlegel & Koeser (2007) hypothesis that SAGBs in a lagoon-retrofitted WRRF are as effective as individual SAGBs. Also, the observed TN reduction in the SAGRs was unexpected since the lagoon-SAGR WRRF was not designed for TN removal. The TN could have been reduced by biomass assimilation, insoluble sedimentation, denitrification, and/or NH_3 stripping. The magnitude of the TN reduction cannot be explained by settling and assimilation alone and the high rate of aeration in the SAGRs certainly minimizes the denitrification potential. More research is needed to fully assess possible TN losses associated with denitrification and NH_3 stripping in SAGRs which could occur in localized microenvironments.

Dissolved oxygen was plentiful in the SAGRs as evidenced by only four exceedances of the permitted DO minima (5 mg L^{-1}) in the secondary SAGRs. Primary SAGR measured DO concentrations were only slightly less than saturation DO (median of differences=1.0) even while providing a majority of the nitrification. This result suggests the primary SAGRs were abundantly sized and/or abundantly aerated. The difference in measured DO and saturation DO in the primary SAGRs was greater than that for the secondary SAGRs (median of differences=0.75) indicating less secondary-SAGR nitrification. Low secondary-SAGR DO in February and April of 2015 still resulted in compliant NH_3 treatment and the hypothetical absence of secondary SAGRs would have caused only four daily maximum NH_3 effluent exceedances (Figure 2.9). Therefore, our data suggest the initial IDNR guidance for SAGR sizing was overly conservative and the recent decision to reduce the SAGR sizing requirement, to achieve NH_3 compliance using existing aeration conditions, is evidence-based.

2.8 Conclusion

We found that SAGRs were an effective lagoon WRRF retrofit in Walker, IA. High NH_3 removal was observed under cold-conditions and the lagoon-SAGR WRRF never exceeded permitted NH_3 limits. The primary SAGRs accounted for a majority of the NH_3 treatment which, combined with overly abundant DO, affirmed the recent decision to reduce SAGR sizing guidance by the IDNR. Municipalities considering a SAGR retrofit for a lagoon WRRF should work with local regulators to determine appropriate SAGR sizing for better secondary SAGR utilization. This could reduce construction and maintenance costs while maintaining effective cold-weather NH_3 removal. Future lagoon WRRF retrofits with SAGRs and continued research will better protect aquatic environments from NH_3 pollution and support cold-climate, small town wastewater treatment.

2.9 Acknowledgements

We thank Kevin Shoop, the lagoon-SAGR WRRF operator at Walker, IA, for collecting and analyzing samples and for providing his expertise and logistical support. We are grateful to Larry Bryant from the IDNR for his support and insight into the SAGR regulations. Members of the Iowa Water Environmental Association (IAWEA is a Water

Environment Federation affiliate) Small Communities Committee provided insight and advice for this work. Funding was provided by the University of Iowa and field sampling support was provided by IIHR – Hydroscience & Engineering.

Table 2.1 The updated NPDES permit limits for Walker, IA enforced from 2014 to 2016 after the biannual discharge facultative lagoons were changed to a lagoon WRRF retrofitted with SAGRs (Beavers, 2011).

Parameter	Limit
$cBOD_5$ Max.	25 mg L^{-1}
$cBOD_5$ 7-Day Avg.	40 mg L^{-1}
TSS Max.	45 mg L^{-1}
TSS 7-Day Avg.	30 mg L^{-1}
pH Range	6.5-9 std. units
DO Min.	5 mg L^{-1}
NH_3 30-Day Avg.	Varies seasonally*
NH_3 Daily Max.	Varies Seasonally*
TN 30-Day Avg.	37.5 lbs. d^{-1}
TN Daily Max.	61.3 lbs. d^{-1}
E. Coli Daily Max.	126 # (100 mL)$^{-1}$

*The seasonal variation for both the 30 Day Average and the Daily Maximum are shown in Figure 5.

Table 2.2 Physical, chemical, and biological parameters analyzed by the operator and certified lab at different time periods and frequencies within our study.

	Certified Lab		**Operator**	
Parameter	**Sampling Interval (days)**	**Sampling Location**	**Sampling Interval by year (days)**	**Sampling Location**
Dissolved Oxygen	NA	NA	1 (2013-2015), 2 (2016)	LE, PE, D
pH	7	D	1 (2013-2015), 15 (2016)	LE, PE, D
Temperature	7	D	1 (2013-2015), 10 (2016)	LE, PE, D
Nitrate & Nitrite	7	D	1 (2013-Aug. 2015), 3 (Aug. 2015-Dec. 2015), 15 (2016)	LE, PE, D
Ammonia	7	D	1 (2013-2016)	LE, PE, D
Alkalinity	14	LE	NA	NA
$cBOD_5$	7	D	NA	NA
TSS	7	D	NA	NA
E. Coli	7	D	NA	NA

LE=Lagoon Effluent, PE=Primary Effluent, D=Discharge. The green indicates parameter that can be used for inter-sample comparison.

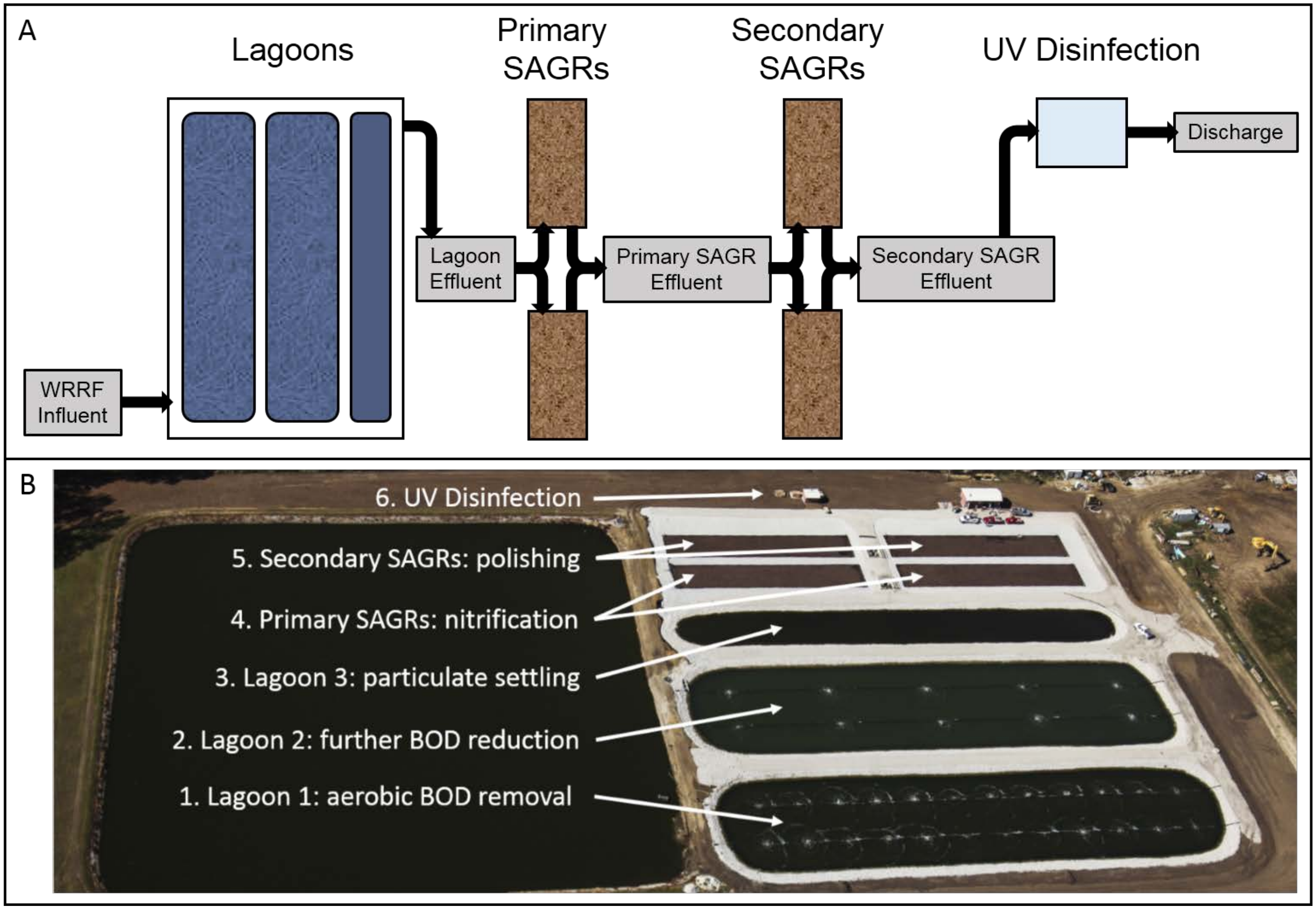

Figure 2.1 Walker, IA lagoon-SAGR WRRF. A) Flow diagram of the system. B) Aerial view of the lagoon-SAGR WRRF. The large lagoon on the left was replicated on the right before the retrofit. The three lagoons and four SAGRs on the right reused the area originally occupied by a second large lagoon. The lagoon on the left is no longer in use.

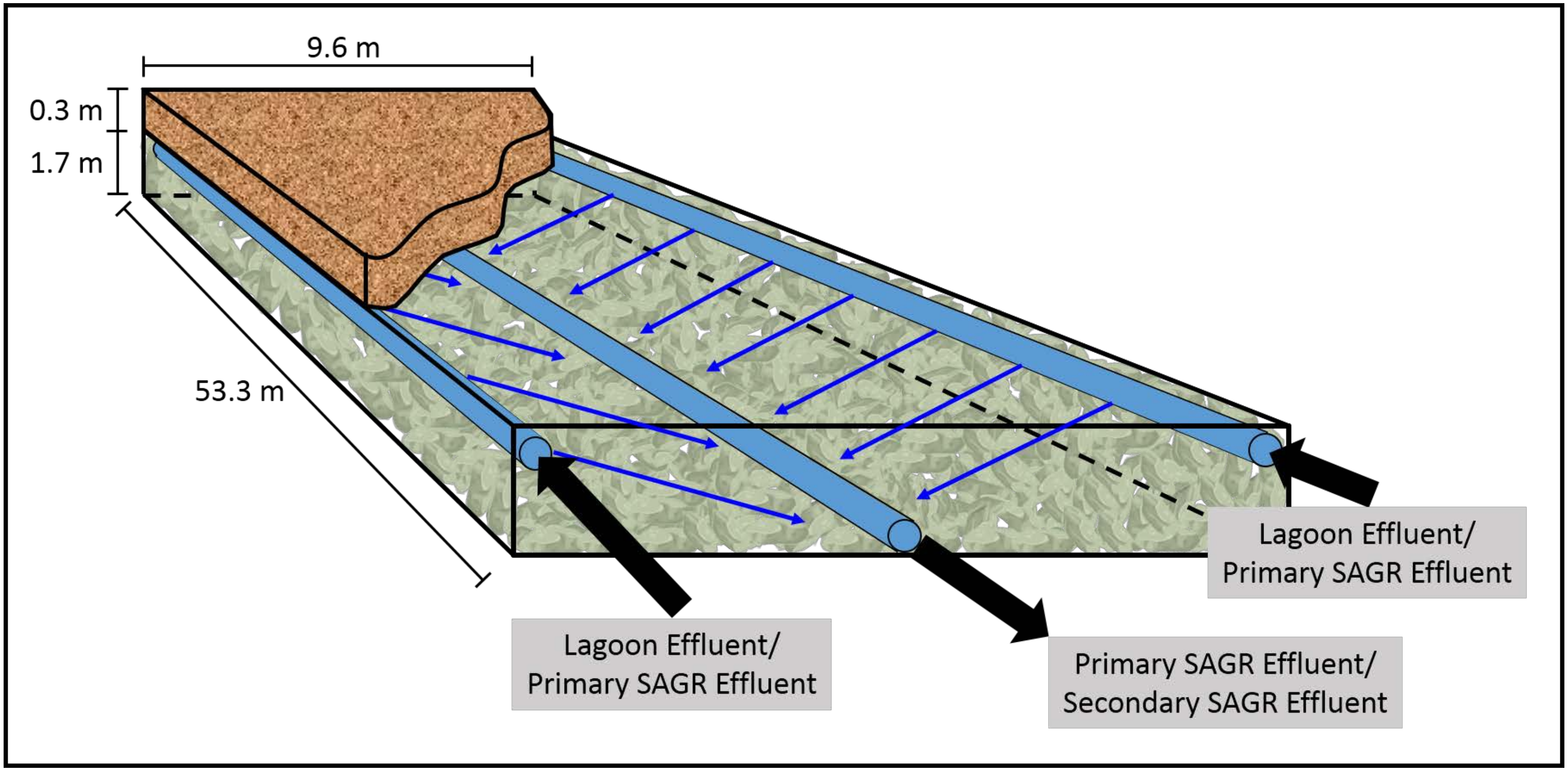

Figure 2.2 Gravity controlled flow scheme of a SAGR below grade, filled with rocks, and continuously aerated to enhance biofilm mediated nitrification.

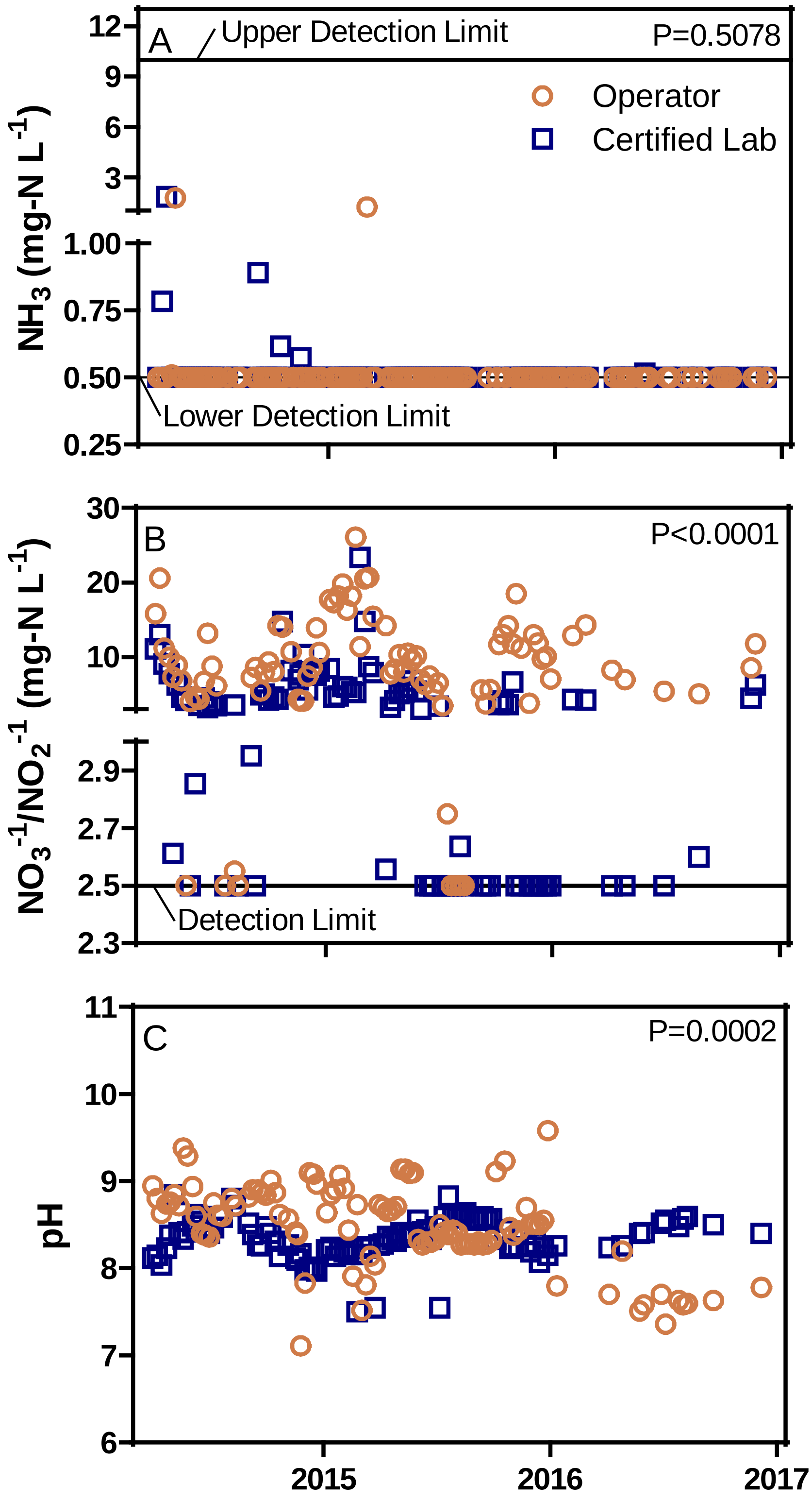

Figure 2.3 Comparison between certified lab and operator analyzed data using the Sign test. A) NH_3 data. B) NO_3^-/NO_2^- data. C) pH data.

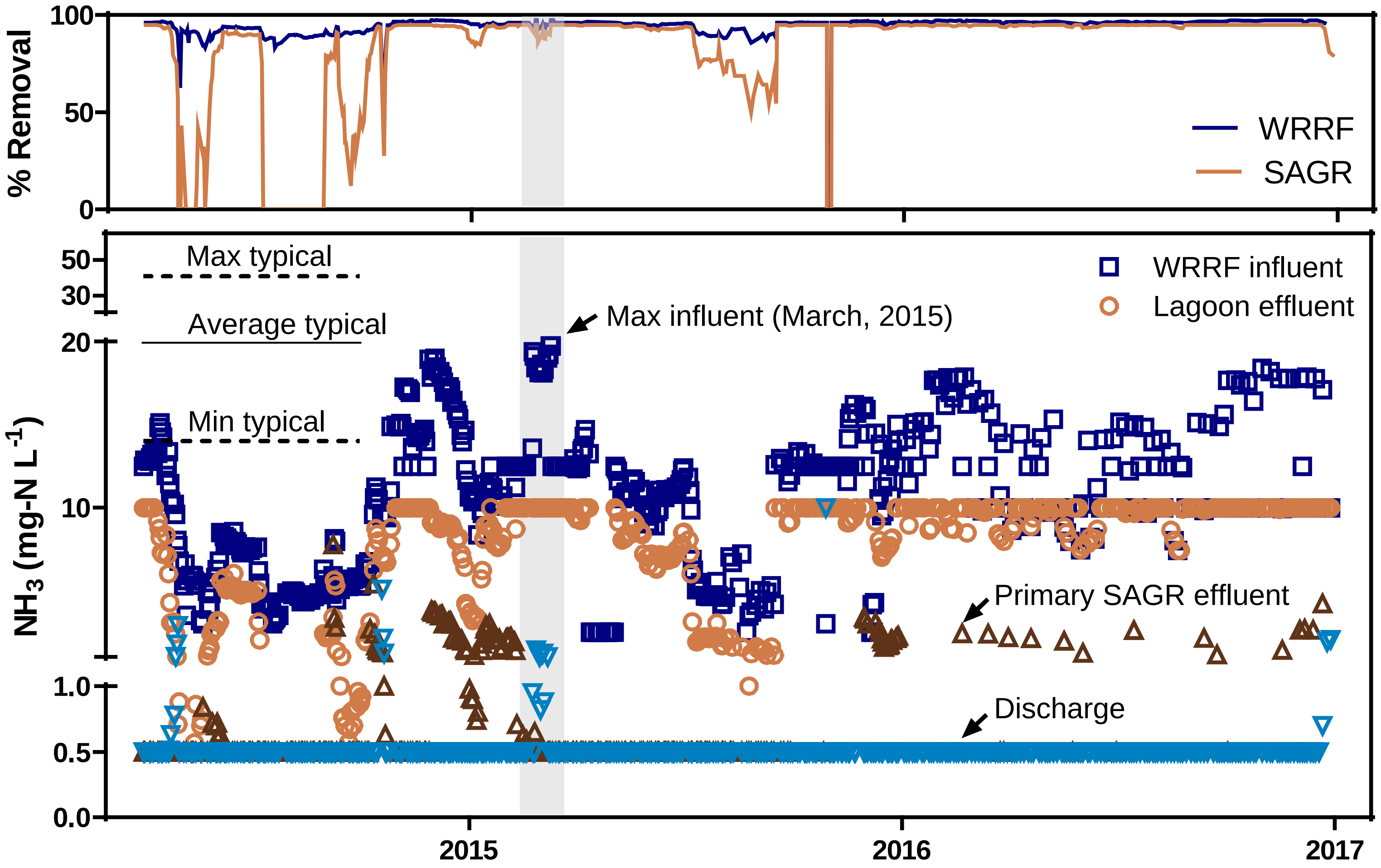

Figure 2.4 Walker lagoon-SAGR WRRF influent and effluent total NH_3 in comparison with typical NH_3 influent levels for domestic wastewater and percent removal. Ammonia removal contributed by the SAGRs is the difference between the gold circles and the light blue triangles.

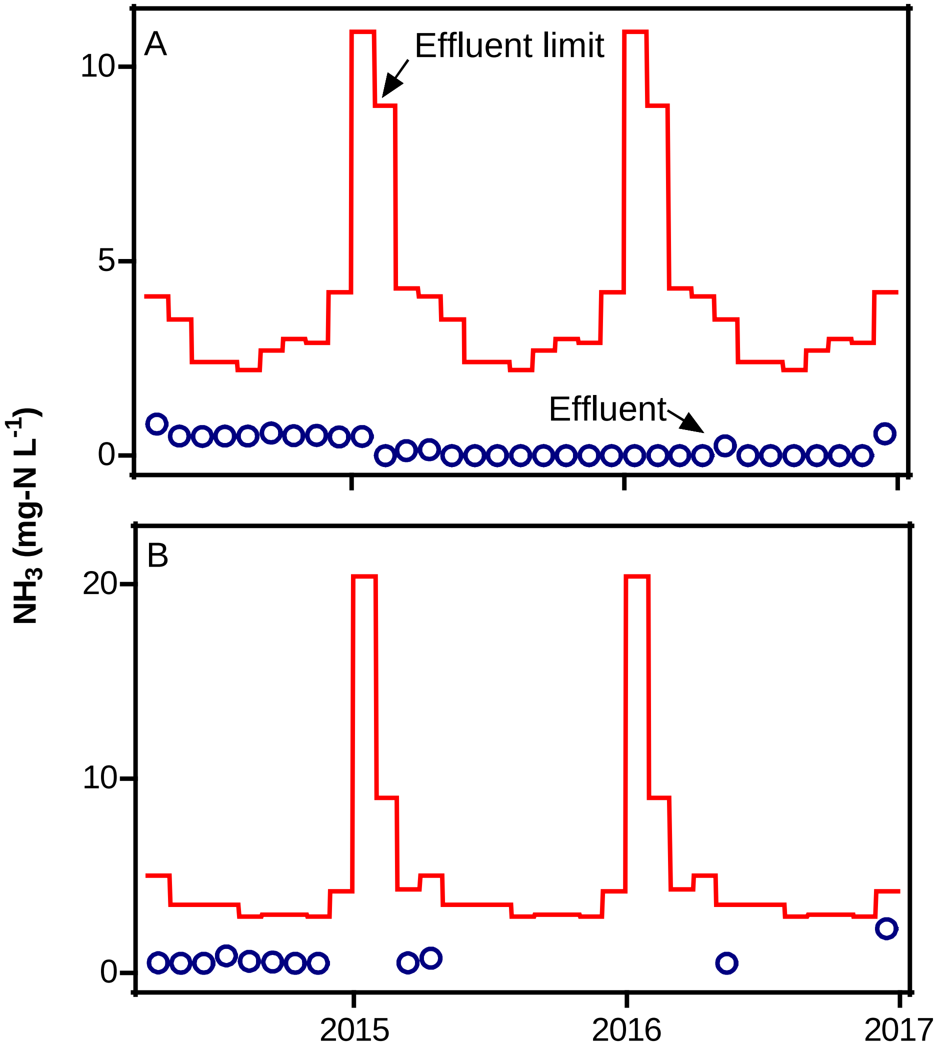

Figure 2.5 Walker lagoon-SAGR WRRF effluent total NH$_3$ and both the A) NPDES 30-day NH$_3$ average effluent discharge limit and the B) NPDES daily maximum NH$_3$ effluent discharge limit. Neither limit was exceeded in the study time period.

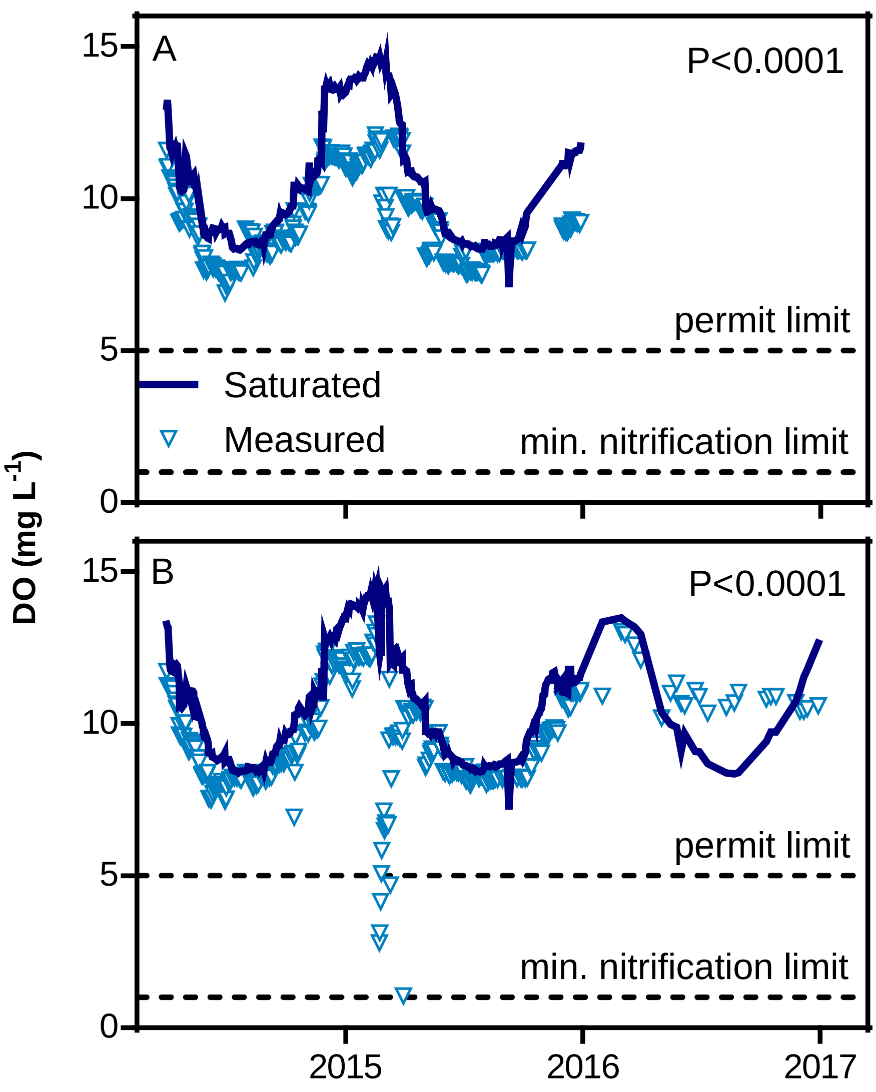

Figure 2.6 DO in the A) primary SAGRs and B) secondary SAGRs in comparison to the Benson/Krause saturation calculated based on water temperature.

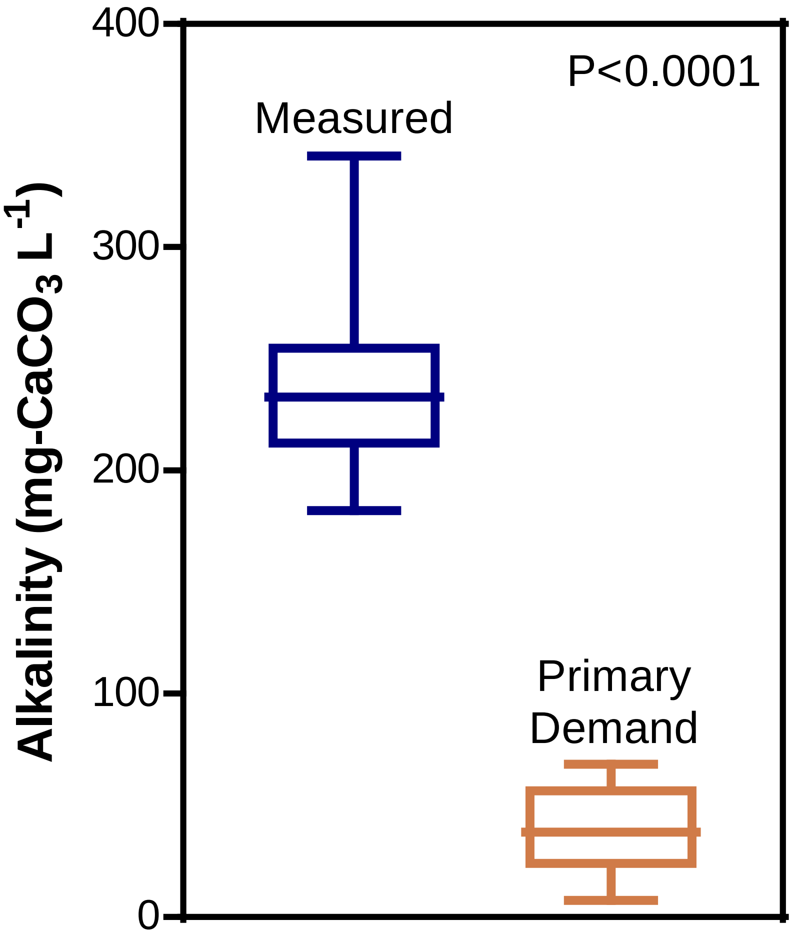

Figure 2.7 Monthly average measured available alkalinity and calculated alkalinity demand corrected for pH and temperature conditions in the primary SAGRs. The box and whisker plot shows the minimum, first quartile, median, third quartile, and maximum.

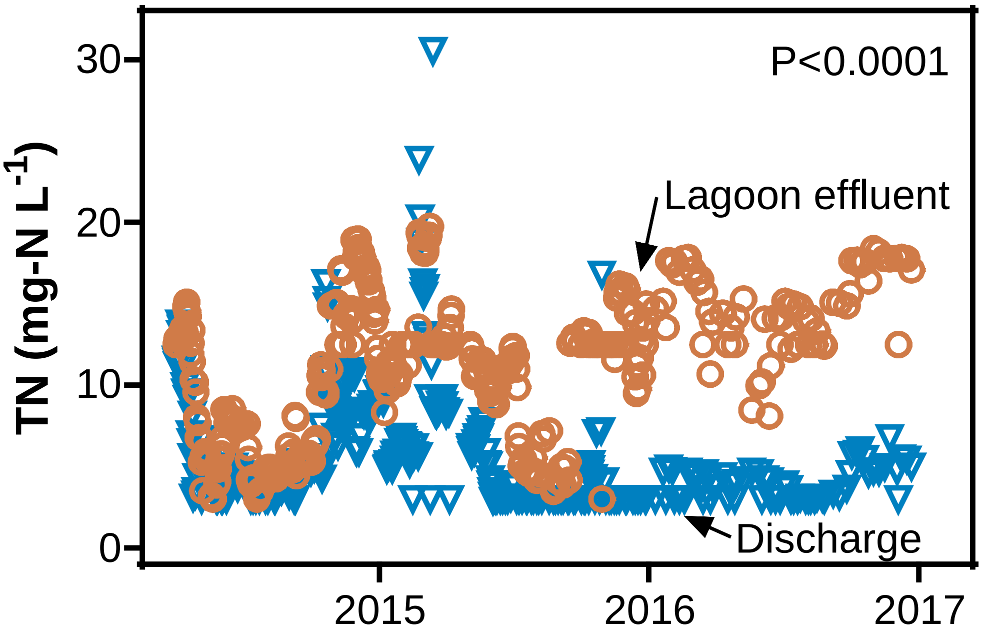

Figure 2.8 Primary SAGR and lagoon-SAGR WRRF effluent TN with improved TN removal in 2016.

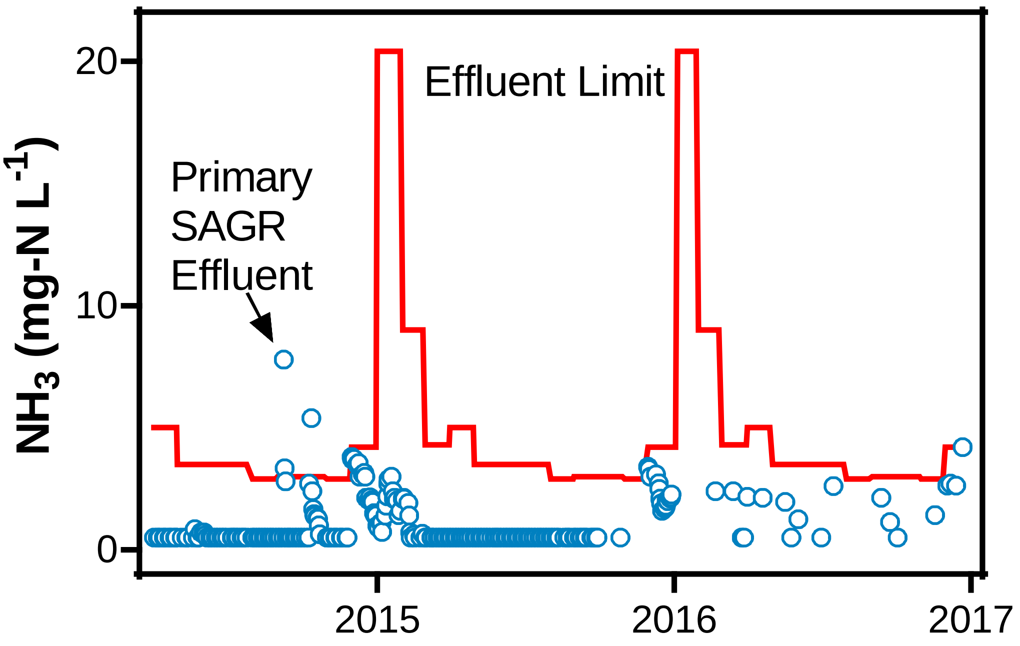

Figure 2.9 Primary SAGR effluent exceedances of the daily maximum NH_3 discharge limit if the secondary SAGRs had not been present.

CHAPTER 3: THE EFFECT OF STEP-FEEDING AND BIOFILMS

Submerged attached-growth reactors for cold-weather ammonia removal: the effect of step-feeding and biofilms

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3.1 Abstract

Submerged attached growth reactors (SAGR^{TM}) are a viable lagoon retrofit for wastewater systems struggling with cold-weather ammonia removal. To understand why these systems are effective and inform future lagoon retrofits, we investigated the effect of increased ammonia loading (step-feeding) on biomass and of biofilms on the microbial abundance in a full-scale SAGR. When step-feeding was implemented, the ammonia permit limit was never exceeded, the kinetic coefficients were maintained (0.5-0.8 d^{-1}) and the ammonia removal rates improved (0.25 kg d^{-1} to 0.45 kg d^{-1}) despite a temperature decrease (25 °C to <16 °C). In the biofilm, microbes with ammonia removal metabolisms were more abundant than in wastewater and ammonia-oxidizing archaea were 10 times more abundant than the ammonia-oxidizing bacteria. The presence of anaerobic ammonium-oxidizing bacteria suggested the existence of an anoxic biofilm zone even under high dissolved oxygen. Our results suggest that increasing SAGR biomass before cold-weather and the abundance of microbes with diverse ammonia removal metabolisms are components of a successful lagoon-SAGR WRRF.

3.2 Key Words

Biofilm, submerged attached-growth reactors, SAGR^{TM}, microbial community, ammonia, wastewater

3.3 Introduction

The 8000 wastewater treatment lagoons operating in the United States benefit small towns because of minimal energy input requirements and low operation and maintenance costs (EPA, 2011; Surampalli et al., 1999). The operational simplicity of a lagoon is ideal for small towns, but constrains cold-weather ammonia (NH_3) removal. Nitrification is limited below 10 °C by microbial kinetics (Kim et al., 2006), and most lagoons lack the system flexibility needed to compensate. Nonetheless, NH_3 must be removed from wastewater to protect aquatic organisms and prevent costly discharge limit violations.

Retrofitting a lagoon with submerged attached growth bioreactors (SAGBs, the non-trademarked name for fixed-film reactors like SAGRs) is one solution for continuous cold-weather NH_3 removal. At the pilot-scale, SAGBs nitrified (Çeçen, 1996; Chui et al., 2001; de Sousa et al., 2008; Fan et al., 2013; Pedros et al., 2008) and maintained NH_3 removal in cold-weather (Choi et al., 2008). Long-term, cold-weather nitrification was also demonstrated in a full-scale, lagoon water resource recovery facility (WRRF) retrofitted with trademarked SAGBs known as SAGRs (Chapter 2). The lagoon-SAGR WRRF maintained simple operation and flexibility while ensuring cold-weather NH_3 removal. The flow-scheme was adjusted for three months each fall to deliver higher NH_3 loads to the SAGRs and hasten biomass growth before winter. Increased substrate dosing (step-feeding) has previously improved SAGB performance (Fan et al., 2013; Stefanakis et al., 2011; X. Wang et al., 2010) and appropriate step-feeding of NH_3 should increase biomass growth in the SAGRs but has not been yet been confirmed as a necessary operational change for cold-weather ammonia removal in a full-scale lagoon-SAGR WRRF.

In addition to providing flexibility via step-feeding, another advantage to SAGR retrofits is biofilm mediated nitrification. High surface-area-to-volume ratios of fixed-film media (Hamoda & Al-Ghusain, 1998) provide extended solids retention time for autotrophic growth, leading to increased nitrifier abundance in biofilms when compared to suspended growth systems (Fatihah & Donnelly, 2009). Biofilms are also more resilient to cold-weather because the biofilm flux insulates attached-growth microbes from limiting temperatures (EPA, 1993; Wijffels et al., 1995). The flux also produces a substrate and DO gradient (Figure 3.1) (Guo et al., 2016). It is theorized that an NH_3 oxidizing zone occurs on the outside of the biofilm, dominated by ammonia oxidizing bacteria (AOB) with clusters of nitrite oxidizing bacteria (NOB) around or behind active ammonia-oxidizers (Okabe et al., 1999). Once the biofilm becomes anoxic, anaerobic ammonium oxidizing bacteria (ANAMMOX) are known to coexist in biofilms dominated by ammonia-oxidizers (Bagchi et al., 2016).

The DO-dependent spatial distribution of nitrifying microbes should include ammonia oxidizing archaea (AOA) which have oxygen affinities similar to other aerobic organisms (Stahl & de la Torre, 2012). Ammonia-oxidizing archaea also have a substrate affinity 200-fold greater than AOB (Martens-Habbena et al., 2009). However, studies on wastewater nitrifying biofilms have not focused on both AOA and AOB. To our knowledge only two studies have investigated AOA and AOB abundance in fixed-media wastewater biofilms and found that AOA were more abundant in a biological aerated filter and a rotating biological contactor (Bai et al., 2012; Sauder et al., 2012). We investigated microbial abundances within aggregate-associated biofilms and changes in biomass concentration from step-feeding in cold-weather to assess NH_3 removal in

SAGRs. Our objectives were to 1) determine if step-feeding increased biomass in the SAGRs and promoted cold-weather NH_3 removal and 2) quantify the nitrifying microbial abundance in SAGR biofilms and determine if AOA were present and more abundant than AOB.

3.3 Methods

The lagoon-SAGR WRRF consisted of three lagoons in series followed by two primary SAGRs in parallel, two secondary SAGRs in parallel, ultraviolet disinfection, and discharge (Figure 3.2A). Influent to each SAGR was split and dosed along the upper outside edges with gravity flow to a centerline effluent pipe (Figure 3.2B). The system layout, including SAGR dimensions and a more detailed flow-scheme, was described in our previous work (Chapter 2). The step-feeding procedure, which constituted a series of lagoon bypasses, began on September 1st by bypassing lagoon 2 to increase substrate loading in the primary SAGRs. On October 1st, the primary SAGRs were bypassed and all the substrate was diverted to the secondary SAGRs. Normal operation resumed on December 1st.

Three water monitoring wells (W1, W2, W3) were installed in a primary SAGR using a modified 10.2 cm diameter ice auger guided by a 12.7 cm diameter PVC well casing (including slats with 2.5 cm spacing). During baseline, non-step feeding, dosing conditions, one water sample was collected from W1, W2 and W3, on three occasions (i.e. n=3, for each time-point), over a two-month span (Table 3.1). During step-feeding, each well was sampled in triplicate (i.e. n=9, for each time-point), on three occasions. Sample aliquots for DNA analysis were field filtered, transported on ice, and kept at -20 °C until extraction using a water DNA isolation kit (MoBio Power Water, Qiagen, Germantown, MD).

Primary SAGR influent and effluent NH_3 was measured at 6 h intervals by water quality sondes (Hydrolab DS5x, OTT Hydromet, Loveland, CO), except between September 5th and September 25th when one sonde malfunctioned. The water quality sondes were outfitted with NH_4^+, pH, and temperature probes which were re-calibrated every three weeks. The NH_3 concentrations were automatically calculated by the water quality sonde and were then converted to loads using the flow rate (Table D.1) reported to the IDNR for the NPDES permit compliance. The 30-day average NH_3 concentration was also reported to the IDNR for the NPDES permit compliance (Table D.2).

The system kinetics were determined using NH_3 loads and SAGR sizing. The median influent and effluent NH_3 loads, from the 28-day span preceding DNA sampling, were utilized because the data was not normally distributed. The NH_3 removal rate was calculated from the influent and effluent loads and the HRT. This data was used to determine the kinetic coefficient for a plug flow reactor (PFR) (3.1) and a continuously stirred tank reactor (CSTR) (3.2):

$$k = -\frac{1}{t} ln\left(\frac{C}{C_0}\right) \tag{3.1}$$

$$k = \frac{1}{\theta}\left(\frac{C_0}{C} - 1\right) \tag{3.2}$$

where k is the reaction coefficient in (d^{-1}), t is time (d), C is final concentration in (kg d^{-1}), C_0 is initial concentration in (kg d^{-1}), and θ is the hydraulic retention time in (d). A $k_{estimated}$ was calculated as the average between the PFR and CSTR kinetics (Table D.3 and D.4).

Six biofilm monitoring wells (identical to W1, W2, and W3) in the primary SAGR each contained four polyester mesh bags (15.2 cm diameter, 33.0 cm tall) filled with 3.8 cm diameter rocks. Before deployment, the rocks were cleaned with non-phosphate detergent, 10% bleach, 10% hydrochloric acid, and muffled at 550 °C for 1 h. The rock bags were deployed for various intervals during baseline dosing conditions (n=12, for each time-point) (Table 3.1). Ten randomly selected rocks from each biofilm sampling event were placed into a bleached, acid washed, and ethanol sprayed 250 ml centrifuge bottle (Beckman Coulter, Indianapolis, IN) containing 100 mL of sterile deionized water (DI). Each bottle was agitated for 10 min at the maximum speed on a vortex mixer (Fisher Scientific, Waltham, MA), and settled for 5 min. Rocks were removed with sterile tweezers and rinsed with sterile DI above the centrifuge bottle which was subsequently centrifuged at maximum speed (JA-14 rotor, Beckman Coulter, Indianapolis, IN) for 10 min. The water was decanted and the resulting biomass was stored at -20 °C until DNA extraction using a biofilm DNA extraction kit (DNeasy PowerBiofilm Kit, Qiagen, Germantown, MD).

Genomic DNA extracted from baseline wastewater and biofilm samples, 20 µL of 1-50 ng μL^{-1}, was sent to Argonne National Laboratory Environmental Sample Preparation and Sequencing Facility (ESPSF) for library preparation targeting the 16S rRNA gene (515F-806R) and sequencing. The primers were region-specific and included adapter sequences for the Illumina flowcell and a barcode on the forward primer (Caporaso et al., 2012; Caporaso et al., 2011).The PCR reaction contained 9.5 µL of MoBio PCR Water (Certified DNA-Free), 12.5 µL of QuantaBio’s AccuStart II PCR ToughMix (2x concentration, 1x final), 1 µL Golay barcode tagged Forward Primer (5 µM concentration, 200 pM final), 1 µL Reverse Primer (5 µM concentration, 200 pM final), and 1 µL of template DNA. The conditions were 94 °C for 3 min, 35 cycles of 94

°C for 45 s, 50 °C for 60 s, 72 °C for 90 s and a final cycle for 10 min at 72 °C. Resulting amplicons were quantified with PicoGreen (Invitrogen, Waltham, MA) and a plate reader (Infinite® 200 PRO, Tecan, Switzerland). Equimolar amounts of each product, combined in one tube, were cleaned using AMPure XP Beads (Beckkman Coulter, Brea, CA,) and quantified using a fluorometer (Qubit, Invitrogen, Waltham, MA). The combined product concentration was diluted to 2 nM, denatured, and diluted to 6.75 pM with a 10% PhiX spike before sequencing on the Illumina MiSeq. Amplicons were sequenced on a 151 bp x 12 bp x 151 bp MiSeq run (Caporaso et al., 2011). Sequences were uploaded to MG-RAST (ID’s: 4771052.3-4771099.3).

The Quantitative Insights into Microbial Ecology (QIIME) open-reference pipeline assigned operational taxonomic units (OTUs) to the 16S rRNA sequences (Navas-Molina et al., 2013). Paired end reads were joined and data was demultiplexed for quality control and clustered into OTUs using the UCLUST method (Edgar, 2010). The resultant OTUs were aligned with the GreenGenes 13.5 database (DeSantis et al., 2006) with a 97% similarity threshold using RDP classifier (Q. Wang et al., 2007). PyNAST aligned multiple sequences and filtered out any with less than a 0.05% taxa abundance to eliminate false positives (Caporaso et al., 2009). A weighted OTU abundance principal component analysis was calculated (core_diversity_analyses.py) and the output was used for downstream analysis at the genus level (Table D.5, D.6, D.7, & D.8). The average abundance and standard deviation of the genera identified as relating to nitrification or ANAMMOX were reported.

The 16S universal gene was quantified with qPCR (ABI QuantStudio 7 Flex Real-Time PCR System, Applied Biosystems, Foster City, CA) with primers 1055f (5’-

ATGGCTGTCGTCAGCT-3’) and 1392r (5’-ACGGGCGGTGTGTAC-3’) (Ferris et al., 1996; Liang et al., 2010). Standard curves were generated using a designed gBlock (Integrated DNA Technologies, Inc., Coralville, IA) containing the universal 16S gene (321 bp) (J01859.1) (Ehresmann et al., 1972) (Table D.9). Composites combining 10 µL of the triplicate wastewater samples from step-feeding condition were quantified along with the individual wastewater samples from the baseline condition. Composites combining 10 µL of the quadruplicate biofilm samples were quantified for both conditions. The reaction mix had a total volume of 25 µL containing 12.5 µL of Power SYBR green (Applied Biosystems, Foster City, CA), 0.75 µL of 10 pmol μL^{-1} forward and reverse primers, 0.02 µL of 10 mg mL^{-1} bovine serum albumin, 2 µL of the DNA sample with an approximate final concentration of 5 ng μL^{-1} measured using a fluorometer (Qubit, Invitrogen, Waltham, MA), and DNA free water. The PCR program was 2 min at 50 °C, 10 min at 95 °C, 40 cycles of 1 min at 95 °C, 1 min at 50 °C, and 1 min at 60 °C (Geets et al., 2007).

Analysis was completed with ABI QuantStudio Real-Time PCR Software (Applied Biosystems, Foster City, CA) and the standard curves were sufficient for quantification (Table D.10). The slope, y-intercept, R^2, and efficiency for runs 1 and 2 were -3.326 and -3.263, 34.205 and 34.039, 0.999 and 0.999, and 99.851 and 102.519, respectively. The cycle threshold for the non-template control was >31 and all the samples had lower cycle thresholds. The qCPR products melted at >80 °C and resulted in primarily single peaks. The biofilm samples showed significant inhibition that was absent from the standards, non-template controls, and wastewater samples. Therefore, only the wastewater samples were used for downstream analysis. The 8/24 wastewater samples were undetermined likely because the DNA concentration post extraction was too low for successful amplification and therefore omitted in subsequent analysis. Exported data quantity mean and standard deviation were converted to gene copies mL^{-1} of filtered water (Table D.11). The measure of universal 16S gene copies mL^{-1} was used as a surrogate for biomass concentration.

3.4 Results & Discussion

3.4.1 Step-feeding and Biomass Growth

To determine if step-feeding ensured NH_3 discharge compliance in cold-weather, we compared four years of NH_3 discharge and operational conditions to permit levels between September 1st, 2013, and December 31st, 2017 (Figure 3.3). The NH_3 discharge exceeded the 30-day average NH_3 limit once (March 2014) during the four-year study-period and was anticipated since step-feeding was not implemented the preceding fall (September 1st, 2013, and October 1st of 2013). Proper implementation of the step-feeding process, beginning in 2014, apparently promoted sufficient biomass growth to avoid additional discharge exceedances.

To determine the relationship between NH_3 loading and biomass, we compared influent NH_3 loads to universal 16S gene concentrations in the bulk wastewater in four cases (Figure 3.4, cases A, B, C & D). In each case, the gene copy concentration was for a specific day and the associated NH_3 load was the median value from the preceding 28 day range (Figure D.1). In all cases, the gene concentration was assumed to be proportional to biomass concentration (Dandie et al., 2007). Case A and Case B represented baseline conditions, Case C was indicative of step-feeding, and Case D was post step-feeding. Biomass was proportional to load for all cases and was reflected in the biomass to load ratio (Table 3.2). To further compare the NH_3 load increase due to step-feeding and biomass growth, we calculated the NH_3 removal rates and estimated the kinetic coefficient ($k_{estimated}$) for each case (Table 3.2). The baseline $k_{estimated}$ values were 0.7 d^{-1} and 0.6 d^{-1}, similar to previously reported coefficients (Strauss et al., 2004). The $k_{estimated}$ values in cases C and D were similar and the NH_3 removal rates were higher (0.5 kg d^{-1} and 0.4 kg d^{-1}) even though the temperature was 10 °C and 20 °C lower than during baseline loading. The greater rate was likely due to increased microbial growth from step-feeding, which maintained cold-weather NH_3 removal in the SAGR. Step-feeding increased the biomass concentration in the SAGR, and NH_3 removal rate was promoted during cold-weather.

3.4.2 Microbial Abundance in the Biofilm

Given that biofilms create redox gradients, we explored the primary SAGR microbial abundance using 16S amplicon sequencing to determine what microbes contributed to nitrification and other mechanisms of nitrogen removal. Nitrifiers, including NOB (*Nitrospira*), AOA (*Nitrosopumilus*), and AOB *(Nitrosovibrio*), were identified at the genus level and were more abundant in the biofilm than in the wastewater (Figure 3.5). The AOA *Canditus Nitrosophaera* was detected in similar relative abundances in both mediums. Nitrite-oxidizing bacteria were the most abundant class of nitrifiers in the biofilm (3.3%), similar to previous findings (Okabe et al., 1999). Our study did not identify the NOB, *Nitrobacter* at the genus level, consistent with previous work showing high *Nitrospira* abundance near the oxic-anoxic interface when *Nitrobacter* was absent (ter Haseborg et al., 2010). Of the NH_3 oxidizers, AOA (2.4%) were more abundant than AOB (0.03%), similar to previous work on other fixed-media reactors (Bai et al., 2012; Sauder et al., 2012). However, in one study looking at fluidized attachment media instead of fixed attachment media found a greater abundance of AOB than total archaea (Xia et al., 2010). Other studies looking at NH_3 oxidizers in biofilms have focused singularly on AOB (Chae et al., 2012; Chae et al., 2008; Daims et al., 2001; Fatihah & Donnelly, 2009; Franco-Rivera et al., 2007; Gieseke et al., 2003; Gieseke et al., 2001; Lazarova et al., 1999; Okabe et al., 1999; Schramm et al., 2000), but our results indicate that AOA could also play a significant role in the nitrifying community.

In addition to nitrifiers, ANAMMOX was identified at the genus level in both the biofilm and wastewater. The presence of ANAMMOX in the primary SAGRS was surprising because previous work has shown DO levels were consistently close to saturation (Chapter 2). The relative abundance of ANAMMOX associated with attached-growth (0.05%) suggests that aerobes depleted the DO before it could fully penetrate the biofilm, whereas NH_4^+ from the wastewater and NO_2^- from NH_3 oxidation likely were able to completely penetrate the biofilm. Increased abundance of ANAMMOX and autotrophic microbes in the biofilm was likely because of the long solids retention time provided by fixed media (Fatihah & Donnelly, 2009).

To determine if AOA, ANAMMOX, and NOB abundance changed due to substrate load, we looked at the genera relative abundance and NH_3 load in three sampling wells. The highest NH_3 load occurred in W1 and decreased along the SAGR flow direction (Figure 3.6). The wastewater microbial abundance did not change in the three sampling wells but there were changes in the biofilm microbial abundance. The AOA relative abundance in the biofilm was inversely proportional to NH_3 load, consistent with previous research (Sauder et al., 2012). However, our study, in addition to Bai et al. and Sauder et al., indicated AOA proliferated in biofilms under a wide range of NH_3 concentrations of less than 0.4 mg-N L^{-1} to 76.6 mg-N L^{-1} (Bai et al., 2012; Sauder et al., 2012). Perhaps influent NH_3, in combination with attached-growth, controls AOA abundance instead of substrate concentration alone. The highest ANAMMOX and NOB abundances were observed in W1 likely because of increased DO consumption due to high substrate levels. A gradient likely provided an oxic-anoxic zone for *Nitrospira* preventing DO inhibition (Okabe et al., 1999; ter Haseborg et al., 2010), and an anaerobic zone for ANAMMOX. The ANAMMOX abundance decreased sharply in W2 while the NOB decreased gradually, highlighting the difference between anaerobes and DO-limited aerobes. The SAGR biofilm supported microbes with metabolisms related to NH_3 removal with diverse DO affinities. The SAGR biofilm selected for NOB, AOA, AOB and ANAMMOX which changed in abundance across the flow direction, likely due to the provision of a substrate and DO gradient in the biofilm.

3.5 Conclusion

Step-feeding a SAGR as a component of a lagoon-SAGR WRRF increased the biomass concentration and improved the NH_3 removal rates. The flow-scheme flexibility provided by this retrofit in comparison to a lagoon system prepared the WRRF for cold-weather nitrification. The diversity of microbes with NH_3 and NO_2^- metabolisms in the system was naturally selected and more abundant in the biofilm. Microbes preferring a diverse range of substrate and DO conditions were present likely due to the gradients known to occur in biofilms. The combination of low substrate and stationary fixed media selected for AOA over AOB and indicated that AOA could significantly contribute to biofilm mediated nitrification in wastewater. Our study of one lagoon-SAGR WRRF found that SAGRs are effective at cold-weather NH_3 removal in part due to the microbial habitat provided by biofilms and the biomass generated by step-feeding. The use of

SAGR retrofits in addition to continued research on cold-weather NH_3 removal from lagoons will support small WRRFs and protect aquatic organisms and recreation.

3.6 Acknowledgements

We recognize Matthew Wildman for sharing his knowledge of the project. We thank Kevin Shoop, the lagoon-SAGR WRRF operator at Walker, IA, for sharing his insight into the system operation, logistical support, and collecting and analyzing additional samples. We are grateful to Larry Bryant from the IDNR for his support. Members of the Iowa Water Environmental Association (IAWEA is a Water Environment Federation affiliate) Small Communities Committee provided insight and advice for this work. Funding was provided by the University of Iowa and field sampling support was provided by IIHR – Hydroscience & Engineering.

Table 3.1 Collection dates for biofilm and wastewater samples and growth time for biofilm samples collected during baseline loading.

Purpose	**Collection**	**Biofilm growth time (d)**
Baseline	6/29/2017	43
	7/24/2017	25
	8/24/2017	31
Step-feeding	10/25/2017	NA
	12/1/2017	NA

Table 3.2 The NH_3 removal rate, average biomass concentration, and estimated kinetic coefficient in four different cases of NH_3 loading and temperature.

	Case A	**Case B**	**Case C**	**Case D**
Median NH_3 load (kg d^{-1})	0.6	0.4	1.4	0.7
Median temperature (°C)	24.2	25.7	15.6	5.3
16S genes (copies*10^6 mL^{-1})	1.1	0.4	1.8	1.2
Biomass (gene copies) to NH_3 load ratio	1.6	1.0	1.3	1.7
Primary SAGR effluent NH_3 (kg d^{-1})	0.3	0.2	0.9	0.3
NH_3 removal rate (kg d^{-1})	0.3	0.2	0.5	0.4
Estimated *k* (d^{-1})	0.7	0.6	0.5	0.8

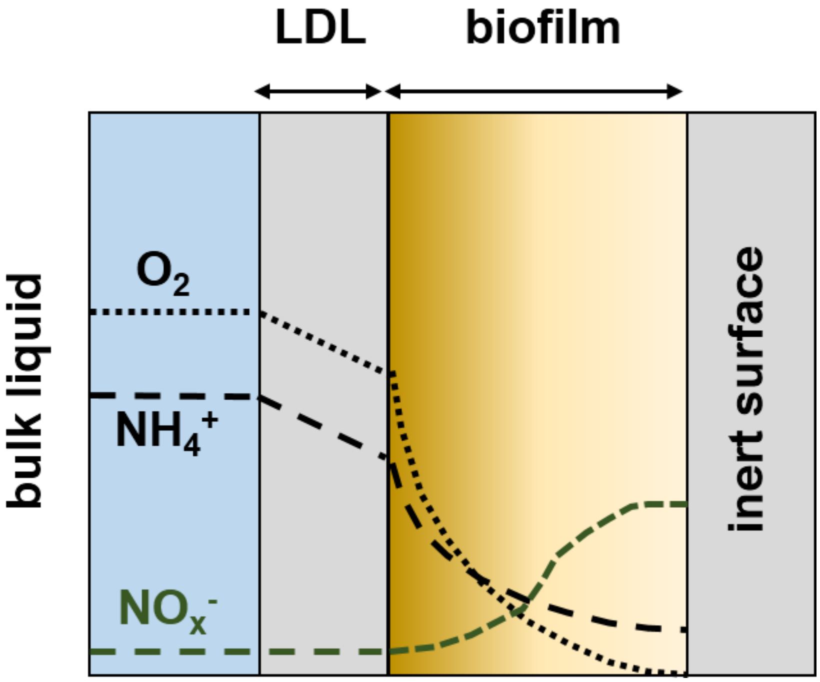

Figure 3.1 The dissolved oxygen and substrate gradients in biofilms in the presence of AOB, AOA, NOB, and ANAMMOX. LDL refers to liquid diffusion layer.

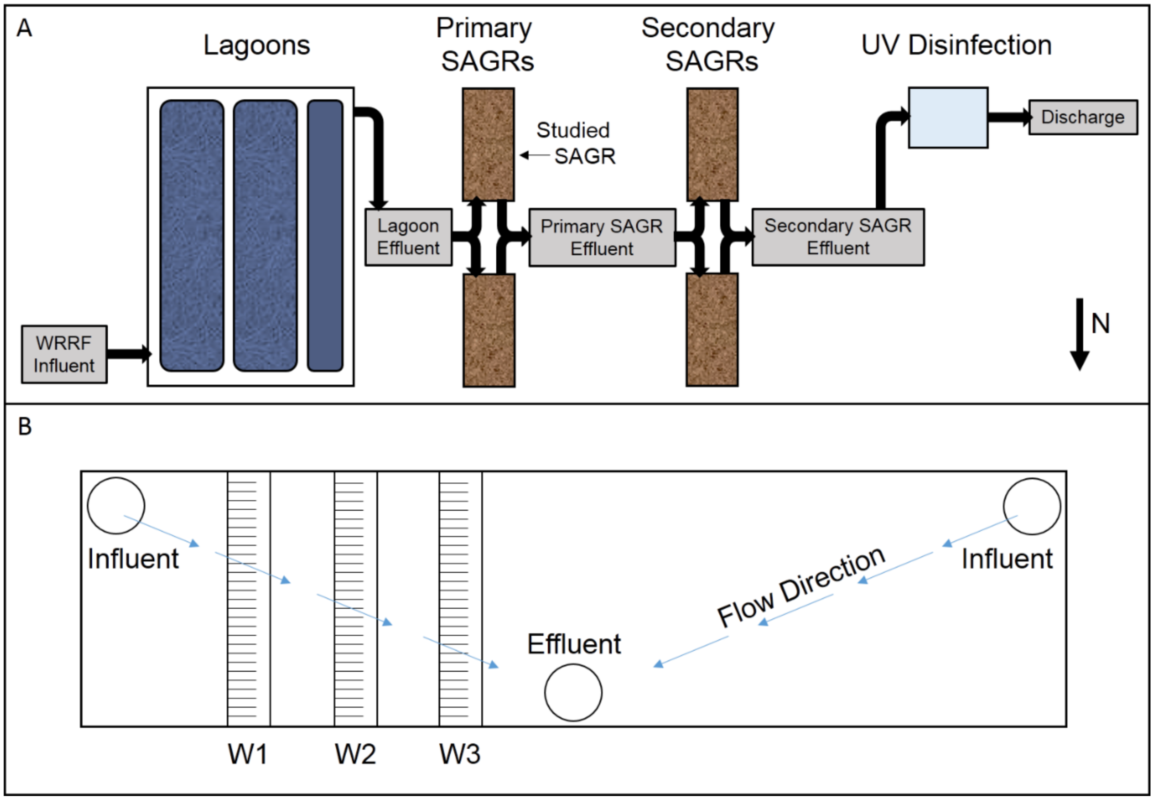

Figure 3.2 Walker, IA lagoon-SAGR WRRF. A) Flow diagram of the system adapted from Chapter 2. B) A section view (width and depth) of the SAGR with the sampling wells, W1, W2, and W3, as well as the gravity flow direction of the system. Note that the SAGRs are full of aggregate so the flow direction is tortuous not linear.

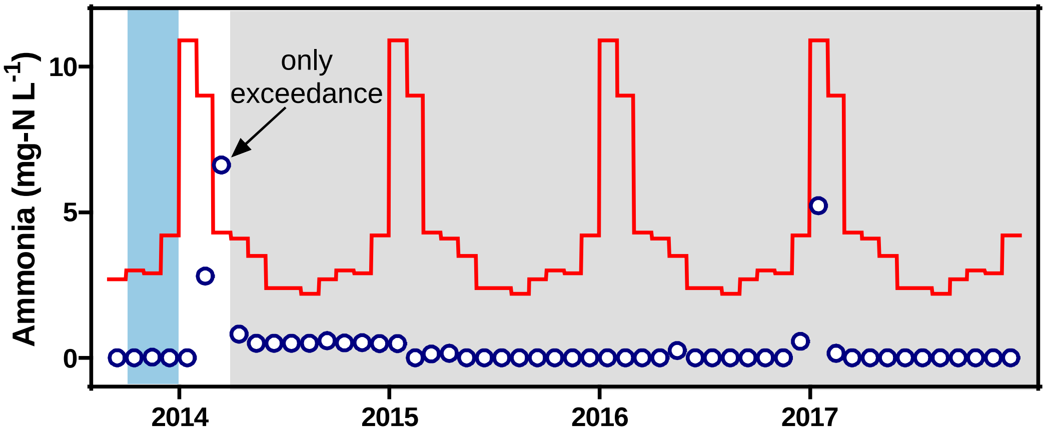

Figure 3.3 Historical NH_3 discharge data and NPDES 30-day NH_3 permit limit (red line) when step-feeding was not used (blue rectangle) and since implementing step-feeding each fall (gray section). A permit citation was not issued after the exceedance because the permit was not active until April 2014.

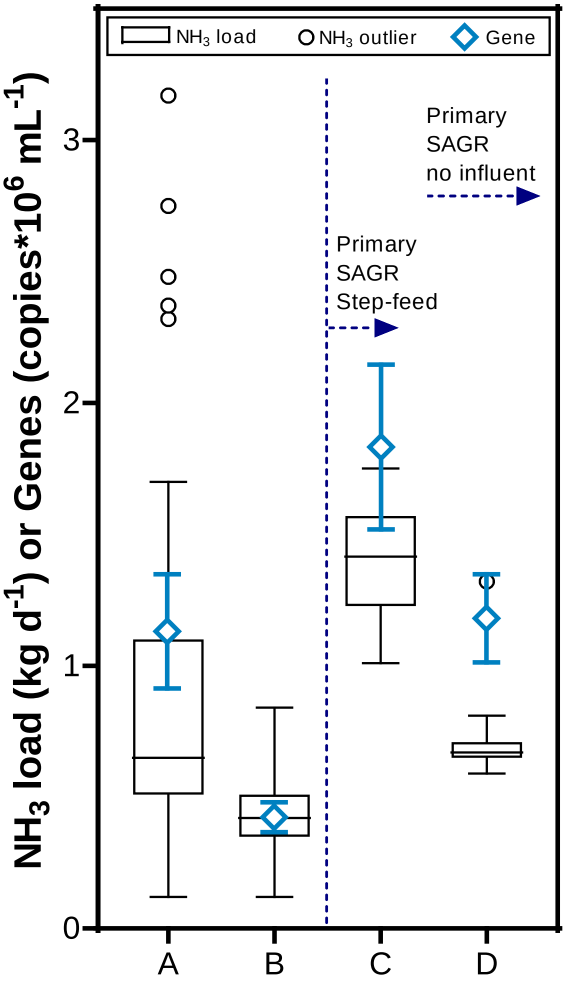

Figure 3.4 Ammonia loading in comparison to the average gene copies mL^{-1} of universal 16S bacteria in the primary SAGR sampling well bulk fluid. The DNA samples were taken on A) 6/29, B) 7/24, C) 10/25, and D) 12/1. The NH_3 loading 28 days prior to the DNA sample is shown in the box and whisker plots as minimum, Q1, median, Q3, and maximum (outliers shown as points, ROUT Q=1%).

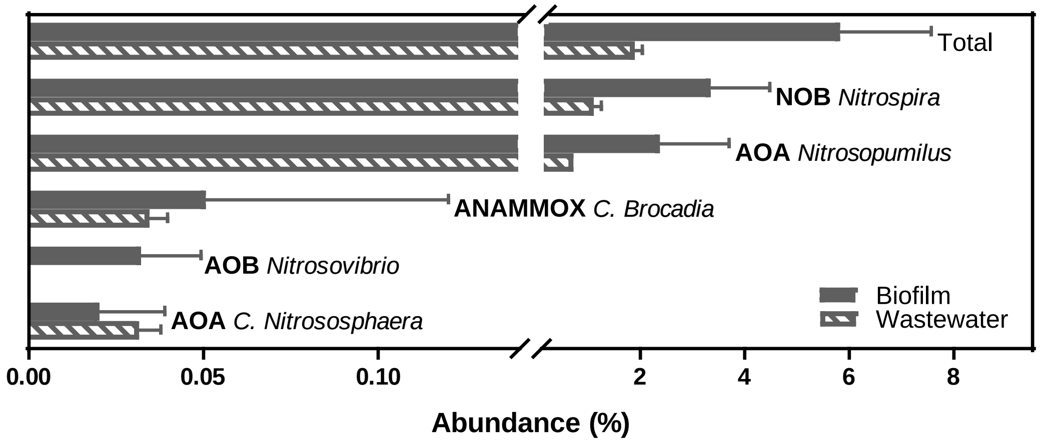

Figure 3.5 Average nitrifying microbial community abundance, error represented by the standard deviation, in the three baseline samples both in the biofilm and wastewater. The n.d. indicates not detected.

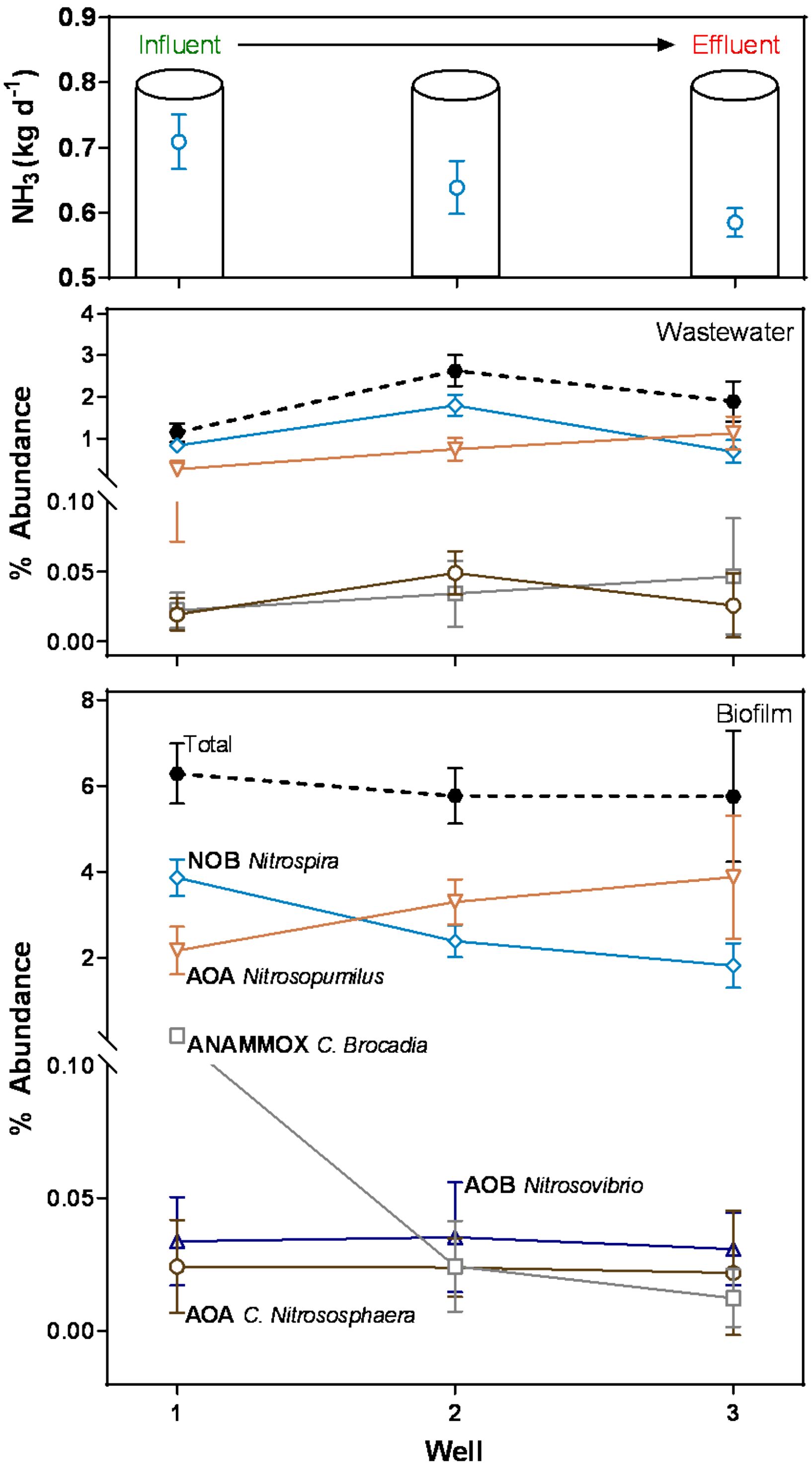

Figure 3.6 The average abundance of nitrifying genera, error represented by the standard deviation, in W1, W2, W3, and the differences between wastewater and biofilm in addition to the change in NH_3 loading along the SAGR flow direction.

CHAPTER 4: CONCLUSION

Submerged attached-growth reactors were an effective lagoon retrofit for cold-weather NH_3 removal in Walker, IA. The lagoon-SAGR WRRF removed NH_3 to below permitted discharge limits 100% of the time during our first study (April 2014 to December 2016) (Chapter 2). In 2017, there were also no NH_3 permit violations (Chapter 3). The median NH_3 removal at the lagoon-SAGR WRRF was 95%, and the SAGRs accounted for 94% of the removal. The evidence of consistently abundant DO and a majority of the NH_3 treatment occurring in the primary SAGRs confirmed that SAGR sizing was overly conservative. The primary SAGRs alone, which constituted half the treatment volume, produced permittable NH_3 levels 98.9% of the time. Our findings confirm the addition of reduced sizing in the IDNR design guidance on SAGRs. To ensure continuous NH_3 removal and engineering redundancy, we suggest reducing the size of both the primary and secondary SAGRs.

The success of the lagoon-SAGR WRRF was partially due to sufficient substrate, DO, and alkalinity (Chapter 2) which served as the electron donor, electron acceptor, and carbon source for nitrifying microbes. In addition to ideal chemical conditions, the lagoon-SAGR WRRF provided the operator the necessary flow-scheme flexibility to prepare the attached-growth system for winter. Increased NH_3 loading was proportional to biomass in the primary SAGR. The estimated kinetic coefficients and biomass to NH_3 load ratios were comparable during baseline loading, step-feeding, and post step-feeding. Even though the temperature significantly decreased, the NH_3 removal rate increased during and post-step-feeding. The increase in biomass due to NH_3 load from step-feeding prevented NH_3 permit violations.

In addition to operational flexibility, the lagoon-SAGR WRRF had the added advantage of biofilms, which also contributed to effective cold-weather nitrification. Niftrifying microbes were more abundant in the biofilm, which has been shown to be more temperature resilient than suspended growth systems. A majority of the nitrification was likely due to the NOB *Nitrospira* and the AOA *Nitrosopumilus,* based on relative abundance. The dominance of AOA which has not been evaluated in many previous studies suggests AOA could play a significant role in biofilm mediated nitrification in wastewater systems. Previous work suggested that AOA proliferate at low substrate concentrations. However, we suggest that substrate concentration and attached-growth systems select AOA, but more work is needed to better understand this relationship. The biofilm also provided an anoxic zone for an ANAMMOX genera to exist in the SAGR where substrate concentrations were the highest. The SAGRs supported microbes with NH_3 and NO_2^- removal metabolisms which had a diverse range of DO affinities. The biofilm flux limiting the impact of inhibitors like temperature and the long solids retention time provided by the attached-growth nature of the system contributed to the lagoon-SAGR WRRF success. The SAGR is an effective lagoon retrofit for cold-weather NH_3 removal and is in part due to the implementation of step-feeding and biofilm growth.

4.1 Implications

Municipalities failing to meet cold-weather NH_3 limits and considering a SAGR retrofit for a lagoon WRRF should work with local regulators to determine appropriate SAGR sizing for better secondary SAGR utilization. This could reduce construction and maintenance costs while maintaining effective cold-weather NH_3 removal. Other potential lagoon retrofits should consider incorporating design elements that have proven effective in the SAGR: utilizing biofilms, maintaining operational flexibility, and increasing biomass to prepare the nitrifying microbial community for cold-weather. Future lagoon WRRFs retrofitted with SAGRs and continued research will better protect aquatic environments from NH_3 pollution and support cold-climate, small town wastewater treatment.

4.2 Future Work

This thesis provides a foundation for future work that could further improve SAGRs and add insight into the system operation. Future research should include the following objectives that could contribute to the aim of helping small communities improve cold-weather NH_3 removal.

- Expand the research to other SAGRs that have been more recently implemented in Iowa to confirm that the results obtained at Walker are consistent with other similar systems.
- Preform a cost analysis on the SAGR system to determine if it is cost effective as a retrofit for small communities.
- Find design equations based on wastewater characteristics, flow, and temperature that could be used for SAGR sizing.
- Determine if COMAMMOX is present in the SAGRs, and use targeted qPCR primers to determine how NOB, AOA, ANAMMOX, AOB and COMAMMOX cohabitate in the reactor and vary spatially within the biofilm.
- Investigate how the microbial community abundance is affected by step-feeding.
- Further the research pertaining to step-feeding by directly quantifying the mass of biomass grown during increases in NH_3 loading using methods described in Appendix A.1.

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APPENDIX A: OTHER EXPERIMENTS

A.1 Biomass Direct Quantification

To directly measure the biomass increase due to step-feeding, we measured the mass of biofilm grown on muffled rocks. This method was implemented during the step-feeding portion of sampling (described in Chapter 3, Table 3.1). Because the biomass growth was not quantified during the baseline sampling, the results were inconclusive. Consequently, we only measured the amount of biomass decay that occurred when no influent substrate was dosed into the primary SAGR (October 1st to December 1st).

A.1.1 Methods

Rocks were deployed in the monitoring wells using the process described in Chapter 3. After collection, the dry mass of the rocks (n=5 for each well depth and location, n_{total}=60 per sampling event) was measured by drying the rocks at 105 °C until a constant mass was measured. The rocks were then muffled at 550 °C for one hour to incinerate all of the biofilm. The rock mass without the biofilm was measured. The change in biomass was calculated, and the surface area of the rocks was determined using the relationship between weight and surface area ($y = 373.13x^{0.6367}$) (Cooper & Testa, 2001). The geometric mean of biomass per surface area was calculated for each sampling event (n=60) because the data was log-normally distributed and there were minimal differences between the wells and different depth samples. The geometric mean of biofilm per surface area was adjusted based on growth days to determine a biofilm flux.

A.1.2 Preliminary Results

We found that biomass was grown from September 8th to December 25th (phase 1), when the primary SAGR was both step-fed (23 days) and received no influent substrate (25 days). During phase 2 (October 25th to December 1st), the primary SAGR received no influent substrate. Less biomass grew in phase 2 than in phase 1. Our final biomass growth sample captured the amount of biomass growth and decay that occurred from September 8th to December 1st. During this phase, which captured the entire duration of both phase 1 and phase 2, we measured the least amount of biomass. After step-feeding and during periods of no substrate influent, we saw biofilm growth, but the mass per surface area decreased throughout the process (Table A.1 and Figure A.1). However, the system was able to retain biomass during two months of no influent substrate. Our results were consistent with the engineered goal of step-feeding and results showing biofilm growth under increased substrate conditions.

Table A.1 Biofilm mass per surface area (SA) and biofilm mass per surface area normalize to growth days in the primary SAGR during different phases of step-feeding. The geometric mean was reported for log-normally distributed data.

	Step Feeding Phase		
Biofilm per	**1**	**2**	**Duration of 1 and 2**
SA (mg/m^2)	102.39	62.08	83.64
SA / Growth Time (mg/m^2*d)	2.18	1.68	1.00
Growth Time (d)	47	37	84

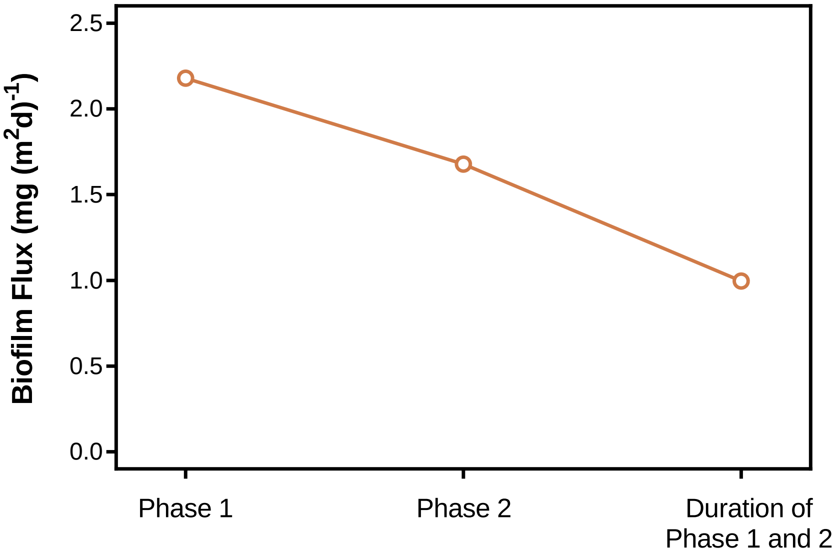

Figure A.1 Change in the geometric mean biofilm flux in the primary SAGR under different step-feeding phases.

A.2 Tracer Study

To determine the actual HRT of the SAGR, we implemented a rhodamine dye tracer study. This study was implemented in January, 2017 during cold-weather to prevent dye degradation and under low flow conditions. We conducted the study over 72 hours. However, we were unable to recover the entire mass of the dye because the study was ended prematurely.

A.2.1 Methods

The tracer study was conducted using 250 mL of 10% food grade rhodamine dye, and the fluorescence was measured every 5 min using a submersible fluorometer (C3 Submersible Fluorometer, Turner Designs, San Jose, CA). The fluorometer was calibrated in the raw fluorescence blank subtraction mode with temperature correction using a 400 ppb response factor (Turner Designs, San Jose, CA). The dye was added to the primary SAGR influent in the splitter box, and the florescence was measured in the primary SAGR effluent via a manhole where the two primary SAGR effluents recombined before entering the secondary SAGR splitter box. The average HRT was calculated using:

$$\overline{HRT} = \frac{\sum t_i C_i \Delta t_i}{\sum C_i \Delta t_i} \tag{A1}$$

where t_i is time (minutes), C_i is concentration (ppb), and Δt_i is the measurement interval (min).

A.2.2 Preliminary Results

We recovered 12% of the dye and calculated an average HRT of 46 h. However, this HRT was not accurate due to the incomplete nature of our study. Based on the flowrate at the time of the study (total=0.05 MGD and SAGR influent=0.025 MGD), the

HRT should have been about 60 hours. From the data, we determined that it took about 10 hours for the dye to appear in the influent, indicating that the system initially behaved similar to a PFR. From about hour 30 to hour 70, a relatively constant amount of dye was detected, which suggested that during this time period the system behaved more similarly to a CSTR. Another tracer study is needed to better understand the system hydraulics.

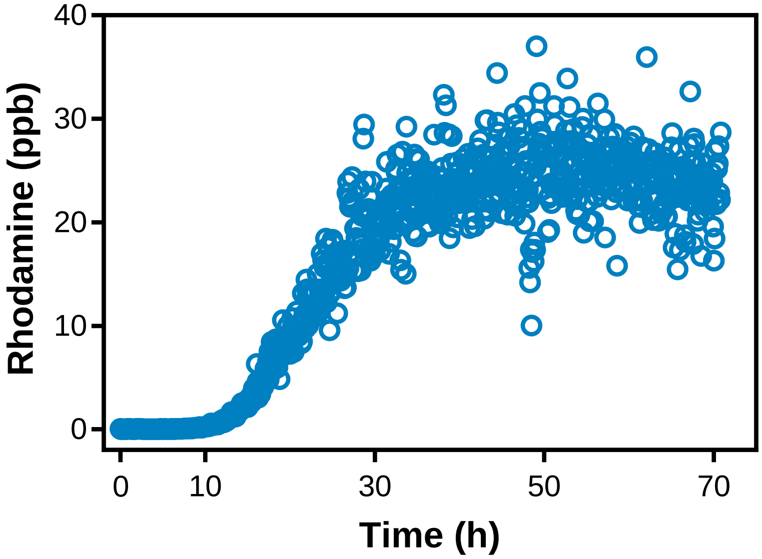

Figure A.2 The rhodamine concentration measured over time in the effluent from the primary SAGR.

APPENDIX B: SELECTED PICTURES

Figure B.1 Aerial view of the Walker, IA lagoon-SAGR WRRF.

Figure B.2 Modified ice auger used to drill the monitoring wells in the SAGR.

Figure B.3 Process used to drill monitoring wells in the SAGR.

Figure B.4 Mesh bag containing sterile rocks deployed in the SAGR for biofilm sampling.

Figure B.5 Complete monitoring wells in the SAGR.

APPENDIX C: SUPPLEMNTAL INFORMATION FOR CHAPTER 2

Table C.1 Censored operator and certified lab data used to determine NO_3^-/NO_2^-, NH_3 and pH statistical differences and create Figure 2.3. Ammonia was censored to 0.5 mg L^{-1} and NO_3^-/NO_2^{-1} was censored to 2.5 mg L^{-1}.

	CL	O	CL	O	CL	O
	NH_3		NO_3^-/NO_2^-		pH	
Date	mg-N L^{-1}				units	
4/2/2014	0.5	0.5	15.8	11.107	8.12	8.95
4/9/2014	0.785	0.5	20.6	12.992	8.15	8.8
4/16/2014	1.83	0.5	11.2	9.081	8.04	8.63
4/24/2014	0.5	0.51	10	7.724	8.23	8.74
4/30/2014	0.5	1.77	7.31	2.612	8.38	8.76
5/7/2014	0.5	0.5	8.93	6.234	8.85	8.85
5/14/2014	0.5	0.5	6.81	4.622	8.41	8.72
5/21/2014	0.5	0.5	2.5	4.211	8.34	9.38
5/28/2014	0.5	0.5	4.03	2.5	8.42	9.29
6/5/2014	0.5	0.5	4.66	2.854	8.49	8.94
6/11/2014	0.5	0.5	4.34	3.518	8.62	8.6
6/19/2014	0.5	0.5	6.74	4.524	8.54	8.4
6/25/2014	0.5	0.5	13.2	3.227	8.43	8.38
7/2/2014	0.5	0.5	8.77	3.932	8.4	8.36
7/9/2014	0.5	0.5	6.12	3.44	8.47	8.75
7/16/2014					8.6	8.61
7/23/2014	0.5	0.5	2.5	2.5	8.59	8.6
8/7/2014	0.5	0.5	2.55	3.556	8.8	8.8
8/13/2014	0.5	0.5	2.5	2.5	8.72	8.72
9/3/2014	0.5	0.5	7.24	2.951	8.52	8.82
9/10/2014	0.891	0.5	8.6	2.5	8.39	8.9
9/18/2014	0.5	0.5	5.47	4.917	8.27	8.9
9/24/2014	0.5	0.5	7.91	5.018	8.26	8.87
10/1/2014	0.5	0.5	9.36	4.217	8.48	8.84
10/9/2014	0.5	0.5	8.04	4.64	8.4	9.01
10/16/2014	0.617	0.5	14.2	4.325	8.31	8.87
10/23/2014	0.5	0.5	14	14.769	8.14	8.62
11/6/2014	0.5	0.5	10.7	8.17	8.27	8.57
11/18/2014	0.573	0.5	4.34	6.986	8.12	8.42
11/21/2014	0.5	0.5	4.1	7.575	8.1	8.39
11/26/2014	0.5	0.5	4.1	10.3	8.17	7.11
12/3/2014	0.5	0.5	7.45	5.626	7.98	7.83
12/10/2014	0.5	0.5	8.64	7.84	8.01	9.1
12/17/2014	0.5	0.5	13.9	7.541	8.01	9.08
12/22/2014	0.5	0.5	10.6	8.141	7.97	8.97
1/7/2015	0.5	0.5	17.7	8.46	8.21	8.64
1/14/2015	0.5	0.5	17.3	4.652	8.24	8.85
1/21/2015	0.5	0.5	18.2	4.76	8.14	8.9
1/28/2015	0.5	0.5	19.8	6.062	8.21	9.07
2/4/2015	0.5	0.5	16.3	5.96	8.19	8.92
2/11/2015	0.5	0.5	18.2	5.33	8.16	8.44
2/18/2015	0.5	0.5	26.1	5.2	8.23	7.91
2/25/2015	0.5	0.5	11.4	23.366	7.5	8.73
3/5/2015	0.5	1.22	20.5	14.804	8.16	7.52
3/11/2015	0.5	0.5	20.7	8.703	8.25	7.81
3/18/2015	0.5	0.5	15.5	7.91	8.23	8.14
3/26/2015					7.55	8.04
4/1/2015					8.27	8.73
4/8/2015	0.5	0.5	14.2	2.557	8.28	8.7
4/15/2015	0.5	0.5	7.74	3.267	8.37	8.65
4/22/2015	0.5	0.5	8.37	4.172	8.33	8.67
4/29/2015	0.5	0.5	10.3	5.07	8.31	8.71
5/7/2015	0.5	0.5	7.97	5.222	8.41	9.14
5/13/2015	0.5	0.5	10.5	5.931	8.41	9.14
5/20/2015	0.5	0.5	9.58	6.832	8.36	9.09
5/26/2015	0.5	0.5	10.2	5.439	8.39	9.1
6/3/2015	0.5	0.5	6.98	3.02	8.55	8.33
6/10/2015	0.5	0.5	6.35	2.5	8.42	8.27
6/17/2015	0.5	0.5	7.45	2.5	8.44	8.3
6/24/2015	0.5	0.5	5.6	2.5	8.33	8.3
7/1/2015	0.5	0.5	6.54	3.43	8.48	8.33
7/8/2015	0.5	0.5	3.48	2.5	7.55	8.5
7/16/2015	0.5	0.5	2.75	2.5	8.59	8.42
7/22/2015	0.5	0.5	2.5	2.5	8.83	8.39
7/29/2015	0.5	0.5	2.5	2.5	8.62	8.44
8/5/2015	0.5	0.5	2.5	2.636	8.58	8.41
8/12/2015	0.5	0.5	2.5	2.5	8.6	8.27
8/19/2015					8.64	8.28
8/26/2015					8.57	8.28
9/2/2015					8.55	8.27
9/8/2015					8.57	8.3
9/9/2015			5.59	2.5		
9/16/2015	0.5	0.5	3.69	2.5	8.59	8.27
9/30/2015	0.5	0.5	5.64	2.5	8.55	8.28
10/7/2015					8.57	8.32
10/14/2015	0.5	0.5	13	4.084	8.44	9.23

Table C.1 continued.

	CL	O	CL	O	CL	O
	NH_3		NO_3^-/NO_2^-		pH	
Date		mg-N L^{-1}			units	
10/21/2015			11.7	3.6	8.33	9.11
10/22/2015			14.2	3.6		
10/29/2015	0.5	0.5	11.8	6.693	8.23	8.47
11/4/2015	0.5	0.5	18.5	2.5	8.25	8.38
11/12/2015	0.5	0.5	11.2	2.5	8.25	8.43
11/18/2015	0.5	0.5				
11/25/2015	0.5	0.5	3.8	2.5	8.25	8.7
12/2/2015	0.5	0.5	13	2.5	8.19	8.51
12/9/2015	0.5	0.5	11.9	2.5	8.29	8.51
12/16/2015	0.5	0.5	9.75	2.5	8.07	8.5
12/22/2015	0.5	0.5	10.1	2.5	8.24	8.55
12/29/2015	0.5	0.5	7.05	2.5	8.15	9.58
1/6/2016	0.5	0.5				
1/13/2016	0.5	0.5			8.26	7.8
1/27/2016	0.5	0.5				
2/3/2016	0.5	0.5	12.9	4.27		
2/10/2016	0.5	0.5				
2/17/2016	0.5	0.5				
2/24/2016	0.5	0.5	14.3	4.22		
4/6/2016	0.5	0.5	8.22	2.5	8.24	7.7
4/14/2016	0.5	0.5				
4/20/2016	0.5	0.5				
4/27/2016	0.5	0.5	6.96	2.5	8.26	8.2
5/4/2016	0.5	0.5				
5/18/2016	0.5	0.5				
5/25/2016	0.515	0.5			8.4	7.51
6/1/2016	0.5	0.5			8.41	7.58
6/29/2016	0.5	0.5	5.39	2.5	8.52	7.7
7/6/2016	0.5	0.5			8.55	7.36
7/27/2016	0.5	0.5			8.48	7.63
8/3/2016					8.57	7.58
8/10/2016	0.5	0.5			8.6	7.6
8/24/2016	0.5	0.5	5.06	2.6		
9/21/2016	0.5	0.5			8.5	7.63
9/28/2016	0.5	0.5				
10/5/2016	0.5	0.5				
10/12/2016	0.5	0.5				
11/16/2016	0.5	0.5	8.55	4.5		
11/23/2016	0.5	0.5	11.8	6.24		
12/7/2016	0.5	0.5			8.4	7.78

Table C.2 Raw and censored data used to calculate the NH_3 percent removal and create Figure 2.4 and Figure 2.9. Ammonia was censored to 0.5 mg L^{-1} and NO_3^-/NO_2^{-1} was censored to 2.5 mg L^{-1}. Where WI is WRRF influent, LE is lagoon effluent, PSE is primary SAGR effluent, D is discharge, P is primary, and S is secondary (Figure 2.1).

	Raw Data				Censored Data					Removal			
	NO_3^-/NO_2^- LE	NH_3 LE	NH_3 PSE	NH_3 D	NO_3^-/NO_2^- LE	NH_3 LE	NH_3 PSE	NH_3 D	NH_3 WI	P SAGR	S SAGR	SAGR	WRRF
Date					mg L^{-1}						%		
4/2/2014	1.70	9.99	0.22	0.09	2.5	9.99	0.5	0.5	12.49	94.99	0	94.99	96.00
4/3/2014	2.86	9.99	0	0	2.86	9.99	0.5	0.5	12.85	94.99	0	94.99	96.11
4/4/2014	2.84	9.99	0	0	2.84	9.99	0.5	0.5	12.83	94.99	0	94.99	96.10
4/7/2014	2.80	9.99	0.11	0	2.80	9.99	0.5	0.5	12.79	94.99	0	94.99	96.09
4/8/2014	3.00	9.99	0	0	3.00	9.99	0.5	0.5	12.99	94.99	0	94.99	96.15
4/9/2014	3.21	9.99	0	0	3.21	9.99	0.5	0.5	13.20	94.99	0	94.99	96.21
4/10/2014	2.80	9.99	0	0	2.80	9.99	0.5	0.5	12.79	94.99	0	94.99	96.09
4/11/2014	3.50	9.99	0	0	3.5	9.99	0.5	0.5	13.49	94.99	0	94.99	96.29
4/14/2014	4.07	9.20	0	0	4.07	9.20	0.5	0.5	13.27	94.57	0	94.57	96.23
4/15/2014	6.09	8.74	0	0	6.09	8.74	0.5	0.5	14.83	94.28	0	94.28	96.63
4/16/2014	6.89	8.21	0	0.07	6.89	8.21	0.5	0.5	15.10	93.91	0	93.91	96.69
4/17/2014	7.26	7.29	0	0.11	7.26	7.29	0.5	0.5	14.55	93.14	0	93.14	96.56
4/18/2014	7.05	7.19	0	0	7.05	7.19	0.5	0.5	14.24	93.05	0	93.05	96.49
4/21/2014	3.60	8.34	0.08	0	3.60	8.34	0.5	0.5	11.94	94.00	0	94.00	95.81
4/22/2014	5.48	7.10	0.08	0.10	5.48	7.10	0.5	0.5	12.58	92.96	0	92.96	96.03
4/23/2014	7.35	6.02	0.14	0.31	7.35	6.02	0.5	0.5	13.37	91.69	0	91.69	96.26
4/24/2014	7.17	4.27	0.20	0.51	7.17	4.27	0.5	0.51	11.44	88.29	-2.00	88.06	95.54
4/25/2014	7.30	3.06	0.44	0.63	7.30	3.06	0.5	0.63	10.36	83.66	-26.00	79.41	93.92
4/28/2014	7.09	3.10	0.40	0.78	7.09	3.10	0.5	0.78	10.19	83.87	-56.00	74.84	92.35
4/29/2014	7.19	2.40	0.41	1.03	7.19	2.40	0.5	1.03	9.59	79.17	-106.00	57.08	89.26
4/30/2014	7.00	1.02	0	1.77	7.00	1.02	0.5	1.77	8.02	50.98	-254.00	-73.53	77.92
5/1/2014	7.00	0.71	0	2.89	7.00	0.71	0.5	2.89	7.71	29.58	-478.00	-307.04	62.52
5/2/2014	5.90	0.88	0	0	5.90	0.88	0.5	0.5	6.78	43.18	0	43.18	92.63
5/6/2014	4.79	0.27	0	0	4.79	0.5	0.5	0.5	5.29	0	0	0	90.54

Table C.2 continued.

	Raw Data				Censored Data					Removal			
	NO_3^- $/NO_2^-$ LE	NH_3 LE	NH_3 PSE	NH_3 D	NO_3^- $/NO_2^-$ LE	NH_3 LE	NH_3 PSE	NH_3 D	NH_3 WI	P SAGR	S SAGR	SAGR	WRRF
Date					mg L^{-1}						%		
5/7/2014	6.11	0	0	0	6.11	0.5	0.5	0.5	6.61	0	0	0	92.44
5/8/2014	3.02	0.25	0	0	3.02	0.5	0.5	0.5	3.52	0	0	0	85.78
5/9/2014	5.11	0.21	0	0	5.11	0.5	0.5	0.5	5.61	0	0	0	91.09
5/12/2014	5.42	0.24	0	0	5.42	0.5	0.5	0.5	5.92	0	0	0	91.55
5/13/2014	5.41	0.22	0	0	5.41	0.5	0.5	0.5	5.91	0	0	0	91.55
5/14/2014	5.37	0.30	0	0	5.37	0.5	0.5	0.5	5.87	0	0	0	91.48
5/15/2014	5.02	0.57	0	0	5.02	0.57	0.5	0.5	5.59	12.28	0	12.28	91.05
5/16/2014	4.47	0.86	0	0	4.47	0.86	0.5	0.5	5.33	41.86	0	41.86	90.62
5/20/2014	2.43	0.70	0	0	2.5	0.70	0.5	0.5	3.20	28.57	0	28.57	84.38
5/21/2014	2.19	0.74	0.13	0.06	2.5	0.74	0.5	0.5	3.24	32.43	0	32.43	84.57
5/22/2014	1.95	0.07	0.84	0	2.5	0.50	0.84	0.5	3.00	-68.00	40.48	0	83.33
5/26/2014	3.89	1.06	0.26	0	3.89	1.06	0.5	0.5	4.95	52.83	0	52.83	89.89
5/27/2014	0.50	1.38	0.07	0	2.5	1.38	0.5	0.5	3.88	63.77	0	63.77	87.11
5/28/2014	1.30	1.58	0	0.08	2.5	1.58	0.5	0.5	4.08	68.35	0	68.35	87.75
5/29/2014	2.22	2.35	0.00	0.03	2.5	2.35	0.5	0.5	4.85	78.72	0	78.72	89.69
5/30/2014	2.87	2.62	0.72	0.31	2.87	2.62	0.72	0.5	5.49	72.52	30.56	80.92	90.88
6/2/2014	3.07	2.72	0.70	0	3.07	2.72	0.70	0.5	5.79	74.26	28.57	81.62	91.36
6/3/2014	3.17	3.10	0.72	0.17	3.17	3.10	0.72	0.5	6.27	76.77	30.56	83.87	92.02
6/4/2014	3.07	3.20	0.60	0.18	3.07	3.20	0.60	0.5	6.27	81.25	16.67	84.38	92.03
6/5/2014	3.67	3.10	0.64	0	3.67	3.10	0.64	0.5	6.77	79.35	21.88	83.87	92.61
6/6/2014	2.90	5.60	0	0	2.90	5.60	0.5	0.5	8.50	91.07	0	91.07	94.12
6/9/2014	2.10	5.76	0	0	2.5	5.76	0.5	0.5	8.26	91.32	0	91.32	93.95
6/10/2014	2.40	5.22	0	0	2.5	5.22	0.5	0.5	7.72	90.42	0	90.42	93.52
6/11/2014	3.13	5.04	0	0	3.13	5.04	0.5	0.5	8.17	90.08	0	90.08	93.88
6/12/2014	2.93	5.10	0	0	2.93	5.10	0.5	0.5	8.03	90.20	0	90.20	93.77
6/13/2014	2.73	5.21	0	0	2.73	5.21	0.5	0.5	7.94	90.40	0	90.40	93.70
6/16/2014	2.43	5.28	0	0	2.5	5.28	0.5	0.5	7.78	90.53	0	90.53	93.57
6/17/2014	2.51	6.04	0	0	2.51	6.04	0.5	0.5	8.55	91.72	0	91.72	94.15
6/18/2014	2.52	5.22	0	0	2.52	5.22	0.5	0.5	7.74	90.42	0	90.42	93.54
6/19/2014	2.72	5.23	0	0	2.72	5.23	0.5	0.5	7.95	90.44	0	90.44	93.71
6/20/2014	2.92	4.90	0	0	2.92	4.90	0.5	0.5	7.82	89.80	0	89.80	93.61
6/23/2014	2.73	4.74	0	0	2.73	4.74	0.5	0.5	7.47	89.45	0	89.45	93.30
6/24/2014	2.52	4.76	0	0	2.52	4.76	0.5	0.5	7.28	89.50	0	89.50	93.13
6/25/2014	2.42	4.80	0	0	2.5	4.80	0.5	0.5	7.30	89.58	0	89.58	93.15
6/26/2014	2.52	4.87	0	0	2.52	4.87	0.5	0.5	7.39	89.73	0	89.73	93.23
6/27/2014	2.62	5.02	0	0	2.62	5.02	0.5	0.5	7.64	90.04	0	90.04	93.46
6/30/2014	2.43	5.00	0	0	2.5	5.00	0.5	0.5	7.50	90.00	0	90.00	93.33
7/1/2014	2.52	4.90	0	0	2.52	4.90	0.5	0.5	7.42	89.80	0	89.80	93.27
7/2/2014	2.63	4.84	0	0	2.63	4.84	0.5	0.5	7.47	89.67	0	89.67	93.31
7/3/2014	2.73	4.83	0	0	2.73	4.83	0.5	0.5	7.56	89.65	0	89.65	93.38
7/7/2014	2.62	5.00	0	0	2.62	5.00	0.5	0.5	7.62	90.00	0	90.00	93.44
7/8/2014	3.09	3.10	0	0	3.09	3.10	0.5	0.5	6.19	83.87	0	83.87	91.92
7/9/2014	3.43	2.02	0	0	3.43	2.02	0.5	0.5	5.45	75.25	0	75.25	90.82
7/10/2014	3.69	0.42	0	0	3.69	0.5	0.5	0.5	4.19	0	0	0	88.07
7/12/2014	3.41	0.26	0.02	0	3.41	0.5	0.5	0.5	3.91	0	0	0	87.20
7/13/2014	3.50	0	0	0	3.50	0.5	0.5	0.5	4.00	0	0	0	87.51
7/14/2014	3.61	0	0	0	3.61	0.5	0.5	0.5	4.11	0	0	0	87.82
7/15/2014	3.71	0	0	0	3.71	0.5	0.5	0.5	4.21	0	0	0	88.12
7/16/2014	3.81	0	0	0	3.81	0.5	0.5	0.5	4.31	0	0	0	88.39
7/19/2014	3.71	0	0	0	3.71	0.5	0.5	0.5	4.21	0	0	0	88.11
7/20/2014	2.30	0	0	0	2.50	0.5	0.5	0.5	3.00	0	0	0	83.33
7/21/2014	2.71	0	0	0	2.71	0.5	0.5	0.5	3.21	0	0	0	84.42
7/22/2014	2.81	0	0	0	2.81	0.5	0.5	0.5	3.31	0	0	0	84.88
7/23/2014	2.91	0	0	0	2.91	0.5	0.5	0.5	3.41	0	0	0	85.32
7/25/2014	3.01	0	0	0	3.01	0.5	0.5	0.5	3.51	0	0	0	85.75
8/1/2014	4.36	0	0	0	4.36	0.5	0.5	0.5	4.86	0	0	0	89.71
8/4/2014	4.36	0	0	0	4.36	0.5	0.5	0.5	4.86	0	0	0	89.72
8/5/2014	4.47	0	0	0	4.47	0.5	0.5	0.5	4.97	0	0	0	89.93
8/6/2014	4.26	0	0	0	4.26	0.5	0.5	0.5	4.76	0	0	0	89.50
8/7/2014	4.46	0	0	0	4.46	0.5	0.5	0.5	4.96	0	0	0	89.91
8/8/2014	4.36	0	0	0	4.36	0.5	0.5	0.5	4.86	0	0	0	89.71
8/11/2014	4.16	0	0	0	4.16	0.5	0.5	0.5	4.66	0	0	0	89.27
8/13/2014	3.84	0	0	0	3.84	0.5	0.5	0.5	4.34	0	0	0	88.48
8/14/2014	3.83	0	0.06	0	3.83	0.5	0.5	0.5	4.33	0	0	0	88.45
8/15/2014	3.75	0	0.15	0	3.75	0.5	0.5	0.5	4.25	0	0	0	88.24
8/16/2014	3.84	0	0.23	0	3.84	0.5	0.5	0.5	4.34	0	0	0	88.49
8/17/2014	3.84	0	0.33	0	3.84	0.5	0.5	0.5	4.34	0	0	0	88.49
8/18/2014	3.94	0	0	0	3.94	0.5	0.5	0.5	4.44	0	0	0	88.74
8/21/2014	3.94	0	0	0	3.94	0.5	0.5	0.5	4.44	0	0	0	88.74
8/22/2014	4.14	0	0	0	4.14	0.5	0.5	0.5	4.64	0	0	0	89.22
8/23/2014	4.24	0	0	0	4.24	0.5	0.5	0.5	4.74	0	0	0	89.46
8/24/2014	4.14	0	0	0	4.14	0.5	0.5	0.5	4.64	0	0	0	89.22
8/25/2014	4.24	0	0	0	4.24	0.5	0.5	0.5	4.74	0	0	0	89.46
8/28/2014	4.36	0	0	0	4.36	0.5	0.5	0.5	4.86	0	0	0	89.71
8/29/2014	4.26	0	0	0	4.26	0.5	0.5	0.5	4.76	0	0	0	89.50
8/30/2014	4.26	0	0	0	4.26	0.5	0.5	0.5	4.76	0	0	0	89.50
9/1/2014	3.88	2.40	0	0.17	3.88	2.40	0.5	0.5	6.28	79.17	0	79.17	92.04
9/2/2014	3.29	2.38	0.12	0.20	3.29	2.38	0.5	0.5	5.67	78.99	0	78.99	91.18
9/3/2014	2.99	2.17	0	0.12	2.99	2.17	0.5	0.5	5.16	76.96	0	76.96	90.30
9/4/2014	2.68	2.29	0	0	2.68	2.29	0.5	0.5	4.97	78.17	0	78.17	89.94
9/5/2014	2.27	2.47	0	0	2.5	2.47	0.5	0.5	4.97	79.76	0	79.76	89.94

Table C.2 continued.

	Raw Data				Censored Data					Removal			
	NO_3^- /NO_2^- LE	NH_3 LE	NH_3 PSE	NH_3 D	NO_3^- /NO_2^- LE	NH_3 LE	NH_3 PSE	NH_3 D	NH_3 WI	P SAGR	S SAGR	SAGR	WRRF
Date					mg L^{-1}						%		
9/6/2014	2.08	2.29	0	0.09	2.5	2.29	0.5	0.5	4.79	78.17	0	78.17	89.56
9/7/2014	2.07	2.41	0	0.10	2.5	2.41	0.5	0.5	4.91	79.25	0	79.25	89.82
9/8/2014	1.88	2.30	0	0.10	2.5	2.30	0.5	0.5	4.80	78.26	0	78.26	89.58
9/9/2014	1.38	3.40	7.78	0.41	2.5	3.40	7.78	0.5	5.90	-128.8	93.57	85.29	91.53
9/10/2014	1.58	5.63	3.34	0.15	2.5	5.63	3.34	0.5	8.13	40.67	85.03	91.12	93.85
9/11/2014	2.68	5.29	2.80	0.04	2.68	5.29	2.80	0.5	7.97	47.07	82.14	90.55	93.72
9/12/2014	3.07	1.38	0	0.18	3.07	1.38	0.5	0.5	4.45	63.77	0	63.77	88.76
9/15/2014	4.07	1.00	0	0.17	4.07	1.00	0.5	0.5	5.07	50.00	0	50.00	90.14
9/16/2014	4.28	1.03	0	0.16	4.28	1.03	0.5	0.5	5.31	51.46	0	51.46	90.58
9/17/2014	4.88	0.76	0	0.09	4.88	0.76	0.5	0.5	5.64	34.21	0	34.21	91.13
9/18/2014	4.88	0.76	0	0	4.88	0.76	0.5	0.5	5.64	34.21	0	34.21	91.14
9/19/2014	4.88	0.70	0	0	4.88	0.70	0.5	0.5	5.58	28.57	0	28.57	91.05
9/22/2014	4.69	0.57	0	0	4.69	0.57	0.5	0.5	5.26	12.28	0	12.28	90.49
9/23/2014	4.69	0.67	0	0.08	4.69	0.67	0.5	0.5	5.36	25.37	0	25.37	90.67
9/24/2014	4.79	0.80	0	0.17	4.79	0.80	0.5	0.5	5.59	37.50	0	37.50	91.06
9/25/2014	4.88	0.81	0	0.20	4.88	0.81	0.5	0.5	5.69	38.27	0	38.27	91.22
9/26/2014	4.98	0.70	0	0.17	4.98	0.70	0.5	0.5	5.68	28.57	0	28.57	91.20
9/29/2014	4.98	0.84	0	0.19	4.98	0.84	0.5	0.5	5.82	40.48	0	40.48	91.41
9/30/2014	4.79	0.96	0	0.21	4.79	0.96	0.5	0.5	5.75	47.92	0	47.92	91.30
10/1/2014	4.49	0.90	0.15	0.17	4.49	0.90	0.5	0.5	5.39	44.44	0	44.44	90.73
10/2/2014	4.40	0.87	0	0	4.40	0.87	0.5	0.5	5.27	42.53	0	42.53	90.51
10/3/2014	4.41	0.92	0	0	4.41	0.92	0.5	0.5	5.33	45.65	0	45.65	90.62
10/6/2014	4.60	2.01	0.14	0	4.60	2.01	0.5	0.5	6.61	75.12	0	75.12	92.44
10/7/2014	4.41	1.90	0	0	4.41	1.90	0.5	0.5	6.31	73.68	0	73.68	92.08
10/8/2014	4.19	2.40	0	0	4.19	2.40	0.5	0.5	6.59	79.17	0	79.17	92.41
10/9/2014	4.19	2.54	0	0.11	4.19	2.54	0.5	0.5	6.73	80.31	0	80.31	92.57
10/10/2014	3.58	3.10	2.70	0.14	3.58	3.10	2.70	0.5	6.68	12.90	81.48	83.87	92.51
10/13/2014	3.37	6.22	5.40	0.17	3.37	6.22	5.40	0.5	9.59	13.18	90.74	91.96	94.79
10/14/2014	3.10	7.49	2.40	0.26	3.10	7.49	2.40	0.5	10.59	67.96	79.17	93.32	95.28
10/15/2014	1.82	8.74	1.68	0.31	2.5	8.74	1.68	0.5	11.24	80.78	70.24	94.28	95.55
10/16/2014	2.03	8.40	1.47	0.31	2.5	8.40	1.47	0.5	10.90	82.50	65.99	94.05	95.41
10/17/2014	1.92	7.98	1.38	0.31	2.5	7.98	1.38	0.5	10.48	82.71	63.77	93.73	95.23
10/20/2014	1.62	7.01	1.30	5.07	2.5	7.01	1.30	5.07	9.51	81.46	-290.00	27.67	46.69
10/21/2014	1.52	7.10	1.27	2.13	2.5	7.10	1.27	2.13	9.60	82.11	-67.72	70.00	77.81
10/22/2014	2.52	6.90	1.00	1.22	2.52	6.90	1.00	1.22	9.42	85.51	-22.00	82.32	87.05
10/23/2014	2.62	6.93	0.63	0.27	2.62	6.93	0.63	0.5	9.55	90.91	20.63	92.78	94.76
10/24/2014	2.70	6.70		0.28	2.70	6.70		0.5	9.40	100		92.54	94.68
10/27/2014	3.20	7.80		0	3.20	7.80		0.5	11.00	100		93.59	95.45
10/28/2014	6.10	8.78		0	6.10	8.78		0.5	14.88	100		94.31	96.64
11/1/2014	4.98	9.99	0	0	4.98	9.99	0.5	0.5	14.97	94.99	0	94.99	96.66
11/4/2014	4.88	9.99	0	0	4.88	9.99	0.5	0.5	14.87	94.99	0	94.99	96.64
11/5/2014	5.08	9.99	0	0	5.08	9.99	0.5	0.5	15.07	94.99	0	94.99	96.68
11/6/2014	4.87	9.99	0	0	4.87	9.99	0.5	0.5	14.86	94.99	0	94.99	96.64
11/7/2014	0.86	9.99	0	0.12	2.50	9.99	0.5	0.5	12.49	94.99	0	94.99	96.00
11/8/2014	7.26	9.99	0		7.26	9.99	0.5		17.25	94.99			
11/11/2014	7.16	9.99	0	0	7.16	9.99	0.5	0.5	17.15	94.99	0	94.99	97.08
11/12/2014	7.06	9.99	0	0	7.06	9.99	0.5	0.5	17.05	94.99	0	94.99	97.07
11/13/2014	6.96	9.99	0	0	6.96	9.99	0.5	0.5	16.95	94.99	0	94.99	97.05
11/14/2014	2.23	9.99	0	0	2.5	9.99	0.5	0.5	12.49	94.99	0	94.99	96.00
11/15/2014	3.63	9.99	0	0	3.63	9.99	0.5	0.5	13.62	94.99	0	94.99	96.33
11/18/2014	4.33	9.99	0	0	4.33	9.99	0.5	0.5	14.32	94.99	0	94.99	96.51
11/19/2014	4.23	9.99	0	0	4.23	9.99	0.5	0.5	14.22	94.99	0	94.99	96.48
11/20/2014	4.44	9.99	0	0	4.44	9.99	0.5	0.5	14.43	94.99	0	94.99	96.53
11/21/2014	4.34	9.99	0	0	4.34	9.99	0.5	0.5	14.33	94.99	0	94.99	96.51
11/22/2014	4.53	9.99	0	0	4.53	9.99	0.5	0.5	14.52	94.99	0	94.99	96.56
11/25/2014	4.73	9.99	0	0	4.73	9.99	0.5	0.5	14.72	94.99	0	94.99	96.60
11/26/2014	3.99	9.99	0	0	3.99	9.99	0.5	0.5	13.98	94.99	0	94.99	96.42
11/27/2014	1.12	9.99	0	0	2.5	9.99	0.5	0.5	12.49	94.99	0	94.99	96.00
11/29/2014	8.95	9.99	0.17	0.15	8.95	9.99	0.5	0.5	18.94	94.99	0	94.99	97.36
12/1/2014	8.75	9.10	3.80	0.44	8.75	9.10	3.80	0.5	17.85	58.24	86.84	94.51	97.20
12/2/2014	9.26	9.00	3.71	0.40	9.26	9.00	3.71	0.5	18.26	58.78	86.52	94.44	97.26
12/3/2014	9.46	9.40	3.70	0.41	9.46	9.40	3.70	0.5	18.86	60.64	86.49	94.68	97.35
12/4/2014	9.66	9.34	3.73	0.04	9.66	9.34	3.73	0.5	19.00	60.06	86.60	94.65	97.37
12/5/2014	9.36	9.10	3.61	0.30	9.36	9.10	3.61	0.5	18.46	60.33	86.15	94.51	97.29
12/8/2014	9.46	8.74	3.50	0.14	9.46	8.74	3.50	0.5	18.20	59.95	85.71	94.28	97.25
12/9/2014	9.16	8.76	3.49	0	9.16	8.76	3.49	0.5	17.92	60.16	85.67	94.29	97.21
12/10/2014	8.76	9.12	3.56	0	8.76	9.12	3.56	0.5	17.88	60.96	85.96	94.52	97.20
12/11/2014	8.65	8.90	3.00	0	8.65	8.90	3.00	0.5	17.55	66.29	83.33	94.38	97.15
12/12/2014	8.06	8.91	3.02	0	8.06	8.91	3.02	0.5	16.97	66.11	83.44	94.39	97.05
12/15/2014	8.06	8.91	3.10	0	8.06	8.91	3.10	0.5	16.97	65.21	83.87	94.39	97.05
12/16/2014	8.26	9.01	3.12	0	8.26	9.01	3.12	0.5	17.27	65.37	83.97	94.45	97.10
12/17/2014	8.06	9.00	3.14	0	8.06	9.00	3.14	0.5	17.06	65.11	84.08	94.44	97.07
12/18/2014	7.46	8.90	2.99	0	7.46	8.90	2.99	0.5	16.36	66.40	83.28	94.38	96.94
12/19/2014	7.75	8.71	2.14	0	7.75	8.71	2.14	0.5	16.46	75.43	76.64	94.26	96.96
12/22/2014	7.85	8.00	2.04	0	7.85	8.00	2.04	0.5	15.85	74.50	75.49	93.75	96.85
12/23/2014	7.46	8.14	2.10	0	7.46	8.14	2.10	0.5	15.60	74.20	76.19	93.86	96.79
12/24/2014	7.16	8.20	2.16	0	7.16	8.20	2.16	0.5	15.36	73.66	76.85	93.90	96.74
12/26/2014	7.16	7.20	2.04	0	7.16	7.20	2.04	0.5	14.36	71.67	75.49	93.06	96.52
12/27/2014	7.06	6.90	1.97	0	7.06	6.90	1.97	0.5	13.96	71.45	74.62	92.75	96.42
12/29/2014	8.25	6.41	1.50	0	8.25	6.41	1.50	0.5	14.66	76.60	66.67	92.20	96.59
12/30/2014	8.05	4.21	1.40	0	8.05	4.21	1.40	0.5	12.26	66.75	64.29	88.12	95.92

Table C.2 continued.

	Raw Data				Censored Data					Removal			
	NO_3^- /NO_2^- LE	NH_3 LE	NH_3 PSE	NH_3 D	NO_3^- /NO_2^- LE	NH_3 LE	NH_3 PSE	NH_3 D	NH_3 WI	P SAGR	S SAGR	SAGR	WRRF
Date					mg L^{-1}					%			
12/31/2014	7.65	4.00	1.40	0	7.65	4.00	1.40	0.5	11.65	65.00	64.29	87.50	95.71
1/2/2015	7.05	3.60	0.98	0	7.05	3.60	0.98	0.5	10.65	72.78	48.98	86.11	95.31
1/3/2015	7.25	3.70	0.91	0	7.25	3.70	0.91	0.5	10.95	75.41	45.05	86.49	95.43
1/5/2015	7.15	3.20	0.90	0	7.15	3.20	0.90	0.5	10.35	71.88	44.44	84.38	95.17
1/6/2015	7.25	3.50	1.10	0	7.25	3.50	1.10	0.5	10.75	68.57	54.55	85.71	95.35
1/7/2015	7.04	3.40	1.12	0	7.04	3.40	1.12	0.5	10.44	67.06	55.36	85.29	95.21
1/8/2015	7.14	3.40	0.74	0	7.14	3.40	0.74	0.5	10.54	78.24	32.43	85.29	95.25
1/9/2015	5.05	3.30	0.80	0	5.05	3.30	0.80	0.5	8.35	75.76	37.50	84.85	94.01
1/12/2015	4.15	5.70	1.40	0.05	4.15	5.70	1.40	0.5	9.85	75.44	64.29	91.23	94.92
1/13/2015	3.45	6.20	1.80	0	3.45	6.20	1.80	0.5	9.65	70.97	72.22	91.94	94.82
1/14/2015	2.15	8.10	2.20	0.07	2.5	8.10	2.20	0.5	10.60	72.84	77.27	93.83	95.28
1/15/2015	1.45	8.90	2.70	0.04	2.5	8.90	2.70	0.5	11.40	69.66	81.48	94.38	95.61
1/16/2015	0.05	8.50	2.90	0.09	2.5	8.50	2.90	0.5	11.00	65.88	82.76	94.12	95.45
1/19/2015	0.05	9.00	3.00	0.10	2.5	9.00	3.00	0.5	11.50	66.67	83.33	94.44	95.65
1/20/2015	0.05	9.99	2.94	0.11	2.5	9.99	2.94	0.5	12.49	70.57	82.99	94.99	96.00
1/21/2015	0.52	8.72	2.40	0	2.5	8.72	2.40	0.5	11.22	72.48	79.17	94.27	95.54
1/22/2015	0.42	8.60	2.10	0	2.5	8.60	2.10	0.5	11.10	75.58	76.19	94.19	95.50
1/23/2015	0.05	7.78	2.13	0	2.5	7.78	2.13	0.5	10.28	72.62	76.53	93.57	95.14
1/26/2015	0.05	7.60	2.02	0	2.5	7.60	2.02	0.5	10.10	73.42	75.25	93.42	95.05
1/27/2015	1.25	7.81	2.10	0	2.5	7.81	2.10	0.5	10.31	73.11	76.19	93.60	95.15
1/28/2015	1.14	7.80	1.42	0	2.5	7.80	1.42	0.5	10.30	81.79	64.79	93.59	95.15
1/29/2015	1.34	7.82	1.44	0	2.5	7.82	1.44	0.5	10.32	81.59	65.28	93.61	95.16
1/30/2015	1.14	8.20	1.60	0	2.5	8.20	1.60	0.5	10.70	80.49	68.75	93.90	95.33
2/2/2015	1.14	9.99	2.10	0	2.5	9.99	2.10	0.5	12.49	78.98	76.19	94.99	96.00
2/3/2015	0.93	9.99	2.14	0	2.5	9.99	2.14	0.5	12.49	78.58	76.64	94.99	96.00
2/4/2015	0.84	9.99	2.10	0	2.5	9.99	2.10	0.5	12.49	78.98	76.19	94.99	96.00
2/5/2015	0.43	9.99	2.14	0.08	2.5	9.99	2.14	0.5	12.49	78.58	76.64	94.99	96.00
2/6/2015	0.74	9.99	2.20	0	2.5	9.99	2.20	0.5	12.49	77.98	77.27	94.99	96.00
2/9/2015	0.72	9.99	1.93	0	2.5	9.99	1.93	0.5	12.49	80.68	74.09	94.99	96.00
2/10/2015	0.03	8.72	1.40	0	2.5	8.72	1.40	0.5	11.22	83.94	64.29	94.27	95.54
2/11/2015	0.04	9.99	0.71	0	2.5	9.99	0.71	0.5	12.49	92.89	29.58	94.99	96.00
2/12/2015	0.04	9.99	0.21	0	2.5	9.99	0.50	0.5	12.49	94.99	0	94.99	96.00
2/13/2015	0.06	9.99	0.54	0	2.5	9.99	0.54	0.5	12.49	94.59	7.41	94.99	96.00
2/16/2015	0.06	9.99	0.62	0	2.5	9.99	0.62	0.5	12.49	93.79	19.35	94.99	96.00
2/17/2015	0.06	9.99	0.44	0	2.5	9.99	0.50	0.5	12.49	94.99	0	94.99	96.00
2/18/2015	0.06	9.99	0.52	0	2.5	9.99	0.52	0.5	12.49	94.79	3.85	94.99	96.00
2/19/2015	1.48	9.99	0.59	0	2.5	9.99	0.59	0.5	12.49	94.09	15.25	94.99	96.00
2/24/2015	3.58	9.99	0.26	0.95	3.58	9.99	0.5	0.95	13.57	94.99	-90.00	90.49	93.00
2/25/2015	9.39	9.99	0.29	0	9.39	9.99	0.5	0.5	19.38	94.99	0	94.99	97.42
2/26/2015	9.14	9.99	0.65	0.36	9.14	9.99	0.65	0.5	19.13	93.49	23.08	94.99	97.39
2/27/2015	8.44	9.99	0	1.43	8.44	9.99	0.5	1.43	18.43	94.99	-186.00	85.69	92.24
3/2/2015	8.14	9.99	0	1.01	8.14	9.99	0.5	1.01	18.13	94.99	-102.00	89.89	94.43
3/3/2015	8.34	9.99	0	0.82	8.34	9.99	0.5	0.82	18.33	94.99	-64.00	91.79	95.53
3/4/2015	8.63	9.99	0	1.20	8.63	9.99	0.5	1.20	18.62	94.99	-140.00	87.99	93.55
3/5/2015	8.13	9.99	0	1.22	8.13	9.99	0.5	1.22	18.12	94.99	-144.00	87.79	93.27
3/6/2015	8.33	9.99	0	0.88	8.33	9.99	0.5	0.88	18.32	94.99	-76.00	91.19	95.20
3/9/2015	9.03	9.99	0	1.01	9.03	9.99	0.5	1.01	19.02	94.99	-102.00	89.89	94.69
3/10/2015	9.23	9.99	0	0	9.23	9.99	0.5	0.5	19.22	94.99	0	94.99	97.40
3/11/2015	9.75	9.99	0	0	9.75	9.99	0.5	0.5	19.74	94.99	0	94.99	97.47
3/12/2015	9.75	9.99	0	0	9.75	9.99	0.5	0.5	19.74	94.99	0	94.99	97.47
3/13/2015	0.08	9.99	0	0	2.5	9.99	0.5	0.5	12.49	94.99	0	94.99	96.00
3/16/2015	0.10	9.99	0	0	2.5	9.99	0.5	0.5	12.49	94.99	0	94.99	96.00
3/17/2015	0.99	9.99	0	0	2.5	9.99	0.5	0.5	12.49	94.99	0	94.99	96.00
3/18/2015	1.40	9.99	0	0	2.5	9.99	0.5	0.5	12.49	94.99	0	94.99	96.00
3/19/2015	1.60	9.99	0	0	2.5	9.99	0.5	0.5	12.49	94.99	0	94.99	96.00
3/20/2015	1.20	9.99	0	0	2.5	9.99	0.5	0.5	12.49	94.99	0	94.99	96.00
3/23/2015	1.20	9.99	0	0	2.5	9.99	0.5	0.5	12.49	94.99	0	94.99	96.00
3/24/2015	1.50	9.99	0	0	2.5	9.99	0.5	0.5	12.49	94.99	0	94.99	96.00
3/25/2015	1.50	9.99	0	0	2.5	9.99	0.5	0.5	12.49	94.99	0	94.99	96.00
3/26/2015	1.40	9.99	0	0	2.5	9.99	0.5	0.5	12.49	94.99	0	94.99	96.00
3/27/2015	1.60	9.99	0	0	2.5	9.99	0.5	0.5	12.49	94.99	0	94.99	96.00
3/30/2015	2.12	9.99	0	0	2.5	9.99	0.5	0.5	12.49	94.99	0	94.99	96.00
3/31/2015	2.98	9.96	0.03	0	2.98	9.96	0.5	0.5	12.94	94.98	0	94.98	96.14
4/1/2015	2.93	9.50	0.04	0.04	2.93	9.50	0.5	0.5	12.43	94.74	0	94.74	95.98
4/2/2015	3.10	9.46	0.03	0	3.10	9.46	0.5	0.5	12.56	94.71	0	94.71	96.02
4/3/2015	3.06	9.29	0.01	0	3.06	9.29	0.5	0.5	12.35	94.62	0	94.62	95.95
4/6/2015	3.20	9.22	0.04	0.01	3.20	9.22	0.5	0.5	12.42	94.58	0	94.58	95.97
4/7/2015	3.44	9.99	0	0	3.44	9.99	0.5	0.5	13.43	94.99	0	94.99	96.28
4/8/2015	3.81	9.74	0	0	3.81	9.74	0.5	0.5	13.55	94.87	0	94.87	96.31
4/9/2015	4.30	9.99	0	0	4.30	9.99	0.5	0.5	14.29	94.99	0	94.99	96.50
4/10/2015	4.70	9.99	0	0	4.70	9.99	0.5	0.5	14.69	94.99	0	94.99	96.60
4/13/2015	3.26	9.99	0		3.26	9.99	0.5		13.25	94.99			
4/14/2015	1.76		0	0	2.5		0.5	0.5	2.50		0		
4/15/2015	0.08		0	0	2.5		0.5	0.5	2.50		0		
4/16/2015	0.08		0	0	2.5		0.5	0.5	2.50		0		
4/17/2015	0.11		0	0	2.5		0.5	0.5	2.50		0		
4/20/2015	0.11		0	0	2.5		0.5	0.5	2.50		0		
4/21/2015	1.41		0	0	2.5		0.5	0.5	2.50		0		
4/22/2015	1.31		0	0	2.5		0.5	0.5	2.50		0		
4/23/2015	1.41		0	0	2.5		0.5	0.5	2.50		0		
4/24/2015	1.81		0	0	2.5		0.5	0.5	2.50		0		

Table C.2 continued.

	Raw Data				Censored Data					Removal			
	NO_3^- / NO_2^- LE	NH_3 LE	NH_3 PSE	NH_3 D	NO_3^- / NO_2^- LE	NH_3 LE	NH_3 PSE	NH_3 D	NH_3 WI	P SAGR	S SAGR	SAGR	WRRF
Date					mg L^{-1}						%		
4/27/2015	2.12		0	0	2.5		0.5	0.5	2.50		0		
4/28/2015	1.92		0	0	2.5		0.5	0.5	2.50		0		
4/29/2015	2.22		0	0	2.5		0.5	0.5	2.50		0		
4/30/2015	2.12		0	0	2.5		0.5	0.5	2.50		0		
5/1/2015	2.52		0	0	2.52		0.5	0.5	2.52		0		
5/4/2015	2.26		0	0	2.5		0.5	0.5	2.50		0		
5/5/2015	2.38	9.99	0	0	2.5	9.99	0.5	0.5	12.49	94.99	0	94.99	96.00
5/6/2015	2.34	9.84	0	0	2.5	9.84	0.5	0.5	12.34	94.92	0	94.92	95.95
5/7/2015	2.31	9.70	0	0	2.5	9.70	0.5	0.5	12.20	94.85	0	94.85	95.90
5/8/2015	2.42	9.12	0	0	2.5	9.12	0.5	0.5	11.62	94.52	0	94.52	95.70
5/11/2015	2.27	8.04	0	0	2.5	8.04	0.5	0.5	10.54	93.78	0	93.78	95.26
5/12/2015	2.60	8.12	0	0	2.60	8.12	0.5	0.5	10.72	93.84	0	93.84	95.34
5/13/2015	2.40	8.14	0	0	2.5	8.14	0.5	0.5	10.64	93.86	0	93.86	95.30
5/14/2015	2.64	8.27	0	0	2.64	8.27	0.5	0.5	10.91	93.95	0	93.95	95.42
5/15/2015	2.43	8.44	0	0	2.5	8.44	0.5	0.5	10.94	94.08	0	94.08	95.43
5/18/2015	2.04	8.40	0	0	2.5	8.40	0.5	0.5	10.90	94.05	0	94.05	95.41
5/19/2015	1.54	9.10	0	0	2.5	9.10	0.5	0.5	11.60	94.51	0	94.51	95.69
5/20/2015	2.04	9.22	0	0	2.5	9.22	0.5	0.5	11.72	94.58	0	94.58	95.73
5/21/2015	1.44	9.01	0	0	2.5	9.01	0.5	0.5	11.51	94.45	0	94.45	95.66
5/22/2015	1.64	9.07	0	0	2.5	9.07	0.5	0.5	11.57	94.49	0	94.49	95.68
5/26/2015	1.84	8.60	0	0	2.5	8.60	0.5	0.5	11.10	94.19	0	94.19	95.50
5/27/2015	1.85	8.50	0	0	2.5	8.50	0.5	0.5	11.00	94.12	0	94.12	95.45
5/28/2015	1.95	8.37	0	0	2.5	8.37	0.5	0.5	10.87	94.03	0	94.03	95.40
5/29/2015	1.85	7.20	0	0	2.5	7.20	0.5	0.5	9.70	93.06	0	93.06	94.85
6/1/2015	2.04	7.00	0	0	2.5	7.00	0.5	0.5	9.50	92.86	0	92.86	94.74
6/2/2015	1.84	6.52	0	0	2.5	6.52	0.5	0.5	9.02	92.33	0	92.33	94.46
6/3/2015	2.04	6.61	0	0	2.5	6.61	0.5	0.5	9.11	92.44	0	92.44	94.51
6/4/2015	2.14	7.14	0	0	2.5	7.14	0.5	0.5	9.64	93.00	0	93.00	94.81
6/5/2015	2.14	7.20	0	0	2.5	7.20	0.5	0.5	9.70	93.06	0	93.06	94.85
6/8/2015	2.24	6.40	0	0	2.5	6.40	0.5	0.5	8.90	92.19	0	92.19	94.38
6/9/2015	2.54	6.28	0	0	2.54	6.28	0.5	0.5	8.82	92.04	0	92.04	94.33
6/10/2015	2.65	7.12	0	0	2.65	7.12	0.5	0.5	9.77	92.98	0	92.98	94.88
6/11/2015	2.76	7.14	0	0	2.76	7.14	0.5	0.5	9.90	93.00	0	93.00	94.95
6/12/2015	3.87	7.16	0	0	3.87	7.16	0.5	0.5	11.03	93.02	0	93.02	95.47
6/15/2015	3.67	7.02	0	0	3.67	7.02	0.5	0.5	10.69	92.88	0	92.88	95.32
6/16/2015	3.77	6.83	0	0	3.77	6.83	0.5	0.5	10.60	92.68	0	92.68	95.28
6/17/2015	3.97	7.11	0	0	3.97	7.11	0.5	0.5	11.08	92.97	0	92.97	95.49
6/18/2015	4.07	6.84	0	0	4.07	6.84	0.5	0.5	10.91	92.69	0	92.69	95.42
6/19/2015	4.07	6.83	0	0	4.07	6.83	0.5	0.5	10.90	92.68	0	92.68	95.41
6/22/2015	3.88	6.92	0	0	3.88	6.92	0.5	0.5	10.80	92.77	0	92.77	95.37
6/23/2015	3.97	7.12	0	0	3.97	7.12	0.5	0.5	11.09	92.98	0	92.98	95.49
6/24/2015	3.87	7.24	0	0	3.87	7.24	0.5	0.5	11.11	93.09	0	93.09	95.50
6/25/2015	3.90	7.20	0	0	3.90	7.20	0.5	0.5	11.10	93.06	0	93.06	95.50
6/26/2015	3.77	7.47	0	0	3.77	7.47	0.5	0.5	11.24	93.31	0	93.31	95.55
6/29/2015	3.77	7.64	0	0	3.77	7.64	0.5	0.5	11.41	93.46	0	93.46	95.62
6/30/2015	3.88	7.81	0	0	3.88	7.81	0.5	0.5	11.69	93.60	0	93.60	95.72
7/1/2015	3.78	8.47	0	0	3.78	8.47	0.5	0.5	12.25	94.10	0	94.10	95.92
7/2/2015	3.88	8.51	0	0	3.88	8.51	0.5	0.5	12.39	94.12	0	94.12	95.97
7/6/2015	3.77	8.04	0	0	3.77	8.04	0.5	0.5	11.81	93.78	0	93.78	95.77
7/7/2015	3.77	7.24	0	0	3.77	7.24	0.5	0.5	11.01	93.09	0	93.09	95.46
7/8/2015	3.86	6.01	0	0	3.86	6.01	0.5	0.5	9.87	91.68	0	91.68	94.93
7/9/2015	3.76	3.12	0	0	3.76	3.12	0.5	0.5	6.88	83.97	0	83.97	92.73
7/10/2015	3.16	3.07	0	0	3.16	3.07	0.5	0.5	6.23	83.71	0	83.71	91.98
7/13/2015	3.14	1.91	0	0	3.14	1.91	0.5	0.5	5.05	73.82	0	73.82	90.10
7/14/2015	3.24	1.94	0	0	3.24	1.94	0.5	0.5	5.18	74.23	0	74.23	90.35
7/15/2015	3.14	2.07	0	0	3.14	2.07	0.5	0.5	5.21	75.85	0	75.85	90.40
7/16/2015	3.34	2.14	0	0	3.34	2.14	0.5	0.5	5.48	76.64	0	76.64	90.88
7/17/2015	3.14	2.19	0	0	3.14	2.19	0.5	0.5	5.33	77.17	0	77.17	90.61
7/20/2015	2.43	2.20	0	0	2.5	2.20	0.5	0.5	4.70	77.27	0	77.27	89.36
7/21/2015	2.10	2.17	0	0	2.5	2.17	0.5	0.5	4.67	76.96	0	76.96	89.29
7/22/2015	1.70	2.19	0	0	2.5	2.19	0.5	0.5	4.69	77.17	0	77.17	89.34
7/23/2015	0.11	2.10	0	0	2.5	2.10	0.5	0.5	4.60	76.19	0	76.19	89.13
7/24/2015	0.12	2.15	0	0	2.5	2.15	0.5	0.5	4.65	76.74	0	76.74	89.25
7/27/2015	0.20	2.17	0	0	2.5	2.17	0.5	0.5	4.67	76.96	0	76.96	89.29
7/28/2015	0.20	2.20	0	0	2.5	2.20	0.5	0.5	4.70	77.27	0	77.27	89.36
7/29/2015	0.11	2.24	0	0	2.5	2.24	0.5	0.5	4.74	77.68	0	77.68	89.45
7/30/2015	0.11	3.04	0	0	2.5	3.04	0.5	0.5	5.54	83.55	0	83.55	90.97
7/31/2015	0.11	2.19	0	0	2.5	2.19	0.5	0.5	4.69	77.17	0	77.17	89.34
8/3/2015	0	1.68	0	0	2.5	1.68	0.5	0.5	4.18	70.24	0	70.24	88.04
8/4/2015	0	1.74	0	0	2.5	1.74	0.5	0.5	4.24	71.26	0	71.26	88.21
8/5/2015	0	1.73	0	0	2.5	1.73	0.5	0.5	4.23	71.10	0	71.10	88.18
8/6/2015	0	2.10	0	0	2.5	2.10	0.5	0.5	4.60	76.19	0	76.19	89.13
8/7/2015			0	0			0.5	0.5			0		
8/10/2015	4.90	2.14	0	0	4.90	2.14	0.5	0.5	7.04	76.64	0	76.64	92.90
8/11/2015			0	0			0.5	0.5			0		
8/12/2015	5.10	1.60	0	0	5.10	1.60	0.5	0.5	6.70	68.75	0	68.75	92.54
8/13/2015			0	0			0.5	0.5			0		
8/18/2015	5.20				5.20				5.20				
8/20/2015	5.60	1.60	0	0	5.60	1.60	0.5	0.5	7.20	68.75	0	68.75	93.06
8/24/2015	1.70		0	0	2.5		0.5	0.5	2.50		0		
8/26/2015	1.90	1.00	0	0	2.5	1.00	0.5	0.5	3.50	50.00	0	50.00	85.71

Table C.2 continued.

	Raw Data				Censored Data					Removal			
	NO_3^- /NO_2^- LE	NH_3 LE	NH_3 PSE	NH_3 D	NO_3^- /NO_2^- LE	NH_3 LE	NH_3 PSE	NH_3 D	NH_3 WI	P SAGR	S SAGR	SAGR	WRRF
Date					mg L^{-1}						%		
8/28/2015	0	1.20	0	0	2.5	1.20	0.5	0.5	3.70	58.33	0	58.33	86.49
9/1/2015	1.10	1.62	0	0	2.5	1.62	0.5	0.5	4.12	69.14	0	69.14	87.86
9/3/2015	3.00	1.47	0	0	3.00	1.47	0.5	0.5	4.47	65.99	0	65.99	88.81
9/5/2015	3.60	1.40	0	0	3.60	1.40	0.5	0.5	5.00	64.29	0	64.29	90.00
9/8/2015	0	1.40	0	0.19	2.5	1.40	0.5	0.5	3.90	64.29	0	64.29	87.18
9/10/2015	3.80	1.10	0	0	3.80	1.10	0.5	0.5	4.90	54.55	0	54.55	89.80
9/14/2015	3.70	1.60	0	0	3.70	1.60	0.5	0.5	5.30	68.75	0	68.75	90.57
9/16/2015	3.07	1.10	0	0	3.07	1.10	0.5	0.5	4.17	54.55	0	54.55	88.01
9/17/2015	2.60	9.99	0	0	2.60	9.99	0.5	0.5	12.59	94.99	0	94.99	96.03
9/22/2015	2.97	9.99	0	0	2.97	9.99	0.5	0.5	12.96	94.99	0	94.99	96.14
9/24/2015	2.70	9.99	0	0.07	2.70	9.99	0.5	0.5	12.69	94.99	0	94.99	96.06
9/28/2015	0.36	9.06	0	0.10	2.5	9.06	0.5	0.5	11.56	94.48	0	94.48	95.67
9/30/2015	2.80	9.16	0	0.07	2.80	9.16	0.5	0.5	11.96	94.54	0	94.54	95.82
10/2/2015	0.36	9.99		0	2.5	9.99		0.5	12.49			94.99	96.00
10/6/2015	3.37	9.99		0.09	3.37	9.99		0.5	13.36			94.99	96.26
10/8/2015	3.10	9.99		0.14	3.10	9.99		0.5	13.09			94.99	96.18
10/12/2015	0.37	9.99		0.17	2.5	9.99		0.5	12.49			94.99	96.00
10/13/2015	3.26	9.99		0.16	3.26	9.99		0.5	13.25			94.99	96.23
10/14/2015	2.00	9.99		0.15	2.5	9.99		0.5	12.49			94.99	96.00
10/15/2015	0.19	9.99		0.16	2.5	9.99		0.5	12.49			94.99	96.00
10/16/2015	1.90	9.99		0	2.5	9.99		0.5	12.49			94.99	96.00
10/19/2015	2.69	9.99		0	2.69	9.99		0.5	12.68			94.99	96.06
10/20/2015	1.60	9.99		0	2.5	9.99		0.5	12.49			94.99	96.00
10/21/2015	1.59	9.99		0	2.5	9.99		0.5	12.49			94.99	96.00
10/22/2015	1.50	9.99		0	2.5	9.99		0.5	12.49			94.99	96.00
10/23/2015	1.50	9.99		0	2.5	9.99		0.5	12.49			94.99	96.00
10/26/2015	1.59	9.99		0	2.5	9.99		0.5	12.49			94.99	96.00
10/27/2015	1.50	9.99		0	2.5	9.99		0.5	12.49			94.99	96.00
10/28/2015	1.59	9.99	0		2.5	9.99	0.5		12.49	94.99			
10/29/2015	1.50	9.99		0	2.5	9.99		0.5	12.49			94.99	96.00
10/30/2015	1.89	0.00		9.99	2.5	0.5		9.99	3.00			-1898.0	-233.00
11/2/2015	0.19	9.99		0	2.5	9.99		0.5	12.49			94.99	96.00
11/3/2015	1.60	9.99		0	2.5	9.99		0.5	12.49			94.99	96.00
11/4/2015	0.19	9.99		0	2.5	9.99		0.5	12.49			94.99	96.00
11/5/2015	1.60	9.99		0	2.5	9.99		0.5	12.49			94.99	96.00
11/6/2015	0.19	9.99		0	2.5	9.99		0.5	12.49			94.99	96.00
11/9/2015	1.50	9.99		0	2.5	9.99		0.5	12.49			94.99	96.00
11/10/2015	0.19	9.99		0	2.5	9.99		0.5	12.49			94.99	96.00
11/12/2015	1.70	9.99		0	2.5	9.99		0.5	12.49			94.99	96.00
11/13/2015	0.19	9.99		0	2.5	9.99		0.5	12.49			94.99	96.00
11/16/2015	1.60	9.99		0	2.5	9.99		0.5	12.49			94.99	96.00
11/17/2015	0.39	9.08		0	2.5	9.08		0.5	11.58			94.49	95.68
11/18/2015	5.07	9.08		0	5.07	9.08		0.5	14.15			94.49	96.47
11/19/2015	6.22	9.14		0	6.22	9.14		0.5	15.36			94.53	96.74
11/20/2015	6.47	9.22		0	6.47	9.22		0.5	15.69			94.58	96.81
11/23/2015	6.80	9.40		0	6.80	9.40		0.5	16.20			94.68	96.91
11/24/2015	0.42	9.99		0	2.5	9.99		0.5	12.49			94.99	96.00
11/25/2015	5.70	9.99		0	5.70	9.99		0.5	15.69			94.99	96.81
12/1/2015	6.12	9.99	3.40	0	6.12	9.99	3.40	0.5	16.11	65.97	85.29	94.99	96.90
12/2/2015	0.47	9.99	3.30	0	2.5	9.99	3.30	0.5	12.49	66.97	84.85	94.99	96.00
12/3/2015	5.92	9.99	3.30	0	5.92	9.99	3.30	0.5	15.91	66.97	84.85	94.99	96.86
12/4/2015	4.44	9.99	3.00	0	4.44	9.99	3.00	0.5	14.43	69.97	83.33	94.99	96.53
12/7/2015	0.41			0	2.5			0.5	2.50				
12/8/2015	4.15			0	4.15			0.5	4.15				
12/9/2015	0.34			0	2.5			0.5	2.50				
12/10/2015	4.27			0	4.27			0.5	4.27				
12/11/2015	5.32	9.15	3.10	0	5.32	9.15	3.10	0.5	14.47	66.12	83.87	94.54	96.54
12/14/2015	0.48	8.02	2.72	0	2.5	8.02	2.72	0.5	10.52	66.08	81.62	93.77	95.25
12/15/2015	6.21	7.61	2.50	0	6.21	7.61	2.50	0.5	13.82	67.15	80.00	93.43	96.38
12/16/2015	0.51	7.01	2.10	0	2.5	7.01	2.10	0.5	9.51	70.04	76.19	92.87	94.74
12/17/2015	4.12	7.14	1.90	0	4.12	7.14	1.90	0.5	11.26	73.39	73.68	93.00	95.56
12/18/2015	0.48	7.27	1.60	0	2.50	7.27	1.60	0.5	9.77	77.99	68.75	93.12	94.88
12/21/2015	4.17	7.50	1.70	0	4.17	7.50	1.70	0.5	11.67	77.33	70.59	93.33	95.72
12/22/2015	5.16	7.61	1.73	0	5.16	7.61	1.73	0.5	12.77	77.27	71.10	93.43	96.08
12/23/2015	5.22	7.70	1.80	0	5.22	7.70	1.80	0.5	12.92	76.62	72.22	93.51	96.13
12/24/2015	0.44	8.12	2.04	0	2.5	8.12	2.04	0.5	10.62	74.88	75.49	93.84	95.29
12/25/2015	5.35	8.17	2.00	0	5.35	8.17	2.00	0.5	13.52	75.52	75.00	93.88	96.30
12/28/2015	0.51	9.99	2.12	0	2.5	9.99	2.12	0.5	12.49	78.78	76.42	94.99	96.00
12/29/2015	5.01	9.99	2.16	0	5.01	9.99	2.16	0.5	15.00	78.38	76.85	94.99	96.67
12/30/2015	3.97	9.99	2.27	0	3.97	9.99	2.27	0.5	13.96	77.28	77.97	94.99	96.42
1/4/2016	0.46	9.99		0	2.5	9.99		0.5	12.49			94.99	96.00
1/6/2016	4.12	9.99		0	4.12	9.99		0.5	14.11			94.99	96.46
1/8/2016	0.40	8.94		0	2.5	8.94		0.5	11.44			94.41	95.63
1/11/2016	4.70	9.99		0	4.70	9.99		0.5	14.69			94.99	96.60
1/13/2016	5.12	9.99		0	5.12	9.99		0.5	15.11			94.99	96.69
1/15/2016	0.42	9.99		0.17	2.5	9.99		0.5	12.49			94.99	96.00
1/19/2016	5.13	9.99		0	5.13	9.99		0.5	15.12			94.99	96.69
1/21/2016	5.17	9.99		0	5.17	9.99		0.5	15.16			94.99	96.70
1/25/2016	4.90	8.64		0	4.90	8.64		0.5	13.54			94.21	96.31
1/27/2016	5.62	8.78		0	5.62	8.78		0.5	14.40			94.31	96.53
1/29/2016	7.68	9.99		0	7.68	9.99		0.5	17.67			94.99	97.17

Table C.2 continued.

	Raw Data				Censored Data					Removal			
	NO_3^- $/NO_2^-$ LE	NH_3 LE	NH_3 PSE	NH_3 D	NO_3^- $/NO_2^-$ LE	NH_3 LE	NH_3 PSE	NH_3 D	NH_3 WI	P SAGR	S SAGR	SAGR	WRRF
Date					mg L^{-1}					%			
2/1/2016	7.70	9.99		0	7.70	9.99		0.5	17.69			94.99	97.17
2/3/2016	7.41	9.99		0	7.41	9.99		0.5	17.40			94.99	97.13
2/5/2016	7.60	9.99		0	7.60	9.99		0.5	17.59			94.99	97.16
2/8/2016	6.42	9.73		0	6.42	9.73		0.5	16.15			94.86	96.90
2/10/2016	8.40	9.42		0	8.40	9.42		0.5	17.82			94.69	97.19
2/12/2016	8.21	8.73		0	8.21	8.73		0.5	16.94			94.27	97.05
2/15/2016	7.90	8.70		0	7.90	8.70		0.5	16.60			94.25	96.99
2/17/2016	7.77	9.99		0	7.77	9.99		0.5	17.76			94.99	97.18
2/19/2016	7.80	9.99		0	7.80	9.99		0.5	17.79			94.99	97.19
2/22/2016	0.42	9.99	2.41	0	2.5	9.99	2.41	0.5	12.49	75.88	79.25	94.99	96.00
2/24/2016	7.87	9.99		0	7.87	9.99		0.5	17.86			94.99	97.20
2/26/2016	7.77	8.47		0	7.77	8.47		0.5	16.24			94.10	96.92
3/1/2016	7.10	9.99		0	7.10	9.99		0.5	17.09			94.99	97.07
3/4/2016		9.99		0		9.99		0.5	9.99			94.99	
3/7/2016	6.47	9.85		0	6.47	9.85		0.5	16.32			94.92	96.94
3/10/2016		9.80		0		9.80		0.5	9.80			94.90	
3/12/2016	6.80	9.71		0	6.80	9.71		0.5	16.51			94.85	96.97
3/15/2016	0.42	9.99	2.40	0	2.5	9.99	2.40	0.5	12.49	75.98	79.17	94.99	96.00
3/17/2016	5.70	9.99		0	5.70	9.99		0.5	15.69			94.99	96.81
3/21/2016		9.99		0		9.99		0.5	9.99			94.99	
3/23/2016	6.12	8.41		0	6.12	8.41		0.5	14.53			94.05	96.56
3/25/2016	0.47	8.20	0	0	2.5	8.20	0.5	0.5	10.70	93.90	0	93.90	95.33
3/28/2016	5.92	7.96	0	0	5.92	7.96	0.5	0.5	13.88	93.72	0	93.72	96.40
3/31/2016		9.99		0		9.99		0.5	9.99			94.99	
4/1/2016		9.99	2.18	0		9.99	2.18	0.5	9.99	78.18	77.06	94.99	
4/4/2016		8.63		0		8.63		0.5	8.63			94.21	
4/6/2016		8.92		0		8.92		0.5	8.92			94.39	
4/8/2016		9.99		0		9.99		0.5	9.99			94.99	
4/11/2016	4.44	9.99		0	4.44	9.99		0.5	14.43			94.99	96.53
4/14/2016		9.99		0		9.99		0.5	9.99			94.99	
4/18/2016	0.41	9.99		0	2.5	9.99		0.5	12.49			94.99	96.00
4/20/2016		8.87	2.13	0		8.87	2.13	0.5	8.87	75.99	76.53	94.36	
4/22/2016	4.15	9.38		0	4.15	9.38		0.5	13.53			94.67	96.30
4/27/2016	0.34	9.99		0	2.5	9.99		0.5	12.49			94.99	96.00
4/29/2016	4.27	9.94		0	4.27	9.94		0.5	14.21			94.97	96.48
5/2/2016		9.99		0		9.99		0.5	9.99			94.99	
5/4/2016		9.99		0		9.99		0.5	9.99			94.99	
5/6/2016		9.72		0		9.72		0.5	9.72			94.86	
5/9/2016	5.32	9.99		0	5.32	9.99		0.5	15.31			94.99	96.73
5/12/2016		9.99		0		9.99		0.5	9.99			94.99	
5/16/2016		9.99		0		9.99		0.5	9.99			94.99	
5/18/2016		8.82	1.97	0		8.82	1.97	0.5	8.82	77.66	74.62	94.33	
5/20/2016		8.47		0		8.47		0.5	8.47			94.10	
5/23/2016		7.96		0		7.96		0.5	7.96			93.72	
5/25/2016		9.99	0	0		9.99	0.5	0.5	9.99	94.99	0	94.99	
5/27/2016		9.99		0		9.99		0.5	9.99			94.99	
5/30/2016		9.99		0		9.99		0.5	9.99			94.99	
6/1/2016		7.46		0		7.46		0.5	7.46			93.30	
6/3/2016	0.48	7.71	1.25	0	2.5	7.71	1.25	0.5	10.21	83.79	60.00	93.51	95.10
6/7/2016	6.21	7.84		0	6.21	7.84		0.5	14.05			93.62	96.44
6/9/2016		8.21		0		8.21		0.5	8.21			93.91	
6/13/2016		8.10		0		8.10		0.5	8.10			93.83	
6/15/2016	0.51	8.70		0	2.5	8.70		0.5	11.20			94.25	95.54
6/18/2016		9.99		0		9.99		0.5	9.99			94.99	
6/21/2016	4.12	9.99		0	4.12	9.99		0.5	14.11			94.99	96.46
6/23/2016		9.99		0		9.99		0.5	9.99			94.99	
6/27/2016	0.48	9.99		0	2.5	9.99		0.5	12.49			94.99	96.00
6/29/2016	4.17	9.99		0	4.17	9.99		0.5	14.16			94.99	96.47
7/1/2016		9.99	0	0		9.99	0.5	0.5	9.99	94.99	0	94.99	
7/4/2016	5.16	9.99		0	5.16	9.99		0.5	15.15			94.99	96.70
7/6/2016		9.99		0		9.99		0.5	9.99			94.99	
7/9/2016	5.22	9.64		0	5.22	9.64		0.5	14.86			94.81	96.64
7/12/2016	0.44	9.71		0	2.5	9.71		0.5	12.21			94.85	95.90
7/14/2016		9.80		0		9.80		0.5	9.80			94.90	
7/16/2016	5.35	9.64	2.61	0	5.35	9.64	2.61	0.5	14.99	72.93	80.84	94.81	96.66
7/18/2016		9.99		0		9.99		0.5	9.99			94.99	
7/21/2016	0.51	9.99		0	2.5	9.99		0.5	12.49			94.99	96.00
7/25/2016	5.01	9.82		0	5.01	9.82		0.5	14.83			94.91	96.63
7/27/2016		9.66		0		9.66		0.5	9.66			94.82	
7/29/2016		9.99		0		9.99		0.5	9.99			94.99	
8/1/2016	3.97	9.99		0	3.97	9.99		0.5	13.96			94.99	96.42
8/3/2016		9.99		0		9.99		0.5	9.99			94.99	
8/5/2016	0.46	9.99		0.24	2.5	9.99		0.5	12.49			94.99	96.00
8/8/2016	4.12	9.99		0	4.12	9.99		0.5	14.11			94.99	96.46
8/10/2016		9.99		0		9.99		0.5	9.99			94.99	
8/13/2016	0.40	9.99		0	2.5	9.99		0.5	12.49			94.99	96.00
8/16/2016	4.70	8.63		0	4.70	8.63		0.5	13.33			94.21	96.25
8/19/2016		8.01		0		8.01		0.5	8.01			93.76	
8/22/2016		7.43		0		7.43		0.5	7.43			93.27	
8/24/2016	5.12	7.42		0	5.12	7.42		0.5	12.54			93.26	96.01
8/26/2016	0.42	9.91		0	2.5	9.91		0.5	12.41			94.95	95.97

Table C.2 continued.

	Raw Data				Censored Data					Removal			
	NO_3^- /NO_2^- LE	NH_3 LE	NH_3 PSE	NH_3 D	NO_3^- /NO_2^- LE	NH_3 LE	NH_3 PSE	NH_3 D	NH_3 WI	P SAGR	S SAGR	SAGR	WRRF
Date					mg L^{-1}							%	
8/29/2016		9.99		0		9.99		0.5	9.99			94.99	
9/2/2016		9.99		0		9.99		0.5	9.99			94.99	
9/5/2016		9.99		0		9.99		0.5	9.99			94.99	
9/7/2016	5.13	9.99		0	5.13	9.99		0.5	15.12			94.99	96.69
9/10/2016		9.99		0		9.99		0.5	9.99			94.99	
9/13/2016		9.83	2.14	0		9.83	2.14	0.5	9.83	78.23	76.64	94.91	
9/16/2016	5.17	9.88		0	5.17	9.88		0.5	15.05			94.94	96.68
9/21/2016		9.99		0		9.99		0.5	9.99			94.99	
9/24/2016		9.99	1.14	0		9.99	1.14	0.5	9.99	88.59	56.14	94.99	
9/26/2016	4.90	9.99		0	4.90	9.99		0.5	14.89			94.99	96.64
9/28/2016		9.99		0		9.99		0.5	9.99			94.99	
9/30/2016	5.62	9.99		0	5.62	9.99		0.5	15.61			94.99	96.80
10/3/2016	7.68	9.99	0	0	7.68	9.99	0.5	0.5	17.67	94.99	0	94.99	97.17
10/5/2016		9.99		0		9.99		0.5	9.99			94.99	
10/7/2016		9.99		0		9.99		0.5	9.99			94.99	
10/10/2016	7.70	9.99		0	7.70	9.99		0.5	17.69			94.99	97.17
10/12/2016		9.99		0		9.99		0.5	9.99			94.99	
10/14/2016	7.41	9.99		0	7.41	9.99		0.5	17.40			94.99	97.13
10/17/2016		9.99		0		9.99		0.5	9.99			94.99	
10/20/2016	7.60	9.99		0	7.60	9.99		0.5	17.59			94.99	97.16
10/22/2016		9.99		0		9.99		0.5	9.99			94.99	
10/25/2016	6.42	9.99		0	6.42	9.99		0.5	16.41			94.99	96.95
10/27/2016		9.99		0		9.99		0.5	9.99			94.99	
11/1/2016	8.40	9.99		0	8.40	9.99		0.5	18.39			94.99	97.28
11/5/2016		9.99		0		9.99		0.5	9.99			94.99	
11/8/2016	8.21	9.99		0	8.21	9.99		0.5	18.20			94.99	97.25
11/10/2016		9.99		0		9.99		0.5	9.99			94.99	
11/14/2016		9.99		0		9.99		0.5	9.99			94.99	
11/16/2016	7.90	9.89		0	7.90	9.89		0.5	17.79			94.94	97.19
11/18/2016		9.94	1.43	0		9.94	1.43	0.5	9.94	85.61	65.03	94.97	
11/21/2016		9.99		0		9.99		0.5	9.99			94.99	
11/23/2016	7.77	9.99		0	7.77	9.99		0.5	17.76			94.99	97.18
11/25/2016		9.99		0		9.99		0.5	9.99			94.99	
11/28/2016		9.99		0		9.99		0.5	9.99			94.99	
12/1/2016		9.99		0		9.99		0.5	9.99			94.99	
12/3/2016	7.80	9.99	2.64	0	7.80	9.99	2.64	0.5	17.79	73.57	81.06	94.99	97.19
12/5/2016	0.42	9.99		0	2.5	9.99		0.5	12.49			94.99	96.00
12/7/2016		9.99	2.70	0		9.99	2.70	0.5	9.99	72.97	81.48	94.99	
12/9/2016	7.87	9.99		0	7.87	9.99		0.5	17.86			94.99	97.20
12/12/2016		9.99		0		9.99		0.5	9.99			94.99	
12/14/2016		9.99	2.63	0		9.99	2.63	0.5	9.99	73.67	80.99	94.99	
12/16/2016	7.77	9.99		0	7.77	9.99		0.5	17.76			94.99	97.18
12/19/2016		9.99		0		9.99		0.5	9.99			94.99	
12/22/2016	7.10	9.99	4.21	0.70	7.10	9.99	4.21	0.70	17.09	57.86	83.37	92.99	95.90
12/26/2016		9.99		1.9		9.99		1.9	9.99			80.98	
12/29/2016		9.99		2.05		9.99		2.05	9.99			79.48	
									Median	78.98	0	94.21	95.65

Table C.3 Public record monthly operation report data for the NPDES permit (#5792001) for the City of Walker provided by the IDNR. Used to determine compliance and create Figure 2.5 and Figure B1.

	7 Day Avg.	7 Day Avg.	30 Day Avg.	Daily Max.	Min.	Daily Max.	Daily Min.	30 Day Avg.	Daily Max.
	$CBOD_5$	TSS	NH_3		DO	pH		TN	
Date	mg L^{-1}					units		lbs day^{-1}	
April 2014	3	7.5	0.81	1.83	9.6	8.38	8.04	8.27	13.31
May 2014	6	5	0.50	0.55	8.36	8.85	8.34	2.26	4.46
June 2014	3	5	0.50	0.52	7.6	8.62	8.43	5.49	13.14
July 2014	3	12	0.5	0.5	8.52	8.6	8.4	8.63	28.89
August 2014	6.07	5	0.50	0.51	7.9	8.9	8.58	1.38	1.84
September 2014	3	7.5	0.59	0.89	8.24	8.52	8.26	5.59	9.82
October 2014	3	5	0.51	0.62	8.4	8.48	8.14	7.94	15.32
November	6	12.65	0.52	0.57	10.09	8.27	8.1	4.22	6.73
December 2014	3	5.7	0.49	0.5	12.	8.01	7.97	7.24	8.23
January 2015	3	5	0.49	0.5	11.9	8.24	8.14	11.25	12.42
February 2015		29.3	0.		4.15	8.23	7.5	10.32	16.29
March 2015			0.13	0.54	6.74	8.25	7.55	12.16	13.69
April 2015			0.15	0.77	10.25	8.37	8.27	7.06	9.37
May 2015		5	0.		8.63	8.41	8.36	7.95	8.41
June 2015			0.		8.36	8.55	8.33	5.35	6.87
July 2015			0.		8.14	8.83	7.55	1.97	4.27
August 2015			0.		8.14	8.64	8.57	2.35	5.81
September 2015			0.		8.17	8.59	8.55	3.43	5.90
October 2015			0.		9.1	8.44	8.23	6.13	6.33
November 2015	3.11		0.		9.7	8.62	8.25	7.16	11.91
December 2015			0.		10.9	8.29	8.07	6.38	9.50
January 2016			0.		10.97	8.29	8.23	16.08	46.29
February 2016			0.		11.9	8.32	8.03	9.35	15.22
March 2016	3.99	8	0.		11.64	8.29	8.15	10.91	15.74
April 2016			0.		9.41	8.3	8.24	6.98	15.20
May 2016			0.25	0.5	9.45	8.45	8.38	3.64	4.49
June 2016			0.		10.39	8.52	8.37	4.09	5.65
July 2016		38.6	0.		9.83	8.55	8.48	3.71	4.89
August 2016			0.		9.83	8.7	8.57	3.82	5.59
September 2016			0.		9.37	8.6	8.5	3.33	3.66
October 2016			0.		9.87	8.6	8.5	4.27	5.04
November 2016			0.		9.87	8.6	8.5	3.54	4.58
December 2016			0.57	2.28	10.21	8.5	8.3	4.16	6.04

Table C.4 Raw DO and temperature data and calculated saturated DO and used to create Figure 2.6.

	Raw				Calculated	
	DO		Temp		DO Saturation	
	P	S	P	S	P	S
Date	mg L^{-1}		°F		mg L-1	
4/2/2014	11.6	11.72	37.1	39.9	13.58	13.03
4/3/2014	11.02	11.26	41.2	38.8	12.78	13.24
4/4/2014	11.06	11.28	41	40.5	12.82	12.91
4/7/2014	10.69	11.24	51.3	47.7	11.14	11.68
4/8/2014	10.65	11.2	51.5	48	11.11	11.63
4/9/2014	10.64	11.22	51.4	48.2	11.12	11.60
4/10/2014	10.6	11.27	52.1	48.7	11.02	11.52
4/11/2014	10.54	11.18	51.3	48.1	11.14	11.62
4/14/2014	10.52	11	51.2	48.2	11.15	11.60
4/15/2014	10.38	10.78	50.4	47.7	11.27	11.68
4/16/2014	10.24	10.66	50.6	48.2	11.24	11.60
4/17/2014	10.11	10.52	50.4	47.2	11.27	11.76
4/18/2014	10.18	10.61	49.1	47.3	11.46	11.74
4/21/2014	9.21	9.94	59.7	54.9	10.03	10.64
4/22/2014	9.23	9.63	57.8	57	10.26	10.37
4/23/2014	9.25	9.6	57.9	57.6	10.25	10.29
4/24/2014	9.26	9.6	58.1	57.6	10.23	10.29
4/25/2014	9.29	9.61	58.3	57.9	10.20	10.25
4/28/2014	9.32	9.6	56.1	57.6	10.48	10.29
4/29/2014	9.6	9.9	53.1	57.2	10.88	10.34
4/30/2014	9.58	9.97	50.2	52.1	11.30	11.02
5/1/2014	9.95	10.03	46.9	49.2	11.81	11.45
5/2/2014	9.87	10.04	49.1	49.6	11.46	11.39
5/6/2014	10.14	9.09	57.1	54.4	10.35	10.71
5/7/2014	9.01	9.46	55.8	55.1	10.52	10.61
5/8/2014	9.24	9.15	63.3	56.4	9.62	10.44
5/9/2014	9.41	9.26	54.6	54.8	10.68	10.65
5/12/2014	9.4	9.36	53.8	54	10.79	10.76
5/13/2014	9.38	9.4	53	53.8	10.90	10.79
5/14/2014	9.3	9.34	53.4	54.3	10.84	10.72
5/15/2014	9.27	9.25	53.8	56.6	10.79	10.42

Table C.4 continued.

	Raw				Calculated	
	DO		Temp		DO Saturation	
	P	S	P	S	P	S
Date	mg L^{-1}		°F		mg L-1	
5/16/2014	9	9.21	53.1	56.7	10.88	10.40
5/20/2014	8.72	8.82	61	59.2	9.88	10.09
5/21/2014	9.1	8.89	66	60.9	9.33	9.89
5/22/2014	8.84	8.74	66.5	60.1	9.27	9.98
5/26/2014	8.14	8.29	69.4	66	8.98	9.33
5/27/2014	8.21	8.32	70.9	66.6	8.84	9.26
5/28/2014	7.99	8.36	72.7	68.9	8.67	9.03
5/29/2014	7.66	8.3	72.5	70.6	8.69	8.86
5/30/2014	8.06	8.27	72.6	71.4	8.68	8.79
6/2/2014	7.6	8.3	71.4	71.6	8.79	8.77
6/3/2014	7.7	8.32	71	71.4	8.83	8.79
6/4/2014	7.68	8.4	71.7	72.3	8.76	8.70
6/5/2014	7.7	8.47	72.5	72.4	8.69	8.69
6/6/2014	7.74	7.54	68.4	70.4	9.08	8.88
6/9/2014	7.85	7.5	68.6	70.3	9.06	8.89
6/10/2014	7.8	7.56	66.4	69.6	9.28	8.96
6/11/2014	7.8	7.6	68.2	69.6	9.10	8.96
6/12/2014	7.78	7.7	68	69.4	9.12	8.98
6/13/2014	7.7	7.9	67.5	69	9.17	9.02
6/16/2014	7.7	7.85	68	69.2	9.12	9.00
6/17/2014	7.72	7.9	68.4	70.2	9.08	8.90
6/18/2014	7.7	7.92	69	69.8	9.02	8.94
6/19/2014	7.68	8.02	70	69.7	8.92	8.95
6/20/2014	7.6	7.94	69.1	69.5	9.01	8.97
6/23/2014	7.6	8	68.7	69.3	9.05	8.99
6/24/2014	7.55	8.05	68.2	69.1	9.10	9.01
6/25/2014	7.5	8.11	68	68.6	9.12	9.06
6/26/2014	7.56	8.04	68	68.3	9.12	9.09
6/27/2014	7.5	8	68.2	68.8	9.10	9.04
6/30/2014	7.54	7.93	68	68.6	9.12	9.06
7/1/2014	6.9	7.45	70.4	71	8.88	8.83
7/2/2014	7.14	7.53	70.1	70.9	8.91	8.84
7/3/2014	7.2	7.9	69.9	70.6	8.93	8.86
7/7/2014	7.2	8.04	70.4	70.6	8.88	8.86
7/8/2014	7.24	8.17	71.4	71.7	8.79	8.76
7/9/2014	7.59	8.14	72.1	72.5	8.72	8.69
7/10/2014	7.6	8.13	72.6	73	8.68	8.64
7/12/2014	7.64	8.23	75.1	75.8	8.45	8.39
7/13/2014	7.65	8.22	75.5	76	8.42	8.37
7/14/2014	7.66	8.24	75.9	76.1	8.38	8.36
7/15/2014	7.65	8.23	75.8	76	8.39	8.37
7/16/2014	7.68	8.19	75.9	76.1	8.38	8.36
7/19/2014	7.68	8.21	76.1	76	8.36	8.37
7/20/2014	7.69	8.2	76	75.9	8.37	8.38
7/21/2014	7.61	8.2	76.1	76.3	8.36	8.35
7/22/2014	7.6	8.22	76	76.5	8.37	8.33
7/23/2014	7.6	8.2	76.3	76.7	8.35	8.31
7/25/2014	7.57	8.15	76.1	76.4	8.36	8.34
8/1/2014	9	8.4	74.1	74.6	8.54	8.49
8/4/2014	8.92	8.41	74.2	74.6	8.53	8.49
8/5/2014	8.9	8.4	73.8	74.1	8.57	8.54
8/6/2014	8.87	8.37	73.7	74	8.58	8.55
8/7/2014	8.9	8.4	73.8	74.1	8.57	8.54
8/8/2014	8.92	8.4	73.4	73.8	8.60	8.57
8/11/2014	8.9	8.38	73.2	73.7	8.62	8.58
8/13/2014	7.72	7.9	73.4	73.7	8.60	8.58
8/14/2014	7.93	7.94	73.4	73.7	8.60	8.58
8/15/2014	8.77	7.92	73.4	73.6	8.60	8.58
8/16/2014	8.2	8.1	73.6	73.4	8.58	8.60
8/17/2014	8.26	7.97	73.6	73.9	8.58	8.56
8/18/2014	8.42	7.96	73.9	74.3	8.56	8.52
8/21/2014	8.36	8.02	73.8	74.3	8.57	8.52
8/22/2014	8.5	8.4	74	74.6	8.55	8.49
8/23/2014	8.5	8.38	74	74.5	8.55	8.50
8/24/2014	8.44	8.3	73.2	74	8.62	8.55
8/25/2014	8.5	8.34	73	73.6	8.64	8.58
8/28/2014	8.54	8.3	72.6	73	8.68	8.64
8/29/2014	8.51	8.34	73.1	73.7	8.63	8.58
8/30/2014	8.5	8.38	73.6	74.4	8.58	8.51
9/1/2014	8.25	8.12	70.1	71.2	8.91	8.81
9/2/2014	8.26	8.17	69.8	71.3	8.94	8.80
9/3/2014	8.2	8.31	69.8	71.1	8.94	8.82
9/4/2014	8.29	8.33	70.2	71	8.90	8.83
9/5/2014	8.25	8.29	70.3	71.2	8.89	8.81
9/6/2014	8.2	8.27	70.7	71.4	8.85	8.79
9/7/2014	8.15	8.22	70.2	71.4	8.90	8.79
9/8/2014	8.12	8.17	69.8	71.3	8.94	8.80
9/9/2014	8.23	8.2	67.1	69.5	9.21	8.97
9/10/2014	8.2	8.24	66.7	69.5	9.25	8.97
9/11/2014	8.21	8.25	66.1	69	9.31	9.02
9/12/2014	8.86	8.61	65.3	68	9.40	9.12
9/15/2014	8.9	8.6	65	67.4	9.43	9.18

Table C.4 continued.

	Raw				Calculated	
	DO		Temp		DO Saturation	
	P	S	P	S	P	S
Date	mg L^{-1}		°F		mg L-1	
9/16/2014	8.87	8.58	65.1	67.3	9.42	9.19
9/17/2014	8.7	8.64	64.2	67	9.52	9.22
9/18/2014	8.67	8.69	64	66.4	9.54	9.28
9/19/2014	8.6	8.7	64.1	66.3	9.53	9.29
9/22/2014	8.57	8.68	64.2	66	9.52	9.33
9/23/2014	8.58	8.7	64	65	9.54	9.43
9/24/2014	8.52	8.67	64	65.2	9.54	9.41
9/25/2014	8.47	8.7	64.1	64.7	9.53	9.46
9/26/2014	8.7	8.71	63.5	64	9.59	9.54
9/29/2014	8.68	8.7	63.4	64.1	9.61	9.53
9/30/2014	8.65	8.72	63.1	64.2	9.64	9.52
10/1/2014	8.6	8.8	65.1	64.6	9.42	9.47
10/2/2014	8.58	8.83	65	64.5	9.43	9.49
10/3/2014	8.6	8.9	65.1	64.5	9.42	9.49
10/6/2014	8.6	8.92	64.7	64	9.46	9.54
10/7/2014	8.58	8.79	64.3	63.7	9.51	9.57
10/8/2014	8.57	8.82	64	63.1	9.54	9.64
10/9/2014	8.6	8.9	63.7	63	9.57	9.65
10/10/2014	8.51	8.96	62.7	62.2	9.68	9.74
10/13/2014	9.17	9.04	62.4	62	9.72	9.76
10/14/2014	9.04	9.01	62	61.5	9.76	9.82
10/15/2014	9.61	6.93	54.6	55.6	10.68	10.55
10/16/2014	8.9	8.4	55.4	57.2	10.57	10.34
10/17/2014	8.73	9.57	55.3	57.3	10.59	10.33
10/20/2014	8.78	8.95	55.1	57.3	10.61	10.33
10/21/2014	8.75	9.04	54.8	57.4	10.65	10.31
10/22/2014	8.8	9.1	54.9	56.6	10.64	10.42
10/23/2014	8.83	9.12	55.2	56.9	10.60	10.38
10/24/2014	8.9	9.14	55.3		10.59	
10/27/2014		8.92	56.3		10.45	
10/28/2014		9.51	53.8		10.79	
11/1/2014	9.6	9.7	57.1	57.5	10.35	10.30
11/4/2014	9.58	9.71	57.2	57.7	10.34	10.28
11/5/2014	9.56	9.72	57.1	57.8	10.35	10.26
11/6/2014	9.5	9.68	56.8	56.1	10.39	10.48
11/7/2014	9.93	9.96	49.9	51	11.34	11.18
11/8/2014	10.19	10.26	53	52.2	10.90	11.01
11/11/2014	10.43	10.09	53	54	10.90	10.76
11/12/2014	10.41	10.06	53	53.2	10.90	10.87
11/13/2014	10.43	10.09	52.9	53.4	10.91	10.84
11/14/2014	10.4	10.04	52.4	53.3	10.98	10.86
11/15/2014	10.47	9.72	54	54	10.76	10.76
11/18/2014	10.45	9.8	53.7	53.6	10.80	10.81
11/19/2014	10.47	9.82	53.7	53.4	10.80	10.84
11/20/2014	10.43	9.8	53.1	52.9	10.88	10.91
11/21/2014	10.4	9.8	49.9	50.3	11.34	11.28
11/22/2014	10.41	9.86	49.6	50.2	11.39	11.30
11/25/2014	10.45	10.53	49.1	50.3	11.46	11.28
11/26/2014	10.47	10.5	49	50.6	11.48	11.24
11/27/2014	11.7	11.25	38.7	40.7	13.26	12.88
11/29/2014	11.67	11.38	44.6	44.6	12.18	12.18
12/1/2014	11.2	12.3	38.7	37	13.26	13.60
12/2/2014	11.27	12.2	38.7	37	13.26	13.60
12/3/2014	11.4	12.25	38.7	36.4	13.26	13.72
12/4/2014	11.36	12.37	38.5	36.5	13.30	13.70
12/5/2014	11.35	12.39	38.5	36.5	13.30	13.70
12/8/2014	11.4	11.72	38	36.1	13.40	13.78
12/9/2014	11.5	11.57	38.1	36.3	13.38	13.74
12/10/2014	11.53	12	37.3	36.9	13.54	13.62
12/11/2014	11.43	12.1	37.5	37	13.50	13.60
12/12/2014	11.4	11.93	37.4	37.1	13.52	13.58
12/15/2014	11.41	11.97	37.1	36.6	13.58	13.68
12/16/2014	11.39	12.04	37.2	36.5	13.56	13.70
12/17/2014	11.5	12.17	36.4	36.8	13.72	13.64
12/18/2014	11.37	12.01	36.5	37	13.70	13.60
12/19/2014	11.4	12.1	37.4	37	13.52	13.60
12/22/2014	11.3	12.02	37.4	37.1	13.52	13.58
12/23/2014	11.28	11.94	37.3	36.9	13.54	13.62
12/24/2014	11.4	11.97	37.1	36.7	13.58	13.66
12/26/2014	11.41	12.1	37.2	37.7	13.56	13.46
12/27/2014	11.5	12.12	36.8	37.4	13.64	13.52
12/29/2014	11.41	11.92	36.4	37.4	13.72	13.52
12/30/2014	11.38	11.74	36.7	37.4	13.66	13.52
12/31/2014	11.4	11.8	36.4	37.7	13.72	13.46
1/2/2015	11	11.7	36	37.4	13.80	13.52
1/3/2015	11.1	11.7	35.4	37	13.93	13.60
1/5/2015	11.12	11.74	35.4	36.5	13.93	13.70
1/6/2015	11.1	11.7	35.5	36.3	13.91	13.74
1/7/2015	11.2	11.7	35	36.4	14.01	13.72
1/8/2015	11.25	12.2	34.1	35.7	14.21	13.87
1/9/2015	11.2	12.18	34	35.4	14.23	13.93
1/12/2015	10.85	11.15	34.5	35.4	14.12	13.93

Table C.4 continued.

	Raw				Calculated	
	DO		Temp		DO Saturation	
	P	S	P	S	P	S
Date	mg L^{-1}		°F		mg L-1	
1/13/2015	10.7	11.4	34.6	35.5	14.10	13.91
1/14/2015	10.77	12.1	34.4	35.4	14.14	13.93
1/15/2015	10.87	12.35	34.2	35.4	14.19	13.93
1/16/2015	10.85	12.38	34	35.2	14.23	13.97
1/19/2015	10.9	12.4	34.5	35.4	14.12	13.93
1/20/2015	10.95	12.44	34.4	35.5	14.14	13.91
1/21/2015	11.03	12.4	34.7	35.3	14.08	13.95
1/22/2015	11.12	12.25	34.6	35	14.10	14.01
1/23/2015	11.1	12.2	34.5	34.9	14.12	14.04
1/26/2015	11.12	12.21	34.5	35.2	14.12	13.97
1/27/2015	11.1	12.2	34.4	35.3	14.14	13.95
1/28/2015	11.17	12.18	33.6	35.1	14.32	13.99
1/29/2015	11.15	12.2	33.7	35.2	14.30	13.97
1/30/2015	11.2	12.17	33.2	35	14.41	14.01
2/2/2015	11.4	12.21	32.7	34.3	14.52	14.17
2/3/2015	11.44	12.27	32.6	33.8	14.55	14.28
2/4/2015	11.4	12.22	32.7	33.5	14.52	14.34
2/5/2015	11.42	12.2	32.9	33.3	14.48	14.39
2/6/2015	11.4	12.2	33.1	33.5	14.43	14.34
2/9/2015	11.44	12.15	32.7	33.4	14.52	14.36
2/10/2015	11.3	12.2	32.4	33.1	14.59	14.43
2/11/2015	11.47	12.28	32.6	33.4	14.55	14.36
2/12/2015	11.5	12.3	32.4	33.1	14.59	14.43
2/13/2015	11.6	12.69	32.3	32.6	14.61	14.55
2/16/2015	11.54	13.02	32	32.5	14.68	14.57
2/17/2015	12.1	12.6	32.4	32.7	14.59	14.52
2/18/2015	11.84	12.91	32.1	32.4	14.66	14.59
2/19/2015	11.93	13.29	32.1	32.2	14.66	14.64
2/23/2015	11.97	2.79	32.1	32.3	14.66	14.61
2/24/2015	11.61	3.12	32.1	32.2	14.66	14.64
2/25/2015	11.75	4.15	34	32.8	14.23	14.50
2/26/2015	11.91	5.07	32.1	32.8	14.66	14.50
2/27/2015	9.86	5.84	33.1	32.5	14.43	14.57
3/2/2015	10.11	7.12	33	32.7	14.45	14.52
3/3/2015	10.08	6.48	33.2	32.6	14.41	14.55
3/4/2015	9.71	6.63	33	33.4	14.45	14.36
3/5/2015	9.4	6.74	33	32.9	14.45	14.48
3/6/2015	9.02	6.8	33.9	34.5	14.25	14.12
3/9/2015	8.94	6.69	34.2	34.9	14.19	14.04
3/10/2015	10.12	9.47	34.3	34.9	14.17	14.04
3/11/2015	9.1	11.47	34.4	35.1	14.14	13.99
3/12/2015	9.05	4.7	34.6	35.8	14.10	13.84
3/13/2015	8.88	8.2	36.4	37.8	13.72	13.44
3/16/2015	9.08	9.59	36.4	37.4	13.72	13.52
3/17/2015	11.98	9.61	39.4	37.6	13.12	13.48
3/18/2015	12	9.6	40.1	37.9	12.99	13.42
3/19/2015	11.96	9.57	40.1	37.6	12.99	13.48
3/20/2015	11.94	9.58	41.2	37.9	12.78	13.42
3/23/2015	12.01	9.6	42.1	39.8	12.62	13.05
3/24/2015	11.97	9.63	42.7	40.4	12.51	12.93
3/25/2015	12.06	9.7	43.2	41.7	12.43	12.69
3/26/2015	12.04	9.65	43.4	42.5	12.39	12.55
3/27/2015	12	9.53	43.5	42.9	12.37	12.48
3/30/2015	11.92	9.44	43.4	43.1	12.39	12.44
3/31/2015	11.5	9.78	44.7	48	12.17	11.63
4/1/2015	10	1.051	53.3	50.1	10.86	11.31
4/2/2015	10.02	10.5	53.2	50	10.87	11.33
4/3/2015	9.97	10.5	53.1	49.5	10.88	11.40
4/6/2015	10.04	10.51	53.4	50.4	10.84	11.27
4/7/2015	9.8	10.27	54.4	52.1	10.71	11.02
4/8/2015	9.71	10.25	55.2	53.1	10.60	10.88
4/9/2015	9.7	10.2	55.1	53	10.61	10.90
4/10/2015	9.82	10.3	55.4	53	10.57	10.90
4/13/2015	9.8	10.33	55.8	52.9	10.52	10.91
4/14/2015	9.8	10.4	56	53.7	10.49	10.80
4/15/2015	9.83	10.35	56.1	53.8	10.48	10.79
4/16/2015	9.9	10.3	56.3	54	10.45	10.76
4/17/2015	9.87	10.32	56.1	54.3	10.48	10.72
4/20/2015	9.9	10.4	56	54.4	10.49	10.71
4/21/2015	9.88	10.39	56.2	54.3	10.47	10.72
4/22/2015	9.91	10.44	56	54.4	10.49	10.71
4/23/2015	9.89	10.42	56	54.7	10.49	10.66
4/24/2015	9.87	10.4	56.1	54.7	10.48	10.66
4/27/2015	9.64	10.37	57.3	55.2	10.33	10.60
4/28/2015	9.7	10.4	57.3	55.4	10.33	10.57
4/29/2015	9.66	10.43	57.5	55.5	10.30	10.56
4/30/2015	9.6	10.4	57.3	55.6	10.33	10.55
5/1/2015	9.7	10.55	57	55.7	10.37	10.53
5/4/2015	9.75	10.5	56.1	55.5	10.48	10.56
5/5/2015	8.12	8.57	59.4	60.2	10.07	9.97
5/6/2015	8.12	8.65	61.5	63.1	9.82	9.64
5/7/2015	8.04	8.63	62.1	63.5	9.75	9.59

Table C.4 continued.

	Raw				Calculated	
	DO		Temp		DO Saturation	
	P	S	P	S	P	S
Date	mg L^{-1}		°F		mg L-1	
5/8/2015	8.1	8.6	62	63.7	9.76	9.57
5/11/2015	8.14	8.8	61.3	63.5	9.84	9.59
5/12/2015	8.2	8.84	61.4	63.4	9.83	9.61
5/13/2015	8.27	9.04	60.3	63	9.96	9.65
5/14/2015	8.3	9.1	59.6	62.1	10.04	9.75
5/15/2015	8.3	9.17	60.2	62.7	9.97	9.68
5/18/2015	8.22	9.1	61	62.9	9.88	9.66
5/19/2015	9.11	9.6	61.3	63	9.84	9.65
5/20/2015	9.2	9.7	61.3	63.1	9.84	9.64
5/21/2015	9.22	9.7	61.6	63	9.81	9.65
5/22/2015	9.25	9.69	61.4	63.2	9.83	9.63
5/26/2015	9.27	9.71	62	63.4	9.76	9.61
5/27/2015	8.98	9.24	63.2	64.1	9.63	9.53
5/28/2015	8.9	9.3	63.7	64.1	9.57	9.53
5/29/2015	8.71	9.16	64.3	65	9.51	9.43
6/1/2015	7.91	8.44	67.1	67.4	9.21	9.18
6/2/2015	7.9	8.42	67.6	68.1	9.16	9.11
6/3/2015	7.91	8.4	69.1	69.9	9.01	8.93
6/4/2015	7.9	8.37	70.4	70.9	8.88	8.84
6/5/2015	7.86	8.4	70.7	70.9	8.85	8.84
6/8/2015	7.83	8.42	71	71.4	8.83	8.79
6/9/2015	7.81	8.4	69.1	70.3	9.01	8.89
6/10/2015	7.82	8.36	69.4	70.4	8.98	8.88
6/11/2015	7.9	8.3	69.2	70.6	9.00	8.86
6/12/2015	7.87	8.33	70.3	71.1	8.89	8.82
6/15/2015	7.88	8.36	71.1	72	8.82	8.73
6/16/2015	7.88	8.4	70.9	72	8.84	8.73
6/17/2015	7.9	8.4	72	72.8	8.73	8.66
6/18/2015	7.87	8.41	72	72.9	8.73	8.65
6/19/2015	7.88	8.4	72.3	72.9	8.70	8.65
6/22/2015	7.87	8.4	72.8	73.2	8.66	8.62
6/23/2015	7.85	8.42	72.8	73.4	8.66	8.60
6/24/2015	7.8	8.39	73	73.5	8.64	8.59
6/25/2015	7.8	8.4	72.8	73.4	8.66	8.60
6/26/2015	7.84	8.42	73	73.6	8.64	8.58
6/29/2015	7.8	8.31	73.3	73.7	8.61	8.58
6/30/2015	8.1	8.37	73	73.5	8.64	8.59
7/1/2015	8.23	8.44	73.5	74.2	8.59	8.53
7/2/2015	8.21	8.45	73.4	74.1	8.60	8.54
7/6/2015	8.27	8.6	73.6	74.4	8.58	8.51
7/7/2015	7.53	8.12	75.7	74.3	8.40	8.52
7/8/2015	7.51	8.14	75.9	74.3	8.38	8.52
7/9/2015	7.54	8.2	75.6	74.4	8.41	8.51
7/10/2015	7.6	8.18	75.6	74.5	8.41	8.50
7/13/2015	7.65	7.98	76	75.2	8.37	8.44
7/14/2015	7.6	8.13	76.1	75	8.36	8.46
7/15/2015	7.66	8.2	76.4	74.8	8.34	8.48
7/16/2015	7.6	8.21	76.6	75.2	8.32	8.44
7/17/2015	7.63	8.27	76.4	75.2	8.34	8.44
7/20/2015	7.6	8.3	77	75.6	8.29	8.41
7/21/2015	7.6	8.31	77	75.4	8.29	8.42
7/22/2015	7.6	8.27	77.3	75.6	8.26	8.41
7/23/2015	7.6	8.3	77.4	75.9	8.25	8.38
7/24/2015	7.61	8.27	77.6	76.2	8.24	8.35
7/27/2015	7.6	8.2	78.1	76.4	8.19	8.34
7/28/2015	7.57	8.21	78	76.3	8.20	8.35
7/29/2015	7.56	8.24	77.4	76.4	8.25	8.34
7/30/2015	7.5	8.26	77.5	76.4	8.24	8.34
7/31/2015	7.52	8.26	77.6	76.4	8.24	8.34
8/3/2015	8.27	8.4	76.1	74.7	8.36	8.49
8/4/2015	8.26	8.37	75.4	74	8.42	8.55
8/5/2015	8.2	8.42	75.6	74	8.41	8.55
8/6/2015	8.1	8.08	76.1	74.7	8.36	8.49
8/7/2015	8.2	8	76.4	75	8.34	8.46
8/10/2015	8.24	8.1	76.3	74.8	8.35	8.48
8/11/2015	8.2	8.21	76.4	75	8.34	8.46
8/12/2015	8.3	8.19	76.3	75.3	8.35	8.43
8/13/2015	8.22	8.17	76.2	75.3	8.35	8.43
8/14/2015	8.2	8.13	76.4	75.2	8.34	8.44
8/17/2015	8.2	8.13	76.4	75.2	8.34	8.44
8/18/2015	8.21	8.17	76.7	75.3	8.31	8.43
8/19/2015	8.24	8.14	76	75.1	8.37	8.45
8/20/2015	8.24	8.17	75.4	74.1	8.42	8.54
8/21/2015	8.2	8.21				
8/24/2015	8.2	8.17	75.3	74.2	8.43	8.53
8/25/2015	8.24	8.2				
8/26/2015	8.27	8.22	75	73.9	8.46	8.56
8/27/2015	8.21	8.23	74.6	73	8.49	8.64
8/28/2015	8.3	8.14				
8/31/2015	8.32	8.17	74	73.1	8.55	8.63
9/1/2015	8.3	8.2	74.1	74.3	8.54	8.52
9/2/2015	8.3	8.17	74.2	73.5	8.53	8.59

Table C.4 continued.

	Raw				Calculated	
	DO		Temp		DO Saturation	
	P	S	P	S	P	S
Date	mg L^{-1}		°F		mg L-1	
9/3/2015	8.27	8.2				
9/4/2015	8.3	8.21	74	73.1	8.55	8.63
9/5/2015	8.32	8.2				
9/8/2015	8.3	8.21	73.6	72.1	8.58	8.72
9/9/2015	8.31	8.17				
9/10/2015	8.33	8.2	74	93.2	8.55	7.08
9/11/2015	8.31	8.22				
9/14/2015	8.3	8.24	74	73.3	8.55	8.61
9/15/2015	8.3	8.2	74.6	73.3	8.49	8.61
9/16/2015	8.32	8.19				
9/17/2015	8.3	8.24				
9/18/2015	8.29	8.2	72	73.7	8.73	8.58
9/22/2015	8.31	8.2				
9/23/2015	8.3	8.2	70.9	73	8.84	8.64
9/24/2015	8.31	8.22				
9/25/2015	8.3	8.2	70.1	72	8.91	8.73
9/28/2015	8.27	8.23				
9/29/2015	8.3	8.2	68.6	69.4	9.06	8.98
9/30/2015	8.25	8.23				
10/1/2015	8.24	8.2	70.1	71	8.91	8.83
10/2/2015	8.25	8.21				
10/5/2015	8.3	8.2	67.2	68.3	9.20	9.09
10/6/2015	8.33	8.21				
10/7/2015	8.3	8.24	63.4	64.5	9.61	9.49
10/8/2015	8.3	8.23				
10/9/2015	8.31	8.22	62.3	63.9	9.73	9.55
10/12/2015	8.3	8.23				
10/13/2015	8.3	8.59	60.6		9.93	
10/14/2015	8.36	8.6	60.4		9.95	
10/15/2015	8.37	8.58	60.1		9.98	
10/16/2015		8.6				
10/19/2015		9.06	57.5		10.30	
10/20/2015		9.05	57.5		10.30	
10/21/2015		9.32	56		10.49	
10/22/2015		9.3	56.2		10.47	
10/23/2015		9.19	54.8		10.65	
10/26/2015		9.02	54.2		10.73	
10/27/2015		9.11	54		10.76	
10/28/2015		9.1	53.7		10.80	
10/29/2015		9.11	53.5		10.83	
10/30/2015		9.04	57.2		10.34	
11/2/2015		9.71	56.4		10.44	
11/3/2015		9.7	56.3		10.45	
11/4/2015		9.73	56.2		10.47	
11/5/2015		9.7	54		10.76	
11/6/2015		9.61	52.9		10.91	
11/9/2015		9.63	52.1		11.02	
11/10/2015		9.6	51.9		11.05	
11/12/2015		9.71	52		11.04	
11/13/2015		9.77	51.2		11.15	
11/16/2015		9.8	51.4		11.12	
11/17/2015		9.83	50.6		11.24	
11/18/2015		9.81				
11/19/2015		9.87	50.7		11.22	
11/20/2015		9.83	51		11.18	
11/23/2015		9.81	51.3		11.14	
11/24/2015		9.77	50		11.33	
11/25/2015		9.7	49.4		11.42	
12/1/2015	9.1	10.8	52.3	51.5	10.99	11.11
12/2/2015	9	10.9	50.4	51.2	11.27	11.15
12/3/2015	8.97	11	50.3	51.2	11.28	11.15
12/4/2015	8.92	11.12	50.4	51.3	11.27	11.14
12/7/2015	8.9	11.1	51	51.6	11.18	11.09
12/8/2015	8.93	11.1	51.2	51.7	11.15	11.08
12/9/2015	8.9	11.01	51.1	51.6	11.17	11.09
12/10/2015	8.92	10.53	50.4	51.5	11.27	11.11
12/11/2015	9.03	10.5	49.7	48.7	11.37	11.52
12/14/2015	9	10.55	49.6	49	11.39	11.48
12/15/2015	9.17	11	49	49.7	11.48	11.37
12/16/2015	9.3	11.1	48.3	49	11.59	11.48
12/17/2015	9.27	11.04	48.1	49	11.62	11.48
12/18/2015	9.25	11	48.1	49	11.62	11.48
12/21/2015	9.22	11.03	47.8	48.7	11.66	11.52
12/22/2015	9.24	11.02	47.4	48.4	11.73	11.57
12/23/2015	9.24	11.04	47.7	48.5	11.68	11.56
12/24/2015	9.2	11.1	47.1	48.3	11.77	11.59
12/25/2015	9.21	11.11	47	48.2	11.79	11.60
12/28/2015	9.17	11.04	47	48.3	11.79	11.59
12/29/2015	9.21	11	46.4	47.9	11.89	11.65
12/30/2015	9.22	11.1	46	47.4	11.95	11.73
1/4/2016		10.14				
1/6/2016			44.2		12.25	

Table C.4 continued.

	Raw				Calculated	
	DO		Temp		DO Saturation	
	P	S	P	S	P	S
Date	mg L^{-1}		°F		mg L-1	
1/8/2016		10.3				
1/11/2016						
1/13/2016						
1/15/2016		11.1				
1/19/2016			37.2		13.56	
1/21/2016		10.74				
1/25/2016						
1/27/2016		10.6				
1/29/2016						
2/1/2016		10.92				
2/3/2016						
2/5/2016						
2/8/2016		10.62				
2/10/2016						
2/12/2016						
2/15/2016		10.7				
2/17/2016						
2/19/2016						
2/22/2016		10.58				
2/24/2016						
2/26/2016		10.6				
3/1/2016		13.04				
3/4/2016						
3/7/2016		12.94				
3/10/2016						
3/12/2016		12.88				
3/15/2016			37.5		13.50	
3/17/2016						
3/21/2016		12.6				
3/23/2016						
3/25/2016		12.41	38.3		13.34	
3/28/2016						
3/31/2016		12.1				
4/1/2016		12.81	43.2		12.43	
4/4/2016						
4/6/2016		12.3	45		12.12	
4/8/2016						
4/11/2016		11.91	47.2		11.76	
4/14/2016						
4/18/2016		12.04	52.1		11.02	
4/20/2016						
4/22/2016		11.84	53.3		10.86	
4/27/2016		11.76	55.2		10.60	
4/29/2016						
5/2/2016		10.2				
5/9/2016		10.21	59.4		10.07	
5/12/2016						
5/16/2016		11.01				
5/18/2016						
5/20/2016		11.15		59.4		10.07
5/23/2016						
5/25/2016		11.34				
5/27/2016						
5/30/2016						
6/1/2016		10.68				
6/3/2016						
6/7/2016		10.6				
6/9/2016						
6/13/2016		10.47		67.1		9.21
6/15/2016						
6/18/2016		10.5		67.4		9.18
6/21/2016						
6/23/2016		11.1				
6/27/2016						
6/29/2016		10.9				
7/1/2016		10.23				
7/4/2016			70.2		8.90	
7/6/2016		10.31				
7/9/2016						
7/12/2016		10.35				
7/14/2016						
7/16/2016		10.4				
7/18/2016			73.3		8.61	
7/21/2016		10.42				
7/25/2016				72.4		8.69
7/27/2016		10.31				
7/29/2016						
8/1/2016						
8/3/2016		10.42				
8/5/2016			75.1		8.45	
8/8/2016						
8/10/2016	10.44	10.54				

Table C.4 continued.

	Raw				Calculated	
	DO		Temp		DO Saturation	
	P	S	P	S	P	S
Date	mg L^{-1}		°F		mg L-1	
8/13/2016						
8/16/2016		10.61		74.8		8.48
8/19/2016						
8/22/2016		10.69				
8/24/2016						
8/26/2016						
8/29/2016	10.9	11.04				
9/2/2016		17.12				
9/5/2016						
9/7/2016		11.1				
9/10/2016			71.3		8.80	
9/13/2016		10.9				
9/16/2016			70.6		8.86	
9/21/2016		11.14				
9/24/2016			70.5		8.87	
9/26/2016		10.91				
9/28/2016						
9/30/2016		11.04	68.1		9.11	
10/3/2016		10.9	64.3	65.7	9.51	9.36
10/5/2016						
10/7/2016						
10/10/2016		10.81	63.1		9.64	
10/12/2016						
10/14/2016						
10/17/2016		10.9	60		10.00	
10/25/2016		10.9	61.1		9.87	
10/27/2016						
10/30/2016				62.3		9.73
11/3/2016		10.8				
11/8/2016	10.74					
11/10/2016				55		10.62
11/14/2016		10.8				
11/16/2016			54.2		10.73	
11/18/2016		10.66				
11/21/2016			54.1		10.75	
11/23/2016						
11/25/2016		10.7	52.6		10.95	
11/28/2016						
12/1/2016		10.4	50.2		11.30	
12/3/2016						
12/5/2016						
12/7/2016		10.4	47.7		11.68	
12/9/2016						
12/12/2016		10.5	46.1		11.94	
12/14/2016						
12/16/2016		10.44				
12/19/2016			44.3		12.24	
12/22/2016		10.53				
12/26/2016						
12/29/2016		10.6	41.1		12.80	

Table C.5 Monthly mean primary SAGR alkalinity calculated based on data shown in Table C6 and used to make Figure 2.7.

	Monthly Mean Primary SAGR Alkalinity	
	Demand	Measured
Date	(mg-$CaCO_3$ L^{-1})	
April 2014	46.49	208
July 2014	20.64	182
September 2014	7.40	186
October 2014	23.81	237
November 2014	64.26	196
December 2014	38.23	237
January 2015	32.76	341
February 2015	60.62	328
March 2015	68.61	221
April 2015	61.01	259
May 2015	51.49	251
June 2015	38.88	246
July 2015	21.59	226
August 2015	10.50	230
September 2015	31.75	265
December 2015	37.93	218

Table C.6 Raw, censored, and calculated data used to calculate the alkalinity demand from operator (O) data and compare it to measured certified lab (CL) data and create Table C5. Ammonia was censored to 0.5 mg L^{-1}. Primary and secondary SAGRs are denoted by P and S, respectively.

	Raw O Data into						Censored O Data into								Raw CL Data
	P	S	P	S	P	S	P	S	P	S	P	S	P-S	P Demand	P
	NH_3		pH		Temp.		NH_3		Temp.		NH_4^+			Alkalinity	
Date	mg-N L^{-1}		units		°F		mg-N L^{-1}		°F		mg-N L^{-1}			mg-$CaCO_3$ L^{-1}	
4/2/2014	9.99	0.22	9.07	9.44	37.1	39.9	9.99	0.5	39.9	37.1	8.87	0.17	8.70	61.37	
4/3/2014	9.99	0	8.88	9.4	41.2	38.8	9.99	0.5	38.8	41.2	9.10	0	9.10	64.17	
4/4/2014	9.99	0	8.54	9.3	41	40.5	9.99	0.5	40.5	41	9.57	0	9.57	67.45	
4/7/2014	9.99	0.11	8.83	8.63	51.3	47.7	9.99	0.5	47.7	51.3	8.80	0.10	8.70	61.33	
4/8/2014	9.99	0	8.74	8.69	51.5	48	9.99	0.5	48	51.5	8.99	0	8.99	63.40	
4/9/2014	9.99	0	8.7	8.62	51.4	48.2	9.99	0.5	48.2	51.4	9.08	0	9.08	63.99	
4/10/2014	9.99	0	8.75	8.66	52.1	48.7	9.99	0.5	48.7	52.1	8.95	0	8.95	63.09	
4/11/2014	9.99	0	8.7	8.63	51.3	48.1	9.99	0.5	48.1	51.3	9.08	0	9.08	64.01	
4/14/2014	9.2	0	8.7	8.63	51.2	48.2	9.2	0.5	48.2	51.2	8.37	0	8.37	58.98	
4/15/2014	8.74	0	8.67	8.6	50.4	47.7	8.74	0.5	47.7	50.4	8.02	0	8.02	56.53	
4/16/2014	8.21	0	8.64	8.57	50.6	48.2	8.21	0.5	48.2	50.6	7.57	0	7.57	53.36	222
4/17/2014	7.29	0	8.6	8.54	50.4	47.2	7.29	0.5	47.2	50.4	6.77	0	6.77	47.74	
4/18/2014	7.19	0	8.6	8.49	49.1	47.3	7.19	0.5	47.3	49.1	6.70	0	6.70	47.27	
4/21/2014	8.34	0.08	8.75	8.94	59.7	54.9	8.34	0.5	54.9	59.7	7.19	0.06	7.12	50.23	
4/22/2014	7.1	0.08	8.75	8.64	57.8	57	7.1	0.5	57	57.8	6.18	0.07	6.11	43.10	
4/23/2014	6.02	0.14	8.76	8.49	57.9	57.6	6.02	0.5	57.6	57.9	5.23	0.13	5.10	35.93	
4/24/2014	4.27	0.2	8.78	8.26	58.1	57.6	4.27	0.5	57.6	58.1	3.68	0.19	3.49	24.59	
4/25/2014	3.06	0.44	8.78	8.26	58.3	57.9	3.06	0.5	57.9	58.3	2.63	0.42	2.21	15.61	
4/28/2014	3.1	0.4	8.91	8.87	56.1	57.6	3.1	0.5	57.6	56.1	2.58	0.34	2.25	15.84	
4/29/2014	2.4	0.41	8.9	8.89	53.1	57.2	2.4	0.5	57.2	53.1	2.05	0.35	1.70	11.97	
4/30/2014	1.02	0	8.84	8.88	50.2	52.1	1.02	0.5	52.1	50.2	0.90	0	0.90	6.35	194
5/1/2014	0.71	0	8.91	8.88	46.9	49.2	0.71	0.5	49.2	46.9	0.63	0	0.63	4.41	
5/2/2014	0.88	0	8.62	9.04	49.1	49.6	0.88	0.5	49.6	49.1	0.82	0	0.82	5.77	
5/6/2014	0.27	0.05	8.78	8.8	57.1	54.4	0.5	0.5	54.4	57.1	0.23	0.04	0.19	1.35	
5/7/2014	0	0	9.13	8.88	55.8	55.1	0.5	0.5	55.1	55.8		0			
5/8/2014	0.25	0	8.76	8.65	63.3	56.4	0.5	0.5	56.4	63.3	0.21	0	0.21	1.48	
5/9/2014	0.21	0	8.68	9.04	54.6	54.8	0.5	0.5	54.8	54.6	0.19	0	0.19	1.33	
5/12/2014	0.24	0	8.62	8.94	53.8	54	0.5	0.5	54	53.8	0.22	0	0.22	1.55	
5/13/2014	0.22	0	8.64	8.97	53	53.8	0.5	0.5	53.8	53	0.20	0	0.20	1.42	
5/14/2014	0.3	0	8.65	8.7	53.4	54.3	0.5	0.5	54.3	53.4	0.27	0	0.27	1.93	
5/15/2014	0.57	0	8.64	8.51	53.8	56.6	0.57	0.5	56.6	53.8	0.52	0	0.52	3.66	
5/16/2014	0.86	0	8.67	8.32	53.1	56.7	0.86	0.5	56.7	53.1	0.78	0	0.78	5.51	
5/20/2014	0.7	0	9.19	9.39	61	59.2	0.7	0.5	59.2	61	0.48	0	0.48	3.37	
5/21/2014	0.74	0.13	9.14	8.91	66	60.9	0.74	0.5	60.9	66	0.49	0.10	0.39	2.75	
5/22/2014	0.069	0.84	9.19	8.89	66.5	60.1	0.5	0.84	60.1	66.5	0.04	0.65	-0.61	-4.28	
5/26/2014	1.06	0.26	9.18	8.81	69.4	66	1.06	0.5	66	69.4	0.65	0.20	0.44	3.12	
5/27/2014	1.38	0.07	9.2	8.82	70.9	66.6	1.38	0.5	66.6	70.9	0.81	0.05	0.75	5.30	
5/28/2014	1.58	0	9.05	8.77	72.7	68.9	1.58	0.5	68.9	72.7	1.03	0	1.03	7.23	
5/29/2014	2.35	0	9.05	8.79	72.5	70.6	2.35	0.5	70.6	72.5	1.53	0	1.53	10.78	
5/30/2014	2.62	0.72	8.82	8.68	72.6	71.4	2.62	0.72	71.4	72.6	1.99	0.59	1.40	9.90	
6/2/2014	2.72	0.7	8.8	8.67	71.4	71.6	2.72	0.7	71.6	71.4	2.11	0.58	1.53	10.81	
6/3/2014	3.1	0.72	8.82	8.7	71	71.4	3.1	0.72	71.4	71	2.39	0.59	1.80	12.70	
6/4/2014	3.2	0.6	8.8	8.7	71.7	72.3	3.2	0.6	72.3	71.7	2.48	0.49	1.99	14.02	
6/5/2014	3.1	0.64	8.78	8.72	72.5	72.4	3.1	0.64	72.4	72.5	2.41	0.51	1.90	13.36	
6/6/2014	5.6	0	8.23	8.44	68.4	70.4	5.6	0.5	70.4	68.4	5.24	0	5.24	36.93	
6/9/2014	5.76	0	8.2	8.44	68.6	70.3	5.76	0.5	70.3	68.6	5.41	0	5.41	38.13	

Table C.6 continued.

	Raw O Data into						Censored O Data into								Raw CL Data
	P	S	P	S	P	S	P	S	P	S	P	S	P-S	P Demand	P
	NH_3		pH		Temp.		NH_3		Temp.		NH_4^+			Alkalinity	
Date	mg-N L^{-1}		units		°F		mg-N L^{-1}		°F		mg-N L^{-1}			mg-$CaCO_3$ L^{-1}	
6/10/2014	5.22	0	8.18	8.43	66.4	69.6	5.22	0.5	69.6	66.4	4.94	0	4.94	34.83	
6/11/2014	5.04	0	8.17	8.5	68.2	69.6	5.04	0.5	69.6	68.2	4.76	0	4.76	33.53	
6/12/2014	5.1	0	8.14	8.5	68	69.4	5.1	0.5	69.4	68	4.83	0	4.83	34.08	
6/13/2014	5.21	0	8.1	8.4	67.5	69	5.21	0.5	69	67.5	4.97	0	4.97	35.00	
6/16/2014	5.28	0	8.16	8.3	68	69.2	5.28	0.5	69.2	68	4.99	0	4.99	35.19	
6/17/2014	6.04	0	8.22	8.31	68.4	70.2	6.04	0.5	70.2	68.4	5.66	0	5.66	39.89	
6/18/2014	5.22	0	8.18	8.27	69	69.8	5.22	0.5	69.8	69	4.91	0	4.91	34.62	
6/19/2014	5.23	0	8.18	8.23	70	69.7	5.23	0.5	69.7	70	4.91	0	4.91	34.60	
6/20/2014	4.9	0	8.15	8.2	69.1	69.5	4.9	0.5	69.5	69.1	4.63	0	4.63	32.62	
6/23/2014	4.74	0	8.1	8.21	68.7	69.3	4.74	0.5	69.3	68.7	4.51	0	4.51	31.77	
6/24/2014	4.76	0	8.12	8.26	68.2	69.1	4.76	0.5	69.1	68.2	4.52	0	4.52	31.87	
6/25/2014	4.8	0	8.1	8.2	68	68.6	4.8	0.5	68.6	68	4.57	0	4.57	32.22	
6/26/2014	4.87	0	8.12	8.27	68	68.3	4.87	0.5	68.3	68	4.63	0	4.63	32.62	
6/27/2014	5.02	0	8.14	8.24	68.2	68.8	5.02	0.5	68.8	68.2	4.76	0	4.76	33.53	
6/30/2014	5	0	8.1	8.17	68	68.6	5	0.5	68.6	68	4.76	0	4.76	33.56	
7/1/2014	4.9	0	8.18	8.2	70.4	71	4.9	0.5	71	70.4	4.59	0	4.59	32.39	
7/2/2014	4.84	0	8.17	8.2	70.1	70.9	4.84	0.5	70.9	70.1	4.55	0	4.55	32.06	
7/3/2014	4.83	0	8.15	8.21	69.9	70.6	4.83	0.5	70.6	69.9	4.55	0	4.55	32.10	
7/7/2014	5	0	8.2	8.2	70.4	70.6	5	0.5	70.6	70.4	4.67	0	4.67	32.95	
7/8/2014	3.1	0	8.43	8.5	71.4	71.7	3.1	0.5	71.7	71.4	2.76	0	2.76	19.46	
7/9/2014	2.02	0	8.51	8.7	72.1	72.5	2.02	0.5	72.5	72.1	1.75	0	1.75	12.36	184
7/10/2014	0.42	0	8.74	8.7	72.6	73	0.5	0.5	73	72.6	0.33	0	0.33	2.34	
7/12/2014	0.26	0.02	8.53	8.9	75.1	75.8	0.5	0.5	75.8	75.1	0.22	0.01	0.21	1.45	
7/13/2014	0	0	8.51	8.89	75.5	76	0.5	0.5	76	75.5		0			
7/14/2014	0	0	8.55	8.91	75.9	76.1	0.5	0.5	76.1	75.9		0			
7/15/2014	0	0	8.54	8.9	75.8	76	0.5	0.5	76	75.8		0			
7/16/2014	0	0	8.52	8.92	75.9	76.1	0.5	0.5	76.1	75.9		0			
7/18/2014									*58.16*	*57.48*					
7/19/2014	0	0	8.54	8.9	76.1	76	0.5	0.5	76	76.1		0			
7/20/2014	0	0	8.54	8.96	76	75.9	0.5	0.5	75.9	76		0			
7/21/2014	0	0	8.54	8.83	76.1	76.3	0.5	0.5	76.3	76.1		0			
7/22/2014	0	0	8.55	8.8	76	76.5	0.5	0.5	76.5	76		0			
7/23/2014	0	0	8.52	8.78	76.3	76.7	0.5	0.5	76.7	76.3		0			181
7/25/2014	0	0	8.54	8.8	76.1	76.4	0.5	0.5	76.4	76.1		0			
7/30/2014									*58.16*	*57.48*					181
8/1/2014	0	0	8.7	8.74	74.1	74.6	0.5	0.5	74.6	74.1		0			
8/4/2014	0	0	8.66	8.7	74.2	74.6	0.5	0.5	74.6	74.2		0			
8/5/2014	0	0	8.67	8.72	73.8	74.1	0.5	0.5	74.1	73.8		0			
8/6/2014	0	0	8.68	8.7	73.7	74	0.5	0.5	74	73.7		0			
8/7/2014	0	0	8.7	8.72	73.8	74.1	0.5	0.5	74.1	73.8		0			
8/8/2014	0	0	8.71	8.73	73.4	73.8	0.5	0.5	73.8	73.4		0			
8/11/2014	0	0	8.68	8.71	73.2	73.7	0.5	0.5	73.7	73.2		0			
8/13/2014	0	0	8.9	8.77	73.4	73.7	0.5	0.5	73.7	73.4		0			
8/14/2014	0	0.06	8.9	8.74	73.4	73.7	0.5	0.5	73.7	73.4		0.05			
8/15/2014	0	0.15	8.92	8.78	73.4	73.6	0.5	0.5	73.6	73.4		0.12			
8/16/2014	0	0.23	9	8.81	73.6	73.4	0.5	0.5	73.4	73.6		0.17			
8/17/2014	0	0.33	9.05	8.77	73.6	73.9	0.5	0.5	73.9	73.6		0.26			
8/18/2014	0	0	8.98	8.76	73.9	74.3	0.5	0.5	74.3	73.9		0			
8/20/2014									*58.16*	*57.48*					207
8/21/2014	0	0	8.96	8.7	73.8	74.3	0.5	0.5	74.3	73.8		0			

Table C.6 continued.

	Raw O Data into						Censored O Data into								Raw CL Data
	P	S	P	S	P	S	P	S	P	S	P	S	P-S	P Demand	P
	NH_3		pH		Temp.		NH_3		Temp.		NH_4^+			Alkalinity	
Date	mg-N L^{-1}		units		°F		mg-N L^{-1}		°F		mg-N L^{-1}			mg-$CaCO_3$ L^{-1}	
8/22/2014	0	0	8.94	8.72	74	74.6	0.5	0.5	74.6	74		0			
8/23/2014	0	0	8.9	8.73	74	74.5	0.5	0.5	74.5	74		0			
8/24/2014	0	0	8.92	8.74	73.2	74	0.5	0.5	74	73.2		0			
8/25/2014	0	0	8.9	8.75	73	73.6	0.5	0.5	73.6	73		0			
8/27/2014									*58.16*	*57.48*					
8/28/2014	0	0	8.82	8.77	72.6	73	0.5	0.5	73	72.6		0			
8/29/2014	0	0	8.8	8.7	73.1	73.7	0.5	0.5	73.7	73.1		0			
8/30/2014	0	0	8.76	8.71	73.6	74.4	0.5	0.5	74.4	73.6		0			
9/1/2014	2.4	0	8.5	8.56	70.1	71.2	2.4	0.5	71.2	70.1	2.11	0	2.11	14.88	
9/2/2014	2.38	0.12	8.5	8.55	69.8	71.3	2.38	0.5	71.3	69.8	2.10	0.10	1.99	14.04	
9/3/2014	2.17	0	8.49	8.55	69.8	71.1	2.17	0.5	71.1	69.8	1.92	0	1.92	13.51	181
9/4/2014	2.29	0	8.51	8.54	70.2	71	2.29	0.5	71	70.2	2.01	0	2.01	14.15	
9/5/2014	2.47	0	8.5	8.57	70.3	71.2	2.47	0.5	71.2	70.3	2.17	0	2.17	15.29	
9/6/2014	2.29	0	8.51	8.56	70.7	71.4	2.29	0.5	71.4	70.7	2.00	0	2.00	14.11	
9/7/2014	2.41	0	8.5	8.57	70.2	71.4	2.41	0.5	71.4	70.2	2.12	0	2.12	14.93	
9/8/2014	2.3	0	8.53	8.56	69.8	71.3	2.3	0.5	71.3	69.8	2.01	0	2.01	14.15	
9/9/2014	3.4	7.78	8.41	8.37	67.1	69.5	3.4	7.78	69.5	67.1	3.09	7.14	-4.04	-28.49	
9/10/2014	5.63	3.34	8.43	8.4	66.7	69.5	5.63	3.34	69.5	66.7	5.11	3.05	2.06	14.52	
9/11/2014	5.29	2.8	8.4	8.38	66.1	69	5.29	2.8	69	66.1	4.84	2.57	2.27	15.99	
9/12/2014	1.38	0	9.02	8.84	65.3	68	1.38	0.5	68	65.3	1.00	0	1.00	7.07	
9/15/2014	1	0	9	8.81	65	67.4	1	0.5	67.4	65	0.74	0	0.74	5.21	
9/16/2014	1.03	0	8.97	8.8	65.1	67.3	1.03	0.5	67.3	65.1	0.77	0	0.77	5.45	
9/17/2014	0.76	0	8.9	8.8	64.2	67	0.76	0.5	67	64.2	0.60	0	0.60	4.21	
9/18/2014	0.76	0	8.84	8.8	64	66.4	0.76	0.5	66.4	64	0.62	0	0.62	4.34	191
9/19/2014	0.7	0	8.86	8.82	64.1	66.3	0.7	0.5	66.3	64.1	0.56	0	0.56	3.96	
9/22/2014	0.57	0	8.87	8.82	64.2	66	0.57	0.5	66	64.2	0.45	0	0.45	3.20	
9/23/2014	0.67	0	8.86	8.8	64	65	0.67	0.5	65	64	0.54	0	0.54	3.79	
9/24/2014	0.8	0	8.85	8.79	64	65.2	0.8	0.5	65.2	64	0.64	0	0.64	4.55	
9/25/2014	0.81	0	8.82	8.8	64.1	64.7	0.81	0.5	64.7	64.1	0.66	0	0.66	4.66	
9/26/2014	0.7	0	8.88	8.79	63.5	64	0.7	0.5	64	63.5	0.56	0	0.56	3.94	
9/29/2014	0.84	0	8.87	8.78	63.4	64.1	0.84	0.5	64.1	63.4	0.67	0	0.67	4.75	
9/30/2014	0.96	0	8.88	8.76	63.1	64.2	0.96	0.5	64.2	63.1	0.77	0	0.77	5.42	
10/1/2014	0.9	0.15	8.67	8.6	65.1	64.6	0.9	0.5	64.6	65.1	0.77	0.13	0.64	4.51	227
10/2/2014	0.87	0	8.68	8.62	65	64.5	0.87	0.5	64.5	65	0.74	0	0.74	5.24	
10/3/2014	0.92	0	8.6	8.62	65.1	64.5	0.92	0.5	64.5	65.1	0.81	0	0.81	5.68	
10/6/2014	2.01	0.14	8.54	8.6	64.7	64	2.01	0.5	64	64.7	1.79	0.12	1.67	11.77	
10/7/2014	1.9	0	8.58	8.62	64.3	63.7	1.9	0.5	63.7	64.3	1.68	0	1.68	11.85	
10/8/2014	2.4	0	8.6	8.61	64	63.1	2.4	0.5	63.1	64	2.11	0	2.11	14.90	
10/9/2014	2.54	0	8.57	8.62	63.7	63	2.54	0.5	63	63.7	2.26	0	2.26	15.92	
10/10/2014	3.1	2.7	8.5	8.6	62.7	62.2	3.1	2.7	62.2	62.7	2.81	2.39	0.42	2.96	
10/13/2014	6.22	5.4	8.55	8.62	62.4	62	6.22	5.4	62	62.4	5.59	4.77	0.82	5.79	
10/14/2014	7.49	2.4	8.6	8.64	62	61.5	7.49	2.4	61.5	62	6.66	2.11	4.55	32.07	
10/15/2014	8.74	1.68	8.69	8.74	54.6	55.6	8.74	1.68	55.6	54.6	7.85	1.49	6.36	44.86	
10/16/2014	8.4	1.47	8.47	8.75	55.4	57.2	8.4	1.47	57.2	55.4	7.85	1.30	6.55	46.19	242
10/17/2014	7.98	1.38	8.4	8.75	55.3	57.3	7.98	1.38	57.3	55.3	7.53	1.22	6.31	44.51	
10/20/2014	7.01	1.3	8.44	8.7	55.1	57.3	7.01	1.3	57.3	55.1	6.58	1.16	5.42	38.22	
10/21/2014	7.1	1.27	8.43	8.7	54.8	57.4	7.1	1.27	57.4	54.8	6.68	1.14	5.54	39.09	
10/22/2014	6.9	1	8.44	8.71	54.9	56.6	6.9	1	56.6	54.9	6.48	0.89	5.59	39.41	
10/23/2014	6.93	0.63	8.45	8.7	55.2	56.9	6.93	0.63	56.9	55.2	6.50	0.56	5.93	41.84	
10/24/2014	6.7		8.45		55.3		6.70		*58.16*	55.30	6.28				

Table C.6 continued.

	Raw O Data into						Censored O Data into								Raw CL Data
	P	S	P	S	P	S	P	S	P	S	P	S	P-S	P Demand	P
	NH$_3$		pH		Temp.		NH$_3$		Temp.		NH$_4^+$			Alkalinity	
Date	mg-N L^{-1}		units		°F		mg-N L^{-1}		°F		mg-N L^{-1}			mg-CaCO$_3$ L^{-1}	
10/27/2014	7.8		8.47		56.3		7.80		*58.16*	56.30	7.27				
10/28/2014	8.78		8.82		53.8		8.78		*58.16*	53.80	7.66				
10/29/2014									*58.16*	*57.48*					243
11/1/2014	9.99	0	8.4	8.44	57.1	57.5	9.99	0.5	57.5	57.1	9.39	0	9.39	66.18	
11/4/2014	9.99	0	8.42	8.5	57.2	57.7	9.99	0.5	57.7	57.2	9.36	0	9.36	65.98	
11/5/2014	9.99	0	8.46	8.52	57.1	57.8	9.99	0.5	57.8	57.1	9.30	0	9.30	65.59	
11/6/2014	9.99	0	8.47	8.5	56.8	56.1	9.99	0.5	56.1	56.8	9.30	0	9.30	65.55	
11/7/2014	9.99	0	8.21	8.29	49.9	51	9.99	0.5	51	49.9	9.69	0	9.69	68.34	
11/8/2014	9.99	0	8.54	9.11	53	52.2	9.99	0.5	52.2	53	9.30	0	9.30	65.54	
11/11/2014	9.99	0	8.5	8.56	53	54	9.99	0.5	54	53	9.35	0	9.35	65.95	
11/12/2014	9.99	0	8.51	8.54	53	53.2	9.99	0.5	53.2	53	9.34	0	9.34	65.85	
11/13/2014	9.99	0	8.52	8.55	52.9	53.4	9.99	0.5	53.4	52.9	9.33	0	9.33	65.77	
11/14/2014	9.99	0	8.51	8.56	52.4	53.3	9.99	0.5	53.3	52.4	9.36	0	9.36	65.96	
11/15/2014	9.99	0	8.87	9.03	54	54	9.99	0.5	54	54	8.57	0	8.57	60.39	
11/18/2014	9.99	0	8.84	8.53	53.7	53.6	9.99	0.5	53.6	53.7	8.66	0	8.66	61.07	196
11/19/2014	9.99	0	8.78	8.6	53.7	53.4	9.99	0.5	53.4	53.7	8.81	0	8.81	62.14	
11/20/2014	9.99	0	8.7	8.59	53.1	52.9	9.99	0.5	52.9	53.1	9.01	0	9.01	63.55	
11/21/2014	9.99	0	8.7	8.62	49.9	50.3	9.99	0.5	50.3	49.9	9.13	0	9.13	64.36	
11/22/2014	9.99	0	8.72	8.65	49.6	50.2	9.99	0.5	50.2	49.6	9.10	0	9.10	64.17	
11/25/2014	9.99	0	8.74	8.63	49.1	50.3	9.99	0.5	50.3	49.1	9.08	0	9.08	64.03	
11/26/2014	9.99	0	8.71	8.6	49	50.6	9.99	0.5	50.6	49	9.14	0	9.14	64.44	
11/27/2014	9.99	0	8.28	8.06	38.7	40.7	9.99	0.5	40.7	38.7	9.78	0	9.78	68.92	
11/29/2014	9.99	0.17	9.37	9.7	44.6	44.6	9.99	0.5	44.6	44.6	7.40	0.10	7.30	51.47	
12/1/2014	9.1	3.8	7.22	8.3	38.7	37	9.1	3.8	37	38.7	9.08	3.71	5.37	37.84	
12/2/2014	9	3.71	7.23	8.29	38.7	37	9	3.71	37	38.7	8.98	3.63	5.35	37.74	
12/3/2014	9.4	3.7	7.15	8.34	38.7	36.4	9.4	3.7	36.4	38.7	9.38	3.61	5.78	40.72	
12/4/2014	9.34	3.73	7.2	8.36	38.5	36.5	9.34	3.73	36.5	38.5	9.32	3.64	5.69	40.10	
12/5/2014	9.1	3.61	7.25	8.3	38.5	36.5	9.1	3.61	36.5	38.5	9.08	3.53	5.55	39.14	
12/8/2014	8.74	3.5	7.6	8.38	38	36.1	8.74	3.5	36.1	38	8.70	3.41	5.29	37.31	
12/9/2014	8.76	3.49	7.52	8.4	38.1	36.3	8.76	3.49	36.3	38.1	8.73	3.39	5.33	37.60	
12/10/2014	9.12	3.56	7.6	8.47	37.3	36.9	9.12	3.56	36.9	37.3	9.08	3.45	5.63	39.70	237
12/11/2014	8.9	3	7.68	8.5	37.5	37	8.9	3	37	37.5	8.85	2.90	5.95	41.97	
12/12/2014	8.91	3.02	7.7	8.47	37.4	37.1	8.91	3.02	37.1	37.4	8.86	2.93	5.94	41.85	
12/15/2014	8.91	3.1	7.64	8.5	37.1	36.6	8.91	3.1	36.6	37.1	8.87	3.00	5.87	41.38	
12/16/2014	9.01	3.12	7.71	8.5	37.2	36.5	9.01	3.12	36.5	37.2	8.96	3.02	5.94	41.90	
12/17/2014	9	3.14	7.8	8.52	36.4	36.8	9	3.14	36.8	36.4	8.94	3.04	5.91	41.64	227
12/18/2014	8.9	2.99	7.81	8.54	36.5	37	8.9	2.99	37	36.5	8.84	2.89	5.95	41.98	
12/19/2014	8.71	2.14	7.67	8.42	37.4	37	8.71	2.14	37	37.4	8.67	2.08	6.59	46.43	
12/22/2014	8	2.04	7.7	8.5	37.4	37.1	8	2.04	37.1	37.4	7.96	1.97	5.98	42.19	246
12/23/2014	8.14	2.1	7.71	8.47	37.3	36.9	8.14	2.1	36.9	37.3	8.10	2.04	6.06	42.72	
12/24/2014	8.2	2.16	7.8	8.4	37.1	36.7	8.2	2.16	36.7	37.1	8.15	2.10	6.04	42.59	
12/26/2014	7.2	2.04	7.6	8.35	37.2	37.7	7.2	2.04	37.7	37.2	7.17	1.99	5.18	36.50	
12/27/2014	6.9	1.97	7.57	8.34	36.8	37.4	6.9	1.97	37.4	36.8	6.87	1.93	4.95	34.88	
12/29/2014	6.41	1.5	7.6	8.37	36.4	37.4	6.41	1.5	37.4	36.4	6.38	1.46	4.92	34.68	
12/30/2014	4.21	1.4	7.7	8.4	36.7	37.4	4.21	1.4	37.4	36.7	4.19	1.36	2.82	19.91	
12/31/2014	4	1.4	7.7	8.42	36.4	37.7	4	1.4	37.7	36.4	3.98	1.36	2.62	18.45	
1/2/2015	3.6	0.98	7.68	8.4	36	37.4	3.6	0.98	37.4	36	3.58	0.96	2.63	18.52	
1/3/2015	3.7	0.91	7.7	8.4	35.4	37	3.7	0.91	37	35.4	3.68	0.89	2.79	19.70	
1/5/2015	3.2	0.9	7.69	8.41	35.4	36.5	3.2	0.9	36.5	35.4	3.18	0.88	2.31	16.26	
1/6/2015	3.5	1.1	7.7	8.41	35.5	36.3	3.5	1.1	36.3	35.5	3.48	1.07	2.41	16.99	

Table C.6 continued.

	Raw O Data into						Censored O Data into								Raw CL Data
	P	S	P	S	P	S	P	S	P	S	P	S	P-S	P Demand	P
	NH$_3$		pH		Temp.		NH$_3$		Temp.		NH$_4^+$			Alkalinity	
Date	mg-N L^{-1}		units		°F		mg-N L^{-1}		°F		mg-N L^{-1}			mg-CaCO$_3$ L^{-1}	
1/7/2015	3.4	1.12	7.72	8.43	35	36.4	3.4	1.12	36.4	35	3.38	1.09	2.29	16.15	352
1/8/2015	3.4	0.74	7.7	8.5	34.1	35.7	3.4	0.74	35.7	34.1	3.38	0.72	2.67	18.79	
1/9/2015	3.3	0.8	7.71	8.47	34	35.4	3.3	0.8	35.4	34	3.28	0.78	2.51	17.67	
1/12/2015	5.7	1.4	7.9	8.04	34.5	35.4	5.7	1.4	35.4	34.5	5.66	1.39	4.27	30.12	
1/13/2015	6.2	1.8	8.14	8.4	34.6	35.5	6.2	1.8	35.5	34.6	6.12	1.76	4.36	30.75	
1/14/2015	8.1	2.2	8.24	8.78	34.4	35.4	8.1	2.2	35.4	34.4	7.97	2.08	5.89	41.51	351
1/15/2015	8.9	2.7	8.31	8.75	34.2	35.4	8.9	2.7	35.4	34.2	8.73	2.56	6.17	43.48	
1/16/2015	8.5	2.9	8.7	9	34	35.2	8.5	2.9	35.2	34	8.12	2.65	5.47	38.55	
1/19/2015	9	3	8.84	9	34.5	35.4	9	3	35.4	34.5	8.44	2.74	5.71	40.22	
1/20/2015	9.99	2.94	9	9.04	34.4	35.5	9.99	2.94	35.5	34.4	9.13	2.66	6.46	45.56	
1/21/2015	8.72	2.4	8.91	9	34.7	35.3	8.72	2.4	35.3	34.7	8.09	2.19	5.90	41.59	
1/22/2015	8.6	2.1	8.87	8.95	34.6	35	8.6	2.1	35	34.6	8.03	1.94	6.10	42.98	
1/23/2015	7.78	2.13	8.9	9.1	34.5	34.9	7.78	2.13	34.9	34.5	7.23	1.90	5.33	37.59	
1/26/2015	7.6	2.02	8.87	9.04	34.5	35.2	7.6	2.02	35.2	34.5	7.10	1.83	5.27	37.16	
1/27/2015	7.81	2.1	8.85	8.97	34.4	35.3	7.81	2.1	35.3	34.4	7.32	1.93	5.39	38.00	
1/28/2015	7.8	1.42	8.84	8.95	33.6	35.1	7.8	1.42	35.1	33.6	7.34	1.31	6.02	42.47	320
1/29/2015	7.82	1.44	8.84	8.93	33.7	35.2	7.82	1.44	35.2	33.7	7.35	1.34	6.02	42.43	
1/30/2015	8.2	1.6	8.8	8.94	33.2	35	8.2	1.6	35	33.2	7.76	1.48	6.28	44.26	
2/2/2015	9.99	2.1	8.83	8.87	32.7	34.3	9.99	2.1	34.3	32.7	9.43	1.97	7.46	52.59	
2/3/2015	9.99	2.14	8.8	8.84	32.6	33.8	9.99	2.14	33.8	32.6	9.47	2.02	7.45	52.53	
2/4/2015	9.99	2.1	8.81	8.83	32.7	33.5	9.99	2.1	33.5	32.7	9.46	1.98	7.47	52.69	315
2/5/2015	9.99	2.14	8.8	8.84	32.9	33.3	9.99	2.14	33.3	32.9	9.46	2.02	7.45	52.49	
2/6/2015	9.99	2.2	8.78	8.84	33.1	33.5	9.99	2.2	33.5	33.1	9.48	2.07	7.41	52.23	
2/9/2015	9.99	1.93	8.7	8.85	32.7	33.4	9.99	1.93	33.4	32.7	9.57	1.82	7.75	54.66	
2/10/2015	8.72	1.4	8.71	8.86	32.4	33.1	8.72	1.4	33.1	32.4	8.35	1.32	7.03	49.58	
2/11/2015	9.99	0.71	8.27	8.4	32.6	33.4	9.99	0.71	33.4	32.6	9.83	0.69	9.14	64.41	
2/12/2015	9.99	0.21	7.9	8.27	32.4	33.1	9.99	0.5	33.1	32.4	9.92	0.21	9.72	68.49	
2/13/2015	9.99	0.54	7.4	7.73	32.3	32.6	9.99	0.54	32.6	32.3	9.97	0.54	9.43	66.49	
2/16/2015	9.99	0.62	7.48	7.3	32	32.5	9.99	0.62	32.5	32	9.96	0.62	9.35	65.89	
2/17/2015	9.99	0.44	7.6	7.26	32.4	32.7	9.99	0.5	32.7	32.4	9.96	0.44	9.52	67.09	
2/18/2015	9.99	0.52	7.53	7.22	32.1	32.4	9.99	0.52	32.4	32.1	9.96	0.52	9.44	66.57	340
2/19/2015	9.99	0.59	7.51	7.19	32.1	32.2	9.99	0.59	32.2	32.1	9.96	0.59	9.37	66.08	
2/23/2015			7.48	7.2	32.1	32.3			32.3	32.1					
2/24/2015	9.99	0.26	8.33	8.59	32.1	32.2	9.99	0.5	32.2	32.1	9.81	0.25	9.56	67.40	
2/25/2015	9.99	0.29	8.46	7.28	34	32.8	9.99	0.5	32.8	34	9.73	0.29	9.44	66.55	
2/26/2015	9.99	0.65	8.33	8.62	32.1	32.8	9.99	0.65	32.8	32.1	9.81	0.63	9.18	64.75	
2/27/2015	9.99	0	8.11	8.42	33.1	32.5	9.99	0.5	32.5	33.1	9.88	0	9.88	69.63	
3/2/2015	9.99	0	8	8.5	33	32.7	9.99	0.5	32.7	33	9.90	0	9.90	69.81	
3/3/2015	9.99	0	8.04	8.46	33.2	32.6	9.99	0.5	32.6	33.2	9.89	0	9.89	69.74	
3/4/2015	9.99	0	8.12	8.4	33	33.4	9.99	0.5	33.4	33	9.87	0	9.87	69.62	
3/5/2015	9.99	0	8.14	8.37	33	32.9	9.99	0.5	32.9	33	9.87	0	9.87	69.58	
3/6/2015	9.99	0	8.2	8.31	33.9	34.5	9.99	0.5	34.5	33.9	9.85	0	9.85	69.41	
3/9/2015	9.99	0	8.3	8.39	34.2	34.9	9.99	0.5	34.9	34.2	9.81	0	9.81	69.14	
3/10/2015	9.99	0	8.17	8.41	34.3	34.9	9.99	0.5	34.9	34.3	9.85	0	9.85	69.46	
3/11/2015	9.99	0	8.24	8.5	34.4	35.1	9.99	0.5	35.1	34.4	9.83	0	9.83	69.29	
3/12/2015	9.99	0	8.32	8.59	34.6	35.8	9.99	0.5	35.8	34.6	9.79	0	9.79	69.05	
3/13/2015	9.99	0	8.45	8.81	36.4	37.8	9.99	0.5	37.8	36.4	9.71	0	9.71	68.43	
3/16/2015	9.99	0	8.5	8.92	36.4	37.4	9.99	0.5	37.4	36.4	9.67	0	9.67	68.19	
3/17/2015	9.99	0	8.49	8.77	39.4	37.6	9.99	0.5	37.6	39.4	9.64	0	9.64	67.94	
3/18/2015	9.99	0	8.46	8.76	40.1	37.9	9.99	0.5	37.9	40.1	9.65	0	9.65	68.03	221

Table C.6 continued.

	Raw O Data into						Censored O Data into								Raw CL Data
	P	S	P	S	P	S	P	S	P	S	P	S	P-S	P Demand	P
	NH_3		pH		Temp.		NH_3		Temp.		NH_4^+			Alkalinity	
Date	mg-N L^{-1}		units		°F		mg-N L^{-1}		°F		mg-N L^{-1}			mg-CaCO$_3$ L^{-1}	
3/19/2015	9.99	0	8.44	8.72	40.1	37.6	9.99	0.5	37.6	40.1	9.66	0	9.66	68.13	
3/20/2015	9.99	0	8.45	8.7	41.2	37.9	9.99	0.5	37.9	41.2	9.64	0	9.64	67.97	
3/23/2015	9.99	0	8.44	8.68	42.1	39.8	9.99	0.5	39.8	42.1	9.63	0	9.63	67.93	
3/24/2015	9.99	0	8.41	8.66	42.7	40.4	9.99	0.5	40.4	42.7	9.65	0	9.65	68.03	
3/25/2015	9.99	0	8.37	8.6	43.2	41.7	9.99	0.5	41.7	43.2	9.67	0	9.67	68.18	
3/26/2015	9.99	0	8.37	8.58	43.4	42.5	9.99	0.5	42.5	43.4	9.67	0	9.67	68.16	
3/27/2015	9.99	0	8.4	8.55	43.5	42.9	9.99	0.5	42.9	43.5	9.64	0	9.64	68.00	
3/30/2015	9.99	0	8.41	8.5	43.4	43.1	9.99	0.5	43.1	43.4	9.64	0	9.64	67.95	
3/31/2015	9.96	0.03	8.4	8.53	44.7	48	9.96	0.5	48	44.7	9.60	0.03	9.57	67.46	
4/1/2015	9.5	0.04	8.84	8.8	53.3	50.1	9.5	0.5	50.1	53.3	8.26	0.04	8.22	57.96	
4/2/2015	9.46	0.03	8.9	8.86	53.2	50	9.46	0.5	50	53.2	8.07	0.03	8.04	56.71	
4/3/2015	9.29	0.01	8.89	8.84	53.1	49.5	9.29	0.5	49.5	53.1	7.96	0.01	7.95	56.03	
4/6/2015	9.22	0.04	8.91	8.85	53.4	50.4	9.22	0.5	50.4	53.4	7.83	0.03	7.79	54.95	
4/7/2015	9.99	0	8.85	8.83	54.4	52.1	9.99	0.5	52.1	54.4	8.60	0	8.60	60.64	
4/8/2015	9.74	0	8.68	8.81	55.2	53.1	9.74	0.5	53.1	55.2	8.75	0	8.75	61.70	
4/9/2015	9.99	0	8.39	8.8	55.1	53	9.99	0.5	53	55.1	9.45	0	9.45	66.59	
4/10/2015	9.99	0	8.3	8.82	55.4	53	9.99	0.5	53	55.4	9.54	0	9.54	67.24	
4/13/2015	9.99	0	8.28	8.86	55.8	52.9	9.99	0.5	52.9	55.8	9.55	0	9.55	67.32	
4/14/2015		0	8.3	8.9	56	53.7		0.5	53.7	56		0			
4/15/2015		0	8.2	8.77	56.1	53.8		0.5	53.8	56.1		0			259
4/16/2015		0	8.24	8.7	56.3	54		0.5	54	56.3		0			
4/17/2015		0	8.26	8.68	56.1	54.3		0.5	54.3	56.1		0			
4/20/2015		0	8.24	8.66	56	54.4		0.5	54.4	56		0			
4/21/2015		0	8.2	8.61	56.2	54.3		0.5	54.3	56.2		0			
4/22/2015		0	8.17	8.6	56	54.4		0.5	54.4	56		0			
4/23/2015		0	8.18	8.6	56	54.7		0.5	54.7	56		0			
4/24/2015		0	8.2	8.62	56.1	54.7		0.5	54.7	56.1		0			
4/27/2015		0	8.22	8.6	57.3	55.2		0.5	55.2	57.3		0			
4/28/2015		0	8.2	8.55	57.3	55.4		0.5	55.4	57.3		0			
4/29/2015		0	8.21	8.56	57.5	55.5		0.5	55.5	57.5		0			259
4/30/2015		0	8.2	8.54	57.3	55.6		0.5	55.6	57.3		0			
5/1/2015		0	8.22	8.5	57	55.7		0.5	55.7	57		0			
5/4/2015		0	8.23	8.51	56.1	55.5		0.5	55.5	56.1		0			
5/5/2015	9.99	0	8.71	8.87	59.4	60.2	9.99	0.5	60.2	59.4	8.73	0	8.73	61.55	
5/6/2015	9.84	0	8.83	9	61.5	63.1	9.84	0.5	63.1	61.5	8.15	0	8.15	57.45	
5/7/2015	9.7	0	8.96	9.03	62.1	63.5	9.7	0.5	63.5	62.1	7.54	0	7.54	53.14	243
5/8/2015	9.12	0	9	9.17	62	63.7	9.12	0.5	63.7	62	6.94	0	6.94	48.96	
5/11/2015	8.04	0	8.99	9.09	61.3	63.5	8.04	0.5	63.5	61.3	6.20	0	6.20	43.69	
5/12/2015	8.12	0	8.9	9.01	61.4	63.4	8.12	0.5	63.4	61.4	6.53	0	6.53	46.06	
5/13/2015	8.14	0	8.78	8.92	60.3	63	8.14	0.5	63	60.3	6.92	0	6.92	48.80	258
5/14/2015	8.27	0	8.76	8.92	59.6	62.1	8.27	0.5	62.1	59.6	7.11	0	7.11	50.12	
5/15/2015	8.44	0	8.7	8.91	60.2	62.7	8.44	0.5	62.7	60.2	7.37	0	7.37	51.93	
5/18/2015	8.4	0	8.74	8.87	61	62.9	8.4	0.5	62.9	61	7.21	0	7.21	50.82	
5/19/2015	9.1	0	8.76	8.9	61.3	63	9.1	0.5	63	61.3	7.74	0	7.74	54.59	
5/20/2015	9.22	0	8.74	8.87	61.3	63.1	9.22	0.5	63.1	61.3	7.90	0	7.90	55.69	
5/21/2015	9.01	0	8.74	8.86	61.6	63	9.01	0.5	63	61.6	7.71	0	7.71	54.32	
5/22/2015	9.07	0	8.71	8.85	61.4	63.2	9.07	0.5	63.2	61.4	7.84	0	7.84	55.28	
5/26/2015	8.6	0	8.76	8.91	62	63.4	8.6	0.5	63.4	62	7.29	0	7.29	51.37	
5/27/2015	8.5	0	8.74	8.9	63.2	64.1	8.5	0.5	64.1	63.2	7.20	0	7.20	50.75	
5/28/2015	8.37	0	8.75	8.92	63.7	64.1	8.37	0.5	64.1	63.7	7.04	0	7.04	49.64	

Table C.6 continued.

	Raw O Data into						Censored O Data into								Raw CL Data
	P	S	P	S	P	S	P	S	P	S	P	S	P-S	P Demand	P
	NH_3		pH		Temp.		NH_3		Temp.		NH_4^+			Alkalinity	
Date	mg-N L^{-1}		units		°F		mg-N L^{-1}		°F		mg-N L^{-1}			mg-$CaCO_3$ L^{-1}	
5/29/2015	7.2	0	8.74	8.9	64.3	65	7.2	0.5	65	64.3	6.05	0	6.05	42.69	
6/1/2015	7	0	8.8	9.12	67.1	67.4	7	0.5	67.4	67.1	5.63	0	5.63	39.70	
6/2/2015	6.52	0	8.82	9.1	67.6	68.1	6.52	0.5	68.1	67.6	5.18	0	5.18	36.49	
6/3/2015	6.61	0	8.81	9.06	69.1	69.9	6.61	0.5	69.9	69.1	5.21	0	5.21	36.70	265
6/4/2015	7.14	0	8.79	9.04	70.4	70.9	7.14	0.5	70.9	70.4	5.62	0	5.62	39.60	
6/5/2015	7.2	0	8.8	9.07	70.7	70.9	7.2	0.5	70.9	70.7	5.62	0	5.62	39.63	
6/8/2015	6.4	0	8.82	9.1	71	71.4	6.4	0.5	71.4	71	4.93	0	4.93	34.77	
6/9/2015	6.28	0	8.8	9.12	69.1	70.3	6.28	0.5	70.3	69.1	4.97	0	4.97	35.04	
6/10/2015	7.12	0	8.78	9.08	69.4	70.4	7.12	0.5	70.4	69.4	5.67	0	5.67	40.01	
6/11/2015	7.14	0	8.81	9	69.2	70.6	7.14	0.5	70.6	69.2	5.62	0	5.62	39.61	
6/12/2015	7.16	0	8.8	9.03	70.3	71.1	7.16	0.5	71.1	70.3	5.61	0	5.61	39.55	
6/15/2015	7.02	0	8.81	9.1	71.1	72	7.02	0.5	72	71.1	5.43	0	5.43	38.30	
6/16/2015	6.83	0	8.84	9.09	70.9	72	6.83	0.5	72	70.9	5.21	0	5.21	36.74	
6/17/2015	7.11	0	8.8	9.12	72	72.8	7.11	0.5	72.8	72	5.49	0	5.49	38.68	227
6/18/2015	6.84	0	8.81	9.09	72	72.9	6.84	0.5	72.9	72	5.25	0	5.25	37.02	
6/19/2015	6.83	0	8.8	9.06	72.3	72.9	6.83	0.5	72.9	72.3	5.26	0	5.26	37.06	
6/22/2015	6.92	0	8.76	9	72.8	73.2	6.92	0.5	73.2	72.8	5.41	0	5.41	38.16	
6/23/2015	7.12	0	8.7	9.01	72.8	73.4	7.12	0.5	73.4	72.8	5.73	0	5.73	40.40	
6/24/2015	7.24	0	8.72	8.97	73	73.5	7.24	0.5	73.5	73	5.76	0	5.76	40.64	
6/25/2015	7.2	0	8.74	9	72.8	73.4	7.2	0.5	73.4	72.8	5.69	0	5.69	40.10	
6/26/2015	7.47	0	8.75	9.02	73	73.6	7.47	0.5	73.6	73	5.86	0	5.86	41.33	
6/29/2015	7.64	0	8.77	9	73.3	73.7	7.64	0.5	73.7	73.3	5.92	0	5.92	41.74	
6/30/2015	7.81	0	8.71	8.89	73	73.5	7.81	0.5	73.5	73	6.25	0	6.25	44.05	
7/1/2015	8.47	0	8.81	9.04	73.5	74.2	8.47	0.5	74.2	73.5	6.41	0	6.41	45.20	196
7/2/2015	8.51	0	8.77	9.05	73.4	74.1	8.51	0.5	74.1	73.4	6.59	0	6.59	46.45	
7/6/2015	8.04	0	8.72	9	73.6	74.4	8.04	0.5	74.4	73.6	6.37	0	6.37	44.91	
7/7/2015	7.24	0	8.19	8.34	75.7	74.3	7.24	0.5	74.3	75.7	6.68	0	6.68	47.09	
7/8/2015	6.01	0	8.18	8.34	75.9	74.3	6.01	0.5	74.3	75.9	5.55	0	5.55	39.13	
7/9/2015	3.12	0	8.2	8.34	75.6	74.4	3.12	0.5	74.4	75.6	2.87	0	2.87	20.26	
7/10/2015	3.07	0	8.21	8.3	75.6	74.5	3.07	0.5	74.5	75.6	2.82	0	2.82	19.90	
7/13/2015	1.91	0	8.24	8.3	76	75.2	1.91	0.5	75.2	76	1.74	0	1.74	12.29	
7/14/2015	1.94	0	8.21	8.33	76.1	75	1.94	0.5	75	76.1	1.78	0	1.78	12.56	
7/15/2015	2.07	0	8.2	8.33	76.4	74.8	2.07	0.5	74.8	76.4	1.90	0	1.90	13.41	
7/16/2015	2.14	0	8.22	8.3	76.6	75.2	2.14	0.5	75.2	76.6	1.96	0	1.96	13.80	227
7/17/2015	2.19	0	8.2	8.31	76.4	75.2	2.19	0.5	75.2	76.4	2.01	0	2.01	14.19	
7/20/2015	2.2	0	8.23	8.4	77	75.6	2.2	0.5	75.6	77	2.01	0	2.01	14.14	
7/21/2015	2.17	0	8.22	8.4	77	75.4	2.17	0.5	75.4	77	1.98	0	1.98	13.98	
7/22/2015	2.19	0	8.19	8.41	77.3	75.6	2.19	0.5	75.6	77.3	2.01	0	2.01	14.17	255
7/23/2015	2.1	0	8.18	8.4	77.4	75.9	2.1	0.5	75.9	77.4	1.93	0	1.93	13.61	
7/24/2015	2.15	0	8.2	8.41	77.6	76.2	2.15	0.5	76.2	77.6	1.97	0	1.97	13.87	
7/27/2015	2.17	0	8.21	8.4	78.1	76.4	2.17	0.5	76.4	78.1	1.98	0	1.98	13.95	
7/28/2015	2.2	0	8.22	8.4	78	76.3	2.2	0.5	76.3	78	2.00	0	2.00	14.12	
7/29/2015	2.24	0	8.24	8.41	77.4	76.4	2.24	0.5	76.4	77.4	2.04	0	2.04	14.35	
7/30/2015	3.04	0	8.22	8.4	77.5	76.4	3.04	0.5	76.4	77.5	2.77	0	2.77	19.55	
7/31/2015	2.19	0	8.2	8.43	77.6	76.4	2.19	0.5	76.4	77.6	2.00	0	2.00	14.13	
8/3/2015	1.68	0	8.22	8.47	76.1	74.7	1.68	0.5	74.7	76.1	1.54	0	1.54	10.85	
8/4/2015	1.74	0	8.2	8.44	75.4	74	1.74	0.5	74	75.4	1.60	0	1.60	11.31	
8/5/2015	1.73	0	8.24	8.5	75.6	74	1.73	0.5	74	75.6	1.58	0	1.58	11.15	232
8/6/2015	2.1	0	8.3	8.51	76.1	74.7	2.1	0.5	74.7	76.1	1.89	0	1.89	13.34	
8/7/2015		0	8.31	8.54	76.4	75		0.5	75	76.4		0			

Table C.6 continued.

	Raw O Data into						Censored O Data into								Raw CL Data
	P	S	P	S	P	S	P	S	P	S	P	S	P-S	P Demand	P
	NH_3		pH		Temp.		NH_3		Temp.		NH_4^+			Alkalinity	
Date	mg-N L^{-1}		units		°F		mg-N L^{-1}		°F		mg-N L^{-1}			mg-$CaCO_3$ L^{-1}	
8/10/2015	2.14	0	8.3	8.5	76.3	74.8	2.14	0.5	74.8	76.3	1.93	0	1.93	13.58	
8/11/2015		0	8.3	8.57	76.4	75		0.5	75	76.4		0			
8/12/2015	1.6	0	8.32	8.6	76.3	75.3	1.6	0.5	75.3	76.3	1.43	0	1.43	10.11	
8/13/2015		0	8.3	8.57	76.2	75.3		0.5	75.3	76.2		0			
8/14/2015			8.36	8.57	76.4	75.2			75.2	76.4					
8/17/2015			8.36	8.57	76.4	75.2			75.2	76.4					
8/18/2015			8.4	8.55	76.7	75.3			75.3	76.7					
8/19/2015			8.4	8.53	76	75.1			75.1	76					227
8/20/2015	1.6	0	8.41	8.5	75.4	74.1	1.6	0.5	74.1	75.4	1.41	0	1.41	9.91	
8/21/2015			8.4	8.54					*58.16*	*57.48*					
8/24/2015		0	8.4	8.51	75.3	74.2		0.5	74.2	75.3		0			
8/25/2015			8.38	8.5					*58.16*	*57.48*					
8/26/2015	1	0	8.38	8.47	75	73.9	1	0.5	73.9	75	0.89	0	0.89	6.26	
8/27/2015			8.4	8.5	74.6	73			73	74.6					
8/28/2015	1.2	0	8.4	8.47			1.20	0.5	*58.16*	*57.48*	1.13	0	1.13	7.94	
8/31/2015			8.41	8.44	74	73.1			73.1	74					
9/1/2015	1.62	0	8.4	8.46	74.1	74.3	1.62	0.5	74.3	74.1	1.44	0	1.44	10.13	
9/2/2015			8.4	8.44	74.2	73.5			73.5	74.2					
9/3/2015	1.47	0	8.41	8.42			1.47	0.5	*58.16*	*57.48*	1.38	0	1.38	9.72	
9/4/2015			8.4	8.44	74	73.1			73.1	74					
9/5/2015	1.4	0	8.37	8.42			1.40	0.5	*58.16*	*57.48*	1.32	0	1.32	9.30	
9/8/2015	1.4	0	8.38	8.4	73.6	72.1	1.4	0.5	72.1	73.6	1.25	0	1.25	8.81	
9/9/2015			8.37	8.4					*58.16*	*57.48*					
9/10/2015	1.1	0	8.38	8.41	74	93.2	1.1	0.5	93.2	74	0.98	0	0.98	6.91	
9/11/2015			8.4	8.4					*58.16*	*57.48*					
9/14/2015	1.6	0	8.41	8.39	74	73.3	1.6	0.5	73.3	74	1.42	0	1.42	9.98	
9/15/2015			8.4	8.41	74.6	73.3			73.3	74.6					
9/16/2015	1.1	0	8.42	8.4			1.10	0.5	*58.16*	*57.48*	1.03	0	1.03	7.26	263
9/17/2015	9.99	0	8.4	8.42			9.99	0.5	*58.16*	*57.48*	9.38	0	9.38	66.12	
9/18/2015			8.4	8.42	72	73.7			73.7	72					
9/22/2015	9.99	0	8.4	8.42			9.99	0.5	*58.16*	*57.48*	9.38	0	9.38	66.12	
9/23/2015			8.41	8.44	70.9	73			73	70.9					
9/24/2015	9.99	0	8.38	8.41			9.99	0.5	*58.16*	*57.48*	9.40	0	9.40	66.30	
9/25/2015			8.4	8.37	70.1	72			72	70.1					
9/28/2015	9.06	0	8.41	8.38			9.06	0.5	*58.16*	*57.48*	8.49	0	8.49	59.88	
9/29/2015			8.4	8.37	68.6	69.4			69.4	68.6					
9/30/2015	9.16	0	8.41	8.39			9.16	0.5	*58.16*	*57.48*	8.59	0	8.59	60.54	266
10/1/2015			8.44		70.1	71			71	70.1					
10/2/2015	9.99		8.42				9.99		*58.16*	*57.48*	9.35				
10/5/2015			8.43		67.2	68.3			68.3	67.2					
10/6/2015	9.99		8.4				9.99		*58.16*	*57.48*	9.38				
10/7/2015			8.41		63.4	64.5			64.5	63.4					
10/8/2015	9.99		8.4		*57.48*		9.99		*58.16*	*57.48*	9.38				
10/9/2015			8.42		62.3	63.9			63.9	62.3					
10/12/2015	9.99		8.4				9.99		*58.16*	*57.48*	9.38				
10/13/2015	9.99		8.43		60.6		9.99		*58.16*	60.60	9.25				
10/14/2015	9.99		8.41		60.4		9.99		*58.16*	60.40	9.29				
10/15/2015	9.99		8.43		60.1		9.99		*58.16*	60.10	9.27				
10/16/2015	9.99		8.43				9.99		*58.16*	*57.48*	9.34				
10/19/2015	9.99		8.34		57.5		9.99		*58.16*	57.5	9.45				

Table C.6 continued.

	Raw O Data into						Censored O Data into								Raw CL Data
	P	S	P	S	P	S	P	S	P	S	P	S	P-S	P Demand	P
	NH₃		pH		Temp.		NH₃		Temp.		NH₄⁺			Alkalinity	
Date	mg-N L⁻¹		units		°F		mg-N L⁻¹		°F		mg-N L⁻¹			mg-CaCO₃ L⁻¹	
10/20/2015	9.99		8.6		57.5		9.99		*58.16*	57.5	9.05				
10/21/2015	9.99		8.39		56		9.99		*58.16*	56	9.43				
10/22/2015	9.99		8.37		56.2		9.99		*58.16*	56.2	9.45				
10/23/2015	9.99		8.34		54.8		9.99		*58.16*	54.8	9.51				
10/26/2015	9.99		8.34		54.2		9.99		*58.16*	54.2	9.52				
10/27/2015	9.99		8.33		54		9.99		*58.16*	54	9.53				
10/28/2015	9.99	0	8.35		53.7		9.99	0.5	*58.16*	53.7	9.52				
10/29/2015	9.99		8.34		53.5		9.99		*58.16*	53.5	9.53				272
10/30/2015	0		8.35		57.2		0.50		*58.16*	57.2					
11/2/2015	9.99		8.31		56.4		9.99		*58.16*	56.4	9.51				
11/3/2015	9.99		8.3		56.3		9.99		*58.16*	56.3	9.52				
11/4/2015	9.99		8.3		56.2		9.99		*58.16*	56.2	9.52				
11/5/2015	9.99		8.33		54		9.99		*58.16*	54	9.53				
11/6/2015	9.99		8.31		52.9		9.99		*58.16*	52.9	9.57				
11/9/2015	9.99		8.34		52.1		9.99		*58.16*	52.1	9.56				
11/10/2015	9.99		8.34		51.9		9.99		*58.16*	51.9	9.56				
11/12/2015	9.99		8.36		52		9.99		*58.16*	52	9.54				294
11/13/2015	9.99		8.35		51.2		9.99		*58.16*	51.2	9.56				
11/16/2015	9.99		8.33		51.4		9.99		*58.16*	51.4	9.58				
11/17/2015	9.08				50.6		9.08		*58.16*	50.6					
11/18/2015	9.08						9.08		*58.16*	*57.48*					
11/19/2015	9.14		8.55	8.37	50.7		9.14		*58.16*	50.7	8.55				
11/20/2015	9.22		8.55		51		9.22		*58.16*	51	8.62				
11/23/2015	9.4		8.57		51.3		9.40		*58.16*	51.3	8.75				
11/24/2015	9.99		8.55		50		9.99		*58.16*	50	9.36				
11/25/2015	9.99		8.54		49.4		9.99		*58.16*	49.4	9.39				302
12/1/2015	9.99	3.4	8.8	8.5	52.3	51.5	9.99	3.4	51.5	52.3	8.83	3.19	5.64	39.75	
12/2/2015	9.99	3.3	8.81	8.5	50.4	51.2	9.99	3.3	51.2	50.4	8.89	3.11	5.78	40.72	238
12/3/2015	9.99	3.3	8.8	8.51	50.3	51.2	9.99	3.3	51.2	50.3	8.91	3.11	5.81	40.93	
12/4/2015	9.99	3	8.78	8.5	50.4	51.3	9.99	3	51.3	50.4	8.95	2.83	6.12	43.18	
12/7/2015			8.77	8.51	51	51.6			51.6	51					
12/8/2015			8.77	8.5	51.2	51.7			51.7	51.2					
12/9/2015			8.75	8.51	51.1	51.6			51.6	51.1					
12/10/2015			8.75	8.5	50.4	51.5			51.5	50.4					
12/11/2015	9.15	3.1	8.75	8.49	49.7	48.7	9.15	3.1	48.7	49.7	8.28	2.93	5.35	37.72	
12/14/2015	8.02	2.72	8.8	8.51	49.6	49	8.02	2.72	49	49.6	7.18	2.57	4.61	32.52	
12/15/2015	7.61	2.5	8.79	8.51	49	49.7	7.61	2.5	49.7	49	6.85	2.36	4.48	31.61	
12/16/2015	7.01	2.1	8.77	8.5	48.3	49	7.01	2.1	49	48.3	6.35	1.99	4.36	30.76	213
12/17/2015	7.14	1.9	8.78	8.52	48.1	49	7.14	1.9	49	48.1	6.46	1.80	4.67	32.89	
12/18/2015	7.27	1.6	8.78	8.51	48.1	49	7.27	1.6	49	48.1	6.58	1.51	5.06	35.71	
12/21/2015	7.5	1.7	8.77	8.5	47.8	48.7	7.5	1.7	48.7	47.8	6.81	1.61	5.20	36.65	
12/22/2015	7.61	1.73	8.75	8.51	47.4	48.4	7.61	1.73	48.4	47.4	6.95	1.64	5.31	37.43	
12/23/2015	7.7	1.8	8.76	8.5	47.7	48.5	7.7	1.8	48.5	47.7	7.01	1.71	5.30	37.38	
12/24/2015	8.12	2.04	8.74	8.51	47.1	48.3	8.12	2.04	48.3	47.1	7.44	1.94	5.50	38.79	
12/25/2015	8.17	2	8.75	8.5	47	48.2	8.17	2	48.2	47	7.47	1.90	5.57	39.28	
12/28/2015	9.99	2.12	8.74	8.5	47	48.3	9.99	2.12	48.3	47	9.15	2.01	7.14	50.34	
12/29/2015	9.99	2.16	9.74	9.52	46.4	47.9	9.99	2.16	47.9	46.4	5.29	1.41	3.88	27.37	202
12/30/2015	9.99	2.27	8.72	8.51	46	47.4	9.99	2.27	47.4	46	9.22	2.16	7.06	49.79	
1/4/2016	9.99		7.56				9.99		*58.16*	*57.48*	9.90				
1/6/2016	9.99				44.2		9.99		*58.16*	44.2					260

Table C.6 continued.

	Raw O Data into						Censored O Data into								Raw CL Data
	P	S	P	S	P	S	P	S	P	S	P	S	P-S	P Demand	P
	NH_3		pH		Temp.		NH_3		Temp.		NH_4^+			Alkalinity	
Date	mg-N L^{-1}		units		°F		mg-N L^{-1}		°F		mg-N L^{-1}			mg-$CaCO_3$ L^{-1}	
1/8/2016	8.94		7.72				8.94		*58.16*	*57.48*	8.82				
1/11/2016	9.99						9.99		*58.16*	*57.48*					
1/13/2016	9.99						9.99		*58.16*	*57.48*					268
1/15/2016	9.99						9.99		*58.16*	*57.48*					
1/19/2016	9.99				37.2		9.99		*58.16*	37.2					
1/20/2016									*58.16*	*57.48*					
1/21/2016	9.99		7.74				9.99		*58.16*	*57.48*	9.85				
1/25/2016	8.64						8.64		*58.16*	*57.48*					
1/27/2016	8.78						8.78		*58.16*	*57.48*					273
1/29/2016	9.99						9.99		*58.16*	*57.48*					
2/1/2016	9.99		7.5				9.99		*58.16*	*57.48*	9.91				
2/3/2016	9.99						9.99		*58.16*	*57.48*					284
2/5/2016	9.99						9.99		*58.16*	*57.48*					
2/8/2016	9.73		7.6				9.73		*58.16*	*57.48*	9.63				
2/10/2016	9.42						9.42		*58.16*	*57.48*					
2/12/2016	8.73						8.73		*58.16*	*57.48*					
2/15/2016	8.7		7.58				8.70		*58.16*	*57.48*	8.61				
2/17/2016	9.99						9.99		*58.16*	*57.48*					276
2/19/2016	9.99						9.99		*58.16*	*57.48*					
2/22/2016	9.99	2.41	7.6				9.99	*2.41*	*58.16*	*57.48*	9.89				
2/24/2016	9.99						9.99		*58.16*	*57.48*					
2/26/2016	8.47						8.47		*58.16*	*57.48*					
3/1/2016	9.99		7.51				9.99		*58.16*	*57.48*	9.91				
3/2/2016									*58.16*	*57.48*					
3/3/2016									*58.16*	*57.48*					243
3/4/2016	9.99						9.99		*58.16*	*57.48*					
3/7/2016	9.85		7.53				9.85		*58.16*	*57.48*	9.76				
3/9/2016									*58.16*	*57.48*					
3/10/2016	9.8		7.57	7.63			9.80		*58.16*	*57.48*	9.71				
3/12/2016	9.71						9.71		*58.16*	*57.48*					
3/15/2016	9.99	2.4	7.58		37.5		9.99	*2.40*	*58.16*	37.5	9.95				
3/16/2016									*58.16*	*57.48*					263
3/17/2016	9.99						9.99		*58.16*	*57.48*					
3/21/2016	9.99		7.61				9.99		*58.16*	*57.48*	9.89				
3/23/2016	8.41						8.41		*58.16*	*57.48*					
3/24/2016									*58.16*	*57.48*					
3/25/2016	8.2	0	7.58		38.3		8.20	0.5	*58.16*	38.3	8.16				
3/26/2016									*58.16*	*57.48*					
3/28/2016	7.96	0					7.96	0.5	*58.16*	*57.48*					
3/30/2016									*58.16*	*57.48*					202
3/31/2016	9.99		7.6				9.99		*58.16*	*57.48*	9.89				
4/1/2016	9.99	2.18			43.2		9.99	*2.18*	*58.16*	43.2					
4/4/2016	8.63						8.63		*58.16*	*57.48*					
4/6/2016	8.92				45		8.92		*58.16*	45					192
4/8/2016	9.99						9.99		*58.16*	*57.48*					
4/11/2016	9.99				47.2		9.99		*58.16*	47.2					
4/14/2016	9.99						9.99		*58.16*	*57.48*					
4/18/2016	9.99				52.1		9.99		*58.16*	52.1					
4/20/2016	8.87	2.13					8.87	*2.13*	*58.16*	*57.48*					
4/22/2016	9.38				53.3		9.38		*58.16*	53.3					

Table C.6 continued.

	Raw O Data into						Censored O Data into								Raw CL Data
	P	S	P	S	P	S	P	S	P	S	P	S	P-S	P Demand	P
	NH_3		pH		Temp.		NH_3		Temp.		NH_4^+			Alkalinity	
Date	mg-N L^{-1}		units		°F		mg-N L^{-1}		°F		mg-N L^{-1}			mg-$CaCO_3$ L^{-1}	
4/27/2016	9.99				55.2		9.99		*58.16*	55.2					232
4/29/2016	9.94						9.94		*58.16*	*57.48*					
5/2/2016	9.99						9.99		*58.16*	*57.48*					
5/4/2016	9.99						9.99		*58.16*	*57.48*					
5/6/2016	9.72						9.72		*58.16*	*57.48*					
5/9/2016	9.99		7.46		59.4		9.99		*58.16*	59.4	9.91				
5/11/2016									*58.16*	*57.48*					
5/12/2016	9.99						9.99		*58.16*	*57.48*					
5/16/2016	9.99						9.99		*58.16*	*57.48*					
5/18/2016	8.82	1.97					8.82	*1.97*	*58.16*	*57.48*					216
5/20/2016	8.47					59.4	8.47		59.4	*57.48*					
5/23/2016	7.96						7.96		*58.16*	*57.48*					
5/25/2016	9.99	0					9.99	0.5	*58.16*	*57.48*					
5/27/2016	9.99						9.99		*58.16*	*57.48*					
5/30/2016	9.99						9.99		*58.16*	*57.48*					
6/1/2016	7.46						7.46		*58.16*	*57.48*					222
6/3/2016	7.71	1.25					7.71	*1.25*	*58.16*	*57.48*					
6/7/2016	7.84						7.84		*58.16*	*57.48*					
6/8/2016									*58.16*	*57.48*					
6/9/2016	8.21						8.21		*58.16*	*57.48*					
6/13/2016	8.1		7.59			67.1	8.1		67.1	*57.48*	8.02				
6/15/2016	8.7						8.70		*58.16*	*57.48*					
6/17/2016									*58.16*	*57.48*					247
6/18/2016	9.99		7.48			67.4	9.99		67.4	*57.48*	9.91				
6/21/2016	9.99						9.99		*58.16*	*57.48*					
6/22/2016									*58.16*	*57.48*					323
6/23/2016	9.99						9.99		*58.16*	*57.48*					
6/27/2016	9.99						9.99		*58.16*	*57.48*					
6/29/2016	9.99						9.99		*58.16*	*57.48*					242
7/1/2016	9.99	0					9.99	0.5	*58.16*	*57.48*					
7/3/2016									*58.16*	*57.48*					
7/4/2016	9.99				70.2		9.99		*58.16*	70.2					
7/6/2016	9.99						9.99		*58.16*	*57.48*					
7/9/2016	9.64						9.64		*58.16*	*57.48*					
7/12/2016	9.71						9.71		*58.16*	*57.48*					
7/13/2016									*58.16*	*57.48*					217
7/14/2016	9.8						9.80		*58.16*	*57.48*					
7/16/2016	9.64	2.61	7.23				9.64	*2.61*	*58.16*	*57.48*	9.60				
7/18/2016	9.99				73.3		9.99		*58.16*	73.3					
7/20/2016									*58.16*	*57.48*					
7/21/2016	9.99		7.27				9.99		*58.16*	*57.48*	9.94				
7/25/2016	9.82					72.4	9.82		72.4	*57.48*					
7/27/2016	9.66						9.66		*58.16*	*57.48*					222
7/29/2016	9.99						9.99		*58.16*	*57.48*					
8/1/2016	9.99						9.99		*58.16*	*57.48*					
8/3/2016	9.99		7.26				9.99		*58.16*	*57.48*	9.94				
8/5/2016	9.99				75.1		9.99		*58.16*	75.1					
8/8/2016	9.99						9.99		*58.16*	*57.48*					
8/10/2016	9.99						9.99		*58.16*	*57.48*					227
8/13/2016	9.99						9.99		*58.16*	*57.48*					

Table C.6 continued.

	Raw O Data into						Censored O Data into								Raw CL Data
	P	S	P	S	P	S	P	S	P	S	P	S	P-S	P Demand	P
	NH_3		pH		Temp.		NH_3		Temp.		NH_4^+			Alkalinity	
Date	mg-N L^{-1}		units		°F		mg-N L^{-1}		°F		mg-N L^{-1}			mg-$CaCO_3$ L^{-1}	
8/16/2016	8.63					74.8	8.63		74.8	*57.48*					
8/17/2016									*58.16*	*57.48*					
8/19/2016	8.01						8.01		*58.16*	*57.48*					
8/22/2016	7.43						7.43		*58.16*	*57.48*					
8/24/2016	7.42						7.42		*58.16*	*57.48*					221
8/26/2016	9.91						9.91		*58.16*	*57.48*					
8/29/2016	9.99						9.99		*58.16*	*57.48*					
8/31/2016									*58.16*	*57.48*					
9/2/2016	9.99						9.99		*58.16*	*57.48*					
9/5/2016	9.99						9.99		*58.16*	*57.48*					
9/7/2016	9.99						9.99		*58.16*	*57.48*					
9/8/2016									*58.16*	*57.48*					202
9/10/2016	9.99				71.3		9.99		*58.16*	71.3					
9/13/2016	9.83	2.14		7.52			9.83	*2.14*	*58.16*	*57.48*		2.12			
9/14/2016									*58.16*	*57.48*					
9/16/2016	9.88				70.6		9.88		*58.16*	70.6					
9/21/2016	9.99						9.99		*58.16*	*57.48*					221
9/24/2016	9.99	1.14			70.5		9.99	*1.14*	*58.16*	70.5					
9/26/2016	9.99						9.99		*58.16*	*57.48*					
9/28/2016	9.99						9.99		*58.16*	*57.48*					
9/30/2016	9.99				68.1		9.99		*58.16*	68.1					
10/3/2016	9.99	0			64.3	65.7	9.99	0.5	65.7	64.3					
10/5/2016	9.99						9.99		*58.16*	*57.48*					227
10/7/2016	9.99						9.99		*58.16*	*57.48*					
10/10/2016	9.99				63.1		9.99		*58.16*	63.1					
10/12/2016	9.99						9.99		*58.16*	*57.48*					
10/14/2016	9.99						9.99		*58.16*	*57.48*					
10/17/2016	9.99				60		9.99		*58.16*	60					
10/19/2016									*58.16*	*57.48*					232
10/20/2016	9.99						9.99		*58.16*	*57.48*					
10/22/2016	9.99						9.99		*58.16*	*57.48*					
10/25/2016	9.99				61.1		9.99		*58.16*	61.1					
10/26/2016									*58.16*	*57.48*					
10/27/2016	9.99						9.99		*58.16*	*57.48*					
10/30/2016						62.3			62.3	57.48					
11/1/2016	9.99						9.99		*58.16*	*57.48*					
11/2/2016									*58.16*	*57.48*					232
11/3/2016									*58.16*	*57.48*					
11/5/2016	9.99						9.99		*58.16*	*57.48*					
11/8/2016	9.99			7.65			9.99		*58.16*	*57.48*					
11/9/2016									*58.16*	*57.48*					
11/10/2016	9.99					55	9.99		55	57.48					
11/12/2016									*58.16*	*57.48*					
11/14/2016	9.99						9.99		*58.16*	*57.48*					
11/16/2016	9.89				54.2		9.89		*58.16*	54.2					284
11/18/2016	9.94	1.43					9.94	*1.43*	*58.16*	*57.48*					
11/19/2016									*58.16*	*57.48*					
11/21/2016	9.99				54.1		9.99		*58.16*	54.1					
11/23/2016	9.99						9.99		*58.16*	*57.48*					
11/25/2016	9.99		7.64		52.6		9.99		*58.16*	52.6	9.90				

Table C.6 continued.

	Raw O Data into						Censored O Data into								Raw CL Data
	P	S	P	S	P	S	P	S	P	S	P	S	P-S	P Demand	P
	NH_3		pH		Temp.		NH_3		Temp.		NH_4^+			Alkalinity	
Date	mg-N L^{-1}		units		°F		mg-N L^{-1}		°F		mg-N L^{-1}			mg-$CaCO_3$ L^{-1}	
11/28/2016	9.99						9.99		*58.16*	*57.48*					
11/30/2016									*58.16*	*57.48*					263
12/1/2016	9.99				50.2		9.99		*58.16*	50.2					
12/3/2016	9.99	2.64					9.99	*2.64*	*58.16*	*57.48*					
12/5/2016	9.99						9.99		*58.16*	*57.48*					
12/7/2016	9.99	2.7			47.7		9.99	*2.70*	*58.16*	47.7					
12/8/2016									*58.16*	*57.48*					
12/9/2016	9.99						9.99		*58.16*	*57.48*					
12/12/2016	9.99				46.1		9.99		*58.16*	46.1					
12/14/2016	9.99	2.63					9.99	*2.63*	*58.16*	*57.48*					
12/16/2016	9.99						9.99		*58.16*	*57.48*					
12/19/2016	9.99				44.3		9.99		*58.16*	44.3					
12/21/2016									*58.16*	*57.48*					
12/22/2016	9.99	4.21					9.99	*4.21*	*58.16*	*57.48*					
12/26/2016	9.99						9.99		*58.16*	*57.48*					
12/28/2016									*58.16*	*57.48*					
12/29/2016	9.99				41.1		9.99		*58.16*	41.1					
				Average	*57.48*	*58.16*									

Table C.7 Raw and censored data used to calculate the TN percent removal and create Figure 2.8. Ammonia was censored to 0.5 mg L^{-1} and NO_3^-/NO_2^{-1} was censored to 2.5 mg L^{-1}. Where WI is WRRF influent, LE is lagoon effluent, PSE is primary SAGR effluent, D is discharge, P is primary, and S is secondary as described by Figure 2.1.

	Raw				Censored						
	LE		D		LE		D		LE	D	
	NH_3	NO_3^-/NO_2^-	NH_3	NO_3^-/NO_2^-	NH_3	NO_3^-/NO_2^-	NH_3	NO_3^-/NO_2^-	TN		Removal
Date	mg-N L-1										%
4/2/2014	9.99	1.70	0.09	11.11	9.99	2.5	0.5	11.11	12.49	11.61	7.07
4/3/2014	9.99	2.86	0	10.91	9.99	2.86	0.5	10.91	12.85	11.41	11.23
4/4/2014	9.99	2.84	0	10.71	9.99	2.84	0.5	10.71	12.83	11.21	12.64
4/7/2014	9.99	2.80	0	13.29	9.99	2.80	0.5	13.29	12.79	13.79	-7.84
4/8/2014	9.99	3.00	0	12.69	9.99	3.00	0.5	12.69	12.99	13.19	-1.50
4/9/2014	9.99	3.21	0	12.99	9.99	3.21	0.5	12.99	13.20	13.49	-2.20
4/10/2014	9.99	2.80	0	12.89	9.99	2.80	0.5	12.89	12.79	13.39	-4.73
4/11/2014	9.99	3.50	0	10.69	9.99	3.5	0.5	10.69	13.49	11.19	17.04
4/14/2014	9.20	4.07	0	9.48	9.20	4.07	0.5	9.48	13.27	9.98	24.76
4/15/2014	8.74	6.09	0	9.08	8.74	6.09	0.5	9.08	14.83	9.58	35.39
4/16/2014	8.21	6.89	0.07	9.08	8.21	6.89	0.5	9.08	15.10	9.58	36.54
4/17/2014	7.29	7.26	0.11	8.69	7.29	7.26	0.5	8.69	14.55	9.19	36.83
4/18/2014	7.19	7.05	0	9.08	7.19	7.05	0.5	9.08	14.24	9.58	32.70
4/21/2014	8.34	3.60	0	6.51	8.34	3.60	0.5	6.51	11.94	7.01	41.26
4/22/2014	7.10	5.48	0.10	6.02	7.10	5.48	0.5	6.02	12.58	6.52	48.18
4/23/2014	6.02	7.35	0.31	5.12	6.02	7.35	0.5	5.12	13.37	5.62	57.96
4/24/2014	4.27	7.17	0.51	7.72	4.27	7.17	0.51	7.72	11.44	8.23	28.02

Table C.7 continued.

	Raw				Censored						
	LE		D		LE		D		LE	D	
	NH_3	NO_3^-/NO_2^-	NH_3	NO_3^-/NO_2^-	NH_3	NO_3^-/NO_2^-	NH_3	NO_3^-/NO_2^-	TN		Removal
Date	mg-N L-1										%
4/25/2014	3.06	7.30	0.63	2.13	3.06	7.30	0.63	2.5	10.36	3.13	69.79
4/28/2014	3.10	7.09	0.78	2.03	3.10	7.09	0.78	2.5	10.19	3.28	67.81
4/29/2014	2.40	7.19	1.03	2.13	2.40	7.19	1.03	2.5	9.59	3.53	63.21
4/30/2014	1.02	7.00	1.77	2.61	1.02	7.00	1.77	2.61	8.02	4.38	45.35
5/1/2014	0.71	7.00	2.89	0.51	0.71	7.00	2.89	2.50	7.71	5.39	30.09
5/2/2014	0.88	5.90	0	4.50	0.88	5.90	0.5	4.50	6.78	5.00	26.19
5/6/2014	0.27	4.79	0	0.91	0.5	4.79	0.5	2.50	5.29	3.00	43.25
5/7/2014	0	6.11	0	6.23	0.5	6.11	0.5	6.23	6.61	6.73	-1.85
5/8/2014	0.25	3.02	0	4.20	0.5	3.02	0.5	4.20	3.52	4.70	-33.69
5/9/2014	0.21	5.11	0	3.80	0.5	5.11	0.5	3.80	5.61	4.30	23.33
5/12/2014	0.24	5.42	0	4.31	0.5	5.42	0.5	4.31	5.92	4.81	18.78
5/13/2014	0.22	5.41	0	4.81	0.5	5.41	0.5	4.81	5.91	5.31	10.28
5/14/2014	0.30	5.37	0	4.62	0.5	5.37	0.5	4.62	5.87	5.12	12.74
5/15/2014	0.57	5.02	0	4.52	0.57	5.02	0.5	4.52	5.59	5.02	10.18
5/16/2014	0.86	4.47	0	4.51	0.86	4.47	0.5	4.51	5.33	5.01	5.91
5/20/2014	0.70	2.43	0	4.42	0.70	2.5	0.5	4.42	3.20	4.92	-53.66
5/21/2014	0.74	2.19	0.06	4.21	0.74	2.5	0.5	4.21	3.24	4.71	-45.40
5/22/2014	0.07	1.95	0	4.01	0.50	2.5	0.5	4.01	3.00	4.51	-50.40
5/26/2014	1.06	3.89	0	1.21	1.06	3.89	0.5	2.5	4.95	3.00	39.33
5/27/2014	1.38	0.50	0	3.30	1.38	2.5	0.5	3.30	3.88	3.80	2.01
5/28/2014	1.58	1.30	0.08	0.00	1.58	2.5	0.5	2.5	4.08	3.00	26.47
5/29/2014	2.35	2.22	0.03	1.21	2.35	2.5	0.5	2.5	4.85	3.00	38.14
5/30/2014	2.62	2.87	0.31	1.76	2.62	2.87	0.5	2.5	5.49	3.00	45.31
6/2/2014	2.72	3.07	0	1.86	2.72	3.07	0.5	2.5	5.79	3.00	48.15
6/3/2014	3.10	3.17	0.17	2.06	3.10	3.17	0.5	2.5	6.27	3.00	52.12
6/4/2014	3.20	3.07	0.18	2.45	3.20	3.07	0.5	2.5	6.27	3.00	52.15
6/5/2014	3.10	3.67	0	2.85	3.10	3.67	0.5	2.85	6.77	3.35	50.42
6/6/2014	5.60	2.90	0	2.79	5.60	2.90	0.5	2.79	8.50	3.29	61.33
6/9/2014	5.76	2.10	0	2.41	5.76	2.5	0.5	2.5	8.26	3.00	63.68
6/10/2014	5.22	2.40	0	2.72	5.22	2.5	0.5	2.72	7.72	3.22	58.35
6/11/2014	5.04	3.13	0	3.52	5.04	3.13	0.5	3.52	8.17	4.02	50.79
6/12/2014	5.10	2.93	0	3.72	5.10	2.93	0.5	3.72	8.03	4.22	47.43
6/13/2014	5.21	2.73	0	3.93	5.21	2.73	0.5	3.93	7.94	4.43	44.18
6/16/2014	5.28	2.43	0	4.02	5.28	2.5	0.5	4.02	7.78	4.52	41.89
6/17/2014	6.04	2.51	0	4.22	6.04	2.51	0.5	4.22	8.55	4.72	44.86
6/18/2014	5.22	2.52	0	4.32	5.22	2.52	0.5	4.32	7.74	4.82	37.70
6/19/2014	5.23	2.72	0	4.52	5.23	2.72	0.5	4.52	7.95	5.02	36.80
6/20/2014	4.90	2.92	0	3.72	4.90	2.92	0.5	3.72	7.82	4.22	46.11
6/23/2014	4.74	2.73	0	3.42	4.74	2.73	0.5	3.42	7.47	3.92	47.50
6/24/2014	4.76	2.52	0	3.22	4.76	2.52	0.5	3.22	7.28	3.72	48.86
6/25/2014	4.80	2.42	0	3.23	4.80	2.5	0.5	3.23	7.30	3.73	48.95
6/26/2014	4.87	2.52	0	3.33	4.87	2.52	0.5	3.33	7.39	3.83	48.23
6/27/2014	5.02	2.62	0	3.73	5.02	2.62	0.5	3.73	7.64	4.23	44.66
6/30/2014	5.00	2.43	0	3.74	5.00	2.5	0.5	3.74	7.50	4.24	43.51
7/1/2014	4.90	2.52	0	3.92	4.90	2.52	0.5	3.92	7.42	4.42	40.46
7/2/2014	4.84	2.63	0	3.93	4.84	2.63	0.5	3.93	7.47	4.43	40.67
7/3/2014	4.83	2.73	0	3.83	4.83	2.73	0.5	3.83	7.56	4.33	42.65
7/7/2014	5.00	2.62	0	4.03	5.00	2.62	0.5	4.03	7.62	4.53	40.50
7/8/2014	3.10	3.09	0	3.24	3.10	3.09	0.5	3.24	6.19	3.74	39.64
7/9/2014	2.02	3.43	0	3.44	2.02	3.43	0.5	3.44	5.45	3.94	27.67
7/10/2014	0.42	3.69	0	3.14	0.5	3.69	0.5	3.14	4.19	3.64	13.03
7/12/2014	0.26	3.41	0	2.26	0.5	3.41	0.5	2.5	3.91	3.00	23.18

Table C.7 continued.

	Raw				Censored						
	LE		D		LE		D		LE	D	
	NH_3	NO_3^-/NO_2^-	NH_3	NO_3^-/NO_2^-	NH_3	NO_3^-/NO_2^-	NH_3	NO_3^-/NO_2^-	TN		Removal
Date	mg-N L-1										%
7/13/2014	0	3.50	0	2.35	0.5	3.50	0.5	2.5	4.00	3.00	25.06
7/14/2014	0	3.61	0	2.35	0.5	3.61	0.5	2.5	4.11	3.00	26.92
7/15/2014	0	3.71	0	2.45	0.5	3.71	0.5	2.5	4.21	3.00	28.69
7/16/2014	0	3.81	0	2.35	0.5	3.81	0.5	2.5	4.31	3.00	30.36
7/19/2014	0	3.71	0	2.05	0.5	3.71	0.5	2.5	4.21	3.00	28.67
7/20/2014	0	2.30	0	2.25	0.5	2.50	0.5	2.5	3.00	3.00	0.00
7/21/2014	0	2.71	0	2.25	0.5	2.71	0.5	2.5	3.21	3.00	6.54
7/22/2014	0	2.81	0	2.35	0.5	2.81	0.5	2.5	3.31	3.00	9.26
7/23/2014	0	2.91	0	2.44	0.5	2.91	0.5	2.5	3.41	3.00	11.92
7/25/2014	0	3.01	0	2.34	0.5	3.01	0.5	2.5	3.51	3.00	14.53
8/1/2014	0	4.36	0	3.45	0.5	4.36	0.5	2.5	4.86	3.00	38.27
8/4/2014	0	4.36	0	3.45	0.5	4.36	0.5	2.5	4.86	3.00	38.31
8/5/2014	0	4.47	0	3.35	0.5	4.47	0.5	3.35	4.97	3.85	22.47
8/6/2014	0	4.26	0	3.65	0.5	4.26	0.5	3.65	4.76	4.15	12.79
8/7/2014	0	4.46	0	3.56	0.5	4.46	0.5	3.56	4.96	4.06	18.16
8/8/2014	0	4.36	0	3.55	0.5	4.36	0.5	3.55	4.86	4.05	16.61
8/11/2014	0	4.16	0	3.65	0.5	4.16	0.5	3.65	4.66	4.15	10.97
8/13/2014	0	3.84	0	2.34	0.5	3.84	0.5	2.5	4.34	3.00	30.88
8/14/2014	0	3.83	0	2.44	0.5	3.83	0.5	2.5	4.33	3.00	30.68
8/15/2014	0	3.75	0	2.24	0.5	3.75	0.5	2.5	4.25	3.00	29.41
8/16/2014	0	3.84	0	2.34	0.5	3.84	0.5	2.5	4.34	3.00	30.94
8/17/2014	0	3.84	0	2.25	0.5	3.84	0.5	2.5	4.34	3.00	30.94
8/18/2014	0	3.94	0	2.85	0.5	3.94	0.5	2.85	4.44	3.35	24.62
8/21/2014	0	3.94	0	2.75	0.5	3.94	0.5	2.75	4.44	3.25	26.83
8/22/2014	0	4.14	0	3.05	0.5	4.14	0.5	3.05	4.64	3.55	23.45
8/23/2014	0	4.24	0	3.05	0.5	4.24	0.5	3.05	4.74	3.55	25.20
8/24/2014	0	4.14	0	3.15	0.5	4.14	0.5	3.15	4.64	3.65	21.36
8/25/2014	0	4.24	0	3.35	0.5	4.24	0.5	3.35	4.74	3.85	18.80
8/28/2014	0	4.36	0	3.36	0.5	4.36	0.5	3.36	4.86	3.86	20.56
8/29/2014	0	4.26	0	3.46	0.5	4.26	0.5	3.46	4.76	3.96	16.87
8/30/2014	0	4.26	0	3.55	0.5	4.26	0.5	3.55	4.76	4.05	14.93
9/1/2014	2.40	3.88	0.17	3.45	2.40	3.88	0.5	3.45	6.28	3.95	37.15
9/2/2014	2.38	3.29	0.20	2.75	2.38	3.29	0.5	2.75	5.67	3.25	42.65
9/3/2014	2.17	2.99	0.12	2.95	2.17	2.99	0.5	2.95	5.16	3.45	33.08
9/4/2014	2.29	2.68	0	3.35	2.29	2.68	0.5	3.35	4.97	3.85	22.49
9/5/2014	2.47	2.27	0	3.45	2.47	2.5	0.5	3.45	4.97	3.95	20.56
9/6/2014	2.29	2.08	0.09	3.34	2.29	2.5	0.5	3.34	4.79	3.84	19.83
9/7/2014	2.41	2.07	0.10	3.33	2.41	2.5	0.5	3.33	4.91	3.83	21.98
9/8/2014	2.30	1.88	0.10	3.14	2.30	2.5	0.5	3.14	4.80	3.64	24.15
9/9/2014	3.40	1.38	0.41	0.95	3.40	2.5	0.5	2.5	5.90	3.00	49.15
9/10/2014	5.63	1.58	0.15	1.25	5.63	2.5	0.5	2.5	8.13	3.00	63.10
9/11/2014	5.29	2.68	0.04	1.05	5.29	2.68	0.5	2.5	7.97	3.00	62.34
9/12/2014	1.38	3.07	0.18	4.71	1.38	3.07	0.5	4.71	4.45	5.21	-17.17
9/15/2014	1.00	4.07	0.17	4.41	1.00	4.07	0.5	4.41	5.07	4.91	3.08
9/16/2014	1.03	4.28	0.16	4.62	1.03	4.28	0.5	4.62	5.31	5.12	3.60
9/17/2014	0.76	4.88	0.09	4.81	0.76	4.88	0.5	4.81	5.64	5.31	5.78
9/18/2014	0.76	4.88	0	4.92	0.76	4.88	0.5	4.92	5.64	5.42	3.97
9/19/2014	0.70	4.88	0	4.72	0.70	4.88	0.5	4.72	5.58	5.22	6.61
9/22/2014	0.57	4.69	0	4.82	0.57	4.69	0.5	4.82	5.26	5.32	-1.06
9/23/2014	0.67	4.69	0.08	4.92	0.67	4.69	0.5	4.92	5.36	5.42	-1.10
9/24/2014	0.80	4.79	0.17	5.02	0.80	4.79	0.5	5.02	5.59	5.52	1.29
9/25/2014	0.81	4.88	0.20	5.12	0.81	4.88	0.5	5.12	5.69	5.62	1.39

Table C.7 continued.

	Raw				Censored						
	LE		D		LE		D		LE	D	
	NH_3	NO_3^-/NO_2^-	NH_3	NO_3^-/NO_2^-	NH_3	NO_3^-/NO_2^-	NH_3	NO_3^-/NO_2^-	TN		Removal
Date					mg-N L-1						%
9/26/2014	0.70	4.98	0.17	4.42	0.70	4.98	0.5	4.42	5.68	4.92	13.47
9/29/2014	0.84	4.98	0.19	4.32	0.84	4.98	0.5	4.32	5.82	4.82	17.26
9/30/2014	0.96	4.79	0.21	4.52	0.96	4.79	0.5	4.52	5.75	5.02	12.73
10/1/2014	0.90	4.49	0.17	4.22	0.90	4.49	0.5	4.22	5.39	4.72	12.55
10/2/2014	0.87	4.40	0	4.32	0.87	4.40	0.5	4.32	5.27	4.82	8.54
10/3/2014	0.92	4.41	0	4.42	0.92	4.41	0.5	4.42	5.33	4.92	7.62
10/6/2014	2.01	4.60	0	4.43	2.01	4.60	0.5	4.43	6.61	4.93	25.42
10/7/2014	1.90	4.41	0	4.54	1.90	4.41	0.5	4.54	6.31	5.04	20.21
10/8/2014	2.40	4.19	0	4.54	2.40	4.19	0.5	4.54	6.59	5.04	23.57
10/9/2014	2.54	4.19	0.11	4.64	2.54	4.19	0.5	4.64	6.73	5.14	23.57
10/10/2014	3.10	3.58	0.14	4.44	3.10	3.58	0.5	4.44	6.68	4.94	26.03
10/13/2014	6.22	3.37	0.17	4.64	6.22	3.37	0.5	4.64	9.59	5.14	46.38
10/14/2014	7.49	3.10	0.26	4.72	7.49	3.10	0.5	4.72	10.59	5.22	50.67
10/15/2014	8.74	1.82	0.31	6.98	8.74	2.5	0.5	6.98	11.24	7.48	33.48
10/16/2014	8.40	2.03	0.31	4.33	8.40	2.5	0.5	4.33	10.90	4.83	55.73
10/17/2014	7.98	1.92	0.31	3.77	7.98	2.5	0.5	3.77	10.48	4.27	59.25
10/20/2014	7.01	1.62	5.07	4.67	7.01	2.5	5.07	4.67	9.51	9.74	-2.42
10/21/2014	7.10	1.52	2.13	8.87	7.10	2.5	2.13	8.87	9.60	11.00	-14.60
10/22/2014	6.90	2.52	1.22	15.07	6.90	2.52	1.22	15.07	9.42	16.29	-72.89
10/23/2014	6.93	2.62	0.27	14.77	6.93	2.62	0.5	14.77	9.55	15.27	-59.88
10/24/2014	6.70	2.70	0.28	14.34	6.70	2.70	0.5	14.34	9.40	14.84	-57.91
10/27/2014	7.80	3.20	0	8.44	7.80	3.20	0.5	8.44	11.00	8.94	18.72
10/28/2014	8.78	6.10	0	5.73	8.78	6.10	0.5	5.73	14.88	6.23	58.13
11/1/2014	9.99	4.98	0	6.17	9.99	4.98	0.5	6.17	14.97	6.67	55.44
11/4/2014	9.99	4.88	0	6.37	9.99	4.88	0.5	6.37	14.87	6.87	53.79
11/5/2014	9.99	5.08	0	7.97	9.99	5.08	0.5	7.97	15.07	8.47	43.81
11/6/2014	9.99	4.87	0	8.17	9.99	4.87	0.5	8.17	14.86	8.67	41.67
11/7/2014	9.99	0.86	0.12	5.83	9.99	2.50	0.5	5.83	12.49	6.33	49.29
11/8/2014	9.99	7.26		7.25	9.99	7.26		7.25	17.25		100.00
11/11/2014	9.99	7.16	0	9.53	9.99	7.16	0.5	9.53	17.15	10.03	41.50
11/12/2014	9.99	7.06	0	9.73	9.99	7.06	0.5	9.73	17.05	10.23	39.98
11/13/2014	9.99	6.96	0	9.94	9.99	6.96	0.5	9.94	16.95	10.44	38.45
11/14/2014	9.99	2.23	0	9.43	9.99	2.5	0.5	9.43	12.49	9.93	20.46
11/15/2014	9.99	3.63	0	6.68	9.99	3.63	0.5	6.68	13.62	7.18	47.26
11/18/2014	9.99	4.33	0	6.99	9.99	4.33	0.5	6.99	14.32	7.49	47.74
11/19/2014	9.99	4.23	0	7.29	9.99	4.23	0.5	7.29	14.22	7.79	45.26
11/20/2014	9.99	4.44	0	7.68	9.99	4.44	0.5	7.68	14.43	8.18	43.30
11/21/2014	9.99	4.34	0	7.58	9.99	4.34	0.5	7.58	14.33	8.08	43.64
11/22/2014	9.99	4.53	0	9.78	9.99	4.53	0.5	9.78	14.52	10.28	29.23
11/25/2014	9.99	4.73	0	10.41	9.99	4.73	0.5	10.41	14.72	10.91	25.87
11/26/2014	9.99	3.99	0	10.30	9.99	3.99	0.5	10.30	13.98	10.80	22.72
11/27/2014	9.99	1.12	0	10.10	9.99	2.5	0.5	10.10	12.49	10.60	15.13
11/29/2014	9.99	8.95	0.15	10.01	9.99	8.95	0.5	10.01	18.94	10.51	44.50
12/1/2014	9.10	8.75	0.44	5.53	9.10	8.75	0.5	5.53	17.85	6.03	66.23
12/2/2014	9.00	9.26	0.40	5.43	9.00	9.26	0.5	5.43	18.26	5.93	67.55
12/3/2014	9.40	9.46	0.41	5.63	9.40	9.46	0.5	5.63	18.86	6.13	67.52
12/4/2014	9.34	9.66	0.04	5.43	9.34	9.66	0.5	5.43	19.00	5.93	68.81
12/5/2014	9.10	9.36	0.30	5.43	9.10	9.36	0.5	5.43	18.46	5.93	67.89
12/8/2014	8.74	9.46	0.14	6.33	8.74	9.46	0.5	6.33	18.20	6.83	62.45
12/9/2014	8.76	9.16	0	7.94	8.76	9.16	0.5	7.94	17.92	8.44	52.92
12/10/2014	9.12	8.76	0	7.84	9.12	8.76	0.5	7.84	17.88	8.34	53.36
12/11/2014	8.90	8.65	0	7.94	8.90	8.65	0.5	7.94	17.55	8.44	51.91

Table C.7 continued.

	Raw				Censored						
	LE		D		LE		D		LE	D	
	NH_3	NO_3^-/NO_2^-	NH_3	NO_3^-/NO_2^-	NH_3	NO_3^-/NO_2^-	NH_3	NO_3^-/NO_2^-	TN		Removal
Date					mg-N L-1						%
12/12/2014	8.91	8.06	0	7.74	8.91	8.06	0.5	7.74	16.97	8.24	51.46
12/15/2014	8.91	8.06	0	7.84	8.91	8.06	0.5	7.84	16.97	8.34	50.85
12/16/2014	9.01	8.26	0	7.94	9.01	8.26	0.5	7.94	17.27	8.44	51.12
12/17/2014	9.00	8.06	0	7.54	9.00	8.06	0.5	7.54	17.06	8.04	52.87
12/18/2014	8.90	7.46	0	7.84	8.90	7.46	0.5	7.84	16.36	8.34	49.02
12/19/2014	8.71	7.75	0	7.94	8.71	7.75	0.5	7.94	16.46	8.44	48.74
12/22/2014	8.00	7.85	0	8.14	8.00	7.85	0.5	8.14	15.85	8.64	45.49
12/23/2014	8.14	7.46	0	8.34	8.14	7.46	0.5	8.34	15.60	8.84	43.31
12/24/2014	8.20	7.16	0	7.74	8.20	7.16	0.5	7.74	15.36	8.24	46.35
12/26/2014	7.20	7.16	0	7.95	7.20	7.16	0.5	7.95	14.36	8.45	41.18
12/27/2014	6.90	7.06	0	8.05	6.90	7.06	0.5	8.05	13.96	8.55	38.77
12/29/2014	6.41	8.25	0	8.25	6.41	8.25	0.5	8.25	14.66	8.75	40.31
12/30/2014	4.21	8.05	0	8.96	4.21	8.05	0.5	8.96	12.26	9.46	22.84
12/31/2014	4.00	7.65	0	9.06	4.00	7.65	0.5	9.06	11.65	9.56	17.91
1/2/2015	3.60	7.05	0	9.27	3.60	7.05	0.5	9.27	10.65	9.77	8.27
1/3/2015	3.70	7.25	0	9.16	3.70	7.25	0.5	9.16	10.95	9.66	11.72
1/5/2015	3.20	7.15	0	9.26	3.20	7.15	0.5	9.26	10.35	9.76	5.62
1/6/2015	3.50	7.25	0	9.17	3.50	7.25	0.5	9.17	10.75	9.67	10.07
1/7/2015	3.40	7.04	0	8.46	3.40	7.04	0.5	8.46	10.44	8.96	14.18
1/8/2015	3.40	7.14	0	9.07	3.40	7.14	0.5	9.07	10.54	9.57	9.21
1/9/2015	3.30	5.05	0	8.77	3.30	5.05	0.5	8.77	8.35	9.27	-11.03
1/12/2015	5.70	4.15	0.05	4.36	5.70	4.15	0.5	4.36	9.85	4.86	50.69
1/13/2015	6.20	3.45	0	4.45	6.20	3.45	0.5	4.45	9.65	4.95	48.68
1/14/2015	8.10	2.15	0.07	4.65	8.10	2.5	0.5	4.65	10.60	5.15	51.40
1/15/2015	8.90	1.45	0.04	4.54	8.90	2.5	0.5	4.54	11.40	5.04	55.82
1/16/2015	8.50	0.05	0.09	4.45	8.50	2.5	0.5	4.45	11.00	4.95	54.97
1/19/2015	9.00	0.05	0.10	4.35	9.00	2.5	0.5	4.35	11.50	4.85	57.82
1/20/2015	9.99	0.05	0.11	4.35	9.99	2.5	0.5	4.35	12.49	4.85	61.15
1/21/2015	8.72	0.52	0	4.76	8.72	2.5	0.5	4.76	11.22	5.26	53.12
1/22/2015	8.60	0.42	0	4.96	8.60	2.5	0.5	4.96	11.10	5.46	50.83
1/23/2015	7.78	0.05	0	5.26	7.78	2.5	0.5	5.26	10.28	5.76	43.97
1/26/2015	7.60	0.05	0	5.36	7.60	2.5	0.5	5.36	10.10	5.86	42.00
1/27/2015	7.81	1.25	0	5.46	7.81	2.5	0.5	5.46	10.31	5.96	42.20
1/28/2015	7.80	1.14	0	6.06	7.80	2.5	0.5	6.06	10.30	6.56	36.29
1/29/2015	7.82	1.34	0	5.96	7.82	2.5	0.5	5.96	10.32	6.46	37.40
1/30/2015	8.20	1.14	0	6.26	8.20	2.5	0.5	6.26	10.70	6.76	36.80
2/2/2015	9.99	1.14	0	6.36	9.99	2.5	0.5	6.36	12.49	6.86	45.09
2/3/2015	9.99	0.93	0	6.15	9.99	2.5	0.5	6.15	12.49	6.65	46.74
2/4/2015	9.99	0.84	0	5.96	9.99	2.5	0.5	5.96	12.49	6.46	48.28
2/5/2015	9.99	0.43	0.08	5.96	9.99	2.5	0.5	5.96	12.49	6.46	48.30
2/6/2015	9.99	0.74	0	5.76	9.99	2.5	0.5	5.76	12.49	6.26	49.88
2/9/2015	9.99	0.72	0	5.86	9.99	2.5	0.5	5.86	12.49	6.36	49.07
2/10/2015	8.72	0.03	0	5.76	8.72	2.5	0.5	5.76	11.22	6.26	44.21
2/11/2015	9.99	0.04	0	5.33	9.99	2.5	0.5	5.33	12.49	5.83	53.32
2/12/2015	9.99	0.04	0	4.71	9.99	2.5	0.5	4.71	12.49	5.21	58.27
2/13/2015	9.99	0.06	0	5.10	9.99	2.5	0.5	5.10	12.49	5.60	55.16
2/16/2015	9.99	0.06	0	0.01	9.99	2.5	0.5	2.5	12.49	3.00	75.98
2/17/2015	9.99	0.06	0	5.10	9.99	2.5	0.5	5.10	12.49	5.60	55.13
2/18/2015	9.99	0.06	0	5.20	9.99	2.5	0.5	5.20	12.49	5.70	54.36
2/19/2015	9.99	1.48	0	5.70	9.99	2.5	0.5	5.70	12.49	6.20	50.36
2/23/2015				4.84				4.84			
2/24/2015	9.99	3.58	0.95	4.72	9.99	3.58	0.95	4.72	13.57	5.67	58.26

Table C.7 continued.

	Raw				Censored						
	LE		D		LE		D		LE	D	
	NH_3	NO_3^-/NO_2^-	NH_3	NO_3^-/NO_2^-	NH_3	NO_3^-/NO_2^-	NH_3	NO_3^-/NO_2^-	TN		Removal
Date	mg-N L-1										%
2/25/2015	9.99	9.39	0	23.37	9.99	9.39	0.5	23.37	19.38	23.87	-23.13
2/26/2015	9.99	9.14	0.36	19.75	9.99	9.14	0.5	19.75	19.13	20.25	-5.90
2/27/2015	9.99	8.44	1.43	17.41	9.99	8.44	1.43	17.41	18.43	18.84	-2.22
3/2/2015	9.99	8.14	1.01	15.32	9.99	8.14	1.01	15.32	18.13	16.33	9.95
3/3/2015	9.99	8.34	0.82	14.72	9.99	8.34	0.82	14.72	18.33	15.54	15.20
3/4/2015	9.99	8.63	1.20	14.62	9.99	8.63	1.20	14.62	18.62	15.82	15.04
3/5/2015	9.99	8.13	1.22	14.80	9.99	8.13	1.22	14.80	18.12	16.02	11.57
3/6/2015	9.99	8.33	0.88	12.21	9.99	8.33	0.88	12.21	18.32	13.09	28.54
3/9/2015	9.99	9.03	1.01	11.71	9.99	9.03	1.01	11.71	19.02	12.72	33.13
3/10/2015	9.99	9.23	0	8.71	9.99	9.23	0.5	8.71	19.22	9.21	52.10
3/11/2015	9.99	9.75	0	8.70	9.99	9.75	0.5	8.70	19.74	9.20	53.39
3/12/2015	9.99	9.75	0	0.86	9.99	9.75	0.5	2.5	19.74	3.00	84.80
3/13/2015	9.99	0.08	0	10.78	9.99	2.5	0.5	10.78	12.49	11.28	9.70
3/16/2015	9.99	0.10	0	30.04	9.99	2.5	0.5	30.04	12.49	30.54	-144.50
3/17/2015	9.99	0.99	0	8.01	9.99	2.5	0.5	8.01	12.49	8.51	31.90
3/18/2015	9.99	1.40	0	7.91	9.99	2.5	0.5	7.91	12.49	8.41	32.67
3/19/2015	9.99	1.60	0	7.81	9.99	2.5	0.5	7.81	12.49	8.31	33.45
3/20/2015	9.99	1.20	0	7.71	9.99	2.5	0.5	7.71	12.49	8.21	34.24
3/23/2015	9.99	1.20	0	7.92	9.99	2.5	0.5	7.92	12.49	8.42	32.61
3/24/2015	9.99	1.50	0	8.02	9.99	2.5	0.5	8.02	12.49	8.52	31.80
3/25/2015	9.99	1.50	0	8.33	9.99	2.5	0.5	8.33	12.49	8.83	29.33
3/26/2015	9.99	1.40	0	8.73	9.99	2.5	0.5	8.73	12.49	9.23	26.10
3/27/2015	9.99	1.60	0	8.53	9.99	2.5	0.5	8.53	12.49	9.03	27.70
3/30/2015	9.99	2.12	0	8.73	9.99	2.5	0.5	8.73	12.49	9.23	26.12
3/31/2015	9.96	2.98	0	8.29	9.96	2.98	0.5	8.29	12.94	8.79	32.04
4/1/2015	9.50	2.93	0.04	7.93	9.50	2.93	0.5	7.93	12.43	8.43	32.18
4/2/2015	9.46	3.10	0	7.73	9.46	3.10	0.5	7.73	12.56	8.23	34.46
4/3/2015	9.29	3.06	0	7.83	9.29	3.06	0.5	7.83	12.35	8.33	32.53
4/6/2015	9.22	3.20	0.01	7.83	9.22	3.20	0.5	7.83	12.42	8.33	32.94
4/7/2015	9.99	3.44	0	2.36	9.99	3.44	0.5	2.5	13.43	3.00	77.66
4/8/2015	9.74	3.81	0	2.56	9.74	3.81	0.5	2.56	13.55	3.06	77.43
4/9/2015	9.99	4.30	0	2.46	9.99	4.30	0.5	2.5	14.29	3.00	79.01
4/10/2015	9.99	4.70	0	2.46	9.99	4.70	0.5	2.5	14.69	3.00	79.58
4/13/2015	9.99	3.26		2.36	9.99	3.26		2.5	13.25		100.00
4/14/2015		1.76	0	2.97		2.5	0.5	2.97		3.47	
4/15/2015		0.08	0	3.27		2.5	0.5	3.27		3.77	
4/16/2015		0.08	0	3.37		2.5	0.5	3.37		3.87	
4/17/2015		0.11	0	4.07		2.5	0.5	4.07		4.57	
4/20/2015		0.11	0	3.97		2.5	0.5	3.97		4.47	
4/21/2015		1.41	0	4.17		2.5	0.5	4.17		4.67	
4/22/2015		1.31	0	4.17		2.5	0.5	4.17		4.67	
4/23/2015		1.41	0	4.37		2.5	0.5	4.37		4.87	
4/24/2015		1.81	0	4.27		2.5	0.5	4.27		4.77	
4/27/2015		2.12	0	4.77		2.5	0.5	4.77		5.27	
4/28/2015		1.92	0	4.87		2.5	0.5	4.87		5.37	
4/29/2015		2.22	0	5.07		2.5	0.5	5.07		5.57	
4/30/2015		2.12	0	5.17		2.5	0.5	5.17		5.67	
5/1/2015		2.52	0	5.47		2.52	0.5	5.47		5.97	
5/4/2015		2.26	0	5.57		2.5	0.5	5.57		6.07	
5/5/2015	9.99	2.38	0	5.75	9.99	2.5	0.5	5.75	12.49	6.25	49.95
5/6/2015	9.84	2.34	0	5.53	9.84	2.5	0.5	5.53	12.34	6.03	51.13
5/7/2015	9.70	2.31	0	5.22	9.70	2.5	0.5	5.22	12.20	5.72	53.10

Table C.7 continued.

	Raw				Censored						
	LE		D		LE		D		LE	D	
	NH_3	NO_3^-/NO_2^-	NH_3	NO_3^-/NO_2^-	NH_3	NO_3^-/NO_2^-	NH_3	NO_3^-/NO_2^-	TN		Removal
Date					mg-N L-1						%
5/8/2015	9.12	2.42	0	5.52	9.12	2.5	0.5	5.52	11.62	6.02	48.19
5/11/2015	8.04	2.27	0	5.42	8.04	2.5	0.5	5.42	10.54	5.92	43.82
5/12/2015	8.12	2.60	0	5.63	8.12	2.60	0.5	5.63	10.72	6.13	42.84
5/13/2015	8.14	2.40	0	5.93	8.14	2.5	0.5	5.93	10.64	6.43	39.56
5/14/2015	8.27	2.64	0	6.33	8.27	2.64	0.5	6.33	10.91	6.83	37.42
5/15/2015	8.44	2.43	0	6.13	8.44	2.5	0.5	6.13	10.94	6.63	39.40
5/18/2015	8.40	2.04	0	6.33	8.40	2.5	0.5	6.33	10.90	6.83	37.31
5/19/2015	9.10	1.54	0	6.63	9.10	2.5	0.5	6.63	11.60	7.13	38.53
5/20/2015	9.22	2.04	0	6.83	9.22	2.5	0.5	6.83	11.72	7.33	37.44
5/21/2015	9.01	1.44	0	6.63	9.01	2.5	0.5	6.63	11.51	7.13	38.05
5/22/2015	9.07	1.64	0	7.33	9.07	2.5	0.5	7.33	11.57	7.83	32.31
5/26/2015	8.60	1.84	0	7.23	8.60	2.5	0.5	7.23	11.10	7.73	30.32
5/27/2015	8.50	1.85	0	5.44	8.50	2.5	0.5	5.44	11.00	5.94	46.01
5/28/2015	8.37	1.95	0	4.70	8.37	2.5	0.5	4.70	10.87	5.20	52.16
5/29/2015	7.20	1.85	0	4.62	7.20	2.5	0.5	4.62	9.70	5.12	47.23
6/1/2015	7.00	2.04	0	3.72	7.00	2.5	0.5	3.72	9.50	4.22	55.58
6/2/2015	6.52	1.84	0	3.41	6.52	2.5	0.5	3.41	9.02	3.91	56.63
6/3/2015	6.61	2.04	0	3.02	6.61	2.5	0.5	3.02	9.11	3.52	61.36
6/4/2015	7.14	2.14	0	2.72	7.14	2.5	0.5	2.72	9.64	3.22	66.57
6/5/2015	7.20	2.14	0	2.43	7.20	2.5	0.5	2.43	9.70	2.93	69.84
6/8/2015	6.40	2.24	0	2.02	6.40	2.5	0.5	2.5	8.90	3.00	66.29
6/9/2015	6.28	2.54	0	1.72	6.28	2.54	0.5	2.5	8.82	3.00	65.99
6/10/2015	7.12	2.65	0	1.92	7.12	2.65	0.5	2.5	9.77	3.00	69.30
6/11/2015	7.14	2.76	0	2.32	7.14	2.76	0.5	2.5	9.90	3.00	69.68
6/12/2015	7.16	3.87	0	2.42	7.16	3.87	0.5	2.5	11.03	3.00	72.80
6/15/2015	7.02	3.67	0	2.22	7.02	3.67	0.5	2.5	10.69	3.00	71.94
6/16/2015	6.83	3.77	0	1.92	6.83	3.77	0.5	2.5	10.60	3.00	71.70
6/17/2015	7.11	3.97	0	1.93	7.11	3.97	0.5	2.5	11.08	3.00	72.92
6/18/2015	6.84	4.07	0	2.23	6.84	4.07	0.5	2.5	10.91	3.00	72.50
6/19/2015	6.83	4.07	0	2.23	6.83	4.07	0.5	2.5	10.90	3.00	72.49
6/22/2015	6.92	3.88	0	2.33	6.92	3.88	0.5	2.5	10.80	3.00	72.22
6/23/2015	7.12	3.97	0	2.23	7.12	3.97	0.5	2.5	11.09	3.00	72.96
6/24/2015	7.24	3.87	0	2.33	7.24	3.87	0.5	2.5	11.11	3.00	73.00
6/25/2015	7.20	3.90	0	2.23	7.20	3.90	0.5	2.5	11.10	3.00	72.97
6/26/2015	7.47	3.77	0	2.63	7.47	3.77	0.5	2.63	11.24	3.13	72.16
6/29/2015	7.64	3.77	0	2.63	7.64	3.77	0.5	2.63	11.41	3.13	72.61
6/30/2015	7.81	3.88	0	2.73	7.81	3.88	0.5	2.73	11.69	3.23	72.39
7/1/2015	8.47	3.78	0	3.43	8.47	3.78	0.5	3.43	12.25	3.93	67.92
7/2/2015	8.51	3.88	0	3.34	8.51	3.88	0.5	3.34	12.39	3.84	69.03
7/6/2015	8.04	3.77	0	3.24	8.04	3.77	0.5	3.24	11.81	3.74	68.33
7/7/2015	7.24	3.77	0	2.14	7.24	3.77	0.5	2.5	11.01	3.00	72.75
7/8/2015	6.01	3.86	0	2.34	6.01	3.86	0.5	2.5	9.87	3.00	69.60
7/9/2015	3.12	3.76	0	2.27	3.12	3.76	0.5	2.5	6.88	3.00	56.41
7/10/2015	3.07	3.16	0	2.24	3.07	3.16	0.5	2.5	6.23	3.00	51.88
7/13/2015	1.91	3.14	0	2.13	1.91	3.14	0.5	2.5	5.05	3.00	40.59
7/14/2015	1.94	3.24	0	2.02	1.94	3.24	0.5	2.5	5.18	3.00	42.12
7/15/2015	2.07	3.14	0	2.10	2.07	3.14	0.5	2.5	5.21	3.00	42.42
7/16/2015	2.14	3.34	0	2.00	2.14	3.34	0.5	2.5	5.48	3.00	45.26
7/17/2015	2.19	3.14	0	2.10	2.19	3.14	0.5	2.5	5.33	3.00	43.67
7/20/2015	2.20	2.43	0	2.00	2.20	2.5	0.5	2.5	4.70	3.00	36.17
7/21/2015	2.17	2.10	0	2.10	2.17	2.5	0.5	2.5	4.67	3.00	35.76
7/22/2015	2.19	1.70	0	2.30	2.19	2.5	0.5	2.5	4.69	3.00	36.03

Table C.7 continued.

	Raw				Censored						
	LE		D		LE		D		LE	D	
	NH_3	NO_3^-/NO_2^-	NH_3	NO_3^-/NO_2^-	NH_3	NO_3^-/NO_2^-	NH_3	NO_3^-/NO_2^-	TN		Removal
Date					mg-N L-1						%
7/23/2015	2.10	0.11	0	2.40	2.10	2.5	0.5	2.5	4.60	3.00	34.78
7/24/2015	2.15	0.12	0	2.40	2.15	2.5	0.5	2.5	4.65	3.00	35.48
7/27/2015	2.17	0.20	0	2.20	2.17	2.5	0.5	2.5	4.67	3.00	35.76
7/28/2015	2.20	0.20	0	2.20	2.20	2.5	0.5	2.5	4.70	3.00	36.17
7/29/2015	2.24	0.11	0	2.40	2.24	2.5	0.5	2.5	4.74	3.00	36.71
7/30/2015	3.04	0.11	0	2.40	3.04	2.5	0.5	2.5	5.54	3.00	45.85
7/31/2015	2.19	0.11	0	2.10	2.19	2.5	0.5	2.5	4.69	3.00	36.03
8/3/2015	1.68	0	0	2.44	1.68	2.5	0.5	2.5	4.18	3.00	28.23
8/4/2015	1.74	0	0	2.64	1.74	2.5	0.5	2.64	4.24	3.14	26.01
8/5/2015	1.73	0	0	2.64	1.73	2.5	0.5	2.64	4.23	3.14	25.86
8/6/2015	2.10	0	0	2.23	2.10	2.5	0.5	2.5	4.60	3.00	34.78
8/7/2015			0				0.5				
8/10/2015	2.14	4.90	0	2.13	2.14	4.90	0.5	2.5	7.04	3.00	57.39
8/11/2015			0				0.5				
8/12/2015	1.60	5.10	0	1.93	1.60	5.10	0.5	2.5	6.70	3.00	55.22
8/13/2015			0				0.5				
8/18/2015		5.20		1.33		5.20		2.5			
8/20/2015	1.60	5.60	0	1.04	1.60	5.60	0.5	2.5	7.20	3.00	58.33
8/24/2015		1.70	0	0.04		2.5	0.5	2.5		3.00	
8/26/2015	1.00	1.90	0	0.00	1.00	2.5	0.5	2.5	3.50	3.00	14.29
8/28/2015	1.20	0	0	0.04	1.20	2.5	0.5	2.5	3.70	3.00	18.92
9/1/2015	1.62	1.10	0	0.00	1.62	2.5	0.5	2.5	4.12	3.00	27.18
9/2/2015				0.03				2.5			
9/3/2015	1.47	3.00	0		1.47	3.00	0.5		4.47		100.00
9/4/2015				0.03				2.5			
9/5/2015	1.40	3.60	0	0.00	1.40	3.60	0.5	2.5	5.00	3.00	40.00
9/8/2015	1.40	0	0.19	0.03	1.40	2.5	0.5	2.5	3.90	3.00	23.08
9/9/2015				0.00				2.5			
9/10/2015	1.10	3.80	0	0.03	1.10	3.80	0.5	2.5	4.90	3.00	38.78
9/11/2015				0.00				2.5			
9/14/2015	1.60	3.70	0	0.03	1.60	3.70	0.5	2.5	5.30	3.00	43.40
9/15/2015				0.00				2.5			
9/16/2015	1.10	3.07	0	0.04	1.10	3.07	0.5	2.5	4.17	3.00	28.04
9/17/2015	9.99	2.60	0	0.04	9.99	2.60	0.5	2.5	12.59	3.00	76.17
9/18/2015				0.00				2.5			
9/22/2015	9.99	2.97	0	0.04	9.99	2.97	0.5	2.5	12.96	3.00	76.85
9/23/2015				1.40				2.5			
9/24/2015	9.99	2.70	0.07	0.04	9.99	2.70	0.5	2.5	12.69	3.00	76.36
9/25/2015				2.70				2.70			
9/28/2015	9.06	0.36	0.10		9.06	2.5	0.5		11.56		100.00
9/29/2015				3.15				3.15			
9/30/2015	9.16	2.80	0.07		9.16	2.80	0.5		11.96		100.00
10/1/2015				3.90				3.90			
10/2/2015	9.99	0.36	0	0.09	9.99	2.5	0.5	2.50	12.49	3.00	75.98
10/5/2015				3.70				3.70			
10/6/2015	9.99	3.37	0.09	0.09	9.99	3.37	0.5	2.5	13.36	3.00	77.54
10/7/2015				3.60				3.60			
10/8/2015	9.99	3.10	0.14	0.09	9.99	3.10	0.5	2.5	13.09	3.00	77.08
10/9/2015				3.80				3.80			
10/12/2015	9.99	0.37	0.17	0.09	9.99	2.5	0.5	2.5	12.49	3.00	75.98
10/13/2015	9.99	3.26	0.16	3.80	9.99	3.26	0.5	3.80	13.25	4.30	67.55
10/14/2015	9.99	2.00	0.15	4.08	9.99	2.5	0.5	4.08	12.49	4.58	63.30

Table C.7 continued.

	Raw				Censored						
	LE		D		LE		D		LE	D	
	NH_3	NO_3^-/NO_2^-	NH_3	NO_3^-/NO_2^-	NH_3	NO_3^-/NO_2^-	NH_3	NO_3^-/NO_2^-	TN		Removal
Date	mg-N L-1										%
10/15/2015	9.99	0.19	0.16	4.39	9.99	2.5	0.5	4.39	12.49	4.89	60.88
10/16/2015	9.99	1.90	0	4.70	9.99	2.5	0.5	4.70	12.49	5.20	58.37
10/19/2015	9.99	2.69	0	3.84	9.99	2.69	0.5	3.84	12.68	4.34	65.80
10/20/2015	9.99	1.60	0	3.80	9.99	2.5	0.5	3.80	12.49	4.30	65.57
10/21/2015	9.99	1.59	0	0.19	9.99	2.5	0.5	2.5	12.49	3.00	75.98
10/22/2015	9.99	1.50	0	3.60	9.99	2.5	0.5	3.60	12.49	4.10	67.17
10/23/2015	9.99	1.50	0	6.59	9.99	2.5	0.5	6.59	12.49	7.09	43.21
10/26/2015	9.99	1.59	0	6.60	9.99	2.5	0.5	6.60	12.49	7.10	43.15
10/27/2015	9.99	1.50	0	0.19	9.99	2.5	0.5	2.5	12.49	3.00	75.98
10/28/2015	9.99	1.59		6.50	9.99	2.5		6.50	12.49		100.00
10/29/2015	9.99	1.50	0	6.69	9.99	2.5	0.5	6.69	12.49	7.19	42.41
10/30/2015	0.00	1.89	9.99	6.81	0.5	2.5	9.99	6.81	3.00	16.80	-460.07
11/2/2015	9.99	0.19	0	3.50	9.99	2.5	0.5	3.50	12.49	4.00	67.97
11/3/2015	9.99	1.60	0	3.60	9.99	2.5	0.5	3.60	12.49	4.10	67.17
11/4/2015	9.99	0.19	0	1.80	9.99	2.5	0.5	2.5	12.49	3.00	75.98
11/5/2015	9.99	1.60	0	1.90	9.99	2.5	0.5	2.5	12.49	3.00	75.98
11/6/2015	9.99	0.19	0	0.00	9.99	2.5	0.5	2.5	12.49	3.00	75.98
11/9/2015	9.99	1.50	0	2.00	9.99	2.5	0.5	2.5	12.49	3.00	75.98
11/10/2015	9.99	0.19	0	0.00	9.99	2.5	0.5	2.5	12.49	3.00	75.98
11/12/2015	9.99	1.70	0	1.90	9.99	2.5	0.5	2.5	12.49	3.00	75.98
11/13/2015	9.99	0.19	0	1.80	9.99	2.5	0.5	2.5	12.49	3.00	75.98
11/16/2015	9.99	1.60	0	0.00	9.99	2.5	0.5	2.5	12.49	3.00	75.98
11/17/2015	9.08	0.39	0	1.60	9.08	2.5	0.5	2.5	11.58	3.00	74.09
11/18/2015	9.08	5.07	0		9.08	5.07	0.5		14.15		100.00
11/19/2015	9.14	6.22	0	1.60	9.14	6.22	0.5	2.5	15.36	3.00	80.47
11/20/2015	9.22	6.47	0	0.22	9.22	6.47	0.5	2.5	15.69	3.00	80.88
11/23/2015	9.40	6.80	0	1.60	9.40	6.80	0.5	2.5	16.20	3.00	81.48
11/24/2015	9.99	0.42	0	1.93	9.99	2.5	0.5	2.5	12.49	3.00	75.98
11/25/2015	9.99	5.70	0	1.50	9.99	5.70	0.5	2.5	15.69	3.00	80.88
12/1/2015	9.99	6.12	0	2.01	9.99	6.12	0.5	2.5	16.11	3.00	81.38
12/2/2015	9.99	0.47	0	2.10	9.99	2.5	0.5	2.5	12.49	3.00	75.98
12/3/2015	9.99	5.92	0	2.00	9.99	5.92	0.5	2.5	15.91	3.00	81.14
12/4/2015	9.99	4.44	0	1.91	9.99	4.44	0.5	2.5	14.43	3.00	79.21
12/7/2015		0.41	0	2.00		2.5	0.5	2.5		3.00	
12/8/2015		4.15	0	2.11		4.15	0.5	2.5		3.00	
12/9/2015		0.34	0	1.90		2.5	0.5	2.5		3.00	
12/10/2015		4.27	0	2.00		4.27	0.5	2.5		3.00	
12/11/2015	9.15	5.32	0	2.00	9.15	5.32	0.5	2.5	14.47	3.00	79.27
12/14/2015	8.02	0.48	0	1.91	8.02	2.5	0.5	2.5	10.52	3.00	71.48
12/15/2015	7.61	6.21	0	2.00	7.61	6.21	0.5	2.5	13.82	3.00	78.29
12/16/2015	7.01	0.51	0	2.11	7.01	2.5	0.5	2.5	9.51	3.00	68.45
12/17/2015	7.14	4.12	0	0.01	7.14	4.12	0.5	2.5	11.26	3.00	73.36
12/18/2015	7.27	0.48	0	2.20	7.27	2.50	0.5	2.5	9.77	3.00	69.29
12/21/2015	7.50	4.17	0	0.01	7.50	4.17	0.5	2.5	11.67	3.00	74.29
12/22/2015	7.61	5.16	0	2.40	7.61	5.16	0.5	2.5	12.77	3.00	76.51
12/23/2015	7.70	5.22	0	0.01	7.70	5.22	0.5	2.5	12.92	3.00	76.78
12/24/2015	8.12	0.44	0	2.50	8.12	2.5	0.5	2.5	10.62	3.00	71.75
12/25/2015	8.17	5.35	0	0.01	8.17	5.35	0.5	2.5	13.52	3.00	77.81
12/28/2015	9.99	0.51	0	2.40	9.99	2.5	0.5	2.5	12.49	3.00	75.98
12/29/2015	9.99	5.01	0	0.00	9.99	5.01	0.5	2.5	15.00	3.00	80.00
12/30/2015	9.99	3.97	0	2.20	9.99	3.97	0.5	2.5	13.96	3.00	78.51
1/4/2016	9.99	0.46	0		9.99	2.5	0.5		12.49		100.00

Table C.7 continued.

	Raw				Censored						
	LE		D		LE		D		LE	D	
	NH_3	NO_3^-/NO_2^-	NH_3	NO_3^-/NO_2^-	NH_3	NO_3^-/NO_2^-	NH_3	NO_3^-/NO_2^-	TN		Removal
Date	mg-N L-1										%
1/6/2016	9.99	4.12	0		9.99	4.12	0.5		14.11		100.00
1/8/2016	8.94	0.40	0		8.94	2.5	0.5		11.44		100.00
1/11/2016	9.99	4.70	0	0.36	9.99	4.70	0.5	2.5	14.69	3.00	79.58
1/13/2016	9.99	5.12	0		9.99	5.12	0.5		15.11		100.00
1/15/2016	9.99	0.42	0.17		9.99	2.5	0.5		12.49		100.00
1/19/2016	9.99	5.13	0		9.99	5.13	0.5		15.12		100.00
1/21/2016	9.99	5.17	0	4.20	9.99	5.17	0.5	4.20	15.16	4.70	69.00
1/25/2016	8.64	4.90	0	0.01	8.64	4.90	0.5	2.5	13.54	3.00	77.84
1/27/2016	8.78	5.62	0		8.78	5.62	0.5		14.40		100.00
1/29/2016	9.99	7.68	0	4.40	9.99	7.68	0.5	4.40	17.67	4.90	72.27
2/1/2016	9.99	7.70	0		9.99	7.70	0.5		17.69		100.00
2/3/2016	9.99	7.41	0	4.27	9.99	7.41	0.5	4.27	17.40	4.77	72.59
2/5/2016	9.99	7.60	0	0.00	9.99	7.60	0.5	2.5	17.59	3.00	82.94
2/8/2016	9.73	6.42	0		9.73	6.42	0.5		16.15		100.00
2/10/2016	9.42	8.40	0		9.42	8.40	0.5		17.82		100.00
2/12/2016	8.73	8.21	0	0.00	8.73	8.21	0.5	2.5	16.94	3.00	82.29
2/15/2016	8.70	7.90	0		8.70	7.90	0.5		16.60		100.00
2/17/2016	9.99	7.77	0		9.99	7.77	0.5		17.76		100.00
2/19/2016	9.99	7.80	0	0.00	9.99	7.80	0.5	2.5	17.79	3.00	83.14
2/22/2016	9.99	0.42	0		9.99	2.5	0.5		12.49		100.00
2/24/2016	9.99	7.87	0	4.22	9.99	7.87	0.5	4.22	17.86	4.72	73.57
2/26/2016	8.47	7.77	0		8.47	7.77	0.5		16.24		100.00
3/1/2016	9.99	7.10	0	3.90	9.99	7.10	0.5	3.90	17.09	4.40	74.25
3/4/2016	9.99		0		9.99		0.5				
3/7/2016	9.85	6.47	0	3.92	9.85	6.47	0.5	3.92	16.32	4.42	72.92
3/10/2016	9.80		0		9.80		0.5				
3/12/2016	9.71	6.80	0	3.14	9.71	6.80	0.5	3.14	16.51	3.64	77.95
3/15/2016	9.99	0.42	0	0.00	9.99	2.5	0.5	2.5	12.49	3.00	75.98
3/17/2016	9.99	5.70	0	4.12	9.99	5.70	0.5	4.12	15.69	4.62	70.55
3/21/2016	9.99		0		9.99		0.5				
3/23/2016	8.41	6.12	0	3.88	8.41	6.12	0.5	3.88	14.53	4.38	69.86
3/25/2016	8.20	0.47	0	0.02	8.20	2.5	0.5	2.5	10.70	3.00	71.96
3/28/2016	7.96	5.92	0	3.23	7.96	5.92	0.5	3.23	13.88	3.73	73.13
3/31/2016	9.99		0		9.99		0.5				
4/1/2016	9.99		0		9.99		0.5				
4/4/2016	8.63		0	4.27	8.63		0.5	4.27		4.77	
4/6/2016	8.92		0	0.00	8.92		0.5	2.5		3.00	
4/8/2016	9.99		0		9.99		0.5				
4/11/2016	9.99	4.44	0	3.92	9.99	4.44	0.5	3.92	14.43	4.42	69.37
4/14/2016	9.99		0		9.99		0.5				
4/18/2016	9.99	0.41	0	0.00	9.99	2.5	0.5	2.5	12.49	3.00	75.98
4/20/2016	8.87		0		8.87		0.5				
4/22/2016	9.38	4.15	0	3.41	9.38	4.15	0.5	3.41	13.53	3.91	71.10
4/27/2016	9.99	0.34	0	0.01	9.99	2.5	0.5	2.5	12.49	3.00	75.98
4/29/2016	9.94	4.27	0	3.52	9.94	4.27	0.5	3.52	14.21	4.02	71.71
5/2/2016	9.99		0	5.17	9.99		0.5	5.17		5.67	
5/4/2016	9.99		0		9.99		0.5				
5/6/2016	9.72		0		9.72		0.5				
5/9/2016	9.99	5.32	0	3.70	9.99	5.32	0.5	3.70	15.31	4.20	72.57
5/12/2016	9.99		0		9.99		0.5				
5/16/2016	9.99		0		9.99		0.5				
5/18/2016	8.82		0		8.82		0.5				

Table C.7 continued.

	Raw				Censored						
	LE		D		LE		D		LE	D	
	NH_3	NO_3^-/NO_2^-	NH_3	NO_3^-/NO_2^-	NH_3	NO_3^-/NO_2^-	NH_3	NO_3^-/NO_2^-	TN		Removal
Date	mg-N L-1										%
5/20/2016	8.47		0	4.20	8.47		0.5	4.20	8.47	4.70	44.51
5/23/2016	7.96		0		7.96		0.5				
5/25/2016	9.99		0		9.99		0.5				
5/27/2016	9.99		0		9.99		0.5				
5/30/2016	9.99		0	4.12	9.99		0.5	4.12	9.99	4.62	53.75
6/1/2016	7.46		0		7.46		0.5				
6/3/2016	7.71	0.48	0	0.00	7.71	2.5	0.5	2.5	10.21	3.00	70.62
6/7/2016	7.84	6.21	0	3.73	7.84	6.21	0.5	3.73	14.05	4.23	69.89
6/9/2016	8.21		0		8.21		0.5				
6/13/2016	8.10		0	3.60	8.10		0.5	3.60	8.10	4.10	49.38
6/15/2016	8.70	0.51	0	0.00	8.70	2.5	0.5	2.5	11.20	3.00	73.21
6/18/2016	9.99		0		9.99		0.5				
6/21/2016	9.99	4.12	0	2.41	9.99	4.12	0.5	2.5	14.11	3.00	78.74
6/23/2016	9.99		0		9.99		0.5				
6/27/2016	9.99	0.48	0	0.00	9.99	2.5	0.5	2.5	12.49	3.00	75.98
6/29/2016	9.99	4.17	0	2.14	9.99	4.17	0.5	2.5	14.16	3.00	78.81
7/1/2016	9.99		0		9.99		0.5				
7/4/2016	9.99	5.16	0	3.42	9.99	5.16	0.5	3.42	15.15	3.92	74.13
7/6/2016	9.99		0		9.99		0.5				
7/9/2016	9.64	5.22	0	3.12	9.64	5.22	0.5	3.12	14.86	3.62	75.64
7/12/2016	9.71	0.44	0	0.00	9.71	2.5	0.5	2.5	12.21	3.00	75.43
7/14/2016	9.80		0		9.80		0.5				
7/16/2016	9.64	5.35	0	1.89	9.64	5.35	0.5	2.5	14.99	3.00	79.99
7/18/2016	9.99		0		9.99		0.5				
7/21/2016	9.99	0.51	0	0.00	9.99	2.5	0.5	2.5	12.49	3.00	75.98
7/25/2016	9.82	5.01	0	2.62	9.82	5.01	0.5	2.62	14.83	3.12	78.96
7/27/2016	9.66		0		9.66		0.5				
7/29/2016	9.99		0		9.99		0.5				
8/1/2016	9.99	3.97	0	1.41	9.99	3.97	0.5	2.5	13.96	3.00	78.51
8/3/2016	9.99		0		9.99		0.5				
8/5/2016	9.99	0.46	0.24	0.00	9.99	2.5	0.5	2.5	12.49	3.00	75.98
8/8/2016	9.99	4.12	0	1.90	9.99	4.12	0.5	2.5	14.11	3.00	78.74
8/10/2016	9.99		0		9.99		0.5				
8/13/2016	9.99	0.40	0	0.00	9.99	2.5	0.5	2.5	12.49	3.00	75.98
8/16/2016	8.63	4.70	0	2.62	8.63	4.70	0.5	2.62	13.33	3.12	76.59
8/19/2016	8.01		0		8.01		0.5				
8/22/2016	7.43		0		7.43		0.5				
8/24/2016	7.42	5.12	0	2.60	7.42	5.12	0.5	2.60	12.54	3.10	75.28
8/26/2016	9.91	0.42	0	0.00	9.91	2.5	0.5	2.5	12.41	3.00	75.83
8/29/2016	9.99		0		9.99		0.5				
9/2/2016	9.99		0		9.99		0.5				
9/5/2016	9.99		0		9.99		0.5				
9/7/2016	9.99	5.13	0	2.84	9.99	5.13	0.5	2.84	15.12	3.34	77.91
9/10/2016	9.99		0		9.99		0.5				
9/13/2016	9.83		0		9.83		0.5				
9/16/2016	9.88	5.17	0	2.71	9.88	5.17	0.5	2.71	15.05	3.21	78.67
9/21/2016	9.99		0		9.99		0.5				
9/24/2016	9.99		0		9.99		0.5				
9/26/2016	9.99	4.90	0	3.15	9.99	4.90	0.5	3.15	14.89	3.65	75.49
9/28/2016	9.99		0		9.99		0.5				
9/30/2016	9.99	5.62	0	4.08	9.99	5.62	0.5	4.08	15.61	4.58	70.66
10/3/2016	9.99	7.68	0	5.22	9.99	7.68	0.5	5.22	17.67	5.72	67.63

Table C.7 continued.

	Raw				Censored						
	LE		D		LE		D		LE	D	
	NH_3	NO_3^-/NO_2^-	NH_3	NO_3^-/NO_2^-	NH_3	NO_3^-/NO_2^-	NH_3	NO_3^-/NO_2^-	TN		Removal
Date	mg-N L-1										%
10/5/2016	9.99		0		9.99		0.5				
10/7/2016	9.99		0		9.99		0.5				
10/10/2016	9.99	7.70	0	5.30	9.99	7.70	0.5	5.30	17.69	5.80	67.21
10/12/2016	9.99		0		9.99		0.5				
10/14/2016	9.99	7.41	0	5.50	9.99	7.41	0.5	5.50	17.40	6.00	65.52
10/17/2016	9.99		0		9.99		0.5				
10/20/2016	9.99	7.60	0	5.00	9.99	7.60	0.5	5.00	17.59	5.50	68.73
10/22/2016	9.99		0		9.99		0.5				
10/25/2016	9.99	6.42	0	4.10	9.99	6.42	0.5	4.10	16.41	4.60	71.97
10/27/2016	9.99		0		9.99		0.5				
11/1/2016	9.99	8.40	0	4.25	9.99	8.40	0.5	4.25	18.39	4.75	74.17
11/5/2016	9.99		0		9.99		0.5				
11/8/2016	9.99	8.21	0	4.21	9.99	8.21	0.5	4.21	18.20	4.71	74.12
11/10/2016	9.99		0		9.99		0.5				
11/14/2016	9.99		0		9.99		0.5				
11/16/2016	9.89	7.90	0	4.50	9.89	7.90	0.5	4.50	17.79	5.00	71.89
11/18/2016	9.94		0		9.94		0.5				
11/21/2016	9.99		0		9.99		0.5				
11/23/2016	9.99	7.77	0	6.24	9.99	7.77	0.5	6.24	17.76	6.74	62.05
11/25/2016	9.99		0		9.99		0.5				
11/28/2016	9.99		0		9.99		0.5				
12/1/2016	9.99		0		9.99		0.5				
12/3/2016	9.99	7.80	0	4.27	9.99	7.80	0.5	4.27	17.79	4.77	73.19
12/5/2016	9.99	0.42	0	0.00	9.99	2.5	0.5	2.5	12.49	3.00	75.98
12/7/2016	9.99		0		9.99		0.5				
12/9/2016	9.99	7.87	0	5.02	9.99	7.87	0.5	5.02	17.86	5.52	69.09
12/12/2016	9.99		0		9.99		0.5				
12/14/2016	9.99		0		9.99		0.5				
12/16/2016	9.99	7.77	0	4.94	9.99	7.77	0.5	4.94	17.76	5.44	69.37
12/19/2016	9.99		0		9.99		0.5				
12/22/2016	9.99	7.10	0.70	4.33	9.99	7.10	0.70	4.33	17.09	5.03	70.57
12/26/2016	9.99		1.9		9.99		1.9				
12/29/2016	9.99		2.05		9.99		2.05				
										Average	46.22
										Median	48.23
										Average 2016	77.83
										Median 2016	75.64

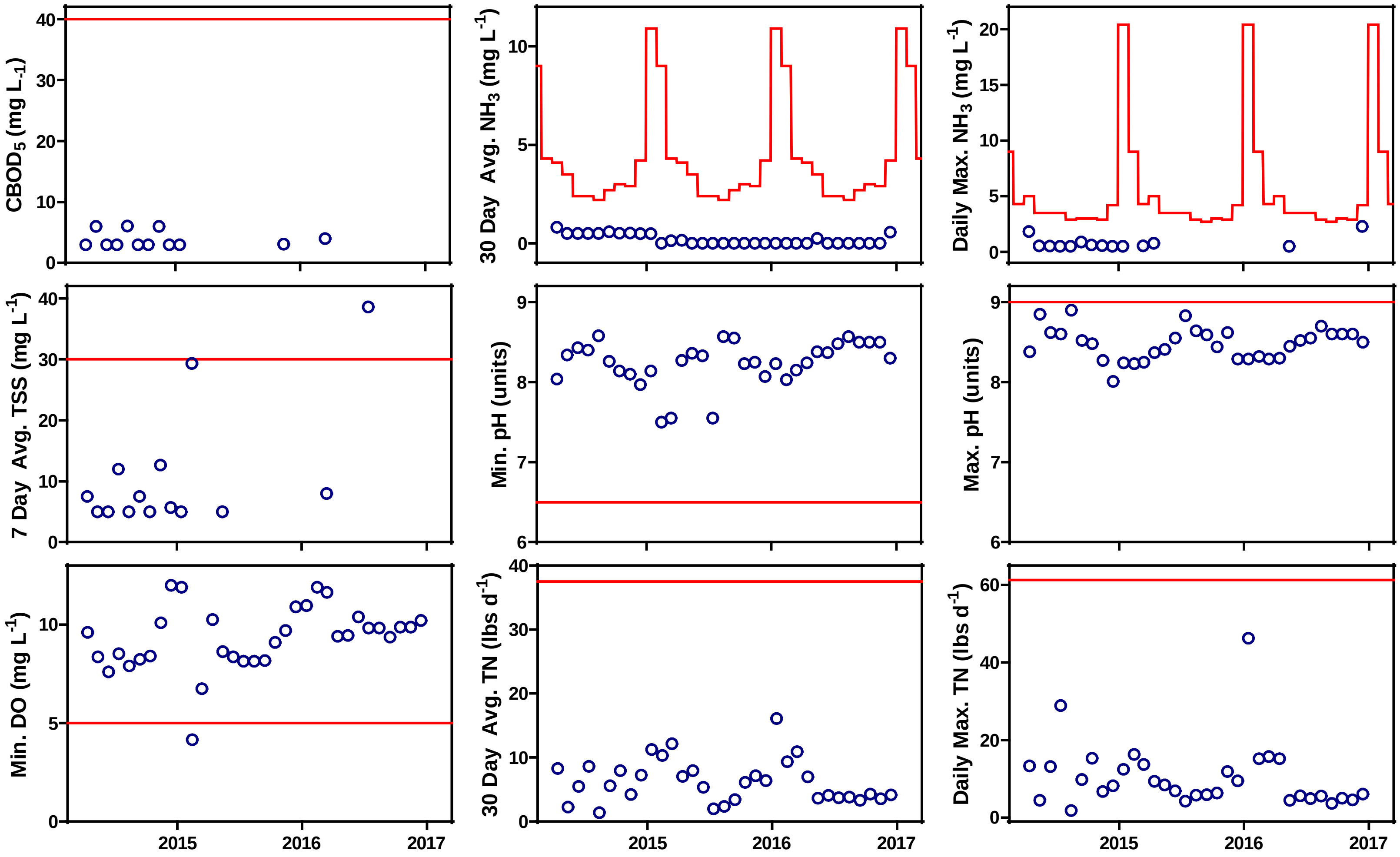

Figure C.1 Public record monthly operation report data for the NPDES permit (#5792001) for the City of Walker provided by the IDNR and the NPDES permit limits. Used to determine compliance.

APPENDIX D: SUPPLEMNTAL INFORMATION FOR CHAPTER 3

Table D.1 Water quality sonde data and flow rate reported to the IDNR for the NPDES compliance (originally in million gallons per day) used to determine the NH_3 loading used in Table 3.2 and Figure 3.4 and temperature and NH_3 removal rates used in Table 3.2.

			Primary SAGR		Secondary SAGR	
	Flow	Temperature	Total NH_3		Total NH_3	
Date	L d^{-1}	C	mg-N L^{-1}	kg d^{-1}	mg-N L^{-1}	kg d^{-1}
5/18/17 6:00	3.22E+05	21.42	8.44	2.71	0.98	0.32
5/18/17 12:00	3.22E+05	20.53	8.18	2.63	0.96	0.31
5/18/17 18:00	3.22E+05	21	7.76	2.50	0.86	0.28
5/19/17 0:00	3.22E+05	20.09	7.78	2.50	0.82	0.26
5/19/17 6:00	3.22E+05	18.05	7.61	2.45	0.78	0.25
5/19/17 12:00	3.22E+05	16.06	7.24	2.33	0.79	0.25
5/19/17 18:00	3.22E+05	15.36	7.26	2.33	0.8	0.26
5/20/17 0:00	3.22E+05	14.62	7.18	2.31	0.81	0.26
5/20/17 6:00	3.22E+05	13.55	7.25	2.33	0.81	0.26
5/20/17 12:00	3.22E+05	12.71	7.14	2.30	0.81	0.26
5/20/17 18:00	3.22E+05	13.14	7.34	2.36	0.8	0.26
5/21/17 0:00	2.08E+05	13.52	7.78	1.62	0.79	0.16
5/21/17 6:00	2.08E+05	13.31	8.04	1.67	0.78	0.16
5/21/17 12:00	2.08E+05	13.08	7.79	1.62	0.77	0.16
5/21/17 18:00	2.08E+05	13.28	7.87	1.64	0.76	0.16
5/22/17 0:00	2.08E+05	12.81	7.58	1.58	0.76	0.16
5/22/17 6:00	2.08E+05	12.16	7.77	1.62	0.75	0.16
5/22/17 12:00	2.08E+05	12.12	7.75	1.61	0.74	0.15
5/22/17 18:00	2.08E+05	14	8.41	1.75	0.75	0.16
5/23/17 0:00	2.08E+05	14.75	8.71	1.81	0.74	0.15
5/23/17 6:00	2.08E+05	14.41	8.41	1.75	0.74	0.15
5/23/17 12:00	2.08E+05	14.53	8.9	1.85	0.75	0.16
5/23/17 18:00	2.08E+05	16.05	9.1	1.89	0.75	0.16
5/24/17 0:00	2.08E+05	15.66	9.23	1.92	0.76	0.16
5/24/17 6:00	2.08E+05	14.84	9.4	1.96	0.77	0.16
5/24/17 12:00	2.08E+05	14.47	9.07	1.89	0.77	0.16
5/24/17 18:00	2.08E+05	15.09	9.09	1.89	0.79	0.16
5/25/17 0:00	2.08E+05	15	8.95	1.86	0.79	0.16
5/25/17 6:00	2.08E+05	14.34	8.72	1.81	0.8	0.17
5/25/17 12:00	2.08E+05	14.39	8.73	1.82	0.81	0.17
5/25/17 18:00	2.08E+05	17.63	9.91	2.06	0.82	0.17
5/26/17 0:00	2.08E+05	18.43	10.45	2.17	0.83	0.17
5/26/17 6:00	2.08E+05	17.48	10	2.08	0.84	0.17
5/26/17 12:00	2.08E+05	16.75	10.16	2.11	0.85	0.18
5/26/17 18:00	2.08E+05	17.7	10.62	2.21	0.88	0.18
5/27/17 0:00	2.08E+05	17.79	10.23	2.13	0.89	0.19
5/27/17 6:00	2.08E+05	16.97	9.9	2.06	0.91	0.19
5/27/17 12:00	2.08E+05	17.05	10.04	2.09	0.92	0.19
5/27/17 18:00	2.08E+05	19.71	11.05	2.30	0.95	0.20
5/28/17 0:00	2.08E+05	18.77	10.5	2.18	0.97	0.20
5/28/17 6:00	2.08E+05	17.94	10.58	2.20	0.98	0.20
5/28/17 12:00	2.08E+05	18.48	10.44	2.17	1.02	0.21
5/28/17 18:00	2.08E+05	22.3	11.7	2.43	1.04	0.22
5/29/17 0:00	2.08E+05	21.19	10.85	2.26	1.06	0.22
5/29/17 6:00	2.08E+05	19.39	10.47	2.18	1.09	0.23
5/29/17 12:00	2.08E+05	19.09	10.44	2.17	1.15	0.24
5/29/17 18:00	2.08E+05	20.93	11.2	2.33	1.17	0.24
5/30/17 0:00	2.08E+05	19.96	10.47	2.18	1.16	0.24
5/30/17 6:00	2.08E+05	18.79	10.2	2.12	1.15	0.24
5/30/17 12:00	2.08E+05	18.42	10.05	2.09	1.2	0.25
5/30/17 18:00	2.08E+05	20.28	10.53	2.19	1.22	0.25
5/31/17 0:00	2.08E+05	19.66	10.42	2.17	1.17	0.24
5/31/17 6:00	2.08E+05	18.47	10.18	2.12	1.16	0.24
5/31/17 12:00	2.08E+05	18.33	9.98	2.08	1.16	0.24
5/31/17 18:00	2.08E+05	21.4	11.04	2.30	1.15	0.24
6/4/17 18:00	3.22E+05	28.22	9.86	3.17	0.99	0.32
6/5/17 0:00	3.22E+05	26.63	8.55	2.75	0.99	0.32
6/5/17 6:00	3.22E+05	24.49	7.71	2.48	0.99	0.32
6/5/17 12:00	3.22E+05	24.02	7.21	2.32	1	0.32
6/5/17 18:00	3.22E+05	25.64	7.36	2.37	1.02	0.33
6/6/17 0:00	2.08E+05	24.56	6.76	1.41	1.04	0.22
6/6/17 6:00	2.08E+05	23.2	6.34	1.32	1.05	0.22
6/6/17 12:00	2.08E+05	22.86	6.07	1.26	1.07	0.22
6/6/17 18:00	2.08E+05	25.36	6.28	1.31	1.09	0.23
6/7/17 0:00	2.08E+05	24.68	6.27	1.30	1.1	0.23
6/7/17 6:00	2.08E+05	23.09	5.93	1.23	1.1	0.23
6/7/17 12:00	2.08E+05	22.79	5.88	1.22	1.11	0.23
6/7/17 18:00	2.08E+05	25.78	5.93	1.23	1.12	0.23
6/8/17 0:00	2.08E+05	25.39	6.05	1.26	1.12	0.23
6/8/17 6:00	2.08E+05	23.7	5.45	1.13	1.12	0.23
6/8/17 12:00	2.08E+05	23.19	5.29	1.10	1.13	0.24
6/8/17 18:00	2.08E+05	24.25	5.36	1.12	1.13	0.24
6/9/17 0:00	2.08E+05	24.16	5.34	1.11	1.14	0.24
6/9/17 6:00	2.08E+05	23.29	5.34	1.11	1.15	0.24

Table D.1 continued.

			Primary SAGR		Secondary SAGR	
	Flow	Temperature	Total NH$_3$		Total NH$_3$	
Date	L d^{-1}	C	mg-N L^{-1}	kg d^{-1}	mg-N L^{-1}	kg d^{-1}
6/9/17 12:00	2.08E+05	23.37	5.17	1.08	1.15	0.24
6/9/17 18:00	2.08E+05	25.57	5.41	1.13	1.16	0.24
6/10/17 0:00	3.22E+05	25.65	5.29	1.70	1.15	0.37
6/10/17 6:00	3.22E+05	24.12	5.16	1.66	1.16	0.37
6/10/17 12:00	3.22E+05	23.44	5	1.61	1.18	0.38
6/10/17 18:00	3.22E+05	24.77	4.78	1.54	1.19	0.38
6/11/17 0:00	3.22E+05	25.22	4.5	1.45	1.19	0.38
6/11/17 6:00	3.22E+05	24.54	4.7	1.51	1.19	0.38
6/11/17 12:00	3.22E+05	24.23	4.37	1.41	1.2	0.39
6/11/17 18:00	3.22E+05	25.9	4.11	1.32	1.21	0.39
6/12/17 0:00	2.08E+05	26.2	3.93	0.82	1.22	0.25
6/12/17 6:00	2.08E+05	25.39	4.28	0.89	1.24	0.26
6/12/17 12:00	2.08E+05	25.38	3.8	0.79	1.23	0.26
6/12/17 18:00	2.08E+05	27.41	3.11	0.65	1.24	0.26
6/13/17 0:00	2.08E+05	26.85	2.69	0.56	1.24	0.26
6/13/17 6:00	2.08E+05	25.62	3.68	0.77	1.25	0.26
6/13/17 12:00	2.08E+05	25.59	3.45	0.72	1.27	0.26
6/13/17 18:00	2.08E+05	27.32	2.7	0.56	1.27	0.26
6/14/17 0:00	2.08E+05	27.54	2.55	0.53	1.29	0.27
6/14/17 6:00	2.08E+05	26.55	3.18	0.66	1.3	0.27
6/14/17 12:00	2.08E+05	25.95	3.06	0.64	1.3	0.27
6/14/17 18:00	2.08E+05	27.03	2.49	0.52	1.33	0.28
6/15/17 0:00	3.22E+05	27.45	2.19	0.70	1.34	0.43
6/15/17 6:00	3.22E+05	26.53	2.67	0.86	1.34	0.43
6/15/17 12:00	3.22E+05	26.52	2.45	0.79	1.35	0.43
6/15/17 18:00	3.22E+05	29.26	1.64	0.53	1.37	0.44
6/16/17 0:00	3.22E+05	27.52	2.37	0.76	1.41	0.45
6/16/17 6:00	3.22E+05	26.12	3.44	1.11	1.42	0.46
6/16/17 12:00	3.22E+05	25.79	3.11	1.00	1.43	0.46
6/16/17 18:00	3.22E+05	27.83	1.76	0.57	1.44	0.46
6/17/17 0:00	3.22E+05	27.37	1.73	0.56	1.49	0.48
6/17/17 6:00	3.22E+05	25.97	3.01	0.97	1.53	0.49
6/17/17 12:00	3.22E+05	26.33	2.47	0.79	1.5	0.48
6/17/17 18:00	3.22E+05	28.26	1.75	0.56	1.47	0.47
6/18/17 0:00	3.22E+05	26.8	2.29	0.74	1.46	0.47
6/18/17 6:00	3.22E+05	25.1	2.91	0.94	1.46	0.47
6/18/17 12:00	3.22E+05	24.41	2.58	0.83	1.47	0.47
6/18/17 18:00	3.22E+05	26.1	1.88	0.60	1.48	0.48
6/19/17 0:00	3.22E+05	25.24	2.1	0.68	1.48	0.48
6/19/17 6:00	3.22E+05	23.91	2.96	0.95	1.47	0.47
6/19/17 12:00	3.22E+05	23.76	2.53	0.81	1.47	0.47
6/19/17 18:00	3.22E+05	25.67	1.85	0.59	1.48	0.48
6/20/17 0:00	3.22E+05	24.83	1.9	0.61	1.48	0.48
6/20/17 6:00	3.22E+05	23.45	2.84	0.91	1.48	0.48
6/20/17 12:00	3.22E+05	23.19	2.71	0.87	1.49	0.48
6/20/17 18:00	3.22E+05	25.87	1.82	0.59	1.49	0.48
6/21/17 0:00	2.08E+05	25.59	1.91	0.40	1.49	0.31
6/21/17 6:00	2.08E+05	24.1	2.8	0.58	1.49	0.31
6/21/17 12:00	2.08E+05	23.56	2.54	0.53	1.49	0.31
6/21/17 18:00	2.08E+05	23.79	2.28	0.47	1.49	0.31
6/22/17 0:00	2.08E+05	23.48	2.53	0.53	1.5	0.31
6/22/17 6:00	2.08E+05	23.02	2.69	0.56	1.5	0.31
6/22/17 12:00	2.08E+05	22.81	2.65	0.55	1.5	0.31
6/22/17 18:00	2.08E+05	23.41	2.44	0.51	1.5	0.31
6/23/17 0:00	2.08E+05	23.76	2.38	0.50	1.49	0.31
6/23/17 6:00	2.08E+05	23.03	2.49	0.52	1.5	0.31
6/23/17 12:00	2.08E+05	24.03	2.18	0.45	1.5	0.31
6/23/17 18:00	2.08E+05	25.92	1.78	0.37	1.49	0.31
6/24/17 0:00	3.22E+05	24.52	1.89	0.61	1.49	0.48
6/24/17 6:00	3.22E+05	22.63	2.45	0.79	1.49	0.48
6/24/17 12:00	3.22E+05	22.05	1.96	0.63	1.51	0.49
6/24/17 18:00	3.22E+05	23.99	1.32	0.42	1.51	0.49
6/25/17 0:00	3.22E+05	22.87	1.29	0.41	1.52	0.49
6/25/17 6:00	3.22E+05	21.6	1.67	0.54	1.51	0.49
6/25/17 12:00	3.22E+05	21	1.7	0.55	1.52	0.49
6/25/17 18:00	3.22E+05	22	1.05	0.34	1.53	0.49
6/26/17 0:00	2.08E+05	21.74	1.15	0.24	1.52	0.32
6/26/17 6:00	2.08E+05	20.61	1.91	0.40	1.52	0.32
6/26/17 12:00	2.08E+05	20.32	1.67	0.35	1.52	0.32
6/26/17 18:00	2.08E+05	22.56	0.71	0.15	1.52	0.32
6/27/17 0:00	2.08E+05	22.33	0.72	0.15	1.5	0.31
6/27/17 6:00	2.08E+05	20.72	1.39	0.29	1.48	0.31
6/27/17 12:00	2.08E+05	20.32	1.55	0.32	1.48	0.31
6/27/17 18:00	2.08E+05	22.24	0.61	0.13	1.48	0.31
6/28/17 0:00	2.08E+05	22.63	0.59	0.12	1.47	0.31
6/28/17 6:00	2.08E+05	20.96	0.9	0.19	1.47	0.31
6/28/17 12:00	2.08E+05	20.65	1.16	0.24	1.48	0.31
6/28/17 18:00	2.08E+05	21.87	0.68	0.14	1.46	0.30
6/29/17 0:00	2.08E+05	21.96	0.8	0.17	1.52	0.32
6/29/17 6:00	2.08E+05	21.54	1.26	0.26	1.49	0.31
6/29/17 12:00	2.08E+05	21.63	1.3	0.27	1.47	0.31
6/29/17 18:00	2.08E+05	23.09	0.7	0.15	1.47	0.31
6/30/17 0:00	2.08E+05	23.48	0.65	0.14	1.47	0.31

Table D.1 continued.

			Primary SAGR		Secondary SAGR	
	Flow	Temperature	Total NH_3		Total NH_3	
Date	$L\ d^{-1}$	C	$mg\text{-}N\ L^{-1}$	$kg\ d^{-1}$	$mg\text{-}N\ L^{-1}$	$kg\ d^{-1}$
6/30/17 6:00	2.08E+05	22.29	0.77	0.16	1.49	0.31
6/30/17 12:00	2.08E+05	22.63	0.71	0.15	1.49	0.31
6/30/17 18:00	2.08E+05	25.88	0.78	0.16	1.49	0.31
7/1/17 0:00	2.08E+05	24.81	0.76	0.16	1.5	0.31
7/1/17 6:00	2.08E+05	23.28	0.81	0.17	1.51	0.31
7/1/17 12:00	2.08E+05	23.07	0.65	0.14	1.53	0.32
7/1/17 18:00	2.08E+05	26.2	0.88	0.18	1.55	0.32
7/4/17 6:00	2.08E+05	25.47	2.11	0.44	0.78	0.16
7/4/17 12:00	2.08E+05	24.62	1.94	0.40	0.79	0.16
7/4/17 18:00	2.08E+05	26.17	2.44	0.51	0.8	0.17
7/5/17 0:00	2.08E+05	27.12	2.49	0.52	0.8	0.17
7/5/17 6:00	2.08E+05	26.02	2	0.42	0.81	0.17
7/5/17 12:00	2.08E+05	25.57	1.95	0.41	0.82	0.17
7/5/17 18:00	2.08E+05	27.97	2.26	0.47	0.83	0.17
7/6/17 0:00	2.08E+05	28.04	2.2	0.46	0.83	0.17
7/6/17 6:00	2.08E+05	26.67	2.01	0.42	0.84	0.17
7/6/17 12:00	2.08E+05	26.14	1.98	0.41	0.85	0.18
7/6/17 18:00	2.08E+05	28.15	2.09	0.43	0.86	0.18
7/7/17 0:00	2.08E+05	28.83	2.22	0.46	0.86	0.18
7/7/17 6:00	2.08E+05	27.52	1.93	0.40	0.86	0.18
7/7/17 12:00	2.08E+05	26.52	1.75	0.36	0.87	0.18
7/7/17 18:00	2.08E+05	27.75	1.76	0.37	0.88	0.18
7/8/17 0:00	2.08E+05	28.03	1.73	0.36	0.88	0.18
7/8/17 6:00	2.08E+05	26.52	1.79	0.37	0.88	0.18
7/8/17 12:00	2.08E+05	25.62	1.8	0.37	0.89	0.19
7/8/17 18:00	2.08E+05	27.34	1.63	0.34	0.9	0.19
7/9/17 0:00	3.22E+05	27.89	1.58	0.51	0.89	0.29
7/9/17 6:00	3.22E+05	26.45	1.43	0.46	0.89	0.29
7/9/17 12:00	3.22E+05	25.62	1.29	0.41	0.9	0.29
7/9/17 18:00	3.22E+05	27.21	1.32	0.42	0.9	0.29
7/10/17 0:00	3.22E+05	27.63	1.39	0.45	0.9	0.29
7/10/17 6:00	3.22E+05	25.54	1.11	0.36	0.94	0.30
7/10/17 12:00	3.22E+05	25.55	1.72	0.55	0.9	0.29
7/10/17 18:00	3.22E+05	27.32	1.38	0.44	0.87	0.28
7/11/17 0:00	3.22E+05	27.48	1.28	0.41	0.86	0.28
7/11/17 6:00	3.22E+05	26.68	1.4	0.45	0.87	0.28
7/11/17 12:00	3.22E+05	26.21	1.52	0.49	0.88	0.28
7/11/17 18:00	3.22E+05	26.4	1.61	0.52	0.89	0.29
7/12/17 0:00	2.08E+05	26.5	1.62	0.34	0.91	0.19
7/12/17 6:00	2.08E+05	26.25	1.61	0.33	0.91	0.19
7/12/17 12:00	2.08E+05	26.15	1.63	0.34	0.92	0.19
7/12/17 18:00	2.08E+05	26.36	1.75	0.36	0.92	0.19
7/13/17 0:00	2.08E+05	26.54	1.85	0.38	0.93	0.19
7/13/17 6:00	2.08E+05	26.06	1.94	0.40	0.93	0.19
7/13/17 12:00	2.08E+05	25.64	1.95	0.41	0.94	0.20
7/13/17 18:00	2.08E+05	26.25	1.87	0.39	0.95	0.20
7/14/17 0:00	2.08E+05	26.38	1.82	0.38	0.95	0.20
7/14/17 6:00	2.08E+05	25.45	1.85	0.38	0.95	0.20
7/14/17 12:00	2.08E+05	24.7	2.12	0.44	0.97	0.20
7/14/17 18:00	2.08E+05	25.14	2.09	0.43	0.98	0.20
7/15/17 0:00	2.08E+05	25.53	1.75	0.36	0.97	0.20
7/15/17 6:00	2.08E+05	24.75	2.15	0.45	0.97	0.20
7/15/17 12:00	2.08E+05	24.46	2.28	0.47	0.98	0.20
7/15/17 18:00	2.08E+05	24.99	2.47	0.51	0.99	0.21
7/16/17 0:00	2.08E+05	25.46	2.17	0.45	0.99	0.21
7/16/17 6:00	2.08E+05	25.58	2.02	0.42	0.98	0.20
7/16/17 12:00	2.08E+05	25.65	2	0.42	0.99	0.21
7/16/17 18:00	2.08E+05	26.25	1.98	0.41	1	0.21
7/17/17 0:00	2.08E+05	26.52	2	0.42	0.99	0.21
7/17/17 6:00	2.08E+05	25.86	2.01	0.42	0.99	0.21
7/17/17 12:00	2.08E+05	25.25	2.03	0.42	1	0.21
7/17/17 18:00	2.08E+05	25.45	2.19	0.46	1.01	0.21
7/18/17 0:00	3.22E+05	25.66	2.2	0.71	1.01	0.32
7/18/17 6:00	3.22E+05	25.38	2.13	0.68	1.01	0.32
7/18/17 12:00	3.22E+05	25.25	2.1	0.68	1.02	0.33
7/18/17 18:00	3.22E+05	25.4	2.31	0.74	1.03	0.33
7/19/17 0:00	3.22E+05	25.46	2.42	0.78	1.02	0.33
7/19/17 6:00	3.22E+05	25.38	2.32	0.75	1.02	0.33
7/19/17 12:00	3.22E+05	25.5	2.22	0.71	1.03	0.33
7/19/17 18:00	3.22E+05	25.92	2.13	0.68	1.05	0.34
7/20/17 0:00	2.08E+05	26.11	2.26	0.47	1.04	0.22
7/20/17 6:00	2.08E+05	25.92	2.21	0.46	1.03	0.21
7/20/17 12:00	2.08E+05	25.93	2.27	0.47	1.05	0.22
7/20/17 18:00	2.08E+05	26.28	2.3	0.48	1.06	0.22
7/21/17 0:00	2.08E+05	26.64	2.56	0.53	1.07	0.22
7/21/17 6:00	2.08E+05	26.49	2.45	0.51	1.07	0.22
7/21/17 12:00	2.08E+05	26.01	2.7	0.56	1.11	0.23
7/21/17 18:00	2.08E+05	26.15	2.8	0.58	1.11	0.23
7/22/17 0:00	2.08E+05	26.36	3.03	0.63	1.09	0.23
7/22/17 6:00	2.08E+05	25.74	3.12	0.65	1.14	0.24
7/22/17 12:00	2.08E+05	25.45	3.41	0.71	1.12	0.23
7/22/17 18:00	2.08E+05	25.82	3.37	0.70	1.1	0.23
7/23/17 0:00	2.08E+05	26.46	3.27	0.68	1.08	0.22

Table D.1 continued.

			Primary SAGR		Secondary SAGR	
	Flow	Temperature	Total NH_3		Total NH_3	
Date	L d^{-1}	C	mg-N L^{-1}	kg d^{-1}	mg-N L^{-1}	kg d^{-1}
7/23/17 6:00	2.08E+05	26.22	3.51	0.73	1.08	0.22
7/23/17 12:00	2.08E+05	25.98	3.32	0.69	1.1	0.23
7/23/17 18:00	2.08E+05	27.06	3.8	0.79	1.11	0.23
7/24/17 0:00	2.08E+05	27.18	4.02	0.84	1.11	0.23
7/24/17 6:00	2.08E+05	25.86	3.94	0.82	1.11	0.23
7/25/17 18:00	2.08E+05	24.93	5.02	1.04	0.86	0.18
7/26/17 0:00	2.08E+05	25.59	5.3	1.10	0.85	0.18
7/26/17 6:00	2.08E+05	25.2	5.12	1.07	0.86	0.18
7/26/17 12:00	2.08E+05	24.98	4.87	1.01	0.87	0.18
7/26/17 18:00	2.08E+05	25.25	4.7	0.98	0.88	0.18
7/27/17 0:00	2.08E+05	25.5	4.64	0.97	0.88	0.18
7/27/17 6:00	2.08E+05	25.24	4.66	0.97	0.88	0.18
7/27/17 12:00	2.08E+05	25	4.5	0.94	0.89	0.19
7/27/17 18:00	2.08E+05	25.38	4.1	0.85	0.9	0.19
7/28/17 0:00	2.08E+05	26.32	4.29	0.89	0.89	0.19
7/28/17 6:00	2.08E+05	25.5	4.4	0.92	0.89	0.19
7/28/17 12:00	2.08E+05	25.03	4.44	0.92	0.9	0.19
7/28/17 18:00	2.08E+05	25.22	4.17	0.87	0.91	0.19
7/29/17 0:00	2.08E+05	25.88	3.94	0.82	0.91	0.19
7/29/17 6:00	2.08E+05	24.99	4.05	0.84	0.9	0.19
7/29/17 12:00	2.08E+05	24.52	4.26	0.89	0.91	0.19
7/29/17 18:00	2.08E+05	24.78	3.66	0.76	0.92	0.19
7/30/17 0:00	2.08E+05	25.27	3.4	0.71	0.92	0.19
7/30/17 6:00	2.08E+05	24.65	3.63	0.76	0.91	0.19
7/30/17 12:00	2.08E+05	24.27	3.75	0.78	0.92	0.19
7/30/17 18:00	2.08E+05	24.33	3.71	0.77	0.92	0.19
7/31/17 0:00	2.08E+05	24.6	3.38	0.70	0.92	0.19
7/31/17 6:00	2.08E+05	24.07	3.66	0.76	0.89	0.19
7/31/17 12:00	2.08E+05	23.82	3.76	0.78	0.91	0.19
7/31/17 18:00	2.08E+05	23.9	3.24	0.67	0.91	0.19
8/1/17 0:00	2.08E+05	24.03	2.58	0.54	0.91	0.19
8/1/17 6:00	2.08E+05	23.81	2.97	0.62	0.9	0.19
8/1/17 12:00	2.08E+05	23.64	2.8	0.58	0.9	0.19
8/1/17 18:00	2.08E+05	23.76	2.44	0.51	0.9	0.19
8/2/17 0:00	2.08E+05	23.91	2.17	0.45	0.89	0.19
8/2/17 6:00	2.08E+05	23.91	2.54	0.53	0.89	0.19
8/2/17 12:00	2.08E+05	23.75	2.3	0.48	0.88	0.18
8/2/17 18:00	2.08E+05	23.9	1.94	0.40	0.89	0.19
8/3/17 0:00	2.08E+05	24.14	2.01	0.42	0.88	0.18
8/3/17 6:00	2.08E+05	24.11	2.16	0.45	0.87	0.18
8/3/17 12:00	2.08E+05	23.44	2.92	0.61	0.91	0.19
8/3/17 18:00	2.08E+05	24.81	2.57	0.53	0.87	0.18
8/4/17 0:00	1.32E+05	24.26	2.67	0.35	0.85	0.11
8/4/17 6:00	1.32E+05	22.76	3.23	0.43	0.82	0.11
8/4/17 12:00	1.32E+05	21.92	2.93	0.39	0.82	0.11
8/4/17 18:00	1.32E+05	22.36	2.36	0.31	0.82	0.11
8/5/17 0:00	1.32E+05	23.01	1.94	0.26	0.82	0.11
8/5/17 6:00	1.32E+05	22.33	2.07	0.27	0.81	0.11
8/5/17 12:00	1.32E+05	21.99	2.49	0.33	0.82	0.11
8/5/17 18:00	1.32E+05	21.96	2.37	0.31	0.82	0.11
8/6/17 0:00	1.32E+05	22.09	2.13	0.28	0.81	0.11
8/6/17 6:00	1.32E+05	22	2.5	0.33	0.81	0.11
8/6/17 12:00	1.32E+05	21.89	2.78	0.37	0.82	0.11
8/6/17 18:00	1.32E+05	21.92	2.12	0.28	0.82	0.11
8/7/17 0:00	1.32E+05	22.09	2.14	0.28	0.81	0.11
8/7/17 6:00	1.32E+05	22.07	2.62	0.35	0.81	0.11
8/7/17 12:00	1.32E+05	21.9	2.89	0.38	0.82	0.11
8/7/17 18:00	1.32E+05	22.1	2.05	0.27	0.82	0.11
8/8/17 0:00	1.32E+05	22.79	1.77	0.23	0.82	0.11
8/8/17 6:00	1.32E+05	22.33	2.3	0.30	0.81	0.11
8/8/17 12:00	1.32E+05	21.93	2.74	0.36	0.81	0.11
8/8/17 18:00	1.32E+05	21.95	2.78	0.37	0.82	0.11
8/9/17 0:00	1.32E+05	21.99	2.08	0.28	0.82	0.11
8/9/17 6:00	1.32E+05	21.81	2.43	0.32	0.81	0.11
8/9/17 12:00	1.32E+05	21.59	2.83	0.37	0.82	0.11
8/9/17 18:00	1.32E+05	21.76	2.23	0.30	0.83	0.11
8/10/17 0:00	1.32E+05	22.48	2.03	0.27	0.83	0.11
8/10/17 6:00	1.32E+05	22.25	2.34	0.31	0.83	0.11
8/10/17 12:00	1.32E+05	21.95	2.17	0.29	0.83	0.11
8/10/17 18:00	1.32E+05	22.31	1.63	0.22	0.83	0.11
8/11/17 0:00	1.32E+05	22.7	1.68	0.22	0.83	0.11
8/11/17 6:00	1.32E+05	22.3	1.64	0.22	0.83	0.11
8/11/17 12:00	1.32E+05	21.67	2.09	0.28	0.83	0.11
8/11/17 18:00	1.32E+05	21.75	1.99	0.26	0.83	0.11
8/12/17 0:00	2.08E+05	22.44	1.93	0.40	0.82	0.17
8/12/17 6:00	2.08E+05	21.89	2.09	0.43	0.81	0.17
8/12/17 12:00	2.08E+05	21.45	2.39	0.50	0.82	0.17
8/12/17 18:00	2.08E+05	21.42	2.47	0.51	0.81	0.17
8/13/17 0:00	2.08E+05	22.06	1.88	0.39	0.82	0.17
8/13/17 6:00	2.08E+05	21.72	1.92	0.40	0.81	0.17
8/13/17 12:00	2.08E+05	21.32	2.09	0.43	0.81	0.17
8/13/17 18:00	2.08E+05	21.23	2.31	0.48	0.82	0.17
8/14/17 0:00	1.32E+05	21.16	1.82	0.24	0.81	0.11

Table D.1 continued.

			Primary SAGR		Secondary SAGR	
	Flow	Temperature	Total NH$_3$		Total NH$_3$	
Date	L d^{-1}	C	mg-N L^{-1}	kg d^{-1}	mg-N L^{-1}	kg d^{-1}
8/14/17 6:00	1.32E+05	20.81	2.12	0.28	0.8	0.11
8/15/17 0:00	1.32E+05	22.48	1.15	0.15	0.64	0.08
8/15/17 6:00	1.32E+05	21.53	1.07	0.14	0.63	0.08
8/15/17 12:00	1.32E+05	21.06	1.07	0.14	0.65	0.09
8/15/17 18:00	1.32E+05	21.17	1.23	0.16	0.64	0.08
8/16/17 0:00	1.32E+05	21.21	1.28	0.17	0.65	0.09
8/16/17 6:00	1.32E+05	21.04	1.35	0.18	0.64	0.08
8/16/17 12:00	1.32E+05	20.98	1.37	0.18	0.64	0.08
8/16/17 18:00	1.32E+05	21.54	1.31	0.17	0.64	0.08
8/17/17 0:00	1.32E+05	22.03	1.32	0.17	0.64	0.08
8/17/17 6:00	1.32E+05	21.97	1.32	0.17	0.64	0.08
8/17/17 12:00	1.32E+05	21.72	1.22	0.16	0.64	0.08
8/17/17 18:00	1.32E+05	22.75	1.26	0.17	0.65	0.09
8/18/17 0:00	1.32E+05	22.66	1.15	0.15	0.64	0.08
8/18/17 6:00	1.32E+05	21.77	1.1	0.15	0.64	0.08
8/18/17 12:00	1.32E+05	21.34	1.04	0.14	0.63	0.08
8/18/17 18:00	1.32E+05	21.61	1.35	0.18	0.63	0.08
8/19/17 0:00	1.32E+05	21.88	1.57	0.21	0.65	0.09
8/19/17 6:00	1.32E+05	21.58	1.55	0.21	0.64	0.08
8/19/17 12:00	1.32E+05	21.15	1.52	0.20	0.64	0.08
8/19/17 18:00	1.32E+05	21.4	1.62	0.21	0.65	0.09
8/20/17 0:00	1.32E+05	21.72	1.64	0.22	0.65	0.09
8/20/17 6:00	1.32E+05	21.64	1.62	0.21	0.65	0.09
8/20/17 12:00	1.32E+05	21.24	1.51	0.20	0.66	0.09
8/20/17 18:00	1.32E+05	21.42	1.5	0.20	0.66	0.09
8/21/17 0:00	1.32E+05	21.95	1.56	0.21	0.66	0.09
8/21/17 6:00	1.32E+05	21.62	1.4	0.19	0.65	0.09
8/21/17 12:00	1.32E+05	21.44	1.54	0.20	0.66	0.09
8/21/17 18:00	1.32E+05	21.74	1.67	0.22	0.66	0.09
8/22/17 0:00	1.32E+05	22.1	1.48	0.20	0.66	0.09
8/22/17 6:00	1.32E+05	21.6	1.55	0.21	0.64	0.08
8/22/17 12:00	1.32E+05	21.21	1.56	0.21	0.66	0.09
8/22/17 18:00	1.32E+05	21.89	1.65	0.22	0.66	0.09
8/23/17 0:00	1.32E+05	22.45	1.94	0.26	0.65	0.09
8/23/17 6:00	1.32E+05	21.69	1.86	0.25	0.64	0.08
8/23/17 12:00	1.32E+05	21.12	2.06	0.27	0.66	0.09
8/23/17 18:00	1.32E+05	21.5	1.86	0.25	0.66	0.09
8/24/17 0:00	1.32E+05	22.16	1.74	0.23	0.66	0.09
8/24/17 6:00	1.32E+05	21.8	1.77	0.23	0.66	0.09
8/24/17 12:00	1.32E+05	21.37	1.87	0.25	0.65	0.09
8/24/17 18:00	1.32E+05	21.26	1.8	0.24	0.67	0.09
8/25/17 0:00	1.32E+05	21.19	1.72	0.23	0.67	0.09
8/25/17 6:00	1.32E+05	21.07	1.81	0.24	0.67	0.09
8/25/17 12:00	1.32E+05	20.73	2.11	0.28	0.67	0.09
8/25/17 18:00	1.32E+05	21.31	1.74	0.23	0.68	0.09
8/26/17 0:00	1.32E+05	21.35	1.51	0.20	0.68	0.09
8/26/17 6:00	1.32E+05	20.65	1.39	0.18	0.68	0.09
8/26/17 12:00	1.32E+05	20.12	1.39	0.18	0.69	0.09
8/26/17 18:00	1.32E+05	20.42	1.34	0.18	0.68	0.09
8/27/17 0:00	1.32E+05	20.59	1.36	0.18	0.68	0.09
8/27/17 6:00	1.32E+05	20.3	1.47	0.19	0.68	0.09
8/27/17 12:00	1.32E+05	20.3	1.38	0.18	0.68	0.09
8/27/17 18:00	1.32E+05	20.93	1.26	0.17	0.68	0.09
8/28/17 0:00	2.08E+05	21.39	1.19	0.25	0.68	0.14
8/28/17 6:00	2.08E+05	20.82	1.07	0.22	0.68	0.14
8/28/17 12:00	2.08E+05	20.35	1.19	0.25	0.68	0.14
8/28/17 18:00	2.08E+05	20.35	1.41	0.29	0.68	0.14
8/29/17 0:00	2.08E+05	20.4	1.5	0.31	0.68	0.14
8/29/17 6:00	2.08E+05	20.1	1.52	0.32	0.68	0.14
8/29/17 12:00	2.08E+05	19.85	1.56	0.32	0.68	0.14
8/29/17 18:00	2.08E+05	19.92	1.65	0.34	0.69	0.14
8/30/17 0:00	2.08E+05	19.84	1.67	0.35	0.69	0.14
8/30/17 6:00	2.08E+05	19.71	1.61	0.33	0.68	0.14
8/30/17 12:00	2.08E+05	19.58	1.64	0.34	0.68	0.14
8/30/17 18:00	2.08E+05	19.72	1.65	0.34	0.69	0.14
8/31/17 0:00	2.08E+05	19.74	1.69	0.35	0.7	0.15
8/31/17 6:00	2.08E+05	19.86	1.56	0.32	0.69	0.14
8/31/17 12:00	2.08E+05	19.81	1.69	0.35	0.69	0.14
8/31/17 18:00	2.08E+05	19.87	1.67	0.35	0.69	0.14
9/1/17 0:00	1.32E+05	19.74	1.56	0.21	0.69	0.09
9/1/17 6:00	1.32E+05	19.34	1.53	0.20	0.69	0.09
9/1/17 12:00	1.32E+05	18.99	1.51	0.20	0.69	0.09
9/1/17 18:00	1.32E+05	19.26	1.57	0.21	0.69	0.09
9/2/17 0:00	1.32E+05	19.27	1.47	0.19	0.69	0.09
9/2/17 6:00	1.32E+05	18.6	1.44	0.19	0.68	0.09
9/2/17 12:00	1.32E+05	18.31	1.43	0.19	0.68	0.09
9/2/17 18:00	1.32E+05	19.03	1.87	0.25	0.68	0.09
9/3/17 0:00	1.32E+05	19.81	2.05	0.27	0.68	0.09
9/3/17 6:00	1.32E+05	19.16	1.9	0.25	0.67	0.09
9/3/17 12:00	1.32E+05	18.68	1.99	0.26	0.66	0.09
9/3/17 18:00	1.32E+05	19.26	3.1	0.41	0.67	0.09
9/4/17 0:00	1.32E+05	20.04	3.48	0.46	0.67	0.09
9/4/17 6:00	1.32E+05	19.52	3.58	0.47	0.67	0.09

Table D.1 continued.

			Primary SAGR		Secondary SAGR	
	Flow	Temperature	Total NH_3		Total NH_3	
Date	L d^{-1}	C	mg-N L^{-1}	kg d^{-1}	mg-N L^{-1}	kg d^{-1}
9/5/17 0:00	1.32E+05	20.13			0.7	0.09
9/5/17 6:00	1.32E+05	19.56			0.71	0.09
9/5/17 12:00	1.32E+05	18.92			0.71	0.09
9/5/17 18:00	1.32E+05	18.8			0.71	0.09
9/6/17 0:00	1.32E+05	19.04			0.71	0.09
9/6/17 6:00	1.32E+05	18.47			0.71	0.09
9/6/17 12:00	1.32E+05	18.01			0.72	0.10
9/6/17 18:00	1.32E+05	17.95			0.72	0.10
9/7/17 0:00	1.32E+05	18.43			0.72	0.10
9/7/17 6:00	2.08E+05	17.94			0.72	0.15
9/7/17 12:00	2.08E+05	17.57			0.72	0.15
9/7/17 18:00	2.08E+05	17.6			0.73	0.15
9/8/17 0:00	2.08E+05	18.23			0.73	0.15
9/8/17 6:00	2.08E+05	18.08			0.73	0.15
9/8/17 12:00	2.08E+05	17.78			0.73	0.15
9/8/17 18:00	2.08E+05	17.75			0.74	0.15
9/9/17 0:00	2.08E+05	17.61			0.75	0.16
9/9/17 6:00	2.08E+05	17.54			0.74	0.15
9/9/17 12:00	2.08E+05	17.4			0.75	0.16
9/9/17 18:00	2.08E+05	17.71			0.75	0.16
9/10/17 0:00	2.08E+05	18.28			0.76	0.16
9/10/17 6:00	2.08E+05	17.92			0.76	0.16
9/10/17 12:00	2.08E+05	17.58			0.77	0.16
9/10/17 18:00	2.08E+05	18.46			0.77	0.16
9/11/17 0:00	2.08E+05	19.1			0.77	0.16
9/11/17 6:00	2.08E+05	18.51			0.77	0.16
9/11/17 12:00	2.08E+05	18.07			0.77	0.16
9/11/17 18:00	2.08E+05	18.91			0.77	0.16
9/12/17 0:00	1.32E+05	19.31			0.78	0.10
9/12/17 6:00	1.32E+05	19.13			0.77	0.10
9/12/17 12:00	1.32E+05	18.57			0.77	0.10
9/12/17 18:00	1.32E+05	18.7			0.78	0.10
9/13/17 0:00	1.32E+05	18.66			0.79	0.10
9/13/17 6:00	1.32E+05	18.65			0.78	0.10
9/13/17 12:00	1.32E+05	18.36			0.78	0.10
9/13/17 18:00	1.32E+05	18.48			0.79	0.10
9/14/17 0:00	1.32E+05	18.51			0.8	0.11
9/14/17 6:00	1.32E+05	18.68			0.8	0.11
9/14/17 12:00	1.32E+05	18.52			0.81	0.11
9/14/17 18:00	1.32E+05	18.72			0.81	0.11
9/15/17 0:00	1.32E+05	19.58			0.82	0.11
9/15/17 6:00	1.32E+05	19.43			0.82	0.11
9/15/17 12:00	1.32E+05	19.25			0.83	0.11
9/15/17 18:00	1.32E+05	19.91			0.83	0.11
9/16/17 0:00	1.32E+05	20.82			0.83	0.11
9/16/17 6:00	1.32E+05	20.57			0.83	0.11
9/16/17 12:00	1.32E+05	20.43			0.84	0.11
9/16/17 18:00	1.32E+05	21.09			0.84	0.11
9/17/17 0:00	1.32E+05	21.79			0.85	0.11
9/17/17 6:00	1.32E+05	21.51			0.85	0.11
9/17/17 12:00	1.32E+05	20.91			0.86	0.11
9/17/17 18:00	1.32E+05	20.99			0.87	0.12
9/18/17 0:00	1.32E+05	21.35			0.87	0.12
9/18/17 6:00	1.32E+05	20.74			0.87	0.12
9/18/17 12:00	1.32E+05	20.14			0.88	0.12
9/18/17 18:00	1.32E+05	20.28			0.88	0.12
9/19/17 0:00	1.32E+05	20.71			0.89	0.12
9/19/17 6:00	1.32E+05	20.24			0.89	0.12
9/19/17 12:00	1.32E+05	19.92			0.89	0.12
9/19/17 18:00	1.32E+05	20.31			0.9	0.12
9/20/17 0:00	1.32E+05	20.8			0.9	0.12
9/20/17 6:00	1.32E+05	20.5			0.91	0.12
9/20/17 12:00	1.32E+05	20.36			0.91	0.12
9/20/17 18:00	1.32E+05	21.37			0.91	0.12
9/21/17 0:00	1.32E+05	22.68			0.92	0.12
9/21/17 6:00	1.32E+05	22.52			0.92	0.12
9/21/17 12:00	1.32E+05	22.05			0.93	0.12
9/21/17 18:00	1.32E+05	21.96			0.93	0.12
9/22/17 0:00	1.32E+05	22.48			0.93	0.12
9/22/17 6:00	1.32E+05	22.56			0.93	0.12
9/22/17 12:00	1.32E+05	22.44			0.94	0.12
9/22/17 18:00	1.32E+05	22.89			0.94	0.12
9/23/17 0:00	1.32E+05	23.98			0.95	0.13
9/23/17 6:00	1.32E+05	23.67			0.96	0.13
9/23/17 12:00	1.32E+05	23.35			0.96	0.13
9/23/17 18:00	1.32E+05	23.67			0.97	0.13
9/24/17 0:00	1.32E+05	24.33			0.98	0.13
9/24/17 6:00	1.32E+05	23.89			0.99	0.13
9/24/17 12:00	1.32E+05	23.3			0.99	0.13
9/24/17 18:00	1.32E+05	23.69			1	0.13
9/25/17 0:00	1.32E+05	24.15			1.01	0.13
9/25/17 6:00	1.32E+05	23.64			1.02	0.14
9/25/17 12:00	1.32E+05	23.27			1.02	0.14

Table D.1 continued.

			Primary SAGR		Secondary SAGR	
	Flow	Temperature	Total NH_3		Total NH_3	
Date	L d^{-1}	C	mg-N L^{-1}	kg d^{-1}	mg-N L^{-1}	kg d^{-1}
9/27/17 0:00	1.32E+05	22.64	11.31	1.50	1.25	0.17
9/27/17 6:00	1.32E+05	21.87	11.19	1.48	1.19	0.16
9/27/17 12:00	1.32E+05	21.13	11.08	1.47	1.2	0.16
9/27/17 18:00	1.32E+05	20.77	10.88	1.44	1.19	0.16
9/28/17 0:00	1.32E+05	20.48	10.65	1.41	1.17	0.15
9/28/17 6:00	1.32E+05	19.84	10.28	1.36	1.16	0.15
9/28/17 12:00	1.32E+05	19.4	9.88	1.31	1.15	0.15
9/28/17 18:00	1.32E+05	19.43	9.48	1.26	1.14	0.15
9/29/17 0:00	1.32E+05	19.74	9.33	1.24	1.14	0.15
9/29/17 6:00	1.32E+05	19.12	8.94	1.18	1.12	0.15
9/29/17 12:00	1.32E+05	18.51	8.55	1.13	1.11	0.15
9/29/17 18:00	1.32E+05	18.65	8.74	1.16	1.13	0.15
9/30/17 0:00	1.32E+05	19.1	8.82	1.17	1.12	0.15
9/30/17 6:00	1.32E+05	18.71	8.65	1.15	1.12	0.15
9/30/17 12:00	1.32E+05	18.29	8.47	1.12	1.1	0.15
9/30/17 18:00	1.32E+05	18.18	8.24	1.09	1.1	0.15
10/1/17 0:00	2.08E+05	18.1	7.97	1.66	1.1	0.23
10/1/17 6:00	2.08E+05	17.53	7.56	1.57	1.09	0.23
10/1/17 12:00	2.08E+05	16.99	7.22	1.50	1.09	0.23
10/1/17 18:00	2.08E+05	17.27	7.05	1.47	1.08	0.22
10/2/17 0:00	2.08E+05	17.39	7	1.46	1.08	0.22
10/2/17 6:00	2.08E+05	17.06	6.87	1.43	1.06	0.22
10/2/17 12:00	2.08E+05	16.96	6.87	1.43	1.07	0.22
10/2/17 18:00	2.08E+05	17.4	6.94	1.44	7.54	1.57
10/3/17 0:00	2.08E+05	17.59	7.17	1.49	7.49	1.56
10/3/17 6:00	2.08E+05	17.76	7.41	1.54	7.51	1.56
10/3/17 12:00	2.08E+05	17.89	7.54	1.57	7.47	1.55
10/3/17 18:00	2.08E+05	18.01	7.6	1.58	7.57	1.58
10/4/17 0:00	2.08E+05	18.16	7.87	1.64	7.44	1.55
10/4/17 6:00	2.08E+05	18.21	7.69	1.60	7.25	1.51
10/4/17 12:00	2.08E+05	18.04	7.74	1.61	7.04	1.46
10/4/17 18:00	2.08E+05	18.02	7.64	1.59	7.04	1.46
10/5/17 0:00	2.08E+05	17.87	7.63	1.59	7.17	1.49
10/5/17 6:00	2.08E+05	17.74	7.53	1.57	7.03	1.46
10/5/17 12:00	2.08E+05	17.68	7.55	1.57	6.89	1.43
10/5/17 18:00	2.08E+05	17.8	7.53	1.57	6.78	1.41
10/6/17 0:00	2.08E+05	17.83	7.52	1.56	6.73	1.40
10/6/17 6:00	2.08E+05	17.81	7.43	1.55	6.61	1.38
10/6/17 12:00	2.08E+05	17.81	7.58	1.58	6.45	1.34
10/6/17 18:00	2.08E+05	17.9	7.62	1.59	6.47	1.35
10/7/17 0:00	2.08E+05	17.99	7.68	1.60	6.22	1.29
10/7/17 6:00	2.08E+05	18.07	7.68	1.60	6.18	1.29
10/7/17 12:00	2.08E+05	18.14	7.87	1.64	6.2	1.29
10/7/17 18:00	2.08E+05	18.21	7.83	1.63	6.19	1.29
10/8/17 0:00	2.08E+05	17.97	7.4	1.54	6.08	1.27
10/8/17 6:00	2.08E+05	17.71	7.21	1.50	6.01	1.25
10/8/17 12:00	2.08E+05	17.54	7.1	1.48	5.88	1.22
10/8/17 18:00	2.08E+05	17.64	7.16	1.49	6.15	1.28
10/9/17 0:00	2.08E+05	17.6	7.11	1.48	6.08	1.27
10/9/17 6:00	2.08E+05	17.36	7.06	1.47	5.98	1.24
10/9/17 12:00	2.08E+05	17.05	6.95	1.45	5.83	1.21
10/9/17 18:00	2.08E+05	17.02	6.88	1.43	5.95	1.24
10/10/17 0:00	2.08E+05	16.64	6.84	1.42	5.98	1.24
10/10/17 6:00	2.08E+05	16.26	6.65	1.38	5.89	1.23
10/10/17 12:00	2.08E+05	15.94	6.62	1.38	5.78	1.20
10/10/17 18:00	2.08E+05	15.35	6.09	1.27	4.92	1.02
10/11/17 0:00	2.08E+05	15.04	6.02	1.25	4.59	0.96
10/11/17 6:00	2.08E+05	14.76	5.94	1.24	4.55	0.95
10/11/17 12:00	2.08E+05	14.61	5.97	1.24	4.54	0.94
10/11/17 18:00	2.08E+05	14.64	6.08	1.27	4.52	0.94
10/12/17 0:00	2.08E+05	14.69	6.14	1.28	4.52	0.94
10/12/17 6:00	2.08E+05	14.73	6.23	1.30	4.62	0.96
10/12/17 12:00	2.08E+05	14.79	6.27	1.30	4.7	0.98
10/12/17 18:00	2.08E+05	14.91	6.4	1.33	4.74	0.99
10/13/17 0:00	2.73E+05	14.88	6.42	1.75	4.82	1.31
10/13/17 6:00	2.73E+05	14.86	6.41	1.75	4.81	1.31
10/13/17 12:00	2.73E+05	14.86	6.43	1.75	4.71	1.28
10/13/17 18:00	2.73E+05	14.89	6.35	1.73	3.99	1.09
10/14/17 0:00	2.73E+05	14.91	6.31	1.72	4.23	1.15
10/14/17 6:00	2.73E+05	14.88	6.25	1.70	4.38	1.19
10/14/17 12:00	2.73E+05	14.92	6.26	1.71	4.44	1.21
10/14/17 18:00	2.73E+05	15.02	6.33	1.72	4.06	1.11
10/15/17 0:00	2.73E+05	15.12	6.42	1.75	4.12	1.12
10/15/17 6:00	2.73E+05	14.99	6.24	1.70	3.98	1.08
10/15/17 12:00	2.73E+05	14.5	5.95	1.62	3.89	1.06
10/15/17 18:00	2.73E+05	14.27	5.82	1.59	3.78	1.03
10/16/17 0:00	2.08E+05	14.03	5.74	1.19	3.79	0.79
10/16/17 6:00	2.08E+05	13.68	5.58	1.16	3.63	0.76
10/16/17 12:00	2.08E+05	13.48	5.55	1.15	3.55	0.74
10/16/17 18:00	2.08E+05	13.57	5.69	1.18	3.41	0.71
10/17/17 0:00	2.08E+05	13.53	5.62	1.17	3.21	0.67
10/17/17 6:00	2.08E+05	13.43	5.59	1.16	3.53	0.73
10/19/17 18:00	2.08E+05	13.77	4.86	1.01	3.65	0.76

Table D.1 continued.

			Primary SAGR		Secondary SAGR	
	Flow	Temperature	Total NH_3		Total NH_3	
Date	L d^{-1}	C	mg-N L^{-1}	kg d^{-1}	mg-N L^{-1}	kg d^{-1}
10/20/17 0:00	2.08E+05	13.85	5.08	1.06	3.61	0.75
10/20/17 6:00	2.08E+05	13.86	5.24	1.09	3.47	0.72
10/20/17 12:00	2.08E+05	13.88	5.44	1.13	3.48	0.72
10/20/17 18:00	2.08E+05	14.03	5.85	1.22	3.36	0.70
10/21/17 0:00	2.08E+05	14.21	6.11	1.27	3.3	0.69
10/21/17 6:00	2.08E+05	14.32	6.08	1.27	3.22	0.67
10/21/17 12:00	2.08E+05	14.42	6.18	1.29	3.1	0.64
10/21/17 18:00	2.08E+05	14.54	6.24	1.30	3.01	0.63
10/22/17 0:00	2.08E+05	14.7	6.41	1.33	2.94	0.61
10/22/17 6:00	2.08E+05	14.86	6.48	1.35	2.75	0.57
10/22/17 12:00	2.08E+05	14.74	5.93	1.23	2.68	0.56
10/22/17 18:00	2.08E+05	14.71	5.93	1.23	2.71	0.56
10/23/17 0:00	2.08E+05	14.52	5.8	1.21	2.74	0.57
10/23/17 6:00	2.08E+05	14.21	5.63	1.17	2.66	0.55
10/23/17 12:00	2.08E+05	14.07	5.56	1.16	2.61	0.54
10/23/17 18:00	2.08E+05	14	5.47	1.14	2.61	0.54
10/24/17 0:00	2.08E+05	13.66	5.35	1.11	2.54	0.53
10/24/17 6:00	2.08E+05	13.22	5.22	1.09	2.47	0.51
10/24/17 12:00	2.08E+05	12.78	5.13	1.07	2.33	0.48
10/24/17 18:00	2.08E+05	12.47	5.07	1.05	2.21	0.46
10/25/17 0:00	2.73E+05	12.16	4.99	1.36	2.03	0.55
10/25/17 6:00	2.73E+05	11.91	4.96	1.35	1.94	0.53
10/25/17 12:00	2.73E+05	11.76	4.95	1.35	1.9	0.52
10/25/17 18:00	2.73E+05	11.79	4.97	1.35	1.82	0.50
10/26/17 0:00	2.73E+05	11.74	4.97	1.35	1.83	0.50
10/26/17 6:00	2.73E+05	11.63	4.96	1.35	1.88	0.51
10/26/17 12:00	2.73E+05	11.55	4.94	1.35	1.92	0.52
10/26/17 18:00	2.73E+05	11.75	5.02	1.37	1.83	0.50
10/27/17 0:00	2.73E+05	11.45	4.85	1.32	1.74	0.47
10/27/17 6:00	2.73E+05	11.08	4.71	1.28	1.68	0.46
10/27/17 12:00	2.73E+05	10.81	4.64	1.26	1.62	0.44
10/27/17 18:00	2.73E+05	10.64	4.61	1.26	1.59	0.43
10/28/17 0:00	2.08E+05	10.37	4.55	0.95	1.56	0.32
10/28/17 6:00	2.08E+05	10.05	4.48	0.93	1.51	0.31
10/28/17 12:00	2.08E+05	9.75	4.41	0.92	1.44	0.30
10/28/17 18:00	2.08E+05	9.54	4.37	0.91	1.37	0.29
10/29/17 0:00	2.08E+05	9.34	4.35	0.91	1.33	0.28
10/29/17 6:00	2.08E+05	9.09	4.3	0.89	1.3	0.27
10/29/17 12:00	2.08E+05	8.94	4.29	0.89	1.24	0.26
10/29/17 18:00	2.08E+05	9.04	4.35	0.91	1.24	0.26
10/30/17 0:00	2.08E+05	9.1	4.39	0.91	1.24	0.26
10/30/17 6:00	2.08E+05	9.09	4.41	0.92	1.24	0.26
10/30/17 12:00	2.08E+05	8.91	4.36	0.91	1.21	0.25
10/30/17 18:00	2.08E+05	8.75	4.3	0.89	1.16	0.24
10/31/17 0:00	2.08E+05	8.44	4.22	0.88	1.11	0.23
10/31/17 6:00	2.08E+05	8.17	4.14	0.86	1.1	0.23
10/31/17 12:00	2.08E+05	7.92	4.09	0.85	1.07	0.22
10/31/17 18:00	2.08E+05	7.88	4.09	0.85	1.05	0.22
11/1/17 0:00	1.89E+05	7.78	4.08	0.77	1.02	0.19
11/1/17 6:00	1.89E+05	7.69	4.07	0.77	1.01	0.19
11/1/17 12:00	1.89E+05	7.59	4.06	0.77	1.04	0.20
11/1/17 18:00	1.89E+05	7.61	4.07	0.77	1.05	0.20
11/2/17 0:00	1.89E+05	7.69	4.07	0.77	1.04	0.20
11/2/17 6:00	1.89E+05	7.79	4.12	0.78	1.05	0.20
11/2/17 12:00	1.89E+05	7.91	4.17	0.79	1.06	0.20
11/2/17 18:00	1.89E+05	8.08	4.27	0.81	0.99	0.19
11/3/17 0:00	1.89E+05	7.97	4.22	0.80	0.97	0.18
11/3/17 6:00	1.89E+05	7.78	4.14	0.78	1.03	0.19
11/3/17 12:00	1.89E+05	7.66	4.1	0.78	1	0.19
11/3/17 18:00	1.89E+05	7.76	4.13	0.78	0.97	0.18
11/4/17 0:00	1.89E+05	7.74	4.11	0.78	0.99	0.19
11/4/17 6:00	1.89E+05	7.8	4.11	0.78	0.98	0.19
11/4/17 12:00	1.89E+05	7.88	4.13	0.78	0.96	0.18
11/4/17 18:00	1.89E+05	8.02	4.16	0.79	1.03	0.19
11/5/17 0:00	1.89E+05	8.1	4.2	0.79	1.04	0.20
11/5/17 6:00	1.89E+05	8.18	4.22	0.80	1.01	0.19
11/5/17 12:00	1.89E+05	8.28	4.24	0.80	1.05	0.20
11/5/17 18:00	1.89E+05	8.3	4.24	0.80	1.12	0.21
11/6/17 0:00	1.89E+05	7.93	4.1	0.78	1.11	0.21
11/6/17 6:00	1.89E+05	7.61	3.97	0.75	1.08	0.20
11/6/17 12:00	1.89E+05	7.35	3.89	0.74	1.07	0.20
11/6/17 18:00	1.89E+05	7.29	3.86	0.73	1.05	0.20
11/7/17 0:00	1.89E+05	7.14	3.83	0.72	1.06	0.20
11/7/17 6:00	1.89E+05	6.98	3.77	0.71	1.05	0.20
11/7/17 12:00	1.89E+05	6.8	3.72	0.70	1.07	0.20
11/7/17 18:00	1.89E+05	6.79	3.72	0.70	1.04	0.20
11/8/17 0:00	1.89E+05	6.67	3.68	0.70	1.06	0.20
11/8/17 6:00	1.89E+05	6.44	3.63	0.69	1	0.19
11/8/17 12:00	1.89E+05	6.3	3.61	0.68	1	0.19
11/8/17 18:00	1.89E+05	6.44	3.64	0.69	1.03	0.19
11/9/17 0:00	1.89E+05	6.42	3.62	0.68	1.04	0.20
11/9/17 6:00	1.89E+05	6.44	3.64	0.69	1.07	0.20
11/10/17 18:00	1.89E+05	4.92	3.5	0.66	2	0.38

Table D.1 continued.

			Primary SAGR		Secondary SAGR	
	Flow	Temperature	Total NH_3		Total NH_3	
Date	L d^{-1}	C	mg-N L^{-1}	kg d^{-1}	mg-N L^{-1}	kg d^{-1}
11/11/17 0:00	1.89E+05	4.81	3.5	0.66	1.92	0.36
11/11/17 6:00	1.89E+05	4.75	3.48	0.66	1.82	0.34
11/11/17 12:00	1.89E+05	4.72	3.47	0.66	1.74	0.33
11/11/17 18:00	1.89E+05	4.89	3.49	0.66	1.73	0.33
11/12/17 0:00	1.89E+05	5	3.49	0.66	1.71	0.32
11/12/17 6:00	1.89E+05	5.08	3.5	0.66	1.71	0.32
11/12/17 12:00	1.89E+05	5.16	3.5	0.66	1.73	0.33
11/12/17 18:00	1.89E+05	5.29	3.52	0.67	1.67	0.32
11/13/17 0:00	1.89E+05	5.27	3.52	0.67	1.71	0.32
11/13/17 6:00	1.89E+05	5.17	3.53	0.67	1.76	0.33
11/13/17 12:00	1.89E+05	5.06	3.52	0.67	1.8	0.34
11/13/17 18:00	1.89E+05	5.18	3.57	0.68	1.8	0.34
11/14/17 0:00	1.89E+05	5.2	3.61	0.68	1.87	0.35
11/14/17 6:00	1.89E+05	5.22	3.62	0.68	1.85	0.35
11/14/17 12:00	1.89E+05	5.3	3.67	0.69	1.78	0.34
11/14/17 18:00	1.89E+05	5.45	3.72	0.70	1.87	0.35
11/15/17 0:00	1.89E+05	5.61	3.76	0.71	1.93	0.37
11/15/17 6:00	1.89E+05	5.76	3.79	0.72	2	0.38
11/15/17 12:00	1.89E+05	5.91	3.83	0.72	2.08	0.39
11/15/17 18:00	1.89E+05	5.99	3.81	0.72	2.13	0.40
11/16/17 0:00	1.89E+05	5.73	3.71	0.70	2.16	0.41
11/16/17 6:00	1.89E+05	5.47	3.64	0.69	2.19	0.41
11/16/17 12:00	1.89E+05	5.31	3.62	0.68	2.13	0.40
11/16/17 18:00	1.89E+05	5.36	3.65	0.69	2.14	0.40
11/17/17 0:00	1.89E+05	5.33	3.63	0.69	2.3	0.44
11/17/17 6:00	1.89E+05	5.24	3.61	0.68	2.36	0.45
11/17/17 12:00	1.89E+05	5.21	3.62	0.68	2.29	0.43
11/17/17 18:00	1.89E+05	5.29	3.66	0.69	2.17	0.41
11/18/17 0:00	1.89E+05	5.39	3.71	0.70	1.76	0.33
11/18/17 6:00	1.89E+05	5.45	3.74	0.71	1.21	0.23
11/18/17 12:00	1.89E+05	5.45	3.76	0.71	1.14	0.22
11/18/17 18:00	1.89E+05	5.46	3.77	0.71	1.08	0.20
11/19/17 0:00	1.89E+05	5.24	3.7	0.70	0.97	0.18
11/19/17 6:00	1.89E+05	4.85	3.6	0.68	0.92	0.17
11/19/17 12:00	1.89E+05	4.56	3.56	0.67	0.89	0.17
11/19/17 18:00	1.89E+05	4.51	3.56	0.67	0.9	0.17
11/20/17 0:00	1.89E+05	4.44	3.54	0.67	1.01	0.19
11/20/17 6:00	1.89E+05	4.4	3.54	0.67	1	0.19
11/20/17 12:00	1.89E+05	4.38	3.53	0.67	1.02	0.19
11/20/17 18:00	1.89E+05	4.53	3.56	0.67	1.03	0.19
11/21/17 0:00	1.89E+05	4.73	3.61	0.68	1.44	0.27
11/21/17 6:00	1.89E+05	4.8	3.61	0.68	1.62	0.31
11/21/17 12:00	1.89E+05	4.72	3.55	0.67	1.61	0.30
11/21/17 18:00	1.89E+05	4.52	3.46	0.65	1.66	0.31
11/22/17 0:00	1.89E+05	4.34	3.42	0.65	1.65	0.31
11/22/17 6:00	1.89E+05	4.18	3.38	0.64	1.61	0.30
11/22/17 12:00	1.89E+05	4.06	3.37	0.64	1.58	0.30
11/22/17 18:00	1.89E+05	4.03	3.37	0.64	1.54	0.29
11/23/17 0:00	1.89E+05	4.06	3.38	0.64	1.55	0.29
11/23/17 6:00	1.89E+05	4.07	3.37	0.64	1.51	0.29
11/23/17 12:00	1.89E+05	4.1	3.37	0.64	1.48	0.28
11/23/17 18:00	1.89E+05	4.2	3.4	0.64	1.46	0.28
11/24/17 0:00	1.89E+05	4.3	3.41	0.64	1.48	0.28
11/24/17 6:00	1.89E+05	4.38	3.42	0.65	1.51	0.29
11/24/17 12:00	1.89E+05	4.5	3.43	0.65	2.14	0.40
11/24/17 18:00	1.89E+05	4.69	3.45	0.65	3.09	0.58
11/25/17 0:00	1.89E+05	4.95	3.48	0.66	3.57	0.68
11/25/17 6:00	1.89E+05	5.14	3.49	0.66	3.71	0.70
11/25/17 12:00	1.89E+05	5.28	3.52	0.67	3.95	0.75
11/25/17 18:00	1.89E+05	5.32	3.45	0.65	4.29	0.81
11/26/17 0:00	1.89E+05	5.41	3.42	0.65	4.3	0.81
11/26/17 6:00	1.89E+05	5.09	3.21	0.61	4.25	0.80
11/26/17 12:00	1.89E+05	4.93	3.14	0.59	4.43	0.84
11/26/17 18:00	1.89E+05	5.05	3.24	0.61	4.73	0.89
11/27/17 0:00	1.89E+05	5.17	3.24	0.61	5.88	1.11
11/27/17 6:00	1.89E+05	5.08	3.17	0.60	5.79	1.10
11/27/17 12:00	1.89E+05	5.06	3.2	0.61	5.62	1.06
11/27/17 18:00	1.89E+05	5.2	3.32	0.63	5.53	1.05
11/28/17 0:00	1.89E+05	5.38	3.37	0.64	5.91	1.12
11/28/17 6:00	1.89E+05	5.57	3.41	0.64	5.66	1.07
11/28/17 12:00	1.89E+05	5.73	3.43	0.65	5.71	1.08
11/28/17 18:00	1.89E+05	5.9	3.44	0.65	5.83	1.10
11/29/17 0:00	1.89E+05	5.97	3.35	0.63	5.72	1.08
11/29/17 6:00	1.89E+05	5.76	3.26	0.62	5.9	1.12
11/29/17 12:00	1.89E+05	5.56	3.2	0.61	6.01	1.14
11/29/17 18:00	1.89E+05	5.59	3.24	0.61	6.6	1.25
11/30/17 0:00	1.89E+05	5.63	3.23	0.61	5.67	1.07
11/30/17 6:00	1.89E+05	5.59	3.15	0.60	5.82	1.10
11/30/17 12:00	1.89E+05				3.28	0.62
12/1/17 12:00	1.89E+05	5.13	6.99	1.32	0.95	0.18
12/1/17 18:00	1.89E+05	5.37	6.58	1.24	0.98	0.19
12/2/17 0:00	1.89E+05	5.43	6.76	1.28	0.93	0.18
12/2/17 6:00	1.89E+05	5.47	6.76	1.28	0.79	0.15

Table D.1 continued.

	Flow	Temperature	Primary SAGR		Secondary SAGR	
			Total NH_3		Total NH_3	
Date	L d^{-1}	C	mg-N L^{-1}	kg d^{-1}	mg-N L^{-1}	kg d^{-1}
12/2/17 12:00	1.89E+05	5.4	6.33	1.20	0.7	0.13
12/2/17 18:00	1.89E+05	5.62	6.09	1.15	0.63	0.12
12/3/17 0:00	1.89E+05	5.5	6.06	1.15	0.56	0.11
12/3/17 6:00	1.89E+05	5.31	6	1.13	0.51	0.10
12/3/17 12:00	1.89E+05	5.21	6	1.13	0.49	0.09
12/3/17 18:00	1.89E+05	5.45	6.14	1.16	0.45	0.09
12/4/17 0:00	1.89E+05	5.68	5.93	1.12	0.44	0.08
12/4/17 6:00	1.89E+05	5.88	5.84	1.10	0.44	0.08
12/4/17 12:00	1.89E+05	6.08	6.02	1.14	0.44	0.08
12/4/17 18:00	1.89E+05	6.25	5.84	1.10	0.43	0.08
12/5/17 0:00	1.89E+05	6.43	5.95	1.13	0.43	0.08
12/5/17 6:00	1.89E+05	6.23	5.85	1.11	0.42	0.08
12/5/17 12:00	1.89E+05	5.8	5.57	1.05	0.4	0.08
12/5/17 18:00	1.89E+05	5.5	5.65	1.07	0.39	0.07
12/6/17 0:00	1.89E+05	5.3	5.21	0.99	0.38	0.07
12/6/17 6:00	1.89E+05	5.17	5.39	1.02	0.38	0.07
12/6/17 12:00	1.89E+05	4.91	5.24	0.99	0.37	0.07
12/6/17 18:00	1.89E+05	4.8	5.17	0.98	0.37	0.07
12/7/17 0:00	1.89E+05	4.53	5.05	0.96	0.36	0.07
12/7/17 6:00	1.89E+05	4.37	5.12	0.97	0.35	0.07
12/7/17 12:00	1.89E+05	4.18	5.08	0.96	0.35	0.07
12/7/17 18:00	1.89E+05	4.11	5.11	0.97	0.35	0.07
12/8/17 0:00	1.89E+05	4.05	5.02	0.95	0.35	0.07
12/8/17 6:00	1.89E+05	4	5.05	0.96	0.35	0.07
12/8/17 12:00	1.89E+05	3.98	5.14	0.97	0.35	0.07
12/8/17 18:00	1.89E+05	4.04	5.17	0.98	0.36	0.07
12/9/17 0:00	1.89E+05	4.14	5.15	0.97	0.36	0.07
12/9/17 6:00	1.89E+05	4.23	5.12	0.97	0.36	0.07
12/9/17 12:00	1.89E+05	4.24	5.02	0.95	0.35	0.07
12/9/17 18:00	1.89E+05	4.11	5	0.95	0.36	0.07
12/10/17 0:00	1.89E+05	4.04	5.04	0.95	0.35	0.07
12/10/17 6:00	1.89E+05	3.99	5.1	0.96	0.35	0.07
12/10/17 12:00	1.89E+05	4	5.17	0.98	0.32	0.06
12/10/17 18:00	1.89E+05	4.15	5.15	0.97	0.32	0.06
12/11/17 0:00	1.89E+05	4.2	5.2	0.98	0.32	0.06
12/11/17 6:00	1.89E+05	4.23	5.24	0.99	0.31	0.06
12/11/17 12:00	1.89E+05	4.31	5.19	0.98	0.32	0.06
12/11/17 18:00	1.89E+05	4.23	4.73	0.89	0.36	0.07
12/12/17 0:00	1.89E+05	3.13	4.99	0.94	0.43	0.08
12/12/17 6:00	1.89E+05	2.25	4.28	0.81	0.75	0.14
12/12/17 12:00	1.89E+05	2.17	4.25	0.80	1.22	0.23
12/12/17 18:00	1.89E+05	3.03	4.33	0.82	1.71	0.32
12/13/17 0:00	1.89E+05	2.39	4	0.76	2.08	0.39
12/13/17 6:00	1.89E+05	2.1	3.99	0.75	2.31	0.44
12/13/17 12:00	1.89E+05	1.92	3.92	0.74	2.39	0.45
12/13/17 18:00	1.89E+05	1.74	3.73	0.71	2.42	0.46
12/14/17 0:00	1.89E+05	1.49	3.77	0.71	2.42	0.46
12/14/17 6:00	1.89E+05	1.33	3.85	0.73	2.4	0.45
12/14/17 12:00	1.89E+05	1.28	3.13	0.59	2.39	0.45
12/14/17 18:00	1.89E+05	1.74	2.87	0.54	2.36	0.45
12/15/17 0:00	1.89E+05	1.6	2.65	0.50	2.34	0.44
12/15/17 6:00	1.89E+05	1.46	2.61	0.49	2.32	0.44
12/15/17 12:00	1.89E+05	1.36	2.52	0.48	2.29	0.43
12/15/17 18:00	1.89E+05	1.57	2.38	0.45	2.27	0.43
12/16/17 0:00	1.89E+05	1.49	2.37	0.45	2.26	0.43
12/16/17 6:00	1.89E+05	1.39	2.4	0.45	2.25	0.43
12/16/17 12:00	1.89E+05	1.33	2.37	0.45	2.24	0.42
12/16/17 18:00	1.89E+05	1.99	2.29	0.43	2.23	0.42
12/17/17 0:00	1.89E+05	1.82	2.31	0.44	2.22	0.42
12/17/17 6:00	1.89E+05	1.6	2.42	0.46	2.22	0.42
12/17/17 12:00	1.89E+05	1.53	2.37	0.45	2.21	0.42
12/17/17 18:00	1.89E+05	1.7	2.28	0.43	2.2	0.42
12/18/17 0:00	1.89E+05	1.62	2.36	0.45	2.19	0.41
12/18/17 6:00	1.89E+05	1.51	2.4	0.45	2.2	0.42
12/18/17 12:00	1.89E+05	1.48	2.37	0.45	2.23	0.42
12/18/17 18:00	1.89E+05	2.13	2.31	0.44	2.24	0.42
12/19/17 0:00	1.89E+05	2.03	2.23	0.42	2.23	0.42
12/19/17 6:00	1.89E+05	1.77	2.43	0.46	2.22	0.42
12/19/17 12:00	1.89E+05	1.69	2.46	0.47	2.22	0.42
12/19/17 18:00	1.89E+05	2.26	2.43	0.46	2.2	0.42
12/20/17 0:00	1.89E+05	2.18	2.38	0.45	2.2	0.42
12/20/17 6:00	1.89E+05	1.82	2.51	0.47	2.21	0.42
12/20/17 12:00	1.89E+05	1.73	2.58	0.49	2.2	0.42
12/20/17 18:00	1.89E+05	2.2	2.5	0.47	2.18	0.41
12/21/17 0:00	1.89E+05	2.25	2.45	0.46	2.18	0.41
12/21/17 6:00	1.89E+05	1.87	2.57	0.49	2.17	0.41
12/21/17 12:00	1.89E+05	1.73	2.65	0.50	2.16	0.41
12/21/17 18:00	1.89E+05	1.77	2.56	0.48	2.15	0.41
12/22/17 0:00	1.89E+05	1.58	2.56	0.48	2.14	0.40
12/22/17 6:00	1.89E+05	1.56	2.6	0.49	2.14	0.40
12/22/17 12:00	1.89E+05	1.58	2.64	0.50	2.15	0.41
12/22/17 18:00	1.89E+05	1.83	2.54	0.48	2.15	0.41
12/23/17 0:00	1.89E+05	1.73	2.51	0.47	2.14	0.40

Table D.1 continued.

			Primary SAGR		Secondary SAGR	
	Flow	Temperature	Total NH_3		Total NH_3	
Date	**L d^{-1}**	**C**	**mg-N L^{-1}**	**kg d^{-1}**	**mg-N L^{-1}**	**kg d^{-1}**
12/23/17 6:00	1.89E+05	1.55	2.59	0.49	2.11	0.40
12/23/17 12:00	1.89E+05	1.44	2.72	0.51	2.06	0.39
12/23/17 18:00	1.89E+05	2.13	2.58	0.49	2.06	0.39
12/24/17 0:00	1.89E+05	2.12	2.51	0.47	2.06	0.39
12/24/17 6:00	1.89E+05	1.81	2.64	0.50	2.04	0.39
12/24/17 12:00	1.89E+05	1.56	2.95	0.56	2.04	0.39
12/24/17 18:00	1.89E+05	1.51	2.92	0.55	2.06	0.39
12/25/17 0:00	1.89E+05	1.38	2.99	0.57	2.07	0.39
12/25/17 6:00	1.89E+05	1.22	3.14	0.59	2.06	0.39
12/25/17 12:00	1.89E+05	1.18	3.23	0.61	2.07	0.39
12/25/17 18:00	1.89E+05	1.26	3.19	0.60	2.09	0.40
12/26/17 0:00	1.89E+05	1.2	3.27	0.62	2.09	0.40
12/26/17 6:00	1.89E+05	1.14	3.4	0.64	2.09	0.40
12/26/17 12:00	1.89E+05	1.09	3.53	0.67	2.11	0.40
12/26/17 18:00	1.89E+05	1.15	3.52	0.67	2.13	0.40
12/27/17 0:00	1.89E+05	1.12	3.6	0.68	2.15	0.41

Table D.2 Public record monthly operation report 30 day average ammonia data for the NPDES permit (#5792001) for the City of Walker provided by the IDNR. Used to create Figure 3.3.

	30 Day Avg.	Permit limit
Date	**NH_4^+ mg L^{-1}**	
September 2013	0	2.7
October 2013	0	3
November 2013	0.03	2.9
December 2013	0	4.2
January 2014	0	10.9
February 2014	2.81	9
March 2014	6.62	4.3
April 2014	0.81	4.1
May 2014	0.50	3.5
June 2014	0.50	2.4
July 2014	0.50	2.4
August 2014	0.50	2.2
September 2014	0.59	2.7
October 2014	0.51	3
November 2014	0.52	2.9
December 2014	0.49	4.2
January 2015	0.49	10.9
February 2015	0	9
March 2015	0.13	4.3
April 2015	0.15	4.1
May 2015	0	3.5
June 2015	0	2.4
July 2015	0	2.4
August 2015	0	2.2
September 2015	0	2.7
October 2015	0	3
Novemver 2015	0	2.9
December 2015	0	4.2
January 2016	0	10.9
February 2016	0	9
March 2016	0	4.3
April 2016	0	4.1
May 2016	0.25	3.5
June 2016	0	2.4
July 2016	0	2.4
August 2016	0	2.2
September 2016	0	2.7
October 2016	0	3
November 2016	0	2.9
December 2016	0.57	4.2
January 2017	5.23	10.9
February 2017	0.15	9
March 2017	0	4.3
April 2017	0	4.1
May 2017	0	3.5
June 2017	0	2.4
July 2017	0	2.4
August 2017	0	2.2
September 2017	0	2.7

Table D.2 continued.

Date	30 Day Avg.	Permit limit
	NH_4^+ mg L^{-1}	
October 2017	0	3
November 2017	0	2.9
December 2017	0	4.2

Table D.3 The measurements needed to complete the kinetics calculations.

Background information necessary for calculations		
Pipe diameter from splitter box to SAGR	20.32	cm
Cross sectional area pipe	324.29	cm^2
SAGR Porosity	0.38	%
SAGR length	53.34	m
SAGR height	1.22	m
Cross sectional area SAGR	24.7	m^2
Distance from splitter to SAGR	3.61	m
Distance along pipe from inlet to well 1	2.59	m
Distance from effluent to second slitter box	6.20	
Distance from SAGR edge to well 1	1.32	m
Distance from well 1 to 2	0.86	m
Distance from well 2 to 3	0.86	m

Table D.4 Ammonia load, temperature and kinetics (raw) used to calculate the biomass to NH_3 load ratio, NH_3 removal rate, and $k_{estimated}$ to make Table 3.2.

Case	Date	Median Temp.	Influent NH_3 Load	Effluent NH_3 Load	Removal rate	Avg. Genes	SD	Gene : NH_3 Load	Median Overall Flow rate	Median SAGR Flow rate	HRT	Velocity in Pipe	Velocity Across SAGR	Time	PF K	CSTR K	Estimated K
		C		kg d^{-1}		copes mL^{-1}			L d^{-1}		d	m d^{-1}	m d^{-1}	d		d-1	
A	6/29/2017	24.33	0.65	0.315	0.34	1.1E+06	6.1E+04	1.74E+06	208000	104000	2.3	3207.0	4.2	0.73	0.99	0.47	0.73
B	7/24/2017	25.66	0.42	0.23	0.19	4.2E+05	1.9E+04	1.01E+06	208000	104000	2.3	3207.0	4.2	0.73	0.83	0.36	0.60
C	10/25/2017	16.45	1.415	0.865	0.55	1.8E+06	9.7E+04	1.30E+06	208000	104000	2.3	3207.0	4.2	0.73	0.68	0.28	0.48
D	12/1/2017	5.30	0.67	0.285	0.39	1.2E+06	7.1E+04	1.76E+06	189000	94500	2.5	2914.0	3.8	0.80	1.07	0.54	0.80

Table D.5 QIIME biofilm output 6/29/2017 processed 16S amplicon sequences of nitrification and ANAMMOX genera (relative abundance). Created Figure 3.6 and Figure 3.7.

					% Abundance											
					6/29											
Phylum	**Class**	**Order**	**Family**	**Genus**	**B1a**	**B1b**	**B1c**	**B1d**	**B2a**	**B2b**	**B2c**	**B2d**	**B3a**	**B3b**	**B3c**	**B3d**
Nitrospirae	Nitrospira	Nitrospirales	Nitrospiraceae	Nitrospira	4.15	6.43	4.03	4.93	3.82	2.60	2.82	3.67	2.06	2.75	3.28	2.19
Crenarchaeota	Thaumarchaeota	Cenarchaeales	Cenarchaeaceae	Nitrosopumilus	0.59	1.03	1.68	0.52	2.10	2.34	1.33	3.21	2.36	3.38	4.11	3.05
Proteobacteria	Betaproteobacteria	Nitrosomonadales	Nitrosomonadaceae	Nitrosovibrio	0.05	0.02	0.00	0.05	0.01	0.04	0.04	0.03	0.03	0.03	0.01	0.03
Planctomycetes	[Brocadiae]	Brocadiales	Brocadiaceae	Candidatus Brocadia	0.21	0.07	0.08	0.18	0.00	0.00	0.02	0.02	0.00	0.00	0.00	0.00
Crenarchaeota	Thaumarchaeota	Nitrososphaerales	Nitrososphaeraceae	Candidatus Nitrososphaera	0.01	0.00	0.01	0.00	0.01	0.01	0.02	0.01	0.02	0.02	0.01	0.01

Table D.6 QIIME biofilm output 7/24/2017 processed 16S amplicon sequences of nitrification and ANAMMOX genera (relative abundance). Created Figure 3.6 and Figure 3.7.

					% Abundance											
					7/24											
Phylum	**Class**	**Order**	**Family**	**Genus**	**B1a**	**B1b**	**B1c**	**B1d**	**B2a**	**B2b**	**B2c**	**B2d**	**B3a**	**B3b**	**B3c**	**B3d**
Nitrospirae	Nitrospira	Nitrospirales	Nitrospiraceae	Nitrospira	4.43	4.67	3.68	4.90	3.65	3.61	5.11	4.21	2.28	3.18	3.26	2.56
Crenarchaeota	Thaumarchaeota	Cenarchaeales	Cenarchaeaceae	Nitrosopumilus	0.56	1.00	0.65	0.92	1.58	3.19	2.17	2.49	2.06	3.46	2.38	1.95
Proteobacteria	Betaproteobacteria	Nitrosomonadales	Nitrosomonadaceae	Nitrosovibrio	0.02	0.05	0.03	0.02	0.02	0.01	0.02	0.02	0.09	0.04	0.04	0.05
Planctomycetes	[Brocadiae]	Brocadiales	Brocadiaceae	Candidatus Brocadia	0.02	0.02	0.03	0.05	0.05	0.04	0.04	0.06	0.01	0.00	0.01	0.00
Crenarchaeota	Thaumarchaeota	Nitrososphaerales	Nitrososphaeraceae	Candidatus Nitrososphaera	0.01	0.02	0.04	0.00	0.02	0.01	0.02	0.09	0.01	0.06	0.02	0.03

Table D.7 QIIME biofilm output 8/24/2017 processed 16S amplicon sequences of nitrification and ANAMMOX genera (relative abundance). Created Figure 3.6 and Figure 3.7.

					% Abundance											
					8/24											
Phylum	**Class**	**Order**	**Family**	**Genus**	**B1a**	**B1b**	**B1c**	**B1d**	**B2a**	**B2b**	**B2c**	**B2d**	**B3a**	**B3b**	**B3c**	**B3d**
Nitrospirae	Nitrospira	Nitrospirales	Nitrospiraceae	Nitrospira	4.44	3.87	3.74	3.41	2.09	2.06	2.52	2.84	2.49	1.79	1.75	1.23
Crenarchaeota	Thaumarchaeota	Cenarchaeales	Cenarchaeaceae	Nitrosopumilus	1.70	2.92	2.22	1.83	4.06	2.92	3.00	3.20	3.73	4.78	5.09	1.91
Proteobacteria	Betaproteobacteria	Nitrosomonadales	Nitrosomonadaceae	Nitrosovibrio	0.06	0.03	0.02	0.02	0.04	0.02	0.02	0.06	0.05	0.03	0.02	0.02
Planctomycetes	[Brocadiae]	Brocadiales	Brocadiaceae	Candidatus Brocadia	0.25	0.20	0.15	0.17	0.00	0.02	0.04	0.04	0.03	0.01	0.01	0.00
Crenarchaeota	Thaumarchaeota	Nitrososphaerales	Nitrososphaeraceae	Candidatus Nitrososphaera	0.05	0.02	0.01	0.02	0.04	0.01	0.02	0.02	0.05	0.02	0.00	0.01

Table D.8 QIIME wastewater output 6/29/2017, 7/24/2017, and 8/24/2017 processed 16S amplicon sequences of nitrification and ANAMMOX genera (relative abundance). Created Figure 3.6 and Figure 3.7.

					% Abundance								
					6/29			7/24			8/24		
Phylum	**Class**	**Order**	**Family**	**Genus**	**W1**	**W2**	**W3**	**W1**	**W2**	**W3**	**W1**	**W2**	**W3**
Crenarchaeota	Thaumarchaeota	Cenarchaeales	Cenarchaeaceae	Nitrosopumilus	0.12	0.20	0.49	0.48	1.03	0.73	0.68	1.31	1.42
Nitrospirae	Nitrospira	Nitrospirales	Nitrospiraceae	Nitrospira	0.71	0.89	0.91	2.01	1.52	1.87	0.98	0.65	0.44
Planctomycetes	[Brocadiae]	Brocadiales	Brocadiaceae	Candidatus Brocadia	0.04	0.01	0.02	0.06	0.02	0.02	0.08	0.06	0.00
Crenarchaeota	Thaumarchaeota	Nitrososphaerales	Nitrososphaeraceae	Candidatus Nitrososphaera	0.01	0.02	0.03	0.04	0.07	0.04	0.04	0.00	0.03

Table D.9 gBlock sequence.

5’ to 3’ gBlock sequence ordered from Integrated DNA Technologies, Inc.
AAATTGAAGAGTTTGATCATGGCTCAGATTGAACGCTGGCGGCAGGCCTAACACATGCAAGTCGAACGGTAACAGGAAGAAGCTTGCTCTTTGCTGACGAGTGGCGGACGGGTGAGTAATGTCTGGGAAACTGCCTGATGGAGGGGGATAACTACTGGAAACGGTAGCTAATACCGCATAACGTCGCAAGACCAAAGAGGGGGACCTTCGGGCCTCTTGCCATCGGATGTGCCCAGATGGGATTAGCTAGTAGGTGGGGTAACGGCTCACCTAGGCGACGATCCCTAGCTGGTCTGAGAGGATGACCAGCCACACTGGAACTGAGACACGGTCCAGACTCCTACGGGAGGCAGCAGTGGGGAATATTGCACAATGGGCGCAAGCCTGATGCAGCCATGCCGCGTGTATGAAGAAGGCCTTCGGGTTGTAAAGTACTTTCAGCGGGGAGGAAGGGAGTAAAGTTAATACCTTTGCTCATTGACGTTACCCGCAGAAGAAGCACCGGCTAACTCCGTGCCAGCAGCCGCGGTAATACGGAGGGTGCAAGCGTTAATCGGAATTACTGGGCGTAAAGCGCACGCAGGCGGTTTGTTAAGTCAGATGTGAAATCCCCGGGCTCAACCTGGGAACTGCATCTGATACTGGCAAGCTTGAGTCTCGTAGAGGGGGGTAGAATTCCAGGTGTAGCGGTGAAATGCGTAGAGATCTGGAGGAATACCGGTGGCGAAGGCGGCCCCCTGGACGAAGACTGACGCTCAGGTGCGAAAGCGTGGGGAGCAAACAGGATTAGATACCCTGGTAGTCCACGCCGTAAACGATGTCGACTTGGAGGTTGTGCCCTTGAGGCGTGGCTTCCGGAGCTAACGCGTTAAGTCGACCGCCTGGGGAGTACGGCCGCAAGGTTAAAACTCAAATGAATTGACGGGGGCCCGCACAAGCGGTGGAGCATGTGGTTTAATTCGATGCAACGCGAAGAACCTTACCTGGTCTTGACATCCACGGAAGTTTTCAGAGATGAGAATGTGCCTTCGGGAACCGTGAGACAGGTGCTGCATGGCTGTCGTCAGCTCGTGTTGTGAAATGTTGGGTTAAGTCCCGCAACGAGCGCAACCCTTATCCTTTGTTGCCAGCGGTCCGGCCGGGAACTCAAAGGAGACTGCCAGTGATAAACTGGAGGAAGGTGGGGATGACGTCAAGTCATCATGGCCCTTACGACCAGGGCTACACACGTGCTACAATGGCGCATACAAAGAGAAGCGACCTCGCGAGAGCAAGCGGACCTCATAAAGTGCGTCGTAGTCCGGATTGGAGTCTGCAACTCGACTCCATGAAGTCGGAATCGCTAGTAATCGTGGATCAGAATGCCACGGTGAATACGTTCCCGGGCCTTGTACACACCGCCCGTCACACCATGGGAGTGGGTTGCAAAAGAAGTAGGTAGCTTAACCTTCGGGAGGGCGCTTACCACTTTGTGATTCATGACTGGGGTGAAGTCGTAACAAGGTAACCGTAGGGGAACCTGGGGGTTTCTACTGGTGGTCACACTATCCTATCAATTTCGTAACACCGGGTATTATGCTTCCAGGTGCGCTGATGCTGGATTTCACGATGTATCTGACACGCAACTGGCTGGTGACGGCTCTGGTTGGAGGTGGATTCTTCGGTCTGCTGTTCTATCCGGGTAACTGGCCGATCTTTGGTCCGACACACCTGCCAATCGTCGTAGAAGGAACACTGTTGTCGATGGCTGACTACATGGGCCATATGTATGTTCGTACGGGTACACCCGAGTATGTTCGTCATATTGAGCAAGGTTCACTGCGTACCTTTGGTGGACATACCACAGTTATTGCAGCGTTCTTCTCTGCATTCGTATCAATGTTGATGTTCACGGTATGGTGGTATCTTGGAAAAGTTTACTGTACAGCCTTTTTCTACGTTAAAGGTAAAAGAGGTCGTATCGTACATCGCAATGATGTTACCGCATTCGGTGAAGAAGGCTTTCCCGAGGGGTAAACCGCTGTCGGGAGTTAAGAAATGCAAGGATGTTAATAGCGTTCTTGCTTGACTAAGGCTCCGGAGGAAGCCACGGCTAACTCTGTGCCAGCAGCCGCGGTAATACAGAGGCGGCAAGCGTTGTTCGGAATTATTGGGCGTAAAGAGCACGTAGGCGGCTGTGTAAGTCGGTTGTGAAAGCCTTCCGCTCAACGGAAGAACGGCATCCGATACTGCATGGCTTGAGTGTGGGAGGGGAGAGTGGAACTTCTGGTGGAGCGGTGA

Table D.10 qPCR standard curves and blanks for wastewater samples.

Run	Target Name	Task	Ct Mean	Ct SD	Quantity (copies)	Tm1 (°C)
1	Universal 16S	STANDARD	28.346	0.324	8.08E+01	84.619
1	Universal 16S	STANDARD	24.341	0.056	8.08E+02	84.521
1	Universal 16S	STANDARD	21.013	0.247	8.08E+03	84.225
1	Universal 16S	STANDARD	17.712	0.188	8.08E+04	84.029
1	Universal 16S	STANDARD	14.325	0.119	8.08E+05	83.635
1	Universal 16S	STANDARD	11.176	0.147	8.08E+06	83.733
1	Universal 16S	STANDARD	7.961	0.061	8.08E+07	83.930
1	Universal 16S	NTC				83.340
1	Universal 16S	STANDARD	4.829	0.053	8.08E+08	83.733
1	Universal 16S	NTC				83.635
2	Universal 16S	STANDARD	28.072	0.190	8.08E+01	84.767
2	Universal 16S	STANDARD	24.465	0.236	8.08E+02	84.668
2	Universal 16S	STANDARD	21.177	0.136	8.08E+03	84.470
2	Universal 16S	STANDARD	18.022	0.117	8.08E+04	84.273
2	Universal 16S	STANDARD	14.718	0.172	8.08E+05	83.976
2	Universal 16S	STANDARD	11.431	0.095	8.08E+06	83.778
2	Universal 16S	STANDARD	8.390	0.011	8.08E+07	83.877
2	Universal 16S	NTC				83.481
2	Universal 16S	STANDARD	4.961	0.028	8.08E+08	83.976
2	Universal 16S	NTC				84.470

Table D.11 Raw qPCR data and DNA concentrations to calculate the gene copies mL^{-1}. Filtered samples were 40 mls of raw wastewater and DNA was extracted into 100 µL. Here und. indicates undetermined.

		Ct		Quantity			Template		Extract		Sample DNA		
	Sample	Mean	SD	Mean	SD	T_{m1}	Conc.	Mass	Conc.	Mass	Mean	Mean	SD
Run				copies		°C	ng µL^{-1}	ng	ng µL^{-1}	ng	copies ng^{-1}	copies mL^{-1}	
1	12/1 W1	15.15	0.14	5.38E+05	5.37E+04	83.73	0.30	0.61	0.45	45.4	8.87E+05	1.01E+06	1.01E+05
1	12/1 W2	14.83	0.20	6.76E+05	9.61E+04	83.83	1.57	3.14	0.40	40.2	2.15E+05	2.16E+05	3.07E+04
1	12/1 W3	14.55	0.17	8.17E+05	9.57E+04	83.93	0.15	0.30	0.34	33.8	2.74E+06	2.32E+06	2.71E+05
2	10/25 W1	13.98	0.09	1.41E+06	9.42E+04	84.67	0.66	1.32	0.77	76.9	1.07E+06	2.06E+06	1.38E+05
2	7/24 W2	18.60	0.36	5.50E+04	1.42E+04	84.07	0.14	0.27	0.12	11.5	2.04E+05	5.86E+04	1.51E+04
2	10/25 W2	14.14	0.25	1.26E+06	2.12E+05	84.57	0.39	0.78	0.69	68.8	1.62E+06	2.78E+06	4.67E+05
2	7/24 W3	16.55	0.19	2.30E+05	3.22E+04	83.98	0.36	0.71	0.71	71.4	3.24E+05	5.79E+05	8.09E+04
2	10/25 W3	15.41	0.48	5.34E+05	1.96E+05	84.67	0.21	0.42	0.21	20.8	1.28E+06	6.65E+05	2.44E+05
2	8/24 W1			und.	und.	50.84	0.22	0.44	0.24	24.3			
2	8/24 W2			und.	und.	51.34	0.11	0.21	0.08	8.1			
2	6/29 W1	14.58	0.18	9.22E+05	1.17E+05	84.07	1.13	2.26	1.74	174	4.08E+05	1.78E+06	2.25E+05
2	8/24 W3			und.	und.	51.73	0.08	0.17	0.06	5.9			
2	6/29 W2	15.77	0.18	4.00E+05	5.19E+04	84.07	0.60	1.21	0.80	79.5	3.31E+05	6.58E+05	8.53E+04
2	6/29 W3	15.13	0.48	6.48E+05	1.97E+05	84.17	0.82	1.64	0.97	97.4	3.94E+05	9.60E+05	2.91E+05
2	7/24 W1	15.97	0.12	3.46E+05	3.01E+04	84.07	0.39	0.77	0.57	56.5	4.48E+05	6.32E+05	5.49E+04

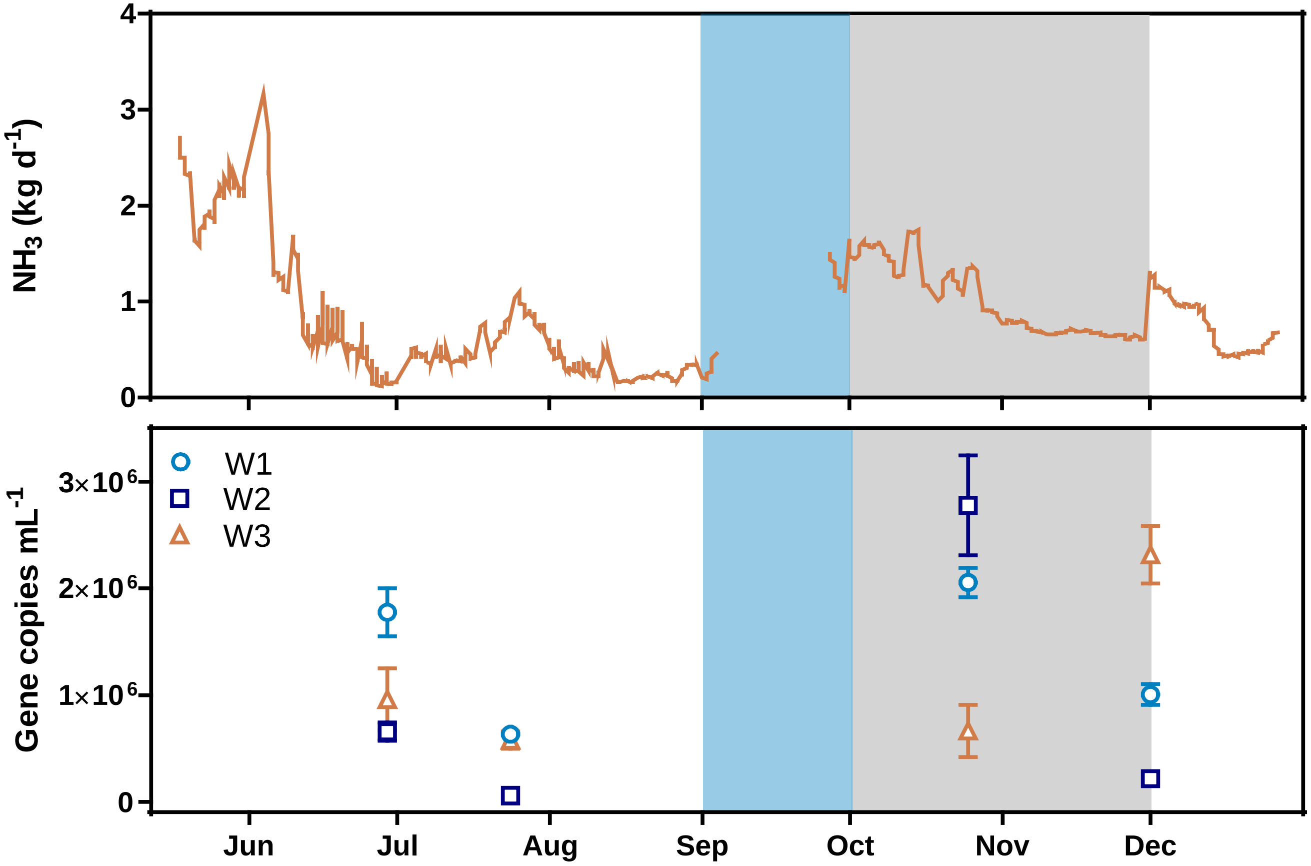

Figure D.1 Ammonia time series data from the water quality sonde and the gene copies mL^{-1} in the three wells taken on 6/29, 7/24, 10/25, and 12/1. The 28 day range was selected for the analysis of the impact of NH_3 load on biomass growth was based on this figure which indicated a relationship between NH_3 load in the month prior to the DNA sample. The 28 day range was chosen because it corresponded with 50 HRT in the SAGR.