FINAL REPORT

Ad Hoc Committee On Alternative Septic Systems

August 24, 2001

The Pinelands Commission

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Ad Hoc Committee on Alternative Septic Systems

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A. Overview

In 2000, the Pinelands Commission formed a special committee of Commission members and representatives of three other organizations to investigate alternative septic system technologies that would better meet the water quality requirements of the Comprehensive Management Plan (CMP) for single family residences on one to three acre lots as provided in Pinelands Commission approved municipal land use ordinances. In conjunction with the CMP's land use policies, these water quality regulations are devised to ensure the long-term protection of the high quality water resources in the Pinelands. The on-site wastewater disposal systems that are currently permitted for use on these smaller lots have not been effective in meeting CMP standards.

After conducting extensive research, including contacting on-site technology demonstration programs nationwide, retaining a consultant to assess the technical performance of selected technologies, meeting with technology vendors and other state and local agencies, and coordinating with the New Jersey Department of Environmental Protection (DEP) on an ongoing basis, the Committee identified several technologies that, based on the review of technologies conducted by the Commission and its consultant, Dr. Anish Jantrania, P.E., can be expected to meet the CMP's water quality standards. To be certain that these technologies perform in the unique conditions of the New Jersey Pinelands as well as they have in other parts of the country, the Committee recommends that periodic testing be conducted as recommended by Dr. Jantrania. The specifics of the testing program will be adopted by the Commission in consultation with DEP. The Committee agreed on an interim program of approval, installation and monitoring of these five technologies for use under certain conditions and safeguards. Development of a long-term program to address the approval and use of these and potentially other alternative technologies on a permanent basis would commence after the interim program is underway. It will be necessary to have in place by the end of the interim period, institutional/government arrangements that will ensure adequate long-term maintenance and monitoring of alternative technologies if permits to build on lots of less than 3.2 acres using these technologies are to be issued on a continuing basis.

This report summarizes the Committee's activities and findings, and presents its recommendations for an interim program and next steps.

B. Background

The high quality of the surface and ground water resources in the Pinelands is one of the defining characteristics of the region, and a major impetus behind the creation of the Pinelands National Reserve. Both the Federal and New Jersey Pinelands statutes call for the preservation, protection and enhancement of the significant values of the land and water resources of the Pinelands and its unique ecosystem. Water resources in the Pinelands are protected by a combination of land use and water quality programs established by the Pinelands Comprehensive Management Plan. The land use program discourages development in important ecological and agricultural areas while directing growth towards more suitable areas. Some of the designated development areas are served by central sewer systems, but others are not. In these unsewered areas, municipalities may zone for residential development on lots as small as 1 acre. One acre lots are also permitted in non-growth areas if certain conditions are met (e.g., grandfathered lots and cultural housing).

The CMP's water quality program is aimed at controlling the amount of nitrogen that enters the environment both because nitrate in itself is a significant pollutant, but also because it serves as an indicator of changes in overall water quality. This goal is accomplished by limiting the concentration of nitrogen in wastewater to 2 mg/l at the property line. Lot size is calculated by use of the Pinelands Septic Dilution Model using standard assumptions specified in the CMP (and listed in Appendix 1) and information on the type of on-site wastewater disposal system used. The Model calculates that a standard septic system, to which no nitrogen removal is attributed, requires at least a 3.2 acre lot to dilute the concentration of nitrogen to 2 mg/l at the property line. If the nitrogen concentration of the wastewater exiting the system is lowered through use of a different type of on-site wastewater treatment system, a smaller, minimum 1 acre lot size lot size is permitted as shown in the table below.

Septic System Nitrogen Removal Rate	Assumed Effluent Nitrogen Concentration After Treatment (mg/l)	Lot Area to Meet 2 mg/l Standard
0%	40 mg/l	3.2 acres
20%	32 mg/l	2.5 acres
35%	26 mg/l	2.0 acres
50%	20 mg/l	1.5 acres
65%	14 mg/l	1.0 acres

Therefore, a home with a lot size of 1 acre requires an effluent concentration (i.e., measured after treatment by a nitrogen-reducing technology, but before dispersal to a drainfield) from any on-site wastewater disposal system of 14 mg/l in order to meet 2 mg/l at the property line as calculated by the Pinelands Septic Dilution Model. A larger lot will allow for higher levels of nitrogen effluent to meet the calculated standard.

Under current CMP regulations, the Commission has approved municipal ordinances that allow lots between 1 and 3.2 acres in size to be developed only if one of two alternative on-site wastewater disposal systems are used to reduce the amount of nitrogen: pressure dosing and RUCK. Field studies undertaken by the Pinelands Commission over the past decade, however, found that the RUCK system was prone to installation and operational failures, and that even functioning systems require a minimum lot size of roughly 1.5 acres to meet the Pinelands nitrogen standard. Another study found that Commission-approved pressure dosed systems, which are now the most common alternative system used on smaller lots, do not remove nitrogen to any greater extent than standard septic systems. The CMP does permit other types of systems to be used on smaller lots provided they pass certain threshold tests. To date, no other system has been authorized.

If 1 acre lots are to continue to be developed in unsewered development areas, other, more effective alternative technologies will need to be approved for use. Recent demonstration projects conducted across the nation have indicated that such technologies may exist. The Ad Hoc Committee on Alternative Septic Systems was formed by the Pinelands Commission in March 2000 to study and assess alternative technologies with nitrogen-reducing capabilities, and if appropriate, to develop a recommended regulatory framework that ensures their long-term performance. This report summarizes the Committee's activities, findings, and recommendations. Members of the Committee and their affiliations are:

S. Joseph Kowalski, Chairman	Pinelands Commission
Candace McKee Ashmun	Pinelands Commission
Sally Dudley	Pinelands Commission
Linda M. Eckenhoff	Pinelands Commission
Theodore Gordon	Pinelands Commission
Jay Edward Mounier	Pinelands Commission
Norman F. Tomasello	Pinelands Commission
Edward McGlinchey	Pinelands Municipal Council
Lee Rosenson	Pinelands Preservation Alliance
John Sheridan	New Jersey Builders Association

Representatives from the New Jersey Department of Environmental Protection's Bureau of Nonpoint Pollution Control also actively participated in meetings of the Committee and provided information on current septic system requirements and new initiatives under consideration.

All meetings of the Ad Hoc Committee were advertised in local newspapers and open to the public. Meeting minutes and other information pertaining to the Ad Hoc Committee have been made available on the Commission's web site at www.state.nj.us/pinelands.

C. Summary of Committee Activities

To brief Committee members on pertinent details, John Stokes, the Commission's Assistant Director, prepared a memorandum in April 2000 that highlighted: 1) the regulatory history of alternative on-site wastewater disposal system use in the Pinelands, 2) types of technologies in use elsewhere and preliminary indications of their performance, 3) the regulatory programs of other states, and 4) potential operation, maintenance, and performance issues (a copy of the memo is available on the Commission's web site). During the next several months, the Committee:

C Met with state and county regulatory personnel in Maryland, Massachusetts, Rhode Island, and

Pennsylvania to review their regulatory provisions, what technologies are approved, and their experiences with these technologies.

- Held a videoconference with researchers at the University of Rhode Island on results of technology performance testing, the University's Wastewater Training Center, and local initiatives to manage on-site systems.

- Discussed the current structure for reviewing septic system permits and issues pertaining to review of alternative technologies with county Health Department representatives.

- Consulted with the New Jersey Department of Environmental Protection (DEP) on development of new requirements for approval of alternative technologies on a statewide basis and their relationship to issues before the Committee.

To support the Committee in its fact-finding and decision-making, Commission staff prepared or compiled a variety of background materials throughout the course of the project. These materials were distributed to Committee members for review prior to each meeting.

To better focus their efforts, the Committee selected a few technologies for a more detailed examination, beginning with those that had been approved for use in other states. Based on these considerations, the Committee selected the following three technologies: AWT Environmental's Bioclere trickling filter, the Bio-Microbics FAST system, and the Cromaglass sequencing batch reactor. The Committee then contracted with a consultant, Dr. Anish Jantrania, P.E., to evaluate available test results and determine what nitrogen discharge level could be attributed to each of the systems. In addition to the three technologies selected by the Committee, Dr. Jantrania expanded his review to include the Amphidrome sequencing batch reactor and Ashco's RFS III system, a proprietary recirculating sand filter design (detailed descriptions of all five technologies examined by the Committee are contained on pages 10-16 of Appendix 2)[1]. Dr. Jantrania presented his findings to the Committee at their meeting on December 18, 2000. The Committee also met with vendors of four of the technologies (Amphidrome, Bioclere, Cromaglass, and FAST) and obtained information on system functioning, track records, and cost.

As a companion piece to Dr. Jantrania's report, Commission staff prepared a matrix of responses to a questionnaire completed by the vendors on technology characteristics, including complexity, cost, operation and maintenance requirements, and other features. Based on the difficulty in developing reliable, comparable cost estimates, Committee members recommended seeking the services of a cost estimating expert. A solicitation was released on February 22, 2001, and a contract was awarded to Pio Lombardo, P.E in May 2001. When completed, the findings from this study will be shared with the Commission as it considers next steps.

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[1] For convenience, the systems examined by the Committee will be referred to as Amphidrome, Bioclere, Cromaglass, FAST, and Ashco RFS III in the remainder of this report.

D. Findings

Based on the activities outlined above, Committee members gained a better understanding of the regulatory and technical issues associated with use of alternative technologies in the Pinelands. Key findings that helped shape the deliberations and recommendations of the Committee are summarized below.

D.1 Regulatory Findings

Committee members examined current requirements governing septic system review and approval in New Jersey, plans for a new statewide program to approve alternative technologies, and programs of other states that have already approved the use of alternative technologies. Several Committee meetings were devoted to discussions with representatives from county and state agencies concerning their authorities and procedures, and experience and ideas on specific issues. Additional information was obtained from other organizations working with alternative technologies, including inter-state efforts, industry groups, and the United States Environmental Protection Agency.

Municipal/County Relationships

- Municipal Boards of Health typically contract with counties to provide centralized public health services, including review and approval of plans for standard septic systems. Local Boards of Health, however, are ultimately responsible for enforcement. Some exceptions to this arrangement exist.

- Final approval of alternative technologies (specifically, non-standard components of alternative on-site wastewater disposal systems) is performed by DEP, with counties responsible for review and approval of standard components of septic systems.

- Counties differ in their requirements for on-site inspections and required certifications to ensure proper installation.

NJ DEP Requirements

- Chapter 9A of NJ DEP's regulations currently governs design and construction of individual septic systems. Chapter 9A does not, however, apply to systems that use technology not specifically authorized in the regulations, when "treatment" of wastewater is intended, or if a system handles more than 2,000 gallons of effluent a day. In all of these cases, individual Treatment Works Approvals must be obtained directly from DEP. Systems handling more than 2000 gpd also require a NJPDES permit, which typically specifies requirements for monitoring.

- DEP currently requires that a licensed professional engineer design a system and (in lieu of certification by the administrative authority) certify that its location, construction, and installation are in compliance with DEP requirements and the approved engineering design.

- NJ DEP is in the process of revising its regulations to allow for generic approvals of specific types of alternative technologies on a statewide basis. The Pinelands Commission participates in a committee established by DEP to develop their regulations, and DEP representatives have actively participated in meetings of the Commission's Ad Hoc Committee. Broad areas of cooperation and understanding to guide the two agencies in their respective rulemaking processes were outlined in a letter to NJ DEP from the Commission (see Appendix 3). Based on this understanding, any technology that can function hydraulically as a standard septic system if a component fails will not require a treatment works approval from DEP, and other technologies determined to be suitable for use in the Pinelands will be permitted under generic treatment works approvals (instead of a case-by-case review) until DEP's revised regulations are promulgated. DEP has indicated that the technologies examined by the Committee would likely qualify for either of these review processes.

- Certain issues can only be addressed by DEP through a change in its regulations. For example, DEP has given preliminary indication that smaller drainfields will be permitted for use in conjunction with certain alternative technologies, but the specific design requirements must await DEP's new regulations. The unique soil and the nature of household water supplies may influence drainfield size in the Pinelands.

- NJ DEP is a participant in a multi-state cooperative effort to review and approve alternative technologies that would foster reciprocity of approvals between states. Once functional, this system should facilitate any review process developed to approve technologies for use in the Pinelands.

- NJ DEP is a partner with the New Jersey Corporation for Advanced Technology (NJCAT), a public/private venture which will likely be used to help verify the performance claims of alternative technologies submitted for statewide approval. Similar to the interstate review effort noted above, verification information from NJCAT will be helpful in determining whether technologies should be approved for use in the Pinelands.

- Three rules currently under development could encourage the use of community systems (i.e., one or more treatment units serving multiple homes) for residential development - watershed management, stormwater planning and management, and municipal stormwater.

Regulations in Other States

- Alternative technologies have been approved for use in other states. Among the provisions in the regulations of other states examined by the Committee are:

  Florida Department of Health regulations for the Florida Keys require a specific nitrogen discharge standard of 10 mg/l, in addition to standards for biochemical oxygen demand, suspended solids and phosphorus. Once installed, each system must be monitored at least once a year to ensure that the effluent meets the 10 mg/l nitrogen standard (and other standards). Florida does not have an approved list of technologies, but among the systems frequently approved is the FAST system.

The Pennsylvania Department of Environmental Protection's regulations for nitrogen sensitive areas require that sewage effluent nitrogen concentrations must not exceed 10 mg/l. Pennsylvania's regulations approve the use of FAST and Cromaglass.

Massachusett's nitrogen sensitive areas have a 5 mg/l nitrogen limit at the lot line. This is significantly less stringent than the CMP. The systems that the Ad Hoc Committee is evaluating can be used in Massachusetts on lots less than 1 acre in size. Bioclere and FAST have provisional approval (i.e., the last step before full approval); Amphidrome and Cromaglass have piloting approval (an interim form of approval to ensure compliance).
Rhode Island has regulations similar to Massachusetts, and to date, has given provisional approval to FAST.

Other Initiatives

C Committee members were also briefed on initiatives underway at other organizations and agencies, including:

The National Small Flows Clearinghouse (NSFC) receives funding from the United States Environmental Protection Agency (EPA) to provide information on innovative wastewater systems for small communities. NSFC manages the National On-Site Demonstration Program, involving the evaluation of alternative technologies and management systems nationwide.
The National Sanitation Foundation, in partnership with EPA's Environmental Technology Verification Program, has developed a draft protocol for the verification of residential wastewater treatment technologies for nutrient reduction. The protocol is intended to provide a framework for independent, standardized performance evaluations of alternative technologies.
The EPA recently issued Draft Guidelines for the Management of Onsite/Decentralized Wastewater Systems that features a tiered system of model management programs designed to address different environmental and technological considerations. EPA also provides funding and technical support to a number of other alternative technology initiatives, including those noted above.

D.2 Technical Findings

Technical information was compiled from a number of sources, beginning with the on-site demonstration programs being conducted across the country. This preliminary information was used to develop the background report distributed to Committee members in April and the subsequent selection of specific technologies for further consideration. The Committee then received more detailed information from a consultant hired to review the selected technologies and technology vendors. Commission staff also contacted additional sources, including the University of Wisconsin, for information on mound systems.

Consultant's Report

The basis for the Committee's key technical findings is the report prepared by a consultant, Dr. Anish Jantrania, P.E., for the Committee (see Appendix 2 for a copy of the report). Dr. Jantrania analyzed available data for each of the technologies under consideration to determine what nitrogen discharge level should be attributed to each type of system. Data were obtained by contacting the manufacturers of each technology and various states that have compiled performance data. Dr. Jantrania also reviewed the technical basis underlying each technology to ensure that the design is based on sound scientific and engineering principles.

Following a statistical method detailed in his report, Dr. Jantrania compared the data for the technologies against the critical effluent levels of 14, 20, and 26 mg/l, which are the concentrations needed to satisfy Pinelands' requirements for 1-acre, 1 ½ acre, and 2 acre lots, respectively. Based on his professional judgment and the results of this analysis, Dr. Jantrania concluded that the systems use proven scientific and engineering principles to treat wastewater, and that the following levels can be safely assigned to characterize operational performance in terms of the "likely concentration of nitrogen in the effluent":

Technology	**Expected Effluent Concentration**
FAST	14 mg/l (1 acre lot)
Cromaglass	14 mg/l (1 acre lot)
Bioclere	14 mg/l (1 acre lot)
Amphidrome	14 mg/l (1 acre lot)
Ashco RFS III	20 mg/l (1½ acre lot)

Dr. Jantrania also noted that performance depends, to some degree, on the quality of the influent wastewater and recommended that, initially, three years of quarterly effluent sampling be conducted in the Pinelands to reconfirm the effluent levels ascertained by his analysis. A monitoring program would also address concerns over the relatively limited data used to judge effluent levels. He recommended that the analysis be made with the same statistical methods he used in his report.

Some additional comments and observations made by Dr. Jantrania include:

- "The principles of biological nitrogen reduction in wastewater are well studied and documented in engineering textbooks with recommended design standards for treatment systems."

- "An effluent discharge level of 10 to 15 mg/l of total nitrogen is realistic for these technologies" (statement during conference call with Dr. Jantrania, 12/18/00).

- "Overall, the operation and maintenance requirements for all these systems are not complex and are such that anyone with a basic understanding of wastewater treatment and adequate training can operate the system." However, Dr. Jantrania also noted that all these technologies use electro-magnetic devices such as pump(s), blower(s), and control systems to treat wastewater to a desired quality, and thus require a certain degree of professional supervision on an ongoing basis.

- If shallow depth (less than 18" from the ground surface) on-site effluent dispersal systems are permitted, Dr. Jantrania reported that: "This analysis suggests that there is a safety factor of almost 2 available in assigning the effluent discharge levels based on the performance data currently available for the selected technologies." It should be noted that this analysis assumes a high level of vegetative uptake with shallow effluent dispersal.

Vendor Survey

The results of the technical analysis reported by Dr. Jantrania were supplemented with additional information on system performance and characteristics compiled by Commission staff from a survey of technology vendors (see Appendix 4 for a summary of vendor responses). Commission staff also contacted the University of Wisconsin and a leading installer of septic systems in Wisconsin for similar information to characterize mounded systems. Findings of interest from the survey include:

- All of the technologies examined have been used in residential settings, both single family and multiple households, although one manufacturer (Cromaglass) indicated a preference for clustered residential settings. The vendors generally acknowledged that clustered settings offer advantages in terms of cost, maintenance, and management.

- Data on the frequency and cause of failures are limited, both in terms of failure to meet nitrogen removal requirements and general hydraulic malfunctions. Extensive incidence of hydraulic failure seems unlikely, however, since hundreds to thousands of each type of system have been installed over a period extending back two decades or more (with the exception of Amphidrome and Ashco RFS III, which are newer technologies).

- All vendors can provide trained personnel and/or training for installation and maintenance.

- All technologies offer a minimum 1-year warranty and recommend or require maintenance contracts, which vary in terms of duration, covered activities, and cost.

- Effluent sampling at the outlet of the alternative technologies is feasible and commonly performed for all technologies.

- Automatic dial-up capability can be added to each type of system to alert homeowners or others (e.g., maintenance provider, regulatory agency) of operational problems.

- Noise and odor should be virtually undetectable for all systems when operating properly. Visible components range from access covers to limited above-ground components and housing.

Although data on system costs were compiled as part of the survey (costs for alternative technologies were generally estimated to range from $1,100 less than a standard septic system to $10,000 more than a standard septic system), the Committee recommended that an outside consultant be retained to develop more accurate estimates of the costs to install, operate, and maintain these technologies in the Pinelands. A consultant, Pio Lombardo, P.E., was retained in May 2001 to develop these estimates for single family homes and cluster residential settings.

E. Recommendations

Based on its findings, the Committee concludes that alternative technologies exist that can be expected to meet the CMP's water quality standards on 1 to 3 acre single family residential lots as provided in a Pinelands Commission approved local land use ordinance. To be certain that these technologies work in the New Jersey Pinelands, the Committee recommends that periodic testing be conducted as recommended by Dr. Jantrania. The specifics of the testing program will be developed by the Committee in consultation with DEP. Consequently, the Committee concludes that the Pinelands Commission should no longer permit the use of the Commission-approved pressure doing system for nitrogen reduction on lots between 1 and 3.2 acres in size when permitting for the alternative technologies commences. Pressure dosed systems or other systems using pumps could continue to be used in the Pinelands for non-nitrogen reduction purposes. The Committee recommends that the Commission establish an interim program to authorize the use of the five alternative technologies examined by the Committee and others that may be found to meet equally high standards. The interim program (at least three years in duration) will: enable effluent data to be monitored; allow the Commission to develop a long-term program consistent with upcoming DEP rules on the use of alternative technologies, and; ensure that the governmental/institutional framework is in place.

The Committee's specific recommendations are presented below.

RECOMMENDED STRATEGIES FOR AN INTERIM DECENTRALIZED WASTEWATER MANAGEMENT PROGRAM

Strategy	Comments
PROGRAM STRUCTURE	
1. The interim program should be designed to remain in place for at least a three-year period while a long-term approach that is coordinated with DEP on-site rules and watershed management policies is developed.	Responsibilities may change between the interim and long-term programs. The interim rule will indicate that a long-term program will follow if performance evaluation results for the five technologies examined by the Committee or any other promising technologies justify such a program.
2. Seek funding to hire a wastewater management coordinator.	A proposal was submitted to DEP and is still under review. A coordinator would allow the Commission to assume more responsibilities and ensure that the interim program is successfully implemented.

Strategy	Comments

TECHNOLOGY APPROVALS

3. Authorize the five technologies examined by the Ad Hoc Committee (Amphidrome, Ashco RFS III, Bioclere, Cromaglass, and FAST) for use in the Pinelands during the interim program, pending submittal of final information (e.g., detailed design and specifications). All the systems, except Ashco RFS III, would be approved for single family residential lots containing at least one acre. The Ashco system would be approved for single family residential lots containing at least 1.5 acres. During the interim period, any additional technologies submitted for approval should be reviewed and evaluated for acceptability by using the CMP's current requirements. (See 7.50-6.84.) During the interim program, the current requirements should be reviewed for whatever modifications might be deemed appropriate.

The consultant's report provides the technical basis for selecting the five technologies. Review and approval of additional technologies will be accomplished to the extent possible with assistance from DEP and the New Jersey Corporation for Advanced Technology. Knowledge gained from the monitoring of the approved technologies and the procedures DEP develops will provide guidance as to what modifications should be made to the CMP requirements, 7:50-6.84, for the long-term program.

4. Amend the Pinelands regulations to authorize the use of the selected systems during the interim program for residential and similar uses specified in the technology approval. Use of these systems for facilities similar to residential uses (e.g., group homes, assisted living facilities) would be allowed on a case-by-case basis provided that the use is otherwise permited by the CMP, obtains all applicable DEP permits, and that these permits require compliance with the CMP's 2 ppm nitrogen standard.

Under the interim program, vendors could define other uses similar to residential uses where such systems have been proven to work, subject to Commission review and approval. Insufficient information is available to justify amending the regulations to specifically allow these systems to be used for other non-residential (e.g., commercial, restaurants) uses. These applications require additional analysis and would require DEP approval if proposed as treatment systems.

5. Revise current CMP requirements for the use of the originally approved RUCK system to require that newly installed systems be subject to the same operation and maintenance safeguards that will apply to all approved alternative technologies.

The current rules were adopted following the Commission's RUCK system study. The originally approved RUCK system will continue to be permitted; however, it will be subjected to the same operation and maintenance safeguards as new systems. It should be noted that no RUCK systems have been installed for a considerable number of years, and new installations of the originally approved RUCK system are unlikely due to subsequent design

Strategy	Comments
	modifications. More recent RUCK designs (e.g., EcoRuck) will need to be submitted to the Commission to determine whether they differ substantially enough from the originally approved system to warrant a separate review and approval. The extent to which design modifications should be accommodated by technology approvals will need to be addressed for all alternative systems.
6. Amend the Pinelands rules to eliminate the automatic use of pressure dosed septic systems on lots less than 3.2 acres in size and otherwise permitted by the CMP.	Pressure dosed systems or other systems using pumps could continue to be used in the Pinelands for non-nitrogen reduction purposes. Some type of grandfathering would permit the use of the Commission-approved pressure dosed systems for applications in progress. The timing of the elimination of the Commission's requirement for the use of pressure dosing systems would coincide with the authorization of the alternative technologies.
7. The rules need to address suspension of further approvals of a particular system during the interim program in a timely manner if persistent operation, maintenance or performance problems are discovered with that system.	The regulations should enable the Commission to take formal action to suspend authorization of any system during the interim program. Any suspension shall be for cause, including potential effects to the environment and public health and safety. The basis for suspension should ensure that sufficient data has been collected and analyzed, in consultation with the manufacturer, DEP, and other affected parties, to enable a determination for cause to be made. While action to formally suspend authorization of a system is pending, the regulations should enable the Pinelands Commission to take precautionary measures, including the temporary suspension of approvals for that system. The Attorney General's office should be consulted in developing the regulatory language relating to suspensions. The interim program also should call for an annual report from the Executive Director describing installation, maintenance, and performance data for each technology.

Strategy	Comments
8. Amend the Pinelands rules to facilitate municipalities permitting the use of community systems for multiple lots smaller than 3.2 acres in Regional Growth Areas, Towns, and Villages as long as overall zone densities and the CMP's water quality standards are met.	Community systems serving multiple houses will more likely meet the 2 ppm nitrogen standard than 6 individual systems on individual lots. Further work with DEP and other affected entities is needed to identify the measures to facilitate and promote community systems, including the parties responsible for operating and maintaining community systems, and to tailor the program accordingly.
9. Pursue community systems with selected rural economic development program communities.	This recommendation does not require a regulatory change to implement.
CONDITIONS FOR THE USE OF SYSTEMS DURING INTERIM PROGRAM	
10. Each system shall be equipped with automatic dialing capability to the manufacturer, or its agent, in the event of malfunction. Periodic dialing or some other fail safe mechanism must be provided to ensure against unauthorized disconnections.	Malfunctions would also be reported to the Pinelands Commission.
11. Each system shall be designed and constructed so that samples of effluent leaving the alternative technology can be readily taken to confirm the performance of the technology.	Parameters to be sampled must be clearly established (see item 12 below).
12. The manufacturer or its agent shall be responsible for providing resources for the collection and analysis of effluent samples from each system or a representative number of systems on a periodic basis for a three-year period. Procedures will be established to ensure an objective process that will give the Commission confidence in its completeness and accuracy. These results will be reported to the Pinelands Commission.	The Commission will need to develop a sampling protocol in consultation with DEP to specify the data to be collected and the methods for collection. A three-year regulatory obligation for testing will be required. The frequency of testing will be developed in consultation with DEP. Nothing in the interim program should preclude monitoring after the initial three-year period.
13. In addition to DEP requirements for a licensed professional engineer, the manufacturer or its agent shall certify that installation has been properly completed.	This requirement is in addition to the current regulatory review conducted by local boards of health or the DEP.

Strategy	Comments
14. The manufacturer shall provide to each owner a complete operation and maintenance manual.	
15. Each system must be covered by a five- year warranty and a five-year maintenance contract.	A non-cancellable maintenance warranty/agreement will be required. Requirements for contract renewal beyond five years will be included in the interim program. The contract, as well as the other safeguards, would continue after the end of the monitoring period and regardless of any change of ownership.
OWNER OBLIGATIONS	
16. The owner shall record a property notice that: identifies the technology; acknowledges the owner's responsibility to operate and maintain it in accordance with the manual; and grants access to the local board of health, the Pinelands Commission and its agents for inspection or monitoring. Through deed restrictions and/or other controls, monitoring requirements would continue to apply to new owners if there is a change in ownership during the monitoring period.	The requirement must be implemented so that the presence of an alternative technology would be detected by a title search. Agents could include all government bodies.
17. The owner shall not be held liable for poor nitrogen removal performance if the system has been properly operated and maintained.	System performance and the response of vendors to performance issues will be evaluated during this interim program.
LOCAL GOVERNMENTS' RESPONSIBILITIES	
18. Systems shall be authorized only in those municipalities in which the local board of health and/or the municipality have adopted an ordinance that is in conformance with CMP requirements and reflects the owner's responsibilities.	The Committee may wish to require that all boards of health (municipal and county if relevant) adopt appropriate ordinances.
19. Boards of health shall continue to review septic system designs as they do now.	Standard components of septic systems will continue to be reviewed by boards of health in accordance with DEP requirements.

Strategy	Comments
	PINELANDS COMMISSION RESPONSIBILITIES
20. The Pinelands Commission will evaluate the monitoring data, and establish a database to track and assess installation, operation, maintenance and other important information.	Effluent data will be evaluated under the monitoring program. Since the assumptions used in the Pinelands Dilution Model are important in assessing adherence of all types of septic systems, including standard septic systems, to Pinelands water quality standards, the Commission should work with DEP, county and municipal governments, and other knowledgeable parties to determine how the assumptions for nitrogen concentration and wastewater flows can be reexamined.
21. The Pinelands Commission shall continue to work with DEP, municipalities and county health departments to develop an integrated, long term program.	A key element of any long term program is an institutional arrangement to ensure that new technologies are evaluated and that approved technologies are properly installed, operated and maintained over the long term.

F. Next Steps

If the Commission agrees with the recommendations presented in this report, the CMP Policy and Implementation Committee should be directed to proceed with rule development in accordance with the Commission's standard process for handling regulatory changes.

Other steps that need to be accomplished when rule development proceeds are:

1. Hire wastewater manager - DEP is reviewing a grant proposal submitted by the Commission in December 2000 as part of the Mullica Watershed planning project. The grant would fund a staff wastewater management position for two years to provide much needed help for rule development, management of the resulting program, and coordination with other alternative technology initiatives. Once final confirmation of funding is obtained, the Commission should immediately seek to fill the position. The primary focus of this position will be to insure the proper installation and maintenance of the approved systems, including:
    a. Developing and maintaining a database. This database would include application information, installation information, quarterly test results of effluent leaving the alternative technology, dial-up problem calls, and significant maintenance issues.
    b. Overseeing and insuring that new installations are inspected.
    c. Overseeing and insuring that the performance of the installed alternative technologies is monitored.
    d. Overseeing and insuring that QA/QC procedures are followed for monitoring data.

e. Evaluating the effectiveness of maintenance practices.
f. Researching and resolving remaining technical and regulatory issues that will affect the design and implementation of the program, such as identification and pursuit of treatment options for selected communities that participated in the Commission's rural economic development pilot program, researching institutional needs and arrangements, and coordinating with DEP on the development of their rules.
g. Working with municipalities and boards of health on all aspects of the program.
h. Reviewing and recommending approval or disapproval of all alternative technology applications.

2. Obtain more accurate cost estimates - As noted above, the Commission has hired a consultant to develop more realistic cost estimates for each of the alternative technologies under consideration. Estimates are being developed for systems in single family and cluster residential settings, and will take into account local conditions and operating costs over a 10-year period.

3. Hold public forums - Given the scope of the recommendations and the technical nature of the subject, rule development will be most successful if a dialogue is established with key interest groups, including municipalities, county boards of health, the design community, developers, the environmental community, and alternative system manufacturers, installers, and maintenance providers. While many interest groups have served on or interacted with the Committee, one or more public meetings should be held to obtain feedback on the recommendations and other key issues before rule development is substantially underway.

Finally, during the implementation of the interim program, the Pinelands Commission will begin work on development of a long-term program. Conditions of use implemented during the interim program shall be in effect until a long-term program for the evaluation, approval, installation, operation and maintenance of alternative on-site wastewater disposal systems is in place.

Appendix 1. Assumptions Used In Pinelands Septic Dilution Model
N.J.A.C. 7:50, Subchapter 6, Appendix A

The CMP requires a concentration of 2 mg/l total nitrogen at the lot line with a loading of:

- 3.5 persons/dwelling
- 11.2 grams of nitrogen produced by each person each day
- 262.5 gallons of wastewater produced per day (3.5 persons @ 75 gpd)
- Total concentration of nitrogen in wastewater prior to any treatment = 39.45 mg/l
- A-type soils are on site with 4.5% vegetal uptake

Appendix 2. Consultant's Report

Performance Expectations for Selected On-Site Wastewater Treatment Systems

PERFORMANCE EXPECTATIONS FOR SELECTED ON-SITE WASTEWATER TREATMENT SYSTEMS

<u>REPORT PREPARED FOR</u>

THE PINELANDS COMMISSION'S AD HOC COMMITTEE ON
ALTERNATIVE SEPTIC SYSTEMS
NEW JERSEY PINELANDS COMMISSION.

<u>REPORT PREPARED BY</u>

ANISH R. JANTRANIA, Ph.D., P.E., M.B.A.
ENVIRONMENTAL ENGINEERING CONSULTANT
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DECEMBER 2000

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ERRATA SHEET

February 26, 2001

Kim Beidler
The Pinelands Commission
PO Box 7
New Lisbon, NJ 08064

Dear Kim:

As you had pointed out earlier, two similar data points (10/6/97 and 10/6/98) are reported for BioMicrobics system operating at Coonamessett Inn, MA on the - Page C2 - of the report. I checked with the company about this and they reported to me that there was an error in their report for the Coonamessett Inn site and that the monitoring data point for 10/6/97 must be deleted. The company also faxed me a copy of their revised table for the Coonamesset Inn site with the remaining data points. I used this information to revise the statistical analysis for the BioMicrobics system. The overall impact of this revision is not significant and the recommendation for the discharge level for this system has not changed from the original value of 14 mg/l. However, the following correction needs to be made in the report -

- The total number of observations (Obs) considered for the statistical analysis changed from 71 to 70. This number is reported in the text on Page 6 and 10 as well as in Tables B-1 and B-2.

- The average effluent concentration (Mean) for BioMicrobics system changed from 15 mg/l to 16 mg/l. This number is reported in the text on Page iii and in Tables B-1 and B-2.

- The Z values in Tables B-1 and B-2 has changed slightely, however the new values did not change the results of the Hypothesis testing. I have revised these tables and attached them separately with this letter.

Once again, this error in data reporting has not changed the final recommendation for the discharge level for BioMicrobics system.

Please let me know if you have any questions about this correction or about any other information presented in the report.

Thank you.

Sincerely,

Anish R. Jantrania, Ph.D., P.E., M.B.A.
Environmental Engineering Consultant.

Attachement:Revised Table B-1 and B-2.

APPENDIX B

Table B-1

This table presents statistical information for each system and for the entire data set, as well as for the relevant data set. A Z- test and t- test are used to determine if the relevant data set is statistically different from the entire data set. If they are, then only the relevant data set is used for further analysis to assign an effluent discharge level of nitrogen to a system.

Dataset									*1.645*	*0.842*
	Obs	Mean	Median	Min	Max	StdDev	Variance	Vx	COR@95%	COR@80%
BioMicrobics-ALL	70	**16**	*11*	3	63	13	176	0.85	0.39	0.71
BioMicrobics-1	25	22	18	5	62	16	254	0.72	0.43	0.72
BioMicrobics%Red-ALL	52			33%	95%					
BioMicrobics%Red-1	21			46%	95%					
	Z =	-1.8715	for Z of +/-1.96, No statistical difference between means; use all data							
	Obs	Mean	Median	Min	Max	StdDev	Variance	Vx	COR@95%	COR@80%
Cromaglass-ALL	98	**8**	*5*	1	121	14	195	1.68	0.29	0.74
Cromaglass-1	13	9	7	3	23	7	45	0.74	0.42	0.71
Cromaglass%Red-ALL	36			70%	98%					
Cromaglass%Red-1	6			83%	95%					
	Z =	-0.32762	for Z of +/-1.96, No statistical difference between means; use all data							
	Obs	Mean	Median	Min	Max	StdDev	Variance	Vx	COR@95%	COR@80%
Bioclere-ALL	103	**14**	*10*	3	103	16	259	1.14	0.34	0.70
Bioclere-1	32	14	12	5	45	9	81	0.65	0.45	0.72
Bioclere%Red-ALL	76			*1%*	91%					
Bioclere%Red-1	23			*1%*	71%					
	Z =	0.100299	for Z of +/-1.96, No statistical difference between means; use all data							
	Obs	Mean	Median	Min	Max	StdDev	Variance	Vx	COR@95%	COR@80%
Amphidrome-ALL	186	17	13	1	80	15	235	0.89	0.38	0.70
Amphidrome-1	69	**12**	*10*	1	62	10	103	0.84	0.39	0.71
Amphidrome%Red-ALL	20			74%	99%					
Amphidrome%Red-1	0			NA	NA					
	Z =	*3.066586*	for Z of +/-1.96, Statistical difference between means; use only Single Home Data							
	Obs	Mean	Median	Min	Max	StdDev	Variance	Vx	COR@95%	COR@80%
Ashco-1	59	38	36	3	82	20	398	0.53	0.50	0.74
Ashco-1N	18	**21**	*15*	2.8	54	17	298	0.81	0.40	0.71
Ashco%Red-1				NA	NA					
Ashco%Red-N				NA	NA					
	Z =	*3.361797*	for Z of +/-1.96, Statistical difference between means; Nitrogen Reduction scheme is effective							

Note that "-ALL" means all the data, "-1" means data for systems used in single family home settings, and in the case of Ashco, "-1N" means data collected when the nitrogen reduction scheme was turned on.

Table B-2

Summary of Relevant Statistical Information

	Obs	Mean	Median	Min	Max	StdDev	Variance	Vx	% Red. Min	% Red. Max
A. BioMicrobics-ALL	70	16	11	3	63	13	176	0.85	33%	95%
B. Cromaglass-ALL	98	8	5	1	121	14	195	1.68	70%	98%
C. Bioclere-ALL	103	14	10	3	103	16	259	1.14	NA	91%
D. Amphidrome-1	69	12	10	1	62	10	103	0.84	NA	NA
E. Ashco-1N	18	21	15	3	54	17	298	0.81	NA	NA

Hypothesis Testing:

Ho: Sample Mean Less Than or Equal to Critical Effluent Limits

Ha: Sample Mean Greater Than Critical Effluent Limits

Critical Effluent Limits = 14 or 20 or 26 mg/l

Decision Rule for alpha = 0.05, one-tailed test:

If Z > 1.65, reject Ho ; or If t >1.74, reject Ho *Note that the critical values of Z and t are obtained from the standard normal tables.*

Use t-test for Ashco-1N since the sample size is less than 30; for the rest use Z test

Calculated Z or t Values: Z or t = (Mean - CriticalEffluentLimit) / ((StdDev/(Obs)^.5))

where CriticalEffluentLimit = 14, 20, or 26

	14	20	26
A. BioMicrobics-ALL	1.002	-2.780	-6.562
B. Cromaglass-ALL	-4.046	-8.304	-12.561
C. Bioclere-ALL	0.041	-3.742	-7.525
D. Amphidrome-1	-1.586	-6.490	-11.394
E. Ashco-1N	1.795	0.320	-1.156

Likely Concentration of Total Nitrogen in Effluent

	T-N mg/l
A. BioMicrobics-ALL	14
B. Cromaglass-ALL	14
C. Bioclere-ALL	14
D. Amphidrome-1	14
E. Ashco-1N	20

Critical Effluent Limits versus % of values equal to or less than as observed

	14	20	26
A. BioMicrobics-ALL	69%	79%	84%
B. Cromaglass-ALL	72%	81%	84%
C. Bioclere-ALL	80%	87%	90%
D. Amphidrome-1	67%	83%	90%
E. Ashco-1N	49%	61%	74%

Critical Removal Rates versus % of values equal to or less than as observed

	65%	50%	35%
A. BioMicrobics-ALL	77%	94%	97%
B. Cromaglass-ALL	100%	100%	100%
C. Bioclere-ALL	46%	59%	70%
D. Amphidrome-1	NA	NA	NA
E. Ashco-1N	NA	NA	NA

Assume 40 mg/l as influent value to determine Critical Removal Rates.

Note that the relevant data set for each technology is included in the following Table B-3. For BioMicrobics, Cromaglass, and Bioclere, this includes all the data, while for Amphidrome and Ashco, only part of the data were found to be relevant based on the statistical analysis for this evaluation.

TABLE OF CONTENTS

EXECUTIVE SUMMARY

The New Jersey Pinelands Commission's Ad Hoc Committee on Alternative Septic Systems is considering changes to the regulatory standards that govern septic system installation in the New Jersey Pinelands. The goal is to facilitate the use of alternative on-site wastewater treatment technologies (alternative to a conventional septic system) that reduce the levels of nitrogen in wastewater prior to discharge in an on-site non-point source disposal system. This of course is a commendable goal given the fact that on-site systems are now being considered as a true option to a centralized collection and treatment of wastewater management. However, a conventional septic tank (commonly used on-site treatment system) does not reduce nitrogen to a level sufficient enough to achieve water quality standards of 2 mg/l on smaller lot sizes typically needed for new developments. The Pinelands Comprehensive Management Plan contains details on the water quality standards, minimum standards for non-point source discharge systems (RUCK and pressure dosed septic systems), and the Septic Dilution Model. A number of pre-engineered on-site treatment technologies are now available for reducing nitrogen levels to a limit that will achieve the desired water quality standards when used with appropriate management infrastructure.

The Committee is considering a two-pronged approach to achieve its goal. One approach relies on an ongoing program to evaluate and approve on-site treatment technologies, coupled with a comprehensive program to ensure their proper installation, operation and maintenance over the long term. The second approach allows for the interim use of a few recognized technologies while the particulars of the comprehensive program are being developed. In pursuit of the second approach, the Committee has selected five on-site treatment technologies that may be authorized for use during the interim period depending on the results of a technical review of their performance data and technical design information. These five technologies are –

- BioMicrobics FAST System;
- Cromaglass System;
- AWT Bioclere System;
- Amphidrome System; and
- Ashco RFS III System.

The selected technologies are being considered as an alternative to a conventional septic system for single family homes and for larger scale systems in many parts of the country. Effluent quality data collected from various projects are available on nitrogen concentration for these technologies. The goal of the technical review is to evaluate the test results and determine what nitrogen discharge level should be attributed to each of the systems. The Pinelands regulations effectively permit a single family home to be developed on a one acre lot if the discharged effluent has a nitrogen concentration less than 14 mg/l. A discharge concentration of 20 mg/l will require 1½ acre lot and 26 mg/l will require a two acre lot for a single family home. Thus, based on the nitrogen discharge level assigned to a technology, its use for a single family home system will be limited to a certain lot size.

The principles of biological nitrogen reduction in wastewater are well studied and documented in engineering textbooks with recommended design standards for treatment systems. Basically, nitrogen in wastewater can be reduced using an on-site treatment system if the nitrification and denitrification can be achieved during the treatment cycle. Aerobic conditions (a dissolved oxygen concentration of at least 2 mg/l) and adequate pH must be maintained along with a few other requirements to achieve nitrification, while anoxic conditions and an adequate supply of carbon must be present to achieve denitrification. The technologies reviewed for this project use different mechanisms for maintaining aerobic conditions in their treatment system, including use of blowers, submersible pumps with venturi aspirators, and biological aeration. All these methods appeared to be adequate for maintaining a dissolved oxygen concentration of at least 2 mg/l that is necessary for nitrification.

Nitrified effluent is typically recycled through the primary tank of the treatment system where anoxic conditions and a carbon source necessary for denitrification are available. Once again, the technologies reviewed for this project appear to have adequate mechanisms employed in their treatment scheme to achieve denitrification. Addition of a carbon source for denitrification and alkalinity for nitrification when/if necessary can be incorporated with any of the five technologies. It is important to note that all the selected technologies use biological principles for nitrogen removal and thus their performance is sensitive to the quality of incoming wastewater. Also, the electro-magnetic components such as blower, pumps, and controls must operate adequately to achieve the necessary reduction in nitrogen levels on an ongoing basis. Thus, appropriate operation, maintenance, and inspection are a must to ensure the necessary performance of these technologies. The selected technologies are not difficult to operate and maintain, and anyone with basic understanding of wastewater systems and training by the manufacturers can perform the necessary tasks to operate the technologies.

Available performance data, mainly the effluent nitrogen levels, for each technology were analyzed using statistical methods and hypothesis testing, to determine the likely concentration of total nitrogen in the effluent. The purpose of this review is not to compare the technologies and so no such effort is made. Each system is reviewed independent of the other. The planned use for the technologies is for individual homes. However, the performance data available for each technology includes data from cluster or community systems that treat wastewater collected from a group of homes (rather than individual homes) and from commercial systems. In order to determine which data set should be used for a technology to determine the "likely effluent nitrogen concentration", the following approach was implemented:

A data set containing data from all the systems (single home, cluster/community, commercial) is compared for each technology to a data set containing data only from single home systems for that technology to determine if the difference between the data sets is statistically significant. If the data sets are statistically not different, i.e., there is no statistical difference between the means of the data sets, then the entire data set is used for determining the "likely effluent nitrogen concentration" for that technology. But, if the data sets are statistically different, then only the data set containing data from single family home systems is used for determining the "likely effluent nitrogen concentration" for that technology. Statistical parameters such as number of observations, mean, standard deviation, and variance were used to determine the appropriate data set for each technology, and finally, to compare the observed mean concentration with the critical effluent levels. Critical effluent levels are 14, 20, and 26 mg/l. When a null hypothesis comparing the mean concentration for a technology with a critical value is accepted, that critical value is assigned as the nitrogen discharge level for that technology.

Based on the above-mentioned method for data evaluation and the performance data available for each technology, the following levels are assigned for the "likely concentration of nitrogen in the effluent":

- BioMicrobics FAST System 14 mg/l;
- Cromaglass System 14 mg/l;
- AWT Bioclere System 14 mg/l;
- Amphidrome System 14 mg/l;
- Ashco RFS III system 20 mg/l.

These assigned values are developed based on the statistical analysis of the available performance data. The values are comparable to the performance claims typically made by the manufacturers of the technologies. The technologies are "designed" to reduce total nitrogen by more than 70% of the influent levels or to less than 10 mg/l of nitrogen in the effluent. The performance data for each technology do indicate the minimum concentration for each technology to be less than 5 mg/l and removal rates of more than 90%. The average effluent concentration was 15 mg/l for the BioMicrobics FAST System, 8 mg/l for the Cromaglass System, 14 mg/l for the AWT Bioclere System, 12 mg/l for the Amphidrome System, and 21 mg/l for the Ashco RFS III System. Based on the average concentration, it appears that the effluent from a Cromaglass System would produce the least concentration of total nitrogen, however, such a conclusion cannot be supported statistically or technically. Thus, based on the consultant's professional judgment and the technical evaluation of the technologies, the above-mentioned values are the "likely nitrogen concentration of effluent leaving each of the systems" when the systems are used for individual home on-site treatment purposes.

The effluent concentration values assigned to each technology in this first step must be reconfirmed based on the actual effluent quality data collected from the Pinelands area and the statistical methods used for determining the initial values. The effluent nitrogen concentration depends not only on the on-site treatment technology, but also to some degree on the quality of influent wastewater. Also, ongoing monitoring of effluent quality at a certain optimum frequency is the key to making sure that the desired effluent quality is maintained from any on-site treatment system on a continuous basis. Thus, it is recommended that initial application of these on-site treatment technologies in the Pinelands requires three years of quarterly effluent sampling to reconfirm the above-mentioned effluent levels. After the three years of quarterly sampling, the frequency may be reduced to annual or semi-annual sampling mainly to reduce the operating cost.

INTRODUCTION

The Pinelands Commission's Ad Hoc Committee on Alternative Septic Systems is considering changes to the regulatory standards that govern septic system installation in the New Jersey Pinelands. The Pinelands is over one million acres of pine oak forests, spacious farms, cross-road hamlets, and small towns stretched across southern New Jersey. The goal of the Committee is to facilitate the use of alternative on-site wastewater treatment technologies in the Pinelands that reduce the levels of nitrogen in wastewater prior to disposal. The Committee is considering the following two approaches to achieve this goal:

- Rely on an ongoing program to evaluate and approve technologies, coupled with a comprehensive program to ensure proper installation, operation, and maintenance of the systems on a permanent basis;
- Allow for the interim use of a few recognized technologies while the particulars of the comprehensive program are being developed.

In pursuit of the second goal, i.e., allow the use of a few recognized technologies, the Committee has selected five alternative on-site treatment systems that may be authorized for use during the interim period. The selected technologies include the following:

- BioMicrobics Fixed Activated Sludge Treatment (FAST) system;
- Cromaglass Sequencing Batch Reactor (SBR) system;
- Bioclere Trickling Filter (TF) system;
- Amphidrome Biologically Aerated Filter (BAF) system; and
- Ashco Rock Filter Storage (RFS III) system.

All of these systems (and the concepts used for operating the systems) are pre-engineered and pre-packaged, and are proprietary technologies with registered trademarks or names. Information used in this report for these systems was obtained from these companies with their permission to analyze it for this project. The names used do not include references to Trade Mark (™) or Registered Trade Mark (®) or any such symbols for simplicity.

Total nitrogen concentration in the effluent prior to disposal in an on-site disposal system is to be considered as a factor mainly in determining the lot size for single family homes. The Pinelands Septic Dilution Model as described in the Pinelands Comprehensive Management Plan (Reference 1) has been used to relate the effluent concentration of total nitrogen and the required dilution area to ensure that the concentration of total nitrogen in the recharge water remains less than 2 mg/l. This model assumes 75 gallons per day per capita flow rate, 3.5 capita per home, 20 inches per acre rain for dilution, and 4.5% or 9% plant uptake of nitrogen. The model calculates that if the treated effluent has a nitrogen concentration of less than 14 mg/l, then a single family home can be developed on a 1 acre lot; while an effluent concentration of 20 mg/l will require a 1½ acre lot, and 26 mg/l will require a 2 acre lot. This relationship between the effluent concentration and the lot size can also be established using a model developed by Hantzsche and Finnemore (Reference 2) and the parameters listed in the Pinelands Comprehensive Management Plan. More discussion on the nitrogen model and the relationship between the effluent nitrogen and groundwater nitrogen for three housing densities (1, 1½, and 2 acres per home) is included in Appendix A.

Nitrogen in Wastewater

Because nitrogen can have adverse impacts on the quality of ground and/or surface water, the discharge of nitrogen in the effluent (treated wastewater) needs to be controlled. Nitrogen in wastewater may be present in various forms - e.g., organic, ammonia, nitrites, or nitrates - and the proportions of these forms change with the level of treatment. In order to account for all the nitrogen present in the effluent, the total nitrogen concentration must be considered for conducting mass-balance analysis. Total nitrogen is the sum of organic nitrogen, ammonium and ammonia nitrogen, and nitrite and nitrate nitrogen. The sum of organic nitrogen and ammonium and ammonia nitrogen is known as Total Kjeldahl Nitrogen (TKN). Thus, the total nitrogen (TN) = TKN + Nitrite-N + Nitrate-N.

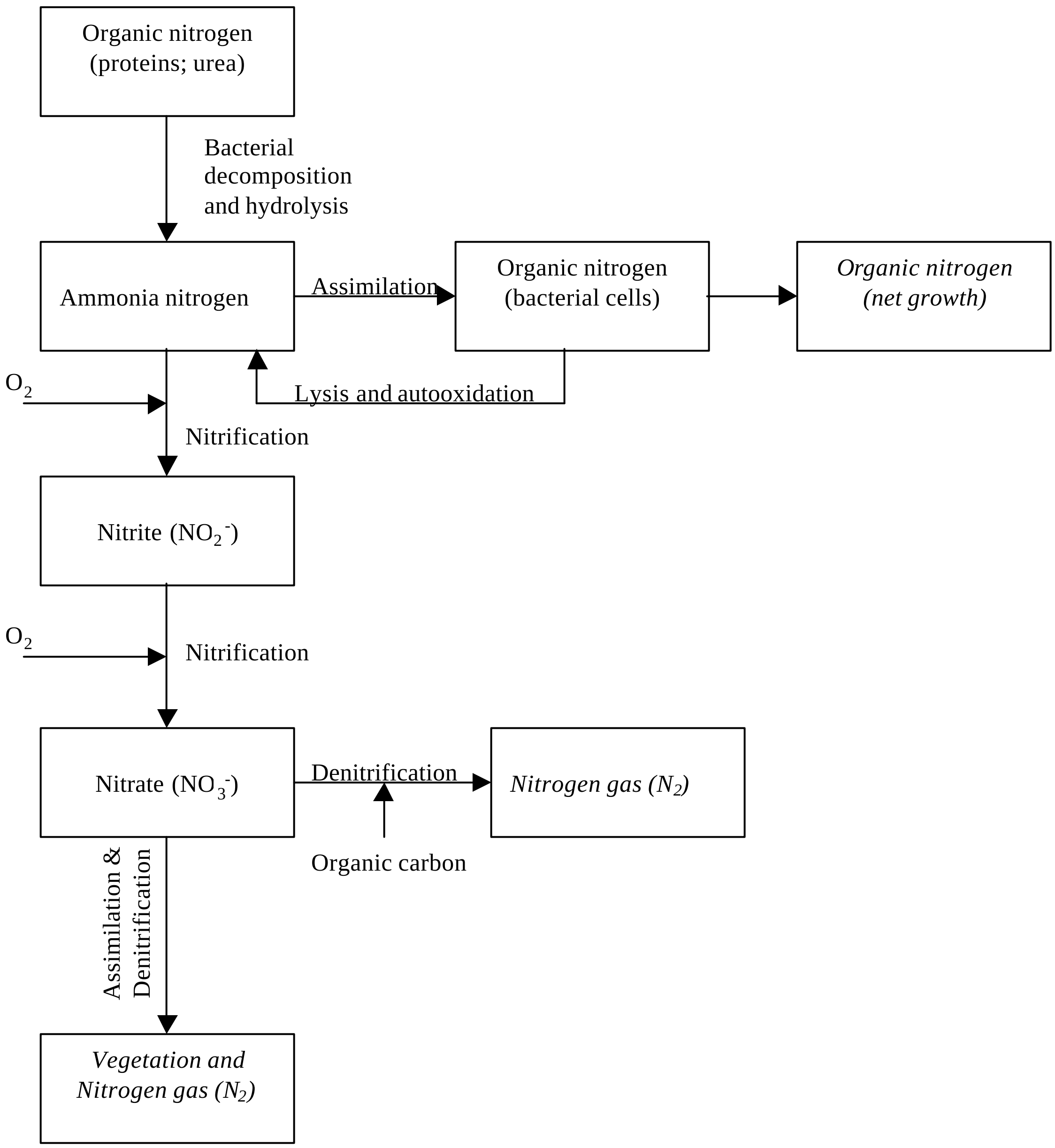
Reduction in total nitrogen in an on-site wastewater system can occur in a treatment system as well as in a disposal system. Figure 1 shows the transformation of various forms of nitrogen in an on-site treatment and disposal system. In the on-site treatment system, reduction in total nitrogen occurs by two principal mechanisms: by assimilation of nitrogen into cell mass and by denitrification of nitrate nitrogen into nitrogen gas. In the on-site disposal system, nitrogen can be removed by assimilation into plants and by denitrification of nitrate nitrogen into nitrogen gas. Nitrogen removal in the treatment system can be achieved on a more predictable and reliable basis than that in the disposal system. Thus, the emphasis is put more on the treatment systems' ability to remove nitrogen than on the disposal system. The following discussion on biological nitrogen removal is taken from the book "Small and Decentralized Wastewater Management Systems" by Crites and Tchobanoglous (Reference 3).

Biological Nitrogen Removal

Nitrogen serves as a nutrient for microorganisms in any biological treatment process. Thus, microorganisms in the treatment process will assimilate ammonia nitrogen and incorporate it into cell mass. The nitrogen assimilated in the cell mass can be removed from the treatment system by removing cells (sludge) from the treatment system. However, in most wastewater, total nitrogen content is typically more than what may be assimilated into sludge. Nitrification and denitrification are important processes in which the removal of nitrogen is achieved in two conversion steps. In the first step, ammonia nitrogen is oxidized biologically to nitrate nitrogen, and in the second step, nitrate is reduced to nitrogen gas, which is vented from the treatment system. Thus, the goal of an on-site treatment system that is designed for nitrogen reduction is to develop and maintain appropriate conditions during the treatment processes necessary for both of these steps to occur in an efficient manner.

The first step in the nitrogen removal process is biological nitrification, in which ammonia is oxidized in two stages: first to nitrite and then to nitrate. Aerobic conditions are necessary for achieving nitrification. The end results of this process is the conversion of ammonia to nitrate and assimilation of ammonia into cell mass. Nitrifying bacteria are sensitive organisms and extremely susceptible to a wide range of inhibitors.

Figure 1: Transformation of various forms of nitrogen in an on-site treatment and disposal system as adapted from "Small and Decentralized Wastewater Management Systems" (Reference 3) with minor modifications.



The factors affecting the nitrification process include: concentration of ammonia and nitrite, the ratio of biological oxygen demand (BOD_5) and TKN, dissolved oxygen concentration, temperature, and pH. A variety of organic and inorganic compounds such as ammonia and nitrous acid can limit the rate of nitrification. Dissolved oxygen concentration above 1 mg/l and pH between 7.5 and 8.6 in the treatment system are necessary for nitrification to occur. An on-site treatment system can be designed to maintain the necessary conditions to achieve adequate nitrification. Note that the organic and ammonia nitrogen that is not assimilated by the cells cannot be removed by the denitrification process without first going through the nitrification process and getting converted into nitrate. Thus, nitrification is the critical step in the overall reduction of total nitrogen. Theoretically, conversion of each milligram of ammonia nitrogen requires 3.96 milligram of oxygen, 7.01 milligram of alkalinity, and 0.16 milligram of inorganic carbon. The nitrification process can occur in either suspended-growth or attached-growth systems. The on-site treatment systems considered for evaluation in this project use both of these concepts and their designs appear to be adequate for achieving a high degree of nitrification.

The second step in the nitrogen removal process is the biochemical denitrification of nitrate to nitrogen gas. The principal biochemical pathways are modified aerobic pathways in which nitrate serves as the electron acceptor. Thus, it is essential to maintain anoxic conditions (no oxygen) in a part of the treatment system to allow denitrifying bacteria to convert nitrate to nitrogen gas. Denitrifying bacteria obtain energy for growth from the conversion of nitrate to nitrogen gas, but require a source of carbon for cell synthesis. Typically, during the nitrification process (the first step), most of the carbonaceous matter is removed, thus an external source of carbon is often required for denitrification. However, the incoming wastewater that has not gone through the nitrification step and/or cell mass can provide the needed carbon source for denitrification, and this concept has been used for operating an on-site treatment system. The factors affecting the denitrification process include: concentration of nitrate, concentration of carbon, dissolved oxygen concentration, temperature, and pH. It has been observed that the rate of denitrification depends primarily on the concentration and nature of the carbon source. As with the nitrification, the denitrification process can occur either in a suspended growth or attached growth systems. The on-site treatment systems considered for evaluation in this project appear to be adequate for achieving denitrification when operated such that an adequate carbon source is available and anoxic conditions are maintained. All the systems except the Ashco filter have the ability to add a carbon source externally if necessary, while the Ashco filter strictly depends on the incoming wastewater for carbon.

Because of the high cost of most organic carbon sources and operational complexity, it is desirable to operate an on-site treatment system for single family homes such that the carbon oxidation (removal of BOD_5), nitrification, and denitrification processes are combined into a single process. Advantages of such a single-stage process include: reduction in the volume of air needed to achieve nitrification and BOD_5 removal, elimination of the need for a supplemental organic carbon source (e.g., methanol) for denitrification, and improved process stability. In the single-stage processes, either the carbon in the wastewater or the carbon in the cell mass is used to achieve denitrification. The five systems considered for the evaluation use a series of alternating aerobic and anoxic stages to achieve denitrification using the carbon in the wastewater and accumulated cell mass.

Since the on-site systems used for a single home typically use a subsurface non-point source disposal system such as a trench, bed, or drip system, most of the remaining nitrogen will be assimilated by the soil/plant system. This final step in an on-site system can act as an additional safety factor for limiting the adverse impact of nitrogen on ground or surface water. Nitrogen is essential for plant growth and plant roots will take-up nitrate nitrogen when available. Also, anoxic conditions and the carbon source present in soil will denitrify the nitrates to some degree. However, any excess nitrate or other form of nitrogen will have tendency to migrate and cause an adverse impact on ground and/or surface water. The Pinelands Comprehensive Management Plan Water Quality requirements set a limit of 2 mg/l nitrate/nitrogen for water exiting from the parcel of land or entering a surface body of water. The Pinelands Septic Dilution Model assumes rainfall of up to 20 inches per year and plant uptake of 4.5% in A soils (sandy) and 9.0% in B soils (other) as means for assimilating nitrogen in an on-site disposal system.

Performance Verification of the Selected Technologies

In order to consider the interim use of a few recognized on-site treatment technologies while the details of the comprehensive management program are developed, the Committee on Alternative Septic Systems has undertaken the performance verification project. Five systems as listed on page 1 have been selected for the performance verification under this project. The primary goal of this project is to evaluate test results from the selected technologies and determine what nitrogen discharge level should be attributed to each of the system types. Specific tasks to achieve this goal include: obtain and review test data, determine which data is the most reliable and indicative of use in a typical residential environment, and determine the likely nitrogen concentration of the effluent leaving each system. The committee is also looking for a method to judge nitrogen removal rates for each of the selected technologies assuming a loading rate of 11.2 grams of nitrogen per capita per day, or 39.2 grams per home per day for 3.5 persons per home.

In order to determine what nitrogen discharge level should be attributed to each of the system types, performance data were gathered from various sources including the manufacturers of the systems and various organizations that have been involved in monitoring these systems. Performance data on nitrogen removal from small on-site technologies are not widely available mainly because nitrogen is not typically an issue with such systems. Reductions in BOD_5 and suspended solids are more of a concern and have been widely monitored for small on-site treatment systems. However, some data are now available for nitrogen removal. Primary sources of information for performance data for this project were the manufacturers themselves who have compiled the data gathered for their systems from various places and sources. The data collected for this project were used mainly to judge the performance of the specific technology and not to compare the technologies with each other. Details on the data collection and analysis are presented in the next section. The nitrogen discharge level attributed to each of the selected systems as presented in the results and discussion section is strictly based on the statistical analysis of the performance data gathered for this project and the evaluation of the design parameters of the technology. The discharge level may change if additional data when made available are used for the statistical analysis. The review of design parameters for each technology indicates that the systems are designed based on sound engineering principles and should achieve the nitrogen discharge levels as observed by the presently available performance data. However, conducting adequate operation and maintenance of the systems following the recommendations of the manufacturers is a must for any of these systems to achieve the necessary nitrogen discharge levels.

DATA COLLECTION AND ANALYSIS

In response to the request for information for this project, all the manufacturers of the systems provided technical information on the design, operation, and maintenance of their systems, and performance data on the effluent nitrogen concentration. Limited amounts of the performance data were received from the State of Florida (Florida Keys Project) and Massachusetts. However, most of these data were included by the manufacturers in their information packages. The performance data included information on effluent quality from single family home systems and large residential or commercial systems. The performance data on the Ashco filter included effluent quality when the filter was not operated in the denitrification mode. All the data were entered into a spreadsheet for each system with a category to indicate a single family home operation (Category = 1) or other operation (Category = 2). In case of Ashco, the data were also categorized to indicate operation in denitrification mode (Category = 1-N). Since the objective of this evaluation is to assign a discharge level for systems to be used in single family home settings, only those performance data adequately representing such settings were used in the analysis. The information provided by the manufacturers of the technologies included data from single family home systems, cluster/community systems that received wastewater from a group of homes, and/or commercial facilities. The following table presents the total number of data points for effluent quality and the number of units from where the data were collected for each technology:

Technology	Total Number of Data Points from All Units	Total Number of Units and (Range of Data Points per Unit)	Total Number of Data Points from Individual Home Units	Total Number of Individual Home Units and (Range of Data Points per Unit)
BioMicrobics	71	10 (1-23)	25	5 (1-17)
Cromaglass	98	14 (1-27)	13	5 (1-9)
Bioclere	103	13 (1-29)	32	5 (1-13)
Amphidrome	186	9 (1-40)	69	3 (17-32)
Ashco	59	2 (13-46)	18*	1 (18)

* Note that only one of the two sites had this technology used for Nitrogen Reduction.

The performance data were provided primarily by the manufacturers of the technology and the quality of the data is assumed to be satisfactory for this project. The number of data points available for effluent concentration appears to be adequate; however, the number of sites from where the data are collected is relatively small. This is not unusual at this time because not many on-site treatment systems are monitored for total nitrogen. Since individual data points are used for further statistical analysis, a site with one data point is given the same weight, i.e., treated the same, as a site with multiple data points.

From the entire set of the performance data for each system, values of statistical parameters – number of samples (Obs), Mean, Median, Minimum (Min), Maximum (Max), Standard Deviation (StdDev), Variance, Coefficient of Variation (Vx) and Coefficient of Reliability (COR) – were calculated by categories. In any statistical analysis a larger data set is desired in order to make necessary inferences. However, the data set should also be relevant to the situation in which the system is going to be used and the treatment objective. In this case, an on-site treatment system is going to be used in a single family home setting and the treatment objective is nitrogen reduction. Thus, the data most relevant for this case must reflect these conditions. A statistical tool known as Hypothesis Testing using a Z-test or t-test (Reference 4) was used to compare the mean values of the entire data set and the data set most relevant for this project for each system. A two-tailed hypothesis test can be conducted to determine if the mean values from two data sets are statistically different or not. Note that the purpose of such a comparison is to select the appropriate data set for each system type and not to compare the systems with each other. For three of the five technologies (BioMicrobics, Cromaglass, and Bioclere), the entire data base was determined to be relevant for further analysis; while for the other two technologies (Amphidrome and Ashco), only part of the data base was determined to be relevant for further analysis. Results of this analysis are presented in Tables B-1, B-2 and B-3 in Appendix B.

For developing decision rules, an α level of 0.05 (maximum probability of a Type I error, i.e., rejecting a true null hypothesis) was used to determine the values Z or t from the appropriate tables (Reference 4) and compared with the calculated value. The null hypothesis for comparing the means was that there is no difference between two means while the alternative hypothesis was that there is a difference between two means. $\{H_0: \mu_1 = \mu_2$ and $H_A: \mu_1 \neq \mu_2\}$ The decision rule was that if the calculated values of Z or t were outside the range of the critical value at the selected α level, then reject the null hypothesis and select only the relevant data set; otherwise, select the entire data set. The values of Z and t were calculated for each data set, one with all the data and one with only the relevant data, using the following equations and the values for mean, variance (Var), and sample size (Obs) for each data set:

$$Z = \frac{(Mean_1 - Mean_2)}{\sqrt{\frac{Var_1}{Obs_1} + \frac{Var_2}{Obs_2}}}$$

$$t = \frac{(Mean_1 - Mean_2)}{S_{pooled}\sqrt{\frac{1}{Obs_1} + \frac{1}{Obs_2}}} \quad \text{where} \quad S_{pooled} = \sqrt{\frac{(Obs_1 - 1)Var_1 + (Obs_2 - 1)Var_2}{Obs_1 + Obs_2 - 2}}$$

Once the appropriate data set is selected for a system, then the values of statistical parameters for that data set were used for further analysis and for determination of the likely concentration of total nitrogen. Table B-3 presents the selected data sets.

In order to determine what nitrogen discharge level should be attributed to each of the system types, the calculated mean value of the system type was compared against each of the critical discharge levels (14, 20, or 26 mg/l). Again, hypothesis testing was used for such a comparison using a one-tailed hypothesis test (Reference 4). The null hypothesis for comparing the sample mean with the critical value was that the sample mean was less than or equal to the critical effluent limits, while the alternative hypothesis was that the sample mean was greater than the critical effluent limits. {$H_0 : \mu_1 \leq$ critical effluent limits and $H_A : \mu_1 >$ critical effluent limits} Depending on the sample size for the data set, a Z test or a t test was used to reject the null hypothesis. The hypothesis for a data set with a sample size of 30 or less was tested using a t test, while the others were tested using a Z test. The values for Z or t were calculated using the following equations and the values of mean, standard deviation (StdDev), and sample size (Obs) for the relevant data set. The calculated values of Z or t were then compared to the critical values of Z or t for the α level 0.05 from the appropriate tables in Reference 4.

$$Z = \frac{Mean - CriticalEffluentLimit}{\frac{StdDev}{\sqrt{Obs.}}}$$, where CriticalEffluentLimit = 14, 20, and 26 mg/l.

The lowest critical effluent limit for which the null hypothesis is not rejected is assigned as the likely concentration of total nitrogen in effluent from a given technology based on the available performance data. Note that the null hypothesis can be rejected only when the calculated value of Z or t is greater than the critical value of Z or t. Or, in other words, if the calculated value is less than the critical value, accept the null hypothesis; i.e., there is no statistical difference between the effluent value calculated from the data set and the critical effluent limit.

The coefficient of variation (Vx) and coefficient of reliability (COR) are calculated for each system type and each data set for the systems. The value of Vx is often used to indicate the relative uncertainty of distributions with different means by adjusting the scales so they are comparable (Reference 4). However, for this project, the values of Vx are not used to compare the technologies and are reported mainly to indicate the expected variation in performance for a system based on the performance data available for that system. Reliability of a treatment system can be defined as the probability that a system can meet the expected performance criteria consistently over extended periods of time (Reference 3). Performance data can be used to calculate the COR at the desired reliability level. COR for each system is calculated for the 80% and 95% reliability levels using the method suggested in the Reference 3.

Finally, for each system type the percentages of measured values equal to or less than the critical limits (14, 20, or 26 mg/l) were estimated from the data set relevant for this project (Reference 3). For this analysis, the effluent data from the relevant data set were first arranged in order of increasing value and assigned a rank serial number. Then, value of plotting position was calculated for each data point. The plotting position represents the percent or frequency of observations that are equal to or less than the indicated value. Thus, the plotting position for a value of 14 mg/l would represent the percentage of times the system would produce effluent with that level. The plotting positions for each of three critical limits were estimated for each system and are reported in Table B-2. This analysis was conducted for the critical removal rates. Critical removal rates were determined based on 40 mg/l influent concentration for total nitrogen and the three critical effluent concentrations. Thus, a 14 mg/l effluent concentration means 65% removal rate, 20 mg/l effluent concentration means 50% removal, and 26 mg/l effluent concentration means 35% removal rate. The data available for the removal rates for each system were less than the data available for effluent quality. However, an attempt has been made to estimate the percentage or frequency of observations that are equal to or less than the desired removal rates.

RESULTS AND DISCUSSION

Each of the five companies selected for this project responded to the request for information on the design and operation of their systems and submitted the performance data available for nitrogen reduction. The technical information on the system design was reviewed using the engineering principles on biological nitrogen reduction as required by the Pinelands Commission (Reference 3). The design standards used by all the systems appear to be quite adequate for treating wastewater from individual home settings and achieve nitrogen reduction when operated in the specified manner. The amount of air supplied in the suspended growth systems and the loading rates, both hydraulic and organic, for both suspended and attached growth systems are within the limits for achieving adequate nitrification. The rate of denitrification, however, will vary with the alkalinity of incoming wastewater and the available carbon source. Typically, mixing nitrified effluent with the incoming wastewater in an anoxic environment in the primary tank is the most appropriate method for achieving denitrification and the reduction in total nitrogen concentration. However, addition of alkalinity and/or methanol can be used for achieving denitrification when necessary. Such an addition would increase operational complexity for a single family home on-site treatment system.

The treatment process and operating scheme for each system type is somewhat unique and may require a different degree of operational complexity. The purpose of this review is not to compare the technologies and so no such effort is made. Each system type is reviewed independent of the others and the results are based strictly on the performance data relevant to the scope of this project. The performance data for individual systems were analyzed using statistical methods to determine the likely concentration of total nitrogen in effluent and percentage of the time such concentration was achieved in the systems that have been monitored. Tables B-1 and B-2 in Appendix B contain the results of the statistical analysis. Original data used for the analysis are included in Appendix-C.

The following discussion on each system is taken from the literature provided by the company.

<u>BioMicrobics FAST System</u>

A FAST (Fixed Activated Sludge Treatment) system is a pre-engineered modular system designed to treat wastewater from a single home, a group of homes, or commercial facilities. FAST is a fixed film, aerated system utilizing a combination of attached and suspended growth treatment principles capable of achieving nitrification and denitrification in a single tank. This combination offers the stability of fixed film media and the effectiveness of activated sludge treatment principles. A typical FAST system provides adequate volume for microorganisms in the aerated media chamber to treat wastewater. The attached growth system functioning on and around the plastic media assures that microorganisms remain inside the system instead of being flushed out, even during the peak hydraulic flow conditions. During the times of low flow, the large volume of thriving microorganisms prevent a dying-off of the system, making the system well suited to intermittent use applications. Special patented technology allows FAST to consistently reduce total nitrogen levels by over 70%. Performance of the FAST system has been evaluated and certified by the National Sanitation Foundation (NSF) and several other similar testing organizations.

A model appropriate for a single family home setting is called “MicroFAST 0.5” that has the capacity to treat up to 500 gallons per day or up to 8 persons. The minimum tank volume necessary for this system is 800 gallons and it uses a 1/3 Hp blower with a capacity of 22 to 25 cubic feet per minute (cfm). The blower for this model is available either for 115 V or 230 V and the power consumption is 0.322 kw/hr, or about 8 kwh per day. The blower is mounted outside on top of the treatment tank or up to 100 feet away from the tank, depending on the site conditions.

Performance data for nitrogen reduction available for the FAST system included data from single family projects in Burnett County, Washington; Bernalillo County, New Mexico; and Massachusetts. Data from projects in several other states including the Florida Keys project were either from a large-scale cluster or community system, or from a non-residential setting. A total of 71 data points (10 sites) are available for effluent nitrogen concentration from all the projects for this system (excluding 20 data points from a unit with a non-standard, supplementary nitrogen reduction component, which are included in the full data set shown in Appendix C), only 25 of which are from a single family home setting (5 sites). However, the difference between the mean concentrations of total nitrogen for both the data sets was statistically not significant, hence the entire data set is considered to be relevant for further analysis.

Even though the data set containing all the data was used for assigning the effluent limit value for this technology, 17 observations from a single family home system operating in Bernalillo County, New Mexico indicated very high removal rates, from 160 mg/l to 10 mg/l, even during poor blower conditions. Similar removal rates, from 188 mg/l to 10 mg/l, were reported during normal blower conditions. The average influent concentration of total nitrogen 122 mg/l appears to be higher than normally reported for single family home (50–90 mg/l Reference 3). However, the treatment system achieved about 77% reduction in total nitrogen on an average basis, with an effluent concentration of 28 mg/l. The manufacturer's claim of more than 70% reduction in total nitrogen is supported by these observations. Effluent concentrations of less than 10 mg/l are reported for a single family home system operating in Burnett, WA, while the effluent concentration for single family home systems operating in Massachusetts ranged from 7 mg/l to 21 mg/l. A commercial system operating in Massachusetts produced effluent with less than 12 mg/l over a period of three years during which 13 samples were collected and analyzed for effluent total nitrogen concentration. The average concentration during this period was 7 mg/l.

Table B-1 presents the results of all statistical parameters for this system. Note that the data set labeled "BioMicrobics-ALL" is the relevant data set for this system. Table B-2 presents the results of statistical parameters only for the relevant data set and determination of the likely concentration of total nitrogen for this system. The mean concentration of total nitrogen is 15 mg/l, which is statistically not different from the critical value of 14 mg/l based on the observations contained in the data set. 69% of the observed values for total nitrogen concentration in the data set were less than 14 mg/l, while 84% of the observed values were less than 26 mg/l. A total nitrogen removal rate of 65% (assuming 40 mg/l influent value) was observed 77% of the times, while a 35% removal rate was observed 97% of the times.

Cromaglass SBR System

The Cromaglass system is a SBR (Sequencing Batch Reactor) that is designed as a continuously fed activated sludge process with clarifiers that are operated on a batch basis. Treatment is achieved by turbulent aeration of incoming wastewater, and batch treatment of bio-mass (sludge) in a separate aeration and quiescent settling chamber within a single vessel. Cromaglass systems are capable of achieving denitrification with the addition of an anoxic cycle following aeration. Air and mixing are provided by submersible pumps with venturi aspirators that receive air through a pipe intake from the atmosphere. Anoxic conditions are created by closing the air intakes of aeration pumps with electric valves, thus stopping aeration but the system continues mixing. Per-batch cycling time is 120 to 240 minutes and there are five cycles to complete the treatment. These five cycles include: fill and aeration, aeration, denitrification, transfer and settling, and discharge. The system is operated using a programmable logical control (PLC) that can store a record of all operational functions, thus providing information on each function of each cycle to the operator. Such information can indicate if service or maintenance is needed.

A model appropriate for a single home setting is called "CA-5" that has the rated capacity for treating up to 500 gallons or up to 1.25 lb of BOD_5 per day. Such a unit is installed in a 923 gallon tank, of which 680 gallons is allocated as aeration volume and 243 gallons is allocated as clarifier volume. The system will discharge the effluent six times per day and the discharge volume per cycle is 85 gallons. Surge capacity in the system is 290 gallons. The aeration capability for this unit is reported to be four lbs of oxygen per day and the power consumption is reported to be 8 kwh per day.

Performance data for nitrogen removal for the Cromaglass system included information from single home units monitored at several locations in Arizona, and community systems monitored in different states including New York, New Jersey, Colorado, and Pennsylvania. A total of 98 data points (14 sites) are available for effluent nitrogen concentrations, of which 13 data points (5 sites) are from a single family home setting. A total of 36 data points are available for % removal rates, of which 6 data points are from a single family home setting. The mean value for effluent nitrogen concentration for the entire data set was statistically not different than that for the single home systems, hence the entire data set was used for further analysis.

Even though the data set containing all the data was used for assigning the effluent limit value for this technology, 10 observations from a single family home system operating in Flagstaff, AZ, indicated total nitrogen concentration of less than 10 mg/l consistently and removal rates of more than 80% during a year of monitoring. The average influent concentration of total nitrogen was 62 mg/l and the average effluent concentration was 6 mg/l, which supports the manufacturer's claim of achieving less than 10 mg/l total nitrogen concentration. Effluent concentrations between 7 mg/l and 23 mg/l were reported at four other single family home systems. The majority of the effluent samples (80 out of 85 data points) from large residential and commercial systems from nine different sites also indicated total nitrogen concentrations of less than 14 mg/l, while remaining values ranged from 15 to 121 mg/l. Thus, the technology appears to be adequately designed to achieve low levels of total nitrogen in the effluent for residential and commercial applications.

Table B-1 presents the results of all statistical parameters for this system. Note that the data set labeled "Cromaglass-ALL" is the relevant data set for this system. Table B-2 presents the results of the statistical parameters only for the relevant data set and determination of the likely concentration of total nitrogen for this system. The mean concentration of total nitrogen is 8 mg/l, which is statistically not different from the critical value of 14 mg/l based on the observations contained in the data set. 72% of the observed values were less than 14 mg/l, while 84% of the observed values were less than 26 mg/l. Total nitrogen removal rate of 65% was observed 100% of the times; i.e., all the observations for removal rates were greater than 65%.

AWT Bioclere System

The AWT (Advanced Wastewater Treatment) Bioclere system utilizes an attached growth trickling filter concept for wastewater treatment for residential or commercial facilities. A trickling filter typically consists of a bed of highly permeable media to which microorganisms are attached and through which wastewater is percolated. The Bioclere unit utilizes a patented plastic media in a randomly packed configuration. The incoming wastewater is passed from the primary settling tank to a baffled area in the sump of the Bioclere in which a dosing pump is located. The dosing pump doses the trickling filter at a predetermined frequency. A forced draught ventilation system provides adequate airflow for maintaining aerobic conditions in the trickling filter. In the tricking filter unit, the organic material present in the wastewater is degraded by microorganisms attached to the filter media. Organic material from the wastewater is converted into bio-mass or a slime layer. As the organisms grow, the thickness of slime layer increases and diffused oxygen is consumed before it can penetrate the full depth of the slime layer. Thus, an anaerobic condition is developed near the surface of the media and the microorganisms near the surface of the media enter into an endogenous phase of their growth and lose their ability to cling to the media. Eventually, the wastewater washes the slime off the media while a new slime layer starts establishing and the process continues. The excess bio-mass or the slime would settle in the bottom and the sludge return pump would pump it back to the primary settling tank. The return of the sludge also enables the nitrates to be combined with a carbon source in the primary tank, allowing denitrification and achieving reduction in total nitrogen concentration.

Performance data for nitrogen reduction available for the Bioclere system included data from single family home settings and community systems from projects in Massachusetts and Rhode Island. Performance of the Bioclere system has also been evaluated and certified by the National Sanitation Foundation (NSF). A total of 103 data points (13 sites) are available for effluent nitrogen concentration from all the projects; 32 data points (5 sites) are specifically from single family home systems. The Bioclere systems are designed for three levels of effluent nitrogen concentrations: less than 10, 19, and 25 mg/l. Performance data available for systems operated at 10 locations had reported values for the designed levels. Bioclere systems operating at five out of the10 sites were designed for achieving less than 10 mg/l total nitrogen, while those operating at four sites were designed for less than 19 mg/l, and one was designed for less than 25 mg/l. Average effluent concentration for the five systems designed for less than 10 mg/l was 9 mg/l, while the average effluent concentration for the four systems designed for 19 mg/l was 12 mg/l, thus indicating adequate design standards. Performance data from all the systems were combined and used as one data set for further statistical analysis to determine the effluent discharge level of total nitrogen for this project.

Statistical analysis indicates that there is no difference between the mean effluent value obtained for the entire data set and the mean effluent value obtained for single family home systems. Hence, the entire data set is considered for further analysis. Table B-1 presents the results of all statistical parameters for this system. Note that the data set labeled "Bioclere-ALL" is the relevant data set for this system. Table B-2 presents the results of statistical parameters only for the relevant data set and the determination of the likely concentration of total nitrogen for this system. The mean effluent concentration of 14 mg/l is statistically not different from the critical value of 14 mg/l based on the observations contained in the data set. 80% of the observed values for the total nitrogen concentration in the data set were less than 14 mg/l, while 90% of the observed values were less than 26 mg/l. A total of 76 data points are available for determining the percentage reduction in total nitrogen. Since the system mixes the treated effluent with the incoming wastewater in the primary tank, it is not possible to calculate the "true" reduction rate of nitrogen for this system without knowing the concentration of total nitrogen in the raw wastewater. Total nitrogen removal rates reported in the information appear to be calculated using the influent concentration (raw wastewater plus the recycled flow) and the effluent concentration. A total nitrogen removal rate of 65% was observed 46% of the time; however, this number may be misleading, and in reality higher rates of removal are likely.

Amphidrome Wastewater Treatment System

The Amphidrome process is an advanced biological treatment that utilizes an attached growth treatment concept and is an example of a biologically aerated filter system. This is a patented treatment system. The system is pre-engineered and designed for the removal of soluble organic nitrogen, and for the nitrification and denitrification processes to occur simultaneously in a single reactor. The process begins operating in an aerobic mode and gradually progresses to an anoxic mode. The cyclical action is created by allowing a batch of wastewater to pass from the anoxic/equalization tank through the granular biological filter into the clear well. The batch of wastewater is then pumped back from the clear well up through the filter, where it overflows into a trough that carries it back to the anoxic/equalization tank. These cycles are repeated multiple times, while the treatment is allowed to progress from aerobic to anoxic conditions within the filter. Once sufficient cycles have been repeated to insure the degree of treatment required, a batch of effluent is discharged. A control system operates the system based on predetermined settings.

The Amphidrome reactor consists of: an underdrain, support gravel, filter media, and backwash trough. The underdrain is located at the bottom of the reactor and provides support for the media and distribution of liquid into the reactor during a reverse flow or backwash. It is also designed as a manifold to distribute air evenly over the entire filter bottom during the aerobic portion of the cycle. On top of the underdrain is approximately 18" of gravel. Several layers of different size gravel are used. Above the gravel is a deep bed of coarse, round silica sand. The deep bed filter design employed in this manner significantly reduces suspended solids and allows for adequate growth of microorganisms for treating wastewater. In order to achieve the necessary degree of nitrogen reduction under a wide range of conditions, this system is equipped with chemical addition pumps that allow the addition of alkalinity for nitrification and/or methanol for denitrification, when necessary.

Performance data for nitrogen removal available for the Amphidrome system include data from single family home systems and large cluster/community systems operating mainly in Massachusetts. A total of 186 data points (9 sites) are available for effluent nitrogen concentration from all the projects for this system, 69 of which are from single family home setting (3 sites). Mean values of effluent concentration for the entire data set and for single family home systems were calculated and tested for statistical difference. The mean values of effluent nitrogen concentration for these two data sets were significantly different based on a Z test, indicating that the larger systems may be operating differently compared to the smaller systems used for single family homes. Hence, the data set considered for further analysis included observations only from single family home settings.

Even though the data set containing only single family home systems was used for assigning the effluent limit value for this technology, 20 data points from a community scale system operating in Massachusetts designed to treat 40,000 gallons per day flows indicated an average effluent concentration of less than 7 mg/l. However, the average effluent concentration from the five other community and commercial systems with 77 reported data points was 27 mg/l. The average effluent concentration for the single family home systems with 69 reported data points from three sites ranged from 8 to 19 mg/l, indicating lesser variability in the effluent concentration compared to the community and commercial applications.

Table B-1 presents the results of all statistical parameters for this system. Note that the data set labeled "Amphidrome-1" is the relevant data set for this system. Table B-2 presents the results of statistical parameters only for the relevant data set and determination of the likely concentration of total nitrogen for this system. The mean concentration of total nitrogen is 12 mg/l, which is statistically not different from the critical value of 14 mg/l based on the observations contained in the data set. 67% of the observed values were less than 14 mg/l, while 90% of the observed values were less than 26 mg/l. Since no information was available on the influent concentration of total nitrogen for single family home systems, it is not possible to calculate the removal rates for this system operating in a single family home setting.

<u>Ashco RFS III System</u>

Ashco RFS III (Rock Filter Storage), patent pending, is an advanced treatment system that utilizes an attached growth concept for treating wastewater and is an example of a biologically aerated filter system. The system has two major components: a primary settling and anoxic tank, and a media filter with effluent storage capacity in the bottom. Wastewater flows by gravity from the home (or other facilities) to the primary settling tank that collects and digests settleable solids (sludge) and allows for denitrification of nitrified effluent that is recycled from the filter. Partially treated effluent from the primary tank flows through an effluent filter into the bottom zone of the media filter. For single family home systems, the bottom zone is sized such that the dilution volume is at least twice the daily flow for the system. The recirculation pump in the bottom zone pumps the effluent via a spray grid on top of the sand filter at a predetermined frequency.

The effluent trickles down the filter media where it is treated by microorganisms attached to the media and returns to the bottom storage zone. After going through several cycles effluent is discharged either by gravity or by another pump. Aerobic conditions are maintained naturally within the media. A portion of the effluent is also recycled back to the front end of the primary tank when it is sprayed on top of the media. Ashco calls this concept a "progressive recycling treatment process" for the reduction of total nitrogen via denitrification. The main purpose of this step is to mix the nitrified effluent (filter effluent) with the carbon source available in the incoming wastewater in the anoxic conditions of the primary tank. It is expected that total nitrogen concentration can be reduced down to less than 10 mg/l by this system.

Ashco RFS III system for a single home typically consists of a 1,000 gallon primary tank with an effluent filter, a 120 to 140 square feet filter with a bottom zone liquid capacity of about 1120 gallons, granular media, a spray grid for effluent dispersal, a recirculation pump, a discharge pump (if necessary), and a control system. This is a pre-engineered and pre-packaged system that for a single family home can be delivered to a site for installation. The media used in the filter typically is Black Beauty product # 1040 with an effective size of 1.00 to 1.70 mm and a uniformity coefficient less than 1.90, or as approved by Ashco. The media must be hard, durable, and free of organic matter.

Performance data for nitrogen reduction available for RFSIII system included data from two individual home sites monitored in Pennsylvania. This system has been successfully used mainly for reduction of organic matter, suspended solids, and fecal coliform and numerous data are available to demonstrate this point. However, use of this system for reduction of total nitrogen with modification of the treatment process is relatively recent. A total of 59 data points (2 sites) are available for effluent nitrogen levels from the Pennsylvania projects; however, only 18 data points (1 site) are available after the nitrogen reduction scheme - i.e., recycling back to the front end of primary tank - was started. The mean concentration of effluent total nitrogen with and without the nitrogen reduction scheme was analyzed to determine if there was a significant difference between them. The difference between the mean concentration of effluent total nitrogen with the nitrogen reduction scheme operating was significantly less than that without, hence, only those data were considered to be relevant for further analysis. Table B-1 presents the results of all statistical parameters for this system. Note that the data set labeled "Ashco-1N" is the relevant data set for this system. Table B-2 presents the results of statistical parameters only for the relevant data set and determination of the likely concentration of total nitrogen for this system. The mean concentration of total nitrogen is 21 mg/l, which is statistically not different from the critical value of 20 mg/l based on the observations contained in the data set. 61% of the observed values were less than 20 mg/l, while 74% of the observed values were less than 26 mg/l. Since the system mixes the treated effluent with the incoming wastewater in the primary tank and information on total nitrogen concentration in the incoming wastewater is not available, it is not possible to calculate the reduction rate for this system.

CONCLUSIONS AND RECOMMENDATIONS

A technical review of five selected on-site treatment technologies was performed to determine what nitrogen discharge level might be attributed based on the available performance data. This review was requested by the Pinelands Commission's Ad Hoc Committee on Alternative Septic Systems. Performance information on each selected technology is reviewed independently and not for the purpose of comparing the technologies to each other. Technical information and performance data for nitrogen removal for each of the selected technologies was obtained from the manufacturers and testing organizations. The design information was compared to the standard engineering requirements for nitrogen removal and the data on effluent quality were analyzed using statistical methods for assigning the likely concentration of total nitrogen to the effluent.

Design Parameters

Important design parameters for reducing total nitrogen includes the ability of the system to maintain aerobic conditions (dissolved oxygen concentration > 2 mg/l) and pH between 7.5 and 8.6 for nitrification, and the presence of anoxic conditions along with an adequate supply of organic carbon for denitrification. Most of the nitrogen present in wastewater is in the form of organic nitrogen that must be nitrified first to nitrates and then nitrates must be denitrified to nitrogen gas, thus achieving nitrogen removal.

Technical information for all five on-site treatment technologies suggests that their designs are adequate for achieving nitrification and denitrification when used in a single family home setting. However, all these technologies use electro-magnetic devices such as pump(s), blower(s), and control systems to treat wastewater to a desired quality, and thus require a certain degree of professional supervision on an ongoing basis. Overall, the operation and maintenance requirements for all these systems are not complex and are such that anyone with a basic understanding of wastewater treatment and adequate training by the manufacturer of the technology can operate the system. With the currently available remote monitoring systems, the operation of individual home on-site systems can be centrally monitored using the existing telephone lines. All the technologies reviewed are either already using such a remote monitoring system or are capable of using it, if required. Centralized management of on-site systems is essential to ensure that the treatment technology is operating properly and the necessary quality of effluent is achieved prior to discharge.

Discharge Levels and Recommendations

Based on the available performance data for each technology and statistical analysis of these data, the following discharge levels for total nitrogen are assigned –

- BioMicrobics FAST System 14 mg/l;
- Cromaglass System 14 mg/l;
- AWT Bioclere System 14 mg/l;
- Amphidrome System 14 mg/l;
- Ashco RFSIII System 20 mg/l.

Assigning a nitrogen discharge level to a technology based on the available effluent data is possible; however, this should be considered as only the first step towards wide-spread application of such a technology in a specific area such as the New Jersey Pinelands. Since on-site systems use subsurface/land-based disposal systems that could further reduce total nitrogen in the soil/plant environment when the disposal systems are installed at a shallow depth in the root zone and the effluent is adequately dispersed throughout the system, a safety factor of about 2, as discussed in Appendix A, is available when assigning these discharge limits.

The values assigned to each of the system types in this first step must be reconfirmed based on the actual effluent quality data collected from the Pinelands and the statistical methods used for determining the initial values. Effluent nitrogen concentration depends not only on the on-site treatment technology but also to some degree on the quality of influent wastewater, which varies from area to area and depends on lifestyle. The amount of data used for assigning the initial values to discharge limits is to some degree limited and most of it is not from the Pinelands area. Also, ongoing monitoring of effluent quality at a certain optimum frequency is the key to making sure that the desired effluent quality is maintained from all the on-site treatment systems on a continuous basis. Thus, it is recommended that more data be collected on effluent quality for these technologies when used in the Pinelands area for on-site treatment. In order to gather an adequate number of data points to reconfirm the conclusions made from this review, a three-year interim period is recommended for approval of each of these technologies. During the three-year period, quarterly samples should be required at least on the effluent quality to determine the total nitrogen concentration. The collected data should then be analyzed to ensure that the technologies are achieving the desired level of nitrogen concentration in the effluent prior to discharge. The lot size allocation for the technology should be adjusted based on such information, if necessary. After three years of quarterly sampling, the frequency may be reduced to an annual or semi-annual sampling, mainly to reduce the operating costs of the on-site treatment systems.

Data Analysis Method

Scientific principles for biological removal of nitrogen from wastewater are documented in engineering textbooks such as Reference 3. A number of pre-engineered on-site treatment systems for single family homes that are designed based on these principles are now available in the market. They are primarily used for removing organic loads and bacteriological contaminants. While reducing organic loads via aerobic decomposition, most of the nitrogen in the wastewater gets converted to nitrate nitrogen by the nitrification process. However, nitrification does not mean reduction in total nitrogen concentration in the effluent. With the recognition for the adverse impact of nitrogen on ground and surface water quality, the on-site treatment technologies are now being considered for significant reduction in total nitrogen concentration in the effluent prior to discharge. How to assign a nitrogen removal rate or nitrogen discharge level to a technology based on the design and performance information is an interesting challenge. A decision making approach using statistical analysis of the performance data was conducted for the five selected technologies. This approach mainly focuses on developing null and alternative hypotheses, and then testing the hypotheses using Z or t test to make conclusions. The number of observations in the data set, mean value, and standard deviation are the main parameters used to determine which hypothesis should be accepted at the desired α level. Thus, it is recommended that when additional information is gathered from these on-site treatment systems operating in the Pinelands, the effluent concentration for total nitrogen be analyzed using the Z test to determine if the systems are functioning as expected based on the initial review as conducted in this project.

REFERENCES

1. Pinelands Comprehensive Management Plan, Chapter 50, Part VIII and Appendix A.

2. Predicting Ground-Water Nitrate-Nitrogen Impacts, Norman N. Hantzsche and E. John Finnemore, Ground Water, July-August 1992, Vol. 30, no. 4.

3. Small and Decentralized Wastewater Management Systems, Ron Crites and George Tchobanoglous, WCB/McGraw-Hill, 1998.

4. Business Statistics A Decision-Making Approach, David Groebner and Patrick Shannon, Merrill Publishing Company, 1989.

APPENDIX A

Reducing Nitrogen Using an On-Site Effluent Disposal System

Unlike a centralized collection system and treatment plant that discharges treated effluent directly into a surface water body using a point-source discharge method, an on-site wastewater system typically discharges treated effluent under ground using a non-point source discharge method. An underground (also called subsurface) non-point source effluent disposal system includes trenches, beds, or a drip system. These systems when installed at a shallow depth (less than 18" from the ground surface) allow for release of adequately treated effluent in the root zone, where the nutrients nitrogen and phosphorus present in the effluent may be assimilated (taken up) by plants. Rainwater that infiltrates at this depth also mixes with the effluent diluting the effluent to some extent. Mathematical models are available to perform a mass-balance analysis to determine the concentration of nutrients after dilution and plant uptake. Such models are used to determine the amount of land necessary to dilute nitrogen present in the effluent from an on-site system to a desired concentration before it reaches the ground or surface water. The Pinelands Comprehensive Management Plan uses the "Pinelands Septic Dilution Model" to determine the land area necessary for maintaining the 2 mg/l nitrogen limit in groundwater exiting the lot or entering the surface water. The standard assumptions required to use the model are also presented in the Comprehensive Management Plan.

A slightly different and simplified approach for predicting nitrogen levels in groundwater exiting a lot has been presented by Hantzsche and Finnemore (Reference 2). However, the model when applied using the standard assumptions listed in the Pinelands Comprehensive Management Plan generates the same results for the lot size requirements based on nitrogen concentration in the effluent. The model uses the following equation –

$$N_r = \frac{INw(1-d)+RNb}{I+R}$$

Where, N_r = concentration of nitrogen in recharge (diluted) water leaving the lot;
- I = volume rate of wastewater applied over the lot, in inches per year;
- N_w = total nitrogen concentration in effluent, mg/l
- d = fraction of nitrogen lost in the soil due to denitrification and/or uptake;
- R = average recharge rate of rainfall, amount of infiltration, inches per year; and
- N_b = background concentration of nitrogen in the recharge water, mg/l;

Typically, volumetric loading rates for treated wastewater (effluent) are expressed as gallons per day per acre; e.g., 1 house on 1 acre generating 262.5 gallons per day means a loading rate of 262.5 gallons per day per acre. This rate can be converted to inches per year by using a multiplication factor of 0.01344, thus making it compatible to the rainfall values in terms of units. Thus, assuming a 75 gallon per day flow rate and 3.5 persons per dwelling, the value for I for the three lot size requirements in the Pinelands would be: For 1 acre per home, I = 3.53, for 1.5; for 1.5 acre per home I = 2.35; and for 2 acres per home, I = 1.76 inches per year.

The proposed effluent limits of 14, 20, and 26 mg/l for on-site systems when used at the proposed dwelling densities will meet the 2 mg/l water quality standards as calculated by Hantsche and Finnemore Model. The results of the mass-balance analysis using the assumptions listed in the Pinelands Comprehensive Management Plan are presented as following:

Assuption for NJ Pinelands:							
Nw =	14 or 20 or 26 mg/l				Flow =	75	gpd/cap
Nb =	0 mg/l				Cap/Home =	3.5	
I =	3.53 or 2.35 or 1.76 in/yr				Flow/Home =	262.5	gpd/home
R =	20 in/yr				Acres/Home	gpd/Acre	I
d =	4.5% or 9%				1	262.50	3.53
					1.5	175.00	2.35
					2	131.25	1.76
Values of Nr for various Nw, I, and d:							
		4.5%				9%	
Nw \ Acres per Home	1	1.5	2		1	1.5	2
14	2.0	1.4	1.1		1.9	1.3	1.0
20	2.9	2.0	1.5		2.7	1.9	1.5
26	3.7	2.6	2.0		3.5	2.5	1.9
40	5.7	4.0	3.1		5.5	3.8	3.0

Note that the discharge of 40 mg/l effluent concentration will exceed the water quality standard of 2 mg/l for all three dwelling densities based on the assumptions for flows, rainfall, and soil/plant uptake factors.

The credits for plant uptake of nitrogen in the Pinelands Comprehensive Management Plan are 4.5% for type A soils and 9% for type B soils. When nitrified effluent is discharged into a shallow-placed subsurface effluent dispersal system, higher removal (assimilation) of nitrogen can be achieved. If we assume a 50% reduction in the soil/plant system, i.e., d = 0.5 in the Hantzsche and Finnemore Model, then the effluent level of 26 mg/l for the density of 1 home per acre would still meet the water quality standards of 2 mg/l. This analysis suggests that there is a safety factor of almost 2 available in assigning the effluent discharge levels based on the performance data currently available for the selected technologies. If for some technical or operational reasons, a technology doesn't perform as expected during the interim period, a limited application of such a technology should not pose any significant danger to groundwater or surface water quality. It is important that quarterly performance data for effluent quality be collected for the first three years of operations for these technologies to ensure that the technologies are performing as expected. Monitoring of effluent quality after the initial three-year period may be reduced to as little as one sample per year for the technologies that meet the desired effluent quality on a consistent basis.

APPENDIX B

Table B-1

This table presents statistical information for each system and for the entire data set, as well as for the relevant data set. A Z- test and t- test are used to determine if the relevant data set is statistically different from the entire data set. If they are, then only the relevant data set is used for further analysis to assign an effluent discharge level of nitrogen to a system.

Dataset									*1.645*	*0.842*
	Obs	Mean	Median	Min	Max	StdDev	Variance	Vx	COR@95%	COR@80%
BioMicrobics-ALL	71	**15**	*11*	3	63	13	175	0.86	0.39	0.71
BioMicrobics-1	25	22	18	5	62	16	254	0.72	0.43	0.72
BioMicrobics%Red-ALL	52			33%	95%					
BioMicrobics%Red-1	21			46%	95%					
	Z =	-1.91682	for Z of +/-1.96, No statistical difference between means; use all data							
	Obs	Mean	Median	Min	Max	StdDev	Variance	Vx	COR@95%	COR@80%
Cromaglass-ALL	98	**8**	*5*	1	121	14	195	1.68	0.29	0.74
Cromaglass-1	13	9	7	3	23	7	45	0.74	0.42	0.71
Cromaglass%Red-ALL	36			70%	98%					
Cromaglass%Red-1	6			83%	95%					
	Z =	-0.32762	for Z of +/-1.96, No statistical difference between means; use all data							
	Obs	Mean	Median	Min	Max	StdDev	Variance	Vx	COR@95%	COR@80%
Bioclere-ALL	103	**14**	*10*	3	103	16	259	1.14	0.34	0.70
Bioclere-1	32	14	12	5	45	9	81	0.65	0.45	0.72
Bioclere%Red-ALL	76			*1%*	91%					
Bioclere%Red-1	23			*1%*	71%					
	Z =	0.100299	for Z of +/-1.96, No statistical difference between means; use all data							
	Obs	Mean	Median	Min	Max	StdDev	Variance	Vx	COR@95%	COR@80%
Amphidrome-ALL	186	17	13	1	80	15	235	0.89	0.38	0.70
Amphidrome-1	69	**12**	*10*	1	62	10	103	0.84	0.39	0.71
Amphidrome%Red-ALL	20			74%	99%					
Amphidrome%Red-1	0			NA	NA					
	Z =	*3.066586*	for Z of +/-1.96, Statistical difference between means; use only Single Home Data							
	Obs	Mean	Median	Min	Max	StdDev	Variance	Vx	COR@95%	COR@80%
Ashco-1	59	38	36	3	82	20	398	0.53	0.50	0.74
Ashco-1N	18	**21**	*15*	2.8	54	17	298	0.81	0.40	0.71
Ashco%Red-1				NA	NA					
Ashco%Red-N				NA	NA					
	Z =	*3.361797*	for Z of +/-1.96, Statistical difference between means; Nitrogen Reduction scheme is effective							

Note that "-ALL" means all the data, "-1" means data for systems used in single family home settings, and in the case of Ashco, "-1N" means data collected when the nitrogen reduction scheme was turned on.

Table B-2

Summary of Relevant Statistical Information	Obs	Mean	Median	Min	Max	StdDev	Variance	Vx	% Red. Min	% Red. Max
A. BioMicrobics-ALL	71	15	11	3	63	13	175	0.86	33%	95%
B. Cromaglass-ALL	98	8	5	1	121	14	195	1.68	70%	98%
C. Bioclere-ALL	103	14	10	3	103	16	259	1.14	NA	91%
D. Amphidrome-1	69	12	10	1	62	10	103	0.84	NA	NA
E. Ashco-1N	18	21	15	3	54	17	298	0.81	NA	NA

Hypothesis Testing:

Ho: Sample Mean Less Than or Equal to Critical Effluent Limits

Ha: Sample Mean Greater Than Critical Effluent Limits

Critical Effluent Limits = 14 or 20 or 26 mg/l

Decision Rule for alpha = 0.05, one-tailed test:

If Z > 1.65, reject Ho ; or If t >1.74, reject Ho *Note that the critical values of Z and t are obtained from the standard normal tables.*

Use t-test for Ashco-1N since the sample size is less than 30; for the rest use Z test

Calculated Z or t Values: Z or t = (Mean - CriticalEffluentLimit) / ((StdDev/(Obs)^.5)) where CriticalEffluentLimit = 14, 20, or 26

	14	20	26
A. BioMicrobics-ALL	0.918	-2.902	-6.721
B. Cromaglass-ALL	-4.046	-8.304	-12.561
C. Bioclere-ALL	0.041	-3.742	-7.525
D. Amphidrome-1	-1.586	-6.490	-11.394
E. Ashco-1N	1.795	0.320	-1.156

Likely Concentration of Total Nitrogen in Effluent

	T-N mg/l
A. BioMicrobics-ALL	14
B. Cromaglass-ALL	14
C. Bioclere-ALL	14
D. Amphidrome-1	14
E. Ashco-1N	20

Critical Effluent Limits versus % of values equal to or less than as observed

	14	20	26
A. BioMicrobics-ALL	69%	79%	84%
B. Cromaglass-ALL	72%	81%	84%
C. Bioclere-ALL	80%	87%	90%
D. Amphidrome-1	67%	83%	90%
E. Ashco-1N	49%	61%	74%

Critical Removal Rates versus % of values equal to or less than as observed

	65%	50%	35%
A. BioMicrobics-ALL	77%	94%	97%
B. Cromaglass-ALL	100%	100%	100%
C. Bioclere-ALL	46%	59%	70%
D. Amphidrome-1	NA	NA	NA
E. Ashco-1N	NA	NA	NA

Assume 40 mg/l as influent value to determine Critical Removal Rates.

Note that the relevant data set for each technology is included in the following Table B-3. For BioMicrobics, Cromaglass, and Bioclere, this includes all the data, while for Amphidrome and Ashco, only part of the data were found to be relevant based on the statistical analysis for this evaluation.

Table B-3

BioMicrobics Relevant Data Set

Influent	Effluent	%Reduction	Category
26.2	5.3	80%	1
66.07	6.58	90%	1
	7.1		1
	8.5		1
	8.7		1
	9.3		1
160	10	94%	1
188	10	95%	1
60	12	80%	1
140	12	91%	1
114	14	88%	1
140	14	90%	1
93.81	17.85	81%	1
112	18	84%	1
104	18	83%	1
64.9	21	68%	1
104	22	79%	1
70	28	60%	1
110	38	65%	1
100	38	62%	1
124	40	68%	1
144	42	71%	1
78	42	46%	1
132	52	61%	1
196	62	68%	1
46.01	2.75	94%	2
	2.88		2
	3.96		2
	4		2
	4.55		2
	4.99		2
39.02	5	87%	2
	5.07		2
	5.07		2
	5.46		2
46.12	5.9	87%	2
	6.3		2
32	6.8	79%	2
65.05	7.4	89%	2
	7.57		2
36	8.8	76%	2

32.01	9.09	72%	2
33	9.3	72%	2
46.02	9.5	79%	2
35	9.5	73%	2
	9.61		2
	10.16		2
62.55	10.29	84%	2
19.25	10.46	46%	2
	10.7		2
36.04	10.7	70%	2
48.01	10.7	78%	2
39	10.8	72%	2
31	10.8	65%	2
29.01	10.9	62%	2
	11.02		2
32.04	11.1	65%	2
46.95	11.16	76%	2
	11.3		2
56.01	12.77	77%	2
37.28	12.99	65%	2
33.01	13	61%	2
44.26	13.2	70%	2
62.01	14.2	77%	2
44.01	14.4	67%	2
38.02	16.2	57%	2
37.45	20.19	46%	2
128.5	23	82%	2
188	29	85%	2
92.7	35	62%	2
92.9	62.5	33%	2

Cromaglass Relevant Data Set

Influent	Effluent	%Reduction	Category
NA	2.8	NA	1
50.8	3.1	94%	1
69.6	3.4	95%	1
NA	3.9	NA	1
NA	4.2	NA	1
43.5	6.2	86%	1
NA	7.27	NA	1
45.8	7.6	83%	1
77.3	9	88%	1
83	10.2	88%	1
NA	18.57	NA	1
NA	18.9	NA	1
NA	22.71	NA	1
54.7	1	98%	2
38.5	1.7	96%	2
36.35	1.7	95%	2
NA	1.9	NA	2
NA	2	NA	2
NA	2	NA	2
NA	2.1	NA	2
NA	2.1	NA	2
41.55	2.1	95%	2
NA	2.4	NA	2
47	2.5	95%	2
51.3	2.5	95%	2
41.9	2.5	94%	2
35.2	2.56	93%	2
NA	2.62	NA	2
37.9	2.6	93%	2
NA	2.7	NA	2
NA	2.7	NA	2
27.7	2.7	90%	2
29.1	2.7	91%	2
NA	2.9	NA	2
43.05	2.9	93%	2
81.3	3	96%	2
55.2	3.1	94%	2
NA	3.1	NA	2
NA	3.3	NA	2
NA	3.4	NA	2
35.6	3.4	90%	2
22.1	3.4	85%	2
NA	3.6	NA	2
NA	3.65	NA	2
NA	3.68	NA	2
NA	3.8	NA	2

NA	3.8	NA	2
NA	4	NA	2
NA	4.1	NA	2
NA	4.2	NA	2
19.3	4.3	78%	2
NA	4.3	NA	2
NA	4.32	NA	2
NA	4.54	NA	2
NA	4.7	NA	2
108	4.7	96%	2
NA	4.8	NA	2
NA	5.1	NA	2
36.6	5.2	86%	2
NA	5.4	NA	2
NA	5.5	NA	2
NA	5.6	NA	2
NA	5.6	NA	2
27.1	5.6	79%	2
23.6	6.3	73%	2
NA	6.4	NA	2
NA	6.4	NA	2
34.4	6.6	81%	2
36.1	6.6	82%	2
NA	6.7	NA	2
NA	6.9	NA	2
44	7.1	84%	2
NA	7.1	NA	2
32.2	7.2	78%	2
NA	7.3	NA	2
28.4	7.6	73%	2
NA	8.2	NA	2
NA	8.4	NA	2
NA	9.2	NA	2
NA	9.2	NA	2
32.1	9.5	70%	2
NA	9.5	NA	2
NA	10	NA	2
NA	10.7	NA	2
NA	10.7	NA	2
NA	10.9	NA	2
NA	11	NA	2
NA	11.2	NA	2
43	11.4	73%	2
NA	12.1	NA	2
49.6	12.2	75%	2
NA	12.6	NA	2
48.4	13.7	72%	2
NA	15.1	NA	2
NA	18.6	NA	2
NA	40.8	NA	2
NA	63.23	NA	2
NA	120.8	NA	2

<u>Bioclere Relevant Data Set</u>

Influent	Effluent	%Reduction	Category
7.8	4.9	37%	1
NA	5.46	NA	1
4.5	7.15	-59%	1
10.6	7.9	25%	1
10	8.3	17%	1
9.88	8.48	14%	1
NA	8.5	67%	1
10.16	8.86	13%	1
NA	9.05	NA	1
NA	9.2	58%	1
8.17	9.56	-17%	1
19.4	9.9	49%	1
NA	10.3	54%	1
NA	10.42	NA	1
NA	11.1	71%	1
NA	11.4	31%	1
NA	11.8	38%	1
NA	11.9	68%	1
10.8	12.1	-12%	1
13.2	12.17	8%	1
NA	12.2	46%	1
19.2	12.3	36%	1
20.8	12.4	40%	1
15.3	13.5	12%	1
12.9	14.4	-12%	1
12.54	15.76	-26%	1
19.6	17.84	9%	1
NA	18.3	NA	1
29.7	21.4	28%	1
33	32.8	1%	1
40	38.6	4%	1
49.4	44.9	9%	1
15.93	2.64	83%	2
NA	3.02	NA	2
40.63	3.78	91%	2
NA	4.2	NA	2
NA	4.28	NA	2
NA	4.43	NA	2
37.8	4.7	88%	2
32.48	4.8	85%	2
27.62	4.92	82%	2
NA	5.34	NA	2
19.57	5.75	71%	2
28.9	5.8	80%	2
49.02	5.86	88%	2
26	6.04	77%	2

NA	6.1	NA	2
17.6	6.13	65%	2
33.83	6.46	81%	2
NA	6.48	NA	2
29.3	6.6	77%	2
NA	6.71	NA	2
29.02	6.84	76%	2
30.6	7.2	76%	2
26.35	7.24	73%	2
9.12	7.24	21%	2
26	7.29	72%	2
28.21	7.5	73%	2
NA	7.61	NA	2
NA	7.61	NA	2
27	7.67	72%	2
27	7.83	71%	2
23.7	8.21	65%	2
NA	8.22	NA	2
9.7	8.3	14%	2
26.7	8.42	68%	2
32	8.91	72%	2
18.95	9.11	52%	2
37.03	9.32	75%	2
20	9.45	53%	2
26.5	9.55	64%	2
47.25	9.58	80%	2
NA	9.8	NA	2
30.31	9.83	68%	2
NA	10.5	NA	2
38.36	10.81	72%	2
35.8	10.9	70%	2
27.41	10.91	60%	2
40.7	10.92	73%	2
34.5	11	68%	2
NA	11	NA	2
19.03	11.37	40%	2
32.2	11.4	65%	2
NA	11.4	NA	2
30.9	11.6	62%	2
39.01	12.03	69%	2
25.01	12.04	52%	2
30.02	12.06	60%	2
26.86	12.85	52%	2

22.12	13.12	41%	2
19.24	13.4	30%	2
NA	14	NA	2
80.5	15.5	81%	2
27.55	16.37	41%	2
11.28	19.94	-77%	2
28	22.6	19%	2
26.1	22.8	13%	2
42.3	36.9	13%	2
43	47.4	-10%	2
57.4	51.5	10%	2
86.3	82.2	5%	2
108	90	17%	2
120.5	102.5	15%	2
30	NA	NA	2

Amphidrome Relevant Data Set

Influent	Effluent	%Reduction	Category
NA	1.2	NA	1
NA	1.69	NA	1
NA	2.3	NA	1
NA	2.45	NA	1
NA	2.6	NA	1
NA	2.9	NA	1
NA	3	NA	1
NA	3.25	NA	1
NA	3.28	NA	1
NA	3.3	NA	1
NA	3.4	NA	1
NA	3.7	NA	1
NA	3.8	NA	1
NA	4.8	NA	1
NA	5	NA	1
NA	5.07	NA	1
NA	5.1	NA	1
NA	5.1	NA	1
NA	5.2	NA	1
NA	5.38	NA	1
NA	5.47	NA	1
NA	5.48	NA	1
NA	5.5	NA	1
NA	5.59	NA	1
NA	6	NA	1
NA	6.2	NA	1
NA	6.65	NA	1
NA	7.26	NA	1
NA	7.43	NA	1
NA	7.8	NA	1
NA	7.82	NA	1
NA	8.26	NA	1
NA	8.5	NA	1
NA	9.7	NA	1
NA	9.7	NA	1
NA	10.58	NA	1
NA	10.63	NA	1
NA	11.1	NA	1
NA	11.88	NA	1
NA	11.9	NA	1
NA	11.9	NA	1
NA	12	NA	1
NA	12.25	NA	1
NA	12.9	NA	1
NA	13.1	NA	1
NA	13.8	NA	1

NA	14	NA	1
NA	14.15	NA	1
NA	14.4	NA	1
NA	14.6	NA	1
NA	15	NA	1
NA	15.28	NA	1
NA	15.5	NA	1
NA	16.1	NA	1
NA	16.3	NA	1
NA	16.56	NA	1
NA	19	NA	1
NA	19.55	NA	1
NA	20.7	NA	1
NA	21.9	NA	1
NA	23.29	NA	1
NA	23.4	NA	1
NA	25.8	NA	1
NA	26.35	NA	1
NA	26.46	NA	1
NA	27.35	NA	1
NA	32.3	NA	1
NA	40.1	NA	1
NA	62.1	NA	1

Ashco Relevant Data Set

STE	Effluent	%Reduction	Category
8.6	2.8	NA	1-N
10.8	6.5	NA	1-N
12.6	7.5	NA	1-N
11.7	8.5	NA	1-N
10.9	8.7	NA	1-N
16.1	9.2	NA	1-N
13.2	10.1	NA	1-N
14.3	11.1	NA	1-N
14.4	12.2	NA	1-N
17.9	17.9	NA	1-N
18.8	19.6	NA	1-N
16.7	20.2	NA	1-N
22.9	21.9	NA	1-N
18.4	25.2	NA	1-N
35	42.5	NA	1-N
36.8	53	NA	1-N
38.2	53	NA	1-N
35.8	53.5	NA	1-N

APPENDIX C

Performance Monitoring Data for the Five Selected Technologies

The following Tables contain original data points for the BioMicrobics, Cromaglass, Bioclere, Amphidrome, and Ashco systems. All the information was obtained from the literature sent by the manufacturers.

BioMicrobics						
Project Name	Design GPD	Date	Influent	Effluent	%Reduction	Category
Burnett, WA	360	4/18/99		8.5		1
		4/28/99		9.3		1
		5/13/99		8.7		1
		6/3/99		7.1		1
Bernalillo County, NM	NA	*5/27/98*	*144*	*42*	*71%*	*1*
		6/10/98	*78*	*42*	*46%*	*1*
		6/24/98	*70*	*28*	*60%*	*1*
		7/8/98	*112*	*18*	*84%*	*1*
		7/22/98	*160*	*10*	*94%*	*1*
		8/6/98	*114*	*14*	*88%*	*1*
		8/19/98	*110*	*38*	*65%*	*1*
		9/2/98	*124*	*40*	*68%*	*1*
		9/16/98	*100*	*38*	*62%*	*1*
		9/30/98	*132*	*52*	*61%*	*1*
		10/14/98	140	14	90%	1
		10/28/98	60	12	80%	1
		11/11/98	188	10	95%	1
		11/25/98	140	12	91%	1
		12/9/98	196	62	68%	1
		12/23/98	104	18	83%	1
		1/6/99	104	22	79%	1
Coonamesset Inn, MA	14990	8/8/96		6.3		2
		9/5/96		3.96		2
		10/6/96		2.88		2
		11/7/96		7.57		2
		1/7/97		4.99		2
		2/5/97		9.61		2
		3/5/97		11.02		2
		6/10/97		5.46		2
		9/10/97		4		2
		10/6/97		5.07		2
		10/6/98		5.07		2
		1/12/99		10.7		2
		4/27/99		10.16		2
Mashpee, MA	5950	3/5/97	92.7	35	62%	2
		1/5/98	188	29	85%	2
		10/26/98	92.9	62.5	33%	2
		2/12/99	128.5	23	82%	2
FL OWNRS Project	NA	11/20/96	19.25	10.46	46%	2
FAST Only		12/18/96	46.95	11.16	76%	2
		1/29/97	62.55	10.29	84%	2
		2/26/97	37.45	20.19	46%	2
		4/2/97	32.04	11.1	65%	2
		4/23/97	46.02	9.5	79%	2
		5/8/97	39.02	5	87%	2

		5/21/97	33.01	13	61%	2
		5/29/97	44.01	14.4	67%	2
		6/11/97	36.04	10.7	70%	2
		7/17/97	NA	11.3		2
		8/28/97	NA	4.55		2
		8/19/98	38.02	16.2	57%	2
		9/22/98	32.01	9.09	72%	2
		1/18/99	62.01	14.2	77%	2
		2/16/99	44.26	13.2	70%	2
		3/23/99	37.28	12.99	65%	2
		4/22/99	29.01	10.9	62%	2
		6/22/99	56.01	12.77	77%	2
		7/27/99	48.01	10.7	78%	2
		8/31/99	65.05	7.4	89%	2
		9/28/99	46.12	5.9	87%	2
		10/21/99	46.01	2.75	94%	2
FL OWNRS Project		11/20/96	19.25	NA		2
FAST-ABF Only		12/18/96	46.95	NA		2
		1/29/97	62.55	21.2	66%	2
		2/26/97	37.45	19.64	48%	2
		4/2/97	32.04	10.2	68%	2
		4/23/97	46.02	7.5	84%	2
		5/8/97	39.02	3.5	91%	2
		5/21/97	33.01	9	73%	2
		5/29/97	44.01	12.6	71%	2
		6/11/97	36.04	10.83	70%	2
		7/17/97	NA	11.1		2
		8/28/97	NA	3.21		2
		8/19/98	38.02	NA		2
		9/22/98	32.01	8.16	75%	2
		1/18/99	62.01	5.2	92%	2
		2/16/99	44.26	10.5	76%	2
		3/23/99	37.28	11.6	69%	2
		4/22/99	29.01	7.4	74%	2
		6/22/99	56.01	9.09	84%	2
		7/27/99	48.01	10.82	77%	2
		8/31/99	65.05	2.31	96%	2
		9/28/99	46.12	2.91	94%	2
		10/21/99	46.01	3.2	93%	2
NSF Test Data	NA	9/17/90	32	6.8	79%	2
		9/29/90	36	8.8	76%	2
		9/24/90	39	10.8	72%	2
		9/27/90	33	9.3	72%	2
		10/1/90	35	9.5	73%	2
		10/4/90	31	10.8	65%	2

Vineyard Haven, MA	NA	9/20/99	66.07	6.58	90%	1
Lite Control, MA	NA	9/2/99	93.81	17.85	81%	1
Wayland, MA	NA	9/28/99	64.9	21	68%	1
		10/2/98	26.2	5.3	80%	1

------- End of data points for BioMicrobics -----

Cromaglass						
Project Name	Design GPD	Date	Influent	Effluent	%Reduction	Category
Smithtown, NY	10500	8/12/99	19.3	4.3	78%	2
		8/31/99	54.7	1	98%	2
		9/24/99	47	2.5	95%	2
		10/13/99	34.4	6.6	81%	2
		10/31/99	32.1	9.5	70%	2
		11/14/99	55.2	3.1	94%	2
		12/8/99	38.5	1.7	96%	2
		12/23/99	51.3	2.5	95%	2
Flagstaff, AZ - WattersR	300	7/21/92	69.6	3.4	95%	1
		8/19/92	45.8	7.6	83%	1
		9/25/92	NA	2.8	NA	1
		10/28/92	83	10.2	88%	1
		11/9/92	50.8	3.1	94%	1
		12/14/92	NA	4.2	NA	1
		1/28/93	43.5	6.2	86%	1
		2/4/93	77.3	9	88%	1
		7/20/93	NA	3.9	NA	1
AZ - HendricksonR		3/17/99	NA	7.27	NA	1
AZ - BarberR		3/17/99	NA	18.57	NA	1
AZ - GlynnR		3/17/99	NA	22.71	NA	1
AZ - Los Abrigatos		3/17/99	NA	2.62	NA	2
AZ - Canyon Portal		3/17/99	NA	40.8	NA	2
AZ - YoungR		3/17/99	NA	18.9	NA	1
AZ - Caesar Santiago DB		3/18/99	NA	120.8	NA	2
AZ - Indian Gardnes TP		3/18/99	NA	63.23	NA	2
Boulder, CO	5000	Jun-98	NA	10.7	NA	2
		Jul-98	NA	9.2	NA	2
		Aug-98	NA	11	NA	2
		Sep-98	NA	3.4	NA	2
		Oct-98	NA	5.4	NA	2
		Nov-98	NA	7.3	NA	2
		Dec-98	NA	10.7	NA	2
		Jan-99	NA	6.4	NA	2
		Feb-99	NA	6.9	NA	2
		Mar-99	NA	10	NA	2
		Apr-99	NA	5.6	NA	2
		May-99	NA	9.5	NA	2

Oak Ridge, NJ	4830	Jul-97	NA	4.1	NA	2
		Aug-97	NA	3.8	NA	2
		Sep-97	NA	4.3	NA	2
		Oct-97	NA	2.1	NA	2
		Nov-97	NA	3.1	NA	2
		Dec-97	NA	3.3	NA	2
		Jan-98	NA	2.9	NA	2
		Feb-98	NA	2	NA	2
		Mar-98	NA	2	NA	2
		Apr-98	NA	2.7	NA	2
		May-98	NA	8.2	NA	2
		Jun-98	NA	6.7	NA	2
		Jul-98	NA	1.9	NA	2
		Sep-98	NA	3.8	NA	2
		Oct-98	NA	2.1	NA	2
Bayshore, NY	11400	4/30/99	NA	4.7	NA	2
		3/23/99	NA	2.4	NA	2
		10/29/98	35.6	3.4	90%	2
		9/20/98	NA	2.7	NA	2
		8/31/98	44	7.1	84%	2
		8/18/98	NA	3.6	NA	2
		7/31/98	NA	4.2	NA	2
		7/24/98	41.6	2.1	95%	2
		7/23/98	43.1	2.9	93%	2
		7/22/98	41.9	2.5	94%	2
		7/21/98	36.4	1.7	95%	2
		7/20/98	37.9	2.6	93%	2
		7/19/98	22.1	3.4	85%	2
		7/18/98	29.1	2.7	91%	2
		7/17/98	35.2	2.6	93%	2
		6/30/98	27.7	2.7	90%	2
		6/14/98	81.3	3	96%	2
		5/29/98	36.6	5.2	86%	2
		4/29/98	43	11.4	73%	2
		3/31/98	NA	8.4	NA	2
		3/17/98	48.4	13.7	72%	2
		2/26/98	49.6	12.2	75%	2
		2/13/98	NA	12.6	NA	2
		1/31/98	NA	18.6	NA	2
		12/15/97	36.1	6.6	82%	2
		11/30/97	108	4.7	96%	2
		9/30/97	NA	15.1	NA	2
Milton, PA	5000	11/13/90	NA	10.9	NA	2
		11/15/90	NA	12.1	NA	2
		11/27/90	NA	11.2	NA	2
		12/13/90	NA	4.3	NA	2
		12/18/90	NA	4.5	NA	2
		1/8/91	NA	3.7	NA	2
		1/10/91	NA	5.6	NA	2
		1/24/91	NA	3.7	NA	2
		1/31/91	NA	5.5	NA	2

		2/5/91	NA	4	NA	2
		2/12/91	NA	4.8	NA	2
		2/14/91	NA	6.4	NA	2
		2/21/91	NA	5.1	NA	2
		3/19/91	28.4	7.6	73%	2
		3/26/91	NA	9.2	NA	2
		4/2/91	27.1	5.6	79%	2
		4/9/91	NA	7.1	NA	2
		4/30/91	23.6	6.3	73%	2
		5/7/91	32.2	7.2	78%	2

------ End of data points for Cromaglass ------

Bioclere						
Project Name	Design GPD	Date	Influent	Effluent	%Reduction	Category
391 Atlantic Avenue		10/27/93	9.88	8.48	14%	1
		11/3/93	13.2	12.17	8%	1
		12/7/93	10.16	8.86	13%	1
		1/11/94	12.54	15.76	-26%	1
		3/29/94	8.17	9.56	-17%	1
		4/26/94	19.6	17.84	9%	1
		7/19/94	15.3	13.5	12%	1
28 Beach Road		10/5/95	NA	18.3	NA	1
		6/13/96	NA	5.46	NA	1
		8/9/96	NA	10.42	NA	1
19 Polk Road		9/19/96	NA	9.05	NA	1
Fairhaven 5 Home Cluster		5/30/95	NA	14	NA	2
Concord, MA Camp		6/12/00	NA	5.34	NA	2
		7/10/00	NA	4.28	NA	2
Littleton, MA	18000	5/16/00	26.5	9.55	64%	2
		6/21/00	19.57	5.75	71%	2
		7/24/00	26.7	8.42	68%	2
Hanson, MA	9900	2/5/99	86.3	82.2	5%	2
		3/11/99	120.5	102.5	15%	2
		4/6/99	108	90	17%	2
		5/5/99	43	47.4	-10%	2
		6/8/99	42.3	36.9	13%	2
		7/6/99	11.28	19.94	-77%	2
		8/11/99	26.35	7.24	73%	2
		9/9/99	19.24	13.4	30%	2
		10/20/99	26.1	22.8	13%	2
		11/16/99	28	22.6	19%	2
		12/1/99	37.8	4.7	88%	2
Marshfield, MA	3150	7/19/94	57.4	51.5	10%	2
		9/7/94	30.31	9.83	68%	2
		10/7/94	17.6	6.13	65%	2
		1/10/95	27.41	10.91	60%	2
		4/25/95	27.55	16.37	41%	2
		7/21/95	28.21	7.5	73%	2
		10/23/95	18.95	9.11	52%	2
		1/12/96	26.86	12.85	52%	2
		4/15/96	9.7	8.3	14%	2
		7/18/96	9.12	7.24	21%	2
		11/22/96	39.01	12.03	69%	2

Swansea, MA	12750	4/3/98	80.5	15.5	81%	2
		5/14/98	32.2	11.4	65%	2
		6/25/98	34.5	11	68%	2
		7/10/98	40.7	10.92	73%	2
		7/23/98	23.7	8.21	65%	2
		8/27/98	28.9	5.8	80%	2
		9/24/98	30.6	7.2	76%	2
		10/21/98	30.9	11.6	62%	2
		11/5/98	29.3	6.6	77%	2
		12/10/98	35.8	10.9	70%	2
		1/19/99	NA	7.61	NA	2
		1/28/99	22.12	13.12	41%	2
		2/25/99	38.36	10.81	72%	2
		3/11/99	19.03	11.37	40%	2
		4/9/99	30.02	12.06	60%	2
		5/13/99	25.01	12.04	52%	2
		6/18/99	29.02	6.84	76%	2
		7/16/99	37.03	9.32	75%	2
		9/8/99	NA	6.48	NA	2
		9/17/99	32	8.91	72%	2
		10/8/99	NA	8.22	NA	2
		10/22/99	26	7.29	72%	2
		11/15/99	NA	6.71	NA	2
		11/18/99	27	7.67	72%	2
		1/18/00	NA	7.61	NA	2
		3/23/00	30	NA	NA	2
		4/20/00	27	7.83	71%	2
		5/31/00	20	9.45	53%	2
		6/22/00	26	6.04	77%	2
Portsmouth, RI	12200	2/11/00	47.25	9.58	80%	2
		2/29/00	NA	6.1	NA	2
		3/14/00	33.83	6.46	81%	2
		4/28/00	49.02	5.86	88%	2
		5/10/00	NA	3.02	NA	2
		5/31/00	40.63	3.78	91%	2
		6/15/00	NA	4.43	NA	2
		7/5/00	15.93	2.64	83%	2
		7/7/00	32.48	4.8	85%	2
		7/31/00	27.62	4.92	82%	2
Cape Cod, MA		Mar-95	NA	10.3	54%	1
		Mar-95	NA	9.2	58%	1
		Apr-95	NA	11.1	71%	1
		Apr-95	NA	12.2	46%	1
		May-95	NA	11.9	68%	1
		May-95	NA	8.5	67%	1
		Jun-95	NA	11.4	31%	1
		Jun-95	NA	11.8	38%	1

South Yarmouth, MA	440	6/3/92	49.4	44.9	9%	1
		6/10/92	33	32.8	1%	1
		6/17/92	40	38.6	4%	1
		6/24/92	29.7	21.4	28%	1
		7/1/92	20.8	12.4	40%	1
		7/8/92	12.9	14.4	-12%	1
		7/15/92	10.6	7.9	25%	1
		7/22/92	19.2	12.3	36%	1
		7/29/92	4.5	7.2	-59%	1
		8/5/92	10.8	12.1	-12%	1
		4/28/93	10	8.3	17%	1
		6/2/93	19.4	9.9	49%	1
		7/7/93	7.8	4.9	37%	1
NSFI, Cape Code, MA	NA	10/14/99	NA	4.2	NA	2
		10/21/99	NA	9.8	NA	2
		11/12/99	NA	11	NA	2
		11/23/99	NA	10.5	NA	2
		12/14/99	NA	11.4	NA	2

------- End of data points for Bioclere -------

Amphidrome						
Project Name	Design GPD	Date	Influent	Effluent	%Reduction	Category
Falmouth, MA	440	4/10/97	NA	16.1	NA	1
		4/11/97	NA	16.3	NA	1
		5/13/97	NA	12.9	NA	1
		9/23/97	NA	2.45	NA	1
		1/14/98	NA	21.9	NA	1
		2/11/98	NA	13.8	NA	1
		3/11/98	NA	20.7	NA	1
		4/2/98	NA	13.1	NA	1
		4/15/98	NA	15	NA	1
		5/8/98	NA	8.5	NA	1
		5/13/98	NA	9.7	NA	1
		6/10/98	NA	5	NA	1
		8/13/98	NA	11.9	NA	1
		9/22/98	NA	5.2	NA	1
		10/7/98	NA	7.8	NA	1
		11/20/98	NA	5.07	NA	1
		12/11/98	NA	5.5	NA	1
		5/7/99	NA	6.65	NA	1
		6/2/99	NA	3.7	NA	1
		6/9/99	NA	3.8	NA	1
		6/16/99	NA	2.9	NA	1
		6/23/99	NA	3.4	NA	1
		7/7/99	NA	2.3	NA	1
		7/14/99	NA	2.6	NA	1
		7/22/99	NA	5.1	NA	1
		7/28/99	NA	3.3	NA	1
		8/4/99	NA	6.2	NA	1
		8/11/99	NA	6	NA	1
		8/18/99	NA	1.2	NA	1
		8/25/99	NA	5.1	NA	1
		9/1/99	NA	4.8	NA	1
		9/15/99	NA	3	NA	1
Mashpee, MA	40000	5/30/97	NA	42	NA	2
		6/26/97	NA	15	NA	2
		7/16/97	NA	10.07	NA	2
		7/21/97	NA	9.3	NA	2
		7/21/97	NA	7.14	NA	2
		7/24/97	NA	6.22	NA	2
		7/31/97	NA	14.39	NA	2
		8/19/97	55	14.3	74%	2
		9/12/97	42	8.42	80%	2
		10/1/97	NA	0.84	NA	2
		10/15/97	46	2.1	95%	2
		11/12/97	NA	1.8	NA	2
		11/25/97	51	2.14	96%	2
		12/30/97	36	2.6	93%	2
		1/28/98	56	6.55	88%	2
		2/24/98	59	2.24	96%	2

		3/24/98	65	1.7	97%	2
		4/30/98	120	1.7	99%	2
		5/28/98	47	4	91%	2
		6/19/98	NA	1.6	NA	2
		7/28/98	NA	30.5	NA	2
		8/14/98	54	1.9	96%	2
		9/25/98	60	4.3	93%	2
		10/21/98	46	1.7	96%	2
		11/25/98	46	2.1	95%	2
		12/29/98	79	2.3	97%	2
		1/21/99	24	3.3	86%	2
		2/16/99	46	4.8	90%	2
		3/17/99	50	5.8	88%	2
		4/17/99	56	7.7	86%	2
		5/19/99	46	6.3	86%	2
		6/21/99	NA	6	NA	2
		7/13/99	NA	10.3	NA	2
		8/17/99	NA	8.6	NA	2
		9/14/99	NA	7	NA	2
		10/20/99	NA	1	NA	2
		11/8/99	NA	2	NA	2
		Dec-99	NA	3	NA	2
		Jan-00	NA	5	NA	2
		Feb-00	NA	5	NA	2
Swansea, MA	12000	1/29/97	NA	10.21	NA	2
		2/6/97	NA	9.9	NA	2
		2/10/97	NA	12.9	NA	2
		2/25/97	NA	17.73	NA	2
		3/28/97	NA	13.1	NA	2
		4/25/97	NA	17.3	NA	2
		4/30/97	NA	22	NA	2
		6/26/97	NA	15	NA	2
		6/30/97	NA	54	NA	2
		7/25/97	NA	33.65	NA	2
		7/31/97	NA	48.1	NA	2
		8/22/97	NA	21.9	NA	2
		9/18/97	NA	18.16	NA	2
		11/13/97	NA	14.49	NA	2
		12/22/97	NA	10.3	NA	2
		1/21/98	NA	17.4	NA	2
		2/26/98	NA	19.75	NA	2
		6/2/98	NA	19.2	NA	2
		6/22/98	NA	19.07	NA	2
		7/29/98	NA	22	NA	2
		8/26/98	NA	12.58	NA	2
		9/16/98	NA	9.11	NA	2
		11/30/98	NA	12.45	NA	2
		12/29/98	NA	11.29	NA	2
		1/26/99	NA	14.48	NA	2
		2/26/99	NA	13.64	NA	2
		3/31/99	NA	15.6	NA	2

		4/18/99	NA	36.32	NA	2
		5/26/99	NA	12.4	NA	2
		6/29/99	NA	6.15	NA	2
		7/30/99	NA	41.58	NA	2
		8/31/99	NA	40.72	NA	2
		9/28/99	NA	70.59	NA	2
		10/28/99	NA	26.6	NA	2
		11/30/99	NA	29.13	NA	2
		12/16/99	NA	24.1	NA	2
		1/19/00	NA	39.8	NA	2
		2/28/00	NA	24.73	NA	2
		3/28/00	NA	26.3	NA	2
		4/25/00	NA	29.52	NA	2
Nantucket, MA	330	7/12/98	NA	3.25	NA	1
		8/14/98	NA	1.69	NA	1
		9/30/98	NA	62.1	NA	1
		10/31/98	NA	19.55	NA	1
		11/25/98	NA	25.8	NA	1
		12/11/98	NA	32.3	NA	1
		4/23/99	NA	26.35	NA	1
		5/12/99	NA	15.28	NA	1
		5/18/99	NA	11.88	NA	1
		5/18/99	NA	14	NA	1
		6/8/99	NA	14.6	NA	1
		6/8/99	NA	9.7	NA	1
		6/22/99	NA	12	NA	1
		7/19/99	NA	10.58	NA	1
		7/20/99	NA	11.9	NA	1
		7/28/99	NA	40.1	NA	1
		8/18/99	NA	11.1	NA	1
Swansea, MA	5000	1/21/98	NA	38.4	NA	2
		3/30/98	NA	26.3	NA	2
		7/28/98	NA	7.04	NA	2
		8/26/98	NA	13.61	NA	2
		9/16/98	NA	10.87	NA	2
		10/19/98	NA	73.4	NA	2
		11/30/98	NA	13.43	NA	2
		12/29/98	NA	27.5	NA	2
		3/31/99	NA	30.79	NA	2
		6/29/99	NA	21.97	NA	2
		8/31/99	NA	20.9	NA	2
		9/28/99	NA	39.6	NA	2
Swansea, MA	9999	5/26/99	NA	24.1	NA	2
		6/29/99	NA	66.5	NA	2
		7/30/99	NA	55	NA	2
		8/31/99	NA	40.33	NA	2
		9/28/99	NA	79.9	NA	2
		10/28/99	NA	32.5	NA	2
		11/30/99	NA	47.42	NA	2

		12/16/99	NA	52.6	NA	2
		1/19/00	NA	48.3	NA	2
		2/28/00	NA	34.68	NA	2
		3/28/00	NA	43.6	NA	2
		4/25/00	NA	36.25	NA	2
Holliston, MA	440	8/31/98	NA	16.56	NA	1
		9/30/98	NA	23.29	NA	1
		10/31/98	NA	19	NA	1
		11/30/98	NA	23.4	NA	1
		12/29/98	NA	14.4	NA	1
		1/29/99	NA	27.35	NA	1
		2/28/99	NA	26.46	NA	1
		3/22/99	NA	12.25	NA	1
		3/31/99	NA	3.28	NA	1
		5/17/99	NA	8.26	NA	1
		6/30/99	NA	15.5	NA	1
		8/9/99	NA	10.63	NA	1
		8/12/99	NA	14.15	NA	1
		9/1/99	NA	5.47	NA	1
		9/23/99	NA	7.43	NA	1
		10/7/99	NA	5.48	NA	1
		10/22/99	NA	7.82	NA	1
		11/22/99	NA	7.26	NA	1
		12/20/99	NA	5.38	NA	1
		2/18/00	NA	5.59	NA	1
Littleton, MA	5500	1/28/99	NA	28.74	NA	2
		2/26/99	NA	18.71	NA	2
		3/26/99	NA	22.57	NA	2
		4/30/99	NA	17.68	NA	2
		5/27/99	NA	29.7	NA	2
		6/17/99	NA	12.23	NA	2
		7/30/99	NA	5.8	NA	2
		8/31/99	NA	12.91	NA	2
		9/24/99	NA	33.3	NA	2
		10/28/99	NA	28.4	NA	2
		11/23/99	NA	30.8	NA	2
		12/22/99	NA	34.3	NA	2
North Eastham, MA	8246	5/4/00	NA	12.15	NA	2

----- End of data points for Amphidrome ------

Ashco RFSIII						
Project Name	Design GPD	Date	STE	Effluent	%Reduction	Category
Van Ords site, PA	300	Dec-98	24.3	34.2	NA	1
		Jan-99	27.3	27.3	NA	1
		Feb-99	21.4	26.6	NA	1
		Mar-99	19.2	31.7	NA	1
		Apr-99	18.4	31.2	NA	1
		May-99	19.9	27.8	NA	1
		Jun-99	19.5	27.2	NA	1
		Jul-99	20.5	18.7	NA	1
		Aug-99	8.2	13.4	NA	1
		Sep-99	10.6	10.3	NA	1
		Oct-99	21.8	28.6	NA	1
		Nov-99	21.8	35	NA	1
		Dec-99	19	33.5	NA	1
Stevick Site, PA		12/7/98	31	81	NA	1
		12/14/98	40.5	82	NA	1
		12/28/98	37	82	NA	1
		1/11/99	39	63	NA	1
		1/18/99	35	58.5	NA	1
		1/25/99	30	34.2	NA	1
		2/2/99	34	36	NA	1
		2/8/99	44	34.8	NA	1
		2/15/99	37	38.5	NA	1
		2/22/99	38.2	45.2	NA	1
		3/1/99	39.2	48.5	NA	1
		3/8/99	40	49.2	NA	1
		3/15/99	37.8	47.5	NA	1
		3/22/99	42.2	49.5	NA	1
		3/29/99	38.5	53.5	NA	1
		4/5/99	36.8	60.5	NA	1
		4/12/99	32	51	NA	1
		4/19/99	33.2	38	NA	1
		4/26/99	37.5	50.5	NA	1
		5/3/99	35.2	51.5	NA	1
		5/10/99	31.8	49.5	NA	1
		5/17/99	32.8	58.5	NA	1
		5/24/99	37.2	54	NA	1
		6/1/99	31.5	53	NA	1
		6/7/99	38.8	51	NA	1
		6/15/99	37.8	54.5	NA	1
		6/21/99	37.5	55	NA	1
		6/28/99	35.8	54.5	NA	1
		7/6/99	36.8	53	NA	1-N
		7/14/99	35.8	53.5	NA	1-N
		7/19/99	38.2	53	NA	1-N
		7/26/99	35	42.5	NA	1-N
		8/4/99	18.4	25.2	NA	1-N
		8/9/99	16.7	20.2	NA	1-N
		8/16/99	14.4	12.2	NA	1-N

		8/23/99	14.3	11.1	NA	1-N
		8/30/99	16.1	9.2	NA	1-N
		9/8/99	10.8	6.5	NA	1-N
		9/13/99	11.7	8.5	NA	1-N
		9/22/99	10.9	8.7	NA	1-N
		9/27/99	8.6	2.8	NA	1-N
		10/5/99	12.6	7.5	NA	1-N
		10/11/99	13.2	10.1	NA	1-N
		3/9/00	22.9	21.9	NA	1-N
		3/29/00	18.8	19.6	NA	1-N
		4/17/00	17.9	17.9	NA	1-N

---- End of data points for Ashco ----

Appendix 3. Letter from Pinelands Commission to DEP and DEP Response

This final report contains 2 letters that are not included in this on-line report. They include:

10/04/2000 Letter to Mr. Barry Chalofsky - Division of Water Quality, Watershed Permitting Element from Mr. John Stokes, Assistant Director Planning and Management of the New Jersey Pinelands Commission.

03/22/2001 Letter to Mr. John Stokes, Assistant Director Planning and Management of the New Jersey Pinelands Commission from Mr. Fred Bowers, Ph.D., Division of Water Quality, NJDEP.

If you would like copies of these letters please call (609) 894-7300. All requests should be directed to Ms. Betsy Piner. E-mail requests can be made at:

planning@njpines.state.nj.us

Appendix 4. Summary of Responses to Technology Screening Questionnaire

Technology Screening Questions

Attribute	FAST	Cromaglass	Bioclere	Amphidrome	Ashco RFS III	Wisconsin Mound*
A. Overall Performance						
1. Is system recommended for individual residential use?	Yes	Yes, but prefer clustering when possible	Yes, within a management program or jurisdiction	Yes	Yes, 300 - 400 gpd	Yes
2. For individual residence: Conc. of N in effluent (mg/l) produced by system? Resulting lot size? (calculated by PC staff)	- 10 mg/l - 0.82 ac. (used % N reduction provided by vendor, see #3 below)	- ≤ 10 mg/l - 0.66 ac. (used calculated % N reduction, see #3 below)	- 8-12 mg/l - 0.49 - 0.82 ac. (used % N reduction provided by vendor, see #3 below)	- ≤ 10 mg/l - 0.16 - 0.82 ac.(used % N reduction provided by vendor, see #3 below)	- 15 mg/l - 1.07 ac. (used % N reduction provided by vendor, see #3 below)	- 34 mg/l - 2.7 ac. (used calculated % N reduction, see #3 below)
3. What is the percent N reduction achieved by the system for an individual residence?	70%	75% - calculated using PC influent conc. & vendor estimate of effluent conc. (vendor doesn't quote % reduction)	70-80%	70-90%	62.5%	14% (calculated using PC influent conc. and measurement of effluent conc. from WI)
4. Optimum # of residential units for system to function effectively?	None; units range from 500-9000 gpd	None; can be sized accordingly	None; size based on flow, composition & concentration limit	None; can be sized accordingly	None; can be sized accordingly	N/A
5. Is the system substantially proven? When developed? Current design since__?	- Smith & Loveless since 1946 - Single family design since early 1970s	- Cromaglass Corp. since 1965 - Current design for 20 yrs.	Since 1960s	- First developed in 1996 - Slight modifications since (last one in 1999)	- System since late 1980s - Current design in use for 2-3 yrs.	- Early 1970s - Designs vary
8. Evaluated under Pinelands conditions (e.g., low pH, sandy soils)? If so, what were impacts. If not, predict impacts if possible.	No; some filamentous bacteria growth would occur in any biological system (remedy with alkaline addition).	No	Yes 9 yrs. ago in Cape Cod - sole source aquifer, high mineral conc. & sandy soils. No negative impacts observed.	Iron hasn't been a problem in 1 pilot system; low pH handled by systems in Cape Cod (< 5.8 might require limestone).	Low pH unknown; system removes iron, but filters may plug if iron too high; No problems with mold or fungi.	Expect similar removal rates from sand

Attribute	FAST	Cromaglass	Bioclere	Amphidrome	Ashco RFS III	Wisconsin Mound*
9. What is the failure history of the system (e.g., how many, age at failure, and reason)?	Failures not tracked specifically. Problems are "very rare" and typically due to blower failure or incorrect installation, especially voltage incompatibility, which can usually be addressed over the phone.	Thousands of systems in use; any problems mostly due to poor O&M, biological upset, or design application error, and beyond manufacturer's scope.	No systems removed. Of 475 units, 2 problems due to poor installation & exceeding capacity (corrected). Most problems due to operator error, disconnects, no servicing or abandonment.	None	Not aware of any long-term failures, able to take corrective actions. One system failed tertiary standards, but still met secondary.	Generally fail because bed gets saturated by solids carryover (as early as 5 yrs.), which can occur with any system; WI now requires filter and installer recommends additional septic tank.
8. What upgrades would be needed for a 2-bdrm. addition to a 3-bdrm. house?	None	If flow exceeds previous maximum, either add parallel unit or replace.	None? May have to go to bigger unit (next sizes for up to 550 gpd and up to 990 gpd).	None	Increase filter surface area by adding another cell.	Sized by # of bdrms. so probably have to add tank and replace current system.
9. How easy is it to sample influent and effluent?	Effluent sampled by adding access to distribution box.	Access via manways; can sample influent, clarified effluent, and mixed liquor.	Influent from septic tank but unreliable due to recycling; effluent from distribution box or final pump chamber (larger units have ports).	Effluent by collection device or directly from clear well; influent hasn't been done for SFDs.	Has access ports; use special sampling device for influent and do valve purge for effluent.	Can sample influent from pump chamber, but effluent requires sampling from under mound.
B. Operation and Maintenance						
1. Is an O&M manual or chart available for: Individual residence? Community system?	Provided copies of manuals (owner's, service, and installation); manuals have troubleshooting guides.	Yes, provided copy of pamphlet. Also have video for larger systems.	Yes, manuals for single family and clustered systems.	Manual available for community system.	Manual available; flowchart under development.	Manual under development (State of WI requirement as of July).
2. What components/ processes are covered by warranty and for how long?	All components covered for 2 years from installation or 3 years from shipment (former usually applies).	All manufactured parts for 1 year.	Different types available; SFD typically 2 yrs. for materials & workmanship. Also do performance-based for non-SFD units.	Pumps, blowers and controls covered for 1 year.	Pump, control panel and floats covered for 2 years (but see response to B.4, below).	Terms and coverage vary; typically 1-3 yrs.

Attribute	FAST	Cromaglass	Bioclere	Amphidrome	Ashco RFS III	Wisconsin Mound*
3. Is a maintenance contract recommended or required? If so, what activities are covered and for how long?	NSF certification requires testing 2x/year and audits for compliance; distributor would provide after 2 years. Typical contract includes 2 visits/yr. to check operation and sludge level.	Company policy requires for 1 year; recommend monthly checks for first 6 months and quarterly or semiannually thereafter. Just check functioning; doesn't cover parts replacement or analytical tests.	They don't require, but regulatory agency usually does. Recommend quarterly check & cleaning of distribution nozzles; also offer perpetual maintenance for life of system.	Maintenance contract recommended; typically an annual visit to change the inlet filters on blowers and inspect the pumps.	Various plans available, from service only to bumper to bumper (suggest management by rural electric cooperative).	Varies; installer recommends cleaning filter every 6 months; doesn't include pumping.
4. What is the parts replacement schedule?	Blower every 7-10 years	Submersible sewage/effluent pumps every 8-10 years.	Pumps (5-7 yrs.), fans (4-5 yrs.), and circuit breakers/relays/ controls (indefinitely)	Inlet filters every year; pumps and blowers average 8 years	Floats warranted 5-7 yrs.; control panel, 10-15 yrs; pumps, 2 yrs.	?
5. Are factory trained maintenance providers and/or installers required or available?	Not required; can provide training for installers/providers; vendor available via phone.	Manufacturer requires network of trained "Servicing Distributors" for installation and O&M.	Factory trained staff provide onsite assistance during installation & start-up; can provide help for problems and O&M training.	Would provide training to local firms	Yes; "will develop" local installer	N/A
6. What is the sludge removal frequency for: individual residence? community system?	- Every 1-3 years, depending on use (levels can be checked easily) - Varies	- Approx. every 2 yrs., varies between houses - Recommend sludge processing tank w/min. 30-d. storage for lg. units	- Every 2-4 yrs., but should be inspected every year - Depends on design (may be annually)	Every 1-3 yrs., depending on load	3-5 yrs.	Waukesha County, WI requires pumping every 2 yrs; installer recommends 1x/yr
7. How is the system generally protected from shock?	Resistant to washout because microbes attached to media	Large vol. of activated sludge in the unit at all times (>550 g)	Recycle rates & retention time in clarifier protect system; viability only affected by biological kill due to toxics (unusual)	Anoxic/equalization tank protects filter; high concentration of biomass in reactor protects system	High volume in recirculation tank (1100 gallons)	Unknown

Attribute	FAST	Cromaglass	Bioclere	Amphidrome	Ashco RFS III	Wisconsin Mound*
8. How long would system need to recover from the following stresses and what actions, if any, are needed to correct the problem? intermittent occupancy (1&2 week vacations) shock (water softener (WS) backwash and dumping of chemically treated recreational vehicle (RV) waste) unusual loading (high/low occupancy & water-intensive home occupation)	Vac.: No adjustments for 1 or 2 wks.; inner layer of microbes will feed on outer layer W.S. : outer layer of bacteria will die and be replaced by bottom layer RV: Construct with larger settling zone hi/lo: no adjustment needed home occ.: Install larger unit	Vac.: No adjustments for 1 or 2 wks W.S. : Can be detrimental resulting in increased sludge RV: Can be detrimental; use biodegradable chemicals & pretreatment hi/lo: Should not cause upset unless max. flow exceeded home occ.: Same as above	Vac.: No adjustments for 1 or 2 wks.; NSF certified for this W.S. : experience indicates not a problem RV: Very dilute conc. ok; no experience with high conc. hi/lo: Should be ok; NSF certified; larger unit for > 550 gpd (only if actual flows exceed design capacity, which would be unusual since actual flow is 50-60% of design capacity) home occ.: May need larger unit; may overload filter due to improper settling of solids	Vac.: 1 or 2 wks. would stress culture, but only require 2-3 days to rejuvenate W.S. : Would stress culture, but consequences unknown RV: Would stress culture, but consequences unknown hi/lo: No problem, may need to adjust aeration home occ.: Adjust return flow rates	Vac.: No adjustments for 1 or 2 wks.; bacteria lay dormant W.S. : Short-term ok, but not long-term RV: No problem (protected by large volume) hi/lo: No adjustment needed home occ.: Size system appropriately	Unknown
9. What conditions may cause solids to carry over into the soil absorption system and what mechanisms prevent such damage?	Would only occur if incorrectly sized or not pumped enough; can add filter if desired.	All conditions listed could cause to occur; no in-line filters; built-in surge capacity of 1/2-1/3 daily flow.	Has not occurred under typical residential conditions; could occur if septic tank not pumped for an extended period (e.g., several years).	Insufficient backwashing (could correct by increasing the frequency).	Difficult to occur; protected by effluent, septic tank, and recirculating sand filters.	Not pumping tank frequently enough will cause; tank baffles, filter, and extra tank help prevent.

Attribute	FAST	Cromaglass	Bioclere	Amphidrome	Ashco RFS III	Wisconsin Mound*
C. Cost						
1. How much does a system cost for an individual residence (assume standard system =$15k)? If possible, itemize costs.	Unit: $2,995 Details: Includes unit, blower, blower housing, control panel, and shipping Extra: Standard system ($15k) - prefer dual compartments Total: $17,995	Unit: $6354-$6554 Details: Includes module ($3800), Denit. option ($1170), PLC controls ($232), Tank tie-down ($284), Outdoor panel ($68), Installation ($800-$1k) Extra: Piping from house and disposal field ($7.5k) Total: $13,854-$14,054	Unit: $5,000 Details: Includes installation supervision & start-up ($400). Extra: Standard system ($15k); concrete mounting pad; tax & shipping Total: $20,000$^+$	Unit: $6500 Details: Underdrain, gravel, media, pumps, & control panel Extra: 2 septic tanks, reactor tank (2' concrete pipe), and disposal field (15^+$k) Total: $21,600$^+$	Unit: See below Details: All-inclusive (targeting $15k in PA, but costs vary by location; e.g., $25k north of Phila. and $20-25k in Gloucester, MA). Extra: Nothing (standard system included in above) Total: $15,000-$25,000	Unit: See below Details: All-inclusive; maximum of $18k in WI (price varies by mound type, which varies according to soil type) Extra: Nothing (standard system included in above) Total: $18,000
2. How much will electricity cost for 1 yr. (assume $0.12/kWh)?	$360/yr; $30/month	$350/yr; $29/month	$151/yr., $13/month	$24/yr., $2/month	$130/yr., $10.83/mo.	Unknown (see Ashco?)
3. What is the annual cost of a maintenance contract?	Approximately $150/yr. (varies by location).	Dependent on servicing distributor; estimate $40-$50/hr. for labor on a quarterly basis plus testing fees; annual total about $260-$350.	For quarterly maintenance, $300-$500/yr. (upper estimate would probably include some sampling). Parts not covered, about $20-$40/year extra (annual cost over 30 years).	Annual maintenance contract is ~ $400.	Varies according to plan (see B.3), from $19/mo. for service only to $34/mo. bumper to bumper; annual cost from $228-$408.	Unknown
4. What replacement costs (parts and labor) are not covered under the maintenance contract?	Parts replacement (blower)	Parts (and labor to replace parts) not covered. Pumps range from $125-$383.	Sampling and parts (see above) plus pump-out	Air filters and lubricating fluids included; any other parts (e.g., blower or pump) additional	Depends on maintenance plan (see B.3); costs ~ $115 for one pump	Unknown
5. Can non-proprietary parts be substituted?	Yes, but due to quantity discount, cheapest through distributor	Yes, except for tanks	Yes, as long as they meet specifications	Yes (only process is proprietary)	Yes	Yes?
6. Are there any other costs not noted above?	Tank pump out	Tank pump out	Tank pump out; sampling, if required	Tank pump out	Tank pump out	Tank pump-out; filter cleaning

Attribute	FAST	Cromaglass	Bioclere	Amphidrome	Ashco RFS III	Wisconsin Mound*
7. How much does the system cost per residence when designed for the optimum number of houses specified in A.4?	Varies; e.g., one 3,000 g unit costs $10k; six 500 g units to serve same flow costs $18k.	Varies	Varies with flow and required effluent quality	Same as answer to C.1	$12,000-$15,000, all-inclusive	Varies
D. Complexity						
1. What types of (and how many) major moving parts are in systems for individual residential use?	1 above-ground blower	1electronically activated ball valve, 2 pumps	1 fan, 2 pumps	1 rotary blower; 2 submersible pumps	2 pumps	1 or 2 pumps depending on design
2. What are the major components in addition to a standard septic system and associated processes?	1. Above-grade blower for aeration, recirculation, and denitrification 2. Artificial media for microbial habitat	1. Fiberglass module replaces standard septic tank and contains treatment chambers for solids retention, aeration/anoxic cycles, and clarification 2. Pumps for aeration and flow transfer 3. Control panel controls timed sequences	1. Modular unit with trickling filter over clarifier 2. Permanent media inside filter for biological growth 3. Fan for oxygenation 4. Dosing pump & spray nozzles introduce wastewater to media 5. Sludge recirculation pump	1. Clear well tank stores flow for recirculation, backwash & discharge 2. Reactor tank contains underdrain, support gravel and media 3. Anoxic tank receives wastewater from bldg. & stores return flow 4. Media serves as filter and fixed-film reactor 5. Underdrain supports media and distributes air 6. Blower provides air to reactor 7. Control panel	1. Septic tank for solids settling 2. Recirculation tank/bottom zone that collects effluent from septic tank and filter 4. Pump moves effluent from bottom zone to sand filter 4. Sand filter has microorganisms for treatment 5. UV unit provides disinfection	1. Septic tank for solids settling 2. Pump tank to discharge effluent 3. Distribution network installed within sand fill
3. What are the components of the control system and what do they regulate?	Audible/visible alarm for high water level or blower failure.	Mechanical clocks or programmable and float activated switches governing cycle phase times (aeration, anoxic, mixing, settling, and discharge).	Analog controls control dosing and recirculation pumps. Fan runs constantly. Controls equipped with alarms. Upgrades available.	Programmable logic controls control aeration, recirculation, discharge and backwash.	Timer controls recirculation rate; alarm controls high water level.	Generally, pump float controls pump; high water float signals when water in pump tank too high and triggers alarm in house.
E. Other Features						

Attribute	FAST	Cromaglass	Bioclere	Amphidrome	Ashco RFS III	Wisconsin Mound*
1. Can an automatic dialer for malfunction alerts, including disconnects, be added to a system for individual residential use? If so, how much would it cost?	Remote dialer (TRACK system) has been approved by the FCC and is under licensing agreement. Costs will range from $150 for 1 line for 1 component to $400⁺ for 4 lines for 4 components.	All systems manufactured with remote dialer that monitors up to 3 parameters (power failure, high levels, and discharge pump failure). Service fee is $72/yr.	Yes, approximately $200-$300.	Yes, approximately $300 (have not provided for SFD).	Testing remote alarm now; doesn't cost much more because just use telephone line.	N/A
2. If the system has a failure, will it still function hydraulically as a standard septic system?	Yes	No	Yes, would act as secondary clarifier (water passes through after septic tank)	Better, because water will flow by gravity through a sand filter	Yes	No
3. Does the system allow for use of on-line back-up pumps and/or blowers?	If desired	None provided; spare pump can be added to reduce "down time"	Single family doesn't have backup pumps; larger units have duplex pumps	Not on residential systems, but designed into larger community systems	No	Multiple pumps can be installed
4. Is the system equipped with a means of measuring wastewater volume or pass through?	Flow meter can easily be added	Totalizers to record the number of batches (defined volumes) can be provided, cost about $100-$150.	Can be added if desired, but suggest using water meter as proxy when possible. Equipment costs around $3000 for SFD.	Yes, run times for each component recorded by PLC.	Use water meters	Theoretically can estimate flow from volume & frequency of pump out; in actual Pinelands study, counters routinely failed.
5. What components are visible above the ground for a residential system and how large are they?	Blower with 24"x18"x16.25" housing	Access covers (2 ft. diameter), air intake (2 in. PVC pipe), small irrigation box for denitrification valve, and control panel	Unit is 4ft. 2 in. in diameter and is installed 18 inches or more above grade	Access covers (up to 5) that are flush with the ground	Typical home has two 6'x12' cells that are covered with mulch that acts as a vent	In NJ, inspection ports required for septic tank, pump tank, and ends of disposal field; vent pipe and junction box for pump tank; and manhole covers for septic & pump tanks
6. Does the system create discernible noise at a distance of 50 feet?	"Slight"; in most instances, will be seen first	No	No	No	No	No
7. Is any odor detectable during normal operating conditions?	No	No	No	No	No	No

Attribute	FAST	Cromaglass	Bioclere	Amphidrome	Ashco RFS III	Wisconsin Mound*
8. How much reduction in drainfield size is possible for a system serving an individual residence?	Up to 60%	30-50%	Most states allow at least a 50% reduction	Up to 67%	1/3 - 1/2	No?
9. What other features enhance the performance, operation, maintenance, and/or homeowner acceptance of your system?	No response provided	- Can be equipped with indicator lights ($100) for each cycle phase and Hands-Off-Auto switches for pumps ($200) - Installation time & cost reduced due to modular construction - All systems have visual alarm lamp and audible alarm buzzer - Constructed completely of non-corrosive materials - Ease of O&M; accessible components, pump change in minutes	- No other features are necessary to enhance the system for individual residential use. Most effective method to improve performance is to use homeowners to manage the system to maintain biological functioning. - Clustering has many benefits including lower costs and protection against poor homeowner practices.	System is entirely below grade and provides high degree of nitrogen removal	Low maintenance, low impact, and not an eyesore	Relatively simple system; low maintenance and electrical costs
Permitting (section to be completed by PC staff)						
1. Require Treatment Works approval?	No	Yes	No	No	No	No
2. Require NJPDES approval?	No, only if > 2000 gpd	No, only if > 2000 gpd	No, only if > 2000 gpd	No, only if > 2000 gpd	No, only if > 2000 gpd	No, only if > 2,000 gpd
3. Subject to Clean Water Act?	No, only if NJPDES	No, only if NJPDES	No, only if NJPDES	No, only if NJPDES	No, only if NJPDES	No, only if NJPDES

* Responses to Questions A.2, A.3, and A.6 provided by Dr. James Converse at the University of Wisconsin; responses to Questions A.7 &8; B.1, 2, 3 &6; C.1 & 6; and E.6-8 provided by Herr Environmental, a leading installer of mound systems in WI; remaining responses provided by Commission Staff.