AN ASSESSMENT OF THE NORTH CAROLINA WATER REUSE REGULATIONS: THEIR APPLICATION TO A NEW RECLAMATION FACILITY AND THEIR KEY FEATURES COMPARED TO NATIONAL WATER REUSE REGULATION TRENDS

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ABSTRACT

The efficacy of the North Carolina water reuse regulations was reviewed in the context of a municipal reuse system in Charlotte, North Carolina. The assessment tasks included: (a) collection and review of monitoring data from the plant; (b) monthly reconnaissance sampling of effluent at the plant and from the irrigation site; (c) a review of recent and pertinent literature on microbiological contaminants associated with reclaimed water; (d) development of a water balance model to predict changes in fecal coliform loadings in run-off flow with various setback distance requirements; and (e) a compilation and review of other state reuse guidelines and regulations related to use of reclaimed water in areas of public access. The monitoring, testing and literature review yielded no evidence that the current regulations are deficient. Water samples were collected during start-up of the reuse system, and there was evidence that treatment reliability was difficult to achieve. The runoff model and the review of state regulations did not produce any compelling evidence that a buffer distance is needed between an irrigation site and a receiving stream to control for fecal coliform wash-off by storm water flow. Both the literature review and our monitoring results suggest that viral contaminants may persist even where bacterial indicators are not found. Given the ambiguity of current limit-setting methods for the types and amount of indicator organisms allowable, it would be prudent for North Carolina to establish a continuous assessment process to insure that the regulations in place are always defensible and consistent with the most up-to-date information available. Guidelines for operator and customer training and for the integration of services required from other municipal units are recommended to minimize start-up problems.

(water reuse, water reclamation, legislation, microbiological contaminants)
# TABLE OF CONTENTS

Acknowledgement ................................................................. iii

Abstract .................................................................................. v

List of Figures ........................................................................... ix

List of Tables ............................................................................ xi

Summary and Conclusions ........................................................ xiii

Recommendations ...................................................................... xvii

Introduction ............................................................................... 1

Background ............................................................................... 3
  National and International Water Reuse .................................. 3
  Water Reuse in North Carolina .............................................. 3
  Assessment of the North Carolina Water Reuse Regulations ....... 4
  Microbiological Contaminants ............................................... 5
    Water Quality Criteria for Microbiological Contaminants ........ 5
    Modes of Exposure ............................................................ 5
    Typical Waterborne Pathogens ............................................ 5
    Monitoring for Pathogens .................................................. 6
    Establishing Water Quality Limits for Microbiological Contaminants .... 7
  Treatment Reliability ............................................................ 9
    Measures to Insure Treatment Reliability ......................... 9
    Methods to Quantify Reliability ......................................... 9
    Operational Standards .................................................... 11
    Operational Measures to Control Water Quality at the Delivery Site .... 11
  Problems with Buffer Limits in North Carolina ..................... 11

Experimental Plan .................................................................... 13

Study Sites ............................................................................... 13
  Mallard Creek Wastewater Reclamation Facility (MCWRF) ......... 13
  Tradition Golf Course ......................................................... 16

Monitoring Data ....................................................................... 16

Sample Collection .................................................................... 16

Test Protocols ........................................................................... 17

Water Balance Model .............................................................. 18
  Model Input and Assumptions ............................................... 19
## Results

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Monitoring Data from the Reuse Effluent at MCWRF</td>
<td>21</td>
</tr>
<tr>
<td>Field Data from MCWRF and the Tradition Golf Course</td>
<td>21</td>
</tr>
<tr>
<td>Water Balance Model</td>
<td>26</td>
</tr>
<tr>
<td>State Regulations</td>
<td>29</td>
</tr>
</tbody>
</table>

## Discussion

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water Quality Monitoring and Testing</td>
<td>31</td>
</tr>
<tr>
<td>Water Quality Model</td>
<td>32</td>
</tr>
<tr>
<td>Treatment Reliability</td>
<td>32</td>
</tr>
<tr>
<td>Comparison of North Carolina Water Reuse Regulations with Those of Other States</td>
<td>34</td>
</tr>
<tr>
<td>Water Quality</td>
<td>34</td>
</tr>
<tr>
<td>Treatment Requirements</td>
<td>35</td>
</tr>
<tr>
<td>Buffers and Storage</td>
<td>36</td>
</tr>
<tr>
<td>Reliability</td>
<td>40</td>
</tr>
<tr>
<td>Site Constraints</td>
<td>40</td>
</tr>
</tbody>
</table>

## References

<table>
<thead>
<tr>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>41</td>
</tr>
</tbody>
</table>

## Appendix: State Water Reuse Regulations

<table>
<thead>
<tr>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>47</td>
</tr>
</tbody>
</table>
LIST OF FIGURES

1. Risk-based conceptual framework or assessing risks to health from microbes
   in drinking water ...........................................................................................................8

2. Mallard Creek Water Reclamation Facility .................................................................14

3. MCWRF Reuse System Schematic ...........................................................................15

22. Loading of 1 cfu/100 mL for 12 da then by 14 cfu/100 mL applied for 18 da. Buffer retains 20% of coliforms in runoff flow. ................................................................. 29

23. North Carolina Coliform Limits Compared to Those in Other States .................................................. 35

24. A Comparison of State Buffer Requirements .................................................................................... 37
SUMMARY AND CONCLUSIONS

There are no federal regulations governing reclaimed water use, and standards have developed state by state. A review of state regulations reveals that under a variety of influences, water reuse standards or guidelines among the states have evolved to be quite different (Asano 1998; J. Crook, P.E. CH2M Hill pers. com. 1998; Crook and Surampalli 1996, Watts, 1992). The North Carolina water reuse regulations were promulgated in 1996 in response to growing municipal interest in water reuse (Section 15A NCAC 21H.0200 of the N.C. code governing "waste not discharged to surface waters"). The regulations were drafted by an expert committee seeking to obtain a sensible integration of regulations used in other states with those recommended in federal documents such as Guidelines for Water Reuse (U.S. EPA, 1992). However, the regulations were written without benefit of any North Carolina pilot or demonstration project data, since none were available.

The first full-scale municipal water reclamation facility in North Carolina began operating under the new state regulations in late summer 2000. The Mallard Creek Water Reclamation Facility (MCWRF) has the capacity to deliver up to 200,000 gallons per day (gpd) to the nearby Tradition Golf Course and the Mallard Creek Park. This research was undertaken to review the state reuse regulations as they applied to this new plant and specifically to assess whether the regulations are generally acceptable and adequate to protect human health. Some of the specific concerns that were to be addressed in the review were the fecal coliform limits and the set-back distance requirements in areas where public access is permitted.

In order to make the assessment, the following activities were undertaken: (a) monitoring data from the plant was collected and reviewed; (b) monthly reconnaissance sampling of effluent at the plant and from the irrigation site was conducted, and samples were assayed for organics, nutrients, and bacterial and viral indicator organisms; (c) a review of recent and pertinent literature on microbiological contaminants associated with reclaimed water was undertaken; (d) a water balance model was developed to predict changes in fecal coliform loadings in run-off flow with various set-back distance requirements; and (e) state regulations from all other states with water reuse regulations or guidelines permitting use of reclaimed water in areas of public access were collected, compiled, and reviewed.

The plant experienced numerous difficulties during the first year of operation that resulted in frequent shut-downs of the system. Much of the difficulty was likely due to the confounding effects of on-going construction at the site. The shut-downs, combined with seasonal reductions in customer need for reuse water, resulted in few productive sampling months for the field study. Plant monitoring data indicated there was difficulty staying within permit limits for several parameters, although it is believed that some of the violations were likely due to sample contamination. Field sampling at the distribution site showed there was variation in the water quality from month-to-month, but generally the samples of irrigation spray contained acceptable levels of organic material and nutrients. The fecal coliform counts were negligible, and the coliphage used as viral indicators were also at very low concentrations in the irrigation spray. It is important to note, however, that this plant is operating under coliform limits that are even more stringent than those stipulated in the regulations. The permit is written to allow a narrower buffer region with lower coliform limits. The grass sampled from beneath the irrigation headers
did show significant viable coliphage accumulation (but negligible fecal counts) on some sampling occasions, while grass from the buffer region and the control site did not. The coliphage accumulation did not persist beyond the first two months of field sampling, so it may have been an anomaly associated with plant start-up. It was beyond the scope of this study to evaluate the risk associated with the accumulations observed.

The survey of other states’ regulations and guidelines revealed that many states apply and adapt their land application of treated wastewater regulations for water reclamation projects. Only a subset of states, including North Carolina, have regulations written specifically to encourage and direct wastewater reclamation aimed at augmenting potable water supplies. North Carolina regulations are among the more comprehensive of these. States like California and Florida (and a few states that have adopted CA regulations), with long histories of water reuse, have regulations that are significantly more detailed to encompass a wider range of use options and some additional reporting. Also other western states, with some of the earliest pressures for supplementary water supplies, have broad and detailed regulations. It was evident during the data collection for this report that there is a resurgence of interest among the states to develop or improve dedicated water reclamation legislation.

When the North Carolina reuse regulations are compared to those of other states, it is clear that North Carolina treatment requirements are few, with reliance on the water quality limits to drive proper treatment. Among the water quality limits, North Carolina requires that the monthly geometric mean fecal coliform level be less than 14 cfu/100 mL, with the daily maximum not to exceed 25 cfu/100 mL. Although direct comparisons are difficult because of variations in the tests and statistical parameters required state-to-state, it is clear that these levels fall about midway in the range of coliform limits allowed by different states (Table 23).

Despite the wide variation in allowable coliform limits among the states, there is no evidence of illness related to contact with water from a properly operated wastewater reclamation facility (U.S. EPA, 1992). Nevertheless, in the absence of any codified way to set microbiological water quality limits, there is something to be said for following the course of states with the longest history of reclaimed wastewater use, since presumably their limits have been subject to the most iteration and refinement based on historical experience. However, incremental lowering of the allowable coliform limits should not be done capriciously, because it significantly increases the challenge to plant operators to reliably meet treatment limits, and an appreciation of this difficulty may serve as a disincentive to municipalities considering water reuse projects.

The other water quality parameters related to microbiological water quality are turbidity and total suspended solids. While North Carolina requires continuous turbidity monitoring, and while a specific maximum turbidity limit was specified for the plant monitored in this study, there is no stated required average or maximum daily turbidity limit in the North Carolina regulations. Instead, like Florida, North Carolina uses total suspended solids as a marker for particulates. Among the states that do use turbidity, many require that certain turbidity limits be met before filtration, so that disinfection is optimized. By setting solids limits for the post-disinfection product, an opportunity for a multiple barrier approach to regulation is sacrificed.
The setback distances cited in the North Carolina regulations are not unusual or excessive compared to other states with buffer requirements (Table 24). North Carolina requires a setback distance of 100 ft from shellfish waters and 25 ft from surface water. Iowa, Maryland, Massachusetts, Missouri, Ohio, Texas, and Wyoming all impose setbacks from surface waters, ranging from 30-300 ft. North Carolina setbacks from wells and property lines are also consistent with many other states, although there are differences with whether setbacks are designated from property lines or just from residences. Like the microbiological limits, it is difficult to anchor setback distances to experimental data, because aerosol transport and pathogen scouring from vegetation and soil are not well characterized. Climate factors such as wind conditions and rainfall also contribute to differences state-to-state. Several states rely on case-by-case buffer distances so that site and situational variations can be taken into account.

The ammonia limit set by North Carolina is one that few other states have for reclaimed water. Presumably it was set to minimize damage to vegetation. It also minimizes the risk of ammonia conversion to nitrification, which would yield nitrate that could readily leach to groundwater.

The site constraints in the North Carolina regulations cover most of the same issues as states with lengthier sections on these topics. The key areas of contractual agreements and public input, awareness, and education are covered. A review of stipulations made by other states (offered in the Appendix) offers some ideas for additional site-related safeguards that could be included in future legislation, especially since some reclaimed water irrigation sites are in residential housing units in North Carolina.

The literature review of recent studies related to safe microbiological water quality requirements, combined with the monitoring results reported here do suggest that viral contaminants may persist even where bacterial indicators are not found. Yet the review also makes clear that there is insufficient data to reliably determine the risks associated with viral indicator organisms, and more study is needed before risk analyses could be used to set limits for coliforms or alternate indicator organisms.

The computer model, which was developed to predict the likely stormwater fecal coliform loadings to the receiving stream under different grassed buffer conditions, showed that there is the potential for substantial fecal coliform loadings under the current allowable coliform limits. However, there is limited information about how likely coliforms in the spray will remain at the surface; how long a coliform on the surface will remain viable; how readily a coliform attached to surface soil or grass will become dislodged by storm water flow; and how readily a dislodged coliform will be retained in a vegetated buffer. Clearly, additional, and in some cases site-specific, research will be necessary. However, with more information about these topics, the model could be used to evaluate buffer requirements under a variety of fecal coliform limits. It is possible that with the lower limits used in some states, a vegetated buffer would prove unnecessary. The model did not assess transport of fecal coliforms in airborne particles, but with the low allowable limits of coliforms in the spray irrigation water, it can be assumed that the small percentage that would be carried in aerosol spray blown from the site would be negligible.
RECOMMENDATIONS

Water Reuse Regulations

The review of state water reuse regulations and guidelines shows that the ways in which states have addressed the inherent safety issues of water reuse are diverse. Yet presumably, each state believes that their particular combination of water quality characteristics, treatment reliability standards, and operating, monitoring and reporting requirements required will yield reuse water that will consistently safeguard public health. North Carolina has already established itself as one of the first to recognize and promote the benefits of water reclamation. Based on the review conducted for this study, the following recommendations are offered:

- Given the ambiguity of current limit-setting methods for the types and amount of indicator organisms allowable and the set back distances needed to control aerosols and coliform loadings in storm runoff, it would be prudent for North Carolina to establish a continuous or cyclical assessment process for the state water reuse regulations. Such a process would ensure that the regulations in place are defensible and consistent with the most up-to-date information available. The monitoring, testing and literature review reported on herein yielded no evidence that the current state water reuse regulations are deficient. However, the monitoring and water quality test results reflect those at a study site that was required to meet limits more stringent than those stipulated in the state regulations. In light of the active pursuit of alternate or additional indicator organisms, new detection methods and better detection limits, a commitment to regular and timely reviews as new findings rapidly become available will increase municipal, practitioner, and public confidence and continue to stimulate new projects across the state.

- It should be clearly recognized that there is insufficient scientific data to unambiguously defend setting a particular maximum allowable level of indicator organisms or setting particular set-back distances in the regulations. Therefore, some judgment must be used, and the most reliable recommendations would likely come from a technical review committee of engineers, scientists, and practitioners. Committee members should be selected from among those who are thoroughly familiar with national water reuse trends, who have no political or financial stake in the outcome, but who have a fundamental understanding of how limit changes will affect required treatment practices.

- Consideration should be given to the differences between municipal application of reclaimed water and residential application. Indicator organism limits and reliability features may need to be different for these two uses, because the level of access and application control is different in each case.

- The reliability requirements used in other states are varied and should be reviewed and evaluated to glean any stipulations that might be applicable in North Carolina. Many of the reliability items included by other states reflect "lessons learned," and as such, they address problems that a technical committee might not otherwise anticipate.

- Buffer requirements under the current North Carolina fecal coliform limits do not seem unreasonable, although some discretion could be allowed on a case-by-case basis if the
quality of the reclaimed water was indeed better than that of nearby surface water, as in the example cited in the introduction of this report.

- Review committee recommendations should be accompanied by written rationales, and they should be made available to subsequent committees to use as changes are considered. This would allow each review committee to benefit from the accumulated expertise and deliberations of prior committees as well as from the new knowledge contributed by current committee members.

- A national clearinghouse for water reuse regulations should be established so that North Carolina as well as other states can access information about regulation changes and justifications for the changes made by other states. The database provided in this report could be the nucleus for such a clearinghouse. It could be managed by the U.S. EPA, by WRRI, by NCDENR, or by the NC AWWA-WFA. Currently, there has been only one other comprehensive review of water reuse regulations published in addition to this one. A web site available to all state water reuse entities that was updated as changes were announced, would prove useful to North Carolina as well as all other states, and bring visibility to North Carolina if the site were housed here.

- Research to assess what fraction of applied coliforms (and pathogens) in reclaimed water irrigation spray will remain on plant or soil surfaces; how long a coliform on the surface will remain viable; how readily a coliform attached to surface soil or grass will become dislodged by storm water flow; and how readily a dislodged coliform will be retained in a vegetated buffer is needed to provide information that can be used to establish scientifically defensible set-back distances.

- Reconnaissance studies at other water reclamation facilities should be conducted during start-up and periodically thereafter to further assess problems encountered and long-term treatment reliability.

Reuse System Operation

- Minimization of start-up difficulties can and should be addressed as more facilities come on-line. The frequent shut-downs of the system studied, although exacerbated by on-going construction at the site, was indicative of the fact that during start-up of a reuse system, good treatment reliability may be difficult to achieve. The problems associated with poor start-up cannot be underestimated. They initiate a cycle of customer distrust and operator frustration, and poor start-up negates the intent of careful crafting of regulatory requirements.

- Training or mentoring programs should be developed to orient operators to the stringent goals that go along with reliably producing a clean water product for sale. Such training would reduce start-up difficulties at a new facility. There is no need for operators at each system to "reinvent the wheel." Master operators with experience producing reclaimed water could be assigned to assist with new start-ups, or potential operators could apprentice at an on-going facility before start-up at their home site.

- There should be a transition period during which on-site irrigation at the treatment facility is practiced until reliable water quality can be achieved. This period could be scheduled for the summer months when irrigation water could be applied frequently and
closely monitored. This period could also be used to teach appropriate teams of municipal personnel how to maintain or repair reclaimed wastewater lines. An extension of this period could include a period of monitoring at the application site once delivery to the customer begins to insure that there is no contamination in the distribution line.

- Provisions for flushing the distribution lines should be included so that contaminated lines can be cleaned.
- If a chlorine residual could be tolerated at the application site, a target residual dose stipulated in the discharge permit might provide an additional safeguard in areas of public access.
- Before start-up commences, chains of command for customer questions about water quality and operator requests for distribution line repair should be established. It has been noted that a wastewater reclamation project is an opportunity to integrate water and wastewater operations in a community (Okun, 1996), and an implementation plan that makes these linkages clear at the onset of a project is a worthy goal.
INTRODUCTION

Water reuse is the practice of capturing treated wastewater and using it as a valuable commodity. In November 1998, the first full-scale municipal reuse project in North Carolina went online in Mecklenburg County. The facility is a 6 million gallons per day (MGD) wastewater treatment plant (The Mallard Creek Water Reclamation Facility, MCWRF) that has the capacity to shunt 200,000 gallons per day (gpd) of treated effluent through 30,000 ft of distribution line to a nearby golf course and park. In addition to conventional secondary treatment, the treatment train includes filtration and UV disinfection. Effluent that is reclaimed as irrigation water is dosed with sodium hypochlorite to prevent microbial regrowth in the distribution lines.

The Mallard Creek facility is the first installation to fall under a revised set of state regulations governing water reuse (Section 15A NCAC 2H.0200 of the NC code governing “waste not discharged to surface waters”). The revisions were prompted by a growing municipal interest in water reuse. The legislation, promulgated in 1996, is principally directed at reclaimed water for “land application to areas intended to be accessible to the public such as residential lawns, golf courses, cemeteries, parks, school grounds, industrial or commercial site grounds, landscape areas, highway medians, roadways and other similar areas.” It was based on recommendations that were drafted by an expert committee seeking to obtain a sensible integration of regulations used in other states with those recommended in federal documents such as Guidelines for Water Reuse (U.S. EPA 1992). However, the committee recommendations were also subject to the necessary process of compromise, and the regulations were written and adopted without benefit of any North Carolina pilot or demonstration project data, since none were available.

Because the new state regulations are based on information and regulations developed in other states; and because little research has been conducted in North Carolina on the impacts of reclaimed water beyond agricultural irrigation use, the start-up of the MCWRF offered the first opportunity to evaluate the efficacy of the revised state regulations. Therefore, this research project was undertaken at the MCWRF and at the Tradition Golf Course, one of its two customers, to assess whether or not: (1) the current regulations set forth the water quality standards needed to safeguard public health; and (2) the existing regulations effectively guide facility planning, design, operation and permitting.

Public health concerns have centered on the fecal coliform limits. While some practitioners believe they are too stringent, others, including some members of the advisory committee charged with recommending limits, would prefer that the coliform limits be lower and more consistent with those in states such as California and Florida. A second concern stems from continued research on pathogen fate and removal. There is building consensus that fecal coliforms may not be the best indicator of the possible presence of microbial pathogens. Studies in water and wastewater have repeatedly shown that enteric viruses and parasites are much more resistant to biological treatment, physical-chemical removal processes and disinfection processes than are total and fecal coliform bacteria and other conventional indicator bacteria (Sobsey 1989; Bitton 1999; Toranzos and McFeters 2001). Third, the rationale for the inclusion of set back distance requirements from streams has been questioned. This issue is probably best captured in a quote from one practitioner:
... current regulations allow the withdrawal of water for irrigation purposes immediately downstream of a wastewater outfall – even when treated effluent from that outfall constitutes more than 90 percent of the stream flow. This water may be applied directly to (say) a golf course with no further treatment or oversight whatsoever. By contrast, if the waste discharger wants to provide that same effluent directly to the golf course for irrigation purposes – but without first discharging it to the stream – it must meet all the treatment and buffering requirements of the reuse regulations.

Based on these concerns and the availability of a treatment facility built and operating according to the new state water reuse regulations, the purpose of this project was to:

(a) Document the quality of reclaimed water that is being produced at the MCWRF in compliance with North Carolina regulations;

(b) Evaluate in the context of this plant whether the state regulations are sufficient to protect public health; and

(c) Evaluate in the context of this plant whether the regulations are reasonable and increase public confidence in water reuse as a viable option in water management planning.
BACKGROUND

National and International Water Reuse

The first U.S. water reuse projects were operated in California for agricultural irrigation over 80 years ago (Crook and Surampalli 1996). Uses for reclaimed wastewater have now expanded to include urban landscape irrigation, provision of fire flow, groundwater recharge, low stream flow supplementation and effluent diversion to injection wells during periods of high stream flow. In states such as Florida and California, where water reuse has been practiced for several decades, demonstration and full scale projects have begun for indirect and direct potable reuse, where the reclaimed water either augments or constitutes a drinking water supply source (WEF-AWWA 1998). Reuse is also practiced widely in many other countries, and alternative uses for reclaimed water, various treatment methods, and designs and practices that ensure product safety and reliability have been extensively reviewed (Asano 1998).

The U.S. has no federal regulations governing reclaimed water use. Therefore, standards have developed state by state under a variety of influences, and they have evolved to be quite different. For example, for the same use categories, some states mandate certain treatment processes, while others stipulate only the required effluent water quality characteristics. Some states require total coliform monitoring, but others use fecal coliform indicators. Items that may or may not be included in a state plan include provisions for process and equipment redundancy, setback distances, piping and pumping requirements, emergency equipment and protocols, and rules regarding transmission and storage distribution. In 1992, the U.S. Environmental Protection Agency published water reuse guidelines to help state agencies establish appropriate water reuse standards (U.S. EPA 1992). There is also a guide produced by the World Health Organization (Blumenthal et al. 2000; WHO 1989), although their recommendations are directed to a more diverse global audience. Several summaries of U.S. state regulations are available, including one published by the North Carolina Water Resources Research Institute (Balogh and Walker 1992; U.S. EPA 1992; Watts 1992), providing documentation that nonpotable reuse is widely practiced and accepted.

In states that have enacted water reuse regulations, the process of assessment and legislative revisions continues even in states with long histories of water reuse. These evaluations are driven by a number of factors, including (1) the emergence of new modes of water reuse; (2) the availability of new information about water quality risks; (3) an accumulation of monitoring data; (4) the availability of new and more precise detection methods, and (5) changes in public perception.

Water Reuse in North Carolina

At the start of the work described in this report, North Carolina had only moderate experience with water reuse systems that were typically small and not under the jurisdiction of a large municipality. However, there was a growing recognition within municipalities and state agencies that water reclamation could offer relief from a number of increasing water quality and supply pressures in the state (Rubin and Carlile 1976; Safrit 1995). These pressures included water quality discharge limitations in coastal areas, reductions in water supply availability in the Triad Region, and strained capacity during high peak demands and drought in densely populated urban
areas. However, there was a reticence to commit to such projects without a state record of successful demonstration projects carried out in compliance with state regulations. Several water reuse feasibility reports indicated that although municipal interest was strong, a pool of willing reclaimed water customers and regulatory experience (Kalb and Esqueda 1997) was not.

In 1996, in an effort to stimulate confidence in the state’s willingness to support water reclamation, North Carolina updated the state regulations to include uses that required a higher level of wastewater treatment than land application of treated wastewater, which has been practiced for over 20 years in North Carolina for agricultural irrigation (Rubin and Carlile 1976). The key difference was that the new uses would allow public access to areas where reclaimed water was applied. Significant leadership in spearheading the new legislation was provided by Don Safrit, who was then with the North Carolina Department of Environment and Natural Resources (DENR). The state also enjoyed the presence and contributions of two prominent experts on water reuse: Dr. Daniel Okun, Kenan Professor of Environmental Engineering Emeritus at UNC-Chapel Hill and Dr. James Crook. Both of these individuals are nationally recognized for their knowledge about and experience with water reuse systems. They were contributing authors to the 1992 U.S. EPA Guidelines for Water Reuse document and assisted with recommendations for the revised state regulations.

In the several years since the water reuse regulations were revised, the Mecklenburg County Mallard Creek Wastewater Reclamation Facility (MCWRF) was the first to launch a full-scale municipal water reuse system. The planning, design, and operations of the reuse system for this plant all fell under the new regulatory stipulations. Plans for a reuse system at the City of Raleigh’s Neuse River Wastewater Treatment Plant were also pursued, but distribution of the reclaimed water to the River Ridge Golf Course was delayed by the golf course during the permitting process, and delivery has never begun. The Town of Cary became the second municipal reuse system to go on-line, and a number of other facilities are now in the planning and implementation stages. The North Carolina chapter of the American Water Works Association-Water Environment Federation (AWWA-WEF) maintains an active Water Reuse Committee, and the Committee maintains a web page that documents the reuse projects in the state (http://www.tec-web.com/ncreuse/). The numerous water reuse projects cited by the committee, along with the numerous well-attended seminars that have been sponsored by the Committee in recent years, testify to the strong interest in and support for water reuse projects across the state.

Assessment of the North Carolina Water Reuse Regulations

A request for assessment of the new regulations was made by the North Carolina WRRI in 1999 in response to recommendations from their technical advisory committee. The recommendation was prompted by what some practitioners perceived to be inconsistencies in the legislation, as well as by more general concerns about how well the regulations are protecting public health. Since water reuse regulations can minimize microbially-based health risks to the public by:

- setting quality criteria for the treated water
- stipulating required equipment and practices at the plant that will optimize treatment reliability and divert unacceptable effluent, and
- mandating certain operating procedures at sites where the water is delivered.
Therefore, the question is whether the particular combination of water quality standards, treatment requirements, and operating, monitoring and reporting requirements stipulated in the North Carolina reuse regulations will adequately safeguard public health. Each of these control modes will be discussed in the following sections.

Microbiological Contaminants in Reclaimed Water

Water Quality Criteria for Microbiological Contaminants. This section contains a discussion of the microbiological issues related to reclaimed water when it is targeted for use in public areas (sports fields, golf courses, residential irrigation systems). The section begins with a description of some of the ways that reclaimed water could transmit disease if it contained pathogens. A review of some of the typical pathogens of concern is presented, and then some ways to monitor and arrive at acceptable limits for them are considered. Finally, several views about the options for setting water quality limits or treatment stipulations are discussed.

Modes of Exposure. If microbial pathogens were present in reclaimed water, the modes of possible direct public exposure to them would include aerosol inhalation, physical contact, or ingestion. Indirect exposure would be possible through contact with surface water receiving reclaimed water runoff or through contact with groundwater recharged by reclaimed water (Bouwer et al. 1998). Aerosol exposure is the most poorly characterized mode; however, all of the occasions for direct contact can be minimized by the inclusion of required or recommended delivery requirements. For example, golf course and park irrigation is usually conducted when the facilities are closed to the public.

Typical Waterborne Pathogens. Waterborne pathogens can be bacteria, protozoa, viruses, or helminthes (Table 1). It is well documented that these organisms are present in untreated water.

<table>
<thead>
<tr>
<th>Organism Name</th>
<th>Corresponding Diseases</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adenovirus</td>
<td>Respiratory illness</td>
</tr>
<tr>
<td>Astrovirus,</td>
<td>Gastroenteritis</td>
</tr>
<tr>
<td>Calicivirus,</td>
<td>Gastroenteritis</td>
</tr>
<tr>
<td>Coronavirus,</td>
<td>Gastroenteritis</td>
</tr>
<tr>
<td>Coxsackievirus A</td>
<td>Meningitis</td>
</tr>
<tr>
<td>Coxsackievirus B</td>
<td>Meningitis</td>
</tr>
<tr>
<td>Enterovirus</td>
<td>Meningitis</td>
</tr>
<tr>
<td>Norwalk virus</td>
<td>Diarrhea, vomiting</td>
</tr>
<tr>
<td>Poliovirus</td>
<td>Paralysis</td>
</tr>
<tr>
<td>Rotavirus</td>
<td>Hepatitis</td>
</tr>
<tr>
<td>Cryptosporidium</td>
<td>Cryptosporidiosis</td>
</tr>
<tr>
<td>Entamoeba</td>
<td>Entamoebiasis</td>
</tr>
<tr>
<td>Giardia lamblia</td>
<td>Giardiasis</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Organism Name</th>
<th>Corresponding Diseases</th>
</tr>
</thead>
<tbody>
<tr>
<td>Campylobacter</td>
<td>Campylobacteriosis</td>
</tr>
<tr>
<td>Enteropathogenic E. coli</td>
<td>Gastroenteritis</td>
</tr>
<tr>
<td>Legionella</td>
<td>Legionellosis</td>
</tr>
<tr>
<td>Leptospira</td>
<td>Leptospirosis</td>
</tr>
<tr>
<td>Naegleria</td>
<td>Encephalitis</td>
</tr>
<tr>
<td>Salmonella</td>
<td>Typhoid, paratyphoid</td>
</tr>
<tr>
<td>Salmonella</td>
<td>Salmonellosis</td>
</tr>
<tr>
<td>Shigella</td>
<td>Dyentery</td>
</tr>
<tr>
<td>Vibrio cholera</td>
<td>Cholera</td>
</tr>
<tr>
<td>Yersinia</td>
<td>Gastroenteritis</td>
</tr>
<tr>
<td>enterocolitica</td>
<td></td>
</tr>
</tbody>
</table>

Source: ASM Ch 14, Hurst, C. J.; U.S.G.A., 1994; Bitton, 1999
wastewater, in partially treated wastewater, and even in the product after all treatment has been completed (Guentzel 1978; Rose 1986; Rose et al. 1996; Crook 1997; Asano 1998; WEF and AWWA 1998). Rose et al. (1996) found pathogenic viruses present in 8% of finished water samples tested and pathogenic protozoa in 25% of the samples. However, as several authors emphasize, these numbers must be compared to the infective dose of each pathogen or to the quantities of similar organisms found in commonly used water sources. Stewart (1990) summarized some typical pathogen concentrations in various stages of wastewater treatment at a California treatment plant and contrasted them with a typical infective dose (Table 2). York (2000) provides data showing that although some pathogenic protozoa were present in reclaimed water from a Florida plant, the levels were not significantly different from those in other “high-quality” irrigation waters.

### Table 2. WWTP Pathogen removal rates and infective doses.

<table>
<thead>
<tr>
<th>Source</th>
<th>Viruses</th>
<th>Salmonella</th>
<th>Giardia</th>
</tr>
</thead>
<tbody>
<tr>
<td>Raw water</td>
<td>500,000</td>
<td>42,500</td>
<td>104,500</td>
</tr>
<tr>
<td>Primary effluent</td>
<td>129,250</td>
<td>935</td>
<td>59,405</td>
</tr>
<tr>
<td>Secondary effluent</td>
<td>117,700</td>
<td>288</td>
<td>30,462</td>
</tr>
<tr>
<td>Tertiary effluent</td>
<td>42</td>
<td>2</td>
<td>784</td>
</tr>
<tr>
<td>Infective Dose</td>
<td>1</td>
<td>&gt;1000</td>
<td>25-100</td>
</tr>
</tbody>
</table>

Monitoring for Pathogens. When legislation is written in terms of water quality criteria, the limits are usually stated as an allowable number of coliforms. Coliforms are non-pathogenic bacteria that inhabit the human gut and are present in large quantities in fecal material. They are monitored on the presumption that if they are found, their presence indicates that live pathogens may also be present. Much of the divergence between states’ reuse legislation relates to coliform bacteria criteria.

In North Carolina, some questions persist about whether the state regulations are sufficiently stringent to safeguard human health. The current coliform and disinfection limits for reclaimed water for areas with unrestricted public access limits require that the mean monthly geometric mean for fecal coliforms be less than 14 colonies/100 mL, and the daily maximum must be below 25 colonies/100 mL. An informal survey of opinions about the current regulations indicated that many of the regulatory personnel and practitioners interviewed believe the limits are too lenient and should be revised. For similar end uses in Florida, the regulations require no detectable total coliforms in more than 75% of samples. In California the comparable limits are less than 2.2 fecal coliform units/100 mL.

Although opinions vary on the on appropriate coliform limits for reclaimed water, an even greater question is whether coliform limits alone are sufficient indicators of the presence of pathogenic viruses or protozoa contamination (Yates 1994; Rose et al. 1996). There is reasonable correlation between coliform bacteria counts and the presence of bacterial pathogens responsible for typhoid fever, cholera, and some dysentery diseases; however, the correlation is not as strong for coliforms and the presence of pathogenic protozoa and viruses (ASM 1998). In the study cited above, where pathogenic protozoa were found in 25% of the finished wastewater samples
tested, indicator coliforms were found in only 9% (Rose 1996). It is well accepted that some viral pathogens can persist longer than fecal coliforms in both wastewater and soil (Gantzzer et al. 2001). Therefore, the absence of coliforms may not indicate successful protozoa or viral pathogen kill. As a result, some states have begun to require enterovirus monitoring (U.S. EPA, 1992; Yanko 1993; Crook and Surampalli 1996 Asano 1998).

Among some other microbial indicators that have been suggested are Bacteroides fragilis (McLaughlin and Rose 2000), and coliphage. Coliphage are viruses that infect Escherichia coli (E. coli) bacteria. They appear to be present wherever total and fecal coliforms are found, but their ratios change because viruses survive longer (Standard Methods 1992). In wastewater, somatic coliphage survived five to seven times longer than fecal coliforms, and the coliforms also adsorbed more readily than coliphage to soil, so that the coliphage moved longer distances and survived longer when the two were compared in soil columns (Gantzzer et al. 2000). It has been suggested that fecal coliphage could serve as adequate indicators of human enteric viruses in water and wastewater (Havelaar et al. 1993; Sobsey et al. 1995).

Establishing Water Quality Limits for Microbiological Contaminants. Several North Carolina stakeholders have expressed a desire for North Carolina water reuse standards to be based on research and data collection rather than on standards copied from other states’ legislation. This is consistent with ongoing discussions in other states about using risk analyses to set quality criteria for reclaimed wastewater. In risk assessment, a water quality limit is set at a numerical value that results from a mathematical analysis of (a) the likelihood of an individual’s exposure to reclaimed wastewater and the frequency with which exposures might occur; (b) the hazard potential of the exposure (how likely is it that a pathogenic organism would be encountered in a given exposure: how many organisms are required to infect a host; how likely is it that the infection will result in disease); and (c) how significant it would be if these exposures and consequences occurred.

In a workshop on non-potable water reuse sponsored by the National Water Research Institute, a ranking of research priorities put improved risk assessment methods first on the list (York and Walker-Coleman 2000). The advantage of a risk assessment approach is that it takes into consideration not only the absolute number of pathogenic organisms present, but the dose size of reclaimed water that an individual is likely to encounter as well as the number of organisms required to cause disease.

A conventional application of risk-assessment would involve assigning a numerical value to each of the factors listed above and then a numerical weighting to each factor to reflect its importance relative to the others. Both the number and weighting given each factor require sufficient data to set numerical values, and invariably, some assumptions must be made. Removal rates for enteric viruses, and pathogenic protozoa at one Florida reclamation facility were measured and used to estimate that the risk of infection from ingestion of a single 100 mL of reclaimed water discharged for irrigation. The risk was estimated to be between 1 in 1 million and 1 in 100 million (10^-6 and 10^-8, respectively) (Rose et al. 1996). Since there are no standards of acceptable risk from reclaimed water, the authors compared their results to the EPA standard for drinking water (no more than a 1/10,000 chance of infection from 21 daily exposures for 365 days; U.S. EPA 1989), and the risk levels for reclaimed water were judged acceptable.
Each treatment train, and the individual components in a train, vary from one plant to another, so that a statistical analysis at one site may not generalize to another. Eisenberg et al. (2000) have proposed an alternate way to estimate risk based on epidemiological evidence. Risk to a population is estimated based on the incubation period for diseases, the immune status of the population, the rate at which those infected become sick, the duration of the disease, and the rate of recovery from the disease.

The advantages of setting water quality criteria by risk analysis is that concentration limits could be stated numerically instead of as a target percent reduction of influent organisms (York and Walker-Coleman 2000). Under most current systems, it is assumed that if coliform limits are achieved, a certain percent reduction in virus and protozoa populations will also occur. This is effective as long as the initial concentration of viruses or protozoa is low, but it may not be adequate when influent levels are high. Further, numeric standards set from a risk analysis would likely be more protective and legally defensible than a level set by a technical advisory group, as long as there was sufficient information to calculate the risk.

The disadvantage of using risk assessment methods to set water reclamation limits is that regulators will need to commit to a particular level of acceptable risk. There must also be sufficient consensus that the current level of knowledge about the dose-response relationship is adequate in the face of some uncertainties, and care must be taken not to over-generalize the behavior of one pathogen to another (York and Walker-Coleman 2000). For example, pathogenic viruses can vary up to 300 fold in their relative infectivity, which makes it difficult to use one model to represent the general case. Finally, there is the significant problem of how to monitor for the various pathogens. In a number of cases, no single method has been found acceptable for detection. In 1999 Florida began to require monitoring of the protozoan pathogens Giardia and Cryptosporidium in reclaimed water, although in 2000 the state had no “approved method” for this analysis (York 2000).

Sobsey et al. (1993) used an existing EPA model for health risk assessments to categorize the kinds of data that would be needed to specifically evaluate health risks from microorganisms in drinking water. A schematic of the model is shown in Fig. 1. Within this framework they

![Figure 1. Risk-based conceptual framework for assessing risks to health from microbes in drinking water. From: Sobsey et al., 1993.](image-url)
identified where the gaps in knowledge exist that would limit reliable risk calculations. It was noted in their conclusions that the gaps were significant. Among the constraints they identified were the following: (1) Hazard identification is difficult because not all pathogenic or toxigenic agents in public water supplies have been identified. The authors cite statistics that indicate that the cause of about half of recent waterborne outbreaks is unknown. (2) The occurrence data on known pathogens is flawed because data collection has not been coordinated to provide one integrated database that includes information on the time and space distribution of microbe concentrations. Also, older data sources reflect analytical methods with weak detection potential compared to some of the newer molecular techniques; (3) good dose-response models are not available for all waterborne pathogens. Even when such relationships have been established for a healthy human host, they do not exist for the same pathogen in an immunocompromised or elderly host who will likely be more susceptible.

In summary, although there is strong support for risk assessment as a better means for setting acceptable water quality limits than historical trends, the reality is that there are large gaps in the data needed to make sound assessments. Although there is a clear trend toward using risk analysis methods to set scientifically justifiable water quality limits, in many cases they will include a fairly high level of uncertainty until more is known about the kinds of pathogens present in reclaimed water, their potential for causing harm, and the best ways to detect their presence. On the other hand, there is a growing body of empirical data to show that use of reclaimed wastewater has not caused disease, even in those who have been exposed to water containing relatively high levels of coliforms in irrigation spray (Devaux et al. 2001). Further, some of these same data gaps in kinds of pathogens present and best detection methods exist for public drinking water supplies, so that the additional risk from reclaimed water use is incrementally small.

Treatment Reliability

Treatment reliability describes how consistently a plant can achieve regulatory compliance with stated water reuse regulations. Clearly, treatment consistency must be optimized if the regulations are to be effective. This section describes some of the measures used in water reuse legislation to regulate treatment reliability, and then there is a discussion of some methods used to quantify reliability for monitoring plant performance, comparing two plants, or comparing alternate treatment trains within a plant.

Measures to Ensure Treatment Reliability. For the most part, the North Carolina regulations follow the guidelines for treatment reliability that were set forth by EPA (U.S. EPA 1992). The EPA standards include requirements for standby power supplies, multiple unit treatment processes, emergency storage or disposal, operator qualifications, and operator availability. All of these measures are designed to minimize the likelihood that reclaimed water that does not meet permit limits is released to a customer and to areas of public access.

Methods to Quantify Reliability. There have been several methods used to quantify reliability and frame it in terms of a risk assessment. Eisenberg et al. (2001) distinguish between evaluating the inherent reliability and the mechanical reliability. The former describes the amount of variability that exists in the effluent, while mechanical reliability focuses on the time each unit is likely to be out of service for planned or unplanned maintenance. Typical analyses using one or
both of these methods have been described (Haas and Trussell 1998; Eisenberg et al. 1998; Olivieri et al. 1999; Eisenberg et al. 2001).

A common theme in assessing reliability is the premise that a treatment train offers multiple barriers to prevent microbial contaminants from reaching a receiving stream. For example, Haas and Trussell (1998) describe two variations for determining inherent reliability. Both consider the treatment plant as consisting of a series of multiple treatment units that all contribute to removal of a contaminant. After the typical removal efficiency of each unit is determined, the overall removal of contaminant can be calculated as the sum of the log reductions for each unit in the sequence. Removal can also be calculated when one unit has failed. In a plant with high inherent reliability, the required removal level will be possible in the absence of the most efficient unit in the treatment train. By applying a factor of safety to the level of treatment required in a particular treatment step, the analysis can be manipulated to account for variability in influent water quality. The more independent each unit is from another, the more each is able to serve as a redundant barrier or second line of defense for another unit. Therefore, reliability criteria for state regulations can apply this premise and require that a treatment train must be able to meet the treatment limits, even after failure of the most efficient treatment unit is assumed.

In the second variation described by Haas and Trussell (1998) to estimate inherent reliability, the performance of each unit is allowed to vary along some continuum between optimum performance and failure. For each unit, this continuum would be described by a probability distribution. After the likely performance of each unit is estimated, the overall performance of a treatment train is analyzed. This method allows estimation of the likelihood that a given process sequence would produce treated water above a designated level of quality. However, there are many different kinds of probability distributions, and there is not yet consensus on what kind of probability distribution applies to each treatment unit. The method requires that performance data from each type of unit process be amassed and evaluated to determine which probability function best fit the observations.

The latter method was attempted at a pilot scale advanced water treatment facility in San Diego, CA (Olivieri et al. 1999; Eisenberg et al. 2001). Individual treatment units were seeded with virus, and the removal efficiencies were measured. These performance data were translated into probability distributions. For example, two of four reverse osmosis units from different vendors had Weibull distributions, while two were better characterized by Gamma distributions. This process was repeated for various units evaluated, and then a Monte Carlo simulation model was used to describe the probability distributions of the effluent quality through various treatment trains.

The Monte Carlo simulation consisted of randomly sampling the probability distribution for each unit and combining it with the performance estimates for each unit in the treatment train. Together, an estimate of overall performance was calculated. The sampling events were repeated 5000 times, and the range of overall performance values was then fit to a probability distribution. The results were used to support decisions made about the particular sequence train to use in a full-scale facility.

Mechanical reliability refers to how likely each mechanical unit will be available for service at any point in time. Eisenberg et al. (2001) have reviewed a number of methods that can be used to
estimate mechanical reliability, and they provide detailed information about the use of a Critical Component Analysis (CCA) at a facility in San Diego, CA (Eisenberg et al. 1998). The CCA method incorporates data on all planned and unplanned down-time for each unit process and applies a chi-square analysis to calculate an expected time between failure (ETBF) and an operating availability time. The availability is expressed as the fraction of time that all components of a unit are operating.

The development of methods to quantify treatment reliability may ultimately lead to the citation of numerical reliability limits in water reuse legislation. Also, data from reports of statistical analyses of unit reliabilities will identify the treatment processes that generally appear to be more or less reliable, so that treatment requirements in the absence of numerical limits can focus on what appear to be the weakest links in the treatment train. Mechanical reliability can be increased through requirements for additional redundancy, so that failure of one unit does not mean that certain treatments will be omitted.

Operational Standards. This section begins with a description of some of the measures typically included in reuse regulations to insure that delivery of the reclaimed water to the customer site and from the customer site does not endanger public health. A discussion of the North Carolina requirement for setback buffers follows, with a description of the presumed rationale for the legislation and a discussion of some of the reasons it has not been well-received.

Operational Measures to Control Water Quality at the Delivery Site. Typical prescribed operational measures include items such as the design of delivery lines, allowable application rates, groundwater monitoring programs and setback distances from property lines, potable wells, and roadways (U.S. EPA 1992). North Carolina regulations include stipulations guiding many of these practices, but they also include an additional requirement for a 50-100 ft buffer region between the edge of the spray and any surface water that receives runoff from the site.

Problems with Buffer Limits in North Carolina

There has been persistent inquiry among North Carolina practitioners about whether or not there is a demonstrable need for requiring setback distances or buffer regions to separate irrigated land from a receiving stream. One plant that discharges to the Neuse River is permitted to release treated wastewater with up to 200 cfu/100 mL directly to the river, while the portion chlorinated and diverted to a holding pond for golf course irrigation cannot come within 50 ft of the river. The implication is that any potential microbial accumulations in the irrigated soil and grass are safe enough for a public access site, but if they were dislodged and diluted in storm water and stream flow, they would pose a health threat to aquatic organisms in the stream. At the Charlotte facility, a compromise was reached whereby the reclaimed water is disinfected to 5 coliform units/100 mL, and the buffer required was lowered to a 5 ft width.
EXPERIMENTAL PLAN

In order to assess how well the North Carolina regulations protect public health, the following activities were undertaken:

- monitoring data from the plant was collected and reviewed;
- monthly reconnaissance sampling of effluent at the plant and from the irrigation site was conducted, and samples were assayed for organics, nutrients, and bacterial and viral indicator organisms;
- a review of recent and pertinent literature on microbiological contaminants associated with reclaimed water was undertaken (contained in the “Background” section of this report);
- a water balance model was developed to predict changes in fecal coliform loadings in run-off flow with various set-back distance requirements; and
- state regulations from all other states with water reuse regulations or guidelines permitting use of reclaimed water in areas of public access were collected, compiled, and reviewed.

Study Sites

Mallard Creek Wastewater Reclamation Facility (MCWRF). Charlotte-Mecklenburg Utilities (CMU) operates the MCWRF, which is an 8 MGD treatment facility which is currently being expanded to 12 MGD capacity (Fig. 2). The secondary and tertiary treatment processes include activated sludge treatment for nitrification, shallow-bed traveling bridge filters, and ultraviolet disinfection. The plant discharges to Mallard Creek, and the plant National Pollutant Discharge Elimination System (NPDES) permit limits are shown in Table 3.

The reuse pumping station is located downstream of the effluent filters and ultraviolet disinfection (Fig. 3). The pumping station consists of a below-grade wetwell, with pumping units mounted on the top slab. Meters continuously monitor turbidity and flow per effluent limitations and monitoring requirements that are included in the NPDES permit. Sodium hypochlorite is introduced into the pipeline conveying the reclaimed water as supplemental disinfection to reduce fecal coliform levels and to control biological growth in the pipeline. Fecal coliforms are monitored by taking daily grab samples at a location in the reuse pipeline where sufficient contact time is achieved from the point of disinfection on the plant site. Since CMU was granted a reduced buffer requirement of 5 ft (instead of 25 ft) from the adjacent surface water, the system is required to meet a geometric monthly mean fecal coliform limit of 5 cfu/100 mL (instead of 14 cfu/100 mL) and a maximum daily limit of 14 cfu/100 mL (instead of 25 cfu/100 mL). The plant is also required to establish a residual in the approximately 5.5 mile distribution pipeline. A summary of the NPDES Permit limits for the reuse system are shown in Table 4.

The meter that continuously monitors turbidity will generate an alarm at the operator workstation if the turbidity level is high. If the turbidity level continues to be high, then the Reuse System will switch over to potable water. The potable water mode will provide reuse water via an 8-inch potable water line when plant effluent turbidity is high. This mode has both system pressure
based and wetwell level based control. There is no storage facility for reclaimed water at the treatment plant. Automatic sensors to detect reduced pressure in the distribution line trigger production of more reclaimed water at the plant.

![Figure 2. Mallard Creek Water Reclamation Facility](image)

**Table 3. MCWRF NPDES Plant Permit Limits**

<table>
<thead>
<tr>
<th>Effluent Characteristics</th>
<th>Monthly Average</th>
<th>Weekly Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flow (mgd)</td>
<td>8.0</td>
<td></td>
</tr>
<tr>
<td>CBOD (mg/L)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Summer</td>
<td>4.2</td>
<td>6.3</td>
</tr>
<tr>
<td>Winter</td>
<td>8.3</td>
<td>12.5</td>
</tr>
<tr>
<td>TSS (mg/L)</td>
<td>39.0</td>
<td>45.0</td>
</tr>
<tr>
<td>Fecal Coliforms (geometric mean)</td>
<td>200 / 100 ml</td>
<td>400 / 100 ml</td>
</tr>
<tr>
<td>NH₃-N (mg/L)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Summer</td>
<td>1.0</td>
<td></td>
</tr>
<tr>
<td>Winter</td>
<td>2.0</td>
<td></td>
</tr>
</tbody>
</table>
Figure 3. MCWRF Reuse System Schematic

Table 4. MCWRF NPDES Reuse Permit Limits

<table>
<thead>
<tr>
<th>Effluent Characteristics</th>
<th>Monthly Average</th>
<th>Weekly Average</th>
<th>Daily Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flow (mgd)</td>
<td>3.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CBOD (mg/L)</td>
<td>8.3</td>
<td></td>
<td>16.7</td>
</tr>
<tr>
<td>TSS (mg/L)</td>
<td>5.0</td>
<td></td>
<td>10.0</td>
</tr>
<tr>
<td>Fecal Coliforms (geometric mean)</td>
<td>5 / 100 ml</td>
<td></td>
<td>14 / 100 ml</td>
</tr>
<tr>
<td>NH₃-N (mg/L)</td>
<td>4.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Turbidity (NTU)</td>
<td></td>
<td></td>
<td>10.0</td>
</tr>
</tbody>
</table>
Turbidity greater than 8 NTU for 10 seconds shall generate an alarm. Plant effluent turbidity at 9 NTU will also generate an alarm. If no operator action occur within 5 minutes, and effluent turbidity remains greater then 9 NTU, plant effluent mode will be shut down and potable water mode will be initiated.

There are two systems that utilize reclaimed water at the plant: the Water Reuse System and the Non-Potable Water (NPW) supply for the plant. Pressurized NPW is supplied throughout the plant for fire protection (red fire hydrants) and various pump seals and hydraulic actuators. Two customers are currently using the reclaimed wastewater; Tradition Golf Course, and Mallard Creek Community Park. Maximum demand during the summer months is approximately 400,000 gallons per day for irrigation.

**Tradition Golf Course.** The Tradition Golf Course is located at 3800 Prosperity Church Road in Charlotte, NC and is situated on approximately 400 acres. Mallard Creek Community Park is located at 3001 Johnston-Oehler Road and is situated on approximately 300 acres. It includes soccer and softball fields and playgrounds. Both the golf course and the park designed their irrigation systems according to NC Administrative Code Section: 15A NCAC 2H.0200 Waste Not Discharged to Surface Waters, including proper marking and identification of the irrigation piping and facilities.

**Monitoring Data**

Monitoring data collected by personnel at MCWRF between June 2000 and June 2001 was obtained to evaluate treatment plant performance and reclaimed water quality. Test data was available for biochemical oxygen demand (BOD₅), fecal coliforms, NH₃-N, and turbidity.

**Sample Collection**

In addition to the data provided by the plant, field samples were collected and analyzed for chemical oxygen demand (COD), nitrate, phosphate, chlorine residual, fecal coliforms, *C. Perfringens*, somatic coliphage, and F⁺ coliphage. Tests for COD and chlorine are simple measures that were used to characterize the system and serve as markers for changes in water quality between the treatment plants and the delivery sites, and between the delivery sites and the receiving streams.

At the treatment plant, grab samples were collected from the same sampling site used by the plant operators. At the golf course, there is no storage pond or tank for reclaimed water, so samples from each of three irrigation headers (third, sixth, and fifteenth greens) were collected during each sampling event. Reuse water was allowed to flow for at least 10 minutes before sampling so that the sprinkler head was flushed and a representative sample was obtained. Grass samples were collected from under the spray area of the same three sprinkler heads. Grass blades were cut at the leaf base. Stream water samples were taken from upstream of the irrigation site and from downstream of the site on each sampling occasion.

All samples for microbiological testing were collected aseptically and handled with the appropriate precautions to avoid contamination. Tests for *C. perfringens*, and somatic and F⁺ coliphage were performed in the water microbiology laboratories at UNC-Chapel Hill. Samples
requiring transport were stored on ice and hand-delivered or sent by overnight mail to UNC-Chapel Hill.

Control samples included grass from the required buffer area around the irrigation site (5 ft) and from a nearby grassed area similar in character to the irrigation site, but which is located well beyond the largest buffer width (100 ft) stipulated in the regulations. The control sites were wetted periodically with potable water, so that soil moisture content did not become a confounding variable.

The frequency of water sampling depended on the golf course irrigation schedule and the status of the reuse system. Irrigation at the golf course was intermittent, and the reuse system was frequently out of service. Therefore, monthly sampling was possible only six times between September 2000 and May 2001. A summary of the monitoring and field sample data and the sampling locations is shown in Table 5.

**Table 5. Summary of Parameters Monitored and Sampling Locations**

<table>
<thead>
<tr>
<th>Sample Location</th>
<th>Parameters</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treatment Plant Monitoring</td>
<td>BOD₅, NH₃-N, turbidity, fecal coliforms (reported by MCWWTP)</td>
</tr>
<tr>
<td></td>
<td>COD, NO₃-N, PO₄-P, fecal coliforms, chlorine residual (n=3); <em>C. perfringens</em>, somatic coliphage, and F⁺ phage (n=1).</td>
</tr>
<tr>
<td>Irrigation flow</td>
<td>Tests performed at test site golf course. Reclaimed water is pumped directly to irrigation headers with no intermediate detention in a holding pond</td>
</tr>
<tr>
<td></td>
<td>COD, pH, NO₃-N, PO₄-P, Cl₂ residual, fecal coliforms, (n=3); <em>C. perfringens</em>, somatic coliphage, and F⁺ phage (n=1)</td>
</tr>
<tr>
<td>Stream flow (up and downstream)</td>
<td>COD, pH, NO₃-N, PO₄-P, Cl₂ residual, fecal coliforms, (n=3); <em>C. perfringens</em>, somatic coliphage, and F⁺ phage (n=1)</td>
</tr>
<tr>
<td>Grass</td>
<td>Tests performed on grass under irrigation headers, on grass in buffer zone, and on grass in control region far from buffer zone</td>
</tr>
<tr>
<td></td>
<td><em>C. perfringens</em>, somatic coliphage, and F⁺ phage (n=1)</td>
</tr>
</tbody>
</table>
alternative aqueous medium for elution from grass sample surfaces; the suspensions were tested for fecal coliforms and the other fecal indicators as described above. Coliphages and spores of \textit{C. perfringens} were analyzed by widely used methods (Bisson and Cabelli, 1979; IAWQ Study Group, 1991). Coliphages were assayed by the single agar layer plaque assay method (Grabow and Coubrough 1986) on host \textit{E. coli} CN13 for somatic coliphages and host \textit{E. coli} Famp for male-specific coliphages. Spores of \textit{C. perfringens} were assayed by first heating samples to 70°C for 15 minutes and then either inoculating iron milk medium for MPN tests or filtering sample through membrane filters for incubation on mCp agar medium, followed by exposure of colonies to ammonium hydroxide fumes.

Water Balance Model

The North Carolina water reuse regulations contain a stipulation that requires an unirrigated buffer region between an area receiving reclaimed water spray and adjacent rivers or streams. The purpose of the buffer requirement is to mitigate against the potential transport of harmful pathogens. Presumably if there were pathogens in the irrigation spray that were transferred to the vegetation or soil, they could be dislodged by storm water flow and carried into nearby surface water. It is well known that storm flow, both urban and agricultural, can carry high loads of fecal coliforms (Novotny 2003), and the use of a vegetated buffer is a commonly used management practice designed to intercept contaminants carried in the storm water flow.

Assuming that a site receiving reclaimed water irrigation is not subject to other sources of fecal contamination (livestock, wildlife, or pets), it should be possible to calculate the maximum fecal coliform loading to a nearby stream based on the surface area irrigated and the maximum allowable coliform limits that apply to the site. A water balance model was constructed and applied to the Tradition Golf Course site to predict coliform loadings to nearby surface water with and without a buffer region under a variety of conditions. The model was designed to predict worst case concentrations of fecal coliforms in the receiving stream, and it was written so that the following parameters could be varied: irrigation rate, fecal coliform concentration in the reclaimed water, topography, soil classification, ground cover, percent coliform capture in the buffer length, and die-off coefficients for fecal coliforms.

The model uses the Soil Conservation Service (SCS) Technical Release 55 (TR-55) procedures (USDA 1986) to calculate storm runoff volume. TR-55, which was first released in 1975, is a widely-used model that offers simplified procedures to calculate storm runoff volume, peak rate of discharge, hydrographs, and storage volumes required for floodwater reservoirs for small urbanized watersheds. A rain event hyetograph was necessary to generate a runoff hydrograph. VTPSUHM was utilized to generate this hyetograph and hydrograph.

In addition to the SCS TR-55 procedures, the model incorporates elements of FecaLOAD (Horsley & Witten, Inc., 1996), a model designed to estimate fecal coliform loadings from various land uses within a watershed. Fecal coliform fate after land application has not been well investigated. Although some studies show that coliforms readily adsorb to soil (Gantzer, et al. 2001), it has also been shown that fecal coliforms can bypass the adsorptive or retentive capacities of the soil matrix and travel readily in water passing through soil macropores (Smith et
al., 1985; McMurry et al., 1998). The model was written as a “worst case scenario,” where all of the fecal coliforms in the spray were assumed to be on the grass and soil surface.

Fecal coliform survival after land application (and when carried in storm water) is a function of a variety of factors, including temperature, solar radiation, soil pH, soil moisture, organic matter and nutrients, and competing microbial populations (Gerba and Bitton, 1984; Droste 1997). Usually the adverse factors override the positive ones, and there is a net die-off over time. Typically the effects of the various factors are represented as a single coefficient in a first order equation, and although numerous values have been published for coliform survival in water, there are very few estimates available for coliforms deposited on a grassed area. The FecalLOAD model assumed values reported by Moore et al. (1982) of 0.51/day in warm months and 0.36/day in cold months. For this model, 0.51/day was used to represent die-off of coliforms deposited on grass and soil during the warm months when most of the irrigation occurs. No die-off was incorporated in the time of travel during the storm event.

Coliform retention on vegetation or its propensity to be dislodged in storm water flow is not well-studied, but it appears that the bacteria already in the storm flow are readily retained in grass. When tests with simulated rainfall were used to measure how well vegetated strips removed fecal coliforms in runoff from a cattle feedlot, two grasses that were tested (orchard grass and sorghum/sudan grass) were effective in reducing bacterial levels by nearly 70 percent (Young et al. 1980). A grass sod filter strip seven feet wide successfully trapped nearly 95% of the bacteria from dairy cow manure under laboratory conditions (Larsen et al. 1994). Therefore, there are multiple fates for the coliforms attached to the grass and soil -- some will be detached and carried with the storm water runoff, and some will stay behind. Of those that detach, some will be recaptured and retained in the buffer as the storm flow traverses it en route to the stream. In the model, it was assumed that all the fecal coliforms from the irrigation flow that were on the soil and grass would travel with the storm water overflow, but the percent capture in the vegetated buffer strip was allowed to vary.

Rain inputs vary by storm return period and duration. Return periods were chosen to provide a typical storm event (2 year), a large storm event (10 year) and an extreme storm event (50 year). Similarly, storm durations were chosen to give a range of rainfall intensities. Therefore, each of the three storm return periods were modeled as 1 hour, 2 hour, 6 hour, and 24 hour storms.

Model Input and Assumptions. A “worst case” scenario for fecal coliform loadings from the golf course to the adjacent surface water was constructed using the following assumptions:

- In one set of trials, the fecal coliform limits stated in the state regulations were used (Monthly geometric mean not to exceed 14 cfu/100 mL; 25 cfu/100 maximum on any day). Irrigation spray was assumed to deliver 1 cfu/100 mL for 6 days and then the maximum allowable daily concentration of 25 cfu/100 mL each day for 24 days consecutively such that the allowable monthly geometric mean of 14 cfu/100 mL was not exceeded.

- Trials were also run using the existing fecal coliform limits at the MCWRF (Monthly geometric mean not to exceed 5 cfu/100 mL; 14 cfu/100 maximum on any day.) Irrigation spray was assumed to deliver 1 cfu/100 mL for 12 days and then the maximum
allowable daily concentration of 14 cfu/100 mL each day for 18 days consecutively such that the allowable monthly geometric mean of 14 cfu/100 mL was not exceeded.

- Rainfall excess was assumed to be uniformly distributed over an overland-flow segment per TR-55.
- Pervious and impervious parts of a segment were assumed to be uniformly distributed over the segment per TR-55.
- Rainfall on noneffective impervious areas was assumed to be instantaneously and uniformly distributed over the pervious area of the watershed.
- The complex and uneven topography of the natural catchment was approximated by planes per TR-55.
- It was assumed that rainfall excess did not infiltrate as it moved overland (once rainfall excess was computed, it was presumed to reach the channel).
- Lateral inflows to the stream were assumed to be uniformly distributed and not routed through a gutter or other channel.
- Laminar flow was assumed throughout.
- When rainfall ceased, it was assumed that infiltration ceased as well.
- The decay coefficient for fecal coliform death due to UV exposure and other environmental conditions was 0.51 log units/day.
- Three first flush scenarios were modeled to remove either 25%, 50%, 90% or 100% of the existing fecal coliforms due to wash off in the first half inch of rain.
- Fecal coliform counts across the buffer strip were assumed to attenuate with a maximum removal efficiency of 90%, 70%, 50% and 0%. (In the trials modeling the limits at MCWRF, a 20% removal efficiency was assumed to account for the negotiated buffer width being 5 ft or 20% of the 25 ft required by the regulations.)
- The stream base flow was assumed to be zero ($Q_{10} = 0$). As a result, no additional dilution will occur.
RESULTS

Monitoring Data from the Reuse Effluent at MCWRF

Daily records of the five-day carbonaceous biochemical oxygen demand (CBOD₅), ammonia nitrogen (NH₃-N), turbidity and fecal coliforms were provided by the treatment plant supervisor (Fig. 4). The CBOD₅ of the reclaimed water was consistently below 15 mg/L, except for a few days at the end of the study period (Fig. 4a). Ammonia nitrogen was generally below the 4 mg/L permit limit, but there was one exceedence in January 2001 and over a week of high ammonia levels in April 2001 (Fig. 4b). Records from the on-line turbidimeter indicate that the turbidity was below 8 NTU (permit limit = 10 NTU) for the entire study period (Fig. 4c), while the fecal coliform levels were elevated on numerous occasions, especially during the spring of 2001 (Fig. 4d).

Field Data from MCWRF and Tradition Golf Course

In samples collected from the treatment plant effluent and in spray from the golf course irrigation headers, organic content measured as COD was generally similar, ranging from 9-23 mg/L (Table 6). There was no evidence of additional organic loading to the golf course stream from the irrigation flow. The stream values tended to track more closely with those from the golf course pond than with those of the irrigation system. The maximum stream COD during the monitoring period was 46 mg/L in May 2001.

Nutrient values in the irrigation spray were negligible in three of the five months when sampling occurred, and they tracked with those measured at the plant only during October and November 2001 (Tables 7 and 8). Nitrate and phosphate levels at the plant were several fold higher in the fall months than in the spring. The receiving stream nutrient concentrations generally followed those of the golf course pond, but not the irrigation system.

The measured chlorine residuals at the plant and in the irrigation flow showed large variations during the sampling period (Table 9). At the treatment plant, chlorine residuals varied from a high of 3.5 mg/L to a low of 0.04 mg/L, and at the irrigation site they ranged from 2.0-0.04 mg/L. Chlorine residual in the pond water likely reflects the addition of potable water by golf course personnel for volume control and not inflow from the reuse system. In the spring months, the chlorine residual was negligible in the pond, and the trace levels of chlorine in the irrigation water are nearly as low as those found in the pond and stream.

Monthly samples from the treatment plant and the irrigation headers never showed the fecal coliform spikes evident in the plant monitoring data (Figure 4d, Table 10). In field samples of irrigation water, no fecal coliforms were detected, although counts in the golf course pond and in the stream were 5-10 cfu/100 mL in October, April, and May.
Figure 4. Monitoring data from MCWRF June 2000-June 2001.
Table 6. COD in Samples from MCWRF and Tradition Golf Course

<table>
<thead>
<tr>
<th></th>
<th>WWTP</th>
<th>Header 1</th>
<th>Header 2</th>
<th>Header 3</th>
<th>Pond</th>
<th>Stream</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sep-00</td>
<td>16 ± 5.0</td>
<td>16 ± 1.0</td>
<td>16 ± 1.5</td>
<td>18±0.88</td>
<td>35 ± 0.58</td>
<td>11±2.0</td>
</tr>
<tr>
<td>Oct-00</td>
<td>15 ± 1.3</td>
<td>13 ± 1.0</td>
<td>23 ± 3.5</td>
<td>16±0.33</td>
<td>37 ± 1.2</td>
<td>28±0.58</td>
</tr>
<tr>
<td>Nov-00</td>
<td>20 ± 0.88</td>
<td>13 ± 0.33</td>
<td>14±0.67</td>
<td>12 ± 0.0</td>
<td>37±0.67</td>
<td>28±0.88</td>
</tr>
<tr>
<td>Apr-01</td>
<td>20 ± 1.9</td>
<td>20 ± 2.7</td>
<td>16 ± 3.1</td>
<td>15 ± 1.0</td>
<td>36 ± 1.5</td>
<td>41 ± 2.6</td>
</tr>
<tr>
<td>May-01</td>
<td>17 ± 2.6</td>
<td>12 ± 0.33</td>
<td>9.3±0.88</td>
<td>10±0.88</td>
<td>33 ± 5.2</td>
<td>46±4.9</td>
</tr>
</tbody>
</table>

All samples were tested in triplicate and results are shown as mean ± standard error.

Table 7. Nitrate (NO₃-N) in Samples from MCWRF and Tradition Golf Course

<table>
<thead>
<tr>
<th></th>
<th>WWTP</th>
<th>Header 1</th>
<th>Header 2</th>
<th>Header 3</th>
<th>Pond</th>
<th>Stream</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sep-00</td>
<td>14±0.33</td>
<td>0.43±0.033</td>
<td>DL*</td>
<td>DL</td>
<td>1.5±0.03</td>
<td>1.3±0.0</td>
</tr>
<tr>
<td>Oct-00</td>
<td>16±2.2</td>
<td>11±0.58</td>
<td>11±0.0</td>
<td>9.7±0.33</td>
<td>0.43±0.03</td>
<td>DL</td>
</tr>
<tr>
<td>Nov-00</td>
<td>14±0.82</td>
<td>17±0.67</td>
<td>15±0.33</td>
<td>15±0.88</td>
<td>0.23±0.03</td>
<td>0.30±0.06</td>
</tr>
<tr>
<td>Apr-01</td>
<td>NR</td>
<td>DL</td>
<td>DL</td>
<td>DL</td>
<td>1.4±0.05</td>
<td>1.4±0.07</td>
</tr>
<tr>
<td>May-01</td>
<td>3.9±0.12</td>
<td>DL</td>
<td>DL</td>
<td>DL</td>
<td>0.50±0.0</td>
<td>0.40±0.0</td>
</tr>
</tbody>
</table>

DL = 0.1 mg/L.

All samples were tested in triplicate and results shown are mean ± standard error.

Table 8. Phosphate (PO₄-P) in Samples from MCWRF and Tradition Golf Course

<table>
<thead>
<tr>
<th></th>
<th>WWTP</th>
<th>Header 1</th>
<th>Header 2</th>
<th>Header 3</th>
<th>Pond</th>
<th>Stream</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sep-00</td>
<td>8.3±0.0</td>
<td>DL*</td>
<td>0.10±0.0</td>
<td>0.10±0.0</td>
<td>1.8±0.0</td>
<td>DL</td>
</tr>
<tr>
<td>Oct-00</td>
<td>4.3±0.11</td>
<td>3.9±0.084</td>
<td>4.3±0.15</td>
<td>3.9±0.22</td>
<td>0.10±0.01</td>
<td>0.07±0.044</td>
</tr>
<tr>
<td>Nov-00</td>
<td>12±0.65</td>
<td>11±0.38</td>
<td>11±0.77</td>
<td>11±0.32</td>
<td>0.12±0.05</td>
<td>0.045±0.01</td>
</tr>
<tr>
<td>Apr-01</td>
<td>0.70±0.015</td>
<td>DL</td>
<td>0.025±0.01</td>
<td>0.030±0.00</td>
<td>0.40±0.02</td>
<td>0.54±0.029</td>
</tr>
<tr>
<td>May-01</td>
<td>0.66±0.12</td>
<td>0.09±0.007</td>
<td>0.10±0.006</td>
<td>0.075±0.003</td>
<td>0.42±0.03</td>
<td>0.51±0.032</td>
</tr>
</tbody>
</table>

DL = 0.01 mg/L.

All samples were tested in triplicate and results shown are mean ± standard error.

Table 9. Chlorine Residual in Samples from MCWRF and Tradition Golf Course

<table>
<thead>
<tr>
<th></th>
<th>WWTP</th>
<th>Header 1</th>
<th>Header 2</th>
<th>Header 3</th>
<th>Pond</th>
<th>Stream</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sep-00</td>
<td>3.5±0.0</td>
<td>0.38±0.007</td>
<td>0.25±0.003</td>
<td>0.47±0.019</td>
<td>0.12±0.0</td>
<td>DL</td>
</tr>
<tr>
<td>Oct-00</td>
<td>0.04±0.01</td>
<td>0.20±0.006</td>
<td>0.19±0.007</td>
<td>0.20±0.013</td>
<td>0.18±0.009</td>
<td>0.04±0.010</td>
</tr>
<tr>
<td>Nov-00</td>
<td>1.9±0.018</td>
<td>1.9±0.003</td>
<td>2.0±0.007</td>
<td>1.9±0.044</td>
<td>0.16±0.012</td>
<td>0.13±0.021</td>
</tr>
<tr>
<td>Apr-01</td>
<td>1.0±0.017</td>
<td>0.043±0.00</td>
<td>0.057±0.00</td>
<td>0.043±0.00</td>
<td>0.037±0.007</td>
<td>0.027±0.00</td>
</tr>
<tr>
<td>May-01</td>
<td>0.063±0.01</td>
<td>0.040±0.01</td>
<td>0.087±0.00</td>
<td>0.067±0.00</td>
<td>0.037±0.003</td>
<td>0.013±0.00</td>
</tr>
</tbody>
</table>

All samples were tested in triplicate and results are shown as mean ± standard error.
The assays of alternate microbial indicators, (C. perfringens, mCP, and somatic coliphage, SAL CN13) in samples from various unit processes in the plant showed that both groups of organisms were present in the raw wastewater and throughout the treatment process (Table 11), with 99.99% and 99.62% overall reductions in the viral and bacteria indicators, respectively.

### Table 10. Fecal Coliforms in Samples from MCWRF and Tradition Golf Course†

<table>
<thead>
<tr>
<th></th>
<th>WWTP</th>
<th>Header 1</th>
<th>Header 2</th>
<th>Header 3</th>
<th>Pond</th>
<th>Stream</th>
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<tbody>
<tr>
<td>Sep-00</td>
<td>&lt;1</td>
<td>&lt;1</td>
<td>&lt;1</td>
<td>&lt;1</td>
<td>&lt;1</td>
<td>&lt;1</td>
</tr>
<tr>
<td>Oct-00</td>
<td>&lt;1</td>
<td>&lt;1</td>
<td>&lt;1</td>
<td>&lt;1</td>
<td>3.0±0.58</td>
<td>3.7±1.2</td>
</tr>
<tr>
<td>Nov-00</td>
<td>&lt;1</td>
<td>&lt;1</td>
<td>&lt;1</td>
<td>&lt;1</td>
<td>&lt;1</td>
<td>&lt;1</td>
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<tr>
<td>Apr-01</td>
<td>&lt;1</td>
<td>&lt;1</td>
<td>&lt;1</td>
<td>&lt;1</td>
<td>4.7±1.5</td>
<td>5.7±2.08</td>
</tr>
<tr>
<td>May-01</td>
<td>&lt;1</td>
<td>&lt;1</td>
<td>&lt;1</td>
<td>&lt;1</td>
<td>5.7±2.08</td>
<td>9.0±5.3</td>
</tr>
</tbody>
</table>

†All triplicate samples were tested and results are shown ± standard error.

### Table 11. Microbial Indicators in Water Samples from Various Stages in the Treatment Process

<table>
<thead>
<tr>
<th>Sampling Location</th>
<th>mCP</th>
<th>SAL CN13</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>cfu/100 mL</td>
<td>pfu/mL</td>
</tr>
<tr>
<td>Raw influent</td>
<td>15840</td>
<td>320</td>
</tr>
<tr>
<td>Pre-filtration</td>
<td>2667</td>
<td>1.6</td>
</tr>
<tr>
<td>Post-filtration</td>
<td>320</td>
<td>4.9</td>
</tr>
<tr>
<td>Post UV Disinfection</td>
<td>61</td>
<td>0.02</td>
</tr>
<tr>
<td>Log reduction</td>
<td>2.41</td>
<td>4.20</td>
</tr>
<tr>
<td>Percent removal</td>
<td>99.615</td>
<td>99.993</td>
</tr>
</tbody>
</table>

Measures of C. perfringens, somatic coliphage and F+ coliphage in water from the plant and field sample sites were generally negligible (Tables 12-14). During two sampling events (October 2000 and April 2001) levels of C. perfringens in the treated wastewater exceeded 15 cfu/mL, but during the other months, the levels were as much as 100,000-fold lower. The levels of C. perfringens in the golf course pond and the receiving stream were also elevated during October and April, but the irrigation header water samples did not show these increases.

Somatic coliphage were present during the fall in all water samples, but there were none detected in water collected during the last three sampling events (November, April and May). F+ coliphage were detected only once at the treatment plant sampling location, but they were present in the headers during both the September and October sampling sessions. High levels of F+ coliphage were found only once in the pond in September 2000; in other months the levels were consistently below 0.01 pfu/mL.
Grass that was sampled from beneath the irrigation headers and tested for fecal coliforms, *C. Perfringens*, somatic and F\(^+\) coliphage never showed evidence of viable fecal coliforms (data not shown), but the other indicators were detected, especially in the fall months (Tables 15-17). In three months, *C. Perfringens* were found at somewhat elevated levels in grass sampled from below the irrigation headers. Samples collected in October were not diluted sufficiently, and the results are not very precise; however, the trends are consistent with the other months, with *C. Perfringens* concentrations on grass high beneath the irrigation headers and lower in the buffer and control regions.

High counts of both types of coliphage were found in grass samples beneath the irrigation headers in September and October, but no high accumulations were detected in subsequent months. Although the control site never yielded high coliphage counts, there were elevated levels of coliphage in the buffer region in samples from October.
Table 15. *C. Perfringens* in Grass Sampled from Tradition Golf Course

<table>
<thead>
<tr>
<th></th>
<th>Header 1</th>
<th>Header 2</th>
<th>Header 3</th>
<th>Buffer</th>
<th>Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sep-00</td>
<td>&lt;2</td>
<td>&lt;2</td>
<td>&lt;2</td>
<td>&lt;2</td>
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<tr>
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<td>&gt;110</td>
<td>&gt;110</td>
<td>&lt;110</td>
<td>&lt;110</td>
</tr>
<tr>
<td>Nov-00</td>
<td>920</td>
<td>250</td>
<td>350</td>
<td>67</td>
<td>&lt;15</td>
</tr>
<tr>
<td>Apr-01</td>
<td>38</td>
<td>140</td>
<td>190</td>
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<td>&lt;2</td>
<td>&lt;15</td>
<td>&lt;2</td>
<td>&lt;15</td>
</tr>
</tbody>
</table>

Table 16. Somatic coliphage in Grass Sampled from Tradition Golf Course

<table>
<thead>
<tr>
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<th>Header 2</th>
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<tr>
<td>Sep-00</td>
<td>TNTC</td>
<td>420</td>
<td>20</td>
<td>10</td>
<td>&lt;2</td>
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<td>Oct-00</td>
<td>TNTC</td>
<td>TNTC</td>
<td>--</td>
<td>TNTNC</td>
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</tr>
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<td>Nov-00</td>
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<td>&lt;15</td>
<td>&lt;15</td>
<td>&lt;15</td>
<td>&lt;30</td>
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<td>Apr-01</td>
<td>&lt;0.05</td>
<td>&lt;0.05</td>
<td>&lt;0.05</td>
<td>&lt;0.05</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td>May-01</td>
<td>&lt;0.05</td>
<td>&lt;0.05</td>
<td>&lt;0.05</td>
<td>&lt;0.05</td>
<td>&lt;0.05</td>
</tr>
</tbody>
</table>

Table 17. F' Coliphage in Grass Sampled from Tradition Golf Course

<table>
<thead>
<tr>
<th></th>
<th>Header 1</th>
<th>Header 2</th>
<th>Header 3</th>
<th>Buffer</th>
<th>Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sep-00</td>
<td>TNTC</td>
<td>420</td>
<td>20</td>
<td>10</td>
<td>&lt;2</td>
</tr>
<tr>
<td>Oct-00</td>
<td>TNTC</td>
<td>TNTC</td>
<td>--</td>
<td>TNTNC</td>
<td>---</td>
</tr>
<tr>
<td>Nov-00</td>
<td>&lt;15</td>
<td>&lt;15</td>
<td>&lt;15</td>
<td>&lt;15</td>
<td>&lt;30</td>
</tr>
<tr>
<td>Apr-01</td>
<td>&lt;0.05</td>
<td>&lt;0.05</td>
<td>&lt;0.05</td>
<td>&lt;0.05</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td>May-01</td>
<td>&lt;0.05</td>
<td>&lt;0.05</td>
<td>&lt;0.05</td>
<td>&lt;0.05</td>
<td>&lt;0.05</td>
</tr>
</tbody>
</table>

Water Balance Model

A typical summer season irrigation flow at the golf course is about 400,000 gpd. This application rate was used to model storm water runoff from the golf course assuming a fecal coliform die-off coefficient of 0.51/day, the decay rate coefficient used in FecalLOAD for warm temperature conditions. The daily fecal coliform loadings were assumed to be as high as allowable without exceeding the geometric monthly mean. For the levels stipulated in the regulations, that would be a daily maximum not to exceed 25 cfu/100 mL, and a geometric monthly mean not to exceed 14 cfu/100 mL. These requirements could be met if the turf were irrigated with reclaimed water containing 1 cfu/100 mL for 6 days, followed by water containing 25 cfu/100 mL for 24 days. [For the MCWRF, these levels were 14 cfu/100 mL and 5 cfu/100 mL, respectively, which could be met if the loadings were 1 cfu/100 mL for 12 days, followed by 14 cfu/100 mL for 18 days.]

To be conservative, the model assumes that no detached bacteria are retained in the spray area. Various detachment rates from the spray area (25%, 50%, 75% and 100%) and various and
retention rates in the buffer (50%, 70%, and 90%) were modeled (Tables 18-20). When the buffer retention rate was set to 0%, the results represented the runoff loading that would be expected if no buffer were required (Table 21).

Table 18. Loading of 1 cfu/100 mL for 6 da then 25 cfu/100 mL applied for 24 da. Buffer retains 90% of coliforms in runoff flow.

<table>
<thead>
<tr>
<th>Rain Event</th>
<th>Percent of Coliforms Detached from Grass or Soil and Carried with Runoff</th>
<th>Predicted Mean Coliform Concentration in Stream (cfu/100mL)*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>25%</td>
<td>50%</td>
</tr>
<tr>
<td>2YR1HR</td>
<td>0.09</td>
<td>0.18</td>
</tr>
<tr>
<td>2YR2HR</td>
<td>0.15</td>
<td>0.31</td>
</tr>
<tr>
<td>2YR6HR</td>
<td>0.25</td>
<td>0.50</td>
</tr>
<tr>
<td>2YR24HR</td>
<td>2.16</td>
<td>4.32</td>
</tr>
<tr>
<td>10YR1HR</td>
<td>0.05</td>
<td>0.09</td>
</tr>
<tr>
<td>10YR2HR</td>
<td>0.06</td>
<td>0.13</td>
</tr>
<tr>
<td>10YR6HR</td>
<td>0.26</td>
<td>0.52</td>
</tr>
<tr>
<td>10YR24HR</td>
<td>18.16</td>
<td>36.32</td>
</tr>
<tr>
<td>50YR1HR</td>
<td>0.03</td>
<td>0.06</td>
</tr>
<tr>
<td>50YR2HR</td>
<td>0.05</td>
<td>0.10</td>
</tr>
<tr>
<td>50YR6HR</td>
<td>2.46</td>
<td>4.91</td>
</tr>
<tr>
<td>50YR24HR</td>
<td>26.12</td>
<td>52.24</td>
</tr>
</tbody>
</table>

*Fractional concentrations are possible if test results of “none detected” are averaged with test results where one or more colonies were detected.

Table 19. Loading of 1 cfu/100 mL for 6 da then 25 cfu/100 mL applied for 24 da. Buffer retains 70% of coliforms in runoff flow.

<table>
<thead>
<tr>
<th>Rain Event</th>
<th>Percent of Coliforms Detached from Grass or Soil and Carried with Runoff</th>
<th>Predicted Mean Coliform Concentration in Stream (cfu/100mL)*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>25%</td>
<td>50%</td>
</tr>
<tr>
<td>2YR1HR</td>
<td>0.27</td>
<td>0.55</td>
</tr>
<tr>
<td>2YR2HR</td>
<td>0.46</td>
<td>0.92</td>
</tr>
<tr>
<td>2YR6HR</td>
<td>0.76</td>
<td>1.51</td>
</tr>
<tr>
<td>2YR24HR</td>
<td>6.48</td>
<td>12.97</td>
</tr>
<tr>
<td>10YR1HR</td>
<td>0.14</td>
<td>0.28</td>
</tr>
<tr>
<td>10YR2HR</td>
<td>0.19</td>
<td>0.38</td>
</tr>
<tr>
<td>10YR6HR</td>
<td>0.79</td>
<td>1.57</td>
</tr>
<tr>
<td>10YR24HR</td>
<td>54.48</td>
<td>108.96</td>
</tr>
<tr>
<td>50YR1HR</td>
<td>0.08</td>
<td>0.17</td>
</tr>
<tr>
<td>50YR2HR</td>
<td>0.15</td>
<td>0.30</td>
</tr>
<tr>
<td>50YR6HR</td>
<td>7.37</td>
<td>14.74</td>
</tr>
<tr>
<td>50YR24HR</td>
<td>78.36</td>
<td>156.71</td>
</tr>
</tbody>
</table>

*Fractional concentrations are possible if test results of “none detected” are averaged with test results where one or more colonies were detected.
Table 20. Loading of 1 cfu/100 mL for 6 da then 25 cfu/100 mL applied for 24 da. Buffer retains 50% of coliforms in runoff flow.

<table>
<thead>
<tr>
<th>Rain Event</th>
<th>Percent of Coliforms Detached from Grass or Soil and Carried with Runoff</th>
<th>25%</th>
<th>50%</th>
<th>90%</th>
<th>100%</th>
</tr>
</thead>
<tbody>
<tr>
<td>2YR1HR</td>
<td></td>
<td>0.46</td>
<td>0.91</td>
<td>1.64</td>
<td>1.82</td>
</tr>
<tr>
<td>2YR2HR</td>
<td></td>
<td>0.76</td>
<td>1.53</td>
<td>2.75</td>
<td>3.05</td>
</tr>
<tr>
<td>2YR6HR</td>
<td></td>
<td>1.26</td>
<td>2.52</td>
<td>4.53</td>
<td>5.03</td>
</tr>
<tr>
<td>2YR24HR</td>
<td></td>
<td>10.81</td>
<td>21.62</td>
<td>38.91</td>
<td>43.23</td>
</tr>
<tr>
<td>10YR1HR</td>
<td></td>
<td>0.23</td>
<td>0.46</td>
<td>0.83</td>
<td>0.92</td>
</tr>
<tr>
<td>10YR2HR</td>
<td></td>
<td>0.32</td>
<td>0.63</td>
<td>1.13</td>
<td>1.26</td>
</tr>
<tr>
<td>10YR6HR</td>
<td></td>
<td>1.31</td>
<td>2.62</td>
<td>4.72</td>
<td>5.24</td>
</tr>
<tr>
<td>10YR24HR</td>
<td></td>
<td>90.80</td>
<td>181.60</td>
<td>326.88</td>
<td>363.20</td>
</tr>
<tr>
<td>50YR1HR</td>
<td></td>
<td>0.14</td>
<td>0.28</td>
<td>0.50</td>
<td>0.56</td>
</tr>
<tr>
<td>50YR2HR</td>
<td></td>
<td>0.25</td>
<td>0.51</td>
<td>0.91</td>
<td>1.02</td>
</tr>
<tr>
<td>50YR6HR</td>
<td></td>
<td>12.28</td>
<td>24.56</td>
<td>44.21</td>
<td>49.12</td>
</tr>
<tr>
<td>50YR24HR</td>
<td></td>
<td>130.59</td>
<td>261.19</td>
<td>470.14</td>
<td>522.38</td>
</tr>
</tbody>
</table>

*Fractional concentrations are possible if test results of "none detected" are averaged with test results where one or more colonies were detected.

Table 21. Loading of 1 cfu/100 mL for 6 da then 25 cfu/100 mL applied for 24 da. Buffer retains 0% of coliforms in runoff flow.

<table>
<thead>
<tr>
<th>Rain Event</th>
<th>Percent of Coliforms Detached from Grass or Soil and Carried with Runoff</th>
<th>25%</th>
<th>50%</th>
<th>90%</th>
<th>100%</th>
</tr>
</thead>
<tbody>
<tr>
<td>2YR1HR</td>
<td></td>
<td>0.91</td>
<td>1.82</td>
<td>3.28</td>
<td>3.64</td>
</tr>
<tr>
<td>2YR2HR</td>
<td></td>
<td>1.53</td>
<td>3.05</td>
<td>5.50</td>
<td>6.11</td>
</tr>
<tr>
<td>2YR6HR</td>
<td></td>
<td>2.52</td>
<td>5.03</td>
<td>9.06</td>
<td>10.07</td>
</tr>
<tr>
<td>2YR24HR</td>
<td></td>
<td>21.62</td>
<td>43.23</td>
<td>77.82</td>
<td>86.46</td>
</tr>
<tr>
<td>10YR1HR</td>
<td></td>
<td>0.46</td>
<td>0.92</td>
<td>1.66</td>
<td>1.85</td>
</tr>
<tr>
<td>10YR2HR</td>
<td></td>
<td>0.63</td>
<td>1.26</td>
<td>2.27</td>
<td>2.52</td>
</tr>
<tr>
<td>10YR6HR</td>
<td></td>
<td>2.62</td>
<td>5.24</td>
<td>9.44</td>
<td>10.49</td>
</tr>
<tr>
<td>10YR24HR</td>
<td></td>
<td>181.60</td>
<td>363.20</td>
<td>653.75</td>
<td>726.39</td>
</tr>
<tr>
<td>50YR1HR</td>
<td></td>
<td>0.28</td>
<td>0.56</td>
<td>1.00</td>
<td>1.11</td>
</tr>
<tr>
<td>50YR2HR</td>
<td></td>
<td>0.51</td>
<td>1.02</td>
<td>1.83</td>
<td>2.03</td>
</tr>
<tr>
<td>50YR6HR</td>
<td></td>
<td>24.56</td>
<td>49.12</td>
<td>88.42</td>
<td>98.24</td>
</tr>
<tr>
<td>50YR24HR</td>
<td></td>
<td>261.19</td>
<td>522.38</td>
<td>940.28</td>
<td>1044.75</td>
</tr>
</tbody>
</table>

*Fractional concentrations are possible if test results of "none detected" are averaged with test results where one or more colonies were detected.
Results obtained when the model was repeated for the actual limits and buffer width used at MCWRF are shown in Table 22.

Table 22. Loading of 1 cfu/100 mL for 12 da then 14 cfu/100 mL applied for 18 da. Buffer retains 20% of coliforms in runoff flow.

<table>
<thead>
<tr>
<th>Rain Event</th>
<th>Percent of Coliforms Detached from Grass or Soil and Carried with Runoff</th>
<th>Predicted Mean Coliform Concentration in Stream (cfu/100mL)*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>25%</td>
<td>50%</td>
</tr>
<tr>
<td>2YR1HR</td>
<td>0.41</td>
<td>0.82</td>
</tr>
<tr>
<td>2YR2HR</td>
<td>0.68</td>
<td>1.37</td>
</tr>
<tr>
<td>2YR6HR</td>
<td>1.13</td>
<td>2.26</td>
</tr>
<tr>
<td>2YR24HR</td>
<td>9.68</td>
<td>19.37</td>
</tr>
<tr>
<td>10YR1HR</td>
<td>0.21</td>
<td>0.41</td>
</tr>
<tr>
<td>10YR2HR</td>
<td>0.28</td>
<td>0.56</td>
</tr>
<tr>
<td>10YR6HR</td>
<td>1.17</td>
<td>2.35</td>
</tr>
<tr>
<td>10YR24HR</td>
<td>81.35</td>
<td>162.70</td>
</tr>
<tr>
<td>50YR1HR</td>
<td>0.12</td>
<td>0.25</td>
</tr>
<tr>
<td>50YR2HR</td>
<td>0.23</td>
<td>0.45</td>
</tr>
<tr>
<td>50YR6HR</td>
<td>11.00</td>
<td>22.00</td>
</tr>
<tr>
<td>50YR24HR</td>
<td>117.00</td>
<td>234.00</td>
</tr>
</tbody>
</table>

State Regulations

A poll of state agencies across the U.S. was used to develop the database shown in the Appendix. Only the regulations, guidelines or practices permitting use of reclaimed wastewater in areas of unrestricted public access were included for comparison with the North Carolina regulations. Some states do not have dedicated regulations for water reuse, but they adapt their land application guidelines or regulations, and some states use the stipulations in the California or Florida regulations to adapt NPDES permit requirements on a case-by-case basis. This is a time of high activity with respect to reuse regulations, and many states are developing regulations or modifying existing ones to address reliability issues and the availability of new membrane technologies.

The summaries were divided into the following categories: treatment stipulations, features or practices to optimize reliability and safety, water quality limits, stipulations aimed at the distribution site, buffer or set-back requirements, and storage requirements. The summaries were drafted to provide readers with a sense of the scope and level of detail of items included from state-to-state and to compare the emphases given to each of the categories. They do not necessarily reflect all of the threads of regulatory requirements within a state that will bear on a particular reuse project.

Most of the states with dedicated regulations or guidelines permit irrigation of parks, municipal grounds, and golf courses, but only a few promoted wider applications, such as toilet flush water, fountains, laundries, snow-making, or impoundments where body contact was allowed.
DISCUSSION

Water Quality Monitoring and Testing

Monitoring data from the treatment plant reveal that the plant had difficulty remaining in compliance with CBOD_{5}, NH_{3}-N, and fecal coliform limits, while turbidity limits were met throughout the study period. It is important to note that these data were collected during the start-up phase of the reuse system and more importantly, while construction was on-going to expand the plant. Therefore, these data represent a “worst-case” scenario of plant performance.

The COD values of samples collected for this study were consistent with those reported by the plant operators, and there was no indication that the level of oxygen-consuming substances was problematic for the irrigation system or excessively high in storm runoff from the golf course. The golf course pond, which does not rely on reclaimed water, appeared to be the major determinant of the downstream characteristics of the receiving stream.

Nutrients were tracked in water sampled from the irrigation headers in order to assess whether there were negative impacts on the receiving stream from any nutrients contained in the reclaimed water. Since some fertilization occurred at the golf course, the low nutrient values in the stream confirmed that neither the golf course fertilization practices nor the irrigation flow were contributing to elevated nutrient levels in the steam flow.

The chlorine residual values were quite variable month-to-month. At no time did chlorination of reclaimed wastewater appear to impact the nearby surface water. During April and May 2001 the chlorine residual of the irrigation water so resembled that of the water in the pond and stream that it suggests the irrigation system may have been feeding potable water from the plant rather than reuse water. This would be consistent with the low nitrate and phosphate levels found in the irrigation water during these same months. The ambiguity of these results will be discussed further in the section on operation considerations below.

Coliphage counts in the aeration headers were low and consistent with those reported for the water leaving the plant. However, the grass beneath the headers did show evidence of an accumulation of viable viruses in September 2000, which was the first month of monitoring. Even in October, where precise quantification was not obtained, it is clear the levels were much higher than during the spring sampling events. This may have been due to a variety of factors, including loading levels in the irrigation water, the amount of flushing provided by stormwater in different months, or the use of potable water when reclaimed water was supposedly being pumped to the golf course.

Although it is beyond the scope of this study to assess the health risks that would be associated with some of the higher levels of coliphage detected, it is clear that when fecal indicators are absent, there can still be a loading of viable viruses in the irrigation water that accumulates on the vegetation. These events occurred when both turbidity and fecal coliform counts at the plant and fecal coliform counts measured during monthly sampling events showed no elevation. Although it is likely that the latter months’ coliphage data are more typical of long-term plant performance, these data suggest that special precautions may be needed during the initial months...
of plant operation because it is possible to deliver fairly high loadings of viruses to the vegetation if the chlorine residual is too low.

Water Balance Model

The modeling showed that using the most conservative assumptions, fecal coliform loadings would remain below 200 cfu/100 mL during moderate storm events. During severe storms, the levels could rise to extreme values if detachment from the spray area was high but retention in the buffer area was low, or if no buffer was present. However, if coliforms tend to readily adsorb to buffer vegetation, they would be equally likely to resist removal under all but the heaviest storm conditions. If they were removed during intense storms, it is also likely that high runoff velocities would allow less detention time in the vegetated buffer zone for reattachment of coliforms to grass blades and soil.

Treatment Reliability

Our ability to assess the plant reuse system suffered from the operators’ need to shut-down the system on numerous occasions. Of course, the shut-downs become part of the performance assessment. Although there were clearly times when they were caused by system malfunctions or simply by a lack of customer demand, in this case, numerous shut-downs were required because of the conflicting demands of construction activities on the site. This confounding element made it difficult to accurately assess how well the new system could reliably produce acceptable effluent, and it distracted the operators from concentrating solely on trouble-shooting and optimizing the reuse system at start-up.

In discussions with the operators, it was clear that they felt they had to retrain themselves to think more like water treatment plant operators. With the low turbidity and fecal coliform levels required, and the continuous monitoring to detect any violation of the limits, the plant operators had to quickly adjust to the new mindset that they were producing a high quality product for a customer. The start-up troubleshooting, as well as other unanticipated plant upsets, created a new kind of performance pressure for them. Plant upsets that caused permit limits to be exceeded were of much greater perceived consequence when water reclamation was occurring than when the water flowed to the receiving stream. As the producers of a product, the operators also found themselves fielding calls from customers, a management task they were not accustomed to or trained to do. Therefore, when the system needed to be shut down, in additional to tending to the cause of a problem, they were also handling customer complaints. Some of the operational problems that arose are recounted here to exemplify the range of issues and situations that had to be resolved to achieve good performance.

It was discovered that when the effluent filters were taken out of service for routine maintenance, the reuse limits could not reliably be met. The final clarifiers and the UV effluent troughs were subject to overgrowths of algae, which contributed to higher effluent solids, and additional training was initiated to monitor solids settling and removal more closely. Additional maintenance of the weirs and troughs has also been instigated to minimize this problem.
Since the plant has no physical storage for reclaimed water (water is pumped from the plant to the irrigation headers on demand), when the reuse system is taken out of service, the plant must shift to a potable water back-up system that fills the wet-well with potable water to deliver to the golf course. It was discovered during the course of this study, that because of the way the piping and valves were configured, the operator could not be truly certain that reuse water and not potable water was being delivered to the golf course. This situation was ultimately corrected, but it may be that some of the data reported as reuse water quality at the irrigation headers was actually potable water data.

Another operational problem that hindered good treatment reliability was the location of the on-line turbidimeter. It was originally located at the outlet of the reuse pump station in the pressure main to the golf course. The problem with this arrangement was that if turbid water was detected, the water was already in the wet well and a source of contamination. To rectify this, a turbidimeter was added upstream of the wet-well, and it was set to automatically trigger a shift from reclaimed to potable water when the turbidity exceeded 8 NTU.

The configuration of the point of disinfection relative to the sampling location for reclaimed water headed for the golf course, as well as conditions at the sampling location, were sources of reliability problems. Chlorine is injected into the discharge side of the pumps delivering water in the force main to the golf course. In order to allow sufficient contact time before sampling, the sampling location was set as far downstream as possible before the pipe left the reclamation facility property. This caused concern because if the sample showed that the water was not adequately disinfected, even if the system was switched over to potable water at the wet-well, all the water between the sampling point and the chlorine injection point would still be delivered to the customer.

There were some instances when even after a shift to potable water was made, fecal coliform violations began to occur (see Fig. 4 June 2002). It is suspected that this was due to regrowth of coliforms that were attached to particulate debris that was accumulating in the wet well. A new maintenance program is planned that will periodically take the wet well out of service for cleaning.

The remote location of the sampling point made it difficult to insure that the sample did not get contaminated. If a sample with high fecal coliform counts was suspected of being contaminated at the sampling site, while the water in the force main was likely adequate, the “false” coliform readings still had to be reported as permit violation. Arrangements for sampling the reclaimed water as it leaves the plant have now been changed so that the water is delivered to an open tap in the plant, with an on-line chlorine residual analyzer placed before the tap and a flushing connection added to the plant drain. Further upgrades will include the additional of a small clean building to house a sampling tap and sink. Currently, the North Carolina Reuse Regulations prohibit flushing connections and hydrants in the distribution line to prevent illegal connections that will allow unacceptable reuse water to be diverted to a receiving stream. However, in this instance, they also prevent flushing of the distribution lines to prevent regrowth.

Jurisdiction for maintenance and repair of the distribution line was also a concern, because it did not fall under the domain of the collection system maintenance staff nor the potable water
distribution system maintenance staff. Further, without proper training, the former were likely to contaminate the reclaimed water, and the latter were likely to contaminate potable water with any tools or equipment that contacted reclaimed water. Therefore, steps to fill this gap were required, so that maintenance and repairs could proceed without prolonged system shut-downs.

Lastly, with regard to distribution piping, plant operators noted that during some plant construction activities reclaimed water pipes marked by a purple stripe rather than a completely purple pipe was probably not adequate. In some instances dirt and mud obscured the stripe or it was on a side opposite to the exposed pipe length. Construction crews must be trained and cautioned to recognize the significance of the purple pipe designation so that the water is not unwittingly contaminated or mistaken for potable water.

Comparison of North Carolina Water Reuse Regulations with Those of Other States

California, Washington, Texas, Arizona and Florida are among the states with the most comprehensive reuse regulations, and because California and Florida had some of the earliest legislation addressing reuse, their current legislation reflects lessons learned from years of historical data. As additional states initiated reuse regulations, some differences began to emerge from state-to-state as elements of existing legislation were used, revised, or supplemented. There are also some differences in the language used for certain stipulations, so that even when the intent and requirements are very similar, they are described differently from state-to-state. There is one requirement on which most states agree: purple is the color that identifies reuse piping.

Water Quality: Water quality requirements are at the core of all reuse regulations, and they are aimed at protecting public health and ecosystems. Limits on the number of indicator organisms is used to minimize the risk from pathogens, although there is not consensus on what indicator organism should be monitored or what organism count is safe. Most states use total or fecal coliforms, although Colorado requires testing for E. coli (Table 23). The North Carolina requirements (maximum 30-day geometric mean of 14 cfu/100 mL and maximum daily of 25 cfu/100 mL) is in the mid-range of national limits. Three states require that 7-day median fecal coliform counts be “none detected,” and Arizona (total coliforms) and Florida (fecal coliforms) have similar requirements for 4 of 7 days’ readings or 75% of readings over 30 days, respectively. Many states have coliform limits set at 2.2 cfu/100 mL, although some use total coliforms measurements (Arizona, California, Idaho, Nevada, Oregon, Washington) while others require fecal indicators (Montana, New Jersey, New Mexico). Only Michigan and North Carolina set fecal coliform levels in the teens, and then levels jump to 20-23 fecal cfu/100 mL (Texas, Delaware, Georgia, Ohio, Tennessee), and then to 200 cfu/100 mL (Kansas, Missouri, North Dakota, Pennsylvania, South Dakota).

Most states set the maximum daily level in the range of 14-23 cfu/100 mL, although Texas, Georgia, and Colorado allow levels three to four-fold higher. Colorado stipulates separate coliform regulations for public access areas (maximum 30-day geometric mean of 126 cfu/100 mL; daily maximum 235 cfu/100 mL) and single family residential dwellings (seven-day median of 2.2 cfu/100 mL; monthly maximum 235 cfu/100 mL). Other microbial stipulations include California and Hawaii requirements that the disinfection and filtration processes together must
achieve a 5 log reduction in F-specific bacteriophage MS2 or polio virus relative to the raw sewage counts. Florida requires monitoring for Giardia and Cryptosporidium. Many states

Table 23. North Carolina solids and coliform limits compared to those in other states

<table>
<thead>
<tr>
<th>State</th>
<th>Solids</th>
<th>Turbidity (NTU) unless noted as TSS, mg/L</th>
<th>Coliforms</th>
<th>Group Monitored F=fecal T=total</th>
<th>Statistic Required and Allowable Value, cfu/100 mL</th>
<th>Max Value in a Single Sample, cfu/100 mL</th>
</tr>
</thead>
<tbody>
<tr>
<td>AZ</td>
<td></td>
<td>2</td>
<td>F</td>
<td>4 of 7 d</td>
<td>N.D.</td>
<td>23</td>
</tr>
<tr>
<td>FL</td>
<td>TSS</td>
<td>5</td>
<td>F</td>
<td>75% of 30 d</td>
<td>N.D.</td>
<td>25</td>
</tr>
<tr>
<td>IN</td>
<td>TSS</td>
<td>5</td>
<td>F</td>
<td>7-d median</td>
<td>N.D.</td>
<td>14</td>
</tr>
<tr>
<td>MA</td>
<td>2</td>
<td>5</td>
<td>F</td>
<td>7-d median</td>
<td>N.D.</td>
<td>14</td>
</tr>
<tr>
<td>UT</td>
<td>2</td>
<td>5</td>
<td>F</td>
<td>7-d median</td>
<td>N.D.</td>
<td>14</td>
</tr>
<tr>
<td>CA</td>
<td>2</td>
<td>5, 10</td>
<td>T</td>
<td>7-d median</td>
<td>2.2</td>
<td>23</td>
</tr>
<tr>
<td>HI</td>
<td></td>
<td>2</td>
<td></td>
<td>7-d median</td>
<td>2.2</td>
<td>23</td>
</tr>
<tr>
<td>ID</td>
<td></td>
<td></td>
<td></td>
<td>7-d median</td>
<td>2.2</td>
<td>23</td>
</tr>
<tr>
<td>MT</td>
<td>2</td>
<td>5</td>
<td>F</td>
<td>7-d median</td>
<td>2.2</td>
<td>23</td>
</tr>
<tr>
<td>NV</td>
<td>TSS</td>
<td>30</td>
<td>T</td>
<td>30 d geo. mean</td>
<td>2.2</td>
<td>23</td>
</tr>
<tr>
<td>NJ</td>
<td>TSS</td>
<td>5</td>
<td>F</td>
<td>7-d median</td>
<td>2.2</td>
<td>14</td>
</tr>
<tr>
<td>NM</td>
<td>2</td>
<td>5</td>
<td>F</td>
<td>7-d median</td>
<td>2.2</td>
<td>23</td>
</tr>
<tr>
<td>OR</td>
<td>2</td>
<td>5</td>
<td>T</td>
<td>7-d median</td>
<td>2.2</td>
<td>23</td>
</tr>
<tr>
<td>MD</td>
<td>TSS</td>
<td>90</td>
<td>F</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td>F</td>
<td></td>
<td></td>
<td>10</td>
</tr>
<tr>
<td>NC</td>
<td>TSS</td>
<td>5, 10†</td>
<td>F</td>
<td>30-d geo. mean</td>
<td>14</td>
<td>25</td>
</tr>
<tr>
<td>TX</td>
<td>3</td>
<td></td>
<td>F</td>
<td>30-d geo. mean</td>
<td>20</td>
<td>75</td>
</tr>
<tr>
<td>DE</td>
<td>5</td>
<td></td>
<td>F</td>
<td></td>
<td></td>
<td>20</td>
</tr>
<tr>
<td>GA</td>
<td>3</td>
<td></td>
<td>F</td>
<td>Geo. mean</td>
<td>23</td>
<td>100</td>
</tr>
<tr>
<td>OH</td>
<td></td>
<td></td>
<td>F</td>
<td>30-d mean</td>
<td>23</td>
<td></td>
</tr>
<tr>
<td>TN</td>
<td>TSS</td>
<td>30</td>
<td>F</td>
<td></td>
<td></td>
<td>23</td>
</tr>
<tr>
<td>CO</td>
<td>3</td>
<td>5†</td>
<td>E.coli</td>
<td>30-d geo. mean</td>
<td>126</td>
<td>235</td>
</tr>
<tr>
<td>KS</td>
<td></td>
<td></td>
<td></td>
<td>Mean 30 d</td>
<td>200</td>
<td></td>
</tr>
<tr>
<td>MO</td>
<td></td>
<td></td>
<td>F</td>
<td></td>
<td></td>
<td>200</td>
</tr>
<tr>
<td>ND</td>
<td>TSS</td>
<td>30</td>
<td>F</td>
<td></td>
<td></td>
<td>200</td>
</tr>
<tr>
<td>PA</td>
<td>TSS</td>
<td>30</td>
<td>F</td>
<td>Geo 30 d</td>
<td>200</td>
<td></td>
</tr>
<tr>
<td>SC</td>
<td>1</td>
<td></td>
<td>T</td>
<td>P/A</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SD</td>
<td></td>
<td></td>
<td>T</td>
<td>Geo</td>
<td>200</td>
<td></td>
</tr>
</tbody>
</table>

TSS = total suspended solids; N.D. none detected; geo geometric; P/A presence/absence
2 Means may be daily or monthly, depending on the state.
† Turbidity may be 5 NTU ≤ 5% of readings and never more than 10 NTU at any time.
* Turbidity may be 5 NTU ≤ 5% of readings
† Mean and maximum respectively.
stipulate a required minimum chlorine residual, with levels ranging from 0.2-2 mg/L (Florida, Indiana, Iowa, New Jersey, New Mexico, South Dakota, Utah, Washington), while others require residual monitoring.

Other parameter requirements, such as turbidity or total suspended solids limits are intended to support good disinfection and indicate good treatment efficiency. Many states require continuous turbidity monitoring, with maximum turbidity levels not to exceed 5 NTU. In states that rely on TSS testing instead of turbidity, maximum allowable levels are typically 5-30 mg/L. North Carolina allows a maximum monthly mean TSS of 5 mg/L and a daily maximum of 10 mg/L. BOD limits are stipulated by some states, including North Carolina (10 mg/L), with allowable concentrations typically ranging from 5-30 mg/L. Some states have also included limits on organic and inorganic contaminants to provide groundwater quality protection. North Carolina is unique in having specific ammonia limits (monthly mean concentration of 4 mg/L and a daily maximum of 6 mg/L). Other states stipulate that the maximum total nitrogen must be below 10 mg/L, and many states require nutrient monitoring and reporting without citing maximum allowable concentrations. In states where water reuse on areas of public access are part of land application regulations, monitoring for a variety of nutrients, metals and organic compounds is required to protect crops and groundwater.

Treatment Requirements. Many states include stipulations about the treatment methods that must be used to achieve the water quality limits. North Carolina requires tertiary treatment and defines it as filtered or equivalent treatment. California requires tertiary treatment but explains that this designation includes coagulation unless stated limits can be met without it. California includes the allowable filter loading rates when it stipulates that soil or membrane filtration is required, and it sets minimum turbidity limits for this treatment step. Florida also sets filter effluent limits, but they are in terms of total suspended solids (TSS) instead of turbidity. In Massachusetts, where the regulations are relatively new, filtration is specifically defined as passage through “natural undisturbed soils or other filter media such as sand and/or anthracite.”

North Carolina is not among the states that discuss disinfection methods and procedures. California provides very detailed operation methods for chlorine disinfection, including the required modal contact time and chlorine concentrations (CT values) based on peak dry weather design flow. Florida and Hawaii also include CT values, while Iowa sets a minimum contact time of 15 minutes. For methods other than chlorine disinfection, California requires that certain log reductions of viruses be achieved. Hawaii provides the most detail about UV disinfection requirements by stating that UV disinfection must be done according to a set of guidelines published by the National Water Research Institute and the American Water Works Association Research Foundation.

Some of the interesting features among the state regulations are the requirement by North Carolina that aerated flow equalization facilities be provided and the specification by Delaware that effluent should not be nitrified because of the potential risks to groundwater. Although many states have language that permits alternative treatments if they are shown to provide equivalent treatment, several states specifically mention some frequently proposed alternates, such as membrane filtration and UV disinfection.
Buffers and Storage. A review of the categories of features from which buffers are required shows that potable water and residences are among the most common items protected (Table 24). Other areas mentioned include surface water (waters of the state, wetlands, streams), impoundments (public lake, decorative pools), and areas where people might be eating or drinking (picnic areas, drinking fountains, potable water hose bibs). Pennsylvania includes setbacks for packing lots and rock outcrops. A few states also include setback distances for reclaimed water impoundments.

Buffer requirements vary from state to state in part because of the different levels of treatment required among the states. Generally, where water quality limits for coliforms are less stringent, greater buffer widths are required. However the correspondence does not always hold; both Arizona and Delaware require no setback distances, although Arizona has some of the strictest fecal coliform requirements, while the Delaware limits are fairly high. Florida and Indiana

<table>
<thead>
<tr>
<th>State</th>
<th>Surface Water &amp; Wells</th>
<th>Impoundments</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>AZ</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CA</td>
<td>50 ft from potable well</td>
<td>Irrigation ponds must be 100 ft from a domestic well supply</td>
<td></td>
</tr>
<tr>
<td>CO</td>
<td>100 ft from domestic water supply well</td>
<td>Impoundments must be 100 ft from a domestic water supply well unless lined with a synthetic material with a permeability of 10E-6 cm/sec or less.</td>
<td>Irrigation at single-family residential dwellings must be more than 500 ft from a domestic supply well and 100 ft from any irrigation well.</td>
</tr>
<tr>
<td>DE</td>
<td>Buffer zones are determined on a case-by-case basis, but they are not normally required. May be required to accommodate aerosol, noise, or nuisance control.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>FL</td>
<td>75 ft between a transmission facility or a wetted area and a potable water supply well</td>
<td>100 ft between an unlined storage pond and a potable water supply well.</td>
<td></td>
</tr>
<tr>
<td>GA</td>
<td>Case by case</td>
<td></td>
<td></td>
</tr>
<tr>
<td>HI</td>
<td>50 ft from a drinking water supply well</td>
<td>Impoundments must be 100 ft from a domestic well supply</td>
<td></td>
</tr>
<tr>
<td>IL</td>
<td>Wetted area cannot encroach on wetlands, streams, surface waters, public road rights of way or residential lot lines. Also, groundwater legislation may apply.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>IN</td>
<td>200 ft from potable well</td>
<td>Impoundments must be 1000 ft from residence or building, 300 ft from state waters, 200 ft from any well, and not in a flood plain.</td>
<td>300 ft from residences</td>
</tr>
<tr>
<td>IO</td>
<td>300 ft from surface water and 1000 ft from a shallow well. 300 ft from a structure, stream or other land feature that may provide a direct connection between the</td>
<td></td>
<td>Spray must be 500 ft from a public lake or impoundments, and 0.5 mi if the lake or impoundment is used as a</td>
</tr>
<tr>
<td>State</td>
<td>Buffer Requirements</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-------</td>
<td>---------------------</td>
<td></td>
<td></td>
</tr>
<tr>
<td>KS</td>
<td>200 ft from surface water and waterways.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MD</td>
<td>200 ft from surface water and waterways. 200 ft from property lines and roads; 500 ft from housing developments, parks, areas where people congregate, but with windbreak or non-spray irrigation, can be 50 ft.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MA</td>
<td>100 ft from surface water and 100 ft from a private well.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MI</td>
<td>2000 ft from a high quality water supply well, 800 ft from other type wells; 300 ft from a domestic well. 100 ft from a building and from residential property.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MO</td>
<td>300 ft from any stream or other physiographic feature that could provide direct connection to groundwater; 300 ft from a potable well. 150 ft from dwellings or public use areas; 50 ft from property lines.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MT</td>
<td>100 ft from a water supply well. Buffers from surface water are determined on a case-by-case basis.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>NV</td>
<td>Impoundments must be 50 ft from property line.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>NJ</td>
<td>75 ft from a potable well. 75 ft from transmission facility to potable well; 100 ft from indoor aesthetic features such as decorative pools and fountains.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>NM</td>
<td>50 ft from potable well. No aerosol within 100 m of residences.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>NC</td>
<td>100 ft from surface water with shellfish designation; otherwise 25 ft from surface water, 100 ft from potable well; 50 ft from non-potable well. 100 ft from a sinkhole, 50 ft from a drainage way, and 100 ft from a road right-of-way. 50 ft from property line.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>OH</td>
<td>50 ft from surface water; 100 ft from a private well and 300 ft from a community well.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>OR</td>
<td>Wind drift calculations should be included in design so that spray doesn’t reach streams and lakes and wells.</td>
<td>Wind drift calculations should be included in design so that spray doesn’t reach dwellings.</td>
<td></td>
</tr>
<tr>
<td>----</td>
<td>-------------------------------------------------------------------------------------------------</td>
<td>-------------------------------------------------------------------------------------------------</td>
<td></td>
</tr>
<tr>
<td>SC</td>
<td>Case by case basis</td>
<td>Buffer recommended to protect from mist and aerosol, but none required if WW has been extensively treated and is suitable for human consumption.</td>
<td></td>
</tr>
<tr>
<td>TX</td>
<td>50 ft from on-site streams and ponds</td>
<td>100 ft from site boundaries</td>
<td></td>
</tr>
<tr>
<td>UT</td>
<td>50 ft from potable well</td>
<td>Impoundments 500 ft from a potable well</td>
<td></td>
</tr>
<tr>
<td>WA</td>
<td>50 ft from potable well</td>
<td>Impoundments 500 ft from a potable well unless unit is lined or sealed, then 100 ft from a potable well.</td>
<td></td>
</tr>
<tr>
<td>WY</td>
<td>30 ft from surface waters, 100 ft from potable wells</td>
<td>30 ft between reuse site and property lines; Public right-of-way land may be used to meet this buffer requirement. Drip irrigation systems may be used in the buffer zones required for spray or flood irrigation.</td>
<td></td>
</tr>
</tbody>
</table>

*States not shown have no regulations permitting irrigation of reclaimed water on areas of unrestricted public access.

have coliform limits similar to those in Arizona, but Florida sets buffer limits of 75 ft for potable water supply wells, and Indiana limits reclaimed water to 200 ft from potable water supply wells, 300 ft from waters of the state, and 300 ft from any residence. Among the states that allow up to 20 or 23 cfu/100 mL of fecal coliforms, Georgia sets limits on a case-by-case basis, while Ohio and Tennessee have numerous stipulated setback requirements. North Carolina, with a fecal coliform limit of 14 cfu/100 mL requires 100 ft between the edge of spray and surface waters classified as shellfish areas and 25 ft between the spray and other surface waters.

Storage requirements are stipulated for both (a) diverted flow that was not properly treated and (b) for reclaimed water to be stored until it is needed for irrigation. Some of the issues in ensuring sufficient and safe storage are whether or not ponds are lined, how their minimum capacity requirements are determined, appurtenances for control and operation of the impoundment, and set-back distances of impoundments from other entities. Capacity for reject water is an important reliability issue, and states typically require a capacity of one or two days’
flow. Some states include detailed information about redundancy, alarm systems, and controls, although most do not.

For treated water impoundments, there is a wide range of methods used to guide design capacity because states' climate and geology factors differ, and because some reclaimed water use is closely tied to crop cycles. In the Florida regulations, specific mention is made of aquifer storage and recovery systems (ASR), where treated water is stored below ground in soil pore space. Texas and Indiana specifically mention the option of leak-proof fabricated tanks for storage. Treated water that sits for long periods in an impoundment is subject to degradation. The Massachusetts regulations address this problem with a detailed list of design recommendations to maintain water quality during storage. Some states, such as Michigan, provide significant detail about liner requirements for ponds storing treated water, while other states require liners on for ponds holding reject water.

Reliability. Statements about reliability range from a few sentences to several pages, and the most common themes are piping color, secure hosebibs, cross-connections, and monitoring requirements. Beyond these, there is a wide variety of stipulations that states have chosen to include. Some states heavily emphasize redundancy, stand-by power, diversion of flow, automatic and manual alarm systems, and protocols for notification of regulatory agencies in the event of a system failure. Many specify required operator training, operator presence, on-site inspections, and record-keeping. There are requirements for submission of an operating manual, descriptions of preventive maintenance programs, and performance reports. Some states require that spare units or parts be kept on-site. In states where irrigation of reclaimed water is included in land application regulations, there is typically emphasis on maintenance of groundwater quality, with installation and sampling of monitoring wells required. Together, the compilation of reliability requirements among the various states leaves little left out, so that a perusal of the entire set offers a menu of items that could be included when drafting or updating reuse legislation.

North Carolina is among the states with more extensive reliability regulations. In addition to the common stipulations noted above, there is a requirement for an air gap separation where a potable water connection is used to supplement reclaimed water. Continuous turbidity or particle count monitoring is required, and all treatment units must be in duplicate. A diversion pond must be present, along with stand-by power. Operator certification is specified, along with requirements for tank trucks hauling reclaimed water.

Site Constraints. Some of the most universal requirements from state-to-state are that site plans showing all wells, surface water and the like be submitted, that flood plains be identified, that depth to groundwater be specified, that spray runoff be absent or contained on site, and that some form of signage be used to inform the public that reclaimed water is being used for irrigation. On golf courses, the public notice may be on the score sheets. In states where irrigation of reclaimed water is included in land application regulations, there are often requirements for maximum allowable slope, wind speed constraints on irrigation, and maximum loading rates for water and sometimes nutrients. Stipulations about the types of allowable sprinkler systems (particularly nozzle types) are present in some regulations. As in the reliability sections, there is a wide range
of site-related issues addressed among the compiled state regulations, so that a review of the compilation offers a comprehensive view of the issues of concern.

In North Carolina, regulations relating to site constraints are nominal. Contractual arrangements are discussed, application rates for irrigation are addressed, and there is a requirement that the public and employees on a site be informed that any reclaimed water in use is not potable.

REFERENCES


Droste, R.L. 1997. Theory and Practice of Water and Wastewater Treatment, John Wiley and Sons, USA.


Gerba, C.P. and G. Bitton 1984. Microbial Pollutants: Their survival and transport pattern to groundwater In Groundwater Pollution Microbiology, G. Bitton and C.P. Gerba (eds), John Wiley and Sons, USA.


APPENDIX
Alabama Department of Environmental Management

Alabama has not formally adopted dedicated water reuse regulations. However, they do permit water reuse facilities by making stipulations in NPDES permits on a case-by-case basis. They follow the criteria developed by the state of Florida. An exception is that they do not allow reuse water to be used to wash vehicles; all reuse water in Alabama is for irrigation only.

Reuse is differentiated from land application of wastewater by the amount of public exposure allowed. Reuse water can be used for irrigation without any public exposure limitations. There are separate guidelines for land application where public access is denied or limited (e.g. irrigation in a fenced area, golf courses at night, or when a course is closed to the public.)

Dennis Harrison

Treatment
Reliability
Water Quality
Site Constraints
Buffers
Storage

Appendix 1
Comments

Alaska Department of Environmental Conservation

Alaska does not have reuse regulations or cases of water reuse projects in public access areas.

Treatment

Reliability

Water Quality

Site Constraints

Buffers

Storage
Comments

Arizona Department of Environmental Quality
Arizona Administrative Code Title 18
Chapter 9 Department of Environmental Quality Water Pollution Control,
Article 7, Direct Reuse of Reclaimed Water and
Chapter 11 Environmental Quality;

Arizona defines "direct reuse" as the beneficial use of reclaimed water for purposes such as residential irrigation, school-ground irrigation, and irrigation in areas of open or restricted access. It may also be used for toilet and urinal flushing, fire protection, commercial closed loop air conditioning systems, vehicle washing, and snowmaking. It may not be used for human consumption, swimming, wind surfing, water skiing, or other full immersion water activity with a potential of ingestion or for evaporative cooling or misting. The Department of Environmental Quality may use its discretion to individually permit uses of reclaimed water not stipulated in the regulations. The Arizona regulations also permit reclaimed water blending facilities.

The state lists stipulations for both Class A+ and Class A reclaimed water. A person may use Class A+ reclaimed water for any type of direct reuse that allows Class A reclaimed water to be used; Class A+ water must meet certain nitrogen limits.

Treatment

- Secondary treatment, filtration, nitrogen removal treatment, and disinfection. Filtration means a treatment process that removes particulate matter from the wastewater by passage through porous media, and disinfection means a treatment process that uses oxidants, UV, or other agents to kill or inactivate pathogenic organisms in wastewater.
- Chemical feed facilities must be provided, although they need not be used if the 24 h average turbidity criterion is achieved without chemical addition.
- Alternative treatment methods may be used provided the owner demonstrates through pilot plant testing, existing water quality data, or other means that the alternative method reliably produces a reclaimed water that meets the disinfection criteria and the total nitrogen criteria before discharge to a reclaimed water distribution system.
- After filtration and immediately before disinfection the mean 24h turbidity of filtered effluent must be ≤ 2 NTU and must not exceed 5 NTU at any time.

Reliability

- Color-coded pipe is required.
- Hose bibs for discharge must be secured.
- Continuous monitoring of turbidity is required.
- A permit will stipulate the reporting requirements, which will include (a) a requirement that water quality test results be provided that demonstrate that the reclaimed water meets the applicable standards and (b) a requirement that the total volume of reuse water generated be reported.
- All monitoring activity records and results, continuous monitoring data, and calibration and maintenance records must be retained for five years from the date of sampling.
- All end users must be allowed access to the records of physical, chemical, and biological quality of the reclaimed water.

Appendix 3
**Water Quality**

- The mean 24h turbidity of filtered effluent must be \( \leq 2 \) NTU and must not exceed 5 NTU at any time.
- Class A+ and Class A: no detectable fecal coliform organisms in 4 of the last 7 days' reclaimed water samples; maximum fecal coliform concentration in any sample must be \( \leq 23 \text{ cfu/100 mL} \).
- For class A+ water, the 5-sample geometric mean concentration of total nitrogen must be \( \leq 10 \text{ mg/L} \).
- For Class A water, the total nitrogen concentration applied must be reported along with the type of vegetation to which it was applied.
- Other monitoring requirements, test procedures, and recording practices may be specified.

**Site Constraints**

- A reclaimed water agent is a person responsible for use of reclaimed water by more than one end user; the agent must have a legally enforceable contract that stipulates the responsibility of the enduser to comply with requirements for specific reuses.
- Reusers can provide additional treatment, and would be permitted accordingly.
- Reusers may apply for approval to blend secondary effluent and higher quality water for reuse.
- Public notice of a preliminary decision to permit a facility is required.
- Irrigation should incorporate methods that minimize public contact and standing water as well as water contact with drinking fountains, water coolers, or eating areas; hose bibbs for reclaimed water must be secured to prevent use by the public.
- Signage is required according to use, as stipulated in a table provided in the regulations. Hose bibbs must be identified in front yards and subdivision entrances where residential irrigation with reclaimed water is installed. School grounds must also have signage for Class A+ or Class A water use, but other open access irrigation sites do not require signage with the use of these high quality waters. All impoundments with open access including lakes, ponds, ornamental fountains, waterfalls, and other water features must be posted with signage regardless of the class of reclaimed water.
- Information about the source of reclaimed water to be used and the annual water volume to be applied at a site must be provided, as well as information about the acreage and type of vegetation to be irrigated.

**Buffers**

**Storage**

- No lining is required for an impoundment storing Class A+ reclaimed water, but a liner is required for Class A water. The liner should use a low hydraulic conductivity artificial or site-specific liner material that achieves a discharge rate of less than 550 gal/acre-day.
Arkansas Department of Environmental Quality
State Permits Branch, Water Division
Application for a No-Discharge Water Pollution Control Permit
Permits land application (Revised October 12, 1999).

Arkansas issues permits for irrigation using reclaimed water in areas of public access on a case-by-case basis.

Treatment
Reliability
Water Quality
Site Constraints
Buffers
Storage
Unrestricted access sites include golf courses, parks and playgrounds, school yards, and residential landscaping. The level of treatment described here is also acceptable for numerous other applications, including flushing toilets, industrial process water, decorative fountains, commercial laundries, artificial snow making, and structural fire-fighting. Water at this level of treatment may also be used for non-restricted recreational impoundments as long as conventional treatment [coagulation/sedimentation/ filtration] was used.

Food crops are also specified in this grouping, with some additional stipulations.

If recycled water is available, a public agency may require that it be used for residential landscaping.

**Treatment**

- Tertiary treatment is required, including coagulation and filtration.
  - Coagulation refers to oxidized wastewater in which colloids and particulates have been destabilized and agglomerated by the addition of floc-forming chemicals.
  - Filtration refers to:
    - passage through natural undisturbed soils or a bed of filter media
    - At a rate ≤ 5 gpm/ft² in gravity, upflow, or pressure filters; or ≤ 2 gpm/ft² in traveling bridge automatic backwash filters, and:
    - So that the average turbidity of the filtered water is ≤ 2 NTU over 24h; 5 NTU ≤ 5% of time in 24h; and 10 NTU at any time, OR
    - use of microfiltration, ultrafiltration, nanofiltration, or reverse osmosis membranes so that the turbidity of the filtered water is < 0.2 NTU > 5% of the time in 24 h and < 0.5 NTU at any time.
  - Coagulation can be omitted if (a) the filter effluent is below 2 NTU, and (b) continuous turbidity monitoring indicates that the influent to the filters does not exceed 5 NTU for more than 15 minutes and never exceeds 10 NTU.
  - Disinfection must be accomplished by:
    - chlorination following filtration that provides a minimum CT (total chlorine residual concentration x modal contact time) of 450 mg-min/L, with the modal contact time ≥ 90 min, based on peak dry weather design flow, OR;
    - a disinfection process following filtration that inactivates 99.999 percent of F-specific bacteriophage MS2 or polio virus in the influent wastewater.
  - Regional boards may prescribe water reclamation requirements for a particular project after consultation and receipt of recommendations from the State Department of Health Services.
  - Novel treatment methods are not excluded, but it must be demonstrated that they can assure an equal degree of treatment and reliability.

**Reliability**

- The design must allow for flexible operation to permit the highest possible degree of treatment under varying circumstances.
- All distribution pipes from a water supplier to a municipality or industry must be colored purple or wrapped with purple tape.
- Recycled water piping systems in areas subject to access by the public may not have hose bibbs, but they may have quick couplers that differ from those of the potable water system.
- A dual-plumbed system must be inspected annually for cross-connections and tested for cross-connections every four years. No physical connection between a recycled water system and a potable water system is permitted. Fees may be levied for site inspection for cross-
connections, which must be performed by a certified tester.

- Backflow prevention devices must be inspected and maintained according to state regulations. Types of backflow prevention devices are stipulated for different levels of hazard that exist on consumers' premises.
- If potable water is used in a back-up system as a supplemental water source, an air gap must be used to separate the systems.
- Continuous turbidity monitoring is required.
- The system must be able to automatically activate chemical addition for coagulation.
- Alarms should be triggered by loss of power, failure of biological treatment, disinfection, coagulation, or filtration. The failure occurrence and cause must be recorded, and the corrective action taken must be described. The alarms must be independent of the normal power supply. Alarms must reach a responsible party even if the facility is not attended full-time.
- A contingency plan for diverting unsatisfactory product must be approved.
- No bypass of partially treated water from the reclamation plant or an intermediate unit process to the point of use is permitted.
- The system must have the capacity to divert wastewater if coagulation is not being used and the influent to the filters exceeds 5 NTU for more than 15 minutes.
- Short-term and long-term retention, disposal, and storage options must automatically be actuated when process failure occurs. They should include all necessary sensors, instruments, valves and other devices to enable automatic diversion as well as a manual reset to prevent automatic restart until the failure is corrected.
- A standby power source is required.
- Coagulation processes must include standby chemical feeders, chemical storage and conveyance facilities, reserve chemical supplies, and automatic dosage control.
- Chlorine disinfection processes require a standby chlorine supply, manifold systems to connect gas cylinders, chlorine scales, and automatic switching from empty to full cylinders.
- The chlorine system may meet reliability requirements by the use of alarms and multiple point chlorination, each with independent power source, separate chlorinator, and separate chlorine supply.
- Similar requirements apply to biological treatment, coagulation, filtration and disinfection units, and an alarm must be used to signal performance failure of these systems unless an automatically actuated long-term storage or disposal diversion is in place.
- A preventative maintenance program is required at the reclamation facility.
- Only a public water system, or a publicly or privately owned or operated recycled water system, may supply a dual-plumbed facility.
- Operating personnel must possess stipulated qualifications to operate a reclamation facility.
- Regional boards may issue a master reclamation permit to a supplier or distributor of reclaimed water, or to both the supplier and the distributor. The permittee must supply quarterly reports to the board and conduct inspections.
- Backflow from a dual-plumbed system from recycled to potable water lines must be reported within 24 hrs.
- Records of analyses, operation problems, plant and equipment breakdowns, discharges of partially treated water to the use area, diversions to emergency storage or disposal, and corrective or preventive actions must be maintained at the reclamation plant.
- Operating records must be filed monthly.

**Water Quality**

- The daily mean operating filter effluent turbidity (continuously monitored) is calculated as the average of turbidity measures at 4-h intervals over 24 h, and it must be reported quarterly. The maximum daily turbidity must be based on measures from continuous monitoring taken at ≤ 1.2 h intervals over 24 h.
- The median total coliform concentration of the last 7 days' analyses may not exceed an MPN (most probable number) of 2.2 /100 mL. The maximum total coliform concentration may not exceed an MPN of 23/100 mL in more than one sample in 30 days. No single total coliform measure may exceed an MPN of 240/100 mL. Samples must be collected at least once daily from the disinfected effluent.
The combined disinfection and filtration process must inactivate 99.999% of F-specific bacteriophage MS2 or polio virus in the influent wastewater.

**Site Constraints**

- Suppliers (wholesale or retail) and consumers are required to sign agreements, some terms of which are stipulated in the regulations.
- The regulations provide guidelines for recycled water rates. Recycled water may be sold wholesale to retail water supplies.
- Recycled water distribution lines must be separate from potable water lines, beginning at the point of entry to the private property being served.
- Spray, mist, or runoff is not permitted to reach dwellings, outdoor eating areas, drinking water fountains, or food-handling facilities.
- Irrigation runoff must remain on the use area unless it does not pose a public health threat and is authorized by the regulatory agency.
- Signage is required; size and message are stipulated. Certain waivers are possible.
- No recycled water can be delivered through a dual piping system for internal use, except for fire suppression.

**Buffers**

- Irrigation must be >50 ft. from a domestic water supply, unless the well owner waives this requirement. (Other actions may also be stipulated to waive this requirement.)
- Impoundments of reclaimed water must be >100 ft. from a domestic well supply.

**Storage**

- Short-term facilities for storage or disposal should be able to accommodate water for at least 24 hrs. Such facilities should include necessary diversion devices, provisions for odor control, conduits, and pumping and pump-back equipment. All except the pump-back equipment should be independent of the normal power supply or provided with standby power.
- Long-term storage or disposal provisions (ponds, reservoirs, percolation areas, sewers) should be similarly equipped and of sufficient capacity for at least 20 days.
- Redundant or standby primary and secondary sedimentation units are required, or long-term storage or disposal provisions must be provided. Multiple units must be capable of producing acceptable effluent with one unit not in operation.
Comments

Colorado Department of Public Health and Environment
Water Quality Control Commission
Regulation No. 84
Reclaimed Domestic Wastewater Control Regulation
November 2000

The regulations are part of the Colorado Water Quality Control Act (CWQCA), section 25-8-101 through 25-8-703. In particular they are promulgated under sections 25-8-202 and 25-8-205.

These regulations apply to direct reuse of reclaimed domestic wastewater for landscape irrigation. Landscape irrigation includes areas of grass, trees, and other vegetation that are accessible to the public including parks, greenbelts, golf courses, and common areas at apartment, townhouse, commercial/business parks, and other similar complexes.

A triennial review of the existing regulations is required.

Treatment

- Oxidation, filtration, and disinfection are required.

Reliability

- Piping, valves, and outlets must be marked to differentiate reclaimed domestic wastewater from domestic water in other piping systems.
- All controllers, valves, etc. must be marked with reclaimed domestic wastewater warning signs.
- An approved reduced pressure principle backflow prevention device or an air gap must be provided at all potable water service connections to reclaimed domestic wastewater use areas.
- Supplementing reclaimed domestic wastewater with potable water is not allowed except through an approved reduced pressure principle backflow prevention device or an air gap. Where a backflow prevention device is used, it must be tested on an annual basis unless there is a physical separation between the potable and reuse distribution systems.
- If irrigation wells or industrial wells are used to supplement reclaimed domestic wastewater, this may only be done through use of an approved reduced pressure principle backflow prevention device.
- A description of the treaters's plan to oversee the use of reclaimed domestic wastewater by applicators to ensure, to the maximum extent practicable, that applicators attain and maintain compliance with reclaimed water regulations must be provided.
- Treaters are to educate applicators, and the education program must be described in the permit application.
- Applicators must sign a statement that certifies that they have been provided with a copy of the reclaimed water treatment regulations and that they agree to comply with the regulations. The applicator must agree to allow the treater or the regulatory agency access to the site of irrigation to assess whether the applicator is in compliance or to collect samples for monitoring and analysis.
- Operation of the reclaimed domestic wastewater system including valves, outlets, couplers, and sprinkler heads must be performed by personnel authorized by the applicator.
- Workers must be informed of the potential health hazards involved with contact or ingestion of reclaimed wastewater, and they must be educated regarding proper hygienic procedures to protect themselves.
- An annual report from the treater must provide information about the water quality produced and the inspections conducted. An annual report from the applicator must include the annual volume of water applied per year or season, the maximum monthly volume applied, and each location with the associated acreage where reclaimed water was applied.
- Treaters and applicators must report any violation of the regulations at their respective facilities in writing within 30 days of becoming aware of the violation. Where the treater finds violations by an applicator, the 30 day period for reporting may be waived for an additional 30 days if the treater and
Applicator are working together to resolve the violation. If the violation is not resolved after a total of 60 days, the treater must report the violation within five working days. Discharges to surface water, cross connections without a backflow prevention device, irrigation outside of an approved area, and exceedances of the standards for E. coli must be reported by the treater or the applicator orally within 24 h of becoming aware of the violation and must be followed up with a written report within five working days. The report must describe the noncompliance, its cause, its duration, and the steps taken or planned to reduce, eliminate, and prevent recurrence.

- Reporting is required of discharge to surface water, cross-connection without backflow prevention, irrigation outside site, or exceedance of the E. coli limit.
- The design specifications must address details of the distribution and transmission systems.
- Tank trucks and other equipment used to distribute reclaimed wastewater must be clearly identified with signage.

**Water Quality**

- The monthly mean turbidity must be ≤ 3 NTU, and not more than 5% of individual analytical results in one calendar month may exceed 5 NTU.
- For landscape irrigation, the monthly geometric mean E. coli concentration must be ≤ 126 cfu/100 mL; the E. coli concentration in any single sample in one month must be ≤ 235 cfu/100 mL.
- For single-family residential use, the 7-day median E. coli concentration must be ≤ 2.2/100 mL; the E. coli concentration in any single sample in one month must be ≤ 23 cfu/100 mL.

**Site Constraints**

- A Letter of Intent must be submitted prior to applying for a permit. The letter must review any decrees regarding water rights for the source of the water to be reclaimed.
- Direct and windblown spray should be confined to the approved area. Public contact should be minimized by spraying at least 1 h before opening or at hours that minimize public exposure.
- Rates of application should be such that surface and ground water quality are protected and ponding is minimized. No reclaimed water may enter state waters; runoff should be strictly minimized, and no direct or windblown spray should leave the area designated for application.
- Stipulations are provided in the regulations for distribution and transmission system design.
- Precautions should be taken so that spray does not reach undesignated areas such as an occupied building, domestic drinking water facilities, or facilities where food is being prepared.
- Signage is required: Public notice of reclaimed water use must be posted.
- Supplementation of reclaimed wastewater with potable water requires approval.

**Buffers**

- No impoundment may be within 100 ft of any domestic water supply well unless the impoundment is lined with a synthetic material with a permeability of 10EE-6 cm/sec or less.
- No irrigation may be within 100 ft of any domestic water supply well.
- For irrigation at single-family residential dwellings, no irrigation water may be within 500 ft of any domestic supply well or within 100 ft of any irrigation well.

**Storage**
Connecticut does not have any specific requirements regarding wastewater reuse. There have been only a few cases of water reuse for irrigation and industrial use.

Mike Harder
Director, Permitting, Enforcement and Remediation

Comments

Connecticut Water Management Bureau
Permitting, Enforcement and Remediation

Reliability

Water Quality

Site Constraints

Buffers

Storage
Comments

State of Delaware Department of Natural Resources and Environmental Control
Guidance and Regulations Governing the Land Treatment of Wastes
Part II: Land Treatment of Wastewaters
Part A: Guidance for Slow Rate Land Treatment
Part B: Regulations for Slow Rate Land Treatment

Delaware permits land application of treated wastewater to areas of unlimited public access under this document. The regulations apply to the State review and permit approval process, the reports and materials to be submitted, and the operational requirements. The guidelines address the soil science, agronomy, and land treatment science that are necessary to produce the design reports required for the permit review process.

Treatment

- Advanced level treatment with high-level disinfection is required. Treatment must include oxidation, clarification, coagulation, flocculation, filtration, and disinfection.
- Effluent should not be nitrified before application because nitrification could increase leaching of nitrate to the groundwater.
- Stipulations about how monitoring equipment is to be installed, used and maintained, as well as the method, frequency, and location of sample collection can be provided on a case-by-case basis by the regulatory agency, so that environmental and human health protection is optimized.
- Continuous on-line turbidity monitoring prior to disinfection is required. Continuous on-line monitoring of residual disinfection concentrations is required at the compliance monitoring point.

Reliability

- The regulations give the regulatory agency broad discretion to include specific permit conditions to protect the environment and the public health.
- An operating protocol must be provided by the permittee, and the protocol must be designed to ensure that the disinfection criteria will be met before the wastewater is released to storage or to the reuse system. The design must include automatic diversion of wastewater that fails to meet operating criteria.
- Provisions must be included in the design for reject water to be stored in a separate offline system or discharged to another permitted reuse system requiring lower levels of treatment, or to a permitted effluent disposal system.
- Flow measurement is required on discharge pumps, and low/high pressure automatic shutoff must be provided.
- Above-ground piping must drain when depressurized, and drain flow must go to wetted area or storage ponds.
- A plan for groundwater and effluent monitoring must be provided.
- Continuous on-line turbidity monitoring prior to disinfection is required. Continuous on-line monitoring of residual disinfection concentrations is required at the compliance monitoring point.
- The site permittee is responsible for proper maintenance and operation of all structures, systems, and equipment.
- The permittee must allow regulatory personnel to enter and inspect records, the facility, equipment, practice, or operation. Regulatory personnel may also sample or monitor any substance for the purpose of ensuring permit compliance.
- The permittee must furnish an oral report of any noncompliance that may endanger the public health or the environment within 24 h from the time the permittee has knowledge of the problem. Written notification is required within 5 days. The report must describe the noncompliance and its cause, the duration of noncompliance, and the estimated time it will continue, and the steps taken or planned to reduce or eliminate reoccurrence of the noncompliance.
- Spray field operation must be described in an operation and management plan.
- Storage must be provided, either as a separate facility, or incorporated into the treatment system if
it can be done without compromising treatment efficiency. A minimum of 15 days’ storage is required unless other measures of controlling flow can be demonstrated. Minimum storage for reject effluent is the volume of 2 days’ flow at the average daily design flow rate of the treatment process.
- Storage and irrigation pumping must not affect design hydraulic retention time.
- Storage ponds must have impermeable liners.

**Water Quality**

- BOD5 must be ≤ 10 mg/L.
- TSS must be ≤ 10 mg/L.
- Turbidity must be ≤ 5 TU (continuously monitored, prior to disinfection).
- Fecal coliforms must be ≤ 20 cfu/100 mL.
- Inorganic constituents in the effluent must be compatible with site soil and site vegetation as stipulated in a table provided to the permittee.
- Nitrate in the percolate must be ≤ 10 mg/L.
- Influent must be monitored as stipulated in the system permit.
  - A site permit will stipulate monitoring requirements and sampling frequency.
  - Continuous on-line monitoring of residual disinfection concentrations is required at the compliance monitoring point.

**Site Constraints**

- The site must be appropriately zoned by the county or municipality with jurisdiction.
- The public must be notified of the application for a permit, and hearings may be held. Permits are issued on a case-by-case basis depending on the site conditions.
- Site-specific conditions related to soil types, geology, hydrology and cultural or historical features about the site must be described. The 100 year flood elevation, existing vegetative cover, and existing land use must be described.
- Soil characteristics must be described, including slope, depth to seasonal high water table, depth to impervious strata, and erodibility.
- The design plans should include information about the nature of the wastewater to be applied, including descriptions of the average and peak daily flows, the biochemical oxygen demand, the chemical oxygen demand, the total organic carbon, the total suspended solids, ammonia, nitrate and nitrite nitrogen, Kjeldahl nitrogen, total phosphorus, chloride, sodium adsorption ratio, electrical conductivity, metals, the presence of any priority pollutants, and the pH.
- The site assimilative capacity for heavy metals must be determined on a constituent by constituent basis to determine the site life for a facility. The number of years wastewater may be applied to a site will be based on the allowable cumulative metal loading rates stipulated by the State. Irrigation must be terminated when any one of the cumulative metal limits is reached.
- Water balance calculations to determine the design water loadings and phosphorus and nitrogen balances consistent with the crop grown and the way it is managed should be provided. The limiting constituent for land application should be identified, as well as the wetted field area and required storage volume. The maximum allowable hydraulic loadings are 2.5 in/wk and 0.25 in/h.
- A plan for groundwater and effluent monitoring must be provided.
- If a perennial stream traverses or bounds a slow-rate land-treatment site, water-quality monitoring upstream and downstream of the wetted field area may be stipulated in a site permit. Domestic wells within 1000 linear ft of the site; irrigation, commercial, industrial, and public wells within 2500 ft of the site; and all abandoned wells within the treatment site must be identified. Shallow and poorly constructed wells must be abandoned and sealed. The permit applicant must demonstrate that the reuse system will not have an adverse effect on the wells.
- Spray field operation must be described in the Plan of Operation and Management. Spray field pressures must be uniform with 10% of the design pressure; otherwise alternate measures must be used to insure uniform application depth.
- Monitoring of daily rainfall, temperature, wind speed and direction may be required.
- If the seasonal high groundwater table is greater than 5 ft, the design percolation rate can be no more than 10% of the mean saturated hydraulic conductivity of the most limiting layer within the first five feet from the surface. If the seasonal high water table is less than 5 ft, drainage...
improvements must be evaluated.

- Soil samples from the wetted field area must be analyzed for pH, with other tests contingent upon the results. A site assimilative capacity for heavy metals must be determined on a constituent by constituent basis to determine site life.
- No runoff is permitted. If there is point source discharge due to drainage improvements at the site, an NPDES permit may be issued.
- Groundwater elevation data must be submitted on a periodic basis. Groundwater monitoring may be stipulated in the site permit:
  - The parameters and frequency are determined on a case-by-case basis. Tests required might include pH, chemical oxygen demand, nitrate nitrogen, total phosphorus, electrical conductivity, chloride, fecal coliform bacteria, metals and priority pollutants.
  - Groundwater influenced by the system must be monitored; one well is required up-gradient, one must be in the wetted field area of each drainage basin involved, and two wells must be placed down-gradient of the irrigation area, in each drainage basin involved. A monitoring well must also be located upgradient and downgradient of the pond treatment and storage facilities in each drainage basin intersected by the land treatment site. Stipulations are provided for construction and labeling of the wells.
- The site must be protected against flooding, ponding, and erosion. Storm runoff can be channeled through or around the site, but channeling reclaimed water is not permitted.
- If a perennial stream traverses or lies at the boundary of a land treatment site, water quality monitoring of the stream may be required, with sampling upstream and downstream of the wetted field area required.

Buffers

- Buffer zones are determined on a case-by-case basis, but they are not normally required.
- A buffer zone may be required to accommodate aerosol containment, noise, and nuisance control.

Storage

- Storage must be provided either as a separate facility or incorporated into the treatment system if it can be done without compromising treatment efficiency.
- A minimum of 15 days' storage is required unless other measures of controlling flow can be demonstrated. Minimum storage for reject effluent is the volume of 2 days' flow at the average daily design flow rate of the treatment process.
  - Storage and irrigation pumping must not affect design hydraulic retention time.
  - Storage ponds must have impermeable liners.
- Automatic diversion of partially treated wastewater to a reject wastewater storage system must be provided.
- An up-gradient and down-gradient well is required for pond treatment and storage.
Comments

Florida Department of Environmental Protection


Allowances are made for systems that differ from what is described if applicant can demonstrate that ground water and surface water quality standards can be met and that the public health will be protected. Public access allows private property not open to the public at large, and it is permitted to be used for toilet flushing, fire protection, decorative ponds or fountains, irrigation of edible crops, dust control, as well as landscape irrigation. Public access is also permitted to sites with subsurface irrigation, where the requirements for treatment fall under a different segment of the regulations.

Edible crops are limited to those that will be peeled, skinned, cooked or thermally processed before consumption. Use for toilet flushing is NOT permitted where the public will have access to the plumbing system for repairs. Other uses that may be approved include commercial laundry water supplies, vehicle washing, sewer and distribution line flushing, road and other outdoor site cleaning, concrete mixes, and ice for skating rinks.

Reclaimed water is water that has received at least secondary treatment and basic disinfection and is reused after flowing out of a domestic wastewater treatment facility.

Treatment

- Secondary treatment with filtration and high-level disinfection is required. Secondary treatment is treatment designed so that the effluent meets certain water quality limits after disinfection. The designation of high level disinfection means that additional total suspended solids (TSS) control beyond secondary treatment levels is required, and the fecal coliform limits required are more stringent than those for secondary treatment.
  - TSS control should be provided by filtration; TSS in any sample before disinfection must be \( \leq 5 \text{ mg/L} \).
- Chemical feed facilities for coagulant aids must be provided even if their use is not necessary to meet the TSS limits.
- Specific CT values are prescribed for different pre-chlorination effluent fecal coliform concentrations. Minimum allowable contact time at peak hourly flow is 15 min.
- Special evaluation and treatment stipulations are required when various classifications of ground water are used for injection of reclaimed water. A key groundwater characteristic of concern in this regard is TDS.
- If a treatment facility receives discharge from significant industrial users, a pretreatment program is required.
- Surface water, ground water, treated storm water, drinking water, and demineralization concentrate may be used to supplement the reclaimed water supply if certain stipulations are met that are specific to each supplemental water supply.
- A facility must have capacity of at least 0.1 mgd in order to provide water for reuse by slow rate land application in public areas, on residential properties, or on edible crops.
- Mixing must be rapid and uniform.
Reliability

- Reliability of the system must comply with what is designated as Class 1 Reliability and described in the document "Design Criteria for Mechanical, Electric, and Fluid System Component Reliability" MCD05, Environmental Quality Instructional Resources Center, The Ohio State University, US EPA, 1974. Class I reliability requires multiple or backup treatment units and a secondary power source.
- Piping, pipelines, valves, and outlets must be color-coded or otherwise marked to distinguish reclaimed lines from other water. Stipulations about the color and method of coding and taping are provided. Supplemental water supply pipes must be color coded differently from potable or reclaimed water lines.
- Hose bibbs may not be located above ground unless they require the use of a special tool that prevents their unauthorized use and are accompanied by signage that indicates the water is nonpotable.
- No cross-connections to potable water systems are allowed.
- If chlorine disinfection is used, continuous on-line monitoring of turbidity before disinfection and total chlorine residual at the compliance monitoring point is required.
- Continuous on-line monitoring of other disinfection residual is required if chlorine is not used.
- Permits are issued to the treatment facility, and the permittee is required to regulate and manage the individual users through binding agreements with each user.
  - A general permit is needed for the addition of a new major user that is not identified in the existing permit and is located within the area designated in an existing permit.
  - The water provider is responsible for inspections in the service area to verify connection, water use, and cross-connections are in compliance. (Separate cross-connection regulations stipulate frequency of the inspections.)
- An operating protocol for the treatment facility must be implemented. A plan must be provided for rejected effluent to be stored for subsequent additional treatment or discharged to another permitted reuse system requiring lower levels of treatment (or a permitted effluent disposal system).
- The protocol specifies the number of operators required to operate a reclamation facility and the operator classifications they are required to have. Facilities must be staffed 24 h/d, 7 d/wk or 6 hr/d for 7 d/wk with diversion of reclaimed water to a reuse system only during operator presence.
- An annual reuse report is required of all facilities treating ≥ 0.1 mgd of which a portion is reclaimed.
- Monitoring wells are required next to unlined storage ponds or lakes, unless it can be demonstrated that reclaimed water will not percolate from the pond to groundwater.
- Groundwater monitoring is required at one upgradient well located as close as possible to the site without being affected by the site's discharge (background well); and at one well at the edge of the zone of discharge down-gradient of the site (compliance well); and at one well downgradient from the site and within the zone of discharge (intermediate well). Other wells may be required on a case-by-case basis.
- Quarterly groundwater monitoring is required for water level, nitrate, total dissolved solids, arsenic, cadmium, chloride, chromium, lead, fecal coliforms, pH and sulfate. Other monitoring may be required on a case-by-case basis.
- No diversion of acceptable reclaimed water is permitted unless an operator is present.
- Reclaimed water may only be used for fire protection; alternate levels of reliability, operation controls and operator attendance may be permitted.
- Truck hauling is permitted in trucks that are not used to transport potable water or fluids of lesser quality than the reclaimed water.

Appendix 16
**Water Quality**

- In general, secondary treatment water quality limits are required.
- CBOD annual mean concentration must be ≤ 20 mg/L.
- TSS must be ≤ 5 mg/L.
- Maximum allowable fecal coliforms in any one sample is 25 cfu/100 mL, and 75% of fecal coliform tests must measure below the detection limit in a 30-day period of sampling.
- Total chlorine residual concentration must be at least 1 mg/L.
- Monitoring is required for Giardia and Cryptosporidium at the point immediately following disinfection:
  - Sampling must occur one time during each 2-year period at plants with treatment capacity ≥ 1 mgd, and one time during each 5-year period at plants with capacity ≤ 1 mgd.
  - The intervals between sampling must be < 2 years or < 5 years, depending on the same treatment capacity criteria.
- Minimum schedule for sampling and testing is based on system capacity. Parameters to be monitored include flow, pH, chlorine residual, dissolved oxygen, suspended solids, CBOD, nutrients, and fecal coliform concentrations. Specific monitoring requirements are determined on a case-by-case basis.
- Primary and secondary drinking water standards must be monitored by facilities treating more than 100,000 gpd.

**Site Constraints**

- If the treatment plant permittee does not own the property on which reclaimed water will be used or disposed of, the permittee must have a binding agreement with the owner to ensure that construction, maintenance, operation, and monitoring meet the State's legal requirements. Reclaimed water application must be controlled by an agreement with the wastewater management entity or by local ordinance.
- A public notification program, and the regulations stipulate the information that must be included.
- All potable and nonpotable water supply wells and monitoring wells within a 0.5 mile radius of the land application site shall be located and described. All surface waters within one mile of the project area must be located, and their classification, uses, and distance from the site must be identified.
- Measures to minimize aerosols must be taken within 100 ft of outdoor public eating, drinking, and bathing.
- New and expanding distribution systems should carry a minimum of 1.5 times the maximum daily flow of the treatment facility.
- Return of reclaimed water to the distribution system after delivery to the user is prohibited.
- The public must be notified of the use of reclaimed water at an irrigation site, storage impoundment or decorative water feature by the posting of advisory signs, notes on scorecards, and the like. Signs must be in English and Spanish and must read “Do Not Drink” along with an international symbol.
- Swimming pool, hot tub, and wading pool uses are not permitted.

**Buffers**

- Low trajectory nozzles are required within 100 ft of outdoor public eating, drinking, and bathing facilities to minimize aerosols.
- Indoor aesthetic features such as decorative pools or fountains that are using reclaimed water must be at least 100 ft from adjacent to indoor public eating and drinking facilities in the same room or building space.
- At least 75 ft is required between a transmission facility or wetted area and a potable water supply well, and municipalities may adopt ordinances that prohibit private drinking water wells in residential areas.
- At least 3 ft of separation must be maintained between reclaimed water lines and potable lines or sewer lines. Concrete encasement of a reclaimed line, or a vertical gap between a reclaimed water line and other lines, can lower this spacing requirement. Separation distances stipulated for reliability in rights-of-ways are recommended but not required on properties where reclaimed water
is being used.

- No setback distance is required from nonpotable wells.
- No setback is required from surface waters or developed areas.
- At least 200 ft is required between an unlined storage pond and a potable water supply well.
- Setback distances are specified for injection and recovery wells and for extended zones of discharge.

**Storage**

- Storage is not required if another permitted reuse system or effluent disposal system is included in the design that ensures continuous facility operation.
- If storage ponds are required to accommodate low customer demand for water, sizing criteria are provided, with a minimum volume equal to three times that portion of the average daily flow of the total reuse capacity for which no alternative reuse or disposal system is permitted.
- Existing ponds or lake can be used for storage of excess treated water as long as the storage does not impair the ability of an impoundment to serve as a storm water management unit.
- Storage can also be provided by use of an aquifer storage and recovery system (ASR), where reclaimed water is injected into a subsurface formation for storage and then recovered at a later date.
- If storage is required for reject flow, minimum volume required is one day flow at the average daily design flow of the treatment facility or the average daily permitted flow of the reuse system, whichever is less. Reject ponds must be lined or sealed to prevent seepage.
Comments

Georgia Department of Natural Resources, Environmental Protection Division. 
Guidelines for Water Reclamation and Urban Water Reuse (Revised February 20, 2002).

Reclaimed water is domestic wastewater or a combination of domestic and industrial wastewater that has been treated to stringent effluent limitations such that the reclaimed water is suitable for use in areas of unrestricted public access.

Reclaimed water may be used for irrigation of golf courses, residential and commercial landscaping, parks, athletic fields, roadway medians, and landscape impoundments.

Treatment

- A biological oxidation process or the equivalent is required; multiple clarification units (or other method, such as membrane filtration) may be acceptable.
- Coagulation is required, although chemical feed systems may remain idle if, after start-up of the system, the 3 NTU level can be maintained without chemical addition.
- Filtration and continuous disinfection or equivalent (other process trains such as physical-chemical treatment followed by membrane filtration) are required after secondary treatment (as defined in 40 CFR 133.102): 30 mg/L BOD5, and 30 mg/L SS.
- Monitoring for detectable disinfection residual or recording of UV output and transmittance is required.

Reliability

- Piping and valves must be labeled.
- If a user supplements reclaimed water with potable, an air gap must be provided between the potable source and the reclaimed water system.
- The system must automatically divert product if it does not meet the 3 NTU requirement, or if any portion of the disinfection system fails.
- Spare parts must be available so that repairs can be completed and the system placed back into operation within a maximum of three days, or emergency storage must be provided. Where there is no alternative method for disposal, multiple process units for critical units are required.
- Permittee is required to inspect and monitor user sites for proper use of reclaimed water. Routine equipment inspections and a calibration schedule are required, and the schedule of inspections should be shown in the operations manual.
- The design must include provisions to isolate and bypass all process units. Also, the system must be able to treat peak flows with the largest unit out of service.

Water Quality

- BOD5 must be ≤5 mg/L, monitored weekly.
- TSS must be ≤5 mg/L, monitored weekly.
- Turbidity must be ≤3 NTU, monitored continuously after filtration.
- Fecal coliform monthly geometric mean of all valid results for a reporting period must be ≤ 23 cfu/100mL; maximum in any daily sample must be ≤ 100 cfu/100 mL.
- Detectable disinfectant residual at the delivery point is strongly recommended. (Monitoring for detectable disinfection residual or recording of UV output and transmittance is required).
- pH between 6 and 9, monitored daily.
Site Constraints

- A written agreement is required between a reclaimed water user and the permittee; the user applies to the permittee. Irrigation times must be stipulated in the written agreement.
- Public notice of the permit application is required.
- The permittee must advise the purveyor of potable water that reclaimed water is being used in the area.
- New developments desiring reclaimed water shall provide a distribution system.
- No irrigation spray is allowed outside established boundaries. Irrigation requires a permanent underground system; low trajectory nozzles are required to minimize aerosol formation if within 100 ft of eating, drinking, or bathing.
- A pumping pond may not receive other runoff water. No runoff of reclaimed water should occur.
- Signage or other public notification methods are required.
- Users must document their participation in the public information program (i.e., education).
- Groundwater monitoring may be required on a case-by-case basis.
- It is permissible for reclaimed water to mix with storm water on the distribution site.
- No reclaimed water may be used in dwelling units; reclaimed water may not be used for human or animal consumption, edible crop irrigation, body contact recreation, or sharing between two properties.

Buffers

- Buffer requirements are stipulated on a case-by-case basis.

Storage

- Accommodations for wet weather periods can be made by providing storage on site or with the user OR with the provision of additional land OR by obtaining an NPDES permit for the flow to be diverted to surface water.
- A storm water detention pond can be used to store reclaimed water, but it must be sized appropriately with a control structure and two outlets.
Comments

Hawaii State Department of Health
Wastewater Branch
Guidelines for the Treatment and Use of Recycled Water, November 22, 1993, revised May 15, 2002

The guidelines are to be reviewed and, if necessary, updated every five years.

Legislation has been proposed to amend Administrative Rule, Title 11, Ch 62, Wastewater Systems, to convert the guidelines to regulations.

Reuse of the highest quality recycled water (R-1 class) can include direct contact irrigation of edible crops eaten raw, as well as fire fighting, high pressure water blasting, animal drinking water (with some exceptions), commercial and public laundries, industrial cooling (under some circumstances), toilet flushing, decorative fountains (with some conditions), basins at fish hatcheries, and washing of hard surfaces.

The guidelines distinguish between transmission lines on a producer site, and distribution lines on a consumer site.

Recycled water means treated wastewater that, by design, is intended or used for a beneficial purpose.

Treatment

- Oxidation, filtration and disinfection are required, such that 99.999% of plaque-forming units of F-specific bacteriophage MS2 or polio virus in the water are inactivated and/or removed and the water meets the stipulated fecal coliform requirements (see below).
- Suggested treatment schemes include filtration with continuous chemical addition/coagulation.
- Chemical pretreatment facilities are required in all cases where granular media filtration is used; membrane filtration may be used.
- Chemical addition/coagulation can be accomplished with a rapid mix unit, or an in-line mixer; flocculation and aggregation may occur subsequently in the lower layers of a deep bed up-flow filter, or in the upper layers of a deep bed gravity filter. Coagulant types and doses, mixing and dispersion requirements, and residence times are stipulated.
- Theoretical chlorine contact time should be 120 minutes or more, and actual modal contact time should be 90 minutes or more, throughout which time the chlorine residual must be 5 mg/l or greater. (Chlorine contact time may also be set by demonstrating that it reliably achieves the virus reductions noted above.) Disinfection must limit fecal coliform bacteria to stipulated water quality limits. The chlorination facilities shall have adequate capacity to maintain a residual of 10 mg/l.
- When UV is used, final effluent must meet the applicable provisions of the UV Guidelines for Drinking Water and Water Reuse dated December 2000 or the latest version, published by the National Water Research Institute (NWRI) and the American Water Works Association Research Foundation (AWWARF).
- UV disinfection systems must be able to meet the required inactivation levels for the target microorganisms. Detailed guidelines for the UV disinfection system design are provided.
- Provisions are included for the demonstration of alternate treatment methods that can meet the cited water quality and reliability requirements.
Reliability

- Process piping, equipment arrangement, and unit structures should allow for efficiency and ease of operation and maintenance, and provide maximum flexibility of operation. Flexibility should permit the necessary degree of treatment to be obtained under varying conditions. All aspects of the facility design shall allow for routine maintenance of treatment units to prevent deterioration of the facilities effluent.
- Distribution lines and service lines, valves, and other appurtenances must be colored purple, suggested color Pantone 522 or equal, and embossed or be integrally stamped/marked "CAUTION: RECYCLED WATER - DO NOT DRINK," or be installed with a purple identification tape, or a purple polyethylene wrap, suggested color index 77742 violet #16, Pantone 512 or equal. Stipulations for identification taping are also cited.
- Valve boxes should have a special triangular, heavy-duty cover. All valve covers on offsite reclamation transmission water lines should have non-interchangeable shape with potable water covers and have a recognizable inscription cast on the top surface "Recycled Water."
- Either an in-line type or end-of-line type drain (blow-off) assembly must be installed for removing water or sediment from a pipe. The line tap for the assembly shall be no closer than 18 inches to a valve, coupling, joint, or fitting, unless it is at the end of the line.
- Pumping facilities to transmit or distribute recycled water must identify the type of water being conveyed, provide acceptable backflow protection, avoid release of recycled water, and provide for proper drainage of the pump packing seal water. Any potable water used as seal water for non-potable water pump seals should be adequately protected from backflow.
- Hose bibs are not allowed on recycled water systems. Quick couplers that are different from those on the potable system must be used if hose connections are necessary. Hoses used with recycled water systems shall conform to the color code and should not be used with potable water systems. When potable quick couplers are within 60 feet of the recycled system, both shall be equipped with appropriate signs. Signs should identify the recycled water quick coupling.
- The pressure in potable water lines should be at least 10 psi higher than in reuse water lines.
- Horizontal and vertical clearances between potable water and recycled water lines are stipulated with water system standards, along with right-of-way widths and minimum cover requirements.
- No pipes or pumps shall be installed that would circumvent critical treatment processes and possibly allow inadequately treated effluent to enter the recycled water distribution system.
- If both potable water and recycled water are supplied, then backflow protection with an approved air gap must be provided at the potable water service connection.
- If temporary potable water connections to the recycled water system are required, the connections must be protected in the same manner as a permanent connection.
- Fully automatic controllers should be used to operate on-site distribution valves. They should be equipped with moisture sensors to avoid activation during rainy periods and be capable of delivering varying flow on varying time schedules.
- The facility must be attended constantly, or alarms must be telemetered to an operator on call. If rapid attention to failure cannot be assured, automatically actuated emergency control mechanisms must be installed and maintained to handle: loss of power, high water levels, failure of pumps or blowers, high head loss on filters, high effluent turbidity, loss of coagulant or polymer feed, or loss of chlorine residual. If UV disinfection is used, monitoring and alarm designs specifically for UV systems must be provided.
- It is recommended that an individual alarm device sound at location and be connected to a master alarm to sound at the location where it can be conveniently observed by the operator.
- The person to be warned should be the facility operator, superintendent, or any other responsible person designated by the management of the reclamation facility and capable of taking corrective action.
- The alarms should be designed to record automatically all high and low priority conditions.
- All required alarm devices should be independent of the normal power supply of the reclamation facility.
- Filtered effluent failing the turbidity limits must be diverted to a backup disposal system.
- Provisions must be available to otherwise treat, store, or dispose of the wastewater until the corrections have been completed.
Continuous turbidity monitoring and recording of the secondary effluent turbidity is required, such that subsequent coagulant addition can be automatically adjusted to provide coagulant dosages under varying conditions.

A continuous recording turbidimeter shall be installed and operated prior to and after the filtration process. A continuous recording may be provided for monitoring each filter to ensure that the filtered water meets the performance criteria.

Automatic control of chlorine dosage and automatic, continuous measuring and recording of chlorine residual are required. The chlorination facilities shall have adequate capacity to maintain a residual of 10 mg/L.

The facility shall be capable of operating during power failures, peak loads, equipment failures, treatment plant upsets, and maintenance shutdowns.

Standby filtration capacity must be capable of processing the peak flow at the approved filtration rate under the most stressful conditions.

All coagulation process units should have standby feeders, adequate chemical storage, and adequate reserve chemical supply.

Chlorination standby equipment must be provided to replace the largest unit during shutdowns; spare parts must also be available.

Facilities with direct filtration should have, at a minimum, two operating units per treatment process (coagulation or rapid mix, and flocculation).

A standby power source shall be provided at all water reclamation treatment facilities and distribution pump stations. Standby power source means an automatically actuated self-starting, alternate energy source maintained in immediately operable condition and of sufficient capacity to provide necessary service during failure of the normal power supply.

- D.C. control power switch-over mechanisms should be installed together with an automatic starter.
- Power distribution to main control centers or control panels within the plant for the critical loads should be supplied from motor control centers connected to in-plant unit substations.
- Critical in-plant power loads should be divided within the motor control center by tie breakers.
- The motor control center should be supplied with power at all times to treat the recycled water.
- Redundancy should be provided for instrumentation and control panels associated with the operation of critical process loads.
- It may be acceptable to connect non-critical process loads to only one power source. However, non-critical loads within a unit operation should be divided as equally as possible between motor control centers so that a single failure will not result in complete unit operation loss.
- The power supply reliability design specific for UV disinfection systems is provided in the guidelines.

Storage or a backup disposal system is required: Provisions for an automatically actuated emergency storage or disposal system and diversion to an approved alternate reuse area is required and shall include all necessary sensors, instruments, valves, and other devices to enable fully automatic diversion of untreated or partially treated wastewater to approved emergency storage or disposal in the event of treatment process failure or violation of operational parameters, and a manual reset to prevent automatic restart until the problem is corrected.

A producer must establish an inspection program for the distribution system, and the guidelines specify the items to be inspected.

A producer must have a treatment monitoring program that stipulates the frequency and location of sampling.

Daily records must be kept of maximum turbidity from clarified water; lowest operational UV dose; highest turbidity from filtered effluent; type and weight of coagulants and/or polymers used; high, low, and average flow measurements of recycled water produced; weight of chlorine used; lowest residual disinfection concentration after contact time; and confirmed fecal coliform data should be recorded daily.

When a backflow device is tested, the test should be performed by a certified tester, and records of the tests, repairs, and overhauling must be kept and also submitted to a cross-connection control inspector.

Stipulations are provided for instances when the recycled water is trucked to a distribution site. The vehicle must be labeled, the truck tank cannot have previous exposure to a variety of potentially
contaminating substances, and any hose or piping to the truck cannot be attached to a potable water supply except with an air gap. The truck may not be used to haul potable water after it has carried recycled water.

**Water Quality**

- Filtered effluent turbidity must be \( \leq 2 \) NTU.
- Median fecal coliform concentration from last seven day's samples of disinfected effluent must be \( \leq 2.2 \) cfu/100 mL. Maximum fecal coliform concentration in any one sample must be \( \leq 200 \) cfu/100 mL; in no more than one sample within a 30-day period may the fecal coliform concentration exceed 23 cfu/100 mL.
- Removal of 99.999\% of plaque-forming units of F-specific bacteriophage MS2 or polio virus is required.
- Composite BOD5 samples must be collected at least weekly, with at least five tests per month required.
- TSS grab samples from treated water before disinfection must be taken at least weekly, with at least five tests per month required. The TSS should be correlated to corresponding turbidity readings.
- Fecal coliforms must be sampled daily for spray irrigation systems.

**Site Constraints**

- The producer of recycled water must supply the user with a copy of the state recycled water guidelines. There must also be a written agreement between a producer and a user of recycled water.
- The producer of recycled water is responsible for its quality. The producer must supply the user with a site management plan, but the user is responsible for maintaining all on-site facilities. Inspection, supervision, and employee training must be provided by the user.
- A design proposal must stipulate the schedule of irrigation and irrigation instructions for the operator.
- The user must designate a recycled water user supervisor.
- A public education plan and an employee training plan must be developed. Detailed specifications are provided about the components of the employee training plan.
- A site development proposal must include information about wind, flood plains, and soil characteristics. The locations of exterior drinking fountains must be identified. (Irrigation spray may not contact an external drinking water fountain.)
- Irrigation over a public drinking water aquifer should not exceed consumptive rates.
- Stipulations are provided to help avoid mosquito problems due to recycled water impoundment, or wetlands design or operation. Water should be managed such that uses do not contribute to proliferation of mosquitoes.
- BMPs to prevent ponding must be implemented.
- The maximum grade for spray irrigation is 15\% for forage, turf and orchards.
- No discharge, runoff, or overspray is allowed beyond the approved use area boundaries.
- Formation of a Groundwater Management Committee is called for in the guidelines, and the Committee will determine target water quality criteria for aquifers underlying a reuse project, target mass loading rates of specific parameters to protect underlying potable water aquifers, and determine site-specific groundwater monitoring strategies.
  - Nitrate and total phosphorus concentrations in percolate from a lysimeter in the irrigation area must be \( \leq 10 \) mg/L and 1 mg/L, respectively.
  - Stipulations are also provided for monitoring groundwater for heavy metals.
- Maximum grades for spray irrigation are 15\% for forage, turf and orchards.
- Irrigation over a public drinking water aquifer should not exceed consumptive rates.
- The design proposal must stipulate the schedule of irrigation, and include irrigation instructions for the operator.
- Nitrate and total phosphorus concentrations in percolate from a lysimeter in the irrigation area must be \( \leq 10 \) mg/L and 1 mg/L, respectively. Stipulations are also provided for monitoring
groundwater for heavy metals.

- No runoff may leave the use area.
- Signage is required
- A public education plan and an employee training plan must be developed. Detailed specifications are provided about the components of the employee training plan.
- A Groundwater Management Committee has been established to determine target water quality criteria for aquifers underlying a reuse project, target mass loading rates of specific parameters to protect underlying potable water aquifers, and to determine site-specific groundwater monitoring strategies.

Buffers

- No irrigation is allowed within 50 ft of a drinking water supply well, and the edge of an impoundment must be >100 ft from a drinking water supply well.

Storage

- The design and operation of system storage capacity shall be sufficient to assure the retention of the recycled water under adverse weather conditions, harvesting conditions, maintenance of irrigation equipment, or other conditions that preclude reuse.
- If storage is provided in the form of a restricted recreational impoundment or landscape impoundment, runoff should be prevented from entering the storage impoundment unless the impoundment is sized to accept the runoff without discharge, or an NPDES permit has been issued for the discharge; no discharge is permitted to any impoundment with less than two feet of freeboard.
- To retain its contents, an impoundment shall have liners impervious to water. Liner stipulations are provided.
- Stipulations are provided for exceptions to the storage requirement and to the 20 day retention time required.
- Storage for reject water is required if another backup disposal system is not provided. Minimum capacity for reject storage is the volume equal to one day's flow at the average daily design flow of the reclamation facility or the average daily design flow of the approved alternate reuse area, whichever is less.
Comments

Idaho Department of Environmental Quality

Unrestricted public access is subdivided into areas where individuals will have access or exposure (golf courses, cemeteries, roadside vegetation), and areas where children will have access or exposure (parks, playgrounds, schoolyards); the latter stipulations are presented in this section. Sites may have other restrictions on a case-by-case basis.

Idaho also allows treated wastewater to contact the edible portion of raw food crops, but the disinfection requirements are more stringent than those listed here.

Treatment

- Water must be oxidized, coagulated, clarified, filtered (or treated by an equivalent process), and adequately disinfected.

Reliability

- An Operation and Maintenance Manual (OM) must be provided that describes the plan of operation, maintenance, and management of the wastewater treatment system.
- A permittee must properly maintain and operate all structures, systems, and equipment for treatment, control, and monitoring.
- A permittee must report any noncompliance that may endanger public health or the environment within 24 h of knowledge of the event and submit a written report within five days of knowledge of the event that describes the steps taken to reduce or eliminate a reoccurrence of noncompliance.
- The OM manual must state the design provisions that will allow flow diversion when the system is shut down or when bacterial concentrations exceed allowable limits.

Water Quality

- Median total coliform concentration must be \( \leq 2.2 \) cfu/100 mL for all samples analyzed in the past seven days. Maximum total coliform concentration in any sample must be \( \leq 23 \) cfu/100 mL. Sampling should occur daily.
- If the system is operating at less than 75% of the nitrogen permit limit (125% of the crop uptake), and no industrial users are contributing to the municipal system providing the treated wastewater, the following parameters may be sampled twice per season rather than monthly: total Kjeldahl nitrogen, chemical oxygen demand, total P, ammonia nitrogen, nitrate + nitrite nitrogen, total dissolved solids, and pH.

Site Constraints

- Wells, public and private drinking water supply sources, springs, wetlands and surface waters on the site must be identified.
- 25-, 50-, and 100-year flood plains must be identified.
- Irrigation must occur during periods of non-use by the public.

Buffers

Storage

Appendix 26
These regulations apply to secondary and tertiary treated domestic wastewater, and to land upon which crops, turf, or trees are grown. Public access areas include urban parks, forest preserves and golf courses.

**Treatment**

- The minimum treatment required is a two-cell lagoon with tertiary sand filtration and disinfection, or a mechanical secondary treatment facility with disinfection.

**Reliability**

- Spare equipment must be available on site.
- The treatment area must be fenced and include signage.
- A site plan must include monitoring equipment for air temperature, soil temperature, precipitation, wind speed and direction, and depth to groundwater.

**Water Quality**

- Calculations for the loading rates of BOD5, nitrogen, phosphorus, and water onto vegetation receiving irrigation spray must be submitted.

**Site Constraints**

- A site design must identify present and proposed water supply wells, abandoned wells, surface waters and waterways, wetlands, and 10-yr floodplains. No floodplains with a return frequency < 10 yrs may be used unless storage or an alternate irrigation site is available.
- Groundwater must be > 4 ft below the surface.
- A water balance that includes the wastewater, run-on from adjacent areas, precipitation, evapotranspiration, permeability, groundwater recharge rate, and effect on water table depth and subsurface tile drainage must be provided.
- Slopes must be < 8% on sodded fields and forested areas. Steeper slopes must have runoff control that is consistent with Soil Conservation Service recommendations.
- Irrigation equipment specifications are cited; spray equipment must be specified and information about the design pressure, wind velocity, height of spray, and spray mist drift distances must be provided.
- The irrigation spray must be uniformly distributed; a design wind velocity of 15 mph must be used for sites in urban areas.
- The design daily percolation rate should be < 10% of the minimum soil permeability. The design must provide for alternate wetting and drying periods and maintenance of aerobic conditions in the topsoil.
- There must be > 10 ft of earth cover over bedrock.
- Nitrogen application should be within agronomic rates and include any application of chemical fertilizer.
- Irrigation must not contribute runoff. No discharge to wetlands, streams, waterways or other surface waters is allowed.
- No spray irrigation is allowed during precipitation.
- Signage is required at 100 yd intervals.
- Existing groundwater must be chemically analyzed, and potential impacts on existing groundwater movement and quality must be evaluated.
- Groundwater monitoring is required, with stipulations about location of wells, well construction,
sampling depths, and parameters to be monitored. Water quality must be compliant with groundwater standards.

**Buffers**

- Setback distances must conform to the terms of state groundwater protection legislation.
- The wetted area cannot encroach on wetlands, streams, waterways, surface waters, public road rights of way or residential lot lines.
- No distance restriction from residential lot lines is imposed if application occurs only during hours between dusk and dawn.
- The treatment area must include signage.

**Storage**

- Storage is required, with the storage volume determined by one of two methods. One method bases the volume on a rational design that requires sufficient capacity for diversion (due to climate constraints, land cultivation, equipment maintenance or the like) during the wettest year with a 20-yr return frequency. The second method requires capacity for 150 days' production at the average design flow.
- Lagoon storage is acceptable.
- Storage capacity must be provided for high groundwater periods.
The Office permits land application to land where public access can occur, but only for land with a low potential for public exposure. Access to such land is to be restricted for 30 days after land application of domestic wastewater.

Treatment

- Secondary treatment is required, also any additional treatment necessary to produce effluent that meets the stated water quality limits.
- Treatment may be by activated sludge processes, trickling filters, rotating biological contactors, stabilization pond systems, or other approved secondary treatment process.
- Disinfection may be by chlorination, ozonation, chemical disinfectant, UV radiation, membrane processes, or another approved method.

Reliability

- The discharge pipe must be equipped with a water-tight valve and a sanitary cap or plug. The inlet must prevent nuisance conditions, safety hazards, or the harborage and breeding of vectors.
- Alternative power must be provided to operate pathogen reduction equipment so that water quality limits are met if power is interrupted. Alternatively, provide an effective disinfection method that does not require electricity for operation.
- Land application must be conducted under the supervision of a certified wastewater treatment plant operator or a person with at least one year of experience in land application management practices and procedures.
- Application rates and site conditions must be recorded daily. Cumulative amounts of certain designated pollutants must be tracked:
  - User must indicate the location of each site receiving water on a given day, the number of acres to which water is applied, and the total amount of water applied to each site.
  - User must report how site restrictions and management requirements are being met.
- Producer must notify regulatory agency if cumulative application of a designated metal is greater than 90% of the quantity specified within 30 days of that level being reached.

Water Quality

- BOD5 must be ≤ 10 mg/L, monitored weekly.
- The mean TSS measured before disinfection must be ≤5 mg/L in 24 h period, monitored daily.
- The median fecal coliform value for the last seven days for which analyses have been completed must be “none detected.” The maximum fecal coliform concentration on any day must be ≤ 14 cfu /100 mL. Fecal coliforms must be monitored daily by membrane filtration or fermentation tube test.
- pH between 6 and 9, monitored weekly.
- If chlorination is used, the total chlorine residual after a minimum contact time of 30 minutes must be ≥1 mg/L, monitored daily.
- Monthly monitoring of total nitrogen, ammonium nitrogen, nitrate nitrogen, phosphorus, and potassium is required.
- Annual monitoring of a list of specified metals is required.
Site Constraints

- A site-specific land application permit is required.
- Application in a flood plain is not permitted unless the water will not enter a wetland or other waters of the state.
- Slope must be ≤ 6%.
- No irrigation is permitted if:
  - the seasonal high water table is within 18 in. of soil surface, or if the seasonal high water table is within 36 in of the soil surface AND any soil layer between 18 in and 36 in below the surface has a permeability of greater than 2 in/hr.
  - No application of irrigation water is permitted if the moisture holding capacity of the soil has been exceeded.
- A minimum depth of 20 in soil over bedrock is required.
- The pH of the receiving soil must be at least 5.5. Methods for calculating the maximum allowable nitrogen loading rates are provided, and heavy metal maximum loadings are stipulated. If the water contains PCBs ≥ 2 mg/dry kg, irrigation is prohibited.
- Irrigation water may not leave the land application site.
- Irrigation on frozen or snow-covered land is not permitted unless the water will not enter a wetland or other waters of the state. Irrigation is not permitted where it is likely to adversely affect a threatened or endangered species or its critical habitat, or where an historic preservation designation requirement prohibits it.
- Unauthorized access to off-site storage must be prevented by locks or fencing and signage.

Buffers

- Irrigation water must be applied:
  - a minimum of 200 ft from potable water supply wells or drinking water springs,
  - a minimum of 300 ft from any waters of the state,
  - a minimum of 300 ft from any residence.
- A management plan has to be approved that stipulates certain conditions about setbacks and application rates.
- Off-site storage must not be within 1000 ft of a residence or public building, within 300 ft of any state waters, within 200 ft of any well, or in a flood plain.

Storage

- A minimum of 90 days storage capacity is required unless an equivalent means of meeting the requirement is approved.
- If reduction, loss or failure of power to disinfection equipment occurs, land application and discharge to storage (for later irrigation) must cease for 72 hours.
- Storage must have a minimum of 1 ft freeboard.
- Off-site storage in underground storage tanks must comply with existing regulations.
- Stipulations are provided for storage structure and construction. Earthen lagoons are permitted, but the setback requirements differ, and a statement from the water producer or the user is required accepting responsibility for closure and abandonment.
Application of treated wastewater to public use areas is permitted; the emphasis of these standards is on distribution site stipulations.

**Treatment**

- The minimum required treatment is a primary lagoon-cell receiving ≤ 25 lb BOD5/acre-day. Additional treatment may be required on case-by-case basis.
- Disinfection is required prior to spraying and after storage. A minimum of contact time of 15 min is required for disinfection.

**Reliability**

- Piping should be marked.
- A parts inventory must be maintained.
- Effluent monitoring is required prior to site application. Monitoring frequency depends on flow; flow greater than 2 MGD requires monthly reporting.
- A minimum of two storage cells is required; they must be capable of operating in parallel or series.
- No discharge from storage to a receiving waterway is allowed unless an NPDES permit is obtained.

**Water Quality**

- Fecal coliforms must be monitored.
- A chlorine residual 0.5 mg/L is required.
- The following parameters must be monitored unless it can be shown that they are present in insignificant amounts: TOC, TDS, SAR, conductivity, total N, ammonia-N, organic-N and nitrate-N, total P, chloride, pH, alkalinity, hardness; and specified trace elements.

**Site Constraints**

- Preliminary groundwater and soil testing are required. There must be >5 ft soil overlaying any sand or gravel layers at the site. The user must specify the need for under-drainage or withdrawal, the effects of the system on the direction and rate of groundwater flow, the extent of the recharge mound. Irrigation in areas prone to floods at a frequency greater than once every ten years require alternate land for disposal. Groundwater table must be > 5 ft below the surface.
- Design must achieve uniform distribution.
- Slope must be < 5% or a runoff control plan must be developed according to SCS and approved by the Soil Conservation District.
- No public access is permitted during spraying.
- Spray equipment must minimize aerosols.
- Hydraulic loading rate requires compliance with stipulated water balance calculations repeated for each month of application. Application must be < 1/2 design sustained permeability rate and < 1 inch/hr. Water percolation is limited to < 10 inches monthly. Nitrogen, phosphorus, salinity, and trace element loadings are stipulated.
- The wetted disposal area must have soil at least 15 ft overlaying any rock, limestone, or impermeable structure.
- No application is allowed during frost or rainfall.
- Drinking water fountains must be protected from direct or windblown reclaimed wastewater spray.
- Signage is required, and trespassing is forbidden. Notification on golf scorecards is required;
signage at water hazards is also required.
- Groundwater monitoring is required, adjacent to the site, at upstream and downstream locations. The quality of groundwater after dilution with affected native groundwater is stipulated; no significant detrimental change in groundwater is allowed. Discharge effluent from the irrigation process requires an NPDES permit.
- Golf course irrigation is given as an example of a permissible application of slow rate land application to public use areas.

**Buffers**
- Wetted area must be > 1000 ft from a shallow public water supply well.
- Wetted area must be > 500 ft from a public lake or impoundment.
- Wetted area must be at least 0.5 mile from any public lake or impoundment used as a source of raw water by a potable water supply.
- Wetted area must be >300 ft from existing dwellings or public use areas.
- There must be >50 ft between a property line and wetted area; case-by-case exceptions may be allowed.
- The wetted area must be > 400 ft from a potable water supply not on the property.
- The wetted area must be >300 ft from a structure, stream, or other land feature that may provide a direct connection between the ground water table and the surface.

**Storage**
- Storage requirements stipulated by state region.
Kansas Department of Health and Environment

Kansas does not have any statutes or regulations addressing use of reclaimed wastewater. Reclaimed wastewater is often used in the state for irrigation of both crop lands and public lands, such as golf courses and ball fields. In order to assure the safe reuse of wastewater for irrigation purposes, KDHE incorporates “supplemental conditions” language into the NPDES permits for those facilities which wish to utilize irrigation.

For facilities that wish to utilize wastewater effluent for irrigation of adjacent crop lands, we include a basic three sentence supplemental conditions which requires that no water run off the property, irrigation water shall be obtained only from the final cell of a multi-cell lagoon treatment system, and that no crops designated for direct human consumption be irrigation with wastewater effluent.

For permittees who desire to irrigate areas such as golf courses, ball fields, or cemeteries where there is a high degree of potential for public contact, we include a more extensive set of supplemental conditions in the NPDES permits. The wastewater must be disinfected to 200 fecal coliform colonies/100ml to be met.

To date other uses for reclaimed wastewater, such as groundwater recharge, have not been seriously considered. Additionally, there has been no interest in the distribution and sale of treated effluent through a distribution system for purposes such as residential irrigation. Most of the irrigation in Kansas occurs in the semi-arid western half of the state, where the use of effluent for irrigation conserves municipal wastewater. Irrigation is also utilized by some cities with non-discharging wastewater stabilization lagoon systems as a method for disposing of excess wastewater when evaporation is not sufficient to maintain normal operating levels.

Mark E. Gerard, P.E.
Technical Services Section
Bureau of Water
July 31, 2002

Treatment

Reliability

• No cross-connections are allowed between treated wastewater and potable water supply lines.
• Maintenance/repairs to the system may be tested any time that the system operator is present and the public is not present.
• Monitoring is required during any calendar month in which any golf course, driving range, cemetery, or softball complex is irrigated with effluent. Monitoring at each distribution site is required, for chlorine residual weekly, and for fecal coliforms monthly. Quarterly reporting of monitoring results is also required.

Water Quality

• Supplemental condition language includes a stipulation that the wastewater be disinfected to ≤ 200 cfu/100 mL monthly average, and a chlorine residual must be maintained at ≥ 0.1 mg/L free or ≥ 1.0 mg/L combined.
• Sampling locations are designated. They include the sprinkler head or sampling tap at the end of the distribution system, for each application site of a given reclamation facility.
Site Constraints

- For crop irrigation, no tail water runoff to state surface waters is allowed, and no ponding is permitted.
- Public access is not allowed while irrigating, unless fecal coliform limits are reduced to 20 cfu/100 mL.
- Signage is required around any reclaimed wastewater holding pond. Notification on golf scorecards is also required.
- Crops for direct human consumption may not be irrigated with reclaimed water.

Buffers

- No runoff to adjacent landowners is permitted.
- Irrigation must occur while the public is restricted from access.
- No irrigation spray is allowed to drift to areas used for picnicking, public drinking fountains, potable water hose bibs, private residences, or any other areas where food or drink is routinely prepared or served.

Storage
Comments
Kentucky Department of Environmental Protection
Division of Water

Kentucky allows land application of sludge, but it does not allow land application of treated wastewater in areas of public access.

Treatment
Reliability

Water Quality

Site Constraints

Buffers

Storage
Comments

Louisiana Department of Environmental Quality

Treatment
Reliability
Water Quality
Site Constraints
Buffers
Storage
Comments

Maine Department of Environmental Protection

There are no specific guidelines or regulations for wastewater reclamation projects in Maine. Proposed projects would be permitted on a case-by-case basis.

Greg Wood
July 8, 2002

Treatment

Reliability

Water Quality

Site Constraints

Buffers

Storage
MARYLAND

Comments

Maryland Department of Environment
Guidelines—For Land Treatment of Municipal Wastewater
Revised January 8, 2001

New regulations will be written to comply with legislative requirements stipulated in Maryland Senate Bill 726 entitled “Reclaimed Water,” which was signed into law April 1, 2002. Land treatment systems are regulated by State Groundwater Discharge Permits Systems, and they are also evaluated by county government for consistency with the county’s Ten-Year Comprehensive Water and Sewage Plan.

Treatment

Reliability

- Monitoring for dissolved solids, nitrate, total phosphorus, and total nitrogen is required. Monitoring is also required in at least two wells that are adjacent to the irrigation site and down gradient from the disposal site. Monitoring frequency is stipulated on a case-by-case basis.
- If groundwater degradation becomes evident, steps must be taken to determine the cause, and any necessary corrective measures must be taken.

Water Quality

- BOD₅ should be ≤ 70 mg/L.
- TSS should be ≤ 90 mg/L.
- Fecal coliforms must be ≤ 3 MPN/100 mL for golf courses.
- pH between 6.5 and 8.5.

Site Constraints

- A public hearing is required to review the permit application.
- Subsurface geology, including the hydraulic conductivity and porosity of soil and rock formations must be reported. The groundwater flow direction must be identified, and the location of nearby private wells must be identified. Existing groundwater quality must be reported before a permit is approved. The soil texture must be USDA clay loam to sandy loam; site must drain moderately well to very well.
- At least one monitoring well must be installed in an area up gradient from the disposal site. The well must be screened from the seasonally high groundwater table downward 15 ft.
- Specifications are provided for monitoring well materials and installation and for sample withdrawal.
- Present or future effects of domestic or commercial pumping on the groundwater flow must be evaluated.
- Depth to groundwater or bedrock must be greater than or equal to 4 ft, except on the Eastern Shore, where a minimum of 2 ft must exist between the soil surface and the groundwater table.
- The most restrictive soil horizon must permit permeability rates of 0.2-6 in/h
- Slope must be less than or equal to 15% on cultivated lands and 25% on uncultivated (forested) land.
- A complete vegetation cover is required.
- Annual average application rate will generally range between 0 and 2 in/wk.
- A reserved area of 25% of the total wetted field area should be provided for future adjustment of the application rate.
- Recommended loading cycle is 1-day load and 6-day rest.
- If groundwater degradation becomes evident, steps must be taken to determine the cause, and any necessary corrective measures must be taken.
Buffers

- The distance from the wetted perimeter of spray irrigation areas to property lines, waterways and roads must be ≥ 200 ft.
- When spray areas are located adjacent to housing developments, parks, or other areas where people congregate, a wetted area buffer of 500 ft is recommended. Exceptions may be permitted.
- If a windbreak is provided or a non-spray irrigation system is employed, the buffer zone may be as low as 50 ft.

Storage

- Storage must be provided for flows generated during periods when treated wastewater cannot be applied to land. Storage capacity requirements will be a function of the climate where the system is located.
- No less than 60 days' storage will be permitted.
The guidelines are intended to provide applicable standards for reuse projects that will be permitted under the Groundwater Discharge Regulations (a Groundwater Discharge Permit is required for drip or spray irrigation). Some projects may also involve the Massachusetts Environmental Policy Act and/or local permits.

The guidelines for urban reuse refer to golf course and landscape irrigation and toilet flushing. Guidelines for irrigation at nurseries are similar to those for golf course irrigation. Reclaimed water irrigation at greenhouses is not allowed. Urban reuse guidelines also include for toilet flushing. The guidelines summarized below are those for urban reuse.

**Treatment**

- Secondary treatment, filtration, and disinfection are required, sufficient to reach BOD and TSS ≤ 30 mg/L. Filtration means passage through natural undisturbed soils or other filter media such as sand and/or anthracite. Disinfection means the destruction, inactivation, or removal of pathogenic microorganisms by chemical, physical, or biological means. This may be accomplished by chlorination, ozonation, other chemical disinfectants, UV radiation, membrane processes, or other processes.
- If proven innovative/alternative technologies deliver comparable effluent quality to these traditional forms of treatment, they may be substituted.

**Reliability**

- Reliability requirements will be set depending on the sensitivity of a location.
- Color coding of potable vs. non-potable piping and fixtures is required.
- The facility design must include a set of best management practices (BMPs) aimed at operating the facility and managing the land to minimize human exposure to and direct contact with the reclaimed water. The BMPs should include provisions for appropriate cross-connection prevention devices and appropriate backflow prevention devices.
- Emergency contingency plans should be provided, and system repairs and replacement must be able to be accomplished during full operation.
- Permit proposals must include an alternative permitted disposal option for use during emergency situations and for non-growing season disposal. (All permitted treatment plants providing some or all of their effluent to reuse projects must have a permitted alternative means of disposal for emergencies and off-season use.) The ability to immediately shift the discharge of effluent from spray irrigation sites to other permitted discharge points must be demonstrated.
- A monitoring program must be planned, and the types of sampling that will occur from the final effluent, groundwater monitoring wells, or lysimeters and proximal surface water should be described. The frequency of on-line sampling, monitoring, and recording must be described.
- An eight-week on-line demonstration program/pilot project is required prior to using the treated wastewater for irrigation. During this time, the effluent should be characterized, the reliability of treatment assessed, and indicator parameters identified for cost-effective long-term monitoring, while treated water is diverted to the alternate discharge location. Pilot testing requires monitoring of: BOD5, TSS and TS; turbidity; total or fecal coliforms; flow; UV intensity and/or chlorine residual; nitrogen species; phosphorus, ortho and total; pH; oil and grease; metals – Cu, Zn, Cd, Hg; SVOCs; VOCs; Enterococci; heterotrophic plate count; MS-2 coliphage; total cultured viruses; and Cryptosporidium/Giardia.
Water Quality

- BOD5 must be ≤ 10 mg/L, monitored weekly.
- TSS must be ≤ 5 mg/L, measured 2 times weekly.
- The mean turbidity (continuously monitored) must be ≤ 2 NTU/24 h, measured prior to disinfection; maximum turbidity must be ≤ 5 NTU.
- The median fecal coliform value for a running 7-day sampling (measured daily) should be "none detected"; the maximum fecal coliform concentration in any sample must be ≤ 14 cfu/100 mL.
- pH 6-9, measured daily.
- The total N concentration must be ≤ 10 mg/L, measured two times monthly.
- The effluent water should be able to meet Class I Groundwater Permit Standards (SDWA Drinking Water Standards), which typically include measures for BOD, TSS, TS, flow, nitrate, total nitrogen, pH, VOC, FC, phosphorus and surfactants.
- Required monitoring includes UV disinfection intensity or chlorine residual (daily); phosphorus (measured two times monthly); heterotrophic plate count (measured quarterly); and MS-2 phage measured quarterly.
- Limits are to be met at the point of discharge from the treatment facility.
- Reclaimed water must be clear, odorless, and virtually pathogen and contaminant free.

(*Toilet flushing allows higher BOD (30 mg/L), TSS (10 mg/L), turbidity (5 NTU), and fecal coliforms (not to exceed 100 cfu/100 mL).

Site Constraints

- The Producer must enter into an approved binding agreement with the User to ensure that construction, operation, maintenance and monitoring of the reclaimed water meets the requirements of the Groundwater Discharge Permit (GWDP) and the Reclaimed Water Interim Guidelines. Contracts with spray irrigating system vendors are recommended as part of a Best Management Plan (BMP).
- The location of all local and regional water resources within 0.5 miles of the proposed project must be identified. A mounding analysis must demonstrate that there is sufficient zone of aeration between the bottom of the leaching or disposal area and the historically high water table. The fate of the discharge must be identified, with a description of its anticipated effect on groundwater quality.
- Spray is not permitted during operational hours.
- A BMP must be submitted demonstrating how the operation of the distribution system will be managed to minimize exposure to humans and prevent direct contact with reclaimed water. The BMP should consider:
  -- Utilization of low trajectory sprayers, spray irrigation during non-use hours,
  -- Signage indicating reclaimed water use,
  -- A nutrient management plan reflecting fertilizer application and nutrients in sprayed wastewater,
  -- Storage ponds designed for maximizing water quality,
  -- Procedure for immediate switch-over to a non-growing season disposal system
  -- Locking caps provided on outside plumbing fixtures with signage
  -- Plans to correlate irrigation with wind speed measures
  -- An education plan for facility personnel responsible for irrigation
- A monitoring plan must be in place that detects the impacts of the project on ground and surface water quality (and on the quality of the water after it has been treated by the soil, if that is part of the intention of the system).
- Golf course fertilization practices should include a reduction in applied fertilizer if nutrients in the reclaimed irrigation water are retained to provide fertilizer value.
- A public awareness program is required that includes: fact sheet/brochures, color coding of all plumbing, and signage (multilingual and pictorial).
Buffers

- Spray is not permitted within 100 ft of a building or residential property; if no private wells are involved, a green barrier in the form of hedges or trees may be placed at the dwelling side of the buffer, and the setback distance can be reduced to 50 ft.
- Spray is not permitted within 100 ft of a private well.
- Spray is not permitted within 100 ft of Class A surface water bodies and surface water intakes.

Storage

- Irrigation ponds must be designed to minimize the degradation of water quality between the time that treated water is stored and then withdrawn for irrigation. Some of the recommended design considerations that will reduce adverse impacts on the water during storage are:
  - pond liners
  - storage capacity that does not change the morphology of the pond
  - aeration
  - minimization of physical hazards associated with the pond
  - inlet/outlet devices to promote circulation
  - sizing to allow frequent turnover of the pond volume
  - diversion of runoff containing fertilizer so that the runoff does not enter the pond
  - stormwater management that minimizes the carriage of nutrients into the pond
  - perimeter landscaping to reduce access of children to the pond water
  - signage
Appendix 43

Comments

Michigan Department of Environmental Quality
Environmental Response Division

Wastewater discharges in Michigan are governed by Part 31 of the Michigan Natural Resources and Environmental Protection Act 451 of 1994. Currently, after treatment, wastewater is either discharged to surface water or groundwater and is not reclaimed. On occasion, wastewater discharges to the ground are used on crops that are not for human consumption or they are used for irrigation of golf courses. Both types of situations would employ a sprinkler system. The discharge from each wastewater site must be in compliance with Part 31, but the component requirements of the wastewater discharge are governed by either Part 22 rules of Part 31 for groundwater discharge or Part 21 rules of Part 31 for surface water discharges.

Richard Brim
July 28, 2000

Treatment

- The treatment system must have the hydraulic capacity to treat organic and inorganic loadings so that the discharge meets the water quality standards.

Reliability

- Permit applications must provide an operations manual (OM). The OM should describe
  - the monitoring procedures,
  - the appropriate response (or facility adjustment) to minimize the impact of emergency situations with the potential to affect the discharge or compliance with the permit in such a way as to facilitate rapid implementation of a correct response during an emergency,
  - application rates, means for even distribution of wastewater, and strategies for periods of adverse weather.
- A maintenance manual and schedule are required.
- Procedures for routine maintenance and inspection of equipment used for irrigation must be provided with the permit application.
- All areas within a system shall be accessible for maintenance equipment.
- Portions of the wastewater distribution system shall be capable of being taken out of service for maintenance and other operational activities, or to provide rest to portions of the irrigation area without disrupting applications to other areas of the system.
- If discharge is in a designated wellhead protection area, the discharger must submit monitoring reports; if standards are exceeded, the discharger must also submit notice to the pertinent public water supply system manager.
- If a violation occurs, notification of the violation is required within 24 h.
- A discharger must monitor the discharge and its effect on groundwater and report the monitoring results.
- If monitoring data indicate that the groundwater or effluent limits have been exceeded, the regulatory agency must be notified within 7 calendar days of making the determination. Samples from the location must be tested within 14 days of making the determination. A report describing the results of the 14-day sample tests and detailing the steps taken, or to be taken to prevent recurrences, must be submitted within 60 days.
- Regulations allow for inspection of facilities by authorized health department representative.
- The treatment facility operator must be certified.
- Records are to be kept of groundwater quality in all wells on site and of the most recent static water levels from all wells on site.
- A discharger may not use groundwater beneath the irrigation site for human consumption unless the groundwater meets state and federal standards for a potable water supply.
Water Quality

- Fecal coliform concentrations must be ≤ 10 cfu/100 mL.
- Wastewater effluent and groundwater receiving the discharge must not exceed 5000 micrograms/L total inorganic nitrogen and not more than 500 micrograms/L nitrite OR, the wastewater effluent limits may be set in a permit such that they meet groundwater standards.
- Phosphorus in the effluent must be < 5000 micrograms/L unless surface water is within 1000 ft hydraulically down gradient of the discharge, in which case effluent must be < 1000 micrograms/L or at a permit limit set to maintain a concentration below this maximum in the groundwater.
- Other effluent standards include: aluminum ≤ 150 micrograms/L, chloride ≤ 250,000 micrograms/L, sodium ≤ 150,000 micrograms/L, sulfate ≤ 250,000 micrograms/L, iron ≤ 300 micrograms/L, manganese ≤ 50 micrograms/L; THMs limits may also be set.
- Other chemical limits may also be set based on the effluent analyses submitted with the permit application. Some organic compounds may have treatment-technology-based standards set in the permit.
- Several conditions are stipulated in the regulations that may lead to changes in the stated water quality limits.
- Methods of monitoring, analytical methods, and sample collection are stipulated for a variety of circumstances.

Site Constraints

- The discharger must sign a legal covenant to the effect that groundwater beneath the irrigation site will not be used for human consumption unless the groundwater meets state and federal standards for a potable water supply.
- All wells, stream flows, springs, wetlands, and water bodies on the site must be identified.
- The permit application must indicate whether discharge is to an area underlain by a usable aquifer, an unusable aquifer, or groundwater not in an aquifer.
- A waste characterization study may be required before a permit to discharge is issued.
- Daily application rate should be ≤ 24 x permeability. The discharge to a land treatment system shall be limited so that the discharge volume combined with the precipitation from a 10-year frequency/24-hour duration rainfall event does not overflow the designed discharge area.
- For slow rate and overland flow treatment systems, the pH of the plow layer within the discharge area shall be maintained between 6.0 and 7.5 standard units. Operation must prevent the developing of sodic conditions. The discharge area must be tested annually for cation exchange capacity, available Bray-P1 phosphorus, pH, and sodium.
- No runoff, ponding, flooding of adjacent property permitted, and no resultant erosion or nuisance conditions are allowed.
- Groundwater quality tests must indicate the specific conductance, concentrations of stipulated inorganics, and pH.

Buffers

- An effluent discharge point must be ≥ 100 ft inside property boundary, although permission for narrower buffers may be approved.
- An effluent discharge point must be ≥ 2000 ft from a Type I or Type Ila water supply well, 800 ft from a type Ilb or III water supply well, and 300 ft from a domestic well, although permission for narrower distances may be approved.

Storage

- If treatment or storage lagoons are used, they must have a composite liner. The base must contain a natural soil barrier, a compacted soil barrier or a geo-composite clay liner. Details about lagoon construction are stipulated. The lagoon may hold only wastewater that meets the permitted water quality limits.

Appendix 44
Comments

Minnesota Pollution Control Agency

Minnesota does not have state regulations for wastewater reuse projects, but the California regulations are used for guidance when writing case-by-case permits.

Bruce Henningsgard

Treatment
Reliability

Water Quality

Site Constraints

Buffers

Storage
Mississippi Department of Environmental Quality

Mississippi has no specific state regulations; permits are handled on a case-by-case basis.

Treatment
Reliability
Water Quality
Site Constraints
Buffers
Storage
Comments

Missouri Department of Natural Resources
Code of State Regulations 10 CSR 20-8: Division 20—Clean Water Commission and Chapter 8—Design Guides. For water reuse in areas of unlimited public access, the requirements described in 10 CSR 20-8.020 are used; additional stipulations or waivers are included in the permit on a case-by-case basis.
February 28, 1999

Treatment

- Minimum treatment requirements are those equivalent to that obtained from a primary wastewater pond cell designed according to state regulations for wastewater treatment.
- Pond depth may be increased to include wastewater storage on top of the primary volume.

Reliability

- All piping and sprinklers associated with the distribution or transmission of the irrigation water must be color-coded and labeled or tagged to warn against the consumptive use of the contents.
- Automatic or semi-automatic controls must be considered for shut off of the system. Manual start-up of the system is recommended.
- An Operation and Maintenance Plan is required for the owner and operator of the irrigation site, and it should include the maintenance of mechanical equipment, the maintenance of the vegetative cover, and plans for operating procedures, monitoring, recordkeeping, application scheduling and winterization.

Water Quality

- The irrigation water must contain as few indicator organisms as possible, and in no case should fecal coliforms exceed 200 cfu/100 mL.
- Irrigation water must not exceed the trace element concentrations stipulated in the EPA Design Manual for Land Treatment of Municipal Wastewater (EPA 625-1/81-013).

Site Constraints

- Public notification is required of intent to issue a permit to a site.
- The design and layout of a system must show existing and proposed buildings, roads, ground or surface water supplies and wells within ½ mi of the site; distance from the treatment and storage facilities to the application site; proximity of the site to industrial, commercial, residential developments; surface water streams; potable water wells; public use areas such as parks and cemeteries; groundwater conditions; existing vegetation; and slopes.
- If the planned application rate is > 24in/yr, a geology report and a report of soil types and characteristics are required.
- The design and plan should show evidence that areas of potential erosion have been considered.
- A site inspection by the state Ground Water Quality Section is required to confirm the suitability of a proposed site for land application.
- An area that floods at a frequency > once/10 yr may not be the sole site for land application.
- The maximum allowable slope in the application area is 20%.
- The public may not be in an irrigation area when the spray is applied.
- Spray equipment must minimize the formation of aerosols.
- Application rates are stipulated based on the design sustained soil permeability rate, the slope, the soil moisture holding capacity, antecedent rainfall and depth to the most restrictive soil permeability layer.
- In no case can the application rate exceed 1 in per day or 3 in per week.
- The maximum annual application rate must not exceed a range of 4-10% of the design sustained

Appendix 47
soil permeability rate for the number of days per year when soils are not frozen.

- The wetted application area must have a soil mantle of at least 5 ft overlying any sand or gravel layers.
- Nitrogen application rates may not exceed the amount of nitrogen that can be used by the cover vegetation.
- The application rate may not result in the runoff of applied wastewater during or immediately following application.
- Irrigation is not permitted during periods of ground frost, frozen soil, or rainfalls.
- Wells located on the application site must be adequately protected from the irrigation spray.
- The design and operating plan must show the proposed irrigation rate, the crops or vegetation to be grown, and plans for cultivation.
- Irrigation piping must be drainable to prevent freezing if pipes are located above the frost line.
- A suitable structure is required for a portable pumping unit or a permanent pump, and the pumping system must provide the capability to vary the withdrawal depth and meet other stipulated specifications.
- Signage is required, with the spacing and message content and format specified.
- A groundwater monitoring program is required that indicates the number and location of existing and proposed monitoring wells; the parameters that will be monitored; and the monitoring frequencies.

**Buffers**

- Standard land application regulations require that the wetted application area must be at least 150 ft from existing dwellings or public use areas, (except roads or highways) and at least 50 ft inside the property line. However, these distances may be reduced depending on the extent of pretreatment and operational techniques. Half the required distances may be used if the wastewater is disinfected to produce a total chlorine residual of 0.5 mg/L after 15 min of contact time at the peak flow rate.
- The wetted application area must be
  - 300 ft from an existing potable water supply well not on the property, and
  - 300 ft from any sinkhole, stream or other structure or physiographic feature that may provide direct connection between the ground water table and the surface.

**Storage**

- Minimum storage requirements for no discharge systems range from 60 days in southern Missouri to 120 days in northern Missouri unless flows are generated only during the application period. In the latter case, a storage capacity of 45 da or the flow generated during the period of operation, whichever is less, is required.
Montana Department of Environmental Quality

Treatment

- Effluent must be oxidized to a level of treatment comparable to that from facilities producing secondary effluent.
- Coagulation is required, either by the addition of suitable floc-forming chemicals, or by an equally effective method.
- Effluent must be filtered through natural undisturbed soils or filter media such as sand or diatomaceous earth.
- Disinfection is required by chemical, physical or biological means to destroy pathogenic organisms.
- Wastewater treatment by a sequence of unit processes that will assure an equivalent degree of treatment and reliability may also be approved.

Reliability

- An operation and maintenance manual must be provided that describes planned procedures for
  - cold weather operation
  - high wind velocity (no application is permitted when wind exceeds 25 mph)
  - drying/wetting ratios to be used (generally advised to be no less than 3:1)
  - cropping practices, nutrient load, water balances to protect groundwater quality
- Groundwater and effluent monitoring requirements are determined on a case-by-case basis, and a plan for monitoring is required in the OM Manual.

Water Quality

- The mean turbidity must be ≤ 2 NTU; turbidity during any 24-h period must be ≤ 5 NTU at least 95% of the time.
- The mean fecal coliform concentration from the last seven days of analyses must be ≤ 2.2 cfu/100 mL; the maximum fecal coliform concentration in any sample must be ≤ 23 cfu/100 mL.
- Effluent must be monitored on a regular basis to show the biochemical and bacteriological quality of the applied wastewater. Required monitoring frequency is determined on a case-by-case basis.

Site Constraints

- Representative data on the chemical quality of the wastewater must be submitted in the project proposal. A list of inorganic compounds required in the report is stipulated.
- The hydraulic, nitrogen and trace element loading rates must be justified in the project proposal. Designated methods must be used to determine the hydraulic and nitrogen loading rates, with the design hydraulic loading based on the wettest year in 10 yrs.

Buffers

- Irrigation must be 100 ft from any water supply well.
- Buffer distances from surface water are set on a case-by-case basis.

Storage

Appendix 49
Comments

The Nebraska Department of Environmental Quality, Water Quality Division, Wastewater Facilities Section.
Guidelines—for Treated Wastewater Irrigation. February 1986 and
Guidelines—for Design and Operation of Irrigation with Treated Wastewater, revised February 1993

Treatment

- Disinfection is required to meet the stated coliform limits.

Reliability

- A plan for periodic monitoring of the irrigation water, soils and groundwater should be provided. Monitoring programs are stipulated on a case-by-case basis.
- If significant flow will come from industry, both the quality and quantity of the industrial flow must be described along with process descriptions. Stipulations are provided describing what constitutes a significant contributing industry.

Water Quality

- If there is a substantial odor or nuisance problem, an allowable BOD loading will be stipulated.
- A fecal coliform limit will be set on a case-by-case basis.
- The permit application must describe the expected total soluble salt (salinity) concentration, the sodium absorption ratio (SAR), the carbonate and bicarbonate anion concentrations related to calcium and magnesium, the concentration of toxic elements (if any), and the relative contributions of industrial waste.

- A plan for periodic monitoring of the wastewater, soils and groundwater should be provided. Monitoring programs are stipulated on a case-by-case basis.

Site Constraints

- A proposal to irrigate with reclaimed wastewater must stipulate the nature of the land access (purchased, leased, contracted) and the type of control that will be maintained by the owner of the wastewater treatment facility. The name of the landowner must be provided, along with any lease or contract agreement between the producer and the landowner or consumer.
- Among the site characteristics that must be identified are abandoned and active drinking water wells, residences or occupied dwellings, surface waters, abandoned or active wells and test holes, the approximate distance from ground surface to the seasonal high groundwater table and the approximate depth to the drinking water aquifer, and the direction of groundwater flow.
- Initial groundwater quality measures may be required.
- Loading rates are considered on a case-by-case basis, but they should be less than 4 in/wk; the ratio of application time to rest time should be 1:3 in most cases.
- Nitrogen loading calculations are stipulated to determine the allowable nitrogen loading; allowable trace element concentrations in the irrigation water are stipulated.

Buffers

Storage
The Nevada Department of Conservation and Natural Resources:
Division of Environmental Protection
Bureau of Water Pollution Control.

WTS-1A: General Design Criteria for Reclaimed Water Irrigation Use
Nevada Administrative Code Reuse Regulations
Use of Treated Effluent for Irrigation NAC 445A.275
September 13, 1991

The regulatory agency is authorized to waive compliance or modify any requirement for a specific project of irrigation depending on the size, type, or location of the project. The irrigation of crops for human consumption is not permitted except for fruit- or nut-bearing trees. Uses allowed include irrigation of cemeteries, golf courses, greenbelts, parks, playgrounds or commercial or residential lawns.

**Treatment**

- A minimum of secondary treatment with disinfection is required.
- Plans submitted for permitting must show the disinfection system, including system redundancy; also disinfection dosing, contact time, and other related factors.
- Plans must specify a filter system design, including system redundancy; also filter design calculations for sizing, pumps, and backwash cycle.
- A design plan must include provisions for backwash disposal.
- A design plan must include provisions for chemical storage and spill containment.

**Reliability**

- Pump stations must contain signage as permanent wording on visible sections of the station to indicate that reclaimed water is being used.
- Documentation is required that the plans for cross-connection controls and backflow prevention have been approved by the governing health authority. Cross-connection certification is also required.
- A system design must include alarm systems, level sensors, redundancy, spill containment, and back-up power.
- Plans submitted for permitting must show the disinfection system, including system redundancy; also disinfection dosing, contact time, and other related factors.
- Plans must specify a filter system design, including system redundancy; also filter design calculations for sizing, pumps, and backwash cycle.
- A design plan must include provisions for backwash disposal.
- A design plan must include provisions for chemical storage and spill containment.
- An operation and maintenance manual must be submitted for permitting.
- A surface water containment system must be provided at the distribution site for protection in the event of a line break in the irrigation system.

**Water Quality**

- BOD5 should be ≤ 30 mg/L.
- TSS should be ≤ 30 mg/L.
- The 30-day geometric mean total coliform concentration must be ≤ 2.2 cfu/100 mL; the maximum total coliform concentration for any one day must be ≤ 23 cfu/100 mL
- Nitrogen forms and concentrations in the reclaimed water must be reported.
- Other recommended monitoring data includes metals, SAR, and other stipulated inorganics.
Site Constraints

- The sprinklers should be operated in a manner that avoids entry of treated effluent into the buffer zones.
- Runoff of treated effluent is not permitted.
- Signage must be posted that warns the general public to avoid contact with the reclaimed water.

Buffers

- No buffer is required in areas of unrestricted public access.

Storage

- Storage must contain, without release, the precipitation that falls within the boundaries for the 25-yr, 24-h storm event at the site. The reservoir must also withstand, without release of reclaimed water, the runoff generated from the 100-yr, 24-h storm at the site.
- Reservoir design requirements must comply with design of wastewater detention basins and additional stipulations from the regulatory agency with respect to liner criteria.
- It is recommended that a minimum of 4 days' storage volume be available in reservoirs for periods when the reuse system is not operating.
Comments

New Hampshire Department of Environmental Services

There have not been a large number of instances when wastewater effluent has been reused or reclaimed in New Hampshire. There are a small number of cases where ski areas have applied a limited amount of wastewater onto the slopes to augment snowmaking operations, and a few cases where wastewater receiving secondary treatment has been land applied to forested ecosystems. The Department does not have administrative rules directed specifically to wastewater reclamation or reuse. Rules from a variety of water programs are used to regulate various aspects of the reuse projects in New Hampshire, including regulations pertaining to wetlands, nonpoint source runoff, wastewater discharge, and groundwater protection.

Tim Drew
July 2000

Treatment

Reliability

Water Quality

Site Constraints

Buffers

Storage

Appendix 53
Comments

New Jersey Department of Environmental Protection
Technical Manual for Reclaimed Water for Beneficial Reuse
Revised April 2000

No use of reclaimed water for primary contact recreation is permitted, such as wading, surfing and water skiing. There are special stipulations for edible crops. No permits are issued to individual property owners.

Reclaimed water for beneficial reuse (RWBR) involves taking what was once considered waste, giving it a high degree of treatment, and using the resulting high-quality reclaimed water for new, beneficial uses.

Treatment

- Secondary treatment is required.
- Secondary treatment and filtration are required.
- Chemical addition may be necessary prior to filtration.
- Prior to disinfection, filtration must achieve TSS ≤ 5 mg/L, with continuous monitoring for turbidity.
- Disinfection must achieve ≤ 2.2 fecal coliforms per 100 mL of reuse water. Alternatives to chlorine for disinfection may be approved after submission of an operating protocol and statistically significant monitoring data that indicate compliance with this specification.

Reliability

- Continuous on-line monitoring for chlorine residual/chlorine produced oxidant at the compliance monitoring point is required. Continuous turbidity monitoring is also required.
- An operating protocol must be submitted containing a detailed set of instructions for the operators of facilities. A correlation between turbidity and TSS shall be established as part of the operations protocol to ensure continuous compliance with the 5.0 mg/L TSS limitation.
- Storage is required if another permitted reuse system or effluent disposal system is not incorporated into the system design. Use of ponds for reuse storage shall not impair the ability of the ponds to function as storm-water management systems. (Note: Storage ponds do not need to be lined.)
- An annual usage report is required.

Water Quality

- TSS limitations (≤ 5 mg/L) must be met both before and after disinfection and prior to discharge to a reuse location.
- The fecal coliform 7-day median value must be ≤ 2.2 cfu/100 mL; the fecal coliform concentration in any sample must be ≤ 14 cfu/100 mL.
- A chlorine residual-produced oxidant of at least 1.0 mg/L must be maintained for a minimum contact time of 15 minutes at peak hourly flow.
- Total nitrogen should be ≤ 10 mg/L, although if the applicant can demonstrate that a higher limit is possible while still protecting the environment, this concentration limit can be modified.
Site Constraints

- A User/Supplier agreement is required.
- Low trajectory nozzles are required within 100 ft of outdoor public eating, drinking and bathing facilities.
- The hydraulic loading rate shall not exceed a maximum annual average of 2 inches per week. Loading rates can be increased based on a site-specific evaluation.
- For spray irrigation, chlorination levels for disinfection should be continually evaluated to ensure chlorine residual levels do not adversely impact vegetation. A chlorine residual of 0.5 mg/L or greater in the distribution system is recommended to reduce odors, slime, and bacterial re-growth.
- No surface runoff or ponding is allowed at the site.
- Special stipulations are provided for irrigation of landscaped areas with a tank truck.
- Signage or scorecard notification is required.

Buffers

- A setback of 75 ft from edge of wetted area to a potable water supply well is required.
- A setback of 75 ft from a reclaimed water transmission facility to all potable water supply wells is required.
- A setback of 100 ft from indoor aesthetic features such as decorative pools and fountains is required.
- The edge of the wetted area shall not cross into adjoining sites.

Storage

- Storage is required if another permitted reuse system or effluent disposal system is not incorporated into the system design. Use of ponds for reuse storage shall not impair the ability of the ponds to function as storm-water management systems.
- Reject storage ponds must be lined, but system storage ponds need not be lined.
NEW MEXICO

Comments
State of New Mexico
Environment Department
Ground Water Quality Bureau
NM Environmental Improvement Division Policy for the use of Domestic Wastewater Effluent for Irrigation
December 1985

Note: More recent guidelines dated July 24, 2000 (published on the Web) have not been approved. (Fred Kalish, Ground Water Quality Bureau, August 2002) Stipulations from the new regulations are shown in parentheses.

Domestic wastewater must be adequately treated and disinfected if it is to be used for the irrigation of parks, playgrounds, school yards, golf courses, cemeteries and other areas where the public has similar access or exposure. The fecal coliform bacteria concentration must meet the stipulated water quality limits at the point of diversion for irrigation to be so used.

Irrigation of food crops is not permitted.

Treatment

- Reclaimed water shall be at all times adequately treated and disinfected, where adequate treatment refers to treatment such that at the point of diversion for irrigation the fecal coliform concentration meets the stated limits.
  - Secondary treatment is required after primary treatment. Secondary treatment options include activated sludge, trickling filters, rotating biological contactors, and many stabilization pond systems.
  - Filtration is required.
  - Disinfection may be accomplished by chemical, physical or biological means, including chlorination, ozonation, other chemical disinfectants, UV radiation, membrane processes, or other processes.

Reliability

- All domestic wastewater lines and appurtenances used for irrigation purposes must be conspicuously labeled as nonpotable, and all staff shall be trained to identify and interpret the marking system used in the program.
- When not in use, lines must be secured so that the public cannot inadvertently initiate a discharge.
- No direct or indirect cross-connections with potable water systems are permitted.
  - If the producer does not possess an NPDES permit for discharge into surface waters, the facility must provide for emergency storage of a volume equal to five days of average design flow, to be used for inadequately treated water, and to allow for periods when permitted use is impractical or impossible.
- Excess application of domestic wastewater must not result in standing or pooling water.

Water Quality

- BOD must be $\leq 10$ mg/L, measured weekly.
- Turbidity must be $\leq 2$ NTU, measured continuously, or the TSS must be $\leq 5$ mg/L, measured daily.
- The median fecal coliform concentration must be $\leq 2.2$ cfu/100 mL for the prior seven days, with no single daily sample for that period exceeding 23 cfu/100 mL, measured daily.
- The fecal coliform concentration in any single sample should be $\leq 100$ cfu/100 mL.
- pH between 6 and 9 (or between 6 and 10 for lagoon treatment), measured weekly.
- If chlorination is used for disinfection, the total residual chlorine must be $\geq 0.2$ mg/L, as measured at the end of the wastewater treatment process.

Appendix 56
**Site Constraints**

- Application must be during times when public contact is not likely to occur.
- Standing or pooling water should be avoided (liquid or frozen, is prohibited).
- All domestic wastewater lines and appurtenances used for irrigation purposes must be conspicuously labeled as nonpotable and be so secured when not in use that the public cannot inadvertently allow a discharge.
  - A system is required that uniformly marks all components of the reuse system. All markings, signs, and labels should be color-coded, and text should be in English and Spanish.
  - The signs and labels shall clearly state: “Caution: Nonpotable Water – Do Not Drink.”
  - Signage should indicate that additional information can be obtained by calling the NM Environment Dept. or Dept. of Health.
  - Signs are required at least every 100 ft.

**Buffers**

- Even if disinfected, irrigation water must not be aerosolized via a sprinkler system within 100 m (328 ft) of human living quarters.
  - A setback of 50 ft is required from potable water supply wells.

**Storage**

- If the producer does not possess an NPDES permit for discharge into surface waters, the facility must provide for emergency storage of a volume equal to 5 days of average design flow, to be used for inadequately treated water, and to allow for periods when permitted use is impractical or impossible.
Comments

New York Department of Environmental Conservation and the New York State Department of Health.

Guidelines for each wastewater reclamation site are set on a case-by-case basis.
Four municipalities (July 2002) have water reclamation projects as test cases for further expansion.

Treatment
Reliability

Water Quality

Site Constraints

Buffers

Storage
Some permitted uses for reclaimed water include decorative ponds or fountains, fire fighting, dust control, soil compaction, street cleaning, and urinal and toilet flushing. Reclaimed water may not be used for irrigation of direct food chain crops, swimming pools, or as a raw potable water supply.

**Treatment**

- A tertiary quality effluent (filtered or equivalent) is required.
- Aerated flow equalization facilities are required with a capacity based on either a representative diurnal hydrograph or at least 25% of the daily system design flow.

**Reliability**

- All valves, storage facilities and outlets must be tagged or labeled to notify the public that the water is not intended for drinking. All piping, valves, and other appurtenances must be color coded, taped, or marked to identify the product as reclaimed water. The color used should be purple (Pantone 522). Stipulations about markings and tapes are provided.
- All reclaimed water valves and outlets must be of a type or secured in such a way that only authorized personnel can have access to them; no above ground hose bibs are permitted unless they can only be accessed by a special tool and present a clear label that the water is nonpotable.
- No direct cross connections between reclaimed water and potable water systems are permitted.
- A reduced-pressure principle backflow-prevention device, or an approved air gap separation, must be installed at any potable water service connection in the use area; the device must be installed such that it can be properly tested.
- If potable water is used to supplement a reclaimed water system, the potable water supplier must approve and regularly inspect an air gap separation between the potable water and reclaimed water systems.
- Turbidity must be monitored continuously or continuous monitoring of particle count and flow is required.
- All essential treatment units must be provided in duplicate.
- Treated water failing the fecal coliform or turbidity limits must be discharged to a five-day side-stream detention pond, unless other permitted disposal options have been arranged. The facility must be able to return the effluent back to the treatment facility, or otherwise meet the water quality requirements, before water is discharged to the irrigation pond.
- An automatically activated standby power source, or other means to prevent improperly treated wastewater from entering an irrigation pond, is required.
- A certified operator of sufficient grade for the facility classification must be on call 24 h/day.
- A report describing the origin, type, and flow of waste to be treated must be provided, including results from an analysis of the waste.
- Methods of construction and means for assuring the quality and integrity of the finished project must be provided during the permitting process.
- No public access is permitted to the reclamation facility or the five-day detention pond.
- City, county or municipal entities providing reclaimed water may submit a program description for local approval of irrigation systems; the program should include design guidance, cross-connection prevention, customer education, loading rate determination procedures and a description of how the program will be managed.
- Tank trucks for reclaimed water distribution must be marked with advisory signs, and they may not be used to transport potable water used for drinking or other potable purposes. Piping to fill tank trucks must not be subsequently used to fill tanks with water from a potable supply.
**Water Quality**

- The monthly mean BOD5 must be \( \leq 10 \) mg/L; the maximum daily BOD5 must be \( \leq 15 \) mg/L.
- The monthly mean TSS must be \( \leq 5 \) mg/L; the maximum daily TSS concentration must be \( \leq 10 \) mg/L.
- The monthly geometric mean fecal coliform concentration must be \( \leq 14 \) cfu/100 mL; the daily maximum fecal coliform concentration in any sample must be \( \leq 25 \) cfu/100 mL.
- The monthly mean fecal coliform concentration must be \( \leq 4 \) mg/L; the daily maximum must be \( \leq 6 \) mg/L.

**Site Constraints**

- If reclaimed water is used on a site not owned by the producer, a contractual agreement between the user and the producer must be in place.
- Public notification at least 30 days is required, prior to issuance of a general permit.
- The rate of application may be determined based on the maximum soil absorption and/or the maximum water needs of a receiving crop.
- The public must be notified that reclaimed water is in use at a site and that the water is not potable.
- If reclaimed water is used for industrial purposes, employees must be notified and informed that the water is not intended for drinking.

**Buffers**

- A 50-ft buffer is required between a five-day detention pond and the property lines.
- A 50-ft buffer is required between an irrigation pond for treated water withdrawal and the property line.
- A 100-ft buffer is required from the edge of spray influence and any surface waters classified SA (shellfish areas). For waters not classified SA, a 25 ft buffer is required.
- A 100-ft buffer is required from the edge of spray influence to any water supply well.
- A 10-ft buffer is required from the edge of spray influence and any nonpotable well.

**Storage**

- Treated water failing the fecal coliform or turbidity limits must be discharged to a five-day side-stream detention pond, unless other permitted disposal options have been arranged.
  - There must be a 50-ft buffer from the side-stream detention pond to property lines.
  - The detention pond must have a liner of natural material that is at least one foot thick with a hydraulic conductivity of no greater than \( 1 \times 10^{-6} \) cm/sec, or a synthetic liner of sufficient thickness to exhibit structural integrity, and a comparable hydraulic conductivity.
- Storage for unused reclaimed water must be provided unless arrangements for other disposal options have been made, e.g. an NPDES permit for discharge to surface waters.
- The size of any irrigation pond that follows the five day detention pond must be designed using a mass water balance based on a recent 25-yr period using monthly average precipitatio data, potential evapotranspiration and soil drainage data that are available from or representative of the area involved.
  - Irrigation ponds are not required to have liners or be located some minimum distance from the groundwater table if it can be demonstrated by calculation or modeling that construction and use of the pond will not result in contravention of assigned groundwater standards at the compliance boundary.
- Public access to a five-day detention pond is not permitted.
North Dakota Department of Health, Division of Water Quality.
Guidelines: Recommended Criteria for Land Disposal of Effluent and Department of Health Criteria for Irrigation with Treated Wastewater.

Sites are permitted according to the guidelines on a case-by-case basis. Treated domestic wastewater from municipal domestic sewage treatment plants may be used for irrigation of public property such as parks and golf courses.

Treatment

- Secondary treatment is required.
- For waste stabilization lagoon systems, only water from secondary or tertiary lagoon cells may be used.
- If chlorination is available, maintenance of a 0.1 mg/L residual is preferred; the residual should be monitored daily at the point of use farthest from the treatment plant.
- Effluent leaving the irrigation site must conform to the Standards of Water Quality for North Dakota.

Reliability

- If waste stabilization ponds are used for treatment, the pond system must have a minimum of 180 days' capacity, measured without considering evaporation. Pond design must follow applicable criteria for waste stabilization ponds.
- A treated wastewater sample should be analyzed for suitability for irrigation.

Water Quality

- BOD5 should be ≤ 25 mg/L, monitored once every 2 weeks.
- TSS should be ≤ 30 mg/L, monitored once every 2 weeks.
- With chlorination, fecal coliforms must be monitored once every two weeks. Without chlorination:
  - effluent from mechanical plants should have fecal coliform concentrations ≤ 200 cfu/100 mL, monitored 2x/wk;
  - effluent from lagoon systems should have fecal coliform concentrations ≤ 200 cfu/100 mL, monitored 1x/wk.
- Grab samples are stipulated.
- The Health Department may adjust limits on a case-by-case basis.

Site Constraints

- If chlorination is used, irrigation may take place at any time.
- Signs should be posted in visible areas during irrigation and for two hours after irrigation. The signs should advise the public that the water is non-potable and should not be used for drinking, bathing.
- Soil salinity monitoring is recommended.
- Effluent from the irrigation site may not be disposed of in areas readily accessible to humans or animals, such as pastures being grazed, hay crops ready for harvesting, or garden crops for human consumption.

Buffers

Storage

Appendix 61
Comments

Ohio Environmental Protection Agency (OEPA)
Division of Surface Water: Agricultural/Sludge/PTI unit.
Guidelines: "Reuse of Reclaimed Wastewater through Irrigation for Ohio Communities, Bulletin 860, K. Mancl, D. Rector, published by The Ohio State University, 1997
(New regulations are being drafted; Cathy Alexander, Division of Surface Water, Ohio EPA).

Reclaimed wastewater use is permitted in parks, golf courses, lawns, highway medians, and playing fields.

Treatment

- Wastewater should be stabilized, aerobic and disinfected.
- Suspended solids should be removed; supplementary screening may be necessary.
- Disinfection should occur prior to storage of water in holding ponds or tanks, or prior to direct application. Chlorination or UV can be used.

Reliability

- An operation and maintenance plan must be submitted with the permit application.
- Recommendations are provided for suitable irrigation system features. Valves that are manual on with an automatic shut-off are recommended so that the operator can check field conditions before irrigation. If totally automated valves are used, they should be easily overridden with manual controls.
- Operational storage should be four-fold times greater than the daily design flow.
- At a minimum, monitoring should include the treatment plant effluent, the storage site (1-2x weekly), the irrigation system (precipitation, wind speed and direction, air temperature and irrigation flow daily during irrigation), and the soil (depth to water table and soil temperature weekly or monthly, and heavy metals and phosphorus 1-2x annually). The vegetation and groundwater may also require monitoring. Stipulations are provided for sample collection and measurement procedures. Monitoring requirements will be a function of the size of the facility and the amount of public access permitted on the site.
- Groundwater monitoring wells should be located upgradient and downgradient of large systems. Wells should be sampled at the beginning and the end of the irrigation season. Monitoring for fecal coliforms, chloride, and nitrate should be performed twice annually.

Water Quality

- BOD5 should ≤ 25 mg/L, monitored 1-2x weekly.
- The 30-day mean MPN for fecal coliforms should be ≤ 23/100 mL, monitored 1-2x weekly.
- The chlorine residual should be monitored.
- Maximum allowable metal concentrations are stipulated for irrigation.
- Large facilities are required to monitor total inorganic nitrogen monthly.
- Effluent limits and monitoring requirements are set on a case-by-case basis.
**Site Constraints**

- Streams, waterways, wetlands, springs, ponds, and lakes should be identified. The 10-year flood frequency, depth to seasonal water table (should be greater than 1 ft), depth to bedrock (should be greater than 2 ft), and direction of groundwater flow should all be evaluated.
- Background levels of specified inorganics in soil should be reported.
- Slope recommendations are: < 20% for turf or pasture, and < 40% for timber.
- There should be no standing surface water.
- Guidelines are provided for calculating required land area based on hydraulic loading rates that are determined through a water balance analysis. Application should not occur when the ground is frozen, and application rates should not exceed 4 in/wk.
- Nutrient loading rates must be calculated, and nitrate levels in the groundwater beneath the site should not exceed 10 mg/L.
- Irrigation should be restricted to times of the day or year when people are not present. A management plan should incorporate such practices.

**Buffers**

- Irrigation flow setback distance requirements are
  - 100 ft from a private water well
  - 300 ft from a community water well
  - 100 ft from a sinkhole
  - 50 ft from a drainage way
  - 50 ft from surface water
  - 100 ft from a road right-of-way unless a windbreak is used, which reduces the requirement to 10 ft
  - 50 ft from the property line

**Storage**

- A seasonal storage system should provide for at least 130 days of design average flow. Storage requirements should be developed considering the wettest year with a 5-year return frequency. Storage should be used when the ground is frozen, when the temperature is less than 35 F, when the wind velocity exceeds 20 mph in urban areas, when snow or water is standing on the ground surface, or when groundwater is within 1 ft of the surface. In some cases, permits may be obtained for surface water discharge during winter months.
- Operational storage should be four-fold times greater than the daily design flow. It is needed to give the operator flexibility to adjust, maintain, and service the irrigation system.
- A freeboard of 2-3 ft is recommended for storage ponds.
Comments

Oklahoma Department of Environmental Quality.
Title 252, Ch 648. Land Application of Biosolids.
Title 252, Ch 621. Non-industrial impoundments and land application; Ch. 656 Water pollution control facility construction.
Codification through the 2001 legislative Session.

Wastewater application is not permitted in public use areas with high potential for skin to ground contact, but it is permitted for golf course irrigation, which is considered a multi-purpose use area.

Treatment

- Multipurpose use areas must receive secondary treatment or equivalent.
- Disinfection is also required.

Reliability

- An emergency response plan describing the actions to be taken by the applicant, including notice for corrective action and remediation associated with spills and releases, must be submitted.
- An analysis of the wastewater characteristics in the treated effluent must be provided in the proposal for a permit.

Water Quality

Site Constraints

- Application must occur during times of non-use; application of treated water is also not permitted during periods of precipitation, or while the soil is saturated or frozen.
- Application is not permitted if it is likely to adversely affect a threatened or endangered species.

Buffers

Storage
OREGON

Comments

Oregon Department of Environmental Quality
Division 55, 340-055-0005 through 340-055-0030
 Regulations Pertaining to the Use of Reclaimed Water (treated effluent) from Sewage Treatment Plants
Effective 8/15/90 and Table 1: Treatment and Monitoring Requirements for Use of Reclaimed Water 11/14/97.
Guidelines—for the Land Application of Industrial Wastewater
December 1992

Other permitted uses include non-restricted impoundments where no limitations are imposed on
body-contact water recreation activities. Use for direct human consumption is prohibited unless, after public
hearing and with the written concurrence of the Health Division, it is so authorized by the Environmental
Quality Commission.

Treatment

• For public access sites, Level IV treatment (as described by the State) is required. Such treatment
  includes biological treatment to produce an oxidized wastewater and coagulation by the addition of
  chemicals or by an equally effective method.
• To meet stipulated turbidity limits, filtration of oxidized, coagulated, clarified wastewater is required,
  using natural undisturbed soils or filter media.
• Disinfection is required by chemical, physical, or biological means.
• Treatment processes that do not utilize coagulation may be approved if equivalent effluent quality
  can be demonstrated.

Reliability

• All piping, valves, and other parts of the system must be constructed and marked to prevent cross-
  connection with potable water systems. Construction and marking of the piping, valves and other
  system components must be consistent with the “Guidelines for Distribution of Nonpotable Water” of
  the California-Nevada Section of the American Water Works Assoc. as revised Sept. 14, 1983.
  Exceptions may be permitted in rural areas where private and public domestic water systems are
  more than 100 ft from any component of the reclaimed water system.
• Any connection between any potable water supply system and the distribution system for reclaimed
  water can only be through either an unrestricted air gap at least twice as wide as the diameter of
  the potable water discharge, or a reduced-pressure principle back-flow prevention device that is
  tested and serviced professionally at least once annually.
• Alarms are required as necessary to provide warning of loss of power and/or failure of process
  equipment essential to the proper operation of the treatment system and regulatory compliance.
• Standby power facilities sufficient to fully operate all essential treatment processes must be
  provided.
• The treatment system owner is the responsible and liable party for meeting the rule requirements.
• An approved Reclaimed Water Use Plan is required before water can be released from the
  treatment plant. The plan must describe the system design and indicate the means for regulatory
  compliance.
• No bypassing of untreated or inadequately treated water is allowed from the treatment
  system or from any intermediate unit process to the point of use.
• The treatment system and monitoring equipment must contain sufficient redundancy to effectively
  prevent inadequately treated water from being used or discharged to public waters.
• Monitoring reports must be submitted monthly. A report describing how effectively the system
  complied with the approved reclaimed water use plan, Division 55 rules, and stipulated permit limits
  and conditions, must be submitted annually.
• Noncompliance must be reported within 24 h of when the permittee becomes aware of an incident of
  noncompliance.

Appendix 65
**Water Quality**

- The 24-h mean turbidity should be $\leq 2$ NTU, sampled hourly, 95% of the time during a 24-h period it should be $\leq 5$ NTU.
- The median seven day total coliform concentration should be $\leq 2.2$ cfu/100 mL; the maximum total coliform concentration should be $\leq 23$ cfu/100 mL, monitored daily.
- When chlorine-based compounds are used for disinfection, a minimum contact time and minimal chlorine residual may be specified in the permit. Use of other disinfection methods may require additional monitoring.
- Permit proposals are also submitted to the Health Division for comment. Additional effluent limitations and permit conditions may be imposed.
- The sampling point for water quality limits will be stipulated in the permit.

**Site Constraints**

- No spray is permitted on areas where food is prepared or served, or where drinking fountains are located.
- No direct public contact with the water is permitted during the irrigation cycle.
- Signage is required around perimeter and other locations.

**Buffers**

Buffers for non-restricted access sites are not required.

**Storage**

 Appendix 66

The State uses land application guidelines for application of treated wastewater to land, and special stipulations for public access irrigation sites would be stipulated in a Part II Water Quality Management permit.

Treatment

- Secondary treatment is required to achieve a minimum of 85% removal of C-BOD5 and TSS.
- Pretreatment requirements are stipulated on a case-by-case basis.
- All wastes containing pathogens must be disinfected prior to application.
- Adjustments to these standards may be made on a case-by-case basis, or the adjustments may be made to minimum concentration requirements for effluent quality.

Reliability

- A monitoring plan must be designed and submitted with the permit application.
- Design must show that climate conditions were considered in site plan and operation plan, so that storage or alternate system management has been included when irrigation cannot occur.
- A plan for additional storage or additional land area must be described for emergency use, wet weather conditions, or occasions when the treatment facility is not producing effluent.
- Proposals with a detailed management and operating plan combining site, seasonal and weather related specifics with automated application and storage capabilities are preferred.
- A description of the evacuation and sampling method for groundwater samples is required in the permit application, and monitoring frequency must be presented for each parameter that will be measured.
- If irrigation application is seasonal, then an NPDES Part I discharge permit is required for discharge to surface waters.

Water Quality

- The 30-day mean C-BOD5 must be ≤ 25 mg/L.
- The 30-day mean TSS must be ≤ 30 mg/L.
- The monthly geometric mean fecal coliform concentration must be ≤ 200 cfu/100 mL.
- Chemical parameters such as pH, phosphorus, nitrate, nitrite, ammonia, Kjeldahl nitrogen, chloride, sulfate, and sodium must be monitored during system operation. Metal analyses may also be required.
- pH must be 6-9.
**Site Constraints**

- If the treatment area and storage cells are not on property owned by the permittee, the permittee must either secure a 20-yr lease renewable for an additional 20 years, or acquire development rights and perpetual rights for the amount of land required.
- All potential surface waters that could be affected by the irrigation of treated wastewater must be identified, including lakes, ponds, impoundments, wetlands, springs, seeps, drainage swales, surface relief channels, and other natural conveyances.
  - The locations of rock outcrops and sinkholes, depths to water table and to bedrock, the direction of groundwater flow, and the locations of groundwater discharge points must be identified.
- Floodplains on the site must be identified.
- The design and operating plan must consider the limiting geologic conditions, the most restrictive horizons, the potential for groundwater mounding, and the potential for contaminant transport to groundwater.
  - Soil characteristics such as pH, buffering capacity, action exchange capacity, sodium absorption ratio, exchangeable sodium percentage, organic content, carbon to nitrogen ratio, base saturation and base metal concentrations must be considered in the site plan. Soil test probes must be used to characterize the soil, and additional tests may be requested depending upon initial results.
  - The plan must show evidence that slope, topography, soil erosion characteristics, presence or absence of floodplains and springs, stream flow patterns, and prevailing wind directions were considered in the design.
- A maximum slope of 8% is typical, although proposals may be submitted for spray irrigation on slopes up to 25%.
- The site design should incorporate small diameter or low trajectory sprinkler heads or other applicators that keep effluent closer to the ground surface and away from areas impacted by the wind.
- The site operating plan should call for the system operator to record the weather conditions during each day of above-ground effluent application, including temperature, precipitation form and amount, wind direction, and wind speed.
- If site-specific design modifications or other methods cannot be used to overcome wind drift limitations, wind velocity and direction criteria must be included in the design and operating plan that will cause cessation of land application and diversion of treated effluent to storage. A wind break should be used to reduce wind velocity across the irrigation site.
- The design and management plan must evaluate the hydraulic budget and the hydraulic acceptance rate based on wet weather conditions.
  - Guidelines are provided for estimating hydraulic, nutrient, organic and solids loading rates.
  - Effluent application may not cause groundwater mounding or runoff from the site. A method and schedule for applying stored effluent during appropriate weather conditions must also be addressed.
  - Effluent may not be applied if more than 0.5 in of rain falls during the previous 24 h, and it may not be applied if snow cover exceeds 1 in.
  - The monitoring plan should characterize the wastewater, estimate the direction of groundwater flow, and describe the proposed monitoring methods for groundwater, soil moisture, and the weather. Stipulations are provided for groundwater well construction, sampling, and monitoring.
  - Plans for establishment of temporary and final vegetation must be described. Stipulations are provided for determining the assimilative capacity (nutrients, metals, organics) and management of vegetative cover on a site. A plan for management of the vegetative cover must be included in the design.

**Buffers**

- A minimum 50 ft buffer zone is required along property boundaries, roadways, parking lots and rock outcrops.
- Wind drift consideration must be used in the design to determine longer downwind lateral distances to site features such as streams and lakes, wells, occupied dwellings, and sinkholes.
Storage

- Storage is required to hold good quality water that is not in use.
- Storage requirements must be calculated according to stipulated methods.
- Storage periods may vary depending on season, or year-round operation; periods may vary from a low of 60 days in southeast PA to a high of 120 days in the northwest.
- Pond construction for storage must comply with stipulated state design criteria for Domestic Wastewater Facilities.
Comments

Rhode Island Department of Environmental Management (RIDEM)
Office of Water Resources

Rhode Island currently does not have any official guidelines, policy or regulations regarding treated wastewater reuse/reclamation. RIDEM is currently in the process of gathering information on the subject in order to draft policy and regulations. To date Rhode Island has approved only a few water reuse projects (a municipal golf course and an industry). These have been on a case-by-case basis and future requests will be denied until statewide guidelines can be put in place.

Bill Psatenaude
Principal Engineer
August 1, 2001

Treatment

Reliability

Water Quality

Site Constraints

Buffers

Storage
Comments

South Carolina Department of Health and Environmental Control (DHEC)
Bureau of Water
SC DHEC Regulation 61-9. State Code Ch 61 Sec 9.505: Land Application Permits and State Permits. A Land Application System permit (also known as a “No Discharge” or ND permit) is required. Other regulations used by DHEC may also determine requirements placed in permits.

Reclaimed wastewater is wastewater treated such that the effluent is of such a high quality to be suitable for irrigation in areas with public contact such as yard irrigation and public open spaces.

Treatment

- Advanced wastewater treatment methods sufficient to achieve the stipulated effluent water quality limits are required.

Reliability

- A permittee must at all times properly operate and maintain in good working order and operate as efficiently as possible all facilities and systems (including all land disposal sites of treatment and control) that are installed or used by the permittee to achieve compliance with the terms and conditions of its permit.
- Proper operation and maintenance includes adequate laboratory controls, appropriate quality assurance procedures, and groundwater monitoring wells, if required.
- If back-up or auxiliary facilities are required, they are included in the operation and maintenance stipulations as well.
- The owner or operator of the source of reclaimed water is responsible to establish and maintain operation records; make reports; install, use and maintain monitoring equipment or other methods; sample and analyze emissions or discharges in accordance with prescribed methods, at required locations and intervals.
- An alternate disposal option must be provided in the design and operation plans for any site that does not accept effluent year round. (A permitted secondary year-round disposal option is possible with an NPDES permit.)
- The permittee must provide the regulatory agency any information requested to determine permit compliance. The regulatory agency maintains the right to enter the premises, access and copy records, and inspect facilities, equipment, monitoring devices and application sites.
- Any non-compliance that may endanger health or the environment must be provided orally within 24 h from the time the permittee becomes aware of the circumstances. This notification should be supplemented within five days with written notification. Details about the information provided in the written report are stipulated. Examples of events requiring 24 h reporting include an unanticipated bypass or an upset. Violation of a maximum daily discharge limit must be reported within 24 h. Monitoring records must be retained for at least three years, including calibration and maintenance records and all strip chart recordings from continuous monitoring instrumentation.
- Groundwater monitoring may be required for new systems to determine if there is a need to evaluate the background groundwater conditions at the site. If a groundwater quality monitoring program is required or proposed, design plans should show the number and location of the wells. Monitoring wells must be installed according to stipulated state standards.
Water Quality

- Monthly mean BOD5 must be ≤ 5 mg/L, and weekly mean must be ≤ 7.5 mg/L.
- Turbidity limits are those used for drinking water (SC Code of Reg. 61-58). One TU, as determined by a monthly average except that five or fewer turbidity units may be allowed if the supplier of water can demonstrate to the State that the higher turbidity does not interfere with disinfection; prevent maintenance of an effective residual disinfectant in the distribution system; or interfere with microbiological determinations. If 5 TUs is permitted, the levels reported should be based on an average for two consecutive days.
- Coliforms limits are those used for drinking water (SC Code of Reg. 61-58). The water quality limits are based on the presence or absence of total coliforms in a sample, rather than coliform density. The number of allowable positive test results is based on the number of samples collected per month, which is based on the size of the facility. For example, for a system that collects at least 40 samples per month, no more than 5% of the samples from the month may be total coliform-positive. Sampling must occur both in the effluent and in the distribution system. At least one measurement per day is required.
- Total residual chlorine should be maintained in a manner such that a detectable residual chlorine level is maintained in the distribution system and the fecal coliform limits are met. Specific residual limits will be based on the site conditions and the distribution system design.
- Nitrate nitrogen concentrations must be monitored and reported, although no specific limits need be set.

- Fecal coliforms should be ≤ 2.2 cfu/100 mL, analyzed weekly. If fecal coliform monitoring indicates noncompliance, daily or even more frequent monitoring should be initiated and the results reported to the permitting authority.
- Analyses are to be performed by the person who prepares the wastewater; Analyses should be performed on representative samples of the treated wastewater according to stipulated procedures. Weekly analyses are required for nitrate as N, ammonia as N, and pH. Other parameters may be included in a permit on a case-by-case basis.

Site Constraints

- A public entity must own the system and be responsible for the operation, maintenance and replacement of all components unless otherwise approved. If a private entity or person owns a system, a decision to issue a permit will be made on a case-by-case basis. DHEC will also require financial assurances for the operation and maintenance of the system.
  - Proof of ownership of the application site must be provided, OR
  - a contract lease or agreement for a period of at least 30 years with an automatic right of renewal for an additional 30 years must be provided.
- Public notification is required of intent to issue a permit to a site.
- A site inspection by the SC Ground Water Quality Section is required to confirm the suitability of the proposed site for land application.
  - A proposed design plan must show the facility, intake and discharge structures, hazardous waste facilities (if any), any wells where fluids are injected underground, and those wells, springs, other surface water bodies, and drinking water wells listed in public records or otherwise known to the applicant.
  - Soil borings may be required to characterize the subsurface.
  - The site may not be located in the 100-yr flood plain, unless there is a permitted secondary year-round disposal option.
  - A description of the water to be land applied must be provided, and if it is not strictly domestic, a detailed characterization must be provided.
- For irrigation sites, slopes must not exceed 10%.
- The distribution system must be designed so that uniform application of spray is optimized.
- Design and operation plans must show the planned application rate and the intended frequency of
application in times per day, week, or other period.
- Maximum allowable application rates are stipulated as a function of depth to the seasonal high water, although higher rates may be permitted for the application of reclaimed water.
- A groundwater monitoring program is required that indicates the number and location of existing and proposed monitoring wells; the parameters that will be monitored; and the monitoring frequencies.
- For land application on golf courses with secondary effluent limits, nine monitor wells must be provided for 18 fairways (or one groundwater well per two fairways for differing course sizes).
- Groundwater monitoring reports must include information about concentrations of chloride, ammonia, nitrate, pH and sodium; they must also indicate the water table elevation and depth.
- No runoff is permitted outside the irrigation area.
- No effluent may be applied during periods when the ground is frozen, ponded, there is standing water on the application site, or the ground is flooded.

Buffers

- No buffers are required.

Storage

- Basins or storage ponds for reclaimed water will not require a liner unless it is specifically stipulated.
- Groundwater monitoring for storage impacts is not required.
- Covered storage may be required in order to maintain effluent quality prior to distribution.
South Dakota Department of Environment and Natural Resources (DENR)
DENR Plans and Specifications
Ch XII, Recommended Design Criteria for Disposal of Effluent by Irrigation

South Dakota does not have dedicated water reuse regulations, but these guidelines would be used to guide development of a water reuse project. The guidelines permit wastewater use for irrigation of golf courses, parks, playgrounds, lawns, and in other areas where the public has access as long as the disinfection criteria are met.

The only reuse application that has arisen is irrigation with treated wastewater, and it tends to be for disposal of wastewater on a one-time basis. The Design Criteria and comments from SD DENR are summarized below.

**Treatment**

- Secondary treatment is required, with disinfection sufficient to ensure the stipulated total coliform levels (from Water Quality section: total coliforms ≤ 200 cfu/100 mL).

**Reliability**

- An alarm device for malfunction of the disinfection system should be provided.
- An automatic switch-over device for chlorine cylinders should be provided. The system should shut off irrigation units automatically if the chlorination system malfunctions.
- The quantity and quality of the effluent discharge at the irrigation site must be measured. The analysis results from a sample of wastewater must be provided.
- Groundwater monitoring may be required, with depths and spacing stipulated on a case-by-case basis. The wells must be constructed according to stipulated regulations. No detrimental change in the groundwater quality is permitted without obtaining a Groundwater Discharge Plan.
- The design disposal period should be a maximum of 18 weeks, but this period can be extended if weather conditions permit.

**Water Quality**

- Geometric mean total coliform concentration must be ≤ 200 cfu/100 mL, which should be adequate to protect human health; the guidelines note that it should be realized that this level probably will not eliminate all pathogenic viruses.
- Chlorine residuals must be at levels non-toxic to grasses, plants, fisheries, or aquatic life. Most grasses can tolerate a 2.0 mg/L total residual chlorine concentration.
- One sample of treated effluent must be collected monthly and tested for total nitrogen, nitrate, nitrite, sulfate, chloride, pH, temperature, total dissolved solids and fecal coliforms; results must be submitted to SD DENR.

**Site Constraints**

- All existing and proposed residences, commercial or industrial development, roads and ground or surface water supplies within 0.5 mi of the proposed site must be identified. In addition:
  - The vertical distance between the surface of the disposal fields and the maximum height of the ground-water table should be a minimum of 6 ft unless under drains are provided so that the minimum can be reduced to 4 ft. Initial ground-water quality data may be required.
  - Representative percolation and infiltration data of the topsoil and the subsoil layers must be provided.
  - Information about the irrigation site geology, soil conditions and hydrology must be provided.
  - Representative data on the chemical and bacteriological quality of the ground-water must be provided, including the elevation of the water table and the rate and direction of flow under existing and proposed conditions of use.
- Design of the area required for disposal should consider soil types, percolation and infiltration data, evapotranspiration data, available rainfall data, the maximum disposal period and application rates, plus an allowance for system maintenance and for drying and harvesting cover crops where applicable.
- Climatological site data must be provided.
  - The distribution pressure and devices for the sprinkler equipment must be installed in such a manner as to minimize wind drift of effluent and formation of aerosols.
  - Maximum effluent application rates are stipulated, and rates may also be set using the S.D. Soil Conservation Irrigation Guide. A maximum application rate to determine land requirements should be 24 in/acre/yr. Application rates should not exceed 0.25 in/hr or 2 in/acre/week.
  - The process design manual for Land Treatment of Municipal Wastewater, October 1981, U.S. EPA should be used to determine the total annual nitrogen loading.
  - Surface runoff of effluent should be prevented.
  - No application is permitted during periods of heavy or prolonged rainfall, snow cover, or when the ground is frozen.
  - Extraneous surface water should be prevented from entering the disposal area.
  - Signage is required to inform the public of the nature of the facility.

**Buffers**

- A windbreak or buffer zone is recommended to protect downwind sites from mist and/or aerosol contamination.
- No buffers are required if the wastewater has undergone extensive treatment and could be considered suitable for human consumption.
- Buffers for sites with public access would be set on a case-by-case basis.

**Storage**

- An effluent storage pond system must be provided with a minimum capacity of 210 days neglecting evaporation.
- The pond design must meet stipulated criteria for wastewater stabilization ponds.
Comments

Tennessee Division of Water Pollution Control
Chapter 16, Slow Rate Land Treatment

Tennessee allows irrigation of treated wastewater on golf courses, cemeteries, green areas, parks, and other public or private land where public use occurs under the state regulations for Slow Rate Land Treatment. The preapplication treatment standards for these areas are reviewed by the TDHE on a case-by-case basis. Currently only drip irrigation is permitted in areas of unrestricted access.

Treatment

- Biological treatment is required with minimal nitrification of effluent.

Reliability

- The permittee must ensure that the certified operator is in responsible charge of the facility and observes the operation of the system frequently enough to ensure its proper operation and maintenance regardless of the effluent monitoring frequency stated in the permit.
- A management plan must be provided that describes management responsibilities and duties, staffing, staff qualifications and training, and plans for operation of the facility. Start up and shut down procedures should be described, along with plans for equipment maintenance and inspection.
- Operating procedures for adverse conditions should be described, including excessive winds and electrical and mechanical malfunctions. Trouble-shooting procedures for common or expected problems should be described.
- Operation and maintenance of back-up, stand-by and support equipment should be specified.
- Plans for maintenance of the buffer zone should be described.
- Plans for frequency and locations of sample collection, procedures for testing, and parameters measured should be provided, along with planned methods to measure rainfall, wind speed and soil moisture.
- Plans for sampling storage ponds, groundwater monitoring wells and surface water (if applicable) should be described.
- Plans for preventive and corrective maintenance records should be described.

Water Quality

- BOD5 monthly mean concentration must be ≤ 30 mg/L
- TSS monthly mean monthly concentration must be ≤ 30 mg/L
- Fecal coliform concentration must be ≤ 23 cfu/100 mL
- A nitrified effluent should not be produced, since nitrate may leach into the groundwater from the application site.
- pH between 6.5 and 8.4
- Recommended maximum concentrations and problematic concentrations of a variety of anions, cations and trace metals are provided in the regulations to guide permitting decisions.
Site Constraints

- No direct discharge to surface water is permitted.
- Sites may not be located within the 10-yr flood plain.
- The site location must take into account dwellings, roads, and streams.
- A design plan must indicate the design wastewater flow, wastewater characteristics, treatment scheme, and area to be irrigated. All storage ponds, pumps, valves and process control points must be identified.
- A plan of the distribution system must be provided.
- Soils that are poorly drained, have high groundwater tables or restrictive subsurface soil layers are not suitable unless drainage improvements are made.
- Information about the infiltration rate, soil permeability, and chemical properties of the first 5-10 ft of the soil profile must be provided.
- The elevation of the seasonal high water table, the groundwater flow direction and gradient, and any subsurface conditions that could limit drainage must be identified. A minimum of one sample per acre should be collected to develop a soils map of the site.
- A saturated vertical hydraulic conductivity test is required for the most limiting horizon of each soil series present, and in certain instances, a horizontal conductivity test will also be required. Test methods and sampling methods are stipulated.
- Soil pH, cation exchange capacity, and percent base saturation must be provided, along with soil nitrogen, phosphorus, and potassium may also be required.
- Procedures are stipulated for determining the design wastewater loadings, based on a water balance and nutrient balance, and the field area requirements.

Buffers

- Treated wastewater must not be applied within 100 ft of the site boundaries.
- Treated wastewater must not be applied within 50 ft of on-site streams, ponds and roads.

Storage
**Comments**

Texas National Resource Conservation Commission (TNRCC)

These requirements and guidelines are separate from those stipulated for "Land Disposal of Sewage Effluent," in Sec 309.20 of state code.

Food crops that may be consumed raw by humans may not be spray irrigated with reclaimed water. Use of reclaimed water to fill swimming pools, hot tubs, wading pools or other structures designed for contact recreation is not allowed.

Orchard irrigation is allowed. Irrigation of edible crops that will be peeled, skinned, cooked, or thermally processed before consumption is allowed.

Reclaimed water is domestic or municipal wastewater that has been treated to a quality suitable for a beneficial use, pursuant to the provisions of this chapter and other applicable rules and permits. Type I Reclaimed Water may be used in areas where the public may be present during the time when irrigation takes place or where the public may come in contact with the reclaimed water. These uses include residential irrigation, including landscape irrigation at individual homes, irrigation of public parks, golf courses, school yards or athletic fields, fire flow in sprinkler systems or external hydrants, impoundments where recreational activities, such as wading and fishing, are anticipated (even though the water body was not specifically designed for such uses), and toilet or urinal flushing.

**Treatment**

**Reliability**

- The provider must have an operation and maintenance plan that contains:
  - A labeling and separation plan for the prevention of cross connections between reclaimed water distribution lines and potable water lines,
  - Procedures for monitoring water transfers and use,
  - User guidelines to minimize the risk of inadvertent human exposure,
  - Routine maintenance schedules,
  - An employee training and safety plan for employees of the provider that addresses reclaimed water treatment, distribution, and management,
  - Measures planned to prevent unauthorized access to reclaimed water facilities and distribution lines, and
  - A contingency plan for the remedy of system failures, unauthorized discharges, or upsets.
- A permit applicant must clearly indicate the planned means for compliance with regulations, including documentation that users will be apprised of their responsibilities as part of a water supply contract or other binding agreement.
- Water quality criteria apply to reclaimed water before discharge to initial holding ponds or a reclaimed water distribution system. It is the responsibility of the producer to establish that the water meets the quality limits at the sample point for the intended use in accordance with stipulated monitoring requirements.
- The producer must submit monthly reports to TNRCC describing the quality of water delivered to users or providers for each water quality criteria requested.
- A provider or user is encouraged to maintain a plan to carry out periodic fecal coliform sampling within certain reclaimed water distribution piping systems. The sampling should occur in instances where residential irrigation, including landscape irrigation at individual homes occurs, or where specific urban uses such as irrigation of public parks, school yards, or athletic fields occur. The plan should specify activities by the provider or user to respond to human health threats if undesirable fecal coliform test results or trends are detected.
- A producer must have a binding agreement with users stating that the producer has the authority to
terminate reclaimed water use that is noncompliant with regulations.

- If the provider is not the producer of reclaimed water, then a statement about the origin, a description of certain stipulated water quality characteristics, and a signed agreement from the producer authorizing the transfer of reclaimed water to the provider, must be provided to the regulatory agency.
- Additional approval is required if: there is a change in the boundary of an approved service area; an additional producer is added to a system; a major change in intended use is made (e.g. conversion from golf course irrigation to residential irrigation); there is a change from use of one category of reclaimed water to another category.
- The producer and provider responsibility to the user is to transfer reclaimed water of at least the minimum quality stipulated to the point of delivery at the user site.
- The producer or provider must notify the regulatory agency in writing within five days of obtaining knowledge of unapproved use of reclaimed water.
- The producer must assure that distribution lines and systems are constructed in accordance with state regulations.
- The provider must report monthly to TNRCC on the volume of reclaimed water delivered to a user or provider.
- Reclaimed water must be transferred from a provider to a user on a demand-only basis, and the user may refuse delivery at any time.
- The provider is responsible for conducting periodic audits of appropriate controls implemented by reclaimed water users.
- The provider and user must maintain five years' of records. For the provider these include notifications made to TNRCC about reclaimed water projects, contract copies, water volume delivery records, and water quality analyses.

**Water Quality**

- Monthly mean BOD5 or CBOD5 concentration must be ≤ 5 mg/L, sampled at least twice weekly.
- Monthly mean turbidity must be ≤ 3 NTU, sampled at least twice weekly.
- Monthly geometric mean fecal coliform concentration must be ≤ 20 cfu/100 mL; fecal coliform concentration in any one sample must be ≤ 75 cfu/100 mL. Coliforms must be sampled at least twice weekly.

**Site Constraints**

- Application of reclaimed water on public access facilities is controlled by agreement with the reclaimed water provider or by local ordinance. A description of the intended use, quantity, quality, origin and location and purpose of intended use must be provided to the regulatory agency.
- The user or provider must determine and document typical irrigation demands for a proposed use. The user must provide reasonable control of the application rates to avoid surface runoff or excessive percolation below the root zone.
- Reclaimed water use may not degrade ground water quality to a degree adversely affecting its actual or potential uses.
- Distribution, use and/or storage of reclaimed water may not result in nuisance conditions.
- The provider or user is responsible for ensuring that irrigation overflow, crop stress, and undesirable soil contamination by a salt does not occur.
- Guidelines are provided to assist with the calculation of appropriate irrigation rates.
- A site must be maintained with a vegetative cover or be under cultivation during times when reclaimed water is applied.
- Irrigation practices must prevent incidental ponding or standing water.

**Buffers**
Storage

- Storage is required to hold good quality water that is not in use.
- Water managed in ponds for storage may not be discharged into waters of the state, except for discharges with issued permits or that result from rainfall events. Unauthorized overflow of a holding pond must be reported to the regulatory agency.
- Storage facilities may not be located within a floodway unless they are authorized in an on-channel pond.
- Holding ponds must be designed and constructed to prevent groundwater contamination; they must meet stipulated requirements for liners and construction.
- Reclaimed water may be stored in leak-proof fabricated tanks.
Utah Department of Environmental Quality
Division of Water Quality

Utah Administrative Code R317-1, with specific rules for reuse projects in R317-1-4, based on revisions effective January 23, 2001

Utah allows the use of domestic wastewater effluent treated to Type I quality specifications to be used for residential irrigation (including landscape irrigation at individual houses), non-residential landscape irrigation, golf course irrigation, toilet flushing, fire protection, and irrigation of food crops where the applied water is likely to have direct contact with the edible part.

**Treatment**

- A secondary treatment process is required, which may include activated sludge, trickling filters, rotating biological contactors, oxidation ditches, or stabilization ponds. After secondary treatment, monthly mean BOD and TSS of the effluent should be <25 mg/L.
- Filtration is required through filter media or approved membrane processes.
- Disinfection is required to destroy, inactivate, or remove pathogenic microorganisms by chemical, physical or biological means. Chlorination, ozonation, other chemical disinfectants, UV radiation, membrane processes or other approved processes are allowed.
- A turbidity standard (5 mg/L TSS or less) must be met before disinfection. If a turbidity standard cannot be met, but it can be demonstrated that there exists a consistent correlation between turbidity and the total suspended solids, then an alternate turbidity standard may be established. This will allow continuous turbidity monitoring for quality control while maintaining the intent of the turbidity standards to assure adequate disinfection.

**Reliability**

- Pipes and valves shall be colored purple (Pantone 522 or equivalent). If identification tape is installed along with the purple pipe, it shall be prepared with white or black printing on a purple field, color Pantone 512 or equivalent, having the words, “Caution: Reclaimed Water – Do Not Drink.” The overall width of the tape shall be at least three inches. Identification tape shall be installed 12 in above the transmission pipe longitudinally and shall be centered. Valve boxes and covers shall be colored purple and of non-interchangeable shape with potable water covers and be marked as reclaimed water. All pumping facilities and piping must be painted purple and labeled. Reclaimed distribution lines parallel to potable lines shall be installed at least 10 ft horizontally from the potable lines.
- No hose bibs are permitted on reclaimed water systems in public areas and at individual residences.
- A labeling and separation plan for prevention of cross connections is required.
- Backflow prevention required. If it is necessary to put potable water into the reclaimed distribution system, an approved air gap must be provided.
- If turbidity exceeds or chlorine residual drops below the instantaneous required value for more than five minutes, an alternative disposal option or diversion to storage must be automatically activated.
- Schedules for routine maintenance must be provided.
- A contingency plan for system failure or upsets must also be provided.
- Blow-off assemblies must be approved for an acceptable location of discharge or runoff.
- Signage must be present at storage facilities.
- Any equipment such as tanks, portable pumps that have been or may be used with reclaimed water, and could be interchangeably used with potable water or sewage, shall be cleaned and disinfected before or after use as appropriate.

Appendix 81
**Water Quality**

- The monthly arithmetic mean BOD should be \( \leq 10 \text{ mg/L} \) after tertiary treatment and disinfection, as determined by daily composite sampling. Composite samples shall be comprised of at least six flow proportionate samples taken over a 24-hour period.
- The daily mean turbidity should be \( \leq 2 \text{ NTU} \), and the maximum turbidity at any time should be \( \leq 5 \text{ NTU} \).
- The weekly median fecal coliform concentration must be "none detected", and no sample may exceed 14 cfu/100 mL. Daily grab samples are required.
- The total residual chlorine shall be measured continuously and shall at no time be below 1.0 mg/L after a 30-minute contact time at peak flow. If alternative disinfection is used, it must be demonstrated that the alternative process is comparable to that achieved by chlorination with a 1 mg/L residual after a 30-minute contact time. If the effectiveness cannot be related to chlorination, then the effectiveness of the alternative disinfection process must be demonstrated by testing for pathogen destruction. A 1 mg/L total chlorine residual is required after disinfection and before the reclaimed water goes into the distribution system.
- pH between 6 and 9, measured in daily grab samples or by continuous monitoring.

**Site Constraints**

- A copy of the contract with the user must be provided to the DWQ. The contract must state how the requirements of the regulations will be met.
- Reclaimed water lines should be installed with a minimum burial depth of 3 ft. Reclaimed water lines parallel to sanitary sewer lines shall be installed at least 10 ft horizontally from the sanitary sewer line if the sanitary sewer line is located above the reclaimed water main and 3 ft horizontally from the sanitary sewer line if the sanitary sewer line is located below the reclaimed water main.
- At crossings, the order of the lines from lowest in elevation to highest should be: sanitary sewer line, reclaimed water line, and potable water line.
- A minimum 18 inches of vertical separation between these utilities shall be provided as measured from outside of pipe to outside of pipe. The crossings shall be arranged so that the reclaimed water line joints will be equidistant and as far as possible from the water line joints and the sewer line joints.
- If the reclaimed water line must cross above the potable water line, the vertical separation shall be a minimum 18 inches and the reclaimed water line shall be encased in a continuous pipe sleeve to a distance on each side of the crossing equal to the depth of the potable water line from the ground surface.
- If the reclaimed water line must cross below the sanitary sewer line, the vertical separation shall be a minimum of 18 inches, and the reclaimed water line shall be encased in a continuous pipe sleeve to a distance on each side of the crossing equal to the depth of the reclaimed water line from the ground surface.
- Drinking fountains and other public facilities (picnic tables, food establishments) shall be placed out of any spray irrigation area or otherwise protected from contact.
- Signage is required where reclaimed water is stored or impounded, or used for irrigation in public areas. Signs must contain as a minimum, \( \frac{1}{2} \) inch purple letters on a white or other high contrast background notifying the public that the water is unsafe to drink. The signs shall include the international symbol for Do Not Drink.
- Residential irrigation, irrigation of food crops where the applied reclaimed water is likely to have direct contact with the edible part, and impoundments of wastewater where direct human contact is likely to occur are all allowed.
Buffers

- Any irrigation must be at least 50 ft from any potable water well.
- Impoundments of reclaimed water, if not sealed, must be at least 500 ft from any potable water well.
- For residential landscape irrigation at individual homes, additional quality control restrictions may be required. The local health authority may be consulted to determine if there are any conditions they require.

Storage
Comments
Vermont Wastewater Management Division.

Vermont does not have specific water reuse regulations, but they are willing to permit certain reuse systems on a case-by-case basis as an innovative technology. They have several systems operating at ski resorts that use reclaimed water in toilets and urinals.

Treatment
Several systems have been installed with permit limits of 10 mg/L BOD and 10 mg/L TSS, with chlorination/dechlorination and monitoring required.

Reliability

Water Quality

Site Constraints

Buffers

Storage
Virginia is in the process of approving "Regulation for Wastewater Reclamation and Reuse (9 VAC 25-740-10 et seq.)

Current requests to use reclaimed wastewater on an area of public access would be handled in accordance with the Virginia Pollution Abatement (VPA) Permit Regulation for land application of treated wastewater (9 VAC 25-32-10 et seq.) and the Sewerage Regulations (12 VAC 5-580-10 et seq.) that provides technical guidelines for land application of municipal wastewater. Currently, most permitted projects are for irrigation of wastewater receiving secondary treatment that is used to irrigate fields where public access is restricted.

Treatment  
Reliability  
Water Quality  
Site Constraints  
Buffers  
Storage
WASHINGTON

Comments

Washington State Department of Health.
Water Reclamation and Reuse Standards, Publication #97-23, published by the Washington State

The standards were developed under the authorization of RCW 90.46, Reclaimed Water
This legislation called for the formation of a Reuse Advisory Committee, and the committee developed the
standards summarized below. These standards are separate from regulations for land treatment systems
(WAC 173-216, 173-240, 246-271)

Reclaimed water is effluent derived in any part from sewage from a wastewater treatment system that has
been adequately and reliably treated, so that as a result of that treatment, it is suitable for a beneficial use or a
controlled use that would not otherwise occur and is no longer considered wastewater.

All reclaimed water generation and use must be covered by a reclaimed water permit that is issued jointly
between Ecology and Health.

The standards designate four classes of reclaimed water, with Class A water suitable for spray irrigation of
food crops, surface irrigation of root crops, and irrigation of open access areas, such as golf courses, parks,
playgrounds, schoolyards, residential landscapes. Class A water may also be used as a source of supply for a
nonrestricted recreational impoundment or a decorative fountain; however, it may not be used as a source of
supply for swimming pools without additional authorization from state health and ecology agencies. Class A
water is suitable for discharge to constructed wetlands, for groundwater recharge, fire protection sprinklers,
toilet and urinal flushing, and some industrial applications.

Treatment

- Wastewater must, at a minimum, be oxidized, coagulated, filtered, and disinfected.
- Treatment methods other than those stipulated may be accepted if the applicant can demonstrate
  that they will assure an equal degree of treatment, public health protection, and treatment
  reliability. Pilot plant or other studies may be required to demonstrate that alternative methods of
  treatment can reliably produce reclaimed water that is essentially free of measurable levels of
  viable pathogens.

Reliability

- High flexibility in design is desirable to permit the highest possible degree of treatment to be
  obtained under varying circumstances.
- Piping, valves, outlets and other appurtenances must be color-coded purple [Pantone 522 or other
  shades of purple acceptable to review agencies] and embossed or integrally stamped or marked
  "CAUTION: RECLAIMED WATER - DO NOT DRINK" or be installed with a purple identification tape
  or polyethylene vinyl wrap. The warning must be stamped on opposite sides of the pipe and
  repeated every three feet or less. The tape must be at least three inches wide and have white or
  black lettering on a purple field with the caution statement. The tape must be installed on top of
  reclaimed water pipelines, fastened at least every ten feet to each pipe length, and run continuously
  the entire length of the pipe.
- Valves and outlets must be of a type, or secured in a manner, that permits operation only by
  authorized personnel; hose bibs are prohibited on reclaimed water lines.
- Cross-connection controls must be included in the design, along with stipulations about the parties
  responsible for compliance and testing. No cross-connections are permitted between reclaimed
  water and potable water systems. A reduced pressure principle backflow prevention device is an
  approved air gap separation must be installed at the potable water service connection to a use area
  if both reclaimed water and potable water are supplied to the area.
- When potable water is used to supplement reclaimed water supplies, there must be an air gap
  separation, approved and regularly inspected by the potable water supplier, between the potable
  water and reclaimed water.
- Reclaimed water may not enter a dwelling unit or a building containing a dwelling unit except for fire

Appendix 86
A preventive maintenance program is required to ensure that all equipment is kept in reliable operating condition.

If UV radiation is used for disinfection, a review and approval of the design and installation will be performed on a case-by-case basis.

Alarms are required to provide warning of:
- loss of power from a normal power supply
- failure of a biological treatment process
- failure of a disinfection process
- failure of a filtration process

All required alarms must be independent of the normal power supply of the reclamation plant.

Biological treatment processes must have either: an alarm and multiple units capable of producing oxidized wastewater with one unit not in operation; an alarm and short-term storage or disposal provisions, and stand-by replacement equipment; an alarm and long-term storage or disposal provisions; or an automatically actuated long-term storage or disposal provision.

Secondary sedimentation processes must have either: multiple units capable of treating the entire flow with one unit not in operation; standby sedimentation units; or long-term storage or disposal provisions.

Coagulation processes must have standby feeders, chemical storage and conveyance facilities, adequate reserve chemical supply, and automatic dosage control.

All coagulation and filtration units must have either: alarm and multiple treatment units capable of treating the entire flow with one unit not in operation; alarm, short-term storage or disposal provisions, and standby replacement equipment; alarm and long-term storage or disposal provisions; automatically actuated long-term storage or disposal provisions; or alarm and stand-by units.

For chlorination, the facility must have a standby chlorinator and standby chlorine supply, a manifold system to connect chlorine cylinders, scales, automatic switch-over capability from one cylinder to another, and continuous measuring and recording of chlorine residual. For reliability, the system must have either: alarm and standby chlorinator; alarm, short-term storage or disposal provisions, and standby replacement equipment; alarm and long-term storage or disposal provisions; automatically actuated long-term storage or disposal provisions; or alarm and multiple point chlorination, where each chlorination point has an independent power source, separate chlorinator, and separate chlorine supply.

Other disinfection unit processes must have either: alarm and standby disinfection unit capable of treating the design flow with the largest operating unit out of service; alarm, short-term storage or disposal provisions, and standby replacement equipment; alarm and long-term storage or disposal provisions; automatically actuated long-term storage or disposal provisions.

The normal power supply should have an alarm and standby power source, an alarm and automatically actuated short-term storage or disposal provisions, or automatically actuated long-term storage or disposal provisions. Automatically actuated system must include all necessary sensors, instruments, valves and other features to enable fully automatic diversion to approved emergency storage or disposal. Such systems should have a manual reset to prevent automatic restart until the failure is corrected.

Alarm warnings should be conveyed to the plant operator, superintendent, or other designated responsible person who can take prompt corrective action.

If the facility is not attended full-time, arrangements (e.g. alarm to police station, fire station) should be made to alert the person in charge at all times.

Storage must be provided for retention of reclaimed water when it is not required by a user unless an alternative disposal system is permitted. Storage should be sufficient to hold water for the duration of a 10-year storm, with the storm duration based on a minimum of 20 years of climate data. At a minimum, storage should be equal to three times that portion of the average daily flow of reuse capacity for which no alternative reuse or disposal system is permitted.

When short-term storage is provided as a reliability feature to retain diverted flow, it should be capable of storing the wastewater for at least a 24-h period. The facilities must include all necessary provisions for odor control, conduits and pumping and pump back equipment. The equipment should be independent of the normal power supply or provided with a standby power source.

Long-term storage for diverted water may consist of ponds, reservoirs, percolation areas,
downstream sewers leading to other treatment or disposal facilities or any other facilities reserved for the purpose of emergency storage or disposal. The facilities must be of sufficient capacity to provide disposal or storage for at least 20 days.

- Diverted water may be directed to a different type of reuse provided that the quality of the partially treated wastewater is suitable for that type of reuse.
- With approval from the Departments of Health and Ecology, diversion to a discharge point where the wastewater meets all discharge requirements is an acceptable alternative to emergency disposal of partially treated wastewater.
- The permittee is responsible for all activities and facilities inherent to the production of the reclaimed water. The permittee may need to use a delegated pretreatment program or ensure that all applicable dischargers have appropriate discharge permits in order to control industrial and toxic discharges that could affect reclaimed water quality.
- The person(s) who distributes reclaimed water, owns, or otherwise maintains control over the use area is responsible for reuse facilities and activities inherent in the distribution and use of the water to ensure that the system operates properly.
- No bypassing of untreated or partially treated wastewater from the plant or a process in the plant to the use site is permitted.
- Operating records must be kept that report results of all required analyses, operational problems, equipment breakdowns, diversions to storage or disposal, and corrective or preventive actions taken. Reports should be filed monthly.
  - Equipment or process failures that trigger an alarm must be recorded with the cause of failure and the corrective action taken
  - Discharge of untreated or partially treated wastewater to a use area must be reported immediately by telephone.
- Items required in an engineering report for permitting must include:
  - descriptions of the reclamation process and reliability features and controls
  - descriptions of the basis for design, such as pilot plant results, recognized design standards, accepted engineering design and operation references, USEPA, state regulatory agencies or site specific experience and operations data
  - results of pilot studies used to compare treatment alternatives
  - results of reliability assessments of complete treatment trains, unit processes, or equipment
  - design calculations for disinfection contact time, coagulation process, filtration process, irrigation process and water balance, if applicable.
  - Stipulations for the Engineering report required for permitting. Requires references for design standards, pilot data if alternative treatment processes used, reliability assessment, disinfection contact time.
  - contingency plans developed to ensure that no untreated or inadequately treated water is delivered to a user or customer.
- Operators of reclamation facilities must have the appropriate state certifications and requirements, and a sufficient number of certified operators must be hired to operate the facility effectively at all times.
- Tank trucks and equipment used to distribute reclaimed water must be identified with advisory signs. The trucks must be inspected and approved for use by the water supplier that services potable water to the use area. The trucks and the on-board piping or hoses may not be used for potable water.

**Water Quality**

- The monthly mean filtered turbidity must be \( \leq 2 \) NTU; maximum allowable is 5 NTU; DO must be present. Continuous turbidity readings are required, with readings at 4-hr intervals.
- Median total coliform for seven days must be \( \leq 2.2 \) cfu/100 mL. Maximum total coliform concentration in any sample must be \( \leq 23/100 \). Grab samples must be collected at least daily and at a time when wastewater characteristics are most demanding on the treatment facilities and disinfection procedures.
- BOD 24-hr composite samples collected at least weekly.
- TSS 24-hr composite samples, collected daily and reported monthly. (If mean monthly TSS is \( \leq 30 \) mg/L, then reduced TSS sampling can be permitted on a case-by-case basis.)

Appendix 88
• Grab samples for DO measurement must be collected at least daily and at a time when wastewater characteristics are most demanding on the treatment facilities.
• When chlorination is used, a minimum residual of at least 1 mg/L after a contact time of at least 30 minutes is required.
  - If pipeline travel is considered part of the contact time, the pipes are considered part of the treatment process and subject to other reclamation facility requirements.
  - A chlorine residual of at least 0.5 mg/L must be maintained in the reclaimed water during conveyance from the reclamation plant to the use area.
  - Maintenance of a chlorine residual is not required in impoundments and storage ponds, and at the discretion of the DHE, a residual may not be required in reclaimed water distributed from a storage pond.
  - A CT value greater than provided in the standard regulations may be required if it is judged that a reuse projects needs additional public health protection.

Site Constraints

• When the reclamation distribution system or use area is not under direct control of the permittee, a binding agreement among the parties involved is required to ensure that construction, operation, maintenance, and monitoring meet all appropriate requirements.
• The public and employees must be notified of the use of reclaimed water at all use areas. This must be accomplished by posting advisory signs, placement of notices on scorecards, distribution of written notices to residents or employees, or by other methods.
• Unplanned ponding of reclaimed water must be prevented.
• For irrigation, the hydraulic loading rate must be based on a water balance analysis, and the calculations and design assumptions must be submitted for approval.
• Runoff and spray must stay on the designated use area.
• Reclaimed water lines should be a minimum of 10 ft horizontally from potable water lines. When such lines cross, a minimum vertical separation of 18 in must be maintained between them, and the potable water line must be above the reclaimed water line.
• No application of irrigation water is permitted when the ground is saturated or frozen.
• No aerosol spray should reach people, buildings, passing vehicles or drinking water fountains.
• Appropriate measures should be taken to avoid breeding of vectors, creation of odors, slimes, or aesthetically displeasing deposits.
• Reclaimed water valves, storage facilities, and outlets must be tagged or labeled to warn the public or employees that the water is not potable. The signage must be colored purple with white or black lettering.
• Impoundments and storage ponds must not contribute to groundwater contamination where the groundwater is used as or suitable to be used as a source of domestic water supply. Such facilities may be unlined if it can be demonstrated that such contamination will not occur.
• A groundwater monitoring program may be required.

Buffers

• There must be at least 50 ft between a reclaimed water line and potable water supply well.
• For spray irrigation, there must be at least 50 ft between the spray area and a potable water supply well.
• When reclaimed water is used for an impoundment or storage pond that is not lined or sealed against seepage, there must be at least 500 ft between the perimeter of the impoundment and a potable water supply well; however, if the unit is lined or sealed to prevent seepage, the setback distance need only be 100 ft.
Storage

- Storage is required to divert water that doesn't meet water quality limits:
  - emergency storage, and
  - alternate permitted discharge locations during upsets.
- Storage must be provided for retention of reclaimed water when it is not required by a user unless an alternative disposal system is permitted. Storage should be sufficient to hold water for the duration of a 10-year storm, with the storm duration based on a minimum of 20 years of climate data. At a minimum, storage should be equal to three times that portion of the average daily flow of reuse capacity for which no alternative reuse or disposal system is permitted.
- When short-term storage is provided as a reliability feature to retain diverted flow, it should be capable of storing the wastewater for at least a 24-h period. The facilities must include all necessary provisions for odor control, conduits and pumping and pump back equipment. The equipment should be independent of the normal power supply or provided with a standby power source.
- Long-term storage for diverted water may consist of ponds, reservoirs, percolation areas, downstream sewers leading to other treatment or disposal facilities or any other facilities reserved for the purpose of emergency storage or disposal. The facilities must be of sufficient capacity to provide disposal or storage for at least 20 days.
Comments
West Virginia Department of Environmental Protection

West Virginia does not have any regulations or guidelines for water reuse, and it does not permit spray irrigation of treated wastewater in areas of unrestricted public access.

Treatment

Reliability

Water Quality

Site Constraints

Buffers

Storage
Wisconsin Department of Natural Resources (DNR)

Wisconsin does not have specific reuse guidelines or regulations, except regulations for spray irrigation of treated wastewater that are intended for isolated agricultural sites. In a few instances where golf course irrigation with treated wastewater was proposed, the EPA Reuse Guidelines were used to determine appropriate requirements for the permits for golf course irrigation. In general, requests for reuse applications in public access areas are infrequent.

Tom Gilbert, DNR, August 2000

Treatment
Reliability
Water Quality
Site Constraints
Buffers
Storage
Irrigation of crops with treated wastewater is permitted on crops consumed directly by humans, but the food may not be harvested for 30 days after irrigation.

**Treatment**

- Advanced treatment and/or secondary treatment is required.
- A level of disinfection is required such that number of fecal coliform organisms is ≤ 2.2/100 mL.

**Reliability**

- Permit applications must adequately demonstrate that the system proposed will meet all requirements of these regulations and will not endanger public health or the environment.
- Treatment reliability will be evaluated based on the inclusion in the design and operational plan of some or all of the following features: unit and equipment redundancy; alternative power sources; alarm systems and instrumentation; operator certification and stand-by capability; bypass and dewatering capability; sampling frequency; hydraulic and organic loading design capabilities and emergency storage provisions.
- A plan to reliably provide treated wastewater may also include a plan to dispose of inadequately treated wastewater in an acceptable manner or direct it to a less restrictive authorized reuse application. A producer may also obtain an NPDES permit to discharge treated wastewater that is not needed by the user or that is below the quality required, as long as it is within the NPDES permit limits.
- If monitoring data indicate noncompliance with the fecal coliform levels, use of the treated wastewater must be discontinued immediately. Monitoring frequency of fecal coliforms should be increased to at least once daily if a noncompliance event occurs.
- The treated wastewater producer is responsible for submitting annual reports that include all monitoring data, a description of how the minimum level of treatment requirements are met; a description of how the treatment reliability requirements are met, and a signed certification statement verifying that the records are not false.
- The person who is responsible for the application of the treated wastewater must provide an operation and maintenance manual for the site as part of a contractual agreement with the producer or as part of a permit application. The manual must include a description of the facilities, the application system, the procedures planned for emergency operation or spill events, the procedures planned to meet permit and regulatory requirements, the maintenance and operation requirements for any mechanical equipment at the site, and a plan for meeting the monitoring, record keeping and reporting requirements of the reuse regulations.
- A user regulated by a permit is responsible for submitting annual reports about the application site to the regulating agency.
- If monitoring data indicate noncompliance with the fecal coliform levels, the noncompliance event must be reported to the permitting authority no later than the next working day. A written report describing a noncompliance event, its duration, related data, and steps taken or planned to reduce, eliminate or prevent reoccurrence must be submitted to the permitting agency within 15 days of
resolution of the event.

- Data and other information used to prepare annual reports must be retained for five years by the entity responsible for the report.
- Treated wastewater must not be applied in a manner that will contaminate a groundwater aquifer.

**Water Quality**

- Fecal coliform concentration must be ≤ 2.2 cfu/100 mL, analyzed weekly. If fecal coliform monitoring indicates noncompliance, daily or even more frequent monitoring should be initiated and the results reported to the permitting authority.
- Analyses are to be performed by the person who prepares the wastewater; Analyses should be performed on representative samples of the treated wastewater according to stipulated procedures. Weekly analyses are required for nitrate as N, ammonia as N, and pH. Other parameters may be included in a permit on a case-by-case basis.

**Site Constraints**

- The producer of treated wastewater must demonstrate that all of the regulatory requirements will be met through steps such as management practices, record keeping and reporting; even if some of these activities are the responsibility of another person who will apply the treated wastewater, the producer must demonstrate that the requirements are being met.
  - If the producer is outside of the state of Wyoming, they must obtain a permit from the State to land apply in accordance with these regulations, or provide the wastewater to a person who has a permit.
  - The demonstration must be in the form of either a written agreement with the applier, specifying his or her responsibilities, or a separate permit application from the applier.
- Wind drift must not leave the application site.
- No surface runoff may leave the application site or enter surface waters of the State.
- Treated wastewater applied for the purpose of beneficial reuse should not exceed the irrigation need or demand of the vegetation at the site. Winter irrigation is considered to be beneficial reuse.
- Signage and fencing are required on land with “moderate potential for public exposure” (accessible to the public, but access is limited during irrigation), because the water quality limits are less stringent than those outlined here; they are not required on “land with a high potential for public exposure,” such as public parks, ball fields, cemeteries, plant nurseries, turf farms, or golf courses that meet the limits summarized here.

**Buffers**

- At least 30-ft separation distance is required between a spray irrigation reuse site and all surface waters.
- At least 100-ft separation distance is required between a spray irrigation reuse sites and potable water supply wells.
- At least 100-ft separation distance is required between a spray irrigation reuse sites and adjacent property lines.
- If flood irrigation is used, at least 30-ft separation distance is required between the reuse site and adjacent property lines. Public right-of-way land may be used to meet this buffer requirement.
- Drip irrigation systems may be used in the buffer zones required for spray or flood irrigation.

**Storage**