

Report

Water Quality Standards Fiscal Impact Review and Alternate Technology Evaluation

Project I.D.: 06I003

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Final Report

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1 Introduction

The Iowa Department of Natural Resources (IDNR) developed a Notice of Intended Action, Group #1 – Water Quality Standards (Chapter 61). The impact of this rule making action was a change of effluent limits that would impact 411 facilities. These facilities would need to be upgraded for ammonia removal (397 wastewater treatment plants) and disinfection (14 wastewater treatment plants.)

An estimate of the cost of the rule implementation was developed in August, 2005 in a Fiscal Impact Statement prepared by IDNR. This fiscal impact was developed based on several assumptions. The first assumption is that the ammonia removal regulations will need to be met by a form of extended aeration activated sludge treatment process (including oxidation ditch and SBR systems). Activated sludge is a common process and has been proven to be effective in achieving low levels of ammonia in the wastewater effluent. Wastewater treatment facilities that do not have an extended aeration activated sludge process would have to be modified to incorporate the extended aeration activated sludge process.

The operation and maintenance (O&M) costs of the 397 ammonia removal wastewater treatment facilities would also be impacted by the changes needed to make the plant an extended aeration activated sludge facility. The second assumption used by IDNR was the O&M cost increase was for an upgrade from an aerated lagoon to an extended aeration activated sludge plant. The difference in O&M cost was assumed to be representative for all the facilities. The annual O&M cost difference was converted to a present worth cost using an interest rate of 3%. The present worth cost was plotted with average design flows for the wastewater treatment plants and a formula developed to estimate O&M present worth for all the impacted facilities.

The cost for disinfection was based on providing chlorination and dechlorination for 411 wastewater treatment facilities. An average present worth cost of \$150,000 per facility was used in this analysis.

The result of the fiscal analysis showed a present worth cost range of \$790,266,000 to \$955,879,000. The higher cost scenario assumed all existing activated sludge facilities would require some physical improvements. The lower cost scenario assumed all existing activated sludge facilities could achieve ammonia removal through a change in operation without physical improvements or capital cost expenditure.

The Iowa Environmental Council supports the change in regulations. However, the cost to implement the regulations based on the above assumptions is imposing and may be unaffordable to some communities. Foth & Van Dyke was retained by the Iowa Environmental Council to evaluate lower cost alternatives to meet the regulations and see what the impact would be on the overall cost.

2 Alternatives for Ammonia Limit Compliance

2.1 Biological Ammonia Removal

2.1.1 Microbiology for Ammonia Removal

Scientists studying wastewater in the late 1800's discovered living organisms converted ammonia to nitrate. More modern studies have shown that autotrophic bacteria (*Nitrosomonas* and *Nitrobacter*) are responsible for converting ammonia to nitrate. These autotrophic bacteria use ammonia as an energy source and obtain carbon for cell growth from inorganic sources. The autotrophic bacteria grow slowly when compared to the heterotrophic bacteria that use organic food sources for cell growth and energy.

The bacteria responsible for nitrification are sensitive to several parameters that affect their growth rate. Temperature is the most important parameter controlling bacterial growth for ammonia removal. Studies have shown nitrification rates at 10°C are 25% to 50% of the nitrification rate at 20°C. Ammonia removal in wastewater at temperatures below 10°C can be difficult and provisions must be made to allow the slow growing bacteria to work at a lower speed.

The autotrophic bacteria responsible for nitrification are also sensitive to pH. The maximum growth rate will occur at a pH of 7.2. As pH increases over 8.0 or falls below 6.5, the nitrification rate will decrease. Studies have shown that if the pH is held steady at a higher or lower value than 7.2, the bacteria can adjust over time and can approach ideal growth rates.

Dissolved oxygen can also impact the nitrification rate. Studies found a correlation of dissolved oxygen concentration with nitrification rates but the minimum dissolved oxygen concentration has varied in the studies. Some of the variation is due to the bacteria floc size which can reduce the amount of oxygen in larger bacterial floc particles. In general, the dissolved oxygen concentration should be maintained at 2.0 mg/l to maximize the nitrification rate.

2.1.2 Appropriate Ammonia Removal Technologies for Mechanical Wastewater Facilities

2.1.2.1 Activated Sludge Facilities

Ammonia removal is easily done in activated sludge facilities. The design considerations for nitrification are to provide for their slow growth, sensitivity to low temperatures, and maintain adequate dissolved oxygen concentrations. For existing activated sludge facilities, nitrification can take place if an adequate amount of nitrifying bacteria is present. Increasing the concentration of nitrifying bacteria can be done by increasing the relative amount of bacteria in the activated sludge system. The amount of bacteria that can be grown in the activated sludge basins can be limited by the basin size or by the solids removal capacity of the final clarifier. In many cases, no change to the existing facilities will be required to implement ammonia removal.

If the existing facilities can not accommodate ammonia removal, additional capacity can be added through increased volume of aeration tanks, fixed media placed in the existing aeration basins, or improved hydraulic or solids removal capacity in the existing clarifiers. These improvements will need to be evaluated on a site by site basis to determine the best option for implementing ammonia removal at an existing activated sludge plant.

2.1.2.2 Trickling Filter/RBC Facilities

Trickling filter/RBC facilities are well suited for carbonaceous BOD removal. Most facilities will require additional processes to remove ammonia. Possible ammonia removal processes following trickling filter/RBC facilities include:

- ◆ Nitrification with activated sludge.
- ◆ Second stage trickling filter/RBC process.
- ◆ Submerged bio-media reactor.
- ◆ Recirculating gravel filter.

The activated sludge alternative is most cost-effective if the activated sludge reactor can be placed after the trickling filter and using the existing clarifier. In many cases, the existing clarifier will be too shallow to meet codes and operate well with the high solids loading from the activated sludge process.

The second stage trickling filter or RBC process can be sized for ammonia removal assuming most of the BOD is removed in the existing process. A second clarifier may be required but if not, a second stage process can be cost-effective.

A submerged bio-media reactor can be a lower cost option than either activated sludge or a second stage trickling filter/RBC process. The tank and equipment for this process can be relatively low in cost but a second clarifier or dissolved air flotation unit will be required to remove solids.

If space is available, the recirculating gravel filter can be cost effective as a low technology means of ammonia removal. The nitrifying organisms will grow on the gravel media but solids generation is low enough that a second clarifier will be not required.

Appendix A contains literature and correspondence on submerged media reactors and their ability to remove ammonia.

2.1.3 Aerated Lagoons

Aerated lagoons can remove ammonia in summer when water temperatures in the lagoon allow the bacteria to complete nitrification. In winter, the water temperature drops and is too low to allow the growth of the nitrification bacteria to complete the nitrification process. In order to use aerated lagoons for nitrification, the nitrification rate must be increased through warmer water temperatures or an increased concentration of bacteria to do the nitrification.

Covering aerated lagoons with an insulated floating cover can be an effective means of retaining heat and allowing the nitrification bacteria to remove ammonia. The LemTec Biological Treatment Process from Lemna Technologies, Inc. provides a cover and aeration process to enhance the aerated lagoon process and remove ammonia. In many cases, only one of two aerated lagoon cells is needed for treatment because of the improved biological activity associated with warmer wastewater temperatures.

Other technologies convert the aerated lagoon process to an activated sludge process. The Environmental Dynamics Inc. Advanced Lagoon Aeration System – Internal Separator process and the Parkson Biolac process are examples of converting an existing aerated lagoon to an activated sludge process. Typically, part of an existing lagoon is separated by a baffle and converted to a complete mix reactor. Clarifier modules are inserted into the lagoon to recycle wastewater solids back to the complete mix cell. Further polishing and solids removal are done in the downstream cells.

Appendix B contains correspondence and literature for ammonia removal in aerated lagoons.

2.1.4 Small Scale Wastewater Treatment Processes

Many public and semi-public wastewater treatment systems are relatively small in size and treat wastewater from an average of 100 people or less. The IDNR listed 120 small scale facilities that were impacted by the proposed regulations.

Where the existing small scale facilities had activated sludge and aerated lagoons for wastewater treatment facilities, the technologies listed above for would be applicable on a smaller scale. For other technologies such as primary treatment, septic tank/sand filter, or “other”, a new process is required to meet the proposed ammonia regulations. Activated sludge or aerated lagoons are appropriate technologies but a lower cost option may be a recirculating sand filter.

Recirculating sand (or gravel) filters can provide good ammonia removal if temperatures can be maintained at 8°C or above. Buried recirculating sand filters use the natural soil as insulation and can retain heat to provide nitrification throughout the winter season. The wastewater distribution system is covered with a coarse gravel material to minimize heat loss and minimize maintenance. An aerated polishing reactor can be provided as a second nitrification step. The polishing reactor could include diffused aeration along with submerged media for retaining biological solids to complete the nitrification process.

2.2 Discharge Alternatives

With the potential change in effluent ammonia limits for a large number of wastewater treatment plants, many plants will consider an alternative to continuous surface water discharge.

Alternative discharge scenarios can modify or avoid the proposed ammonia limits. The potential discharge alternatives include:

- ◆ Flow-Variable Effluent Limits
- ◆ Controlled Discharge Lagoon
- ◆ Land Application

2.2.1 Flow-Variable Effluent Limits

The idea for this alternative is to match the capacity of the receiving stream to assimilate ammonia to the wastewater discharge. Wastewater treatment plants that choose this alternative will need to be able to store the wastewater for part of the year when the stream flow cannot assimilate all the wastewater from the plant. The treatment plant will also need to monitor stream flow to be able to adjust the effluent flow to match the stream flow. This alternative may be cost effective for smaller facilities where land for wastewater storage is available.

This alternative will not be evaluated in detail because the implementation of this alternative is site specific. Only sites that have a stream with an adequate flow to provide some treatment/dilution when compared to the wastewater flow would be appropriate candidates for this technology.

2.2.2 Controlled Discharge Lagoon

Controlled discharge lagoons are designed to discharge two times per year – in spring and in fall. These lagoons are not subject to the new ammonia regulations. Existing facilities could look at converting their existing facilities into controlled discharge type facilities.

2.2.3 Land Application

Ammonia limits can be avoided by applying wastewater to land rather than to a surface water. The most common land application method is spray irrigation. This alternative combines plant uptake of water and nutrients with the percolation through the soil. The short growing season in Iowa is a challenge to land application systems. The average wastewater storage requirement is 210 days with land application occurring approximately 155 days during the active growing season. The cost associated with this alternative is the storage lagoon and spray irrigation land and equipment. This alternative is typically associated with smaller flows of less than 100,000 gpd.

For flows less than 10,000 gpd, wastewater disposal through an absorption field or drip irrigation becomes feasible. Soils that are suitable for these types of land application are clay loam or coarser soils such as silt loam, sandy loam or sand. These soils will typically treat 0.5 gallons per day per square foot. This value may increase with coarser soils. If suitable land area is available, this type of wastewater disposal can be cost effective and have significantly lower operating costs than a surface water discharge.

2.3 Other Technologies

The Fiscal Impact Statement mentions other innovative treatment techniques such as artificial wetlands as potential alternatives for meeting the ammonia removal regulations. Acute ammonia toxicity can also be related to pH in the water and the wastewater.

2.3.1 Artificial Wetlands

Wetlands can be used provide biological treatment of wastewater and have been successful in northern climates such as Iowa. Artificial wetlands are typically used to enhance natural processes and improve the ability of wetlands to remove wastewater pollutants. Excellent BOD and suspended solids removal has been documented in numerous projects. Nutrient removal can be accomplished in wetlands but special designs and processes are needed to reach low levels of nutrients such as the ammonia concentrations in the proposed regulations. Wastewater temperatures can drop near freezing in winter and limit ammonia removal. The natural processes (plant growth and decay) that take place in wetlands create a balance of nitrogen uptake and release but are not efficient in maintaining low levels of ammonia. These reasons may limit the use of artificial wetlands in providing low level ammonia treatment.

2.3.2 pH Control

Acute ammonia toxicity is typically related to the pH of the wastewater. The lower the pH, the more ammonium ion is present (NH_4^+) and the less the toxic ammonia (NH_3) molecule is present. If acute toxicity is a primary concern, pH control could be implemented to increase the allowable ammonia concentration and potentially change the technical approach to the ammonia removal system.

3 Economic Impact Analysis Methodology

3.1 IDNR Capital Cost Evaluation

Foth & Van Dyke obtained the capital cost formula used by IDNR and applied it to the 397 facilities impacted by the ammonia removal regulations. The formula was based on nine recent projects in Iowa that involved an activated sludge upgrade. The flow rates for these projects ranged from 0.4 MGD to 1.8 MGD. The costs for these projects were developed into an equation that was used to estimate costs for the 397 facilities. When Foth & Van Dyke reviewed the costs for projects that were larger or smaller than the sample range, it was observed that the equation estimated project costs actually decreased for facilities with flow rates over 2.0 MGD. Due to the small sample size and the inaccuracies of the equation outside the project size range, Foth & Van Dyke developed an independent cost analysis for the existing facilities under the same assumptions that IDNR used. This method will also be more comparable to cost estimates for lower cost alternatives developed as part of this study.

3.2 IDNR Operation and Maintenance Cost Evaluation

The O&M costs developed by IDNR were based on converting an aerated lagoon to an activated sludge facility and applied to all other facilities. Where the existing facility is an activated sludge type or trickling filter type, the increase in O&M cost will be significantly less than for the aerated lagoon case. Mechanical wastewater treatment plants typically have service buildings, preliminary treatment facilities, laboratories, and sludge handling facilities that are not part of the typical aerated lagoon. The cost to operate a mechanical treatment plant for ammonia removal will not be a significant increase compared to the increase for an aerated lagoon to upgrade to an activated sludge facility. Therefore, Foth & Van Dyke developed O&M costs for each type of treatment facility to more accurately reflect the change in operation cost.

While the above changes effectively lower the IDNR fiscal impact, the assumption that an upgrade to an extended aeration activated sludge facility is necessary for all facilities leads to a relatively high fiscal impact for compliance with the new regulations. The purpose of this report is to determine the potential cost savings of using alternative technologies when compared to the assumption that extended aeration activated sludge facilities will be needed for all of the wastewater treatment plants.

3.3 Foth & Van Dyke Cost Evaluation – Base Fiscal Cost

Foth & Van Dyke developed a base fiscal cost impact using the same assumptions as IDNR. The base fiscal cost assumed the following:

- ◆ All activated sludge facilities would need to add aeration basin tanks and aeration equipment to meet the ammonia removal requirements. However, the cost assumed no other significant modifications (pumps, clarifiers, sludge handling, buildings) are needed to meet the requirements.
- ◆ All trickling filter and rotating biological contactor (RBC) facilities will be converted to activated sludge. The cost includes aeration basins, aeration equipment, final clarifiers, sludge pumping and an equipment building. No cost increase was assumed for sludge

treatment and handling or for preliminary/primary treatment. No service building modifications were included in the cost.

- ◆ All aerated lagoons will be abandoned and new activated sludge facilities constructed. The cost includes service building, screening, aeration basins and equipment, final clarifiers and equipment, sludge pumping, aerobic sludge digestion, and sludge digestion equipment.
- ◆ All semi-public wastewater treatment facilities will be abandoned and a new extended aeration activated sludge package plant was assumed for all facilities.

The capital costs for each of the above categories were developed for an assumed flow. All municipal facilities had a cost developed based on population and the following formula:

$$\text{Cost X} = \text{Cost N} \times (\text{Population X} / \text{Population N})^{0.6}$$

Where N is cost example population and associated upgrade cost and X is the actual population for facility X.

Semi-public facilities were estimated based on a uniform design flow rate of 10,000 gpd.

O&M costs were developed for the four examples above using information from the EPA guide referenced in the IDNR fiscal cost analysis and Foth & Van Dyke experience with typical operating costs. The assumptions are as follows:

- ◆ Activated sludge facilities will have a minor increase in aeration power cost and equipment maintenance. No additional staffing, sludge handling, chemical usage or other costs were included.
- ◆ Trickling filter/RBC facilities will have a significant increase in aeration power and sludge pumping. No additional staffing, sludge treatment, chemical usage, or other costs were included.
- ◆ Aerated lagoon facilities upgraded to activated sludge will have an extensive increase in operating costs including preliminary treatment, final clarifiers, aerobic digestion, sludge application and one full time staff addition.
- ◆ The semi-public activated sludge process includes increases in power, labor (10 hours/week) sludge hauling and sampling/testing.

The cost for disinfection was assumed to be the same as the IDNR cost.

3.4 Foth & Van Dyke Cost Evaluation – Alternate Fiscal Cost

Foth & Van Dyke developed an alternative fiscal cost impact using technologies that can achieve compliance with the regulations at a lower capital and operating cost. While there are many potential alternatives to achieve compliance, the fiscal analysis assumed the following:

- ◆ All activated sludge facilities will be able to modify operation to achieve ammonia removal. The modifications will be to operate at a higher sludge age. This will be possible in many treatment facilities especially in those that are significantly below design loading.
- ◆ All trickling filter and RBC facilities will be upgraded to add a submerged media bio-reactor after the trickling filter process. Included in the process are tanks, bio-reactor equipment, and dissolved air flotation separator with polymer feed and building. No cost increase was assumed for sludge treatment and handling or for preliminary/primary treatment. No service building modifications were included in the cost.
- ◆ All aerated lagoons will be converted to the “Lemna” process. This process includes covering the aerated lagoons with an insulated cover, providing aeration and mixing in the first cell and an effluent polishing reactor to complete the nitrification process. All new equipment is provided but no new lagoons will be required. Sludge handling is not required with this process on a regular basis.
- ◆ Semi-public wastewater treatment facilities that are aerated lagoons will be converted to “Lemna” process. This process is identical to above process but at a much smaller scale.
- ◆ Semi-public wastewater treatment facilities that are trickling filters will be upgraded to provide ammonia removal through a recirculating gravel filter (RGF).
- ◆ Semi-public wastewater treatment facilities that are primary treatment or other types, will be upgraded to a recirculating gravel filter/bio-reactor process.

The capital costs for each of the above categories were developed for an assumed flow. All municipal facilities had a cost developed based on population and the following formula:

$$\text{Cost X} = \text{Cost N} \times (\text{Population X} / \text{Population N})^{0.6}$$

Where N is cost example population and associated upgrade cost and X is the actual population for facility X.

Semi-public facilities were estimated based on a uniform design flow rate of 10,000 gpd.

O&M costs were developed for the four examples above using information from the EPA guide referenced in the IDNR fiscal cost analysis and Foth & Van Dyke experience with typical operating costs. The assumptions are as follows:

- ◆ Activated sludge facilities will have a minor increase in aeration power cost and equipment maintenance. No additional staffing, sludge handling, chemical usage or other costs were included.
- ◆ Trickling filter/RBC facilities upgraded with a submerged media bio-reactor will have a significant increase in aeration and DAF operation power, polymer cost for DAF

operation, maintenance on additional equipment, and an increase in labor cost of 8 hours per week. No additional sludge treatment, chemical usage, or other costs were included.

- ◆ Aerated lagoon facilities upgraded to a “Lemna” process will have energy for mixers, additional maintenance for the additional mixer equipment, and additional labor for the additional equipment (2 hrs/wk). Other operating costs for the existing aerated lagoon are assumed to be the same as the “Lemna” process.
- ◆ Semi-public wastewater treatment facilities that are aerated lagoons will have a small increase in O&M for additional mixing energy and 1 hour/week for labor.
- ◆ Semi-public wastewater treatment facilities that are trickling filter/RGF systems will have additional O&M costs for the power and operation of the RGF system.
- ◆ Semi-public wastewater treatment facilities that are primary treatment or other types, will have additional O&M costs for the power and operation of the RGF system.

The disinfection costs were evaluated using UV light as the disinfection system. This technology uses a significantly smaller tank size and has no toxic chemicals involved in the process.

Appendix C contains cost estimating tables for the above analyses.

4 Fiscal Impact Findings

The Foth & Van Dyke base fiscal impact cost had a total cost as follows:

| Nitrification Capital Cost | Nitrification O&M Present Worth Cost | Disinfection Present Worth Cost | Total Present Worth Cost |
|----------------------------|--------------------------------------|---------------------------------|--------------------------|
| \$447,586,000 | \$207,315,000 | \$61,650,000 | \$716,550,000 |

The Foth & Van Dyke alternative fiscal cost impact had a total cost as follows:

| Nitrification Capital Cost | Nitrification O&M Present Worth Cost | Disinfection Present Worth Cost | Total Present Worth Cost |
|----------------------------|--------------------------------------|---------------------------------|--------------------------|
| \$249,876,000 | \$63,792,000 | \$49,983,000 | \$357,059,000 |

This preliminary analysis shows that the capital cost for nitrification can be reduced to approximately 56% of the base cost, the O&M costs for nitrification can be reduced to 31% of the base cost, the disinfection cost can be reduced to 81% of the base cost, and the total present worth cost can be reduced to 51% of the base cost.

The largest cost decrease in the alternative cost analysis is the capital and operating cost for the numerous aerated lagoon facilities. Systems like the “Lemna” process use the existing aerated lagoon structures as part of the process to reduce the capital cost. The covered lagoons can provide much improved treatment for BOD removal and ammonia removal due to the higher water temperatures. The polishing reactor provides a source of ammonia removal bacteria at the end of the process to ensure low ammonia levels in the wastewater plant effluent. With the operating process nearly identical to the existing aerated lagoon and without the complex equipment and testing associated with the activated sludge process, operation costs will be similar to the existing aerated lagoon process and much lower than a comparable activated sludge process.

Other cost savings include using existing trickling filters and RBC units as carbonaceous BOD removal systems and providing an ammonia removal system (like a submerged media bio-reactor) as an additional unit rather than replacing the trickling filter or RBC unit. Using the existing system will lower capital and operating costs.

The small semi-public systems can reduce cost when compared to an activated sludge process by using a fixed media system such as a recirculating gravel filter followed by a bio-reactor. A well operated recirculating gravel filter designed to retain heat can produce a low ammonia wastewater. The addition of a bio-reactor for ammonia polishing can aid in meeting the low ammonia levels in the regulation. This process is much less costly to operate mainly in labor, testing and sludge handling.

5 Cost Comparisons for Other Alternative Technologies

5.1 Activated Sludge Facilities

The IDNR base case assumed all activated sludge facilities would need to be upgraded for nitrification. The Foth & Van Dyke alternate fiscal cost (and IDNR low cost scenario) assumed that no modifications were required for existing activated sludge facilities. The reality of the ammonia regulations is that some existing facilities will require no change and some may require a change to meet the new ammonia regulations.

If an activated sludge facility cannot meet the ammonia regulations with the current operation, the remedy is to increase the mass of bacteria in the system. This can be done by operating at a higher concentration in the existing aeration basins, adding aeration basins, or adding fixed media to the aeration basins to encourage additional bacteria growth. The options that do not require building additional aeration basins will be the lowest cost to implement.

Because the appropriate technology is specific to the site and the type of activated sludge facility, it is not possible to generalize on potential upgrades to activated sludge facilities beyond the base cost or the alternate cost.

5.2 Trickling Filter/RBC Facilities

The Foth & Van Dyke alternative fiscal cost assumed a submerged bio-media reactor would be used for providing nitrification for trickling filter/RBC facilities. Other potential cost effective technologies that continue use of the existing trickling filter/RBC facilities may be appropriate on a site by site basis.

Adding an activated sludge system after the trickling filter may be cost-effective if the final clarifier is suitable for the higher flow and load from an activated sludge process. A second stage trickling filter can be designed for nitrification but care must be taken to maintain good bacterial growth and minimize nuisance flies and other organisms that eat the bacteria. For small flows, the recirculating gravel filter can be used without a clarifier to minimize costs.

Because the appropriate technology is specific to the site and the type of trickling filter/RBC facility, it is not possible to generalize on potential upgrades to these facilities. However, the above options that continue to use the existing trickling filter/RBC process with added processes for ammonia removal are clearly less costly than replacing the existing process with a new activated sludge process.

5.3 Aerated Lagoon Facilities

Because aerated lagoons are typically used for smaller flows and may be located in a less populated area, they are good candidates for alternative discharge options such as storage/land application or controlled discharge lagoons.

Foth & Van Dyke prepared a preliminary cost for a lagoon storage/land application system following an aerated lagoon treatment system. The capital cost for this discharge alternative is approximately 40% higher than the LemTec process used in the alternative evaluation. Operation and maintenance costs will be higher than the aerated lagoon cost but may be slightly

less than the LemTec cost. Effluent sampling costs will be reduced due to the shorter discharge season. In general, it appears that a storage/land application system may be appropriate in some cases but it does not appear to be generally more cost-effective than converting an existing aerated lagoon to a nitrification process.

Using a controlled discharge lagoon system is a common treatment approach in Iowa for smaller communities. The cost to change from an aerated lagoon to a controlled discharge stabilization pond system is a higher capital cost than the aerated lagoon modification to a LemTec system. However, the operation cost for a controlled discharge lagoon is less costly than an aerated lagoon. The controlled discharge system will reduce the amount of sampling required due to the fewer months of discharge. The lack of mechanical aeration reduces the power and labor cost. With a reduction in operation cost, the overall present worth cost at flows of approximately 50,000 gpd will be nearly equal to the LemTec alternative. Based on this analysis, small flow systems (100,000 gpd or less) should always consider controlled discharge systems as an alternative to meeting the ammonia regulations. Larger flow systems will have a larger capital cost increase and the savings in operation and maintenance will not change proportionately with the larger flow. These factors will likely make the controlled discharge system too expensive when compared to other alternatives.

5.3.1 Small Scale Wastewater Treatment Processes

Wastewater treatment plants with flows in the range of 10,000 gpd are not suitable for many types of wastewater treatment processes. The Foth & Van Dyke alternate cost analysis assumed using existing facilities when possible to minimize costs. Where new facilities were required, the recirculating gravel filter/bio-reactor process was used as an appropriate technology. Other technologies that may be appropriate include:

- ◆ Controlled discharge lagoon.
- ◆ Storage lagoon/land application.
- ◆ Soil absorption/drip irrigation land disposal.

Each of the above systems should be evaluated for small-scale wastewater treatment systems with an emphasis on low operation and maintenance costs.

6 Conclusions and Recommendations

6.1 Conclusions

- ◆ The IDNR fiscal analysis assumed that all wastewater treatment plants impacted by new ammonia regulations will require modifications to convert the treatment plant to an extended aeration activated sludge facility. All disinfection upgrades were assumed to be chlorination/dechlorination. The present worth cost ranged from \$790 million to \$955 million for the 411 wastewater treatment plants.
- ◆ The keys to biological ammonia removal are maintaining temperatures above 8°C, a neutral pH, and dissolved oxygen concentrations above 2 mg/l.
- ◆ Improving activated sludge facilities will require an increase in the amount of bacteria used to provide treatment. This can be done through a change in operation or adding additional tanks and equipment.
- ◆ Improving trickling filter/RBC facilities will require an added process for ammonia removal. A submerged bio-reactor was a technology used in the alternate fiscal analysis.
- ◆ Improving aerated lagoons will require maintaining higher wastewater temperatures in winter or increase the bacteria concentration through converting the lagoons to an activated sludge facility.
- ◆ Small scale facilities can meet the ammonia regulations through several lower cost options such as controlled discharge lagoons, land application, covered aerated lagoons, and recirculating gravel filters.
- ◆ Alternatives that avoid meeting stringent ammonia limits (controlled discharge and land application) are most applicable to smaller facilities due to a relatively large land area requirement.
- ◆ Alternative technologies will be able to reduce the present worth by 49% when compared to the activated sludge/chlorination base cost.
- ◆ Other technologies were identified which may be equivalent in cost and performance to the alternatives used in the Foth & Van Dyke fiscal analysis.

6.2 Recommendations

- ◆ IDNR should be open to alternative technologies using the basic principles of ammonia removal while keeping existing facilities in operation.
- ◆ IDNR should consider pH control as a suitable means of reducing acute toxicity.
- ◆ Where possible, IDNR should consider less restrictive limits for small wastewater treatment facilities to allow lower cost and lower technology systems to meet ammonia limits.