Annotated Septic System Bibliography

From "Effects and Costs of Septic Systems Within the Chesapeake Bay"
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This annotated bibliography presents some of the literature that has been produced in the last two decades on conventional and alternative on-site disposal systems. There is a vast amount of literature regarding septic system performance, design, and maintenance, far more than could be included in this list. There are also many educational materials for septic system owners, and the reader is advised to contact their local health department or natural resource agency to obtain a sample of this literature.

We have categorized the entries in this bibliography in two ways. First, each reference has been placed into one of four information categories. The categories are:

1). Environmental Impacts of Septic Failure	This category includes references on the ground and surface water impacts of septic effluent from phosphorus, nitrogen, and bacterial loads present in septic effluent. Papers discussing estimated nutrient load numbers from the use of various models are included in this category.
2). The Costs Associated with Septic Systems	This category includes references on the installation and operation and maintenance costs associated with different onsite treatment technologies.
3). Septic System Performance and Siting	This category includes references discussing the ability of various onsite systems to remove pollutants, the impact of septic system density, and alternative on-site technologies.
4). Management Issues and Policy Trends	This category includes references discussing land use planning and growth, the administration and regulation of onsite treatment systems, and new ideas to improve the management of on-site disposal systems.

Secondly, since many of the references include information for more than one category, the field called **information key** shows the reader all the general information categories that apply to the reference. For example, an information key listing of 1, 3, means that the reference contains information on environmental impacts and septic system siting or performance considerations.

Environmental Impacts

Anderson, Damann L. 1998. **Natural Denitrification in Groundwater Impacted by Onsite Wastewater Treatment Systems**. In *On-Site Wastewater Treatment: Proceedings of the Eighth International Symposium on Individual and Small Community Sewage Systems*. American Society of Agricultural Engineers, St. Joseph, MI.

Information Key: 1

This article discusses the results of a review of previous on-site wastewater treatment systems field investigation in Florida. The goal was to evaluate the potential for natural denitrification as a mechanism in the reduction of nitrate-nitrogen concentrations in groundwater. Based on previous investigations and a literature review, the author found that natural denitrification in groundwater may contribute to significant reductions in groundwater nitrate concentrations in Florida flatwood soils. Denitrification rates were found to be positively correlated with soil organic content, and the author recommended further research to verify the results and create models that could be used in locating wastewater treatment systems.

Bauman, B.J. and W.M. Schafer. 1985. **Estimating Ground-Water Quality Impacts from On-Site Sewage Treatment Systems**. In On-Site Wastewater Treatment: Proceedings of the Seventh International Symposium on Individual and Small Community Sewage Systems. American Society of Agricultural Engineers, St. Joseph, MI.

Information Key: 1

This paper describes a methodology for estimating the likelihood of groundwater pollution from septic systems. Using various forms of analyses, estimates can be made of the possibility of septic systems contributing to increases in pollutant loads to groundwater aquifers. The authors include factors that should be included in any site evaluation of the impact of septic systems on groundwater quality.

Canter, Larry and Robert Knox. 1985. **Septic Tank System Effects on Ground Water Quality**. Lewis Publishers, Inc., Chelsea, MI.

Information Key: 1,3

This book describes the sources and mechanisms of ground water pollution from septic tank systems and reviews methodologies for evaluating the ground water pollution potential of these systems. The transport and fate of various contaminants (bacteria, viruses, phosphorus, nitrogen and organic constituents) through soils and groundwater are examined, as well as models for determining the effects of septic tank systems on ground water quality. An annotated bibliography describes additional studies and reports pertaining to septic tank system impacts and predictive models.

Carodona, M. 1998. **Nutrient and Pathogen Contributions to Surface and Subsurface Waters From On-site Wastewater Systems - A Review**. North Carolina State University Cooperative Extension Service, Raleigh, NC.

Information Key: 1

This report reviews past studies conducted to assess the contributions of onsite wastewater systems to surface and subsurface water pollution. The paper summarizes the results of various monitoring studies on the movement of nutrients and pathogens through soils that have allowed researchers to identify factors that can determine potential nitrogen, phosphorus and bacteria loading from septic effluent. The paper also includes information on the typical concentrations of pathogens in septic tank and raw wastewater effluent and a list of references for further information.

Chen, Chen-Peng and John Harkin. 1998. **Transformations and Transport of ^{15}N-based Fixed Nitrogen from Septic Tanks in Soil Absorption Systems and Underlying Aquifers**. In *On-Site Wastewater Treatment: Proceedings of the Eighth International Symposium on Individual and Small Community Sewage Systems*. American Society of Agricultural Engineers, St. Joseph, MI.

Information Key: 1

This article examines the removal of nitrogen in septic systems and the role of on-site sewage disposal systems in supplying nitrate-nitrogen to groundwater. The results of the study found that on average septic systems eliminated 44.5% of the fixed nitrogen introduced into the septic tank/soil absorption systems. The study also found that N abundance was reduced by 74.7% compared to the original level as a result of joint treatment in the system and the monitored groundwater, and lead the authors to suggest that septic systems are not necessarily a dominant source of nitrate-nitrogen in groundwater underlying sewage disposal systems for treating household wastewater.

Cogger, Craig. 1988. **On-Site Septic Systems: The risk of groundwater contamination**. *Journal of Environmental Health*, Volume 51. September/October. 1988. Pages 12-16. National Environmental Health Association, Denver, CO.

Information Key: 1

This article provides an overview of the potential impacts of traditional on-site wastewater treatment systems to groundwater quality. The article looks at four possible contaminants-bacteria and viruses, nitrates, and phosphates. The author reviews published research to illustrate the current knowledge regarding the transport and removal of these contaminants from drainfields to groundwater.

Duda, A. and K. Cromartie. 1982. **Coastal Pollution From Septic Tank Drainfields**. *Journal of Environmental Engineering*, Volume 108, Number ee6. American Society of Civil Engineers, Environmental Engineering Division, New York, NY.

Information Key: 1

This paper examines the results of monitoring of coliform bacteria densities in waters draining residential areas of North Carolina. A comparison of bacterial levels in residential areas with differing septic systems densities and soil types indicated that septic tank drainfields installed on unsuitable soils were a major source of contamination for shellfish waters. The authors include options for rehabilitating septic system to reduce concentrations of failing septic systems and offer suggestions for management practices that minimize the bacterial contamination in estuarine waters.

Fehr, Stephen and Peter Pae. 1997. **Aging Septic Tanks Worry D.C. Suburbs**. Washington Post, May 18, 1997.

Information Key: 1

This article describes the growing concern in the Chesapeake Bay region over the possibility that many septic systems have reached the end of their design life and may begin to fail at increasing rates. This failure could contribute large amounts of nitrogen and raw sewage in local waterways, affecting both public and environmental health. The article examines the problems that several communities in the Washington, D.C. suburbs have encountered, and presents an overall picture of the many challenges facing local officials responsible for managing septic systems.

Harman, J., W.D. Robertson, J.A. Cherry, and L. Zanini. 1996. Impacts on A Sand Aquifer from an Old Septic System: Nitrate and Phosphate. G*round Water*, Volume 34, Number 6. Pages 1105-1112. National Water Well Association, Worthington, OH.

Information Key: 1,3

The paper presents the results of a study of a septic plume below a 44 year old septic system servicing a school in Ontario, Canada. The septic plume contained high levels of nitrate and above background levels of phosphate. Phosphate concentrations at the water table suggest that precipitation is a more important process in the unsaturated zone than sorption for phosphate attenuation. The migration of phosphate in groundwater was greater than that for younger septic systems, and suggested that long-term phosphate migration was controlled by adsorption processes that allowed slow but progressive advancement of phosphate, and that many years or decades could pass before phosphate loading to nearby surface waters was evident.. Nitrate levels were also high in the septic plume, and the authors concluded that septic systems probably contributed to the large number (30%) of domestic well contaminated by nitrate.

Horsley, Scott, Daniel Santos, and Derek Busby. 1996. **Septic System Impacts for the Indian River Lagoon, Florida**. Published in the Proceedings of Watershed 96': Moving Ahead Together Technical Conference & Exposition held in Baltimore, Maryland. U.S. Environmental Protection Agency, Office of Water, Washington, D.C.

Information Key: 1

This paper is a brief overview of a project to quantify pollutant loadings from septic and wastewater plant discharges. Using a nitrogen loading model, estimates of nitrogen loading rates were calculated from several sources. The project findings suggest that septic systems produce about 10% of the nitrogen load to receiving waters.

Kaplan, O. Benjamin. 1991. **Septic Systems Handbook**. Lewis Publishers, Chelsea, MI.

Information Key: 1,3

This comprehensive book emphasizes basic theory and provides practical advice for everyday use for all types of professionals who deal with septic system use and approval. Sections include case histories, codes, and ethics. Health issues associated with septic systems are examined, basic septic system design concepts are described, and the impacts of these sewage treatment systems on the environment are discussed.

Lee, Sijin, Drew McAvoy, James Szydlik, and Jerald Schnoor. 1998. **Modeling the Fate and Transport of Household Chemicals in Septic Systems**. *Ground Water*, Volume 36, Number 1. National Water Well Association, Worthington, OH.

Information Key: 1

This article describes a mathematical model developed for the purpose of predicting the fate and transport of down-the-drain chemicals in septic systems. Results from model simulations and field studies indicate that this model is satisfactory as a screening level tool for predicting household chemical biodegradation and transport in septic systems.

Maizel, M., G. Muehlbach, P. Baynham, J. Zoerkler, D. Monds, T. Iavari, P. Welle, J. Robbin, and J. Wiles. 1997. **The Potential for Nutrient Loadings from Septic Systems to Ground and Surface Water Resources and the Chesapeake Bay**. U.S. Environmental Protection Agency, Chesapeake Bay Program, Annapolis, MD.

Information Key: 1,3

This report describes a study of the population and physical data of the Chesapeake watershed to determine the potential contribution of nitrogen loadings from septic system to ground and surface waters. Several techniques were used to calculate current loadings from septics and to estimate potential future loadings. The authors concluded that the techniques used to estimate nitrogen loads had practical applications and that this type of study could be extended to better quantify septic impacts and identify communities where economic assistance might best be used to reduce nitrogen impacts from septic systems

Maryland On-Site Sewage Disposal Task Force. 1999. **Reducing the Environmental Impacts from On-site Sewage Disposal Systems**. Maryland Department of Natural Resources, Tributary Strategies Program, Annapolis, MD.

Information Key: 1,3,4

This report details the recommendations of a task force convened to provide comment on newly revised septic system regulations drafted by the Maryland Department of the Environment. The goal of the task force was to encourage the use of new non traditional on-site disposal technologies that are better at reducing nutrient output while still removing pathogenic wastewater. The task force came up with 36 different recommendations, divided into five general categories: overarching issues, education, conventional systems, non-traditional systems, and shared systems. Among the recommendations of the task force; identify Areas of Special Concern for pollutant impacts, require management districts or maintenance agreements for Areas of Special Concern, community and shared systems, and establish a tracking system to assure better maintenance and operation of onsite systems. The task force also recommended expanding education programs, establishing demonstration areas, and requiring onsite system inspectors, installers, and haulers to be trained and certified.

Mandel, Ross and Douglas A. Haith. 1992. **The Impact of Septic Systems on Surface Water Quality**. Department of Civil and Environmental Engineering, Department of Agriculture and Biological Engineering, Cornell University, Ithaca, NY.

Information Key: 1,3

This paper presents a planning model for estimating the monthly contribution of septic systems to nitrogen and phosphorus loads at the watershed scale. Using a classification system that divides septic system into four types based on quantity of nutrients delivered to surface water and the mode of transport, the model allows watershed planners to better estimate the impact of malfunctioning systems on nutrient levels. The paper also contains a literature review of the components of the conventional septic system and the nitrogen, phosphorus, and pathogenic impacts of septic systems. A case study where the model was applied to a New York watershed is also presented.

Meschke, J. and M. Sobsey. 1998. **Microbial Pathogens and On-Site Soil Treatment Systems**. North Carolina State University Cooperative Extension Service, Raleigh, NC.

Information Key: 1

This study reviews published literature on the pathogenic organisms present in onsite wastewater effluent and their potential for groundwater contamination. Factors that may contribute to microbial survival in soils are examined along with historic case studies of groundwater contamination from on-site wastewater systems.

National Small Flows Clearinghouse. 1996. **On-Site Wastewater Disposal and Public Health**. *Pipeline*, Volume 7, Number 3. National Small Flows Clearinghouse, Morgantown, WV.

Information Key 1

A short paper discussing the impact of on-site wastewater treatment on water quality and public health. The paper provides an overview of why wastewater treatment is such an important consideration for small communities, including discussing diseases that might be spread by wastewater.

Nizeyimana, Egide, G. W. Petersen, M. C. Anderson, B. M. Evans, J. M. Hamlett, and G. M. Baumer. 1996. **Statewide GIS/Census Data Assessment of Nitrogen Loadings from Septic Systems in Pennsylvania**. *Journal of Environmental Quality*, Volume 25, March/April. Pages 346-354. Published cooperatively by the American Society of Agronomy, Crop Science Society of America, and Soil Science Society of America, Madison, WI.

Information Key: 1

The authors of this article describe the development of a methodology for assessing nitrogen released by septic systems at the state level and to present results for N loading estimates. The methodology was based on using GIS systems to compute N loads based on Census data, soil limitations, and a review of daily N estimates per capita in septic system effluent from published literature. The authors then placed 104 watersheds into three categories (high, medium, and low) based on N loading estimates. The study indicated that the high N producing watersheds were generally located in suburbs adjacent to larger metropolitan areas.

Ohrel, Ron. 1995. **Dealing With Septic System Impacts**. *Watershed Protection Techniques*, Volume 2, No. 1. Pages 265-272. Center for Watershed Protection, Ellicott City, MD.

Information Key: 1,2,3

This article reviews the potential water quality impacts of both functioning and failing septic systems. Recent research and local criteria for siting septic systems to reduce failure rates are examined, as well as innovative septic system alternatives that have greater pollutant removal capability. In addition, innovative programs which have been designed to improve the level of septic system maintenance are highlighted. The article compares conventional and alternative septic system designs for average effectiveness at reducing certain water quality pollutants, and includes the average capital cost and maintenance costs for both the conventional and alternative system designs.

Pinnette, Steven R., William T. Noble, Daniel B. Locke, and Marc C. Loiselle,. 1999. **Residential Septic System Impacts on Groundwater Quality in Maine -- Characterization of Nitrate Concentrations in Domestic Wells at 18 Subdivisions**. Maine Department of Environmental Protection, Bureau of Land and Water Quality, Augusta, ME.

Information Key: 1,3

This report details the results of a study by the Maine Department of Environmental Protection and the Maine Geological Survey to determine ground water quality impacts from on-site disposal systems. By examining nitrate-nitrogen concentrations in domestic wells at 18 unsewered subdivisions, the authors were trying to establish the effectiveness of Maine Subsurface Wastewater Disposal Rules at protecting well water quality and to identify the site factors that exert the greatest influence on groundwater quality. The authors conclude that the Rules were adequately protecting residential wells, but that additional protections could be implemented to further protect well water quality. Among the recommendations for implementation were; deeper bedrock wells, longer well casings, locating wells as far upgradient from septic systems as possible, and beginning a licensing program for septic system installers.

Reneau, R.B. and Charles Hagedorn. 1998. **Onsite Treatment and Disposal of Domestic Wastewater: Magnitude and Impact**. Crop and Soil Environmental News, Virginia Cooperative Extension, Blacksburg, VA.

Information Key: 1

This paper provides a brief review of onsite wastewater treatment systems use in both the United States and the Commonwealth of Virginia, including information on the number of households using public sewer and onsite systems and the quantity of effluent produced in Virginia.

Schueler, Thomas. 1999. **Microbes and Urban Watersheds - II. Concentrations, Sources, and Pathways**. *Watershed Protection Techniques*, Volume 3, Number 1. Center for Watershed Protection, Ellicott City, MD.

Information Key: 1

This journal article examines the role of microbes in influencing urban water quality and where these microbial agents may be originating. The article recognizes septic systems as a source of microbes, gives bacterial densities for failed septic systems, and the failure rates for traditional septic systems.

Stolt, Mark and Raymond Reneau. 1991. **Potential for Contamination of Ground and Surface Waters from Onsite Surface Disposal Systems**. Virginia Department of Health, Richmond, VA.

Information Key: 1,3

This 96-page document summarizes the results of a literature survey of on-site wastewater disposal systems and their contributions to degradation of ground and surface waters. The report discusses the movement of septic effluent through soils and reviews the fate and transport of various components of septic tank effluent. Numerous studies are examined to determine the contributions of nitrogen, phosphorus, bacteria and viruses from septic effluent to ground and surface water pollution. This publication is extensively devoted to reviewing studies on the environmental impacts from the release of nitrogen and phosphorus contained in septic system effluent. The summary also contains an extensive reference section with 300+ citations regarding septic effluent and water quality.

Tuthill, Anna, D.B. Meikle, and Michael C.R. Alavanja. 1998. **Coliform Bacteria and Nitrate Contamination of Wells in Major Soils of Frederick County, Maryland**. Journal of Environmental Health, 60(8):16-21 National Environmental Health Association, Denver, CO.

Information Key: 1,3

This article discusses the results of an investigation into whether inadequate septic system construction or placement may cause contamination of wells with coliform bacteria and/or nitrates. The relationship of coliform bacteria and nitrate levels to lot size and casing length was tested for all wells in unsewered areas and for wells in ten soil groups in Frederick County, Maryland. A negative correlation between lot size and coliform bacteria and nitrate contamination was found, along with a negative correlation between well casing length and coliform bacteria. The results suggest that septic systems are a source of contamination in wells as lot size decreases and that casing length required in well construction should be increased.

Urish, Daniel and Anthony Gomez. 1998. **Determination of the Quantity, Quality, and Location of Coastal Groundwater Discharge to a Marine Embayment: Greenwich Bay,**

Rhode Island. University of Rhode Island, Department of Civil and Environmental Engineering, Narragansett, RI.

Information Key: 1,3

This report explores the sources of nitrogen loading to a coastal embayment and the effects that sewering would have in reducing those loads. Both the Greenwich Bay watershed and 23 sub-basins within the watershed were delineated and a regional water and nitrogen budget were calculated. This information together with monitoring data from sample wells and thermal infrared aerial imagery allowed the researchers to identify the sources and location of nitrogen discharges. It was determined that the largest contributor of nitrogen was septic systems (~80%), and that total sewering to eliminate on-site disposal system wastewater discharges would alter the nitrogen budget by 78 percent.

Washington Suburban Sanitary Commission. 1994. **Septic Systems: Concerns Regarding Their Impacts on the Patuxent Reservoirs and Best Available Technologies for Enhancing Performance**. Washington Suburban Sanitary Commission, Laurel, MD.

Information Key: 1,4

This report examines the impacts of septic system use on two Washington Suburban Sanitary Commission reservoirs used to supply water to Prince George's, Montgomery, and Howard Counties in Maryland. The report discusses the potential problems associated with septic systems and some of the regional conditions that may contribute to the contamination of both ground and surface waters.

Yates, Marylynn. 1985. **Septic Tank Density and Ground-Water Contamination**. G*round Water*, Volume 23, Number 5. Pages 586-591. National Water Well Association, Worthington, OH.

Information Key: 1,3

This article reviews the role of septic systems in ground water pollution and how the number of systems found in an area can increase the likelihood of contamination of groundwater aquifers. Examples from around the country of reported increases in pollutant levels (especially nitrates) in areas of high septic density are highlighted, and approaches for developing regulations to control septic tank densities are discussed.

The Costs Associated With Septic Systems

Bedinger, M.S., J.S. Fleming, and A.I. Johnson. 1997. **Site Characterization and Design of On-site Septic Systems**. American Society for Testing and Materials, West Conshohocken, PA.

Information Key: 2

This reference is a collection of papers presented at the Site Characterization and Design of On-Site Septic Systems Symposium in 1997. The papers in this publication address the following: septic system operation and evaluation, septic system site characterization and design, and alternative systems, and component design.

Bilanin, Jeanne.E. and Victor E. Tervala. 1999. **Water and Sewer Service in Rural Baltimore County, Maryland**. Institute for Governmental Service, Center for Applied Policy Studies, University of Maryland, College Park. 55pp

Information Key: 2,3

This report discusses the findings of a study on how water and sewer services might be brought to rural Baltimore County. Included in the report are discussions on management options for on-site wastewater disposal systems, and whether a sanitary district should and legally could be established in rural Baltimore County. The report also examined the costs of both onsite systems, community systems, and the cost of providing public sewer and water. Projections of how new growth in rural Baltimore County will affect wastewater treatment and how to address areas of existing failing on-site wastewater systems are also reviewed.

University of Rhode Island Cooperative Extension.. No date. **On-site Wastewater Systems: Block Island Wastewater Management Program**. University of Rhode Island, Narragansett, RI

Information Key: 2,3

This matrix is part of a report on the Block Island Wastewater management project currently underway in Rhode Island. The matrix provides cost and performance data for nine different on-site wastewater treatment systems. The matrix also examines the site limitations, the ability of the system to protect sensitive resources, installation considerations, and maintenance and inspection costs.

Community Environmental Services. No date. **Onsite Treatment (Pretreatment) and Onsite Disposal System Fact Sheets**. City of Austin Water & Wastewater Utility, Austin, TX.

Information Key: 2,3

This collection of fact sheets provides information on twenty-four onsite wastewater treatment technologies that have been identified by an Alternative Wastewater Management Project as providing adequate and cost-effective treatment. Each system fact sheet includes the following information: a brief description, the status of the technology, its applications, limitations, and performance. There is also discussion of the operation and maintenance requirements and potential environmental impacts of each type of system. Installation and maintenance costs are reviewed and the net present worth over a twenty-year period is calculated. Typical concentrations for effluent and schematics of system design are included when available.

Hoover, Michael. 1997. A **Framework for Site Evaluation, Design, and Engineering of On-Site Technologies Within a Management Context**. Marine Studies Consortium, Waquoit Bay National Estuarine Research Reserve, and ad hoc Task Force for Decentralized Wastewater Management, Chestnut Hill, MA.

Information Key: 2,4

This document provides an approach to the use and management of decentralized systems for Massachusetts communities. It describes a process for site evaluation, design, and engineering of on-site systems within a management context that protects water resources from adverse impacts through the use of a local or regional wastewater management entity. The process identifies and protects public water supplies and highly valuable water resources from contamination and provides for remediation of existing, failing conventional septic systems by allowing substantial flexibility of the prescriptive siting criteria In short, this document describes a

systematic approach to providing an affordable wastewater management infrastructure for small communities when public sewers and regional wastewater treatment plants are not economically feasible that may be useful throughout the nation. The paper also includes an appendix with cost estimates for 46 different on-site systems in the Barnstable Massachusetts community based on a model the author helped develop called the Costs of On-Site Management Options model.

Klink, R.E., D.F. Pirrung, and P.J. Wintheiser. 1984. **Cost-Effectiveness Analysis for Various On-Site Wastewater Treatment Alternatives**. In On-Site Wastewater Treatment: Proceedings of the Fourth International Symposium on Individual and Small Community Sewage Systems. American Society of Agricultural Engineers, St. Joseph, MI.

Information Key: 2

This paper details the results of wastewater management studies done in Wisconsin to assess the impact of on-site treatment systems and to develop cost effective and environmentally sound alternatives for specified project areas. The authors examined five different wastewater treatment systems and determined the costs associated with each one, and the reader will benefit from seeing how present value costs break down for sanitary sewer service versus on-site treatment.

Loomis George W. and David Dow. 1998. **Utilizing Advanced Treatment Technologies to Remediate Failed On-site Systems on Marginal Sites Located in Sensitive Coastal Environments**. In *On-Site Wastewater Treatment: Proceedings of the Eighth International Symposium on Individual and Small Community Sewage Systems*. American Society of Agricultural Engineers, St Joseph, Michigan.

Information Key: 2,4

This paper presents details on a demonstration project in the Narragansett Bay Watershed in Rhode Island to replace failing septic systems with innovative on-site wastewater treatment systems. The paper discusses the site conditions and constraints for each type of system used, along with construction costs, and some preliminary performance data. Because of the relatively new age of the systems, continued monitoring to determine long-term performance is on-going.

U.S. Environmental Protection Agency. 1993. **Guidance Specifying Management Measures for Sources of Nonpoint Pollution in Coastal Waters**. U.S. EPA, Office of Water, Washington, D.C.

Information Key: 1,2,3,4,

This comprehensive manual provides guidance to states and territories of the U.S. in managing sources of nonpoint pollution in coastal waters. It is required under section 6217 of the Coastal Zone Act Reauthorization Amendments of 1990 (CZARA). Nonpoint source pollution and national efforts to control it are described. Management measures are broken down into six broad categories: agriculture sources; forestry; urban areas; marinas and recreational boating; hydromodification (channelization, channel modification, dams, streambank and shoreline erosion); and wetlands, riparian areas, and vegetated treatment systems. Chapter 4 pages 97-118 discusses management of on-site disposal systems, which is one of the six identified sources of urban nonpoint pollution. Guidance on reducing onsite system impacts is provided, as well as information on the cost and effectiveness of varying types of onsite disposal systems.

U.S. Environmental Protection Agency. 1980. **Design Manual: Onsite Wastewater Treatment and Disposal Systems** (EPA 625/1-80-012). U.S. EPA Office of Research and Development, Municipal Environmental Research Laboratory, Cincinnati, OH.

Information Key: 1,2,3

This manual provides technical information on onsite wastewater treatment and disposal systems, focusing on the planning, design, construction and management of these systems. The manual details a plan for evaluating sites being considered for onsite disposal systems and presents a procedure for selecting appropriate systems. The characteristics of domestic wastewater and methods for modifying wastewater flow prior to treatment are also described. Two chapters detail the various onsite treatment methods available, as well as wastewater disposal methods and disposal of residuals (septage). Finally, management entities and program functions are discussed to ensure the continued proper operation of onsite systems. This manual is currently being updated, and a new version with more current wastewater characteristics data is scheduled for 2000.

Septic System Performance and Siting

American Society of Agricultural Engineers. 1998. **On-Site Wastewater Treatment**: Proceedings of the Eighth International Symposium on Individual and Small Community Sewage Systems. Edited by Dennis Sievers. American Society of Agricultural Engineers, St. Joseph, MI.

Information Key: 1,2,3,4

This collection of papers from a conference organized by ASAE examines new research and management ideas in the field of on-site wastewater treatment. Papers discussing topics such as siting considerations, new treatment technology, soil capability for accepting and treating wastewater, ability of systems to remove pollutants, small community options for treating wastewater and managing septic systems, and field research on the viability of alternative systems are included. Of particular interest to the Chesapeake Bay area are the observations regarding various on-site wastewater systems, specifically recirculating sand filters, aerobic treatment units and constructed wetlands. Presentations at the conference present evidence that recirculating sand filters appear to be capable of providing consistently high quality effluent and can achieve nitrogen removal rates of about 60-70%. Constructed wetlands can also produce high quality effluent, but with greater variability in treatment levels. Part of this variability is due to retention times and the fact that constructed wetlands are a natural system with greater dependence on the environment. Aerobic treatment units can be a viable alternative for sites with limited space, but require the most frequent maintenance of the systems studied.

Note: Interested parties may wish to consult the earlier proceedings as an overview of how issues and trends in on-site wastewater treatment have evolved in the last twenty-five years.

Anderson, Damann L., Mark B. Tyl, Richard J. Otis, Timothy G. Mayer, Kevin M. Sherman. **Onsite Wastewater Nutrient Reduction Systems (OWNRS) for Nutrient Sensitive Environments. 1998.** In *On-Site Wastewater Treatment: Proceedings of the Eighth International Symposium on Individual and Small Community Sewage Systems*. American Society of Agricultural Engineers, St Joseph, Michigan.

Information Key: 3

This paper reviews the results of a demonstration project to assess the capabilities of five different on-site wastewater systems to reduce the concentrations of nutrients discharged to the near-shore of the Florida Keys. Results after one year indicated that these modified systems

could reach effluent concentrations of 5mg/L $CBOD_5$, 5mg/L TSS, 10mg/L total nitrogen and 1mg/L total phosphorus without chemical addition using combinations of treatment processes. It was determined that combinations of the tested technologies could consistently meet Florida's advanced wastewater treatment standards for $CBOD_5$, TSS and TP and that TN reductions of 70% are achievable without supplemental carbon addition and 90% with carbon addition. Unfortunately, construction and operation of the systems indicated that they would require considerable greater capital and operation and maintenance cost in comparison to conventional on-site wastewater treatment systems.

Bounds, T.R. 1994. **Septic Tank Septage Pumping Intervals**. In On-Site Wastewater Treatment: Proceedings of the Seventh International Symposium on Individual and Small Community Sewage Systems. American Society of Agricultural Engineers, St. Joseph, MI.

Information Key: 1,3

This paper examines the use of effluent sewers and how to determine septic tank pumping intervals that allow for proper functioning of the system while keeping operational costs down. By using data from the town of Glide, Oregon which used an effluent sewer system in combination with septic tanks, the author was able to create guidance on how often tanks needed to be pumped based on occupancy, loading, and tank size.

Brown, R.B. and T.J. Bicki. 1987. **On-site Sewage Disposal- Influence of System Densities on Water Quality**. Florida Water Resources Research Center, Gainesville, FL.

Information Key: 1,3

This fact sheet specifically examines the influence of increasing septic system density on the quality of groundwater. Studies indicate that with increases in population density and decreases in lot sizes there is an increased likelihood of well contamination and increased on-site sewage disposal systems loadings to qroundwater aquifers. The paper reviews the results of more than seventeen studies that confirm this positive correlation between water contamination and OSDS density.

Cogger, Craig. 1988. **Septic System Performance on a Coastal Barrier Island**. *Journal of Environmental Quality*, Volume 17 (3). Pages 401-407. Published cooperatively by the American Society of Agronomy, Crop Science Society of America, and Soil Science Society of America, Madison, WI.

Information Key: 1

This article discusses the results of a field experiment to evaluate wastewater treatment by septic systems under conditions typical of Atlantic coastal barrier islands. The effects of loading rate and water table depth on the ability of the soil to effectively treat wastewater. The results showed that inadequate separation distances to water tables and increased loading rates can negatively influence the ability of septic systems to remove wastewater constituents. The authors concluded by recommending greater separation distances to ensure effective microbial and phosphorous removal and to reduce nitrate loads to groundwater.

Deal, Karen. 1998. **Analysis of Septic System Failure in Gallatin County, Montana**. Montana State University Extension Service, Bozeman, MN.

Information Key: 3,4

This report assesses the reasons for septic system failure in Gallatin County, Montana. The goal was to identify correlations between failures and poor site evaluation, improper installation, or insufficient system maintenance. The result of the research is being used to create educational materials and bring attention to professional opinions regarding septic system installation and maintenance.

Doley, Todd and Waldon Kerns. 1996. **Individual Homeowner & Small Community Wastewater Treatment & Disposal Options**. Virginia Cooperative Extension, Blacksburg, VA.

Information Key: 3,4

This paper examines the wastewater treatment system options for those residences and small communities where centralized public sewer systems are not currently options. Each type of onsite sewage disposal system is briefly described, including a discussion of the advantages of each system with some design considerations.

Edwards, Daniel and Alvaro DeCarvalho. 1998. **Assessing the Impact of Household Cleaning Products on Wastewater Systems**. *Small Flows Journal*. National Small Flows Clearinghouse, Morgantown, WV.

Information Key: 1,2

This paper reviews the techniques used to evaluate the toxicity of cleaning products to residential wastewater treatment processes and examines available data to determine the effects of common household cleaning products on septic tank function.

Gold, Arthur, William DeRagon, W. Michael Sullivan and Jerrell Lemunyon. 1990. **Nitrate-Nitrogen Losses to Groundwater from Rural and Suburban Land Uses**. *Journal of Soil and Water Conservation*, Volume 45, Number 2. Soil Conservation Society of America, Ankeny, IA.

Information Key: 1,4

This article contains the results of a two-year study of the nitrate-nitrogen losses to groundwater from different land uses in the Kingston, Rhode Island area. The study found that septic systems had an annual average flow-weighted concentration of nitrate-N in excess of 10mg/l. The author suggests that in areas where sewering is not an option, zoning densities of less than five homes/hectare or the use of denitrification systems for on-site wastewater disposal may be necessary to insure groundwater quality in residential areas.

Grant, William. No date. **Movement of Septic System Effluent From Lake Developments Into Near-Shore Areas of 18 Indiana Lakes**. LaGrange County Health Department, LaGrange, IN.

Information Key: 1,3

This study identified the subsurface movement of septic effluent as a potential source of high bacterial counts and high ortho-phosphate concentrations in several lake development projects in Indiana. Even after dye-testing and replacement of dye-positive systems, septic plumes were discovered entering the lake. Leachate detector testing and follow-up testing confirmed the presence of plume positive areas. This study was used as justification for the installation of sanitary sewer systems around the lakes in LaGrange County.

Glasoe, Stuart and Mark Tompkins. 1996. **Sanitary Surveys in Mason County, WA**. *Puget Sound Notes*, Number 39 June. Puget Sound Water Quality Authority, Olympia, WA.

Information Key: 3

This article discusses the results of sanitary surveys conducted around shellfish waters in Mason County, Washington. Watershed professionals will be most interested in the discussion of the protocols for visual and dye testing in Mason County. The article begins by providing background on the history of on-site sewage systems and their impact on local shellfish beds, and how the creation of clean water districts facilitated the management of on-site systems. The discussion of the survey methodology for each on-site inspection follows, and the procedures for conducting both visual and dye-test surveys are highlighted. The reliability of the dye test methodology is safeguarded by a series of checks and balances, which are also listed.

Hepner, Larry. 1999. **Working With Nature: New Wastewater Technologies for Pennsylvania**. Delaware Valley College, Doylestown, PA.

Information Key: 3

This document is an educational packet that relays the results of an examination of new on-lot sewage system technologies. The assessment identifies six applicable technologies for the state of Pennsylvania: constructed wetlands, at-grade absorption beds, drip irrigation, and a variety of sand and other filter media technologies.

Jantrania, A.R., K.C.Sheu, A.N. Cooperman, O.C. Pancorbo. 1998. **Performance Evaluation of Alternative System - Gloucester, MA**. In *On-Site Wastewater Treatment: Proceedings of the Eighth International Symposium on Individual and Small Community Sewage Systems*. American Society of Agricultural Engineers, St Joseph, Michigan.

Information Key: 3

This paper presents the findings of a monitoring study of several alternative systems installed on seven lots in the City of Gloucester, MA. The study evaluated the performance of these alternative systems at removing conventional pollutants from septic effluent, and the effects on groundwater of discharging treated effluent using alternative disposal systems. Monitoring results indicate that the alternative on-site treatment systems tested can effectively reduce the organic and inorganic waste from septic tank effluent, and that bacteriological contamination of groundwater was not a concern when using these systems. Nitrogen removal capabilities for the systems varied, with the highest being a 71 percent removal rate for total nitrogen a recirculating trickling filter. The results showed that a combination of two or more treatment methods might be necessary to achieve reduction goals for all conventional septic pollutants.

National Small Flows Clearinghouse. 1998. **On-Site Disposal Fact Sheets: A Technical Overview**. National Small Flows Clearinghouse, Morgantown, WV.

Information Key: 2,3

These fact sheets provide information on a number of wastewater disposal practices for both individual households and small communities. Each fact sheet includes a brief description of the practice, its advantages and disadvantages, and performance and application. Operation and maintenance concerns for each system are discussed, along with costs for implementing the systems if available.

National Small Flows Clearinghouse. 1995. **Computer Search on Sand Filters**. National Small Flows Clearinghouse, Morgantown, WV.

Information Key: 4

This reference contains a bibliography of manuals, articles and papers which deal with the use of sand filters and other alternative technologies to provide on-site treatment of wastewater.

Postma, Frank, Arthur Gold, and George Loomis. 1992. **Nutrient and Microbial Movement from Seasonally-Used Septic Systems**. *Journal of Environmental Health*, Volume 55. Sept/Oct 1992. Pages 5-10. National Environmental Health Association, Denver, CO.

Information Key: 3

This study examines the impact of three seasonally-used septic systems on ground water quality by monitoring the movement and attenuation of nitrogen, phosphorus, and two bacterial indicators of human fecal contamination. Results indicated that Nitrate-N concentrations were often three to four times greater than the drinking water standards at wells 6 meters from the soil absorption fields. Elevated numbers of both bacterial indicators were observed in groundwater at both two and six meters away from the absorption system. When the systems were excavated at the end of summer occupancy, there were no biological clogging mats found. These mats are considered to be critical for even distribution of wastewater within a drainfield, and it was hypothesized that seasonal occupancy may result in incomplete formation of the mats, allowing greater transmission of contaminants.

Perkins, Richard. 1989. **Onsite Wastewater Disposal**. Lewis Publishers, Chelsea, MI.

Information Key: 1,3

This book provides easy-to-understand methods of proper septic system practices suited to a broad range of site conditions, and the reasons for using them. Potential problems both with the system components and the people who regulate septic systems are described, and potential solutions provided. The book also includes sample codes and regulations, selection criteria, and water conservation tips.

Piluk, R. and Peters, E. 1995. **Recirculating Sand Filters: A Better Nitrogen-removing Alternative to Conventional Septic Systems**. *Watershed Protection Techniques*, Volume 2, Number 1. Center for Watershed Protection, Ellicott City, MD.

Information Key: 1,2,3

This paper examines the use of small recirculating sand filters in Anne Arundel County, Maryland to treat septic tank effluent. A description of the sand filter design and schematics for the design are included, along with information on the pollutant removal efficiency of this alternative design compared to the conventional septic system. Some of the studies done on these systems suggest that they may be capable of realizing significant reductions in biological oxygen demand, suspended solids, total nitrogen, and fecal coliform levels.

Reed, Sherwood, Ronald Crites, and E. Joe Middlebrooks. 1995. **Natural Systems for Waste Management and Treatment**. McGraw-Hill, Inc, New York, NY.

Information Key: 3

This book presents information on wastewater management systems that incorporate natural features into the wastewater treatment process. A chapter is devoted to on-site wastewater management systems and reviews several of the on-site treatment and disposal choices. A brief

description of each system is included, along with design criteria and performance information for selected systems.

Saxena, J.L. 1998. **National Onsite Demonstration Project Summary Report: Phase 1**. National Onsite Demonstration Project, Morgantown, WV.

Information Key: 1,2,3

This report examines the results of the first phase of a multi-phase project to demonstrate alternative wastewater systems in typical settings where central sewering is not feasible. Phase one provided money to six communities representing different geographic regions for the design and installation of new alternative treatment systems or the retrofit of existing systems. Monitoring of each alternative wastewater system was included in the planning. Thirty-six different systems were installed or retrofitted and monitored, and the results for each community were examined for site constraints, system costs, observations, and lessons learned about using alternative systems.

Sprehe, Thomas. 1997. **On-site Wastewater Management Practices in the Upper Patuxent Watershed**. George, Miles & Buhr, Hunt Valley, MD.

Information Key: 1,3

This report assesses the current technologies and practices for management of onsite wastewater treatment systems and their applicability to the Upper Patuxent Watershed. The report begins by reviewing the potential for impacts from septic systems to groundwater and drinking water supply reservoirs, and then examines low-cost technologies for improving the pollutant removal abilities of conventional onsite systems. The report suggests that deep trench use may be affecting groundwater quality, and changes in siting practices and pretreatment technologies may provide enhanced treatment opportunities for onsite wastewater treatment.

Tchobanoglous, G. and Burton, F.L. 1991. **Wastewater Engineering: Treatment Disposal, Reuse**. Metcalf & Eddy, 3rd edition. McGraw-Hill, Inc., New York, NY.

Information Key: 1,3

This comprehensive book on wastewater treatment includes information on individual and small wastewater treatment systems. A brief description of several on-site disposal systems is presented, along with cost and performance information. Selection and design criteria are also discussed, as well as sizing considerations and flow distribution for soil absorption fields. The book also includes descriptions of wastewater treatment options for small communities, and design and operation issues for several systems. A review of septage treatment and disposal is also presented.

Uebler, R. L., S.L. Steinbeck, and J.D. Crowder. 1994. **Septic System Failure Rate on a Leon (Hardpan) Soil and Feasibility of Drainage to Improve System Performance**. In On-Site Wastewater Treatment: Proceedings of the Seventh International Symposium on Individual and Small Community Sewage Systems. American Society of Agricultural Engineers, St. Joseph, MI.

Information Key: 1,3

This paper discusses the viability and problems associated with siting septic system soil absorption fields on a particular soil type (Leon). Since this soil type occurs in the state of Virginia in close proximity to coastal waters, research into siting is of great interest. This paper details the

results of a site study in Brunswick County, North Carolina for failure rates of traditional septic systems and what soil characteristics may dictate that failure.

U.S. Environmental Protection Agency. 1987. **Septic System Siting to Minimize the Contamination of Groundwater by Microorganisms**. EPA/440/6-87-007. U.S. EPA, Office of Water, Washington, D.C.

Information Key: 1,3

This report discusses the impact of groundwater contamination on public health and how to minimize the contributions of pathogens from septic systems. The purpose of the report was to develop a rating system that could be used as a tool in siting systems and review what factors are important in influencing the movement and survival of microorganisms in the subsurface environment. The rating system that was developed could be used to screen potential sites for likely groundwater contamination by pathogens in septic tank effluent.

Vanhuizen, David. 1995. **An Analysis of the Potential Impacts on Groundwater Quality of On-site Wastewater Management Using Alternative Management Practices**. Septic Tank Page website. http://www.geocities.com/RainForest/Vines/5240/Septic_Tanks.html.

Information Key: 1,3

This paper focuses on the use of alternative on-site wastewater treatment systems and reviews the factors that affect the quality of percolate delivered to groundwater. The author discusses improvements that can be made to conventional system designs to decrease system failure and prevent pollutant loads to groundwater, as well as examining the pollutant attenuation mechanisms in the soil. The parameters reviewed include nitrogen, phosphorus, and bacterial pathogens, along with other organic and inorganic materials that influence groundwater quality. Since the paper was originally used as a support document for a town in Wisconsin that was seeking permission to use alternative systems, the second part of the paper describes how these alternative systems might work in Wisconsin soils. Alterations to drainfield design to improve effluent treatment are highlighted and basic conclusions regarding the influence of limiting factors are reviewed.

Yates, Marylynn and S. Yates. 1989. **Septic Tank Setback Distances: A Way to Minimize Virus Contamination of Drinking Water**. *Ground Water*, Volume 27, Number 2, March/April 1989. Pages 202-208. National Water Well Association, Worthington, OH.

Information Key: 1,3

This paper examines the use of probability modeling to estimate the appropriate setback distances for septic systems from drinking water wells to meet some specified virus reduction criteria. The study used a goal of a seven-order-of-magnitude reduction in virus numbers to calculate the conditional probabilities of meeting that goal for a variety of setback distances. The probability results are presented in two ways; given a setback distance, what is the probability that the level of the virus will be within acceptable limits, and given a desired probability level for treatment, what setback distances are required to achieve that level of confidence. The authors suggest that both methods may help in community land-use planning by determining were to place septic systems to achieve a desired viral treatment goal.

Policy Issues and Future Trends

Costa, J.E., D. Janik, N. MacGaffey, and D. Martin. 1994. **Use of a Geographic Information System to Estimate Nitrogen Loading to Coastal Watersheds**. U.S. EPA National Estuary Program, Buzzards Bay Project, Marion, MA.

Information Key: 1,3

This technical report discusses the development of a method for evaluating existing and potential future inputs of anthropogenic nitrogen from the embayment's drainage basin to determine if these inputs will exceed recommended nitrogen loading limits. Using land use analysis and census data, non-point source nitrogen loads to the embayment were calculated and management action areas were identified. It was found that on-site wastewater systems and lawn fertilization were the two principal sources of non point source nitrogen.

Gray, Donald and James Gidley. 1987. **Operating Experience of Alternative Sanitary Sewers**. Proceedings of the 1987 Water Resources Symposium held in Chicago, Illinois. American Society of Civil Engineers, Rosemont, IL.

Information Key: 2,4

This paper presents information on alternative sanitary sewer systems that small communities can use to meet treatment objectives while keeping costs down. The paper describes the sanitary sewer technologies available and the characteristics of the various types of technologies. The operation and maintenance costs for each sewer type are also examined.

Jantrania, Anish. 1999. **Onsite Wastewater Management in the 21st Century**. *Small Flows*, Volume 13, Number 2. National Small Flows Clearinghouse, Morgantown, WV.

Information Key: 3

This is the first in a series of three articles on the future of onsite wastewater treatment systems. These articles review onsite wastewater treatment through the use of new technology, regulatory methods, and management techniques. This article discusses some of the new technologies available that can enhance the ability of on-site systems to remove nutrients and protect water quality of both groundwater and surface water. A brief description of several practices is presented, including factors affecting performance and the effectiveness.

Jantrania, Anish. 1999. **Onsite Wastewater Management in the 21st Century: the "Utility System" Concept**. *Small Flows*, Volume 13, Number 3. National Small Flows Clearinghouse, Morgantown, WV.

Information Key: 3

This is the second in a series of three articles on the future of onsite wastewater management and regulation. This particular article deals with the development of a new management system that can provide treatment services for people using onsite wastewater treatment systems that is comparable to the services currently provided to those using centralized sewer systems. The author highlights some of the characteristics of such a system and the potential services that such a utility may offer, as well as how the system can provide for better protection of public health and the environment.

Jantrania, Anish. 1999. **Onsite Wastewater Management in the 21st Century: An Effective and Accountable Regulatory Framework**. *Small Flows*, Volume 13, Number 4. National Small Flows Clearinghouse, Morgantown, WV.

Information Key: 3

This is the third in a series of three articles focusing on the future of onsite wastewater management and technology. This particular article discusses the flaws in current regulatory requirements for on-site systems and the changes that are needed to allow for better performance of these systems. The author recommends that a utility be established to ensure the adequate operation and maintenance of individual wastewater treatment systems, and changes in regulatory approaches to stress post-installation issues are in order. Other recommendations include development of a manual of practice for onsite wastewater systems that would be updated yearly to keep current with the development of new technologies; use of performance-based standards to select the appropriate technology for a site; and providing funding through the use of operational permits for on-site wastewater systems.

Jesperson, Kathy. 1997. **Alternative Sewers: Technologies Provide Cost-effective Option for Many Small Systems**. *Small Flows*, Volume 11, Number 4. National Small Flows Clearinghouse, Morgantown, WV.

Information Key: 4

This article examines a number of alternative sewer options for small communities seeking to treat wastewater in a more centralized way. Each sewer type is described and a case study of a community that has employed the system is presented. The cost for installing a system is presented, along with the estimated final cost to customers for certain systems. The article finishes by explaining the advantages of alternative sewers and provides contacts for more information on the case studies.

Johnson, Barry. 1998. **Strategies to Address On-site Sewage System Problems**. Rouge River National Wet Weather Demonstration Project, Detroit, MI.

Information Key: 4,3

This document examines the need for creating septic system maintenance programs to control non-point pollution from on-site disposal systems (OSDS). The document proposes an implementation strategy to assure the proper operation and maintenance of on-site sewage disposal systems. The document also reviews some existing on-site sewage system maintenance programs and the types of systems that currently can be used in three counties in the Rouge River watershed. Sources of funding for replacement of on-site sewage disposal systems or extension of public sewer systems and a model program for requiring on-site system inspections at the time of sale of property are presented in the appendices, along with other management materials.

Maryland Office of Planning. 1999. Septic Systems and Growth Issues and Trends. Maryland Office of Planning, Baltimore, MD.

Information Key: 4

This document discusses the role of septic systems in determining growth and system impacts on the environment. The paper examines some of the facts regarding nitrogen inputs to the Bay from both septic systems and wastewater treatment plants, including the amount of nitrogen

contributed per person/per year. Issues regarding land consumption are also discussed, and projections for septic system use in Maryland in the near future are also presented.

Maryland Septic System Advisory Committee. 2000. **Final Report**. Maryland Department of the Environment.

Information Key: 1,2,3,4

This is the final report of a committee convened by the State of Maryland to make recommendations for an "Areas of Concern" approach for reducing nutrient pollution from septic systems. The report contains the finding and recommendations of the Committee and a draft legislation that was proposed. The report examines several key issues, including septic system cost, nutrient reduction technology, and impacts of septic system on nitrogen loads.

McKenzie, Margaret. 1998. **Land-Use Planning and Septic Disposal Systems**. *Small Flows*, Volume 12, Number 2. National Small Flows Clearinghouse, Morgantown, WV.

Information Key: 3

This article describes how land-use planning influences growth and the choices available for sewage treatment. The author discusses open space design and how septic systems can be incorporated into that type of development to meet sewage treatment needs. Tips on selecting the right type of sewage treatment system for your community are also included.

McKenzie, Margaret Caigan. 1998. **Hamilton County, Ohio: An Onsite Wastewater Management Success Story**. *Small Flows*, Volume 12, Number 4. National Small Flows Clearinghouse, Morgantown, WV.

Information Key: 3

This article describes a new management system created by the health commissioner for Hamilton County, Ohio to deal with wastewater aeration systems that were creating public health concerns. The article reviews the steps used to improve management of onsite treatment systems and how the health department worked to build a relationship with members of the community. By implementing an inspection program for home sewage disposal systems and offering credit to homeowners who hooked up to a public sewer, the county was able to improve water quality. GIS tracking of stream quality data, home sewage systems, and communicable disease data allows the county to find patterns or clusters of pollution that may indicate system failure.

McKenzie, Margaret Caigan. 1999. **Education Paves the Way for Regulation**. *Small Flows*, Volume 13, Number 2. National Small Flows Clearinghouse, Morgantown, WV.

Information Key: 3

This article describes how the Clermont County Health District in Ohio improved support for their expanded onsite sewage management program by performing homeowner education prior to implementing the program. The article also describes the methods that were most effective in reaching homeowners and hidden resources that might prove helpful in improving the program's effectiveness.

National Small Flows Clearinghouse. 1996. **Summary of Onsite Systems in the United States, 1993**. National Small Flows Clearinghouse, Morgantown, WV.

Information Key: 2,3

This report contains information provided by 1566 health departments from around the country regarding the status of onsite system use for the year 1993. The report provides information on the number of permits issued, the number of failing systems, the cost of systems, and operation and inspection practices for local health departments.

National Small Flows Clearinghouse. 1996. **Management Programs Can Help Small Communities**. *Pipeline*, Volume 7, Number 2. National Small Flows Clearinghouse, Morgantown, WV.

Information Key: 3

This article describes the benefits of incorporating a community management program to better control installation and maintenance of on-site systems. A broad series of goals for a management program is presented, and options to organize the program and tools and strategies for proper management are reviewed. Case studies of communities that have instituted some of these management ideas are also presented.

National Small Flows Clearinghouse. 1995. **Septic Systems- a Practical Alternative for Small Communities**. *Pipeline*, Volume 6, Number3. National Small Flows Clearinghouse, Morgantown, WV.

Information Key: 1,4

This issue of the newsletter "Pipeline" has several articles on the benefits of using on-site septic systems. Among the topics discussed: how septic systems work, what homeowners need to know about septic tank design, and alternative septic system designs.

Otis, Richard. 1998. **Decentralized Wastewater Treatment: A Misnomer**. *Small Flows*, Volume 12, Number 3. National Small Flows Clearinghouse, Morgantown, WV.

Information Key: 3

This article discusses management issues and the advantages and disadvantages of both centralized sewer service versus on-site systems. The author reviews the use of both types of treatment systems and recommends an integrated approach that selects the most appropriate technology for a site.

Pennsylvania Department of Environmental Protection. 1998. **Pennsylvania Code. Title 25. Environmental Protection. Chapters 71-73 Sewage Facilities**. Pennsylvania Department of Environmental Protection, Harrisburg, PA.

Information Key: 3

This document provides the code of regulations for the state of Pennsylvania current through April 18, 1998. These chapters detail all of the state requirements regarding the planning, permitting, and standards for sewage disposal facilities and on-site wastewater systems.

Pennsylvania Department of Environmental Protection. 2000. **Alternate and Experimental Systems Guidance**. Pennsylvania Department of Environmental Protection, Harrisburg, PA.

Information Key: 4

This document provides the current technical standards for all alternate and experimental on-lot systems permitted in the state of Pennsylvania. Each system is examined with regards to siting standards, permitting and planning requirements, and currently approved units.

Rupp, Gretchen. 1998. **Administrative Techniques for Curtailing Septic System Pollution**. Montana State University Extension Service, Bozeman, MT.

Information Key: 3

This report examines the options available to local regulatory agencies to mitigate groundwater pollution from septic systems. The paper provides an array of policy, procedural and educational options that have been used by local jurisdictions to manage existing septic systems and reduce the risk of failure. Based on the results of a previous survey of septic professionals within Gallatin County, Montana, the paper reviews each of the problems that were identified by local septic experts and details how other jurisdictions have instituted solutions/actions to address the problem.

Sagona, Frank. 1988. **Color Infrared Aerial Surveys of Septic Systems in the Tennessee Valley Region**. Tennessee Valley Authority, Chattanooga, TN.

Information Key: 1,3

This paper examines the use of color infrared (CIR) aerial photography to characterize the performance of septic systems. This method has been found to be a quick and cost-effective method for assessing the potential impacts of failing systems to reservoir water quality. The technique uses variations in vegetative growth or stress patterns over septic system fieldlines to identify those systems which may potentially be malfunctioning. The paper examines the basic steps to conducting an aerial CIR survey, and includes a table explaining the characteristics of the four conditions in which septic tank systems can be placed after an interpretation of the survey. Several case studies in the Tennessee valley region are included which illustrate the ability of this technique to screen for potential nonpoint source pollution from failing systems.

Schwartz, J., A. Waterman, A. Lemley, L. Wagenet, P. Landre, and D. Allee. 1998. **Homeowner Perceptions and Management of Private Water Supplies and Wastewater Treatment Systems**. *Journal of Soil and Water Conservation*, Volume 53, Number 4. Pages 315-319. Soil Conservation Society of America, Ankeny, IA.

Information Key: 4

This article examines the results of a three county study in upstate New York to determine the depth of knowledge of homeowners using wells or springs for their water supply. Examination of 244 wells found that one-third of the homes using private water supplies tested positive for the indicator bacteria coliform. Nearly half the participants in the study had never tested their drinking water for possible contamination, and more than one-third never pumped their septic tanks. The authors concluded that the general lack of homeowner knowledge indicated that increased educational programs were necessary, and that further research to determine what influenced the management decisions of homeowners was required.

Shepard, Frank. 1996. **Managing Wastewater: Prospects in Massachusetts for a Decentralized Approach**. Marine Studies Consortium, Waquoit Bay National Estuarine Research Reserve, and ad hoc Task Force for Decentralized Wastewater Management, Chestnut Hill, MA.

Information Key: 3

This report discusses the various methods that have been used across the country to create a wastewater management entity to regulate decentralized wastewater systems. The report begins by examining some of the conventional and innovative technologies available for treating wastewater and the advantages and disadvantages of both central and on-site treatment. The regulatory framework for controlling wastewater discharges is also discussed, with a review of national and Massachusetts specific laws regarding wastewater discharges. Two chapters describe the types of management alternatives that have been used to regulate wastewater, and detail the responsibilities and considerations of a management program. Also included are six case studies of areas that have implemented onsite management programs.

U.S. Environmental Protection Agency. 1991. **Alternative Wastewater Collection Systems Manual**. U.S. EPA, Office of Research and Development & Office of Water, Cincinnati, OH and Washington, D.C.

Information Key: 3

This manual examines alternative sewage collection systems that can be utilized by rural and small communities to meet their sewage treatment needs. These systems provide low-cost sewerage to communities where conventional gravity sewers can prove too expensive for sewage treatment and disposal. The manual begins with an overview of alternative conveyance systems, and the following three chapters provide a more detailed description of each of three general categories of alternative systems. A review of the design and construction considerations, operation and maintenance requirements, system costs, and management considerations for each category are included, along with schematics and photographs of system components. The final chapter provides design examples for each of the system types, and case studies of locations that have incorporated these alternative systems are included in each chapter.

U.S. Environmental Protection Agency. 1986. **Septic Systems and Groundwater Protection: An Executive's Guide**. U.S. EPA, Office of Groundwater Protection, Washington, D.C.

Information Key: 1,4

This document is designed to help state and local government officials in improving existing septic systems regulations and codes to provide better protection of the nation's groundwater. Recommendations for improving septic system management programs are presented, based on the advice of a technical panel of nationally recognized septic system experts.

U.S. Environmental Protection Agency. 1999. **Voluntary National Standards for Management of Onsite/Decentralized Wastewater Systems**. U.S. EPA, Office of Wastewater Management, Washington, D.C.

Information Key: 4

This document is an outline for a future guidance manual that will create voluntary national standards for onsite management programs. It addresses issues such as siting, performance, design, and maintenance of decentralized systems. The document also outlines the strengths and weaknesses of current management strategies and provides guidelines for establishing more effective programs.

U.S. Environmental Protection Agency, Office of Water. 1997. **Response to Congress on the Use of Decentralized Wastewater Treatment Systems**. U.S. EPA, Office of Water, Washington, D.C.

Information Key: 4

This report discusses the EPA response to a request from the Congressional House Appropriations Committee to report on the benefits of decentralized wastewater system alternatives compared to current centralized systems and the potential savings and costs associated with the use of alternative systems. The Committee request highlighted several alternative approaches for managing wastewater including upgrading of systems failing at individual homes, innovative technologies for pretreatment on properties with unfavorable conditions, the use of watershed planning to specify precise standards for zones designated as sensitive areas, and programs to detect failure and ensure proper functioning of onsite systems.

U.S. Environmental Protection Agency. 1994. **Guide to Septage Treatment and Disposal**. U.S. EPA, Office of Research and Development, Office of Science, Planning and Regulatory Evaluation and Center for Environmental Research Information, Cincinnati, OH.

Information Key: 3

The purpose of this manual is to present practical information on the handling, treatment, and disposal of septage in an easy-to-use format specifically for administrators of waste management programs, septage inspectors, and haulers, and managers and operators of septage handling facilities. It also provides contact information for state and EPA regional septage coordinators.