REPORT OF THE
VIRGINIA DEPARTMENT OF ENVIRONMENTAL QUALITY

LAND APPLICATION, RECLAMATION AND REUSE OF WASTEWATER

TO THE GOVERNOR AND
THE GENERAL ASSEMBLY OF VIRGINIA

HOUSE DOCUMENT NO. 92

COMMONWEALTH OF VIRGINIA
RICHMOND
2000

PREFACE

House Joint Resolution 662 (1999) (Appendix A) requested that the Department of Environmental Quality (Department or DEQ) study issues surrounding land application and reclamation and reuse of wastewater.

The Department was directed to convene an advisory group to conduct the study. The advisory group membership comprises representatives of engineering firms with expertise in the reclamation and reuse of wastewater; environmental organizations; agricultural organizations; professional organizations; Virginia Polytechnic Institute and State University; owners of wastewater treatment works; the Department of Health; and the Department of Conservation and Recreation. In addition, staff members at the DEQ provided assistance to the group.

The advisory group met four times over a three-month period. Dr. Ray Reneau, Virginia Tech, was elected as the chair of this group at the first meeting. In order to facilitate completion of the tasks, the group was further divided into three subgroups. These subgroups are as follows:

A. Review of other states' regulations/guidelines - Greg Evanylo (Chair), Daniel Horne, John Johnson, George Kennedy, and Randy Kepler.

B. Review of EPA Process Design Manual - Ray Reneau (Chair), Jeff Corbin, David Frackelton, William Gaidos, John Johnson, Russ Perkinson, and Cal Sawyer.

C. Ground water recharge issues - Terry Wagner (Chair), Jeff Corbin, and John Johnson

The Department would like to thank the advisory group for its hard work and technical expertise provided to the staff throughout this study.

HJR 662 (1999) WATER REUSE ADVISORY GROUP MEMBERS

Mr. Jeff Corbin	Chesapeake Bay Foundation
Dr. Greg Evanylo	Department of Crop and Soil Environmental Sciences - Virginia Tech
Mr. David G. Frackelton	Virginia Agribusiness Council
Mr. William Gaidos	Friends of the North Fork of the Shenandoah
Mr. Daniel B. Horne	Virginia Water Environment Association, Inc. and Virginia Section - American Water Works Association
Mr. John Johnson	Sheaffer International, Ltd.
Mr. George Kennedy	Virginia Association of Municipal Wastewater Agencies
Mr. Randy Kepler	Anderson and Associates
Mr. Larry Land	Virginia Association of Counties
Mr. Russ Perkinson	Department of Conservation and Recreation
Dr. Raymond B. Reneau	Department of Crop and Soil Environmental Sciences - Virginia Tech
Dr. Cal Sawyer	Department of Health
Mr. Wilmer Stoneman	Virginia Farm Bureau Federation

<u>DEQ STAFF MEMBERS</u>

Mr. Dwight Sours	Valley Regional Office
Mr. David Gussman	Tidewater Regional Office
Mr. Terry Wagner	Central Office
Ms. Lily Choi	Central Office

TABLE OF CONTENTS

EXECUTIVE SUMMARY

House Joint Resolution 662 (1999) charged the Department of Environmental Quality to study issues surrounding land application and reclamation and reuse of wastewater.

The resolution requested the study to include, but not be limited to, (i) the environmental soundness of reclamation and reuse of wastewater for irrigation of golf courses, athletic fields, forests, and farmland, as well as for snowmaking and fire protection in the Commonwealth; (ii) the potential environmental benefits and risks of using reclaimed wastewater for the purpose of recharging ground water aquifers; (iii) whether the Commonwealth should encourage and promote the use of such technology and, if so, under what conditions; and (iv) options, including, but not limited to, establishing a general permit for reclamation and reuse, modifying the Virginia Pollution Abatement Permit or modifying other regulations, so as to provide a predictable and certain process for the approval or denial of requests for the reclamation and reuse of wastewater. An advisory group was convened to conduct the study.

The study reveals that water reuse is already widespread both in the U.S. and the world. Much of this precedent recently established in Florida and North Carolina, whose water related issues are similar to Virginia's, may be applicable to Virginia. It also indicates that a high quality reclaimed water could be used for many purposes for which we are now employing potable water. Uses that may not require the same level of treatment as is required for drinking water include irrigation of landscapes (e.g., residential lawns, golf courses, and greenbelts), agricultural irrigation (e.g., fodder, feed, fiber, food and nursery crops), certain industrial processes (e.g., cooling, boiler feed, stack scrubbing, and process water), non-potable urban (e.g., fire protection, street washing, and vehicle washing), environmental (e.g., stream flow augmentation/fishery sustainability, and wetlands restoration), ground water recharge for certain purposes (e.g., saltwater intrusion control), and miscellaneous (e.g., snowmaking, dust control, and construction). The study determined that properly treated reclaimed water can be utilized, when properly managed, in water reuse projects that are fully protective of both public health and the environment. Water reuse is a beneficial method, which is under utilized in Virginia, to meet water demands with less than potable water and to reduce increasing water withdrawals from already strained sources.

Because Virginia is a party to the Chesapeake Bay Agreement which has a stated objective "to evaluate and institute, where appropriate, alternative technologies...such as land application" of treated wastewater effluent, and given the huge expense faced by industry and local governments in upgrading wastewater treatment plants to reduce nutrient pollution, and given the frequent water supply problems throughout the Commonwealth and the competing needs of its citizenry, the need to preserve green space, and the desirability of drought free farming, it is incumbent upon the Commonwealth to encourage and promote reclamation and reuse.

The advisory group recommends the Commonwealth encourage the reclamation and reuse of wastewater effluent by developing a new regulation or amending existing regulation (i.e., Virginia Pollution Abatement Permit Regulation, 9 VAC 25-32-10 et seq.); and developing interim guidance, that are protective of the health and safety of the Commonwealth's waters. Thus, water reuse could be, to the extent possible, economically competitive with other forms of effluent disposal. Water reuse should be encouraged through incentives, little or no fees, and monitoring requirements which are limited to the level necessary to ensure protection of public health and the environment.

The advisory group further recommends that the Commonwealth conduct a detailed review of other states' regulations and guidelines, the EPA Process Design Manual for Land Application of Municipal Wastewater (1981) and other relevant documents, and produce Virginia specific regulations for reuse of reclaimed water. While a general regulatory framework currently exists for land irrigation of reclaimed water, it is lacking in many specifics. Development of new water reuse regulations for land irrigation and other categories would probably take several years. Thus, the advisory group recommends development of a comprehensive regulation in the long term and revised guidance in the interim to expedite practical and beneficial reuse of reclaimed water in the short term. The comprehensive regulation should be developed as expeditiously as possible from a broadly focused stakeholder perspective that includes as many of those potentially affected by reusing reclaimed waters as possible, and initiated immediately. Statutory authority could be sought from the General Assembly, but the regulation can be promulgated under existing authority. The regulation should include definitions and standards for varying quality of reclaimed waters.

The advisory group concludes that both general and individual permits should be considered for reclamation and reuse. General permits should be considered for only the highest quality reclaimed water whose specific use would not endanger the public health or safety of the environment. Such a permit could prescribe the design, monitoring, and reporting requirements that must be met for a facility to qualify as a water reuse operation. The Department would confirm the prerequisites and provide general permit coverage. This would be a consistently predictable process for approval or denial of a permit. A general permit would expedite the permitting process while ensuring that facilities are properly designed and managed. Coverage under the general permit would also result in reduced permit fees for the owners. Individual permits would be issued for all but the highest quality reclaimed water. Individual permits would be required in such cases because of site specific differences that could impact public health or the quality of the receiving ground or surface water. Furthermore, the individual permit provides the public with the opportunity to comment on projects that influence their environment.

The study also includes an examination of the potential environmental benefits and risks of using reclaimed water for the purpose of recharging ground water aquifers, directly and indirectly. The advisory group concludes that more information regarding the occurrence and quality of ground water statewide should be obtained before considering any direct ground water recharge projects. The group also concludes that the Virginia Ground Water Standards (9 VAC 25-260-190 through 9 VAC 25-260-240) should be evaluated, and potentially revised, to clarify their application to projects which involve indirect ground water recharge.

The advisory group recommends that the Commonwealth initiate statewide ground water characterization efforts that are necessary to determine whether direct ground water recharge projects are feasible. The group also recognizes that this effort is not as high a priority as issues related to indirect ground water recharge.

The advisory group concludes that indirect ground water recharge has the potential to produce positive environmental results when the quality of the percolate (the portion of reclaimed water recharging ground water) is higher, for all constituents, than the naturally occurring ground water quality at the site of concern. In addition, indirect ground water recharge has the potential to improve ground water quality on sites where existing ground water quality has been degraded. In these cases, consideration must be given to the potential that indirect recharge may move existing ground water contamination off of the site of concern to other ground water or surface water receptors. The group recommends that the Virginia Ground Water Standards be evaluated, and potentially revised, to clarify their application on sites where the native ground water has been degraded due to previous activities.

The advisory group notes the previous interest of the General Assembly in one other type of wastewater reuse and recycling: that of gray water reuse. Past sessions of the Assembly have indicated their interest in this specific type of reuse, adopting HJR 587 (1997) and HB 912 (1998). The latter action, in part, directed the Virginia Department of Health to develop guidelines for the use of gray water. The advisory group believes that the logical next step for the implementation of those guidelines is for the Virginia Department of Health to develop a comprehensive regulation, revise an existing regulation, or establish formal guidance which will address the mechanism for issuance of permits for gray water systems, with input from appropriate stakeholders.

I. Introduction

As a result of the 1999 legislative session, House Joint Resolution 662 requested the Department of Environmental Quality study issues surrounding land application and reclamation and reuse of wastewater.

More specifically, the resolution requested the study to include, but not be limited to, (i) the environmental soundness of reclamation and reuse of wastewater for irrigation of golf courses, athletic fields, forests, and farmland, as well as for snowmaking and fire protection in the Commonwealth; (ii) the potential environmental benefits and risks of using reclaimed wastewater for the purpose of recharging ground water aquifers; (iii) whether the Commonwealth should encourage and promote the use of such technology and, if so, under what conditions; and (iv) options, including, but not limited to, establishing a general permit for reclamation and reuse, modifying the Virginia Pollution Abatement Permit or modifying other regulations, so as to provide a predictable and certain process for the approval or denial of requests for the reclamation and reuse of wastewater.

In carrying out this study, the resolution required the Department to examine how other states, including, but not limited to, North Carolina, Delaware, Pennsylvania, and Illinois, allow or prohibit reclamation and reuse. It also required the Department to examine the EPA Process Design Manual for Land Application of Municipal Wastewater (1981) and the body of scientific research currently available on reclamation and reuse.

The resolution also directed the Department to convene an advisory group to conduct the study. At the first meeting, the group identified available states' regulations and/or guidelines and a list of review criteria were developed. The task of this regulatory review was shared among the members. The EPA Process Design Manual for Land Treatment of Municipal Wastewater (1981) and the SCS Irrigation Manual (1993) were also assigned to members for review. In order to facilitate completion of its tasks, the group was further divided into three subgroups at the second meeting. These subgroups and their respective assignments are as follows:

A. Review of other states' regulations/guidelines

1. Prepare a Summary of regulations/guidelines from other states.
2. Create a list of definition for related terms - reuse, reclaim, etc.
3. Consider regulatory approaches and permit options

B. Review of EPA Process Design Manual

1. Review and develop a statement on the use of the EPA Process Design Manual for Land Treatment of Municipal Wastewater
2. Review the SCS Irrigation Manual for design of land application rates of wastewater.

C. Ground water recharge issues

1. Examine the potential environmental benefits and risks of using reclaimed water for the purpose of recharging ground water aquifers.

2. Address direct and indirect ground water recharge issues

The draft reports prepared by these three subgroups were reviewed and discussed at the third meeting. The final subgroup reports (Appendix B) and this final report reflect the consensus reached by the advisory group.

II. Definitions

An understanding of the terminology associated with wastewater reclamation and reuse is critical to the issue of determining whether and under what conditions reuse of municipal and industrial wastewater should be regulated and permitted. The following are key definitions of terms as they relate to the operation of wastewater reclamation and reuse systems.

Direct Potable Reuse	The treatment of community wastewaters to a sufficient degree that they would be acceptable for drinking and for their direct discharge into a single potable water distribution system.
Direct Recharge Of Ground Water	The use of injection wells, rapid infiltration basins or other methods that are designed to introduce large quantities of reclaimed water directly into aquifers that are or may be used as a public water supply. This does not include ground water recharge by percolate from land irrigation of reclaimed water.
Gray Water	Untreated wastewater from bathtubs, showers, lavatory fixtures, wash basins, washing machines, and laundry tubs. It does not include wastewater from toilets, urinals, kitchen sinks, dishwashers, or laundry water from soiled diapers.
Indirect Potable Reuse	The discharge of reclaimed water into an aquifer or raw water impoundment used for a drinking water source. Indirect potable reuse is contrasted with "direct potable reuse" which involves the discharge of reclaimed water directly into a drinking water treatment facility or into a drinking water distribution system.
Indirect Recharge of Ground Water	The supplementing or mounding of ground water produced by the percolate from the land irrigation of reclaimed water.
Land Irrigation of Reclaimed Water	The introduction of reclaimed water into or onto the ground for treatment or reuse.
Non-Potable Water	Any water, including reclaimed water, not meeting the drinking water standards of Federal, State and local authorities for human consumption.
Percolation	The generally vertical movement of water through soil or other unconsolidated medium to the water table and to lower aquifers where occurring.

Potable Water	Water which conforms to the drinking water standards of federal state and local authorities for human consumption.
Reclaimed Water	Water, which, as a result of treatment of domestic, municipal or industrial wastewater, is suitable for a direct beneficial use or a controlled use that would not otherwise occur. Specifically excluded from this definition is "gray water".
Recycled Water	Same as "Reclaimed Water".
Wastewater	The combination of liquid and water-carried pollutants from residences, commercial buildings, industrial plants, and institutions together with any ground water, surface runoff or leachate that may be present.
Water Reclamation	The treatment of domestic, municipal or industrial wastewater to produce reclaimed water for a direct beneficial use or a controlled use that would not otherwise occur.
Water Reuse	The use of reclaimed water for a direct beneficial use or a controlled use that is in accordance with the state and local regulatory requirements.

III. The Status of Land Irrigation and Reclamation and Reuse of Wastewater in Virginia

Prior to the formation of the advisory group, the staff conducted a file search to examine the status of wastewater land application or spray irrigation in Virginia. The information was shared with the advisory group and served as background information for this study.

Currently, there are thirty-seven facilities in Virginia that employ spray irrigation, rapid infiltration or overland flow technologies under permits issued by DEQ. These facilities are regulated under either the Virginia Pollution Abatement (VPA) Permit Regulation (9 VAC 25-32-10 et seq.) or the Virginia Pollutant Elimination Discharge (VPDES) Permit Regulation (9 VAC 25-31-10 et seq.). The Department issues a VPA permit to the entity that is responsible for the wastewater reclamation and reuse involving land irrigation. If, in addition to land irrigation, a facility has an option to discharge the reclaimed water through a point source, a VPDES permit is issued. This VPDES permit incorporates any applicable requirements pertaining to land irrigation. The following table displays information regarding these permits issued and their distribution throughout the various regions within the Department.

Regional Office	# of Permits Issued VPA/VPDES	% of Permits Issued	# of Permits Issued by Type of Land Irrigation		
			Slow Rate (Spray Irrigation)	Rapid Infiltration	Overland Flow
Tidewater	8/0	22%	6 VPAs (1 MW[1]/5 IW[2])	2 VPAs (MW)	0
Piedmont	7/2	24%	7 VPAs (3 MW/4 IW) 1 VPDES (MW)	0	1 VPDES (MW)
Northern Virginia	8/2	27%	8 VPAs (5 MW/3 IW) 1 VPDES (MW)	0	1 VPDES (MW)
Valley	7/0	19%	7 VPAs (2 MW/5 IW)	0	0
West Central	3/0	8%	3 VPAs (1 MW/2 IW)	0	0
Southwest	0/0	0%	0	0	0
Total	33/4	100%	31 VPAs (12 MW/19 IW) 2 VPDESs (MW)	2 VPAs (MW)	2 VPDESs (MW)

[1] **Municipal wastewater**
[2] **Industrial wastewater**

A regulatory framework for wastewater reclamation and reuse involving land irrigation in Virginia has been established through the VPA Permit Regulation. However, the VPA Permit Regulation does not prescribe any technical standards for this type of operations. The Sewerage Regulations, jointly adopted by the Virginia Department of Health (VDH) and the State Water Control Board in 1977, include the pretreatment standards and minimum design requirements for land application of municipal wastewater. The VDH is in the process of replacing these regulations by developing a separate set of regulations entitled "Sewage Collection and Treatment (SCAT) Regulations". When the SCAT Regulations are formally adopted, the joint Sewerage Regulations will be rescinded by the Board of Health and the State Water Control Board. These pretreatment standards have been implemented through the permits issued by the Department on a case-by-case basis. It has been the staff guidance to use the Sewerage Regulations, the proposed SCAT Regulations, and the EPA Process Design Manual (PDM) for Land Treatment of Municipal Wastewater as the basis for review and approval of land irrigation projects in Virginia. In order to assist the permit staff in reviewing permit applications and drafting permits, the Department developed two sets of guidance documents (land application of municipal wastewater effluent and land application of food processing waste) in 1993-1994. These guidance documents were primarily designed to help the staff determine application completeness and select appropriate monitoring requirements and permit conditions in the draft permit.

Review of the ground water monitoring data of some permits issued to land irrigation projects in Virginia indicated that insufficient storage period, excessive hydraulic loading rates, insufficient land base, and inadequate irrigation scheduling may have contributed to a negative impact on ground water quality. However, direct linkage has not been established. In addition, the staff experiences indicated that the existing criteria, such as a minimum of 60 days storage requirement and lack of agronomic considerations in irrigation scheduling, may not be adequate to protect state waters.

It is apparent that updated guidance and more specific regulations are greatly needed. The Department has taken the initiative to update its guidance. A task force composed of DEQ regional and central offices staff is in the process of revising the guidance at this time.

As to wastewater reclamation and reuse options other than land irrigation, such as non-potable urban uses, direct ground water recharge, etc., no specific regulations or guidelines have been established in Virginia. There is anecdotal evidence that at least some municipalities and industries have informally implemented certain reuse options, and discussions have been held with VDH and DEQ staff concerning the possibility of formally instituting specific reuse options. There is currently no inventory of reuse projects already implemented in the Commonwealth.

Interest has been posed by a number of parties in the specific reuse option of gray water use. This interest led to Assembly action in HJR 587 (1997), which directed DEQ and VDH to report on various issues relating to gray water reuse. That action was followed by HB 912 (1998), which directed VDH to develop guidelines for gray water reuse. VDH did develop the draft guidelines and a copy of this document is provided in Appendix C.

IV. Review of Other States' Regulations/Guidelines

The advisory group reviewed the following states' regulations and guidelines related to wastewater reclamation and reuse: Arizona, California, Delaware, Florida, Illinois, Indiana, North Carolina, Pennsylvania, Texas, and Washington. The summary of the regulatory review was compiled by Subgroup A in a survey form entitled "A Survey of State Reuse Regulations" (Appendix D). Specific survey questions developed by the group include: definitions for reuse, recycle, and reclaim; permit requirement; agencies involved; basis (regulations or guidance); water quality criteria specified; site requirements (buffers, application rates, time or weather restriction, nutrient management requirements, land feature restrictions, and monitoring requirements); crops restrictions; aquifer recharge allowed (specify direct or indirect); and storage requirements. For the purposes of comparison, Virginia's regulations and guidance requirements were included in the survey form. The group also reviewed the EPA Manual "Guidelines for Water Reuse" (1992) as supplemental background information.

The advisory group's review indicates that water reuse is already widespread both in the U.S. and the world, and much potentially applicable precedent has been recently established in Florida and North Carolina, whose water related issues are similar to Virginia's. The more arid states (i.e., Arizona, California), whose issues may be different from Virginia's and whose regulations may not be completely applicable, have done much relevant research and experimented with many similar useful operational technologies.

The study also concludes that a high quality reclaimed water could be used for many purposes for which we are now employing potable water. Uses that may not require the same level of treatment as is required for drinking water include irrigation of the landscape (e.g., residential lawns, golf courses, and greenbelts), agricultural irrigation (e.g., fodder, feed, fiber, food and nursery crops), certain industrial processes (e.g., cooling, boiler feed, stack scrubbing, and process water), non-potable urban (e.g., fire protection, street washing, and vehicle washing), environmental (e.g., stream flow augmentation/fishery sustainability, and wetlands restoration), ground water recharge for certain purposes (e.g., saltwater intrusion control), and miscellaneous (e.g., snowmaking, dust control, and construction). Water reuse is a beneficial method, which is under utilized in Virginia, to meet water demands with less than potable water and to reduce increasing water withdrawals from already strained sources. The advisory group reviewed data from many of the existing reuse projects, and determined that, given proper treatment of the reclaimed water and proper operation and management of the water reuse project, water reuse can be implemented in a manner which is fully protective of public health and the environment. Such projects could reduce demands for high-quality potable water and allow the Commonwealth to allocate scarce water supplies to appropriate needs.

As to the gray water reuse program, a number of other states, primarily in the arid Southwest but also in other parts of the country, have implemented or are in the process of developing such programs. The experience of other states with gray water reuse has had somewhat mixed success, primarily due to conflicts over regulatory purview of gray water systems between agencies with jurisdiction over health codes and those with jurisdiction over building and plumbing codes. The advisory group believes that a properly crafted regulation adopted by the VDH, developed through a stakeholder process, would eliminate such conflicts and would allow implementation of the VDH guidelines.

V. Review of EPA Process Design Manual and Other Relevant Publications

The EPA Process Design Manual (PDM) for Land Application of Municipal Wastewater (1981) gives guidance for many of the steps necessary for reuse of water and nutrients in both agricultural, turf, and forest systems. The PDM is used by DEQ staff as a reference source to review permit applications and develop permit conditions for land irrigation. Subgroup B was tasked to identify the problems associated with the PDM and provide recommendations to the Department in order to address concerns related to land irrigation design.

The advisory group found that the PDM has many features that are beneficial in determining the suitability of a site and the design of a land-based system for reuse of reclaimed water. The advisory group determined that, (i) the PDM provides an excellent description of the hydraulic pathway for slow rate spray irrigation, rapid infiltration and overland flow systems; (ii) the planning and technical assessment sections of the PDM provide a logical procedure for site evaluation; and (iii) the PDM recommendations on slopes, soils and field investigations are appropriate.

However, there are several limitations that restrict the usefulness of this manual. Through the review of this manual and other relevant publications, the group identified specific issues and provided recommendations pertaining to land irrigation design. These issues and recommendations are summarized below.

1. **Issue**: Although the PDM planning and assessment sections give a logical stepwise procedure for site evaluation, our regional geological features, such as the potential for flooding and karst topography, were not taken into consideration.
Recommendation: Additional rating factors such as the potential for flooding and consideration of karst topographic features would strengthen this

section. For example, proposed wastewater reuse projects in karst topographic regions must be given special technical review.

2. **Issue**: The procedure for hydraulic assimilative capacity presented in the PDM is suitable for estimating the total amount of water that can percolate through the profile without resulting in extended periods of saturation. However, the accuracy of the hydraulic assimilative capacity of a site is highly dependent on reliable measurements of the hydraulic conductivity of the soil being used for treatment. The PDM acknowledges the variability associated with soil hydraulic conductivity measurements and stresses the importance of evaluating multiple tests across the site to determine a reasonable average. It also gives guidance on the type of averaging to employ when vertical hydraulic conductivity methods are employed.
Recommendation: To help alleviate the inherent variability with site conductivity measurements, application rates and timing of application may be based on measured, real-time, in situ soil moisture monitoring data. It is important to establish a protocol for determining the moisture status in soils so that decisions can be made on when to irrigate and how much water can be applied at an irrigation event. To make these calculations, a decision needs to be made on the type of moisture monitoring equipment; the number of water measuring devices to be installed; and the depth of installation. Also, information has to be developed on the moisture holding capacity of the soil system to determine the quantity of wastewater that can be applied at an irrigation event. Alternatively, a model that considers soil moisture holding capacity, infiltration rates, and evapotranspiration may be appropriate to make these decisions.

3. **Issue**: A relative comparison of the suitability of field, forage, turf, and forest crops based on their potential as a revenue producer, water user, nitrogen user, and moisture tolerance is given in the PDM. However, regional considerations, particularly for nutrients, are missing in this process.
Recommendation: Regional data on crop suitability and nutrient requirements for irrigated crops need to be developed to assist in calculating allowable rates of application and timing of land irrigation.

4. **Issue**: Elements other than nitrogen may be the limiting design factor in some wastewaters. These have not been addressed in adequate detail in the PDM.
Recommendation: A procedure for evaluating the impact of these elements needs to be considered. The impact of certain chemical constitutes on soil properties (e.g., % sodium saturation) needs to be considered in greater detail. The equation used to estimate hydraulic loading based on nitrogen can potentially be modified to estimate the concentration of other contaminants in the percolate.

5. **Issue**: Timing of nitrogen application (in reclaimed waters) to the crop has not been addressed in adequate detail.
Recommendation: Additional uptake versus time data for selected crops when nitrogen is the limiting design factor needs to be developed. Sigmodial relationships between nitrogen uptake and date from planting can be developed from existing data to meet this need.

6. **Issue**: The guidelines provided by the PDM for nitrogen, phosphorus, and potassium uptake for forage and field crops and nitrogen uptake for forest do not reflect Virginia's regional conditions.

Recommendation: The suggested rates in the PDM appear reasonable but need to be modified based on regional crops grown, soil type, management level, etc. Nutrient uptake data from Virginia and adjacent states where irrigation is used needs to be reviewed and crop nutrient uptake data specific to Virginia conditions for irrigated crops needs to be developed. This review should include the DCR nutrient management criteria. The PDM suggests that local conditions, projected yields, etc. should be considered when determining nutrient uptake. Also information on uptake of additional nutrients (e.g., sulfur and chloride) would be useful.

7. **Issue:** The PDM assumes that all the nitrogen in the reclaimed water is in plant available form. However, some reclaimed waters will have significant amounts of organic nitrogen that may not be completely mineralized during the year of application and, therefore, is not available as plant nutrient.
Recommendation: The availability of the organic nitrogen fraction, over time, needs to be considered in these wastewaters.

8. **Issue:** The PDM gives an equation to estimate the percolate nitrogen concentration that considers the percolate nitrogen concentration, precipitation, evapotranspiration, crop nitrogen uptake, nitrogen concentration in the reclaimed water, and the fraction of applied nitrogen removed via gaseous losses. This equation has undergone limited testing primarily where grass has been used as the vegetative cover (Giggey et al.,1989; Jenkins and Palazzo, 1981; and Monnett et al., 1996). These studies show that inorganic nitrogen concentrations in the percolate were generally lower than the estimated values when nitrogen is the limiting design factor.
Recommendation: A more extensive review of literature that compares estimated versus measured nitrogen in the percolate needs to be conducted for a broader range of cropping systems and soil types. Additional research may be necessary to fully address this issue.

9. **Issue:** The model provided in the PDM to be used to estimate nitrogen removals in ponds during ice-free periods is an important part of any land-based treatment design. However, it only includes detention time as a variable.
Recommendation: Additional factors such as temperature, pH, and pond depth should be taken into consideration. Some of the newer models incorporate additional factors, such as pH and a temperature-dependent rate constant, when estimating nitrogen removal (Reed et al., 1995).

10. **Issue:** There are questions concerning the suitability of EPA Climate Model III for determining nonoperational days and days of storage required.
Recommendation: What constitutes a nonoperational day needs to be defined. Also soil moisture status, temperature, and planting and harvest operations need to be taken into consideration when determining nonoperational days.

The Advisory Group agrees that storage is an important aspect of any land based treatment system and should be given careful consideration to ensure adequate storage capacity during the life of the system. However, there is enough difference in opinion among members of the group on storage requirements to recommend that the EPA Climate Models used in the PDM to estimate storage be examined in greater detail. In particular, the EPA Climate Model III for moderate climates should be evaluated and compared with storage requirements in Virginia and adjacent states.

The advisory group felt that the PDM was published in 1981 and thus does not take into consideration research or results from field installations since that time. The group recommends that the Department should conduct a detailed review of the PDM and other relevant documents. A list of suggested relevant publications is provided in Appendix E. Regulations developed by other states should be evaluated in greater detail. In particular, Pennsylvania's Department of Environmental Protection has developed a manual entitled "Manual for the Land Application of Treated Sewage and Industrial Wastewater" published in 1993 that appears to address concerns with land application of wastewater similar to those present in Virginia.

The advisory group recommends that the Commonwealth conduct a detailed review of the PDM and other relevant documents and produce Virginia specific regulations for reuse of reclaimed water via land irrigation.

VI. Potential Environmental Benefits and Risks of Using Reclaimed Water for the Purpose of Recharging Ground Water Aquifers

Subgroup C was tasked to examine the potential environmental benefits and risks of using reclaimed water for the purpose of recharging ground water aquifers. The group considered two distinct recharge mechanisms for the potential recharge of ground water. They are defined as direct and indirect ground water recharge. Direct recharge of ground water is the use of injection wells or other methods of rapid infiltration where the primary purpose of the process is to provide additional water to an aquifer. Indirect recharge describes the incidental addition of water to an aquifer where the primary purpose is the use of treated wastewater for a beneficial purpose through a slow rate infiltration system, such as land application of treated wastewater as irrigation for the purpose of crop production. These two recharge mechanisms are discussed below.

Direct Ground Water Recharge

There are several potential environmental benefits of direct ground water recharge. These benefits include establishment of saltwater intrusion barriers in coastal aquifers, augmentation of available ground water supplies, and control of land surface subsidence. Each of these benefits could be realized in Virginia, especially in the Coastal Plain. There are numerous technical considerations that must be addressed to allow the successful implementation of a direct ground water recharge project on a regional basis. One primary concern is an accurate characterization of the quality of existing ground water to assure that the injected fluid will not cause precipitation and clogging in the injection well or in the aquifer material itself. In large areas of Virginia the ground water quality is not known with enough certainty to allow the development of direct ground water recharge projects. While this current lack of information may preclude the use of direct ground water recharge, Virginia should consider developing a program to characterize ground water quality and occurrence to a level of detail that would allow the consideration of this technology.

A major environmental risk associated with direct ground water recharge is the potential for contamination of existing ground water quality due to the quality of the injected reclaimed water. Any direct recharge of ground water would require a very high quality reclaimed water to assure no ground water contamination would occur. The use of reclaimed water for direct ground water recharge may also result in the reduction of stream flows where the treated wastewater was previously discharged to surface waters. This issue has the potential to be problematic during times of low flow, predominately in the western non-tidal portion of the state. Since the tidal Coastal Plain area of the state is the most likely area to realize the benefits of direct ground water recharge, diminishment of stream flows is likely to be a minor concern related to direct ground water recharge.

The advisory group recommends that the Commonwealth initiate statewide ground water characterization efforts that are necessary to determine whether direct ground water recharge projects are feasible. The group also recognizes that this effort is not as high a priority as issues related to indirect ground water recharge.

Indirect Ground Water Recharge

The potential environmental benefits and risks associated with indirect ground water recharge are similar to those associated with direct ground water recharge, on a much smaller and primarily localized scale. In most all cases, any indirect recharge of ground water will primarily impact the unconfined water table aquifer. In some areas of the Commonwealth this aquifer is not the primary aquifer of use for potable water supplies. In other areas, the unconfined water table aquifer is routinely used as a source of potable water, especially for private domestic use. In all cases, the unconfined water table aquifer is defined as State Waters for purposes of implementation of the Virginia Ground Water Standards.

Indirect ground water recharge has the potential to augment the amount of water available from unconfined aquifers to support an assortment of water uses. In areas where the unconfined aquifers are not directly used, augmentation of unconfined aquifers may result in indirect augmentation of deeper confined aquifers, fractured rock aquifers, or solution channel aquifers in carbonate areas.

In areas where the native ground water has been degraded by human activities, indirect ground water recharge has the potential to improve ground water quality in the immediate area of ground water recharge so long as the treated wastewater is of better quality than the existing ground water. This potential benefit must be weighed against the potential risk of moving a ground water contamination plume from the site of recharge to an offsite receptor. Potential receptors include users of the ground water resource as well as surface water streams that may be recharged by ground water.

Depending on the quality of the reclaimed water there are potential risks that existing ground water quality can be degraded. This potential may result in impacts to surface water bodies and associated biota or to users of ground water for potable or other purposes. This risk is mitigated with increased wastewater treatment, as the quality of the reclaimed water increases the associated risk decreases. The use of reclaimed water for indirect ground water recharge may also result in the reduction of stream flows where the treated wastewater was previously discharged to surface waters. This issue has the potential to be problematic during times of low flow, predominately in the western non-tidal portion of the state. Conversely, indirect ground water recharge that occurs in alluvial areas associated with streams may provide additional contribution to stream flows during times of low flow.

The Virginia Ground Water Standards (9 VAC-25-260-190) are designed to prevent the entry of pollutants into ground water in any aquifer. This regulation requires that natural ground water quality be maintained for all constituents. The regulation allows mixing zones in ground water on a case-by-case basis that are as small as possible. The Standards do not specifically address the situation where indirect recharge occurs in an aquifer that has been contaminated and does not represent natural conditions. Any indirect ground water recharge project must be designed to comply with this regulation.

The advisory group concludes that indirect ground water recharge has the potential to produce positive environmental results when the quality of the percolate (the portion of the reclaimed water recharging ground water) is higher, for all constituents, than the naturally occurring ground water quality at the site of concern. In addition, indirect ground water recharge has the potential to improve ground water quality on sites where existing ground water quality has been degraded. In these cases consideration must be given to the potential that indirect recharge may move existing ground water contamination off of the site of concern to other ground water or surface water receptors. The group recommends that the Virginia Ground Water Standards be evaluated, and potentially revised, to clarify their application on sites where the native ground water has been degraded due to previous activities.

VII. Options and Recommendations

Since Virginia is a party to the Chesapeake Bay Agreement which has a stated objective "to evaluate and institute, where appropriate, alternative technologies...such as land application" of treated wastewater effluent, and given the huge expense faced by industry and local governments in upgrading wastewater treatment plants to reduce nutrient pollution, and given the frequent water supply problems throughout the Commonwealth and the competing needs of its citizenry, the need to preserve green space, and the desirability of drought free farming, it is incumbent upon the Commonwealth to encourage and promote reclamation and reuse. The advisory group recommends that Virginia should encourage the reclamation and reuse of wastewater effluent by developing a new regulation or amending existing regulation (i.e., Virginia Pollution Abatement Permit Regulation, 9 VAC 25-32-10 et seq.); and developing interim guidance, that are protective of the health and safety of the Commonwealth's waters. Thus, water reuse could be, to the extent possible, economically competitive with other forms of effluent disposal. Water reuse should be encouraged through incentives, little or no fees, and monitoring requirements which are limited to the level necessary to ensure protection of public health and the environment.

In order to provide a predictable and certain process for the approval or denial of requests for the reclamation and reuse of wastewater, the advisory group explored various options for the Commonwealth's considerations. The group's finding and recommendations are provided below.

Approach to Regulation and Guidance

The advisory group concludes that water reuse should be a regulated activity that should require permits. Guidance alone is not sufficient because this model results in direction that is not as predictable or certain as regulation; however, regulation has already been developed (i.e., Virginia

Pollution Abatement Permit Regulation, 9 VAC 25-32-10 et seq.) for some reuse categories, and guidance would expedite the permitting process in these cases. For example, wastewater spray irrigation is a currently regulated activity, though the regulations lack many specifics. The advisory group recommends development of water reuse regulations that encompass all of the activities in the six groups below. Since the regulatory process may take several years, the advisory group recommends development of interim guidance to expedite practical and beneficial reuse in the short term. This comprehensive regulation should be developed as expeditiously as possible from a broadly focused stakeholder perspective that includes as many of those potentially affected by reusing reclaimed waters as possible, and initiated immediately. Statutory authority could be sought from the General Assembly, but the regulation can be promulgated under existing authority.

Standards and requirements for environmentally sound water reuse (especially land irrigation) should include, but not be limited to, the following issues:

a) Definition of reclaimed water, water reuse, etc.;
b) Variety of land irrigation and other wastewater reuse systems;
c) Water quality standard requirements;
d) Site specific soil types and capabilities;
e) Cropping system requirements;
f) Buffer and setback requirements;
g) Slope limitations for cultivated land, permanent hayland, forestland and urban land;
h) Nutrient management;
i) Augmentation of local groundwater through indirect recharge;
j) Basis for determining winter storage requirements;
k) Size of treatment facilities and effluent volume;
l) Certification program for operators;
m) Effect on stream flow, where applicable;
n) Opportunities for public access or exposure;
o) Opportunities for worker exposure;
p) Water quality needs for the intended uses; and
q) The extent of regulation by other Codes (i.e., Plumbing Code, etc.).

Adverse impacts on state waters could result from operation and management of the reclamation and reuse systems, as well as from inadequate design of facilities. As part of the regulatory process, the Department should review cases it believes have impacted the waters of the state to determine if the impacts resulted from design or management flaws.

Recommended Categories of Water Reuse

The advisory group recommends the Department consider the following six water reuse categories for development of regulations and/or guidance. Examples of these reuses have been provided in Section IV Review of Other States' Regulations/Guidelines.

Group 1 - Land irrigation for agricultural, forest, and landscape uses
Group 2 - Direct ground water recharge and indirect potable reuse
Group 3 - Industrial processes
Group 4 - Non-potable urban
Group 5 - Environmental
Group 6 - Miscellaneous

Permitting Requirements

Anyone constructing, modifying, or operating a water reuse system should be required to obtain a permit. If the use of reclaimed waters is provided by an existing permit, the end user should not be required to obtain a separate permit.

Currently, VDH has one set of regulation adopted and another in process for adopting (which will replace the existing regulation), DEQ has two sets of guidance, and DCR provides input. There sometimes may be conflicts in interpretations and in the decision-making processes among these agencies. One set of rules is needed for Virginia that clearly and specifically describes the process and requirements. A water reuse permit should be developed in consultation with VDH, DCR, and other state agencies as appropriate, but it should be administered by the DEQ. An exception would be for gray water reuse projects, where the permit should be issued by VDH in consultation with the local Building Official.

The advisory group concludes that both general and individual permits should be considered for reclamation and reuse. General permits should be considered for only the highest quality reclaimed water whose specific use would not endanger the public health or safety of the environment. Such a permit could prescribe the design, monitoring, and reporting requirements that must be met for a facility to qualify as a water reuse operation. The Department would confirm the prerequisites and provide general permit coverage. This would be a consistently predictable process for approval or denial of a permit. A general permit would expedite the permitting process while ensuring that facilities are properly designed and managed. Coverage under the general permit would also result in reduced permit fees for the owners.

Individual permits would be issued for all but the highest quality reclaimed wastewater. Individual permits would be required in such cases because of site specific differences that could impact the quality of the receiving ground or surface water. A more detailed evaluation of a proposed water reuse project by the Department is necessary when reusing lower quality reclaimed water because of the differences in the land receiving the reclaimed water, the great variability of reuse option types, and the variability in the quality of receiving waters. Furthermore, the individual permit provides the public with the opportunity to comment on projects that influence their environment.

Conclusion

In summary, Virginia should take all necessary steps to refine and develop a regulatory program providing a certain and predictable process for permitting and regulating the reclamation and reuse of wastewater. The goal of these efforts should be to establish Virginia as a leader in the eastern United States in promoting reclamation and reuse as a method for better allocating water resources and addressing water quality issues.

REFERENCES

Giggey, Michael D., Ronald W. Crites, and Karl A. Brantner. 1989. Spray irrigation of treated septage on reed canarygrass. J. Water Pollution Control Fed. 61:333-342.

Jenkins, T. F. and A. J. Palazzo. 1981. Wastewater treatment by a prototype slow rate land treatment system. U.S. Army Cold Regions Research and Engineering Laboratory. CRREL Report 81-14.

Monnett, G. T., R. B. Reneau, Jr., and C. Hagedorn. 1996. Evaluation of spray irrigation for on-site wastewater treatment and disposal on marginal soil.

Pennsylvania Department of Environmental Resources. 1993. Manual for Land Application of Treated Sewage and Industrial Wastewater.

Reed, Sherwood C., Ronald W. Crites, and E. Joe Middlebrooks. 1995. Natural Systems for Waste Management and Treatment. 2nd Edition. McGraw-Hill, Inc.

Soil Conservation Service. 1993. Irrigation water requirements. p. 2-i - 2-284. In United States Department of Agriculture, Part 623 National Engineering Handbook. Washington, DC.

USEPA. 1981. Process design manual for land treatment of municipal wastewater. U.S. Environmental Protection Agency, Center for Environmental Research Information. EPA 625/1-81-013.

USEPA. 1992. Manual: Guidelines for Water Reuse. U.S. Environmental Protection Agency, Center for Environmental Research Information. EPA/625/R-92/004.

GENERAL ASSEMBLY OF VIRGINIA -- 1999 SESSION

HOUSE JOINT RESOLUTION NO. 662

Requesting the Department of Environmental Quality to study issues surrounding land application and reclamation and reuse of treated wastewater.

Agreed to by the House of Delegates, February 8, 1999
Agreed to by the Senate, February 23, 1999

WHEREAS, the Commonwealth is a party to the Chesapeake Bay Agreement, which establishes the goal of reducing nutrient loadings to the Chesapeake Bay by 40 percent by the year 2000; and

WHEREAS, many local governments and industries are faced with significant costs for upgrading conventional wastewater treatment plants with biological nutrient removal technology; and

WHEREAS, the land application of treated effluent is an alternative method for disposal of treated wastewater; and

WHEREAS, one of the objectives of the 1987 Chesapeake Bay Agreement is to "evaluate and institute, where appropriate, alternative technologies...such as...land application" of treated wastewater effluent; and

WHEREAS, the United States Congress established in the Clean Water Act the goal of ending the discharge of pollutants to the waters of the United States by 1985; and

WHEREAS, the reclamation and reuse of treated wastewater has substantial potential to assist the Commonwealth in meeting the goals of the Chesapeake Bay Agreement and the Clean Water Act; and

WHEREAS, reclaimed treated wastewater has been used for the irrigation of golf courses, athletic fields, forests, and farmland, as well as for snowmaking and fire protection; and

WHEREAS, the Commonwealth suffers periodic droughts, producing agricultural stress and regional depletion of ground and surface water and reclamation and reuse may be a potential source of water for alleviating water shortages locally; and

WHEREAS, the Commonwealth recognizes that water is a precious commodity and should be managed as efficiently as possible for as many uses as possible; and

WHEREAS, the Commonwealth should be committed to encouraging the use of innovative technologies to provide solutions to environmental challenges; and

WHEREAS, questions have arisen regarding the adequacy of the Commonwealth's regulatory structure and existing guidance for the reclamation and reuse of treated wastewater; now therefore, be it

RESOLVED by the House of Delegates, the Senate concurring, That the Virginia Department of Environmental Quality be requested to study the issues surrounding land application and reclamation and reuse of treated wastewater. The study shall include, but need not be limited to, (i) the environmental soundness of reclamation and reuse of wastewater for irrigation of golf courses, athletic fields, forests, and farmland, as well as for snowmaking and fire protection in the Commonwealth; (ii) the potential environmental benefits and risks of using reclaimed wastewater for the purpose of recharging groundwater aquifers; (iii) whether the Commonwealth should encourage and promote the use of such technology and, if so, under what conditions; and (iv) options, including, but not limited to, establishing a general permit for reclamation and reuse, modifying the Virginia Pollution Abatement Permit or modifying other regulations, so as to provide a predictable and certain process for the approval or denial of requests for the reclamation and reuse of wastewater. In carrying out this study, the Department shall examine how other states, including, but not limited to, North Carolina, Delaware, Pennsylvania, and Illinois, allow or prohibit reclamation and reuse. The Department shall examine the United States Environmental Protection Agency's Process Design Manual for the Land Application of Municipal Wastewater and the body of scientific research currently available on reclamation and reuse.

The Department shall convene an advisory group to assist in its study. The advisory group shall include representatives of engineering firms with expertise in the reclamation and reuse of wastewater; environmental organizations; agricultural organizations; the State Department of Health; and Virginia's academic institutions who have expertise in the issues raised by the reclamation and reuse of wastewater.

APPENDIX A

All agencies of the Commonwealth shall provide assistance to the Department of Environmental Quality in the conduct of this study, upon request.

The Department shall complete its work in time to submit its findings and recommendations to the Governor and the 2000 Session of the General Assembly as provided in the procedures of the Division of Legislative Automated Systems for the processing of legislative documents.

APPENDIX B
Subgroup A Report

Recommendations on Wastewater Reuse in Virginia

A report to the Virginia Department of Environmental Quality
by the Water Reuse Advisory Group

Introduction

Water is a precious and essential resource. The limits of this resource, once thought to be boundless, have been approached repeatedly in the recent past throughout the Commonwealth. We must always assure that an adequate supply of potable water is available.

Alternative sources of water for non-potable uses must be utilized when possible. It is foolish to insist on using water fit for drinking for all purposes, from irrigating crops to quenching hot metals to washing sidewalks and roads. When looking at the inventory of available water resources we must do a better job of matching the intended use to the quality of the available water.

Background

Water reuse is already widespread both in the U.S. and the world. It is no longer a leading edge technology. It is time for the Commonwealth to follow suit and become stewards of the total water resource inventory. We already have much precedent from which to draw. Fortunately, much of this precedent has been recently established in our neighboring southeastern states, Florida and North Carolina, whose water related issues are similar to our own. Other more arid states (i.e., Arizona, California), whose issues may be different from ours and whose regulations may not be completely applicable, have done much relevant research and experimented with many similar useful operational technologies.

A high quality reclaimed water could be used for many purposes for which we are now employing potable water. Uses that may not require the same level of treatment as is required for drinking water include irrigation of the landscape (e.g., residential lawns, golf courses, and greenbelts), agricultural irrigation (e.g., fodder, feed, fiber, food and nursery crops), certain industrial processes (e.g., cooling, boiler feed, stack scrubbing, and process water), non-potable urban (e.g., fire protection, street washing, and vehicle washing), environmental (e.g., stream flow augmentation/fisheries sustainability and wetlands restoration), ground water recharge (e.g., Recharge potable aquifer and saltwater intrusion control), and miscellaneous (e.g., snowmaking, dust control, and construction). Water reuse is a beneficial method to meet the demands of less than potable water and to reduce increasing water withdrawals from already strained sources.

An example of just one class of reuse projects is that of golf course irrigation. Large numbers of golf courses nationwide irrigate with reclaimed water, with such courses ranging from arid states such as Arizona to humid, wet states such as Florida, and moderate climate states such as North Carolina and Maryland. One study in 1994 indicated that there were over 200 golf courses nationwide which were either currently irrigating with reclaimed water or would be irrigating with reclaimed water within the year, including such nationally known courses as Pebble Beach in California and the TPC Course at Sawgrass, Florida. In fact, California and Florida require (via either law or regulation) new golf courses to prove that they cannot be provided with reclaimed water before they are allowed to use either potable water from a central water system or native ground water.

One other major class of reuse that has drawn significant national attention is that of gray water reuse, particularly use of gray water generated by a home or a small commercial establishment for on-site irrigation of lawns and ornamentals. A number of states have adopted regulations in the past several years to allow such reuse, and the Virginia state-wide Plumbing Code has recently been modified to allow certain types of gray water reuse. The General Assembly has previously expressed interest in gray water reuse, adopting HJR 587 (1997) and HB 912 (1998). In response to HJR 587, DEQ submitted a report indicating the possible usefulness of certain gray water reuse systems. HB 912, in part, directed the Virginia Department of Health to develop guidelines for the use of gray water. Those guidelines have been developed in draft, and are provided as Appendix C to this report.

As mentioned previously, much research has been undertaken on various aspects of water reuse, including perhaps the most important aspect of public health impacts. Numerous studies have been undertaken to determine the safety of various types of reuse projects, and possible public health impacts. While studies have shown that there are significant risks associated with inappropriate uses of untreated wastewaters, study after study has shown that there are little to no risks associated with properly managed reuse operations utilizing properly treated reclaimed waters. This research has looked at reuse options including golf course irrigation, irrigation of food crops, and various types of cooling tower operations, among others.

Since Virginia is party to the Chesapeake Bay Agreement which has as a stated objective "to evaluate and institute, where appropriate, alternative technologies...such as land application" of treated wastewater effluent, and given the huge expense faced by industry and local governments in upgrading wastewater treatment plants to reduce nutrient pollution, and given the frequent water supply problems throughout the Commonwealth and the competing needs of its citizenry, the need to preserve green space, and the desirability of drought free farming, it is incumbent upon the Commonwealth to encourage and promote reclamation and reuse. Virginia should encourage the reuse of reclaimed water by developing regulation or, where regulation has already been adopted, guidance that is protective of the health and safety of the Commonwealth's waters and, to the extent possible, economically competitive with other forms of effluent disposal. Water reuse should be encouraged through incentives, little or no fees, and monitoring requirements which are limited to the level necessary to ensure protection of public health and the environment.

Recommended Categories of Water Reuse

Listed below are six water reuse categories that should be considered by DEQ for development of regulations and/or guidance. Examples of these reuses have been provided above.

Group 1 - Land irrigation for agricultural, forestal, and landscape uses.
Group 2 - Direct groundwater recharge and indirect potable.
Group 3 - Industrial processes.
Group 4 - Non-potable urban.
Group 5 - Environmental.
Group 6 - Miscellaneous.

Approach to Regulation and Guidance

Water reuse should be a regulated activity that should require permits. Guidance alone is not recommended because this model results in direction that is not as predictable or certain as regulation; however, regulation has already been developed for some reuse categories, and guidance would expedite the permitting process in these cases. For example, wastewater spray irrigation is a currently regulated activity. Development of new water reuse regulations that encompass all of the activities in the six groups above would probably take several years. Implementation of more practical criteria for water reuse irrigation would be delayed unless guidance options were to be developed in the interim. Thus, we recommend development of a comprehensive regulation in the long term and guidance to expedite practical and beneficial reuse in the short term. This regulation should be developed as expeditiously as possible from a broadly focused stakeholder perspective that includes as many of those potentially affected by reusing treated waters as possible. If necessary, statutory authority should be sought from the General Assembly.

Definitions of reclaimed water, water reuse, and related terms are critical to the degree of regulation required. A tiered approach to regulating water reuse based on appropriate and safe uses for reclaimed water meeting specific quality standards is recommended. Reclaimed water of highest quality could be used with few restrictions, and lower quality reclaimed water would be more strictly controlled. Standards and requirements for environmentally sound wastewater reuse (especially land irrigation) should be developed by considering the following issues:

a) definition of reclaimed water, water reuse, etc.;
b) variety of land irrigation and other wastewater reuse systems;
c) water quality standard requirements;
d) site specific soil types and capabilities;

e) cropping system requirements;
f) buffer and setback requirements;
g) slope limitations for cultivated land, permanent hayland, forestland and urban land;
h) nutrient management;
i) augmentation of local groundwater through indirect recharge;
j) basis for determining winter storage requirements;
k) size of treatment facilities and effluent volume;
l) certification program for operators;
m) effect on stream flow;
n) opportunities for public access or exposure;
o) opportunities for worker exposure;
p) water quality needs for the intended uses; and
q) the extent of regulation by other codes (i.e., Plumbing Code, etc.).

Permitting Requirements

Anyone constructing, modifying, or operating a water reuse system should be required to obtain a permit. If the reuse of reclaimed waters is provided by an existing permit, the end user should not be required to obtain a separate permit.

Currently, VDH has one set of regulation adopted and another in process of adoption (which will replace the existing regulation), DEQ has two sets of guidance, and DCR provides input. There may sometimes be conflicts in interpretations and in the decision-making processes among these agencies. One set of rules is needed for Virginia that clearly and specifically describes the process and requirements. A permit should be developed in consultation with VDH, DCR, and other state agencies as appropriate, but it should be administered by DEQ. An exception would be for gray water reuse permits, where the permit should be issued by VDH in conjunction with the local Building Official.

Both General and Individual permits should be considered for reclamation and reuse. General Permits should be considered for only the highest quality reclaimed water whose specific use would not endanger the public health or safety of the environment. Such a permit could prescribe the design, monitoring, and reporting requirements that must be met for a facility to qualify as a water reuse operation. DEQ would confirm the prerequisites and provide the General Permit coverage without detailed review. This would be a consistently predictable process for approval or denial of a permit. A General Permit would expedite the permitting process while ensuring that facilities are properly designed and managed.

Individual permits would be issued for all but the highest quality reclaimed water. Individual permits would be required in such cases because of site specific differences that could impact the quality of the receiving ground or surface water. A more detailed evaluation of a proposed water reuse project by DEQ is necessary when reusing lower quality reclaimed water because of the differences in the land receiving the reclaimed water and the variability in the quality of receiving waters. Furthermore, the individual permit provides the public with the opportunity to comment on projects that influence their environment.

Other Issues

Most water applied to land will at some time reach ground water through infiltration. Application rates for reclaimed water should be established that account for evapo-transpiration and percolation (runoff should not be allowed). Indirect ground water recharge should be permitted providing that the reclaimed water meets appropriately developed standards that will not compromise Virginia's groundwater standards. Nutrient and metal loading should be evaluated to insure ground water is protected.

Direct ground water recharge of shallow aquifers should be evaluated to determine whether this constitutes disposal or reuse. Injection into aquifers used for drinking water should only be permitted if appropriate water quality standards are met.

Definitions

An understanding of the terminology associated with water reuse is critical to the issue of determining whether and under what conditions reuse of municipal and industrial wastewater should be permitted. The following are key definitions of terms as they relate to the operation of reclaimed wastewater systems.

Direct Potable Reuse	The treatment of community wastewaters to a sufficient degree that they would be acceptable for drinking and for their direct discharge into a single potable water distribution system.
Direct Recharge Of Ground Water	The use of injection wells, rapid infiltration basins or other methods that are designed to introduce large quantities of reclaimed water directly into aquifers that are or may be used as a public water supply. This does not include ground water recharge by percolate from land irrigation of reclaimed water.
Gray Water	Untreated wastewater from bathtubs, showers, lavatory basins, wash basins, washing machines, and laundry tubs. It does not include wastewater from toilets, urinals, kitchen sinks, dishwashers, or laundry water from soiled diapers.
Indirect Potable Reuse	The discharge of reclaimed water into an aquifer or raw water impoundment used for a drinking water source. Indirect potable reuse is contrasted with "direct potable reuse" which involves the discharge of reclaimed water

	directly into a drinking water treatment facility or into a drinking water distribution system.
Indirect Recharge of Ground Water	The supplementing or mounding of ground water produced by the percolate from the land irrigation of reclaimed water.
Land Irrigation of Reclaimed Water	The introduction of reclaimed water into or onto the ground for treatment or reuse.
Non-Potable Water	Any water, including reclaimed water, not meeting the drinking water standards of Federal, State and local authorities for human consumption.
Percolation	The generally vertical movement of water through soil or other unconsolidated medium to the water table and to lower aquifers where occurring.
Potable Water	Water which conforms to the drinking water standards of federal state and local authorities for human consumption.
Reclaimed Water	Water, which, as a result of treatment of domestic, municipal or industrial wastewater, is suitable for a direct beneficial use or a controlled use that would not otherwise occur. Specifically excluded from this definition is "gray water".
Recycled Water	Same as "Reclaimed Water.
Wastewater	The combination of liquid and water-carried pollutants from residences, commercial buildings, industrial plants, and institutions together with any ground water, surface runoff or leachate that may be present.
Water Reclamation	The treatment of domestic, municipal or industrial wastewater to produce reclaimed water for a direct beneficial use or a controlled use that would not otherwise occur.
Water Reuse	The use of reclaimed water for a direct beneficial use or a controlled use that is in accordance with the state and local regulatory requirements.

Review of the LAND TREATMENT OF MUNICIPAL WASTEWATER Process Design Manual

DEQ currently uses agency guidance and the VDH draft SCAT regulations to develop permits for land application of wastewater. A DEQ land application committee is in the process of updating agency guidance. The Process Design Manual (PDM) is used as a reference source in both of these activities.

Summary

The PDM has many features that are beneficial in determining suitability of a site and design of a land based system for reuse of wastewater. The PDM gives guidance for many of the steps necessary for reuse of water and nutrients in both agricultural, turf, and forest systems. However, there are several limitations that restrict the usefulness of this manual. These include:

a. The PDM was published in 1981 and thus does not take into consideration research or results from field installations since that time.
b. The PDM does not include a procedure for determining the moisture status in soils. This information facilitates making decisions on when to irrigate and how much water to apply at an irrigation event.
c. Elements other than nitrogen (N) may be the limiting design factor in some wastewaters. A procedure for evaluating the impact of these elements needs to be considered.
d. The impact of certain chemical constituents on soil properties (e.g., % sodium saturation) needs to be considered in greater detail.
e. Timing of N application (in wastewaters) to the crop needs to be addressed in more detail.
f. Regional data on crop suitability and nutrient requirements for irrigated crops needs to be developed to assist in determining allowable rates of application and timing of wastewater application.
g. There are questions concerning the suitability of EPA Climate Model III for determining nonoperational days and days of storage required.
h. Existing information should be reviewed to determine the effectiveness of the equation used to calculate hydraulic loading rate based on the N concentration in the wastewater. There is particular interest in the relationship between predicted and measured N concentrations in the percolate for various cropping systems.

The Advisory Group recommends that Virginia conduct a detailed review of the PDM and other relevant documents and produce Virginia specific guidelines for reuse of wastewater via land application.

APPENDIX B
Subgroup B Report

Specific Comments

1. The description of the hydraulic pathway for slow rate spray irrigation, rapid infiltration, and overland flow systems is excellent.

2. The planning and technical assessment sections give a logical stepwise procedure for site evaluation. The recommendations on slopes, soils and field investigations are appropriate and adequate steps in planning a land application system have been identified.

   However, additional rating factors such as the potential for flooding and consideration of karst topographic features would strengthen this section. It is unclear if karst topographic features, prominent throughout western Virginia, are adequately evaluated or protected. Review of proposed wastewater reuse projects in karst topographic regions must be given special technical review.

3. The methods for estimating hydraulic conductivity, either with infiltration techniques or measurement of vertical hydraulic conductivity, encompass most of the procedures that are commonly utilized and give some of the advantages and disadvantages for each procedure. The PDM acknowledges the variability associated with soil hydraulic conductivity measurements and stresses the important of multiple test across the site being evaluated to determine a reasonable average. This section also gives guidance on the type of averaging to employ when vertical hydraulic conductivity methods are employed. To help alleviate the inherent variability with site conductivity measurements, application rates and timing of application may be based on measured, real-time, in situ soil moisture monitoring data.

4. A relative comparison of the suitability of field, forage, turf, and forest crops based on their potential as a revenue producer, water user, N user, and moisture tolerance is given in this manual. This comparison is very useful. However, regional data on crop suitability and nutrient requirements for irrigated crops needs to be developed to assist in calculating allowable rates of application and timing of waste application.

5. The PDM gives guidelines for N, phosphorus, and potassium uptake for forage and field crops and N uptake for forest. These rates appear reasonable, but need to be modified based on region grown, soil type, management level, etc. Nutrient uptake data from Virginia and adjacent states, where irrigation is used, need to be reviewed and crop nutrient uptake data specific to Virginia conditions for irrigated crops developed. This review should include the DCR nutrient management criteria. The PDM suggests that local conditions, projected yields, etc. should be considered when determining nutrient uptake. Also information on uptake of additional nutrients (e.g., sulfur and chloride) would be useful.

6. Timing of N application needs to be addressed in more detail. An example of N uptake versus growing days for selected annual and perennial crops is given in the manual. However, there is a need to develop additional uptake versus time data for selected crops when N is the limiting design factor. Sigmodial relationships between N uptake and date from planting can be developed from existing data to meet this need.

7. The model used to estimate N removals in ponds during ice-free periods is an important part of any land based treatment design. Some of the newer models incorporate additional factors, such as pH and a temperature-dependent rate constant, when estimating N removal (Reed et al., 1995).

8. Hydraulic assimilative capacity is calculated monthly and is based on a water balance equation that considers evapotranspiration, precipitation, and allowable percolation. The allowable percolation is based on a percentage of the soil hydraulic conductivity and the number of operational days per month. This procedure is suitable for estimating the total amount of water that can percolate through the profile without resulting in extended periods of saturation. The amount of water allowed to percolate through the soil system ranges from 4-10% of the soil hydraulic conductivity. The value selected from this range depends on the soil and site variability. The accuracy of the hydraulic assimilative capacity of a site is highly dependent on reliable measurements of the hydraulic conductivity of the soil being used for treatment. What constitutes a nonoperational day needs to be defined. Also soil moisture status, temperature, and planting and harvest operations need to be taken into consideration when determining nonoperational days.

9. The hydraulic loading rate is also determined based on N concentration in the wastewater. Nitrogen is frequently the limiting design factor when protection of groundwater is considered. An equation is developed that considers the percolate N concentration, precipitation, evapotranspiration, crop N uptake, N concentration in the wastewater, and the fraction of applied N removed via gaseous losses. This equation allows the designer to choose a concentration of N that can be lost below the root zone in the percolate. Normally a very conservative approach is used to ensure that N concentrations in the receiving groundwater at the project boundary meet the design criteria.

   The PDM assumes that all the N in the effluent is in plant available form. However, some effluents will have significant amounts of organic N that may not be completely mineralized during the year of application. The availability of the organic N fraction, over time, needs to be considered in these wastewaters.

   A number of studies were reviewed where grass has been used as the vegetative cover (Giggey et al.,1989; Jenkins and Palazzo, 1981; and Monnett et al., 1996) These studies show that inorganic N concentrations in the percolate were generally lower than the estimated values when N is the limiting design factor. A more extensive review of literature that compares estimated versus measured N in the percolate needs to be conducted for a broader range of cropping systems and soil types.

   Comparisons between predicted (using the PDM equation) and measured N concentrations of N in the percolate for cropping systems other than grass need to be developed for Virginia.

10. The equation used to estimate hydraulic loading based on N can potentially be modified to estimate the concentration of other contaminants in the percolate. However, this has not been addressed in the PDM.

11. After the hydraulic loading rates have been determined based on both soil hydraulic properties and N concentration in the wastewater, these two rates are compared and the most conservative value is used to determine the monthly allowable application rate.

12. There are several problems with the procedure used in this manual for estimating the quantity of wastewater that can be applied to a land based treatment system.

    The PDM does not address a mechanism for determining the moisture status in soils so that decisions can be made on when to irrigate and how much water can be applied at an irrigation event. To make these calculations a decision needs to be made on the type of moisture monitoring equipment, the number of water measuring devices to be installed, and the depth of installation. Also, information has to be developed on the moisture holding capacity of the soil system to determine the quantity of wastewater that can be applied at an irrigation event. Alternatively, a model that considers soil moisture holding capacity, infiltration rates, and evapotranspiration may be appropriate to make these decisions.

13. Elements other than N may be the limiting design factor for some wastewaters. These have not been addressed in adequate detail in the PDM. Also, the impact of certain chemical constituents on soil properties (e.g., % sodium saturation) needs to be considered in system design.

14. The DEQ Advisory Group agrees that storage is an important aspect of any land based treatment system and should be given careful consideration to ensure adequate storage capacity during the life of the system. However, there is enough difference in opinion between members of the group on storage requirements to recommend that the EPA Climate Models used in the PDM to estimate storage be examined in greater detail. In particular, the EPA Climate Model III for moderate climates should be evaluated and compared with storage requirements in Virginia and adjacent states.

15. The calculation of the area required for a land based treatment system is based on average daily flow of wastewater, net gain or loss in stored wastewater, and the design annual hydraulic loading rate. Once the above factors are determined this calculation can be employed with confidence.

16. Regulations developed by other states should be evaluated in greater detail. In particular Pennsylvania's Department of Environmental Protection has developed a manual entitled "Manual for the Land Application of Treated Sewage and Industrial Wastewater" published in 1993 appears to address concerns with land application of wastewater similar to those present in Virginia.

APPENDIX B
Subgroup B Report

IRRIGATION WATER REQUIREMENTS
Chapter 2; part 623 National Engineering Handbook

Summary
This chapter is valuable in that it provides an improved method to estimate monthly crop water requirements through the use of the detailed crop coefficients. However, it is designed for maximizing irrigation efficiency and may not be entirely applicable to systems designed for water
and nutrient reuse

Specific Comments

1. Design of an irrigation system based on N reuse takes into consideration the fact that plants are capable of extracting a highly mobile ion like nitrate from a larger volume of water than that transpired by the plant. This occurs because N can be extracted from the wastewater as it flows through the root zone by a combination of mass flow and diffusion. A system designed based on N reuse may result in additional recharge of the groundwater with a percolate that has a low N concentration.

2. The Blaney-Criddle (modified by SCS) method described in this publication for estimating evapotranspiration (ET) appears to be very applicable to use with design of land based treatment systems for the following reasons:

   * Most sites will have climatic data available that can be used with the modified Blaney-Criddle method to estimate ET.

   * Since temperature data is readily available at a number of locations over extended time periods, the modified Blaney-Criddle method to estimate ET will offer both continuity and maximum flexibility. The modified Blaney-Criddle method had been used successfully in this region. Also growing season dates, for a particular crop at a location are identified with this procedure is identified for the crop for the individual site.

3. This chapter also gives additional information that can be effectively used in design of a land based treatment system. These include:

   * Guidelines for irrigation water quality.
   * A list of salt tolerance for a large number of crops.
   * Tolerance of a large number of crops to chloride, sodium, and boron are listed.
   * Procedure for estimating effective precipitation.
   * Procedure for estimating wet soil evaporation.

References

Giggey, Michael D., Ronald W. Crites, and Karl A. Brantner. 1989. Spray irrigation of treated septage on reed canarygrass. J. Water Pollut Control Fed. 61:333-342.

Jenkins, T. F. and A. J. Palazzo. 1981. Wastewater treatment by a prototype slow rate land treatment system. U.S. Army Cold Regions Research and Engineering Laboratory. CRREL Report 81-14.

Monnett, G. T., R. B. Reneau, Jr., and C. Hagedorn. 1996. Evaluation of spray irrigation for on-site wastewater treatment and disposal on marginal soil.

Reed, Sherwood C., Ronald W. Crites, and E. Joe Middlebrooks. 1995. Natural Systems for Waste Management and Treatment. 2nd edition. McGraw-Hill, Inc.

Soil Conservation Service. 1993.Irrigation water requirements. p. 2-i - 2-284. In United States Department of Agriculture, Part 623 National Engineering Handbook. Washington, DC.

USEPA. 1981. Process design manual for land treatment of municipal wastewater. U.S. Environmental Protection Agency, Center for Environmental research Information. EPA 625/1-81-013.

APPENDIX B
Subgroup C Report

Potential Environmental Benefits and Risks of Using Reclaimed Waste Water For the Purpose of Recharging Ground Water Aquifers

The Water Reuse Advisory Group considered two distinct recharge mechanisms for the potential recharge of ground water. They are defined as direct and indirect ground water recharge. Direct recharge of ground water is the use of injection wells or other methods of rapid infiltration where the primary purpose of the process is to provide additional water to an aquifer. Indirect recharge describes the incidental addition of water to an aquifer where the primary purpose is the use of treated wastewater for a beneficial purpose through a slow rate infiltration system, such as land application of treated wastewater as irrigation for the purpose of crop production. These two recharge mechanisms are discussed below.

Direct Ground Water Recharge

There are several potential environmental benefits of direct ground water recharge. These benefits include establishment of saltwater intrusion barriers in coastal aquifers, augmentation of available ground water supplies, and control of land surface subsidence. Each of these benefits could be realized in Virginia, especially in the Coastal Plain. There are numerous technical considerations that must be addressed to allow the successful implementation of a direct ground water recharge project on a regional basis. One primary concern is an accurate characterization of the quality of existing ground water to assure that the injected fluid will not cause precipitation and clogging in the injection well or in the aquifer material itself. In large areas of Virginia the ground water quality is not known with enough certainty to allow the development of direct ground water recharge projects. While this current lack of information may preclude the use of direct ground water recharge, Virginia should consider developing a program to characterize ground water quality and occurrence to a level of detail that would allow the consideration of this technology.

A major environmental risk associated with direct ground water recharge is the potential for contamination of existing ground water quality due to the quality of the injected wastewater. Any direct recharge of ground water would require a very high quality wastewater to assure no ground water contamination would occur. The use of treated wastewater for direct ground water recharge may also result in the reduction of stream flows where the treated wastewater was previously discharged to surface waters. This issue has the potential to be problematic during times of low flow, predominately in the western non-tidal portion of the state. Since the tidal Coastal Plain area of the state is the most likely area to realize the benefits of direct ground water recharge, diminishment of stream flows is likely to be a minor concern related to direct ground water recharge.

The advisory group recommends that the Commonwealth initiate statewide ground water characterization efforts that are necessary to determine whether direct ground water recharge projects are feasible. The group also recognizes that this effort is not as high a priority as issues related to indirect ground water recharge.

Indirect Ground Water Recharge

The potential environmental benefits and risks associated with indirect ground water recharge are similar to those associated with direct ground water recharge, on a much smaller scale. In most all cases, any indirect recharge of ground water will primarily impact the unconfined water table aquifer. In some areas of the Commonwealth this aquifer is not the primary aquifer of use for potable water supplies. In other areas, the unconfined water table aquifer is routinely used as a source of potable water, especially for private domestic use. In all cases the unconfined water table aquifer is defined as State Waters for purposes of implementation of the Virginia Ground Water Standards.

Indirect ground water recharge has the potential to augment the amount of water available from unconfined aquifers to support an assortment of water uses. In areas where the unconfined aquifers are not directly used, augmentation of unconfined aquifers may result in indirect augmentation of deeper confined aquifers, fractured rock aquifers, or solution channel aquifers in carbonate areas.

In areas where ground water has been degraded by human activities, indirect ground water recharge has the potential to improve ground water quality in the immediate area of ground water recharge so long as the treated wastewater is of better quality than the existing ground water. This potential benefit must be weighed against the potential risk of moving a ground water contamination plume from the site of recharge to an offsite receptor. Potential receptors include users of the ground water resource as well as surface water streams that may be recharged by ground water.

Depending on the quality of the wastewater there are potential risks that existing ground water quality can be degraded. This potential may result in impacts to surface water bodies and associated biota or to users of ground water for potable or other purposes. This risk is mitigated with increased wastewater treatment, as the quality of the wastewater increases the associated risk decreases. The use of treated wastewater for indirect ground water recharge may also result in the reduction of stream flows where the treated wastewater was previously discharged to surface waters. This issue has the potential to be problematic during times of low flow, predominately in the western non-tidal portion of the state. Conversely, indirect ground water recharge that occurs in alluvial areas associated with streams may provide additional contribution to stream flows during times of low flow.

The Virginia Ground Water Standards (9 VAC-25-260-190) are designed to prevent the entry of pollutants into ground water in any aquifer. This regulation requires that natural ground water quality be maintained for all constituents. The regulation allows mixing zones in ground water on a case-by-case basis that are as small as possible. The Standards do not specifically address the situation where indirect recharge occurs in an aquifer that has been contaminated and does not represent natural conditions. Any indirect ground water recharge project must be designed to comply with this regulation.

The advisory group concludes that indirect ground water recharge has the potential to produce positive environmental results when the quality of the treated wastewater is higher, for all constituents, than the natural occurring ground water quality at the site of concern. In addition, indirect ground water recharge has the potential to improve ground water quality on sites where existing ground water quality has been degraded. In these cases consideration must be given to the potential that indirect recharge may move existing ground water contamination off of the site of concern to other ground water or surface water receptors. The group recommends that the Virginia Ground Water Standards be evaluated, and potentially revised, to clarify their application on sites where ground water is degraded due to previous activities.

APPENDIX C

VDH Graywater Guidelines (DRAFT)

General

Graywater is untreated wastewater collected from certain plumbing fixtures and drains. Graywater is sewage, but is not highly contamined with toxic levels of chemicals, organic matter, suspended solids and microorganisms that are potentially pathogenic. Graywater includes wastewater collected from bath tubs, showers, lavatory fixtures, clothes washing machines, and laundry tubs. In addition, rainwater may be collected to supplement graywater flows. Graywater does not include industrial waste or wastewater passing from toilets, urinals, kitchen sinks, dishwashers or laundry water exposed to soiled diapers.

Graywater is typically collected and stored for irrigation uses through a subsurface piping system. However, graywater may be treated through an approved process and used for either above ground irrigation or toilet flushing purposes. The plumbing fixtures, valves, storage container, pumps, irrigation piping, etc., are referred to as a graywater system.

Permit

A permit issued under the authority of the State Health Commissioner is to be obtained prior to installation and use of a graywater system. The plumbing fixtures used in a graywater system must comply with the requirements of the statewide building code. The graywater system must also comply with applicable state and local regulations and policies implemented through the Virginia Department of Health. A preliminary meeting with local and state health department staff to discuss the proposed graywater system is desirable prior to submission of the permit application.

A complete permit application is to be submitted to the local health department for evaluation and approval prior to installation of a graywater system. The permit application is to include a transmittal letter identifying: the applicant, their means of ownership of the graywater system, and the location of the proposed graywater system. A suitable diagram of the property boundaries, location of residences, buildings, water and sewage utilities, paved areas and irrigation areas that are connected to or within 100 feet of the graywater system is to be submitted with the application. Some construction details such as vent piping, traps, valving, overflows, pump specifications, filters, chemical addition, etc., may be required. Complete information necessary to evaluate site soils, their wastewater adsorption capacity, and water table location, would be required for irrigation systems.

The permit application is to specify the capacity of the graywater system in terms of: estimated flows, storage provided, irrigation area and layout, pump capacity, overflow rates, filtration rates, chemical dosing rates, etc.

Graywater collected from commercial, industrial, or institutional systems is to be characterized as to volume and content based on appropriate records or approved sampling and testing results obtained by the graywater system owner.

Installation

All necessary local permits (Health and Building Code) are to be issued prior to initiating installation of a graywater system.

Components of a graywater system designed to ensure proper treatment and disinfection as required for proposed uses are to be designed and certified by an appropriately licensed professional consultant or have been certified as to treatment performance by a nationally recognized testing authority such as the National Sanitation Foundation (NSF).

Storage tanks are to be installed in a manner to prevent leakage or spillage of graywater and are to be provided with proper traps and venting and provided with an overflow to an approved sewage collection system, or sewage disposal system. Installation of all graywater system components must comply with the issued permit. The graywater system is not to be connected to any potable water system without an approved air gap to prevent any possible backflow. A rainwater collection piping system is to include an approved diversion valve to limit the volume discharge to the storage tank. The constructed graywater system is to be inspected by local and State Health Department staff prior to operation.

During an inspection of construction, certain components on the graywater system are to be tested to ensure proper operation. Exposed graywater system components are to be permanently coded and marked to indicate that the graywater is unsuitable for drinking or personal contact. The graywater system installation is to comply with all buffer zones and set-backs required by existing state and local regulations and ordinances.

Operation

During operation, no untreated or undisinfected graywater is to either reach the ground surface, or be used for toilet flushing. A set of acceptable operation and maintenance instructions is to be developed and remain available to the system owner. Graywater used for toilet flushing is to be dyed or colored by approved methods. The graywater system capacity is to be sufficient to use the generated daily flow. The volume of any rainwater diverted to the graywater system is to be controlled so as not to exceed the established permitted capacity.

A SURVEY OF STATE REUSE REGULATIONS			
	John Johnson	Dan Horne	Dan Horne
QUESTION	ARIZONA	CALIFORNIA (current)	CALIFORNIA (proposed)
1. Definitions: (give essentials)			
a. Reuse	"Reuse" means the use of reclaimed wastewaters.	Not Defined	Not Defined
b. Recyle	Not defined.	Recycled Water: 4 classes defined, distinguished by the level of disinfection achieved and the pretreatment processes employed	"Recycled Water": Defines 4 classes distinguished by the level of disinfection and the pretreatment processes employed.
c. Reclaim	"Reclaimed wastewater" is effluent that meets the standards for specific reuses contained in R 18-9-703. (These standards range from 1,000 cfu/100 ml for fecals to 2.2 cfu/100 ml.)	Water which as a result of treatment of domestic wastewater is suitable for direct beneficial use or a controlled use...	"Reclaimed Water": Proposed for deletion
2. Permit Required? (Respond Y/N w/ duration if Y)	Yes, five years.	Yes. Issued for indefinite time period. Revokation is difficult process, or modification with agreement only or with new permit.	Yes. Permit of indeterminate length (same details as for current regs).
a. Are uses other than land application allowed?	Yes	Yes, reuse permit covered uses range from fodder/fiber irrigation to body-contact recreation, all require a special reuse permit.	
b. Who holds the permit?	The owner of the reclaimed wastewater (which may be different than the owner of the treatment facility)	Circumstances dictate the holder. If the generator (POTW operator) is the party responsible for the land application use, then they hold the special reuse permit. If the generator sells/transmits the reclaimed water to a separate entity as the end user, then the end user is issued the resue permit, and the generator has special conditions placed into their NPDES permit.	
3. What Agencies are involved? (List state agencies)	Department of Environmental Quality	State Water Resources Control Board, acting through 9 semi-autonomous Regional Water Quality Control Boards (permit conditions from CA Dept of Health Services)	State Water Resources Control Board, acting through 9 semi-autonomous Regional Water Quality Control Boards (permit conditions from CA Dept of Health Services)
4. What is the basis? (Regulation/guidance/???)	Regulation R 18-9-703	Cal Admin Code (Title 22, Div 4 :adopted regulations AND developed guidance) plus the Cal Water Code	Cal Admin Code (Title 22, Div 4 :adopted regulations AND developed guidance) plus the Cal Water Code
5. Is water quality criteria specified? (Y/N)	Yes.	Yes: Total Coliform always. Turbidity sometimes. RWCQB may set other water quality objectives as part of permit process, on case-by-case basis.	Yes: Total Coliform always, Turb., almost always. Case by case Water quality objectives possible by RWCQB and process performance objectives possible by CDOHS.
a. Are there use restrictions dependent on WQ critieria? (Y/N)	Yes, ten categories of uses and associated WQ standards: range from 1,000 cfu/100 ml fecal; general farm irrigation to 2.2 cfu/100 ml fecal for irrigation of food consumed raw by humans.	Sort of. The uses allowed are dependent upon the treatment processes utilized and disinfection achieved	Yes: Uses allowed are dependent upon the treatment processes utilized and disinfection achieved
6. SITE REQUIREMENTS			
a. Buffers or setbacks? (Y/N)	None mentioned.	Not in regulations. Currently found in guidance.	Y. Recycled water of highest class has very few while lower the class has more restrictions.
b. Specified application rates? (Y/N)	None specified, but rates are subject to Department approval.	Contained only in guidance. Based on agronomic rates as determined during design report phase, and as set in permit. No runoff allowed at all. Standardized rates set for GW recharge projects.	Based on agronomic rates as determined during engineering report phase. Depends also on class of applied water.
If Y for applications rates list methods allowed.		Spray irrigation, overland flow, drip irrigation.	
c. Time or weather restrictions? (Y/N)	Only restriction is to avoid saturated soil conditions.	Not in regulations. Currently found in guidance.	Very few proposed, if recycled water is highest class. If any questions about public access or exposure, requirement is to meet highest class.
d. Is Nutrient Management required? (Y/N)	No.	"No runoff allowed, so no need for nutrient management." Nitrogen looked at on case-by-case basis for GW recharge projects.	"No runoff allowed, so no need for nutrient management." Nitrogen looked at on case-by-case basis for GW recharge projects.
e. Are there land feature restictions? (Y/N)	No	Set on case-by-case basis during engineering report phase leading to permit issuance.	Set on a case-by-case basis during engineering report development and permit issuance.
f. Monitoring requirements? (Y/N)	Yes	Yes	Yes
If Y list parameters.	flow volume, fecals, and turbidity	turbidity, total coliform, settleable solids	Process performance monitoring for treatment. Applied water requirements set case-by-case. More monitoring required for lower class water. Recharge projects have extensive requirements.
g. Are there restrictions on crops/vegetation types? (Y/N)	No	Yes: the crops/vegetation types which can be irrigated depend upon the disinfection achieved and the treatment processes utilized	Yes: the crops/vegetation types which can be irrigated depend upon the disinfection achieved and the treatment processes utilized
7. Is aquifer recharge allowed? (Y/N)	Not addressed specifically, but reference is made to a groundwater permit for direct point discharge.	Yes.	Title 22 sets criteria for surface spreading/infiltration. State Water Code sets criteria for injection projects.
a. If Y list types/methods.		Title 22 sets criteria for surface spreading/infiltration. State Water Code sets criteria for injection projects.	
b. Are any contributions to GW allowed? (Y/N)	Not addressed. (arid climate).	No, irrigation projects limited to the crop agronomic uptake rate (assimilative capacity). Exceeding this rate or causing GW build-up is considered disposing and is prohibited.	
8. Are there storage requirements? (Y/N)	Yes	Yes	Yes (no change from existing regs)
If Y describe basis.	5 day minimum requirement	Short-term: at least 24 hours (depends on system design); Long-term: 20 days minimum (depends on system design)	Short-term: at least 24 hours (depends on system design); Long-term: 20 days minimum (depends on system design) (No change from current regs)

A SURVEY OF STATE REUSE REGULATIONS

	David Frackelton	Greg Evanylo	Jeff Corbin
QUESTION	DELAWARE	FLORIDA	ILLINIOS
1. Definitions: (give essentials)			
a. Reuse	Not Defined	The deliberate application of reclaimed water, in compliance with Department and District rules, for beneficial purposes.	Not Defined
b. Recyle	Not Defined	Not Defined	Not Defined
c. Reclaim	Not Defined	Reclaimed water is water that has received at least secondary treatment and basic disinfection and is reused after flowing out of a domestic wastewater facility	Not Defined
2. Permit Required? (Respond Y/N w/ duration if Y)	Y, 5 Years, Land Treatment System Permit	Yes, 10 years	Permit, but duration unspecified
a. Are uses other than land application allowed?	No permit is only for slow rate land app	Yes	Regs only address land application
b. Who holds the permit?	Owner of the treatment works	Anyone who constructs, modifies, or operates a wastewater reuse or land application system	Operator of the system
3. What Agencies are involved? (List state agencies)	Delaware Department of Natural Resources and Environmental Control(DNREC)	Department of Environmental Protection	Illinois EPA
4. What is the basis? (Regulation/guidance/???)	Regulation and Guidance	Rule	Regulations
5. Is water quality criteria specified? (Y/N)	Y, for access	Yes	Design Crieria only, 2-cell system with tertiary filtration/disinfection
a. Are there use restrictions dependent on WQ critieria? (Y/N)	50 BOD, 50/90 TSS, 200 fecals/100ml - Restricted to authorized personnel; 30 BOD, 30 TSS, 200 fecals - Landscaped areas limited to public; 10 BOD, 10 TSS, 20 Fecals, 5 NTU Turb. - parks, golf	Yes	Ag-land = secondary, urban areas = tertiary treatment
6. SITE REQUIREMENTS			
a. Buffers or setbacks? (Y/N)	Y for restricted access, 150' prop., 100' waterway, 50' storm swale	Yes	Yes
b. Specified application rates? (Y/N)	Y 2.5" per week, 0.25" per hour, based on hydr. Cond., increase if supported	Yes	"low"
If Y for applications rates list methods allowed.		Based on assimilative capacity of soil-plant system	Equipment reqs for spray irrigation (heads, wind velocity, nozzle pressure)
c. Time or weather restrictions? (Y/N)	Y, not during excess rain, excess snowfall, saturated and frozen soils	No direct weather restrictions; time restrictions for lactating cattle grazing	Yes
d. Is Nutrient Management required? (Y/N)	Y, N and P(when phosphorus adsorption reaches saturation) and metals	Yes	No formal NMP, but nutrient loading must be calculated
e. Are there land feature restictions? (Y/N)	Y, 7% row crops, 15% forage, 30% forest	Yes, for projects requiring additional level of pretreatment	Yes, ie. slope, depth to GW and bedrock, distance to surface water
f. Monitoring requirements? (Y/N)	Y, influent and effluent, groundwater, surface water if app., soil, rainfall and climatic	Yes	Yes
If Y list parameters.	soil - pH, Cation Exchange, Percent Base saturation, Phosphorus Adsorption, metals	For certain systems, groundwater nitrate, wastewater effluent TSS, turbidity, Cl, nitrate, BOD, Organic C, halogens, bioassays	NO3, NH4, PO4, pH, TDS, TN, Cl, fecal
g. Are there restrictions on crops/vegetation types? (Y/N)	N	Yes	N
7. Is aquifer recharge allowed? (Y/N)	N, not directly, excess leaching is ok if BOD etc.loadings are considered and calculated N	Yes	No. General language prohibits.
a. If Y list types/methods.	loading is less than 10 mg/l nitrate	Rapid infiltration basins and absorption fields, injection for groundwater recharge, and indirect potable reuse for salinity barriers	
b. Are any contributions to GW allowed? (Y/N)	Yes, annual nutrient uptake must be such that calculated NO3 is < 10 mg/l	Yes	Language suggests that incidental may be allowed, but direct recharge is not mentioned.
8. Are there storage requirements? (Y/N)	Yes	Yes	Yes
If Y describe basis.	operational + wet weather = water balance, municipal typ. 45-60 days	Varies for different systems. Based on 10 yr recurrence interval, greater than or equal to three times the average daily flow of the portion of reuse that has no alternative discharge contingency. Three feet of freeboard required.	Storage adequate for 150 days plus 20-yr storm event and for times when application restricted due to high groundwater, rain, frozen ground

A SURVEY OF STATE REUSE REGULATIONS			
	Randy Kepler	C.M. Sawyer	George Kennedy
QUESTION	INDIANA	MARYLAND	NORTH CAROLINA
1. Definitions: (give essentials)			
a. Reuse	Not Defined	Not Defined	Use of reclaimed water for a direct beneficial use or a controlled use that is in accordance with the state and local regulatory requirements.
b. Recyle	Not Defined	Not Defined	Not Defined
c. Reclaim	Not Defined	Not Defined	Water which, as a result of treatment of domestic, municipal or industrial wastewater, is suitable for a direct benficial use or a controlled use that would not otherwise occur. Excludes "gray water."
2. Permit Required? (Respond Y/N w/ duration if Y)	Permits are required for land application projects, permits last up to 5 years	Yes, State Groundwater (GW) Discharge Permit	Yes
a. Are uses other than land application allowed?	Not that are listed in the regulations. There are two or so golf courses with this system		Yes, includes process, cooling, fire fighting decorative ponds, urinal flushing, soil compaction, street cleaning, etc.
b. Who holds the permit?	Producer of the wastewater		Treatment facility
3. What Agencies are involved? (List state agencies)	Office of Solid and Hazardous Waste Management, Land Application Section	Maryland Department of the Environment	Department of Environment, Health and Natural Resources
4. What is the basis? (Regulation/guidance/???)	Indiania Administrative Code (IAC) 327, Article 6 and Article 7	Guidance	Regulation (15A NCAC 2H.0200 REGULATIONS)
5. Is water quality criteria specified? (Y/N)	Yes	Yes, Preapplication Treatment	Yes
a. Are there use restrictions dependent on WQ critieria? (Y/N)	Yes	Yes, State GW Discharge Permit	Yes, only defines two general use categories with exactly the same WQ for both.
6. SITE REQUIREMENTS			
a. Buffers or setbacks? (Y/N)	Yes	Yes	Yes (very few)
b. Specified application rates? (Y/N)	Yes	Yes	Yes (site specific)
If Y for applications rates list methods allowed.	Based on Hydraulic and nutrient limits, also look at metal loading and Soil CEC	Calculated based on water and nitrogen balance equations.	Max soil absorption and crop water needs
c. Time or weather restrictions? (Y/N)	Yes	Yes	No
d. Is Nutrient Management required? (Y/N)	Yes	Yes, nitrogen balance	No
e. Are there land feature restictions? (Y/N)	Yes	Yes	No
f. Monitoring requirements? (Y/N)	Y - parameters when appropriate needs to be in wet weight and dry weight basis	Yes	Yes (reuse water only)
If Y list parameters.	application rates, site conditions, metals, PCB, fecal, BOD5, nitrogen, CEC of soils, pH, volatile solids	Permit specific effluent and GW sampling and testing	TSS, Fecals, BOD, NH3, turbidity(or particle count) and flow
g. Are there restrictions on crops/vegetation types? (Y/N)	Yes	No, a complete vegetative cover on the application site is required	Yes (general prohibition against direct food chain crops)
7. Is aquifer recharge allowed? (Y/N)	N - don't believe so but not mentioned.	Yes	No
a. If Y list types/methods.	N/A	High rate infiltration	
b. Are any contributions to GW allowed? (Y/N)	Y- Land disposal methods for wastewater effluent would allow for contributions to GW. Permeability must be < 6 in/hr thus limiting the amount allowed. No reference to level of contaminants allowed.		High rate infiltration ponds must meet reuse water quality standards. Intentional contributions to GW are prohibited.
8. Are there storage requirements? (Y/N)	Yes	Yes	Yes
If Y describe basis.	Minimum of 90 days storage	Minimum of 60 days for slow rate and overland flow systems	Described in general terms based on diurnal hydrograph or at least 25% of daily system flow.

A SURVEY OF STATE REUSE REGULATIONS	John Johnson	Jeff Corbin
QUESTION	PENNSYLVANIA	TEXAS
1. Definitions: (give essentials)		
a. Reuse	Not Defined	Defined in another section of code.
b. Recyle	Not Defined	Defined in another section of code.
c. Reclaim	Not Defined	Type I - Human Contact Likely; Type II - Human Contact Unlikely
2. Permit Required? (Respond Y/N w/ duration if Y)	Yes, 5 Years	Yes. "No Discharge" permit or NPDES.
a. Are uses other than land application allowed?	Not addressed. Guidance is specific to land application.	Yes. Many uses allowed, but differing water quality pertain to each (Type I or II criteria)
b. Who holds the permit?	Whoever controls and operates the wastewater treatment facility	Requirements must be met for "Producers, providers and /or users". "No discharge" permit required for user
3. What Agencies are involved? (List state agencies)	Department of Environmental Resources	TNRCC
4. What is the basis? (Regulation/guidance/???)	Guidance: "Manual For Land Application of Treated Sewage and Industrial Wastewater"	Regulation
5. Is water quality criteria specified? (Y/N)	Yes. CBOD5 25 mg/l, TSS 30 mg/l, Fecal 200 colonies/100 ml, 30 day averages, variances allowed	Yes. "No Discharge" permit or NPDES.
a. Are there use restrictions dependent on WQ critieria? (Y/N)	No.	WQ criteria different for Type I (human contact) vs. Type II (No contact) - BOD, Turbidity, Fecal
6. SITE REQUIREMENTS		
a. Buffers or setbacks? (Y/N)	Yes, 50 feet from property lines, roads, parking lots and rock outcrops.	Yes. 50 feet from waterways and wells. Property separation is site-specific. (309 subchapter B)
b. Specified application rates? (Y/N)	Yes, soil and site specific, up to 2 inches per week, no runoff allowed.	Yes. "Irrigation Demand" must be calculated (Table example) - no ponding/standing water allowed.
If Y for applications rates list methods allowed.	Wastewater Loading + Precip. = Evapotranspir. + Percolate + Precip. Runoff. Sprinkler, drip, flooding, ridge and furrow irrigation application allowed.	
c. Time or weather restrictions? (Y/N)	Yes, consistent with U.S. EPA Climate Model III, (no irrigation when >0.5 in. rain in previous 24 hrs, min. low temp. of 26 deg. F, min high temp of 40 deg F.)	Yes. Not on frozen/saturated ground.
d. Is Nutrient Management required? (Y/N)	Yes, application must match crop uptake of nitrogen + 15 - 25 % denitrification.	Yes. Nitrogen-based loading calculation.
e. Are there land feature restrictions? (Y/N)	Yes, slopes < 12 % or less for cultivated land, <20 % for permanent turf/hay, <40 % for forestland, no irrigation of sinkholes, rock outcrops or high water tables	Yes. "Unsuitable site" restrictions. Slope >8-10 percent (Policy only)
f. Monitoring requirements? (Y/N)		Yes. Treated water analyzed 1-2x/week; annual soil sample analysis. GW mon. rare.
If Y list parameters.	Yes, quarterly groundwater monitoring and weather conditions during irrigation.	BOD, Turbidity, Fecal
g. Are there restrictions on crops/vegetation types? (Y/N)	No	Yes. No spray irrigation on crops to be consumed raw. Restrictions depend on Type I vs. Type II water.
7. Is aquifer recharge allowed? (Y/N)		Preferably not, but possible if GW will not be degraded so that it will adversely effect actual or potential use (treated water better than GW quality may be allowed).
a. If Y list types/methods.	Yes, 4 - 55 % of soil hydraulic capacity for slow rate irrigation. Rapid infiltration and deep well injection also allowed.	
b. Are any contributions to GW allowed? (Y/N)	Yes. Groundwater recharge is stated in law [9.115 (a)] as a benefit of land application.	Not specifically stated but incidental may be allowed as evidenced by the language "avoid excessive application of reclaimed water that results in surface reunoff or excessive percolation below the root zone."
8. Are there storage requirements? (Y/N)		Yes.
If Y describe basis.	Yes, based on U.S. EPA Climate Model III, with 60 day minimum and 120 maximum	Not allowed in "Floodway", synthetic or compacted liner, berm specifics, etc.

A SURVEY OF STATE REUSE REGULATIONS			
	Lily Choi	Cal Sawyer and Lily Choi	Horne
QUESTION	VIRGINIA	VIRGINIA	WASHINGTON
1. Definitions: (give essentials)			
a. Reuse	Not Defined	Not Defined	Use of reclaimed water in compliance with …regulations and standards, for a direct beneficial use.
b. Recyle	Not Defined	Not Defined	Not Defined
c. Reclaim	Included in "treatment works"	Included in "treatment works"	Effluent derived in any part from sewage from a wastewater treatment plant that has been adequately and reliably treated…is suitable for a beneficial use or a controlled use…
2. Permit Required? (Respond Y/N w/ duration if Y)	Yes. VPA 10 years	Yes. VPDES 5 years, VPA 10 years	Y: State Waste Discharge (groundwater recharge projects) or NPDES (all others): 5 years
a. Are uses other than land application allowed?	Not addressed	Not addressed	
b. Who holds the permit?	Whoever controls and operates the wastewater treatment facility	Whoever controls and operates the wastewater treatment facility	
3. What Agencies are involved? (List state agencies)	DEQ w/ VDH, as needed	DEQ and VDH w/ DCR	Permit issued by WA Dept of Ecology, with conditions as established by WA Dept of Health
4. What is the basis? (Regulation/guidance/???)	VPA Permit Reg; VPA Permit Manual; DEQ Guidance	1977 Sewage Regulations	Title 90.46 RCW in State Code, authorizing DOH to develop standards (done) and regulations. Formal regulations not yet adopted, but standards are in effect.
5. Is water quality criteria specified? (Y/N)	No	Yes, pretreatment for land application	Yes: Total Coliform, BOD, suspended solids, turbidity, and DO (depending on class of reclaimed water. Other constituents (nutrients) on a case-by-case basis. Nitrogen specified for all GW recharge.
a. Are there use restrictions dependent on WQ critieria? (Y/N)	No, only land application	No, only land application	Indirectly. Treatment processes provided determine class of reclaimed water, which in turn determines allowable uses.
6. SITE REQUIREMENTS			
a. Buffers or setbacks? (Y/N)	Yes	Yes	Yes: varies depending upon class of water
b. Specified application rates? (Y/N)	Yes	Yes	Case-by-case determination: based on agronomic rates, physiographic zone, etc.
If Y for applications rates list methods allowed.	Water balance to establish site area design. Operational restrictions on hydraulic loading with restrictions on annual rate based on crop uptake of nitrogen.	Water balance to establish site area design. Operational restrictions on hydraulic loading with restrictions on annual rate based on crop uptake of nitrogen.	
c. Time or weather restrictions? (Y/N)	Yes	Yes	Case-by-case: depends on class of reclaimed water and type of use
d. Is Nutrient Management required? (Y/N)	Yes	Yes	Case-by-case: based on agronomic needs (both hydraulic and nutrient)
e. Are there land feature restictions? (Y/N)	Yes	Yes	Case-by-case: depends on class of reclaimed water and type of use
f. Monitoring requirements? (Y/N)	Yes	Yes	Y. GW monitoring set on case-by-case basis (anti degradation applies). No runoff allowed.
If Y list parameters.	Wastewater, soil and groundwater	Wastewater, soil and groundwater	Parameters set on case-by-case basis.
g. Are there restrictions on crops/vegetation types? (Y/N)	Yes, no crops consumed raw, water tolerant grass.	Yes, no crops consumed raw, water tolerant grass.	Yes: the crops/vegetation types which can be irrigated depend upon the class of reclaimed water applied.
7. Is aquifer recharge allowed? (Y/N)	No	No	Yes
a. If Y list types/methods.		However, high rate infiltration could be designed to recharge shallow groundwater (minimum depth to mound)	Surface percolation only. Injection prohibited.
b. Are any contributions to GW allowed? (Y/N)	Yes	Yes	
8. Are there storage requirements? (Y/N)	Yes	Yes	Yes
If Y describe basis.	Crop non-growing season and inclement weather based on climatological data or a fixed minimum storage period (60 days or more).	Crop non-growing season and inclement weather based on climatological data or a fixed minimum storage period (60 days or more).	Short-term: at least 24 hours (depends on system design); Long-term: 20 days minimum (depends on system design)

APPENDIX E

OTHER RELEVANT PUBLICATIONS

General Reuse

1. American Water Works Association and Water Environment Federation. 1994. Water Reuse Symposium Proceedings.
2. American Water Works Association and Water Environment Federation. 1996. Water Reuse Conference Proceedings.
3. American Water Works Association and Water Environment Federation. 1998. Water Reuse Conference Proceedings.
4. Takashi Asano (Editor). 1998. Wastewater Reclamation and Reuse. Technomic Publishing Company, Inc.
5. Water Environment Federation. 1989. Water Reuse: Manual of Practice SM-3. 2nd Edition.
6. Water Environment Research Foundation. 1994. Assessment Report: Water Reuse.
7. California-Nevada Section, American Water Works Association. 1992. Guidelines for Distribution of Nonpotable Water.
8. California-Nevada Section, American Water Works Association. 1997. Guidelines for the On-site Retrofit of Facilities Using Disinfected Tertiary Recycled Water.
9. American Water Works Association. 1994. Manual M24: Dual Water Systems.
10. USEPA. 1980. Wastewater Aerosols and Disease: Proceedings of a Symposium.

Irrigation (Agricultural and Urban)

1. U. S. Golf Association. 1994. Wastewater Reuse for Golf Course Irrigation. Lewis Publishers.
2. Water Environment Federation. 1992. Urban and Agricultural Water Reuse Conference Proceedings.
3. World Health Organization. Technical Report Series. 1989. Health Guidelines for the Use of Wastewater in Agriculture and Aquaculture.
4. National Research Council. 1996. Use of Reclaimed Water and Sludge in Food Crop Irrigation. National Academy Press.
5. California State Water Resources Control Board. 1985. Irrigation with Reclaimed Municipal Wastewater - A Guidance Manual. Lewis Publishers.

Other Reuse Options

1. USEPA. 1980. Industrial Reuse and Recycle of Wastewaters (Literature Review).
2. Virginia Department of Environmental Quality and Department of Health, Report to the General Assembly of Virginia pursuant to HJR 587 (1997). 1998. Gray Water Use and Rainwater Capture: Potential benefits in the Commonwealth of Virginia.
3. National Research Council. 1994. Groundwater Recharge Using Waters of Impaired Quality. National Academy Press.
4. National Water Research Institute. 1999. Non-Potable Water Recycling: Workshop Report.