Title 5 Executive Order 562 (EO562) Comments

During MassDEP's regulatory review efforts under Executive Order 562, a number of stakeholders asked MassDEP to consider changes to the Title 5 regulations (310 CMR 15.00) and related changes to the Groundwater Discharge Permitting regulations (314 CMR 5.00). Changes sought include review of Title 5 design flows, changing the threshold for flows that now trigger groundwater discharge permits (e.g. allow higher flows to be handled under Title 5), allowing increased use of holding tanks for peak flows, reducing the current requirement for separation from groundwater for innovative Title 5 systems, and implementing a statewide uniform Title 5 code (thus eliminating ability for municipalities to have more stringent requirements). This document is a compilation of those comments received during EO 562 in 2015.

To navigate the document in Chrome: click the Bookmarks symbol at upper right to open the Bookmarks menu.

To navigate the document in Firefox or Internet Explorer: click the "Acrobat" symbol at the bottom of the screen to open the Bookmarks menu (the second icon from the top) or click on the outline symbol as shown in the second image.

In early 2017, MassDEP will be convening an external stakeholder group representing a variety of interests and viewpoints to help consider which changes MassDEP should propose.

BU

Boston University School of Public Health
Department of Environmental Health

June 24, 2016

Regulatory Comments regarding the MassDEP Proposed Amendments to 310 CMR 15.00, 310 CMR 32.00, and 314 CMR 18.00

RE: Land Application of Composting Toilet Liquid By-Product

Dear Commissioner Martin Suuberg:

The Massachusetts Department of Environmental Protection has been a leader in protecting the Commonwealth's waters. It can broaden its reach by further reducing nitrogen loading in Massachusetts' water by allowing for the responsible agronomic application of composting toilet leachate.

Wastewater from septic tanks and municipal wastewater treatment plants are a major form of nitrogen pollution. [1] Nitrogen discharges from wastewater treatment plants to receiving water bodies are measured in the thousands of pounds per day. [2] Nitrogen mitigation is critical for the integrity of Massachusetts' waters and public health. Technologies that reduce nitrogen, such as advanced septic systems designed for high-level nitrogen removal, and composting toilets that have zero discharge of nitrogen (leachate is contained for mechanical removal) have the highest cost-effectiveness as measured by dollars per kg of nitrogen removed from the watershed.[3]

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[1] Per capita contribution to Nitrogen in domestic wastewater is 8-12 lb of N/yr. About 60% is in the form of ammonia and 40% is bound in organic matter. Conventional primary and secondary treatment extracts approximately 25% of the total nitrogen, leaving most of the remainder as ammonia in the effluent.

[2] Deer Island releases approximately 70,000 lb/day of total nitrogen. http://www.mwra.state.ma.us/harbor/enquad/pdf/2015-01.pdf

[3] Cost-effectiveness of nitrogen mitigation by alternative household wastewater management technologies. A. Wood et al. Journal of Environmental Management 150 (2015)

Nitrogen, in the forms of nitrate, nitrite, or ammonium, is an essential nutrient for plant growth, but in water it can cause adverse health and ecological effects. [4] For instance, concentrations of nitrate in lakes and streams greater than 5 mg/L (measured as nitrogen) can lead to eutrophication and the excessive growth of blue-green algae (cyanobacteria). If nitrate exceeds 10 mg/L in drinking water, it can cause a condition called methemoglobinemia or "blue baby syndrome" in infants. [5] The International Agency for Research on Cancer (IARC) classifies nitrates and nitrites as "probably carcinogenic to humans." [6] Nitrite is extremely toxic to most fish and aquatic life.

Boston's Deer Island Wastewater Treatment Plant releases approximately 12,000 metric tons of total nitrogen per year into the Atlantic Ocean. This is near the "caution threshold" for nitrogen stipulated in the MWRA's NPDES discharge permit (No. MA0103284).[7] Chemically reducing nitrogen in wastewater treatment plants is a technically difficult and costly option.

Denitrification of municipal wastewater requires a carbon source, such as methanol. The addition of methanol increases sludge production at the rate of about 0.6 lb/lb of nitrate nitrogen reduced, adding thousands of pounds of sludge production per day. The MWRA estimates that reducing nitrogen to 4mg/L at the Deer Island plant would result in an additional production 47,000 lbs/day of sewage sludge. [8]

A 2007 engineering report for the DEP estimated that at twenty-one WWTPs in Central Massachusetts the total costs to achieve annual total nitrogen limits of 8 mg/L is $750 million and 5 mg/L is $900 million. [9]

Composting toilets do not reduce nitrogen as part of their treatment process. Instead, single batch systems like the Clivus Multrum, capture nitrogen, with no effluent discharged. Currently Massachusetts' regulations require that leachate from composting toilets go to wastewater treatment plants, adding to an already high nitrogen load at these facilities. The state can reduce this nitrogen load by allowing for the mechanical removal of the leachate and use in agriculture (agronomic rates for nitrogen application are well-established). Science-based rules can assure the treatment, storage, transport, and safe disposition of leachate from a composting toilet so that the state can have reasonable confidence that is not causing harm to public health or water quality. Fecal coliform and total coliform can be tested and benchmarks established that are protective of public

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[4] http://water.usgs.gov/edu/nitrogen.html

[5] http://www.atsdr.cdc.gov/csem/csem.asp?csem=28&po=10

[6] The International Agency for Research on Cancer (IARC) classifies nitrates and nitrites as "probably carcinogenic to humans" (Group 2A) under certain conditions. http://www.atsdr.cdc.gov/csem/csem.asp?csem=28&po=10

[7] http://www.mwra.state.ma.us/harbor/enquad/pdf/2015-01.pdf

[8] http://www.mwra.state.ma.us/harbor/enquad/pdf/2015-01.pdf

[9] http://www.mass.gov/eea/docs/dep/water/resources/n-thru-y/potwexec.pdf

health. [10] Agronomic application will put this important nutrient where it belongs: on plants.

Sincerely,

Laura Orlando, Civil Engineer, MPA
Adjunct Assistant Professor
Boston University School of Public Health
lorlando@bu.edu
16 Ackers Terrace, Brookline, MA 02445

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[10] Testing of Clivus Multrum leachate in 2016 showed <0.2 MPN/100 ml Fecal Coliform and <161 MPN/100 ml Total Coliform.

Clivus New England, Inc.
P.O. Box 127
North Andover, MA 01845
(978) 794-9400
Fax: (978) 794-9444
E-mail: 123CNE@clivusne.com

clivus new england incorporated

COMPOST LEACHATE - 3rd Method Reuse

15.289: Humus/Composting Toilets

We request that under 15.289 (1)(a) a 3rd method, specifically reuse of any compost leachate from composting units (as described in Revised April 2006 DEP publication), be allowed.

Presently known as liquid by-product, it is required to be disposed of in one of two ways: in a septic tank or at a sewage treatment plant. Either disposal method creates water pollution.

The liquid by-product (compost leachate) from composting units is high in Soluble Inorganic Nitrogen which is a nutrient resource for plants, trees, and other land based vegetation. The ability to recycle and reuse this resource would be a great benefit as a natural fertilizer.

Hauling to, and disposing at, a sewage treatment plant wastes valuable resources and generates even more pollution. There is no need to require this practice. Composting units, especially at public and commercial facilities, generate significant amounts of compost leachate (compared to residential installations) which can be put to good use instead of creating pollution.

We respectfully request that under 15.289 (1)(a) the following third method be inserted using the alternative name “compost leachate.”

“   3. compost leachate recycled onto the land for absorption of the nutrients, where applicable, by plants and trees (excluding any human food crops) for soil erosion control and/or forest floor betterment.”

Thank you for allowing me to participate in a very interesting and well-run meeting yesterday. The opening statement, and particularly the statistics being developed by the Department in the map you showed were captivating. With that many people using onsite systems in Massachusetts it explains why there is such interest in getting the regulations tweaked and adjusted.

While I look forward to discussing topics such as rural camping privies and flow calculations from cluster housing units, I think it more important at this time for me to provide a follow-up to my closing remarks asking if the Department would consider revising the layout of Title 5. The issue is frankly larger than that and I was not sure if I should have brought it up in the meeting so I decided to let it sit and send this email instead.

The truth is that we have a generally failed operational system as it relates to onsite wastewater here in Massachusetts. It is not a fault of the Department's, but unfortunately I only see the Department being able to resolve it. The concepts below, if acted on, would not only help the environment and remove considerable duress, it would also fit nicely into the goal of Executive Order 562 and show EOEEA and others how the Department is a leader in streamlining regulations and their impact.

Some of the biggest issues are:

- The 1995 Code was predicated on DEP having staff dedicated to overseeing and advising on its implementation and offering routine training to practitioners. Due to budget cuts over the last decade or two this has been essentially completely eliminated. The Department's primary role in onsite seems to be dealing with specific permits/applications which need to come its way, and also assisting on a case-by-case basis when asked. As we sit today there is no comprehensive leadership, training, advice or information provided

- The 1995 Code is hard to read. I think most people would rather spend time reading War and Peace rather than trying to decipher some of the arcane sections, confusing subjects and choppy organization that exists at 310 CMR 15

- Title 5 has generally not been updated to deal with the current state of knowledge of onsite wastewater treatment and dispersal (except to allow for some of the newer I/A technologies)

- There are multiple people who use and implement this code including property owners, designers, pumpers, excavation contractors, professional health department staff, volunteer board of health members, people who maintain systems and others. Having a good regulation and reaching these folks with good sound quality information so informed decisions can be made is a real challenge. I would guess most other regulations the Department writes have a much more limited audience

- Municipal health departments and boards of health are generally not well equipped to deal with proper implementation of Title 5. Part of this relates to lack of knowledge being shared from the Department as described above, part of this is a result of tightening municipal budgets providing for reduced staffing in municipalities, part of this is a result of the myriad of responsibilities falling on under-staffed health departments, part of this is the awkward system that exists with lay volunteer board members who supervise professional health department staff, and part of this is the lack of a career path that exists for local health officials which results in a weak talent pool

What can be done about this? Here are a few thoughts which the Department, with or without this committee, could see to:

- Learn from CT and RI. I think this could provide easy and low hanging fruit. The RI code is soundly based on science. They understand what happens with onsite systems, containerized treatment systems, and soil-based treatment of effluent and have a set of rules which are real smart. They also have a technical advisory committee that meets regularly to review and update these. The CT Code is not great, but they have a state-wide regulation with local health department implementation just like Massachusetts so a lot could be learned about implementation. The CT DPH (not DEP) has a section chief and three staff who work with and advise local health officials and as such its implementation is similar to what Massachusetts used to strive for. What they have also done in CT is to provide a supplement to their version of Title 5 which they call their Technical Standards. This is much like the GW Discharge Guidance document that the DEP has, and the beauty is it does not require a code revision to update it. In fact the Technical Standards are updated every two years to reflect the latest understanding of onsite wastewater. CT also has a regular quarterly meeting of a Code Advisory Committee to help ensure good dialogue. Both these agencies have smart and capable staff who I would think jump at the chance for a call or two or a road trip to try learn best practices.

- Learn from national experts. You have Larry Stephens as a resource, and NOWRA can get you others. Perhaps explain to these people the issues I have outlined above or other issues that you see, and ask what models or ideas they can share with you that other places have implemented. In every state the stakeholders are the same and the goal to achieve proper wastewater treatment is the same.

- Revise Title 5 to be more readable. Even if a single word is not changed but it is simply formatted differently it would immensely help the mis-interpretation of the document and generally increase the level of understanding and compliance. For example, I have attached the Idaho onsite system regulations table of contents. They have organized things into nice easy to follow sections depending on who the user is. We have nothing of the sort. The confusion that is in the regulations boils down to confusion in the field and that is not good for the environment nor proper implementation.

- Work with professional associations such as MMA, MEHA, etc. to get them to acknowledge the shortcomings of the current system and how it is implemented at the municipal level. I am not advocating removal of local powers, rather I am asking the Department to lead discussions with these folks to help develop a better system across the state. There are towns on the Cape and elsewhere with PhD folks running their health departments, and towns elsewhere with myopic and small-minded people in charge and no budget to support them. This uneven implementation leads to much frustration. The system is broken and if you ask local officials most of them would agree with you. They are generally under-staffed and under-trained in onsite wastewater issues. They should be able to acknowledge this and help build a coalition towards finding a better solution.

I understand this presents a boatload of work if it were to be implemented but it truly has been since 1995 that this issue has been looked at in earnest in Massachusetts and I think the time is right to do so now. Feel free to share this email with others as you see might be appropriate.

I hope this helps. If I can be of further assistance please do not hesitate to contact me.

Best,

Dan Ottenheimer

Table of Contents

58.01.03 - Individual/Subsurface Sewage Disposal Rules

Meta-analysis of data relating to fecal coliform penetration to different depths beneath standard septic system leachfields.

Data from Massachusetts Alternative Septic System Test Centers from various studies conducted between 2001 and present.

Compiled by George Heufelder, Barnstable County Department of Health and Environment, gheufelder@barnstablecounty.org

The following presents a meta-analysis of data from various studies in which there was successively greater vertical separation between the lowest soil-wastewater interface and the collection point. All studies involved stone-in-pipe trenches of various configurations, hydraulically loaded at the prescribed rate of 0.74 gal/sq ft./day in sandy soils (< 2 min/inch percolation rate). Vertical separations between six inches and five feet are included.

Brief Descriptions of Studies Used

STUDY 1 includes the first trenches installed at MASSTC and were used as control trenches in a number of comparative studies. Sample collection was by means of pan lysimeters situated beneath the trench at depths of one foot, two feet and five feet. In addition, a liner under the entire set of trenches collected the percolate collectively under all three trenches. Since the five-foot pan lysimeter did not collect percolate in sufficient volume, data from the entire collection sump are combined to represent the five-foot level of removal. These later data would actually represent a 5+ foot separation.

Below is a schemata of a representative sampling lysimeter.

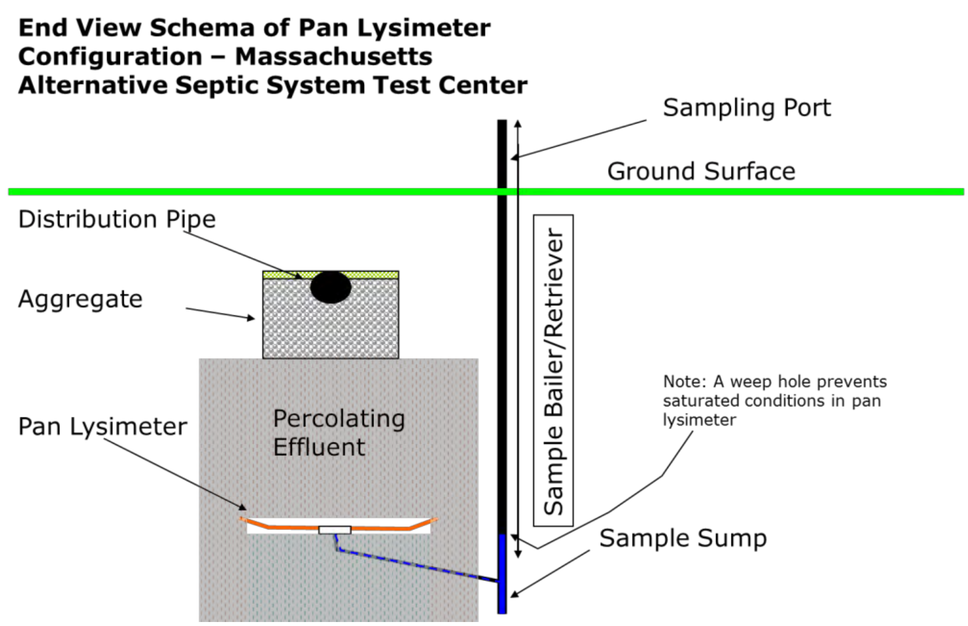

Figure 1 Schemata of pan lysimeters used to collect fecal coliform samples at MASSTC.

STUDY 2 was part of a National Sanitation Foundation study where the data reported here was collected during experiments where the trenches were used as control comparisons. In this study five parallel trenches were sampled 18 times within approximately six months and the data are combined. There was a common septic tank influent. Samples were collected from a liner that was continuous under the entire leach trench.

STUDY 3 was part of a comparison test where the three trenches reported on here were control comparisons. This study combined three parallel one foot x one foot trenches. This is the only data point for a six-inch separation. Samples were collected from a liner that was continuous under the entire leach trench.

Results

An evaluation was made of the relationship between depth of collection point (a surrogate measure of the separation distance to groundwater) and the $\log_{10}$ fecal coliform removal using Pearson's correlation. An analysis using Pearson's correlation coefficient indicates a statistically significant linear relationship between the two *($r^2 = 0.85$, $p < .001$).* As expected, the greater separation between the wastewater-soil interface and the sample collection point, the greater the fecal coliform removal (table 1 – figure 2)

Table 1. Vertical separation between wastewater-soil interface and associated $\log_{10}$ reductions of fecal coliform.

Vertical Separation	Log(10) Reduction in Fecal Coliform
0.5	2.60
1	3.03
1	3.19
1	2.92
1	3.81
2	3.80
2	3.27
2	3.53
2	4.25
5	4.60
5	5.34
5	4.70
6	4.88
6	5.05
6	4.99

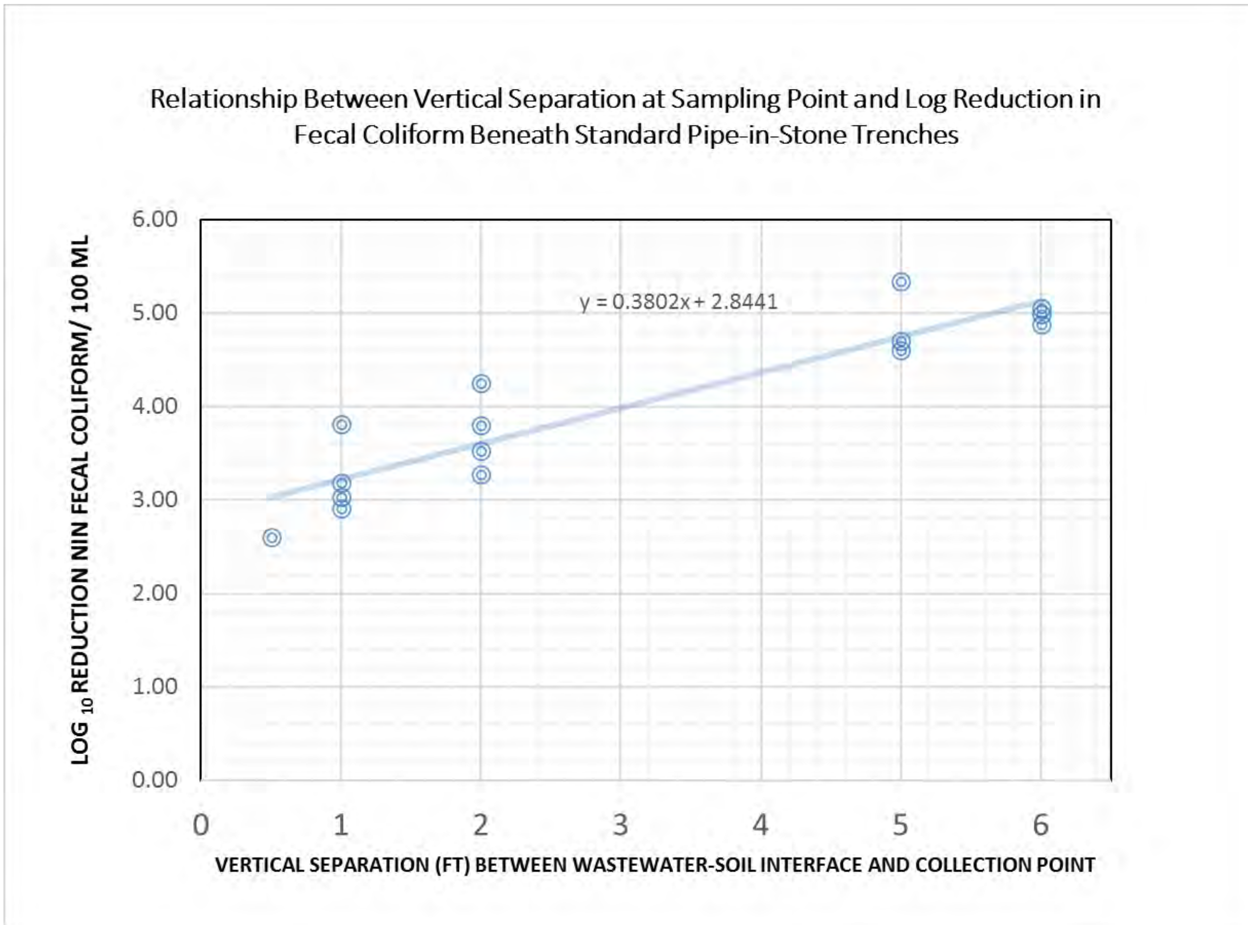

Figure 2. Correlation between vertical separation and fecal coliform reduction.

Discussion

The relationship between the reduction in fecal coliform (as expressed by $\log_{10}$reduction) and vertical separation between wastewater-soil interface and collection point is expressed herein for a standard stone trench of various configurations and hydraulically loaded at 0.74 gal/sq. ft/day. The reader should understand that the actual removal rate will be dependent on factors specific to the location including hydraulic loading rate, method of application of the wastewater, soil type, rate of application (instantaneous vs. intermittent), geometry of the drainfield, dispersal mechanism (i.e. trench vs. bed) and other factors. It should also be understood that, although the fecal indicator of fecal coliform is generally used as a surrogate measure of public health threat, it is may not be an indicator of virus entrainment with the wastewater. Below, we present the information from previous work. This is particularly important since the infective dose of viruses is generally considered one virus particle compared with bacteria, many of which have higher infective doses (> 1000 organisms).

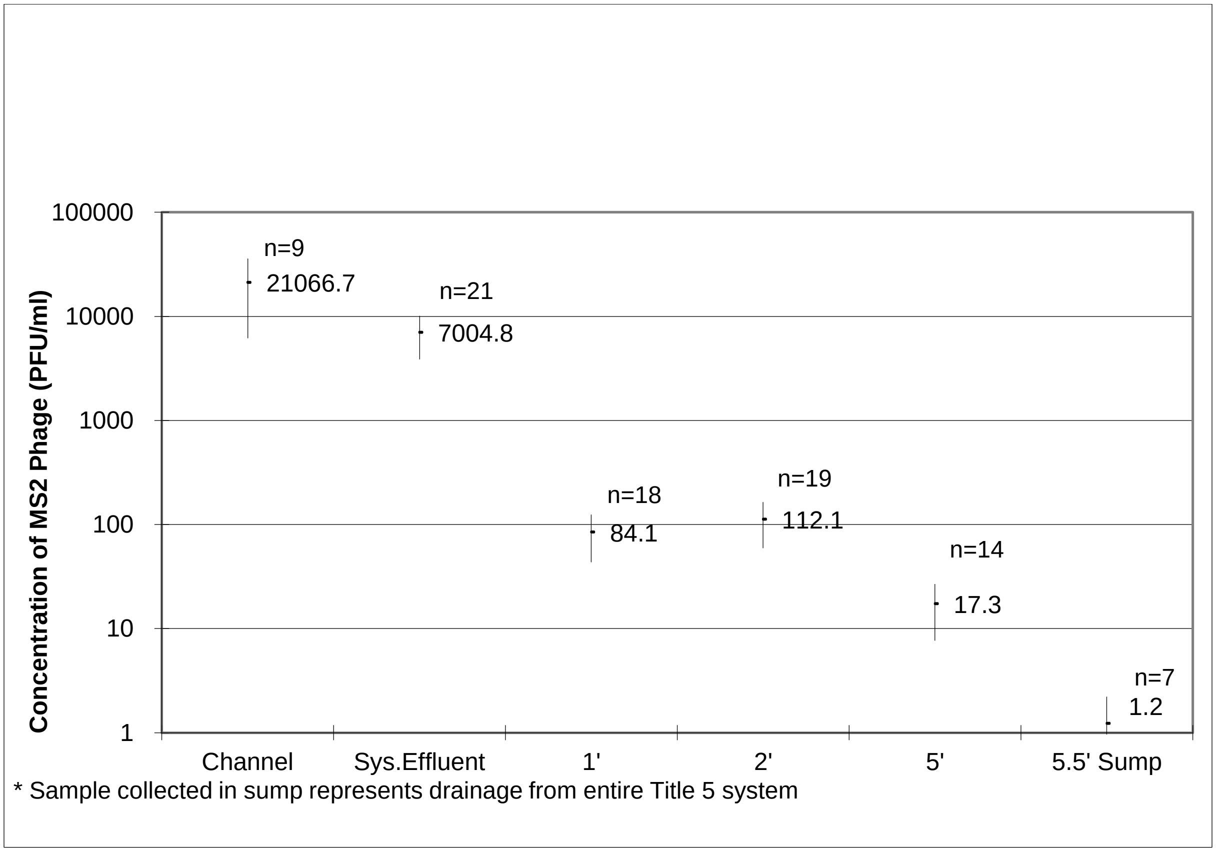

Figure 3 MS-2 Phage virus removal compared with vertical separation between wastewater-soil interface and collection point.

Relative to virus transport and implications for vertical separation, this prior report[1] concluded:

[1] Higgins, J.J., G. Heufelder, and Sean Foss. 1999. Removal Efficiency of Standard Septic Tank and Leach Trench Septic Systems for MS2 Coliphage. Proc. 10th Northwest On-Site Wastewater Treatment Shortcourse. September 20-21, 1999, Univ. of Washington, Seattle, WA. pp. 81-88.

"Collectively, the data suggests that the Massachusetts regulations requiring a five-foot vertical separation between the bottom of the leaching system and groundwater (for sandy soils with a percolation rate of < 2 minutes per inch) provides for over a 3 log10 or 99.9% removal of viruses at the allowable loading rate (3 cm/day or 0.74 gal/sq. ft/day)."

DETERMINING THE EFFECTIVENESS OF ON-SITE SEPTIC SYSTEMS FOR THE REMOVAL OF VIRUSES

PROJECT NUMBER 98-01/319

PREPARED BY:
BARNSTABLE COUNTY DEPARTMENT OF HEALTH AND THE ENVIRONMENT
SUPERIOR COURTHOUSE, ROUTE 6A
BARNSTABLE, MASSACHUSETTS 02630

PREPARED FOR:

MASSACHUSETTS DEPARTMENT OF ENVIRONMENTAL PROTECTION
BUREAU OF RESOURCE PROTECTION

AND

U.S. ENVIRONMENTAL PROTECTION AGENCY
REGION 1

MASSACHUSETTS EXECUTIVE OFFICE OF ENVIRONMENTAL AFFAIRS
Robert Durand, Secretary

DEPARTMENT OF ENVIRONMENTAL PROTECTION
Lauren A. Liss, Commissioner

BUREAU OF RESOURCE PROTECTION
Cynthia Giles, Commissioner

DIVISION OF MUNICIPAL SERVICES
Michael Rotondi, Director

DIVISION OR WATERSHED MANGE MENT
David Terry, Director

DETERMINING THE EFFECTIVENESS OF ON-SITE SEPTIC SYSTEMS FOR THE REMOVAL OF VIRUSES

PROJECT NUMBER 98-01/319

CONDUCTED 1998-2001

PREPARED BY:

BARNSTABLE COUNTY DEPARTMENT OF HEALTH AND THE ENVIRONMENT
SUPERIOR COURTHOUSE, ROUTE 6A
BARNSTABLE, MASSACHUSETTS 02630

PREPARED FOR:

MASSACHUSETTS DEPARTMENT OF ENVIRONMENTAL PROTECTION
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AND

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DETERMINING THE EFFECTIVENESS OF ON-SITE SEPTIC SYSTEMS FOR THE REMOVAL OF VIRUSES

PROJECT NUMBER 98-01/319

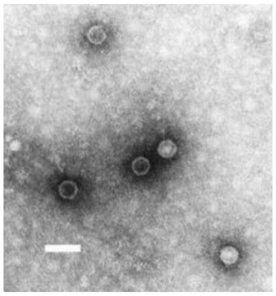
PREPARED BY:
BARNSTABLE COUNTY DEPARTMENT OF HEALTH AND THE ENVIRONMENT
SUPERIOR COURTHOUSE, ROUTE 6A
BARNSTABLE, MASSACHUSETTS 02630

EXECUTIVE SUMMARY

In 1995, the Commonwealth of Massachusetts made significant changes to its regulations governing onsite septic systems to reflect advancements in the knowledge base of onsite wastewater treatment. While these changes reflect many of the advances in our understanding of the treatment for certain constituents, much was still not understood about the role of standard septic tank-leach fields in the treatment for pathogens, notably viruses. The need for this type of understanding was amplified when the state allowed the use of innovative/alternative (I/A) septic systems, which under certain approvals were allowed to compensate for certain deficiencies that an applicant might present (i.e. less distance to groundwater or less available soil absorption system area). While the efficacy of I/A for treatment of certain constituents was widely accepted, questions arose as to whether the "credits" granted to I/A technology were appropriate in light of the present knowledge base regarding pathogens. The purpose of this study was to determine the efficiency of standard septic systems for the removal of viruses and compare this performance with selected I/A technology. The study further endeavored to place the findings in context of recent literature and make recommendations for maximizing virus removal from onsite septic systems.

Results from our study were presented in many forums including two journals, four national meetings, two regional meetings, and two annual meetings of the Massachusetts Environmental Health Association. Copies of all presented/published papers are supplied herein. Although there is considerable research still to be conducted, this grant has allowed us to serve as a valuable resource to DEP and Boards of Health for issues regarding pathogens. Our research corroborates the decision by DEP to require pressure dosing of leachfields where I/A technologies receive "credits" for leachfield size or reductions to groundwater. A review of the literature along with concurring research under this grant compelled certain recommendations that are included in this report. The findings of this study will also be incorporated into revisions of training materials yet to be compiled and including the Department's "*Self-Pace Course in Title 5***"** for local Boards of Health.

This project was funded by the Massachusetts Department of Environmental Protection with funds from the Environmental Protection Agency under a Section 319 competitive grant. The contents do not necessarily reflect the views or policies of the department not does the mention of any product or trade name constitute and endorsement



INTRODUCTION

What have we learned about viruses?

Since the beginning of our understanding of the role of improper human waste disposal in disease transmission, it is broadly accepted that wastewater systems should discharge their contents as far as practical from points of human exposure. Societies generally struggle, however with the question of *how far is enough?* Unfortunately, the lack of understanding sometimes results in debilitating human disease (evidence the polio[1] epidemics of the early 50's) and forces readjustments to our strategies. In response to the proposed National Primary Drinking Water Regulations: Ground Water Rule, published May 10, 2000, in the *Federal Register*, the American Society for Microbiology (ASM) commented that "Emerging contaminants, including new viruses, will be discovered in the future and effective monitoring programs must be in place". Their comments reflect our absence of a complete understanding of the various aspects of viral pathogens, their modes of transmission, and the various factors that determine their entrainment and persistence in groundwater. The overall goal of the present project is to incorporate the latest understanding of the various factors controlling the presence and persistence of septic-system-derived pathogens and incorporate this knowledge into recommendations for prudent practices that protect the public health.

Beginning in the early 1990's, the Commonwealth of Massachusetts began the process of evaluating The State Environmental Code 310 CMR 15.00 (commonly referred to as "Title 5"[2]), in order to incorporate the state of knowledge regarding sound environmental and public health principles into their requirements for the construction and siting of onsite septic systems. As a first step, the firm of DeFeo, Wait and Associates, Inc. was commissioned to perform a Technical Evaluation of Title 5. Although the review of the then-present state of

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[1] The illustration is that of a polio virus taken from the EPA website www.epa.gov/nerlcwww/images.htm
[2] Full citation: **THE STATE ENVIRONMENTAL CODE, TITLE 5: STANDARD REQUIREMENTS FOR THE SITING, CONSTRUCTION, INSPECTION, UPGRADE AND EXPANSION OF ON-SITE SEWAGE TREATMENT AND DISPOSAL SYSTEMS AND FOR THE TRANSPORT AND DISPOSAL OF SEPTAGE**.

science regarding viral pathogens in this evaluation was somewhat cursory, the final recommendations of the report included two important design recommendations that are now generally acknowledged as promoting better pathogen removal during onsite treatment and disposal. Although not explicitly incorporated for pathogen treatment, these recommendations included *the lowering of the hydraulic loading or application rate of effluent to the soil absorption system*, and the *increased vertical separation requirements between the bottom of the soil absorption system and estimated high groundwater in coarse soils*. Both these recommendations, subsequently incorporated into the regulations, are supported in theory by work of Marylynn Yates (1987) in a report for the Office of Groundwater Protection (USEPA) titled “Septic System Siting to Minimize the Contamination of Ground Water by Microorganisms” as well as other authors.

The minimal consideration of the virus issue in evaluations performed prior to 1990 is understandable in light of the fact that the majority of pertinent research has only more recently been conducted. For instance, 71 out of 135 articles (over 50%) referenced in a recent benchmark review of the removal of viruses in soil passage by Schijven and Hassanizadeh (2000) were published since 1990, and many of these were published only after 1995.

The purpose of the present study was:

- to conduct practical research in the area of treatment for viruses by standard onsite wastewater treatment systems
- to perform limited research on the treatment of viruses by standard and selected innovative/alternative onsite septic systems
- to present the results of the research in a wide variety of forums for training purposes and comments
- to make recommendations to the Commonwealth and local Boards of Health relative to ways that sound research can be incorporated into regulation and/or policies that protect the public health.

- To incorporate any recommendations made into training and educational outreach materials for Boards of Health.

RESULTS

In keeping with a primary objective, results of the research under this grant were presented in a variety of forums, beginning with a presentation of the study outline and concept before the National Onsite Wastewater Recycling Association at their annual meeting in 1997. The culmination of the research was recently presented at two wastewater treatment short courses (one in Washington State and one, the first of its kind, in New England). The various papers and their forums are presented below.

Heufelder, G. and S. Foss. 1997. Virus Transport Studies at an Alternate Onsite Septic System Testing Center in Cape Cod. Conference Proceedings, National Onsite Wastewater Recycling Association, College Station Texas, October 1997.

Heufelder, G. 1998. Survival of Viruses in Two Types of Onsite Systems. Conference Proceeding, National Onsite Wastewater Recycling Association, Ft. Mitchill Kentucky, October, 1998.

Heufelder, G. R. 1999. Preliminary Results: Virus Removal Efficiency of Newly-Started Trickling Filters and a Standard Leaching Trench. Environment Cape Cod. Vol. 1(3):86-90.

Higgins, J., G. Heufelder, S. Foss. 1999. Removal Efficiency of Standard Septic Tank and Leach Trench Septic Systems for MS2 Coliphage. In Seabloom, R.W. (Ed). Proceeding of the 10th Northwest On-Site Wastewater Treatment Short Course and Equipment Exhibition, September 20-21,1999, Seattle, Washington. Engineering Professional Programs, University of Washington, Seattle. Pp. 81-87.

Higgins, J., G. Heufelder, S. Foss. 1999. Removal Efficiency of Standard Septic Tank and Leach Trench Septic Systems for MS2 Coliphage. Small Flows Research. Vol 1(2).

Higgins, J., G. Heufelder, S. Foss. 1999. Removal Efficiency of Standard Septic Tank and Leach Trench Septic Systems for MS2 Coliphage. Environment Cape Cod. Vol 2(2). Pp 26-29.

Howes, B.L., J. Higgins, G. Heufelder and S. Foss. 2000. Removal of MS2 Coliphage Virus by Standard Septic Tank-Leach Trench Septic Systems. N.E. Water Environment Association Annual Meeting.

Foss, S., J. Higgins, and B. Berstene. 2002. Comparison of Standard Septic Tank-Leach Trench Septic Systems with Two Enhanced-Treatment Septic Systems for Attenuation of MS2 Coliphage. Proceeding of the 11th Northwest On-Site Wastewater Treatment Short Course and Equipment Exhibition, September April 3-4,2002, Seattle, Washington. Engineering Professional Programs, University of Washington, Seattle.

Foss, S., J. Higgins, and B. Berstene. 2002. Comparison of Standard Septic Tank-Leach Trench Septic Systems with Two Enhanced-Treatment Septic Systems for Attenuation of MS2 Coliphage. Proceedings of the First Onsite Wastewater Treatment Short Course and Equipment Exhibition. March 25-25, 2002. Newport, Rhode Island (in press)

In addition to these publications, the results of our efforts were also presented at two annual meetings of the Massachusetts Environmental Health Association.

The value and credibility of our work in regard to virus transport may also be measured by the number of times the work is cited in work of other researchers in the field. Our work was cited in at least two papers contained in the *Proceedings of the 9th Symposium on Individual and Small Community Sewage Treatment*. Fort Worth, Texas. American Society of Agricultural Engineers, St. Joseph, Michigan. These papers are authored by leading researchers in the field of virus transport beneath septic systems and our work is cited as a credible source of information. In addition, our research was again cited in a conference sponsored by the U.S. Environmental Protection Agency, Electric Power Research Institute, and the National Decentralized Water Resources Capacity Development Project, titled **National Research Needs Conference: Risk-Based Decision Making for Onsite Wastewater Treatment,** May 19 – 20, 2000 St. Louis, Missouri. Our work was cited in two "White Papers" (Design and Performance of Onsite Wastewater Soil Absorption Systems, co-authored by Robert L. Siegrist, Environmental Science and Engineering Division, Colorado School of Mines; E. Jerry Tyler, Soil Science Department, University of Wisconsin; and Peter D. Jenssen, Agricultural Engineering Department, Agricultural University of Norway, and Research Needs in Decentralized Wastewater Treatment and Management: Fate and Transport of Pathogens by Dean O. Cliver, Department of Population Health and Reproduction, School of Veterinary Medicine, University of California, Davis). Again, these authors cited our work as credible information on virus reductions in onsite septic systems.

Copies of all articles published under this grant are presented in the appendices.

RECOMMENDATIONS AND COMMENTS

As this project developed, we framed the information gathered and the literature reviewed around a series of practical questions relating to the changes in Title 5 that were promulgated in 1995, the allowances and credits given innovative/alternative technologies under Remedial Use Approvals, and local regulations that, for the most part, continued to exceed the requirements of Title 5 in many cases regarding horizontal setbacks to resources. These questions were:

- Do the changes made in Title 5 promote better removal of pathogens, particularly viral pathogens?
- What are the implications of the "credits" given to the use of innovative/alternative technology under their Remedial Use Approval letters? (this refers to the relief of 2 ft. of separation between the bottom of the soil absorption system and groundwater or the allowance for up to 50% reduction in the size of the soil absorption system when I/A technology is used)
- Is there continued justification for local increased setback requirements in certain situations?

Do the changes made in Title 5 promote better removal of pathogens, particularly viral pathogens?

Despite our research and considerable work by others, there are still many unanswered questions regarding the factors that influence virus transport both through the unsaturated (or vadose) zone beneath the septic system and in the saturated groundwater flow. There is, however nearly unanimous agreement that the primary treatment for viruses in the onsite septic system is in the vadose zone beneath the system. Additionally, the degree of "true" saturation greatly affects virus attenuation. Our early experiments with a new (hence immature) leaching trench showed virtually no removal of MS2 at a depth of 2 ft. beneath the bottom of the trench (Heufelder, 1999) as opposed to 99% removal in mature leach trenches

(Foss et. al. 2001). We posit that in the first situation, no biological mat had yet formed to promote a more even distribution of effluent over the entire infiltrative surface and there was in effect saturated flow to the collection lysimeters. In the second situation where a restrictive biomat promoted some "ponding" (suspension of a shallow depth of effluent across the entire bottom infiltrative surface), a more even distribution of effluent takes place. This situation (see Van Cuyk, S. and R.L. Siegrist, 2001) is generally conducive to better removal of pathogens.

The 1995 changes to Title 5 allowed for at least three changes that, in concurrence with the recent literature, promote virus attenuation. Foremost, the effluent loading rates (Specified in 310 CMR 15.242) were reduced. Ostensibly, these reductions reflected the concept of long-term acceptance rate (LTAR), but coincident work done by this author in 1991 (Heufelder, 1991) based on adjusted regression equations presented in Yates (1987) indicate that the new loading rates also theoretically promoted >5 log reduction in viruses in sandy soils (assuming a 5-ft vertical separation between the bottom of the leachfield and groundwater).

The second change in Title 5 that promotes better virus removal was the increased distance to groundwater required for "fast" soils (percolation rates <2 minutes/inch). This change is supported by literature summarized by Yates and Yates (1988) and others that indicate that certain viruses have been shown to vertically travel greater distances in coarser soils. Accordingly to force greater travel distances under unsaturated conditions would intuitively lead to greater virus removal and more hydraulic residence time and contact with reactive soil surfaces.

The third change in Title 5 that enhances virus removal unfortunately was not adopted in its fully recommended scope. The Technical Evaluation of Title 5 (DeFeo, Wait and Associates, Inc. 1991) concluded that wastewater distribution systems should promote more even distribution over the entire infiltrative surface. This could be achieved by reducing the distribution lateral diameter (even in gravity fed systems) and alternately dosing and resting the soil absorption system (Section 14.2 - DeFeo, Wait and Associates, Inc. 1991). These recommendations were only partially incorporated into Title 5. At this point, dosing of the soil absorption system is only required in system exceeding 2000 gal/day flow, and smaller diameter pipes on gravity systems are not allowed. Pressure dosing is also required under the Remedial Use Approval of all I/A technologies and will be discussed below.

The even distribution of effluent over the entire soil absorption system area addresses a critical feature that regulates virus removal in the vadose zone - the wastewater application rate. It is generally believed that until a mature biomat is formed, a standard gravity-fed soil absorption system is characterized by localized areas of higher application rates. That is, when a gravity-fed septic system is started, the effluent, exiting the lowest holes in the distribution laterals, exerts a locally high application rate in gal/sq ft/day compared with the theoretical design loading which assumes the discharge volume is spread over the entire *available* area. But until the genesis of a biomat causes uniform distribution of effluent over the entire available area, there are areas of application rates far exceeding the design loading (in gal/sq ft/day). This concept, most recently described in Van Cuyk, S. and R.L. Siegrist (2001), is generally understood and accepted. True lower wastewater application rates promote virus attenuation by encouraging lower effluent velocities across more soil surfaces. It is on the soil surface, particularly if the media is reactive toward the contaminant, that the virus is retained and often inactivated. Chu et.al.(2001) reports that, for instance, when metal oxides are present to “bind” with viruses (such as would be present in many sand sediments found in Barnstable County), flow velocities are inversely related to virus removal. Ryan et al. (in press) confirms that soils in Barnstable County have a reactive coating of iron oxides that offers the opportunity to maximize virus removal, if system designs encourage unsaturated flows.

We conclude that recent literature and understanding of virus transport in the vadose zone supports strongly the original recommendations by DeFeo, Wait and Associates. In areas with sensitive receptor sites (wells, downgradient recreational waters), all practical means to promote use of the maximum infiltrative surface within the shortest possible timeframe is warranted. Although this author is not aware of the results from gravity fed soil absorption systems using smaller diameter pipes, this seems to be one possible means of distribution that should be subject to further investigation. This later strategy may address the objections to pressure dosing: objections that are usually economically based. In seasonal situations, where the biomat is essentially restarted at the beginning of each season, this may be particularly relevant.

What are the implications of the "credits" given to the use of innovative/alternative technology under their Remedial Use Approval Letters?

The rationale for the requirement that all I/A systems receiving "credits"[3] must employ pressure dosing is unknown. It is, however, believed to be appropriate. At the initiation of the policy little was known about the pathogen reductions within the I/A technologies themselves. It was generally understood however, that the low organic loads of the I/A effluent would prolong the formation of a biomat, which as stated promotes uniform distribution in the soil absorption system. Since pathogen removal is enhanced by uniform distribution (and conversely pathogen removal is less when there is preferential flow), it was prudent to require some accepted mechanism to compensate for the lack of a biomat and that would promote uniform distribution. Pressure dosing promotes uniform distribution by more closely approximating the theoretical design application rate from the first day of operation. A *gravity-fed* system following secondary treatment causes preferential flow (and hence less pathogen removal) for an indefinite period. For instance, two standard leach trenches at the Massachusetts Alternative Septic System Test Center (MASSTC) exhibited a restrictive biomat in the leaching trench after two years of operation, while none of the advanced treatment systems have exhibited a restrictive biomat in this same time period.

Research conducted under this grant shows that while some systems (i.e. a "mature" trickling filter) remove between 0.5-1 log of viruses reliably, another type of I/A system (Fixed

[3] I/A systems in remedial situations are allowed to be sited two feet vertically closer to groundwater <u>or</u> are allowed to reduce the size of the receiving soil absorption system by 50% compared with no treatment.

Activated Sludge system) relied totally on retention time in the tank for reduction in viruses (see Foss et al, 2002).

Our observations at MASSTC indicate that I/A systems with gravity fed leaching trenches exhibit no restrictive biomat after two years of operation. Our further research demonstrates that I/A technologies themselves remove less that 99 % of the viral pathogens (Foss et al., 2002). These two findings beg the question as to whether the present requirement of pressure dosing following I/A technology[4] compensates adequately for the higher wastewater application rate (when the system is allowed with up to a 50% reduction in size) or reduction in hydraulic residence time (when given a 2 ft relief in the requirement for vertical separation to groundwater)? The inability to answer this question encourages prudence on the part of regulators when situating I/A technology near sensitive receptor sites. Our research does appear to confirm that the I/A technologies tested alone (with approximately 90-99% or 1-2 log removal) do not compensate for the 2 ft. of soil "credit" they receive, since this amount of soil achieves a 99-99.9% (2-3 log) removal of viruses under unsaturated conditions in a standard septic system after biomat formation. It is important to understand, however, that the biomat itself in our standard systems (as opposed to the merely the unsaturated conditions it promotes) may be responsible for some virus removal. Until we can segregate and understand the role of the biomat, we cannot conclusively determine the soil-depth equivalency of the I/A treatment-pressure dosed system. It would only appear from our early experiments with new leachfields challenged with virus loads, that without a biomat, *gravity fed* effluent from I/A technologies would receive limited, if any, further treatment for viruses in the soil passage. Further, this total treatment (I/A + gravity distribution) would not be as efficacious for virus removal as a standard system, despite its obvious advantage for other contaminants.

[4] Pressure dosing is a requirement in all I/A systems installed under Remedial Use Approvals.

A short word about Pressure Distribution Systems

This author believes that the design guidance for pressure distribution systems, particularly for treated effluent, should be investigated for improvements. At present, discharge holes may be spaced over five feet apart, and the majority of designs reviewed by this author are indeed placed at this interval. The reason for this common design feature likely is that the pump can be economically sized with the least number of holes. This author believes that design recommendations should include a “rotating” or “alternating” zone valve that sequentially changes the zones of a system that are fed. With this type of system, an intermediate-spaced set of distribution laterals could be placed and alternately dosed, more completely utilizing the soil infiltrative surfaces.

Is there continued justification for local increased setback requirements in certain situations?

There is perhaps no issue that has drawn more controversy when discussing onsite septic systems than the issue of vertical and horizontal setback requirements from points of potential exposure to humans. While Title 5 has provided a table (310 CMR 15.211: Minimum Setback Distances) with required setbacks, many communities have chosen to increase these setback requirements, ostensibly due to the belief that local conditions warrant such. The rationale behind many of these increased setbacks are, for the most part lost. So, the question remains – Are increased setbacks justified in light of published studies and our research?

To answer this question, we must first dissect the question into the two dimensional component parts: vertical and horizontal setbacks.

VERTICAL SEPARATION

Vertical separation refers to the separation between the bottom of the soil absorption system and the estimated seasonal high groundwater elevation. Title 5 specifies that this must be at least 4 feet in soils with a percolation rate of 2 minutes per inch or slower and 5 feet in soils where the percolation rate is less than 2 minutes/inch. Some towns have increased these vertical separation requirements. The purpose of the vertical separation is to provide for a treatment zone characterized by unsaturated flow of wastewater.

There is near unanimous agreement of researchers that the unsaturated or vadose zone beneath the soil absorption systems provides the most favorable opportunity for treatment for pathogens, particularly if the flow of percolate (from the leachfield) though this zone is unsaturated. To understand this concept, some explanation of terms is necessary. When a large volume liquid is poured over a porous media (such as sand), it immediately percolates downward in response to gravity, filling the voids between the particles, such that a large volume of the flow is conveyed through large pore spaces. This is referred to as *saturated flow* through the vadose zone. While some of the liquid is drawn away and dispersed laterally by capillary action and other physical forces, the greater the volume applied per unit area, the greater the percent of the applied volume flows downward through large pore spaces. Applying the same volume of liquid referenced above over a larger area results in the percolating liquid being less influenced by gravitational downward movement and more influenced by the physical forces that tend to disperse and direct the flow over the soil particles (as opposed to through the large pore spaces). Flow through the vadose zone that is characterized by a tortuous path of an entrained particle over the soil particle surfaces is referred to as *unsaturated flow*. One study (Powelson and Gerba, 1994) indicated that unsaturated flow conditions resulted in an average removal coefficient more than three times greater that saturated conditions.

Although a large number of numerical models (van der Heijde, 1996) have been developed to predict contaminant removal in the vadose zone, their application generally requires an unrealistic amount of site-specific knowledge to accurately predict contaminant removal. Despite the apparent complexity of the issue, however, certain principles have emerged that can be broadly applied.

More is Better (but let's keep it realistic) – Charles Gerba, a world-known microbiologist, in commenting on the white paper, *Research Needs in Decentralized Wastewater Treatment and Management: Fate and Transport of Pathogens*[5] states "Ideally, given enough depth all of the pathogens could be removed in the vadose zone". Further pointing out that in most regions of the country we are not afforded the opportunity to use this feature to have a significant impact on pathogen reduction, regulators are left with the question as to what the most reasonable/realistic vertical separation should be. The Commonwealth of Massachusetts is among a number of states that have vertical separation requirements of 4 ft. or greater. Although this feature is undoubtedly important, the oft-time inability to increase the required vertical separation, particularly in remedial situations, should compel Boards of Health to focus on more controllable features, such as those discussed below. Boards of Health can however, armed with an understanding of the principle that greater vertical separation translates to greater protection, incorporate this understanding into their decisions. For instance, when asked to grant variances near critical resources, and the applicant can reasonably locate the system to allow for greater vertical separation, they can encourage this strategy. If variances are requested from horizontal setbacks, but the applicant demonstrates significantly greater vertical separation than is required, the Board granting certain variances can feel comforted by the added protection afforded by the vertical component. Unfortunately, a direct determination of substitution (the amount of vertical separation that compensates for a given horizontal setback deficiency) is not possible at this time.

[5] National Research Needs Conference Proceedings: Risk-Based Decision Making for Onsite Wastewater Management – Final Report, March 2001.

<u>It's all in how you get it there – distribution systems</u> – Perhaps the most controllable aspect of the soil absorption system that can be modified to address the issue of pathogen removal is the distribution system. In the ideal situation, a well-matured layer of biological growth (biomat) at the soil interface will prevent preferential flow beneath the soil absorption system, in effect spreading the wastewater over the entire infiltrative surface. A particle (such as a virus) entrained in the percolate, will take a tortuous path downward passing across the surface area of many soil particles. If the soil particles are reactive toward the particle in any way, the particle may be adsorbed and its passage delayed if not indefinitely halted. In the case of a virus, the delay in its downward path may be long enough for it to become destabilized and be no longer infective.

Despite the ideal situation described above, the process of biomat formation can take months and even years to occur. In the case of treated effluent (where nutrients are removed), the biomat may never form to the point that it encourages unsaturated flow beneath it. In the formative stages of a standard septic system, the flow beneath the soil absorption system is saturated flow. Saturated flow is characterized by passage through the large pores in the receiving soil. In this instance, an entrained particle avoids the many potentially reactive soil surfaces and makes a comparatively more rapid downward passage through large pore spaces until it encounters groundwater.

In real situations, the above processes occur to varying degrees in nearly every septic system and hence it is rarely an "all or none" situation. The underlying principle, however, is that the more the effluent is evenly distributed over the entire surface infiltrative area, the more the flow is unsaturated and the higher the expected pathogen removal. Boards of Health, with understanding of this principle, can incorporate pressure distribution into their decisions when they desire to maximize protection from pathogens. For instance, if under Local Upgrade Approval, an applicant wishes to reduce the vertical separation between the bottom of the soil absorption and the groundwater, the Board might consider pressure distribution as a mitigating strategy in areas where the potential for human exposure is high (wells, bathing beaches, shellfish areas). Conversely, Boards of Health might not require this added expense in areas where the risk of exposure is very low. The negative aspect of pressure distribution systems is the fact that they require quarterly maintenance at the homeowner's expense.

HORIZONTAL SETBACKS

Even more controversial than the than vertical separation requirements is the issue of appropriate horizontal setbacks to critical resources. It is often argued that the Commonwealth's setbacks are already too restrictive, and that further more restrictive requirements are unwarranted. The argument advances that if the state-required setbacks were inadequate, one would observe many more illnesses that we presently do.

While the later argument might be countered with statistics to show that our actual surveillance for waterborne diseases is not adequate to detect many problems, this particular issue is outside the realm of this report. Many field investigations show that viruses, once in groundwater, can travel considerable distance. In a study pertinent to our area (carried out in a shallow sandy soil aquifer) Vaughn et al. (1983) detected enteroviruses > 100 ft. from the source (a leaching system for a housing complex). Other investigators (DeBorde et al. 1999, Literature Summarized in Heufelder and Rask, 1999) have found similar results, however, many studies report only limited entrainment of virus beneath septic systems. This author believes that preponderance of the investigations suggest that viruses are highly mobile in groundwater. Accordingly, at least in sandy soil aquifers, I believe that the 100 ft. horizontal setback requirement between soil absorption system and a critical resource (the most common local amendment to Title 5) is justified and can be supported with credible science. The contended sensitivity of shallow sandy soil aquifers to virus contamination is supported by statements of the American Microscopical Society, which in its comments regarding the proposed Groundwater Rule supported the EPA Drinking Water Committee Science

Advisory Board's (DWCSAB) recommendation that sandy aquifers also be designated as sensitive (along with karst, gravel and fractured rock aquifer settings).

CONCLUSIONS

The issue of viruses from onsite septic systems has many aspects that preclude a simple generalized approach. Despite considerable research by ourselves and others actually on Cape Cod (Bales et al. 1995, Pieper et al. 1997, Ryan et al, in press, and others), many of the variables necessary to accurately predict virus entrainment beneath septic systems are still unknown. Numerical models generally require an unrealistic number of input variables and would prove too cumbersome to assist in the determination of any meaningful best management practice. Nevertheless certain principles are revealed in the literature that can assist in engaging in prudent design practices to minimize virus contamination. Research in this report suggests that innovative/alternative septic systems of themselves may not treat for viruses to an appropriate degree. Due to the low infective doses assumed for viruses, even a 99.9% (3 log) removal might prove inadequate if the remaining soil treatment following disposal is nonexistent, as was suggested by our earliest work (Heufelder, 1999). The literature strongly suggests that the majority of treatment for viruses occurs in the vadose or unsaturated zone beneath the soil absorption system. It further suggests that the degree of saturation is inversely related to virus removal (the greater the saturation the less the virus removal). Given these two widely accepted premises, the achievement of low actual effluent loading rates would appear the best strategy to minimize virus contamination in groundwater. This can be achieved by pressure dosing the leachfield. The literature support the continuance of the policy to require pressure dosing in situations where I/A technologies are granted certain credits for reduction in leachfield size or distance to groundwater between the soil absorption system and the groundwater. This author believes that any further credits granted I/A technologies should only be done if disinfection is required prior to discharge. This would include situations where I/A technologies are granted additional relief from horizontal-setback requirements by Boards of Health. Again, the literature strongly supports the concept of achieving uniform distribution of effluent over the entire infiltrative surface of

the soil absorption system to minimize virus breakthrough. In the early stages of standard septic system biomat genesis, as well as when discharging treated effluent under gravity distribution, the locally high effluent loading rates contradict the goal of virus removal.
As with any research project, we identify a number of research needs. These include:

- The need to quantify the benefit of pressure-dosed leachfields for the removal of viruses;
- The need to determine the role of the biomat in virus removal;
- The need to identify practical ways to disinfect treated effluent prior to discharge to leachfields;
- The need to reassess the most recent numerical models to identify if there are opportunities to incorporate their use into design criteria, and:
- The need to research findings of virus studies done in conjunction with EPA Ground Water Rule to determine whether these finding have relevance to onsite septic system placement near various potential exposure locations (wells, beaches, shellfish areas).

The issue of viruses in onsite wastewater systems will always be fraught with uncertainties. The incorporation of the best science in order to minimize potential exposure to this pervasive type of pathogen or to develop risk assessment models portends to be a significant challenge to public health officials into the foreseeable future. The sensitivity of certain aquifers (our in Barnstable County included), however, compels us to attempt to develop the most conservative approach in our wastewater disposal practices.

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APPENDIX

DETERMINING THE EFFECTIVENESS OF ON-SITE SEPTIC SYSTEMS FOR THE REMOVAL OF VIRUSES

PROJECT NUMBER 98-01/319

Contents

REMOVAL OF MS2 COLIPHAGE BY STANDARD SEPTIC TANK –LEACH TRENCH SEPTIC SYSTEMS

John Higgins[1], George Heufelder[2],
Sean Foss[2], and Brian Howes[3]

INTRODUCTION

The Alternative Septic System Test Center (ASSTC) located at the Otis Air National Guard Base in Sandwich, Massachusetts is a collaborative undertaking involving the Buzzards Bay Project, the Barnstable County Department of Health and the Environment, the University of Massachusetts Center for Marine Science and Technology, and the Massachusetts Department of Environmental Protection (MADEP). Designed to assess the efficiency of alternative and innovative (I/A) onsite wastewater treatment technologies, this newly constructed facility has received support from the USEPA Environmental Technologies Initiative (ETI) Program, MADEP, Massachusetts Environmental Trust, Barnstable County and others.

The ongoing verification testing at the ASSTC is one part of the Commonwealth of Massachusetts' overall effort to facilitate and promote new and innovative environmental technologies. The role of the ASSTC is to provide I/A technology vendors with both the opportunity to accelerate Massachusetts regulatory approvals and to reduce the substantial cost of the monitoring necessary to receive permits for sale of onsite systems in Massachusetts. The information collected at the ASSTC may also be useful in obtaining approvals for I/A elsewhere.

At the ASSTC, treatment efficiencies of both I/A and standard septic systems are evaluated over two year test-cycles based upon numerous standard wastewater and nutrient related parameters. All systems are operated in triplicate and receive residential wastewater from the Otis Air

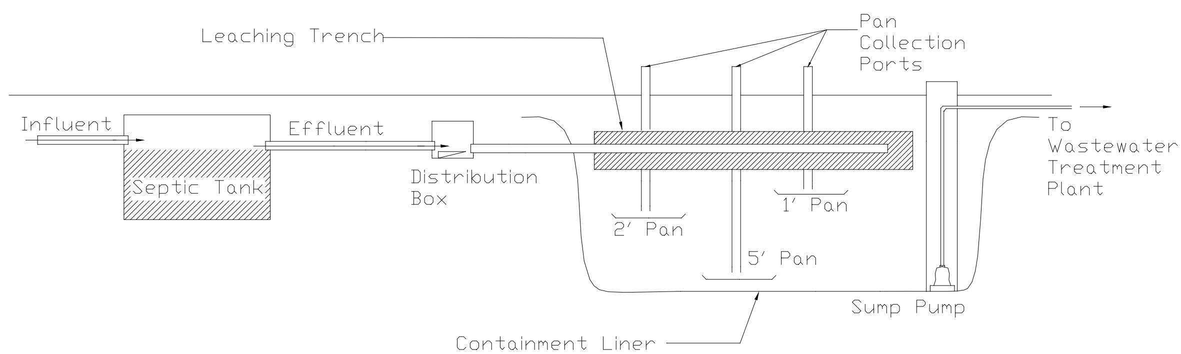
[1] Massachusetts Department of Environmental Protection Training Center, 50 Route 20, Millbury, Massachusetts 01527
[2] Barnstable County Department of Health and the Environment, Superior Courthouse, Route 6A, Barnstable, Massachusetts 02630
[3] Center for Marine Science and Technology, University of Massachusetts, 706 Rodney French Blvd, New Bedford, MA 02744

National Guard Base sewage system. An additional mission of the ASSTC is to develop and test new protocols and parameters to be used for evaluation of onsite systems. Part of this effort involves the transport of viruses both within I/A and standard septic systems and leaching fields. While this effort is still in its initial stages, this paper presents the initial data on virus transport throughout the treatment process within standard septic tank-leachfield systems and preliminary results of removals by various I/A technologies.

METHODS AND MATERIALS

Three standard septic tank – leaching field systems (Massachusetts Title 5) were tested for virus removal. These systems, which are the primary focus of this paper, serve as controls for comparison to the alternative technologies at the test facility and benchmarks for onsite systems currently in the field. Each of the triplicate systems includes a 5678 l (1500 gal) single-compartment septic tank, a Dipper™ distribution box, and a leaching trench with bottom and sidewall dimensions of 0.61 m (2 ft). The trenches were installed in medium sand fill that met the Massachusetts specifications for fill material (<5% pass a #200 Standard Sieve). The hydraulic loading rate was adjusted to 3 cm d^{-1} (0.74 gal ft^2 d^{-1}) with weekly calibration. The leaching fields are situated within lined basins to allow pumping of all leachate to an adjacent Wastewater Treatment Facility and prevents any interactions with the groundwater system. Water samples were collected from the influent, septic tank effluent, pan collection devices located at elevations of 30.5 cm (1 ft), 61 cm (2 ft), and 152 cm (5 ft) beneath the base of the leaching trench, and in the sump underdraining the leaching facilities at elevation 168 cm (5.5 ft) below the leaching trenches (Figure 1). Additional, influent/effluent sampling was conducted on four I/A technologies: open-cell foam trickling filter, layered sand filter, activated sludge, recirculating sand filter. These data were used to assess their relative viral removal rates from influent wastewater before discharge to the leaching field compared to the standard septic tank system.

Figure 1
Schemata of standard onsite septic system located at the Alternative Septic System Test Center. Leaching field is enclosed in a watertight liner draining to a sump. Sampling for MS2 coliphage was from influent, effluent, in pan collectors and sump outflow.



To avoid the problems associated with the handling of human pathogenic viruses, a surrogate virus, MS2 male-specific coliphage, was chosen because it is innocuous and approximately the same size and shape as pathogenic animal viruses commonly found in wastewater. In brief, the method of detecting these viruses in wastewater entails: collecting a water sample, removing the bacteria from the sample by filtration or by adding antibiotics to the media, depositing serial dilutions of sample into agar filled petri dishes along with a host bacteria that selectively promotes the growth of the desired virus, and incubating the petri dishes for approximately 16 hours at 35.7^{o}C. The appearance of plaques (absence of bacterial growth within an otherwise dense growth pattern) signifies the presence of viable viruses. Plaque numbers ranging from 20–100 plaques per plate are considered appropriate for statistical purposes. The preparation of plates from 3-4 different levels of diluted sample is generally required to ensure that the appropriate density of plaques is obtained. All plates are run in triplicate and control plates are run to test the sterility of all media.

Experiments conducted during May–August 1999, in collaboration with Dr. Oscar Pancorbo, Massachusetts Department of Environmental Protection, Wall Experimental Station, Lawrence Massachusetts, determined that ambient levels of MS2 coliphage within the incoming wastewater to the ASSTC were adequate for evaluating removals by onsite treatment systems. Our prior studies of field septic systems required the seeding each septic tank with a known concentration of MS2 coliphage and collecting samples over a period of weeks to months until the virus reached pre-seeded levels (generally < 10 pfu/ml). These pulse studies raised concerns over the applicability of following a single high titre ($10^{5\text{-}6}$) of virus, when the more common condition is a more constant influx. The finding of elevated levels of MS2 virus (10^4) in incoming sewage (from approximately 600 housing units at the U.S. Coast Guard unit on the Massachusetts Military Reservation) yields the opportunity for testing under "continuous injection" or "steady state" conditions.

Three types of experiments were conducted from June-August 1999. First, time-series sampling of the concentration of MS2 coliphage in the influent wastewater was carried out to ensure that calculations based on steady state were valid and to yield the influent concentrations for removal studies. Second, temporal sampling of MS2 coliphage levels at each of the five locations within each of the triplicate standard septic systems was conducted to evaluate removals of MS3 coliphage within the different system components. Third, effluent sampling of four I/A technologies (open-cell foam trickling filter, layered sand filter, activated sludge, recirculating sand filter) was used to determine MS2 coliphage removals for comparison to those within the standard septic systems.

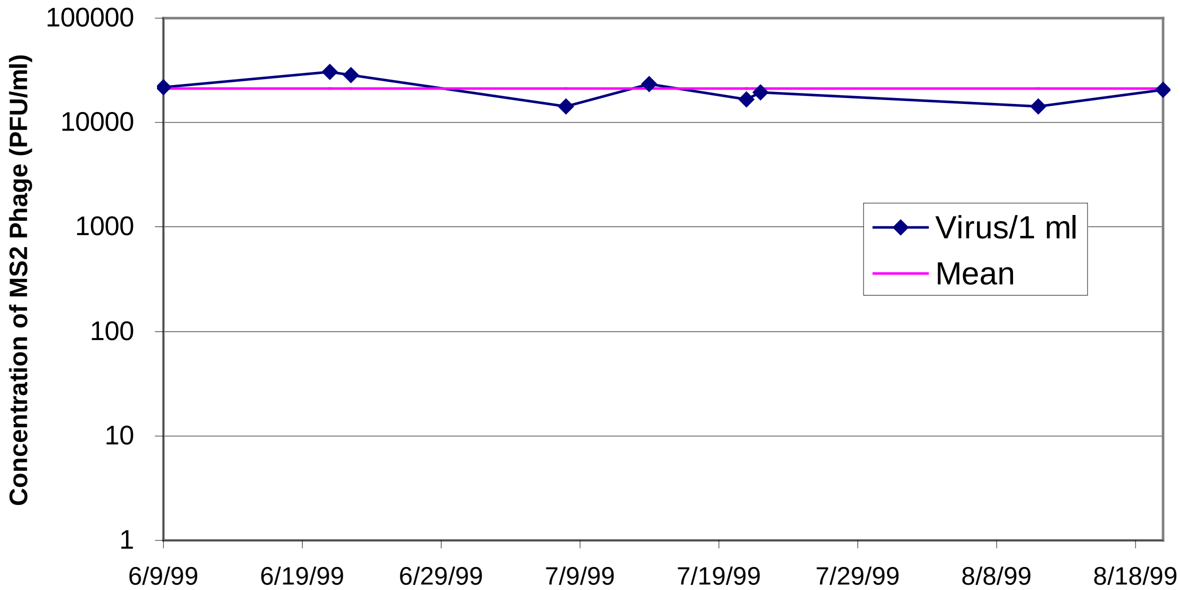
RESULTS AND DISCUSSION

Both standard septic systems and alternative innovative onsite technologies were found to significantly reduce the virus levels in influent residential wastewater, as measured using the MS2 coliphage assay. Variations in removal rates were found between the different I/A technologies. Additional reductions in virus levels were observed with passage of effluent through the standard leach field.

Time-course measurements of ambient MS2 coliphage levels within the influent wastewater to the ASSTC allowed for evaluation of virus removals using a continuos relatively constant source of MS2 coliphage to each technology for a period of about 2 months. The influent levels were stable and relatively high (21000 PFU/mL) throughout the experimental period (Figure 2). However, MS2 coliphage levels can vary seasonally at the test facility (unpublished data), so that temporal sampling of influent and effluent is conducted throughout all virus removal determinations. The constant delivery of MS2 coliphage to the test systems, allowed for the pooling of results from parallel sampling from locations within the systems. Therefore, evaluation of virus removal includes variability in system performance during normal operation over a summer season.

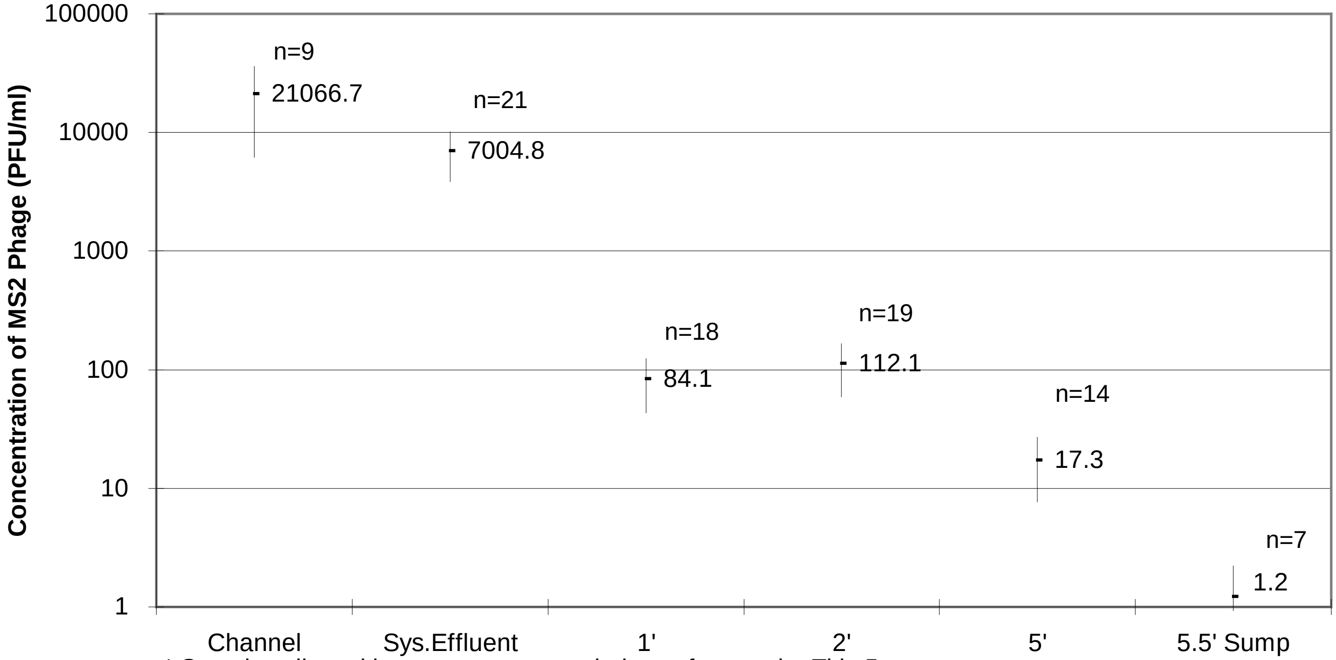
Levels of MS2 coliphage decreased as the wastewater progressed through the various treatment components within the standard onsite septic system and leach field (Figure 3). With little exception (1' pan collector) MS2 levels tended to decline several fold with each successive treatment stage. Reductions across the septic tank were significant (≈ 67%) and compared well with results of Payment et al. (1986) who found a 75% reduction in enteric viruses with primary settling, such as would occur in a septic tank. Similarly, a range of 24-83% virus removal during primary settling has been reported by Roa et al. (1981). Viruses are rarely free and isolated in the environment, but tend to be in aggregate form or linked with organic matter or suspended solids. In addition to biological digestion, the purpose of the septic tank is to allow time for suspended solids to settle. Monitoring of influent and effluent to the septic tanks at the study site shows a 30-50% removal of the suspended solids. It is likely that sedimentation plays an important role in the observed level of virus removal in these systems.

Figure 2.
Mean Density of MS2 Phage Virus in Influent to a standard septic tank assayed using an Ampicillin-resistant *Escherichia coli* host (Mean and 2SE).



Passage of the septic tank effluent through the leaching field provided a further 99.8% reduction in levels of MS2 coliphage most occurring within the first 30.5 cm (1 ft) of soil passage (and biofilm within the leach trench). At present it is unclear why there was not a decrease between the 30.5 cm and 61 cm depths in all three replicate test systems. However, the observed removal rate within the 61 cm soil column (.063-0.126 $\log_{10}$ per cm of soil passage) compares with observations of Butler et al. (1954) (as cited in Yates 1987) who reported a .051 $\log_{10)}$ per cm of passage through sandy soil at comparable loading rates. Combining the observations taken at the 1 ft and 2 ft pan collectors indicates that 99.5% of the wastewater influent virus level is attenuated by the processes operating within the septic tank, leach trench and initial 2 feet of soil.

Figure 3.
Mean Density of MS2 Phage Virus assayed using an Ampicillin-resistant *Escherichia col*i host at selected locations within a standard septic tank and leachfield septic system treating residential wastewater (Mean and 2SE; dilution corrected based on specific conductivity).



* Sample collected in sump represents drainage from entire Title 5 system

The removal of virus particles with passage through the sand beneath the leaching trenches likely results from the concurrent removal of suspended organic matter with adsorbed virus load through the filtering process. Actual filtering of the unadsorbed viruses is unlikely since the critical pore space for medium sand (effective size 0.5 mm – critical pore size .072 mm) exceeds 1,000 times the diameter of the virus (0.00002 - 0.00003 mm). This would allow or easy passage of single unadsorbed viruses. However, sorption by the soil matrix of non-particle attached viruses is possible particularly in soils containing moderate amounts of clay minerals.

Data from samples taken 152 cm (5ft) beneath the leaching trenches suggested that, although virus removal increased with increased soil passage, the efficiency of removal declined. This is based upon the 99.8% removal of MS2 coliphage from the septic tank effluent to the 2’ soil depth, but only an 83% removal between the 61 cm (2 ft) and 152 cm (5 ft) soil depths. Diminished removal capability may be related to the attachment of MS2 coliphage to very small particles which are transportable through the soil matrix. It should be noted that the number of MS2 coliphage reaching the 152 cm (5 ft) soil depth represents a whole system removal efficiency of >99.9%.

Analysis of the MS2 coliphage levels can also be conducted on a transport time basis. We have not yet completed tracer studies to determine the mean time of passage of wastewater through the various components of the standard onsite septic system. However, based upon loading rates, system volumes and characteristics of the leaching field a time course was constructed. The time of passage was used to determine an average "decay" or "removal" constant for the whole system or 0.5 d^{-1}. The relatively short travel time <14 days supports the contention that the primary virus removal mechanism is sedimentation/filtration.

Collectively, the data suggests that the Massachusetts regulations requiring a five-foot vertical separation between the bottom of the leaching system and groundwater (for sandy soils with a percolation rate of < 2 minutes per inch) provides for over a 3 $\log_{10}$ or 99.9% removal of viruses at the allowable loading rate (3 cm/day or 0.74 gal/sq ft/day).

One of the goals of these experiments is to enable Public Health officials to determine the degree to which alternative onsite septic system technologies "compensate" for soil removal of pathogens. For reasons of both cost and that some regions do not have sufficient depth to the groundwater table, many manufacturers of I/A systems seek "credits" that will allow a decreased vertical separation to groundwater when their system is used. For instance, if a particular unit is shown to consistently remove 99.8% of human pathogens, this might compensate for 2 ft of soil passage (assuming similar soil type and hydraulic loading rate) and only a 3 ft soil column would be used. This might, in some instances, obviate the need for a more costly or obtrusive mounded system at some locations. However, ultimately it is the total virus level which remains which will guide public health considerations.

Very preliminary results of MS2 phage removal rates of different technologies are presented in Table 1. The results suggest the eventual promise that some reduction in vertical separation may be attainable with some technologies in cases where pathogens are the only concern. We must stress that the approach for establishing reduced separation distances needs to include a variety of virus and soil types and conditions and that the data presented below are preliminary. Also, a number of factors that control the persistence and entrainment of viral pathogens require further research. However, it is clear that some I/A technologies tested (activated sludge, recirculating sand filter) are approaching measured soil removal rates for MS2 coliphage (Table 1).

Table 1

Preliminary Results of Virus Reduction Rates from Septic Tank Effluent to System Effluent

Alternative Septic System	Percent Reduction of MS2 Virus
Open-Cell Foam Trickling Filter	32-62
Layered Sand Filter	78
Activated Sludge Treatment System	95
Recirculating Sand Filter (Immature Biomat)	98
Recirculating Sand Filter (Mature Biomat)	99

Yates (1987) has summarized compelling research indicating that virus removal in soils is inversely related to the hydraulic loading rate. Thus, any distance-to-groundwater credits awarded an alternative technology should not be coupled with concurrent allowances for reduced leachfield size, since reduced size translates to a higher hydraulic loading rate. In addition, since the effluent from many alternative technologies has a lower biological strength, a slower formation of a biomat in the leaching facility might be expected. It is likely that the large reduction in MS2 coliphage observed between the tank effluent and the 1 ft depth is in part due to the biomat associated with the leaching trench. Research is needed to show whether impeded formation of the biomat, resulting from pretreatment by I/A technologies, appreciably affects the ability of the leaching facility to remove viruses. As a conservative measure, alternative septic systems installed in remedial situations in Massachusetts may receive either vertical-separation-to groundwater relief <u>or</u> a reduction in leachfield size must use pressure distribution for effluent disposal in order to ensure that even hydraulic loading rate occurs across the infiltrative surface. This measure likely maximizes the treatment for pathogenic viruses.

SUMMARY

The data presented indicate that the standard 5678 l (1500 gal) septic tank receiving 330 gal/day removes approximately 67% of the viruses. Presumably, this reduction in viruses is due to their association with organic particles that are settled out in the septic tank. The leach trench receiving effluent at 3 cm/day (0.74 gal/sq ft/day) and placed in medium sand fill removes an additional 99.9% of the surrogate virus in a passage of 152.5 cm (5 ft). Of the alternative septic systems tested, a recirculating sand filter with a mature biological surface appears to offer the best treatment for viruses and compensates for approximately 61 cm (2 ft) of soil passage, based on the MS2 coliphage studies. Further studies to be conducted at the Massachusetts Alternative Septic System Test Center will include evaluation of mechanisms of virus removal and processes controlling removal rates under standard and high loadings. These studies and those of other groups are needed to produce the science-based rationale for establishing separation-to-groundwater and leachfield reduction “credits” for each alternative septic system technology while still addressing public health concerns.

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COMPARISON OF STANDARD SEPTIC TANK-LEACH TRENCH SEPTIC SYSTEMS WITH TWO ENHANCED-TREATMENT SEPTIC SYSTEMS FOR ATTENUATION OF MS2 COLIPHAGE

Sean Foss[1], John Higgins[2] and Beth Berstene[3]

INTRODUCTION

The Alternative Septic System Test Center (ASSTC) located at the Otis Air National Guard Base in Sandwich, Massachusetts is a collaborative undertaking involving the Buzzards Bay Project, the Barnstable County Department of Health and the Environment, the University of Massachusetts Center for Marine Science and Technology, and the Massachusetts Department of Environmental Protection (MADEP). Designed to assess the efficiency of alternative and innovative (I/A) onsite wastewater treatment technologies, the Test Center currently receives the major portion of its operating budget from the MADEP as part of its initiative to identify and permit promising onsite septic system technologies. The Test Center is also testing four technologies under the Environmental Protection Agency- National Sanitation Foundation Environmental Technology Verification Program (ETV).

As part of its mission, the Test Center began investigations relative to the pathogen removal performance of systems undergoing nitrogen testing. It is reasoned that, the relatively “clear” effluent typical of many denitrifying units being tested at the Center might challenge the receiving soils with pathogens while not concurrently providing for growth of a biological mat or unsaturated flow at point of discharge (in gravity-fed soil absorption systems). These features are is generally believed necessary for pathogen removal. Additionally, Massachusetts’ regulations require that any alternative treatment systems must prove that they provide an equal degree of environmental protection as is

[1] Barnstable County Department of Health and the Environment, Superior Courthouse, Route 6A, Barnstable, Massachusetts 02630
[2] Massachusetts Department of Environmental Protection Training Center, 50 Route 20, Millbury, Massachusetts 01527
[3] Barnstable County Department of Health and the Environment, Superior Courthouse, Route 6A, Barnstable, Massachusetts 02630

afforded by a standard septic tank-soil absorption system. Health officials were concerned that the pathogen issue might not be adequately addressed.

In 2000 (Higgins et. al. 1999, 2000), we reported on the attenuation of viruses in triplicate septic tank-leachfield systems using background levels of 10^4 PFU/ml MS2 coliphage as a surrogate indicator of pathogenic viruses. The purpose of those studies was to establish the level of protection from pathogens that is afforded by a “standard” system. The purpose of the present study is to corroborate past findings involving a standard septic tank-leach trench system and compare these results with treatment by two alternative septic systems, the Waterloo Biofilter® a trickling filter system and the F.A.S.T® a fixed activated sludge treatment system that are challenged with known levels of viruses.

METHODS AND MATERIALS

In this study, two approaches were first undertaken to verify previous results for the standard septic system. First, “steady state” tests were performed by adding known quantities of viruses for a period of time that was considered necessary to induce steady state conditions in the distribution box following the septic tank, and in the receiving soils. These tests, conducted in March-April 2000, maintained inputs to the septic tank that resulted in levels of 10^5 PFU/ml at the distribution box for 2 weeks. Monitoring at the distribution box and pan lysimeters beneath the leaching trenches was conducted for an additional 4 weeks. To avoid the problems associated with the handling of pathogenic viruses, a surrogate virus, MS2 male-specific coliphage, was chosen because it is innocuous and approximately the same size and shape as pathogenic animal viruses commonly found in wastewater. Methods of detection were previously described (Higgins et. al. 2000).

Three standard systems were tested. The systems each include a 5678 l (1500 gal.) single-compartment septic tank, a Dipper™ distribution box, and a leaching trench with bottom and side dimensions of 0.6 m (2 ft.). The hydraulic loading rate is set for 3 cm/day (0.74 gal/sq ft/day). Calibrations of dosing rates occurred monthly. Testing locations include septic tank effluent, pan collection devices located at elevations of 1’, 2’ and 5’ beneath the leaching trench, and in the sump underdraining the leaching facilities at an elevation 5.5’ below the leaching trenches (Figure 1).

Following the steady state experiments, “slug” tests were performed both on the standard septic systems and two alternative septic system technologies, the Waterloo Biofilter and the F.A.S.T system. During slug experiments, a titer of virus, and for the standard septic system a volume of bromide tracer, was added to each septic tank to cause resulting levels of $10^{4.5}$- 10^{6} PFU /ml MS2 (and 80-100 mg/l bromide tracer in the case of the standard septic system). Measurements of these parameters were subsequently conducted for 17 days for the standard septic system and 14 days for the alternative septic system units. All systems were dosed with 330 gallons per day over 15 equal doses.

Waterloo Biofilter® System

The Waterloo Biofilter used in this study was configured as a single-pass filter situated between the septic tank and the leachfield. Flow proceeds from the 1500-gallon septic tank to a 50-gallon pump chamber (Figure 2). The effluent is distributed under pressure to the top of the media bed. The media, which is 2” x 2” open-cell foam is contained in a 8’ x 4’ x 4’ closed container. The effluent/filtrate drains to the leaching facility by gravity. Ventilation of the system is achieved by 3” vents on the sides of the unit fitted with activated charcoal filters.

MicroF.A.S.T. ® System

The MicroF.A.S.T. system consists of a baffled septic tank where the first compartment is 500-gallon capacity and the second compartment is 1000-gallon capacity. The second chamber contains a submerged media bed fixed in position near the discharge end of the tank (Figure 3.). An air blower located above-ground continuously supplies air down a central tube to the bottom of the submerged media at about 200 cubic feet of air per minute. Wastewater enters the first chamber, where primary settling takes place. Passing through a central baffle, the wastewater entering the second chamber is airlifted through the media bed. A portion of the airlifted wastewater is returned via a return tube to the primary settling chamber and a portion exits the tank at the discharge end.

RESULTS AND DISCUSSION

Only standard septic tank-leach trench system #1 yielded consistent samples from the 1-ft and 2-ft. lysimeters, although the sporadic results from the other trench systems do yield useful information (Figure 4) for the steady-state experiments. Combined, the results indicate a 1-2 log (90-99%) reduction within the first 2 feet of soil passage, when the soil absorption system is challenged with virus densities of 10^5 PFU/ml. The few exceptions to this trend are exhibited in data from system #2 and system #3 (where little or no attenuation of viruses is periodically observed). In these lysimeters the recovery volumes of sample from the lysimeters was inconsistent and suggested that steady-state flow patterns beneath these trenches was disrupted and/or not yet established. A considerably more erratic pattern of virus removal is indicated at the one-foot depth, suggesting that in our trenches this stratum was particularly unstable zone in relation to the establishment of flow patterns. Data from the sump that collects from all three-trench systems at a depth of 5.5 ft (Figure 5) indicates that with few exceptions there is a 1.5-2-log reduction in viruses. This result is somewhat unexpected and suggests very little attenuation compared to two feet of soil passage discussed above. It is unfortunate that no consistent collections were obtained from the 5-ft lysimeters to corroborate this finding.

The consistency in lysimeter sample volumes during the September 2000 slug tests suggested that only standard System #1 was appropriate for the test. These data (Fig.6) indicate a fairly consistent 2-log+ removal (99%) of virus following two feet of soil passage. These data closely agree with attenuation rates previously observed (Higgins et al. 1999,2000). Removal of viruses after one ft. of passage ranged from little or no removal at the higher influent densities (10^5 PFU/ml), to a 1+ log removal (90%+) removal rates at densities below 10^4 PFU/ml indicating that the overall percentage reduction is related to the magnitude of the challenge. This trend, although not as obvious, was also observed for the 2-ft lysimeters. Collectively the data indicate that greater challenges to the soil system resulted in less removal efficiency. Of interest in these slug experiments was the fact that following the introduction of the high titer of viruses on September 11, 2000, the one-ft lysimeter demonstrated its peak value two days later, and the two-ft lysimeter demonstrated a peak level three days later on September 14th. The lack of correspondence of the virus peak density with the peak bromide concentration at the 1-ft. lysimeter may be explained by the sampling interval (Figure 7.). We believe that due to the relatively long intervals between sampling events, we may have missed the bromide tracer peak in the1-ft lysimeter.

The reasons for the lower variability in virus attenuation during the September 2000 slug tests compared with the previous April-May steady-state experiments can only be speculated. It may be that the biomat formation in September had reached a point where it supported more uniform unsaturated flow beneath the soil absorption system. The sporadic low attenuation observed during the April-May tests do suggest that during some of the sampling periods there was preferential flow in the area of the lysimeters (hence possibly indicating an immature biomat).

Collectively the data from both the steady-state and slug tests agree with data previously presented (Higgins et al., 2000) with some exceptions. Foremost, the present studies indicate a higher degree of variability in the removal efficiency of 1-ft of sand. In some instances, no attenuation of viruses was noted at this depth. While this phenomena was also observed for the 2-ft depth of sand, it was not as common.

Data from the three replicates during the steady-state portion of this study strongly suggest a cautious approach to predicting removal efficiencies. The pan lysimeters at each replicate were highly variable in their performance (ability to collect a sample) among replicates and among sampling dates. This variability is likely due the highly variable rate of biomat formation, its periodic disruption and reformation, and the non-uniform preferential downward flow that these conditions impart. It was decided that data from sample volumes less than 50 ml would not be included in our analysis, since these volumes suggested an inadequate recharge of the lysimeter and dilution with condensation from the sides of the riser pipe would be significant. Sample volumes ranged from 5-4000 ml. Again this variable sample volume suggests that there is differential flow across the bottom area of the leach trenches that prevents accurate prediction of virus attenuation until, perhaps a stable biomat forms that will allow an even unsaturated flow beneath the soil absorption system.

Commonwealth of Massachusetts approvals for many alternative septic systems allow for the soil absorption system to be situated 2 ft vertically closer to the water table than systems without these treatment units. These approvals have been made in the past without benefit of the understanding of the pathogen reduction "credit" of either the soil beneath the soil absorption system or the treatment unit itself. This portion of the study suggests that the two-foot relief from the required vertical separation should only be granted it a 2-log reduction of viruses is achieved prior to discharge.

Tests of Alternative Technologies

Results from slug experiments of the two enhanced treatment systems, the Waterloo Biofilter® and the F.A.S.T® treatment system, show that both the extent of virus attenuation and the mechanisms for attenuation differ considerably.The attenuation of viruses in the Waterloo Biofilter was variable and ranged from 0.5-log reduction during the initial three days of the challenge, to a 1-2 log reduction in the days following this initial period. Within each day, there was commonly a 0.5 log variability in the removal rates. A closer inspection of the data suggests a reason for this within-day variability. The dosing pattern to each system at the Test Center is 15 equal doses at 0600 hr, 0700 hr, 0730 hr, 0800 hr, 0900 hr, 1100 hr, 1200 hr, 1300 hr, 1400 hr, 1700 hr, 1730 hr, 1800 hr, 1900 hr, 1930 hr. and 2000 hr. Sample times during this study were chosen necessarily based on available time between other Center Tasks. As can be seen from the dosing schedule, the 1100 hr, 1700 hr and 0600 hr doses are preceded by at least a two-hour period where no dosing takes place and presumably the filter becomes less saturated as it drains. In nearly every day in which multiple samples were taken at different times, the lowest virus levels in the effluent corresponded to sampling following the 1100 hr or 1700 hr dose (no samples were taken at the 0600 hr dose for any day). Conversely, the highest virus levels were observed during the 0900 dose which is preceded by the 0600hr, 0700hr, and 0800hr doses (Table 1). This strongly suggests that the saturation state of the filter material affects removal efficiency for viruses, with the less saturated condition being more conducive to higher removal rates. The overall reduction of viruses in the septic tank of the Waterloo system over the 14 days of measurements likely reflects only reductions due to the dilution as opposed to inactivation. The projected virus density trendline in Figure 8 was based on a simple dilution model and parallels a trendline through the actual virus densities observed. We believe that exact correspondence is precluded by the variability induced by dosing volume ($\pm$ 10%), sample variability (estimated $\pm$ 10%), and analytical variability (estimated $\pm$ 10%). Alternately however, exact correspondence of observed values and projected values based on dilution may be due some limited replication of MS2 in the septic tank during this period. The later hypothesis is challenged by the generally accepted belief that MS2 phage do not replicate at the temperatures (<15 C) observed. In any event, it is clear that there are no inherent qualities of the incoming wastewater that appear to be destructive to MS2 phage. This is an important assumption in the following discussion of results from the F.A.S.T. unit.

Table 1. Dosing time exhibiting the highest daily virus density for the Waterloo Biofilter® at the Massachusetts Alternative Septic System Test Center from November 6 – 19, 2001. Emphasized dosing periods are preceded by successive doses at 1hour intervals. Other doses are preceded by a non-dosing period of at least 2 hours.

Date	Dose Exhibiting Highest Density of Virus	Number of Doses Sampled
6-Nov	11:00	4
7-Nov	**7:00**	4
8-Nov	**9:00**	3
9-Nov	**9:00**	2
10-Nov	**9:00**	2
11-Nov	**9:00**	3
12-Nov	**9:00**	2
13-Nov	**9:00**	2
16-Nov	**9:00**	2
18-Nov	17:00	2
19-Nov	**9:00**	2

Results from the MicroF.A.S.T treatment system suggest a considerable difference in both the degree of treatment and the mechanism of attenuation. Figure 9 again contrasts the results from the septic tank with that of treated effluent. The near correspondence between the septic tank and the effluent is apparently the result of the mixing within the two-compartment tank. Again, the expected reductions in the septic tank are projected based on a simple dilution (330/1500 or 22% per day). The difference between this expected density of viruses and the observed levels in both the septic tank and the effluent, is the overall virus reduction of the system. The data suggests that the overall reduction of viruses in this system will depend on residence time in the system itself.

Unfortunately, the apparent extent of mixing within the F.A.S.T. system itself confounds our ability to assign an accurate virus removal benefit for the F.A.S.T. This can be illustrated by example. When initializing the experiment, we introduced the virus titer into the first compartment of the septic tank during the 0900 hr dose and mixed the compartment moderately but not such that we would resuspend settled solids. After two hours, we sampled the system during a dosing cycle (1100 hr). At that time the approximate difference between the effluent and the septic tank was 0.5 log (approximately 30%). Since no additional viruses were added to the system, the environment in the system continued to inactivate viruses at a rate dependent on the average residence time in the tank. Accordingly after 2 days the effluent virus densities were reduced by approximately 1 log (90%), after 6 days there was a 2-log or 99% reduction, and after 6 days, there was over a 3-log or 99.9% reduction. These reductions are estimated based on expected levels of virus due to simple dilution. The reader can recall that the "control" or standard septic tank (data derived from the Waterloo septic tank which is not intermixed with treated effluent and can therefore be considered exhibiting a pattern of virus reduction control for comparison purposes) only exhibits dilution reductions (Figure 8).

The data indicate that overall the virus removal in the MicroF.A.S.T. will be highly dependent on the residence time of the viruses in the system itself. High virus loading accompanied by low hydraulic loading will result in higher retention times and more virus removal. The MicroF.A.S.T. in our study was supplied influent near its design loading for Massachusetts (when configured for denitrification). In this scenario it appears that there is approximately a 30% reduction in viruses, however even this value depends on the loading patterns during the day. Should the hydraulic loading be less, greater virus attenuation can be expected, however due to the complete mixing of this system, only average residence times can be calculated. These values are inappropriate to use for virus level prediction since the uniform mixing of the viruses in each batch of incoming wastewater can not be confirmed.

Conclusions

This study was initiated, in part, to clarify the relative treatment of a standard septic tank-leach trench system, including 5 ft. of soil passage, for viruses compared with alternative septic system technologies' treatment for viruses without the soil system. The study is the first step in determining whether pretreatment of septic tank effluent (STE) should be allowed to substitute for any portion of the soil system. Presently in Massachusetts, selected alternative septic system technologies allow an applicant to substitute for 2 ft. of vertical separation to groundwater or 50% of a soil absorption system size (infiltrative surface).

Our data suggests that neither of the two systems tested compare with a standard septic-tank leachfield for virus attenuation *by themselves (without a soil system).* This information raises the question as to whether pretreatment of septic tank effluent accompanied by a soil absorption system offers the same degree of pathogen removal as a standard septic tank-leach trench system. Some authors (Van Cuyk and Siegrist, 2001) have indicated that the state of knowledge in this area is not adequate to answer the question. These authors point to the range of studies that underscore the importance of the clogging layer in removing viruses and bacterial pathogens and the dearth of information on the genesis of the biomat in systems using pretreatment. They suggest that the regulatory reliefs that enable the substitution of pretreatment for vertical separation or soil absorption system size (=higher hydraulic loading rates) should expand their consideration beyond merely hydraulic efficacy. This concern should be heightened in areas of coarse sand where the removal of viruses is likely less due to decreased adsorption characteristics.

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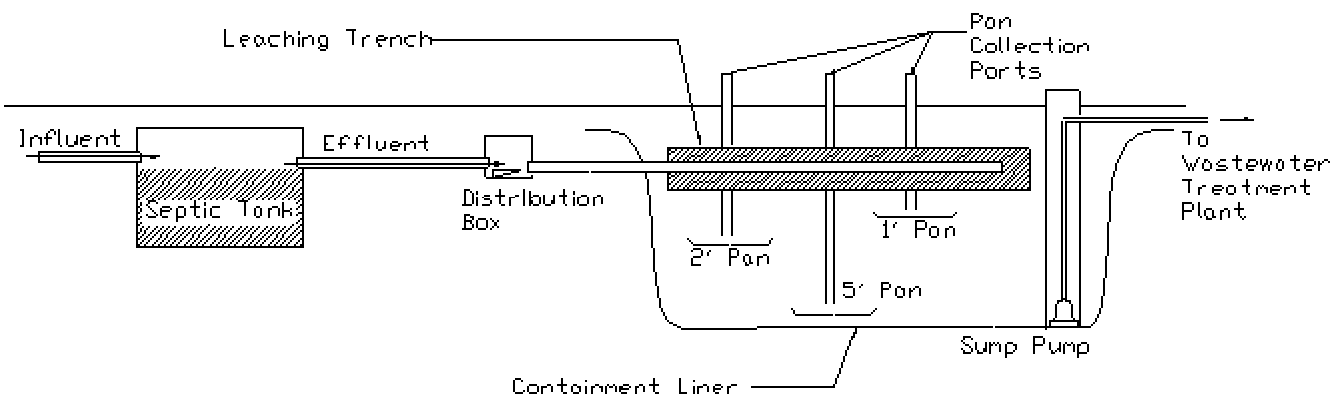

Figure 1. Profile of standard septic tank, distribution box, and leaching trench septic system design at the Massachusetts Alternative Septic System Test Center.

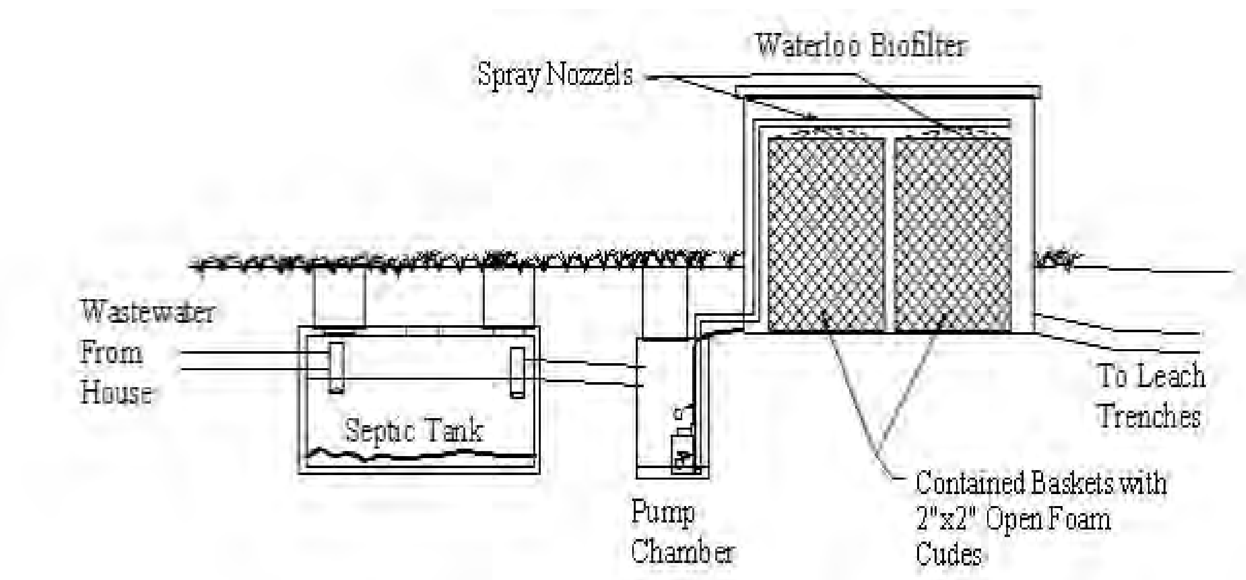

Figure 2. Profile of Waterloo Biofilter system at the Massachusetts Alternative Septic System Test Center.

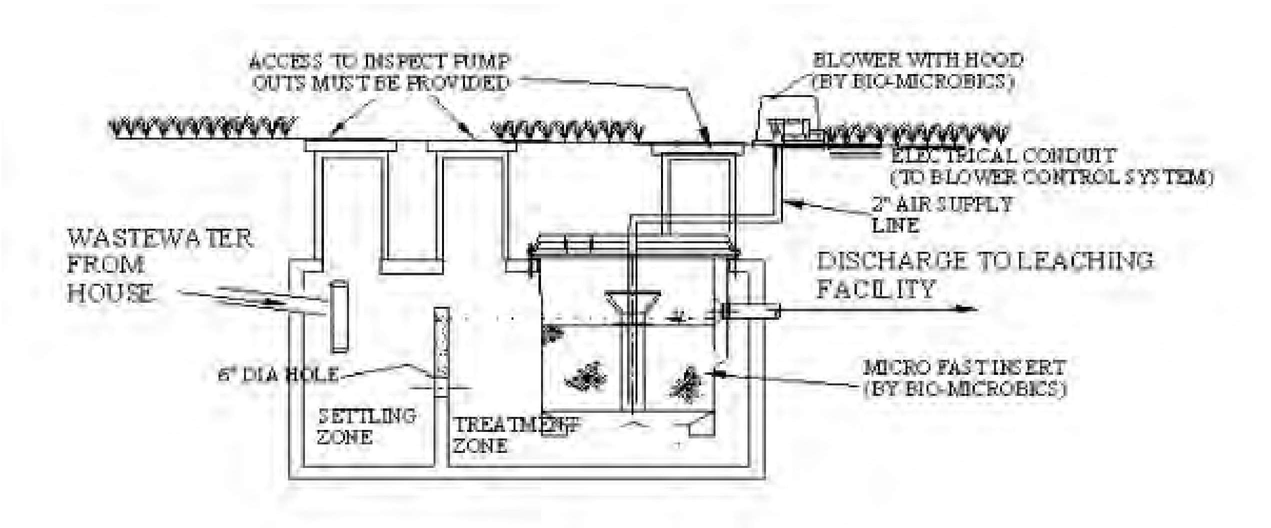

Figure 3. Profile of FAST system at the Massachusetts Alternative Septic System Test Center.

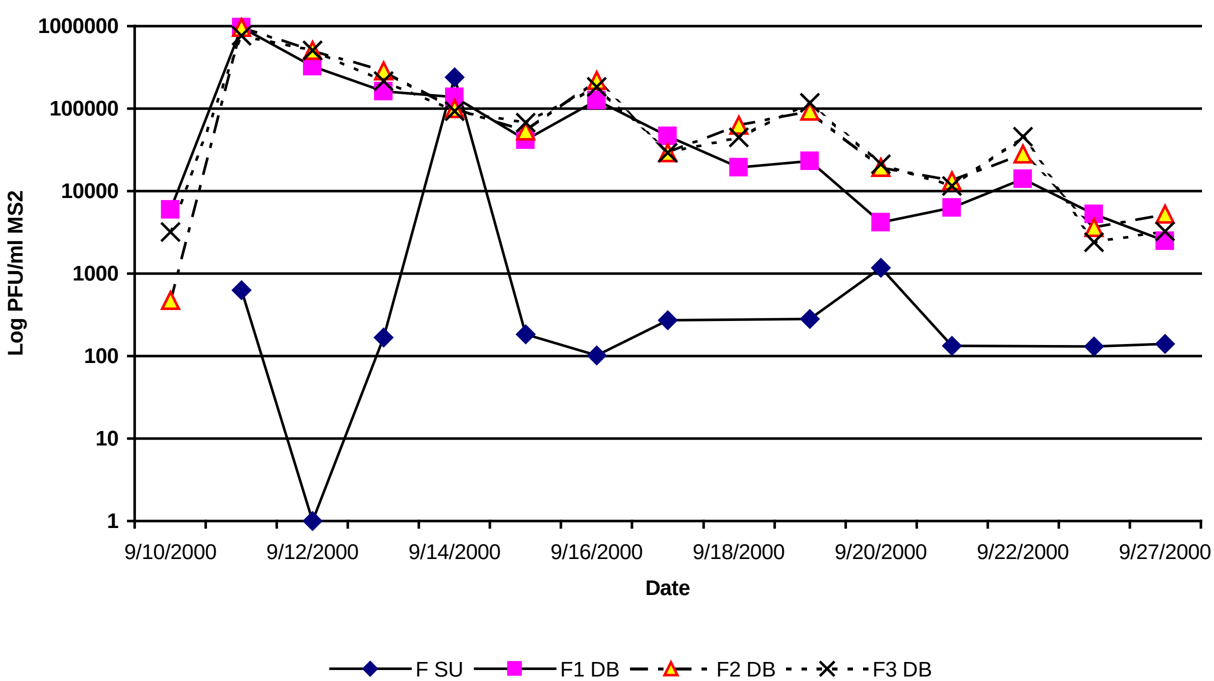

Figure 5. MS2 virus (PFU/ml) removal slug test for standard septic tank/leach trench systems 1 – 3 in the distribution boxes and sump at the Massachusetts Alternative Septic System Test Center from September 10 – September 27, 2000.

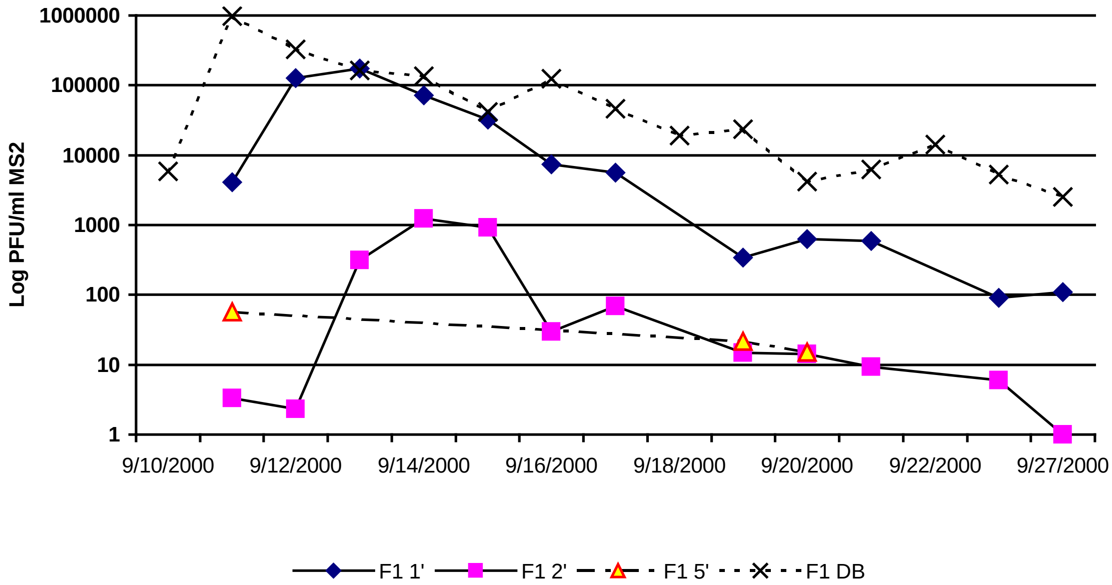

Figure 6. MS2 virus (PFU/ml) removal slug test for standard septic tank/leach trench systems 1–3 in the distribution boxes and lysimeters at the Massachusetts Alternative Septic System Test Center from September 10 – September 27, 2000.

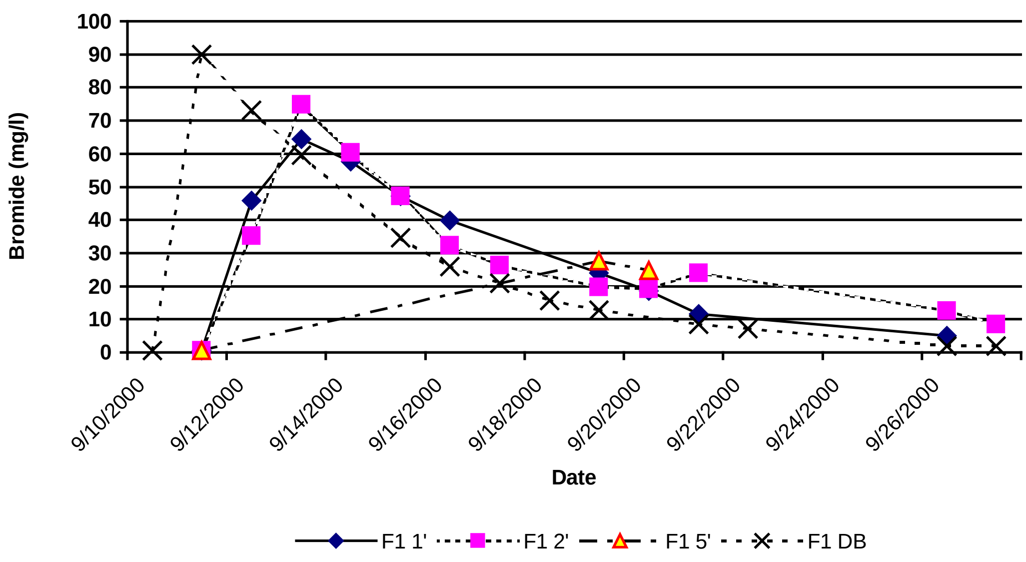

Figure 7. Sodium bromide (mg/l) slug test for standard septic tank/leach trench system 1 in the distribution box and lysimeters at the Massachusetts Alternative Septic System Test Center from September 10 – September 27, 2000.

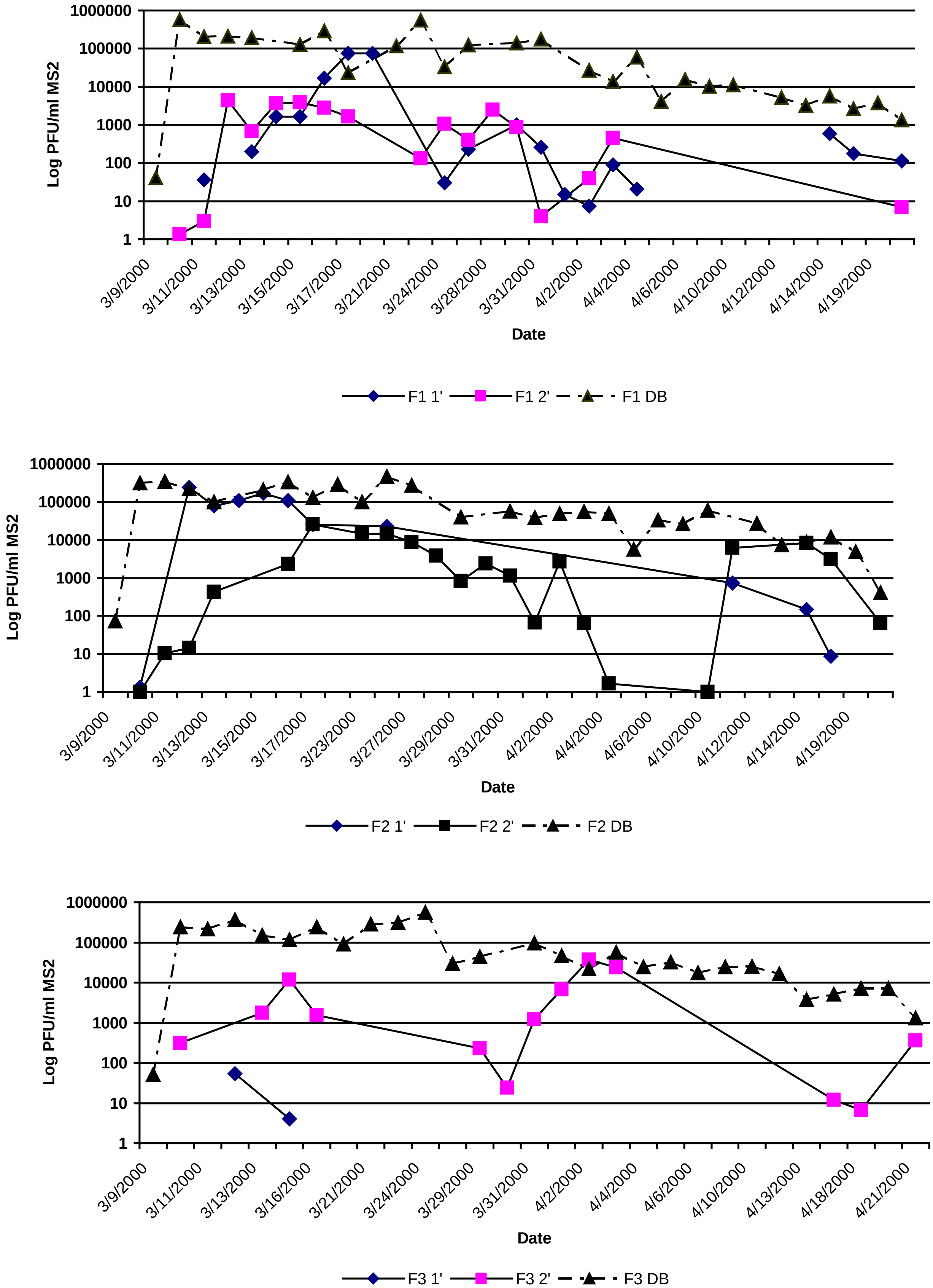

Figure 4. MS2 virus (PFU/ml) removal steady state test for standard septic tank/leach trench systems 1 – 3 in the distribution boxes and lysimeters at the Massachusetts Alternative Septic System Test Center from March 9 – April 21, 2000.

Sewage Rules Create Gap in Housing Supply in Massachusetts

A Report Prepared for the Massachusetts Housing Partnership

By Joseph D. Peznola, PE - Hancock Associates

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Author

Joseph D. Peznola is a Professional Civil Engineer and Director of Engineering at Hancock Associates, a full service Engineering, Land Surveying and Environmental Science firm providing land development consulting services to private, public and non-profit clients in Massachusetts, New Hampshire, Rhode Island and Connecticut with offices in Danvers, Chelmsford, Acton, Marlborough and Salem NH. Mr. Peznola has nearly 30 years of experience with a special focus in the strategic planning, design and permitting of complex multi-family residential projects.

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The Gap in Housing Supply

It’s a fairly simple problem in economics. The Commonwealth of Massachusetts has a bright regulatory threshold in dealing with the handling of on-site sewage treatment and disposal for residential development projects: 10,000 gallons per day. Sounds simple, but when examined more closely, being on either side of the threshold translates to hundreds of thousands of dollars in design, permitting construction and operation costs to projects. Projects above the threshold can only economically exist with numbers of units well above this bright line, resulting in a gap or a hole in projects sizes. Ever wonder why there are so many forty-four-unit condominium developments in the state? Read on to find out why.

Contact Information for the Author

Joseph D. Peznola, PE
Hancock Associates
315 Elm Street Marlborough, MA 01752
978-766-5915
jpeznola@hancockassociates.com

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Introduction

It's no secret that Massachusetts needs to produce more housing to sustain its economy and to keep young professionals from moving elsewere. The Metropolitan Area Planning Council (MAPC) estimates we need produce 500,000 units between 2010 and 2040 just to maintain our existing base of employment and to compensate for more than a million Baby Boomers that will leave the work force. Producing housing at such an ambitious rate will have to include development in areas of eastern Massachusetts that do not have access to municipal sewer. Involvement of the private for-profit and not-for profit development communities will also be critical to building the housing we need.

Massachusetts regulates sewage treatment and disposal through regulations enacted by the Massachusetts Department of Environmental Protection (MassDEP) and administered and enforced through local city and town Boards of Health. Within this regulation is a sewage flow threshold, below which offers projects relatively simple systems to handle their sanitary waste. The problem is that this threshold is a hard or "bright" line, above which projects have to incur very expensive systems to permit and construct as well as operate and maintain. To absorb these high costs, projects must be large enough to spread both the initial and long-term costs over more residential units. A sizing gap therefore exists between projects that stay under the threshold and the larger projects. Many times suitable land exists that warrants a project size within the gap. Reduction below the threshold lead to economic infeasibility given Massachusetts’ high cost of land. Larger projects either do not physically fit within the site or do not fit the character of the neighborhood. Many times projects proposed by not-for-profit organizations have funding requirements that demand they have a unit count right in the middle of this gap. The state's environmental regulators and housing advocates should come together to address this gap in an environmentally responsible and financially sound manner.

A peripheral but directly related issue involves municipalities enacting local sewage treatment and disposal regulations that are more stringent than the state requirements. These requirements are rarely backed by strong technical justification and only lead to drive project costs higher while providing suspect increased environmental and public health protections.

This reports looks to detail these issues with facts, figures and to offer the author's opinions formed over nearly 30 years in the business of the design, permitting and development of housing in Massachusetts.

Section 1

The Regulations

Title 5 - 310 CMR 15.000

The State Environmental Code (310 CMR 15.000), also known as Title 5, is the standard requirement for the siting, construction, inspection, upgrade and expansion of on-site sewage treatment and disposal systems. Essentially if one does not have access to a town sewer system, this regulation outlines what to do with what we put down our drains. The regulation covers what to do with sanitary waste from all types of uses, from commercial to industrial to residential. The state has determined that by following the requirements of Title 5 in the investigation of soil conditions, proper siting, adequate sizing of system components and minimum maintenance of those components, the environment is suitably protected from potential adverse impacts from discharging sanitary waste into the ground.

Since 1978, Title 5 has had several revisions, but the basic approach to the design and construction of these systems has not changed. As designers, we visit a site with a backhoe, dig a big hole to determine where seasonal high groundwater exists and to test how fast water travels through the soil (a percolation test), and then design the on-site sewage disposal system based on the anticipated daily flow. This flow is estimated using Title 5 design flows for various uses. In the case of a residential project, Title 5 requires systems to be designed forecasting 110 gallons per day (gpd) per bedroom. There are some that believe this quantity to be overly conservative. Adjustments have not been made over the years to consider the fact that the average family size in the U.S. has decreased from 3.06 persons in 1972 to 2.54 persons in 2013[2], or the fact that the use of water conserving plumbing fixtures and appliances has increased during the last twenty years. An old clothes washing machine used 40- 50 gallons per load; today's machines use as little as 17 gallons[3].

MassDEP convened a working group of regulators and industry experts in 2012 to discuss the issue of the appropriateness of Title 5 design flows. The group researched data from a variety of existing users as well as available data and requirements from other states. With regard to residential use, the group concluded that while 110 gallons per bedroom appears appropriate for a single-family home given the lack of control over the number of persons residing, but that the regulations offer no considerations for the economy of scale and statistical reductions in total flow realized in larger residential projects. The group reviewed actual flow data for 25 active private wastewater treatment facilities at condominiums and apartment communities ranging in size from 68 bedrooms to 712 bedrooms. The group observed the average flow per bedroom to be 68 gallons per day, with a low of 22 and a high of 114 gallons per bedroom per day.

Even very large Title 5 systems, while complex, are afforded the assumption that if designed and installed in accordance with the regulations, the system serves to protect the environment. While frequent and proper maintenance is a very good idea with all these systems, it is not required, monitored or tracked. Maintenance for on-site systems features pumping of septic tanks every one to three years. In accordance with Title 5,

[2] U.S. Census Date - www.census.gov

[3] www.home-water-works.org data related to water conservation.

systems must be inspected upon the sale of the property. These inspections are quite intense and often lead to the required replacement of failed systems.

Title 5 sets a limitation on the use of on-site sewage disposal systems at no more than 10,000 gallons per day. At 110 gallons per bedroom, this equates to 90 bedrooms. This is the reason there is an abnormally high number of 44-unit 2-bedroom condominium projects proposed in the state every year (88 x 110 = 9,680). Projects exceeding 10,000 gallons per day must provide treatment of wastewater prior to discharge to the ground through the construction of a private on-site wastewater treatment facility. These very expensive systems require constant oversight, sampling, monitoring and reporting to MassDEP. Plants must be inspected daily by a licensed plant operator. The plants are required to meet strict treatment requirements of the Massachusetts Groundwater Discharge Regulations (314 CMR 5.0). The required operation, monitoring and reporting result in a very high degree of control and insured environmental protection.

So let's go back to that 44-unit 2-bedroom condominium project with a 9,680-gallon-per-day sewage disposal system. The system is presumed to be protecting the environment with no insurance that maintenance is being done properly or at all. And since there is never a sale of the entire condominium development, there is no requirement to inspect the system. You might say there is a flaw in the Title 5 regulation and our state's environment is in peril. It is not the case. By all accounts, the Title 5 regulations are working. Old failing systems are being repaired, and the environment is being properly protected.

Groundwater Discharge Permit - 314 CMR 5.00

Now let's look at adding just three bedrooms to our forty-four-unit condominium project. The bedrooms add 330 gallons to the total, and we exceed the 10,000-gallon bright line. We now need a wastewater treatment plant. These systems require a Groundwater Discharge Permit in accordance with 314 CMR 5.00. The regulations govern wastewater treatment systems with design flows of 10,000 gallons per day or greater and are administered by MassDEP. The local Board of Health does not permit a system of this size. In some towns the local Board of Health have regulations governing these systems, but these regulations do not supersede the state regulations as they do with Title 5. MassDEP has sole permit-issuing authority.

The state-level regulations require significant analysis of a proposed discharge site to ensure the treated effluent will not create a public health or environmental nuisance in the future. This includes testing the suitability of subsurface soils, mapping groundwater flow, and identifying downgradient impacts, including the cumulative impacts to drinking water supplies and coastal embayments. They also require an applicant to submit a fully engineered design for the disposal facility and an engineering report describing the overall design of the treatment facilities. Treatment plant designs must comply with MassDEP's Guidelines for the Design, Construction, Operation, and Maintenance of Small Wastewater Treatment Facilities with Land Disposal (MassDEP publication, April 2004). The leaching field area requirements for wastewater treatment plants is significantly less compared to Title 5 systems due to the higher treatment. With good soils, the loading rate can be up to six times faster than that for a Title 5 system, requiring significantly less land for the disposal facility.

The design of these systems include a complex hydrologic analysis that has to consider how the effluent from the plant will affect down gradient wells. A treatment plant discharge must be separated from a public supply well by a distance equal to a two-year time of travel for groundwater. For example, if groundwater is moving at an average speed of one foot per day (typical of sandy soils), a treatment plant discharge must be a minimum of 730 feet from the well. A 730-foot radius around a well is 38 acres of land. This obviously can have a dramatic impact on housing projects needing both a wastewater treatment facility and a well, requiring substantially more land.

Stepping over the bright line of 10,000 gallons per day, we now have an exponential increase in environmental protection and ironclad insurance that the system continues to function providing the required treatment. The system is inspected daily, effluent sampled and analyzed and reports sent to MassDEP. Sounds expensive? It is. We will explore costs later in the report, but it’s safe to say that the revenue from the extra three bedrooms will not cover the cost.

Local Regulations

The Massachusetts Home Rule Amendment (Article 89) and a state statute known as the Home Rule Procedures Act.2 (MGL Ch. 43B) were adopted in 1966. The purpose of the Home Rule Amendment is, by its own terms, to “grant and confirm to the people of every city and town the right of self-governance in local matters.”

Municipalities are allowed to adopt regulations under Home Rule that are more stringent than state regulations. In the case of on-site sewage disposal, many communities have adopted local septic regulations. The Pioneer Institute and Rappaport Institute studied 187 communities within 50 miles of Boston in 2005. There are 109 communities that have local septic regulations beyond those in Title 5. Increasing the depth to groundwater for leaching fields, increasing design flow above 110 gallons per day per bedroom, and increasing setbacks of systems to property lines, wells and wetlands are just a few of the features of these local rules that make it harder and more expensive to install conventional or shared systems. Thirty of the communities studied have some additional restrictions or outright prohibitions on the use of shared systems.[4]

The Comprehensive Permit Law (MGL CH 40B) does allow developments including affordable housing to seek waivers from these local rules. A disproportionate share of multi-family housing being built in Massachusetts’ suburban communities are utilizing Chapter 40B since by-right multi-family housing is almost non-existent in the Commonwealth, due to either zoning constraints or the availability of adequate lands zoned for multi-family.

[4] Residential Land-Use Regulation in Eastern Massachusetts, Amy Dain Pioneer Institute, December 2005

Section 2

The Costs

The cost of an on-site sewage disposal system designed in accordance with Title 5 can vary widely depending on system design flow and soil conditions at a particular site. If we focus on larger multi-family residential systems with design flows approaching the 10,000 gallon limit, cost variation seem to narrow. Actual construction costs have been gathered for several systems installed within Massachusetts over the past several years are presented in Table 1.

Table 1 On-site Sewage Disposal System Construction Costs

Town	Project	No. of Bedrooms	Design Flow gpd	System Cost	Cost per Bedroom
Oxford	Pinewood on the Green	46	5060	$160,000	$3,478.00
Littleton	Littleton Ridge	54	5090	$200,000	$3703.00
Sudbury	Coolidge at Sudbury	67	7370	$220,000	$3,283.00
Wayland	89 Oxbow[5]	37	4070	$182,500	$4,932.00

The costs associated with operation and maintenance of sewage disposal systems are directly related to design flow as the major cost item is septage hauling and disposal costs from the required septic tank pumping. Actual maintenance costs for several large systems are presented in Table 2.

Table 2 On-site Sewage Disposal System Maintenance Costs

Town	Project	No. of Bedrooms	Design Flow gpd	Annual Budget	Cost per Bedroom
Oxford	Pinewood on the Green	46	5060	$3,700	$81.00
Littleton	Littleton Ridge	54	5090	$4,900	$91.00
Sudbury	Coolidge at Sudbury	67	7370	$4,500	$67.00
Wayland	89 Oxbow[6]	37	4070	$5,000	$135.00

Wastewater treatment facility costs are primarily driven by the cost of the actual treatment apparatus. Various types of treatment package treatment plants are available and have been proven to effectively meet the treatment requirements of 314 CMR 5.00. In the past several years MassDEP has recommended the use of membrane bioreactor systems that rely on microorganisms suspended in the wastewater to treat it. Other options include, activated sludge and anaerobic digestion.

[5] 89 Oxbow project included a recirculating sand filter due to being within a wellhead protection area.
[6] 89 Oxbow project included a recirculating sand filter due to being within a wellhead protection area.

Generally all the treatment options that are approved for use with have pricing driven by market competition and will be somewhat similar. Full systems start at $1 million and run up to $2 million for very large private systems. Effluent (leach) fields for disposal of treated wastewater are not required to be as large as those for Title 5 systems but due to large flows involved still come at a substantial cost. Operation and maintenance for these facilities generally exceed $100,000 for any facility given the need for the systems to be monitored daily by a licensed wastewater treatment facility operator, energy costs and required continual funding of an escrow account required by MassDEP to make large repairs and replacement of system components.

Tables 3 and 4 below are some examples of system construction costs and also annual operation budgets.

Table 3 Wastewater Treatment Facility Construction Costs

Town	Project	No. of Bedrooms	Design Flow gpd	System Cost	Cost per Bedroom
Westford	Graniteville Woods	396	43,560	$1.8M	$4,545.00
Littleton	Village Green	498	55,000	$1.75M	$3,514.00
Westford	Princeton	352	39,000	$1.6M	$4,545
Sterling	Choksett Crossing	90	9,900	$1.1M	$12,200
Holliston	Crest View	118	13,000	$1.2M	$10,170
Westport	Edgewater	72	11,000	$1.1 M[7]	$15,277

As you can see the larger the system the closer cost per bedroom begins to approach the cost for large septic systems.

Table 4 Wastewater Treatment Facilities Maintenance Costs

Town	Project	No. of Bedrooms	Design Flow gpd	Annual Budget	Cost per Bedroom
Westford	Graniteville Woods	396	43,560	$125,000	$315.00
Littleton	Village Green	498	55,000	$125,000	$251.00
Westford	Princeton	352	39,000	$115,000	$326.00
Sterling	Choksett Crossing	90	9,900	$102,000	$1,133.00
Holliston	Crest View	118	13,000	$100,000	$847.00
Westport	Edgewater	72	11,000	$125,000	$1,500.00

[7] The actual Edgewater system cost of $900,000 has been converted to present day worth for comparison given the system was constructed 12 years ago.

However operation costs are 10 to 15 times that of conventional septic systems. These costs put an incredible strain on condominium associations in particular. In the case of Choksett Crossing MassDEP is working with the association to reclassify the system as a Title 5 system to reduce annual operation costs seeing that the system has a design flow below the 10,000 gallons per day. The project was originally proposed with a wastewater treatment facility to mitigate nitrogen impacts to a sensitive area.[8]

One of the other smallest projects is the 72-unit age restricted Edgewater Apartments in Westport. This project was permitted using 150 gallons per apartment unit for age restricted housing in accordance with Title 5. Completed in late 2002, the project implemented an Enviroquip® MBR (membrane bioreactor) technology for the wastewater treatment. This 11,000 gpd system was completely constructed underground with additional equipment housed in the apartment building's basement.[9] The initial cost of the system installation was $900,000 and annual operation runs $120,000. This translates to a very high $12,500 per unit in construction cost and $1,200 per bedroom in annual operating costs. Compare this to the Title 5 system installed at the Coolidge at Sudbury. This 67-unit age restricted project has only five fewer units and designed using only 110 gallons per day per bedroom under the residential flow. This approach was allowed by the local Board of Health. MassDEP has recently revised Title 5 in the 2014 to recognize design flow of 110 gallons per day for one-bedroom senior housing. Prior to this, MassDEP did not formally recognize the one bedroom housing for the elderly requiring all units to use 150 gallons per day regardless of the number of bedrooms. The Coolidge's system features a conventional septic tank and leach field implementing a Presby© system for the leach field. Due to site grades, the system does require a pump chamber. The cost for this system however was only $220,000 or $3,200 per unit almost one quarter the price. The operating cost here is only $81.00 per unit compared to $1,200 at Edgewater, almost 15 times the cost.

Initial construction costs become appear to be feasible for projects with more than 200 bedrooms. Operation costs are comparatively very high in all cases. The financial feasibility of absorbing these annual expenses seem to require more than 300 bedrooms within a project.

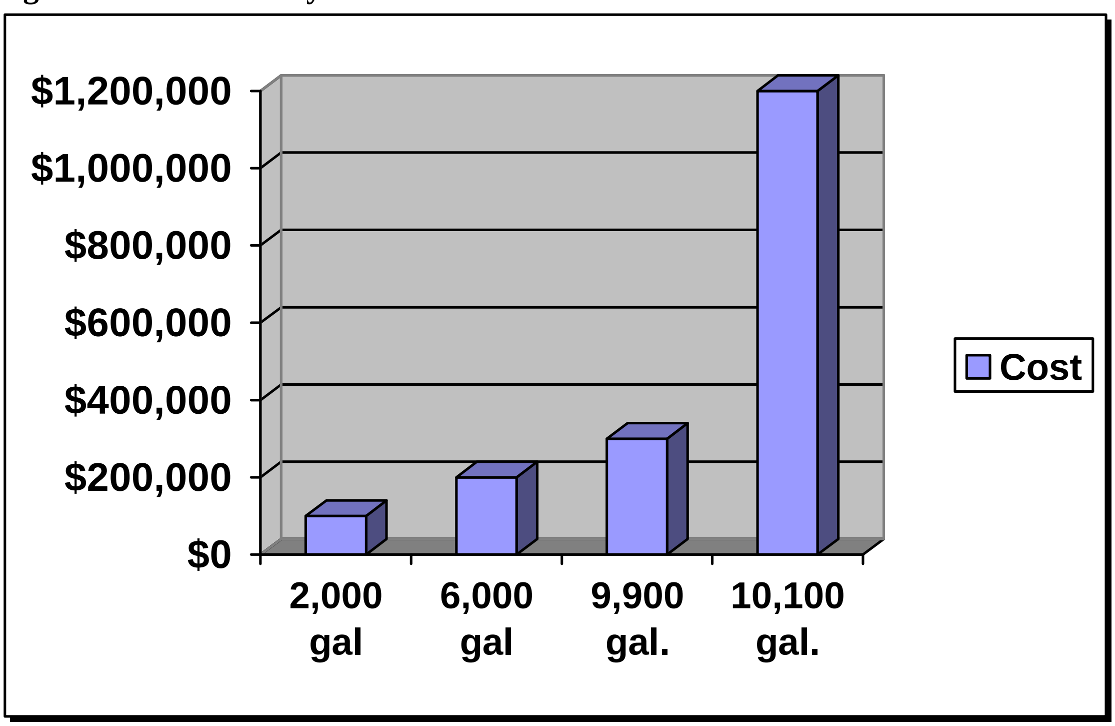
MassDEP provided a similar comparison within their Smart Growth/Smart Energy Series web page. MassDEP makes the argument in the Table 5 below that the increased density of multi-family project justifies the cost. If we assume two-bedroom units, their numbers do not seem to correlate to those gathered in preparation of this report. MassDEP provides further justification based on the cost of land per unit based on the cost of land. The argument fails to address the simple fact that projects having between 90 and 300 units are not economically feasible.

[8] Information regarding Choksett Crossing provided by Counsel for the Association.
[9] Ovio (GLV, Inc.) Project Highlight Sheet – Edgewater Apartments – www.mbrcentral.com

Table 5
Wastewater Construction Costs for Different Approaches and Densities[10]

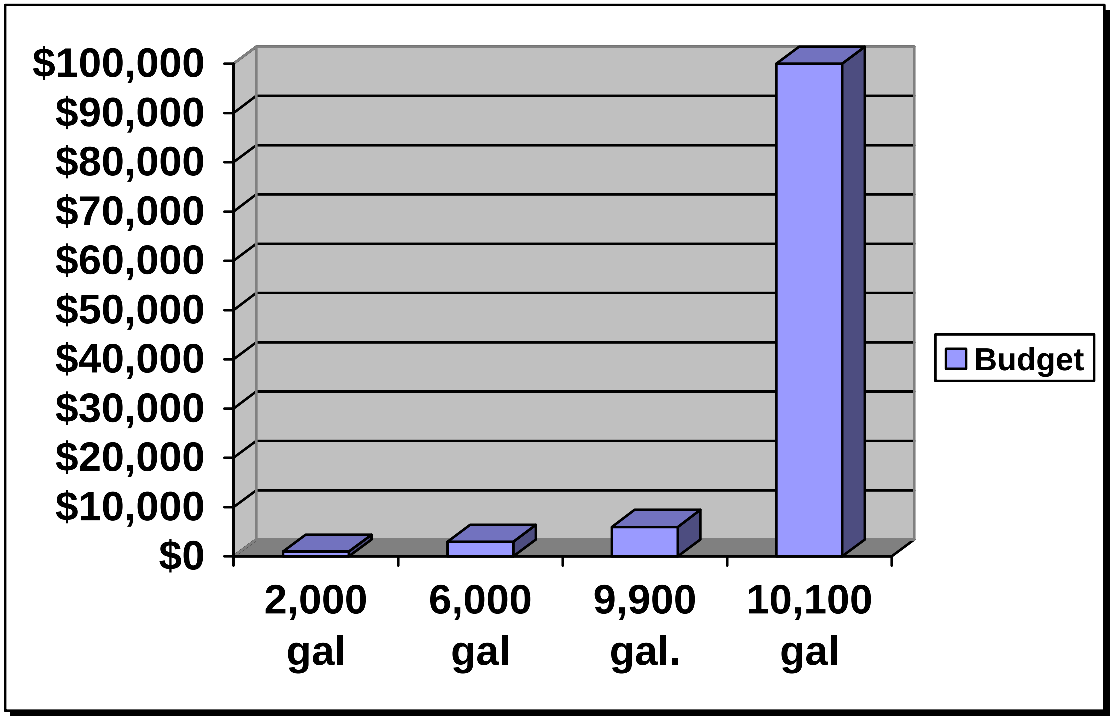
	Title 5	I&A	Centralized Sewage Treatment
Sewage Cost	$7,500/Unit	$15,500/Unit	$45,000/Unit
Density (units/acre)	1	1.5	8
Land & Sewage Cost/Unit ($)			
For land costing $50,000/acre	$57,500	$43,667	$11,875
For land costing $100,000/acre	$107,500	$82,167	$57,500
For land costing $200,000/acre	$207,500	$148,833	$70,000
For land costing $300,000/acre	$307,500	$215,500	$82,500

Figure 1 Wastewater Systems Construction Costs



[10] Table taken from MassDEP Smart Growth/Smart Energy Toolkit Wastewater Alternatives

Figure 2 Wastewater Operation and Maintenance Annual Budget



Section 3

The Numbers

There are approximately 63 active residential wastewater treatment facilities in Massachusetts. The regulation require continual monitoring and reporting of data from these facilities. The information reported includes both original design flow as well as actual flows leaving the facilities on a daily basis.

Of the 63 active residential wastewater treatment facilities reviewed the average design flow is 43,000 gallons per day corresponding to an average number of bedrooms of 393. Only eight or 13 percent of the total residential facilities reviewed had fewer than 200 bedrooms. The largest system has over 200,000 gallons per day and the smallest is just over 7,000 gallons per day. This smallest facility and one other with flow under the threshold are special cases where facilities are treating wastewater in accordance with MassDEP Groundwater Discharge Permit Regulations while being below 10,000 gallons per day. Choksett Commons in Sterling was discussed earlier in this report, the other is Brookside Mills in Westford. Brookside took advantage of the leaching requirement reduction a wastewater treatment facility offers to increase the yield on a tight environmental sensitive site. According to the Westford Board of Health Agent, Brookside has had continual problems leading to very expensive operating costs per unit. Representatives could not be reached to report actual costs.

One of the other smaller project is the 72-unit Edgewater Apartments in Westport discussed earlier. These small projects appear to be unique anomalies and should be discounted from a global analysis of project feasibility.

Anecdotally, the development community has avoided wastewater treatment as well as public water supplies unless project numbers are at 100 to 150 units or 200-300 bedrooms as the cost number presented in this report support. In some cases projects have been divided to avoid these systems. This practice is closely scrutinized by MassDEP and communities. The regulations do not allow such division for the sake of regulatory avoidance. MassDEP requires that projects are clearly separate and distinct having separate and distinct ownership separation and funding sources. Examples have included singly permitted condominium projects being split having totally separate legal condominium associations with independent board of trustees. This practice only serves to increase costs to home owners and increase the complexity of permitting and oversight.

The Coolidge at Sudbury and Edgewater Senior Apartments comparison shows that small variations in numbers with regard to project size and design flow applied can make extreme differences in projects cost and economic feasibility.

Table 6 Design Flow Data[11]

FACILITY NAME	TOWN	Type	DESIGN FLOW
BUCK ISLAND CONDO	YARMOUTH	R	30,000
LINCOLN HOMES	LINCOLN	R	26,000
GREENBRIAR ESTATES CONDO	NORTH READING	R	40,000
SEACREST CONDO ASSOC	FALMOUTH	R	85,000
HILDRETH HILLS CONDO.	WESTFORD	R	44,700
FARMBROOK CONDO.	ACTON	R	105,000
COLONIAL DRIVE CONDO.	ANDOVER	R	33,110
FRIENDS CROSSING CONDO.	EASTON	R	31,000
PARK COLONY CONDOS.	NORTH READING	R	26,000
SUMMER HILL CONDO.	PLYMOUTH	R	48,970
FULLER POND VILLAGE	MIDDLETON	R	48,000
WHITE CLIFFS CONDO.	PLYMOUTH	R	80,000
GREAT ROAD CONDOMINIUMS	ACTON	R	27,720
ACORN PARK CONDO. TRUST	ACTON	R	39,750
OCEAN POINT CONDOS.	PLYMOUTH	R	30,000
MAYFLOWER PLACE	YARMOUTH	R	25,000
LAKESHORE VIL/WOODLANDS	LUNENBURG	R	12500
HITCHIN' POST GREENS CONDO	WESTFORD	R	80,500
WEDGEWOOD CONDOMINIUMS	SOUTHBOROUGH	R	31,680
THE VILLAGES AT DUXBURY	DUXBURY	R	54,000
PONDSIDE APARTMENTS	LITTLETON	R	23,130
ORCHARD HILL ESTATES	OXFORD	R	45,000
MACINTOSH FARM COMMUNITY	SHARON	R	35,000
HILLS @ MAINSTONE CONDO.	WAYLAND	R	36,000
NASHOBA VIEW II	WESTFORD	R	39,900
TRADITIONS WWTF	WAYLAND	R	27,120
MEADOWS @ MAINSTONE FARM	WAYLAND	R	24,640
BROOK VILLAGE CONDO.	BOXBOROUGH	R	33,000
ACTON RETIREMENT COMMUNITY	ACTON	R	34,520
PINEHILLS LLC WWTF	PLYMOUTH	R	215,000
ROLLING PINES CONDOMINIUMS	EASTON	R	36,000
BOXBOROUGH MEADOWS	BOXBOROUGH	R	158,420
MEETING HOUSE AT STOW	STOW	R	120,000
VILLAGE AT STONE RIDGE	WESTFORD	R	25,000
EDGEWATER APARTMENTS, LLC	WESTPORT	R	11000
BROOKSIDE MILL CONDOMINIUM	WESTFORD	R	7,480
HARVARD RIDGE CONDO. TRUST	BOXBOROUGH	R	33,130

[11] Data obtained from MassDEP PWWTF Database. Note: Facilities with design flows greater than 150 gallons per day per bedroom were omitted as not representative of a standard residential design flow.

VILLAGE @ FLATHILL	LUNENBURG	R	14850
THE JEFFERSON	BELLINGHAM	R	54,000
MILL POND VILLAGES	YARMOUTH	R	44,800
HARMONY CROSSING	EAST BRIDGEWATER	R	22,000
WHITE PINE VILLAGE	EAST BRIDGEWATER	R	25,000
CRESTVIEW CONDOMINIUM	HOLLISTON	R	13000
STOW VILLAGES, LLC	STOW	R	34,000
LAUREL HILL	WESTFORD	R	96,000
VILLAGES AT RIVERS EDGE	NORFOLK	R	32,000
CHOCKSETT CROSSING	STERLING	R	9,900
SUMMER VILLAGE	WESTFORD	R	68,000
ABBOTT MILL	WESTFROD	R	21560
AVALON COHASSET	COHASET	R	33,500
WAYSIDE FARM	EAST BRIDGEWATER	R	22,000
THE PRESERVE AT OAK HILL	WRENTHAM	R	27,280
SPRING HILL COMMONS APTS.	ACTON	R	20,570
EDGEWOOD LUXARY APART.	NORTH READING	R	63,240
CODMAN HILL CONDOMINIUM	BOXBOROUGH	R	19800
RESIDENCES AT CANAL BLUFFS	BOURNE	R	31,994
SAWYER HILL HOUSING	BERLIN	R	21,600
WILBER SCHOOL APARTMENTS	SHARON	R	18150
GRANBY HEIGHTS CONDOS	GRANBY	R	17600
CONCORD MEWS	CONCORD	R	66,000
THE VILLAGES AT MARSHFIELD	MARSHFIELD	R	57,310
GRANITEVILLE WOODS	WESTFORD	R	43,560
AVERAGE			**43,242**
AVERAGE NUMBER OF BEDROOMS (assumes 100 per)			**393**
MAXIMUM			215,000
MINIMUM			7,480

Actual flow data was gathered for some of the residential wastewater treatment facilities and is presented in Table 7 below shows actual flows per bedroom to be much less than Title 5 required design flow of 110 gallons per day.

Table 7 Actual Flow Data[12]

Project	Town	Total Bedrooms	Average Flow per Bedroom
Acorn Park	Acton	648	34
Great Pond	Acton	506	46
Spring Hill Commons	Acton	187	46
Colonial Drive	Andover	301	76
Longview	Bellingham	500	22
Harvard Ridge	Boxborough	271	41
Yule Properties	Easton	332	91
Crest View	Holliston	118	105
Indian Brook	Hopkinton	223	52
Lincoln Homes	Lincoln	220	79
Pondside	Littleton	183	91
Village at Flat Hill	Lunenburg	137	109
Stafford Pond	Mashpee	305	57
Windchime Point	Mashpee	314	114
Fuller Pond Village	Middleton	425	100
Greenbrier Estates	North Reading	279	64
Park Colony	North Reading	257	91
Orchard Hill	Oxford	407	86
Pembroke Woods	Pembroke	390	76
White Cliffs	Plymouth	712	27
Wedgewood	Southborough	240	48
Choksett Crossing	Sterling	90	56
Brookside Mill	Westford	68	73
Hitching Post Green	Westford	608	46
Village at Stone Ridge	Westford	217	80
Edgewater Apartments	Westport	100	67
Average			**68.3**
Minimum			**22**
Maximum			**114**

[12] Data obtained from MassDEP PWWTF Database. Note: Facilities with design flows greater than 150 gallons per day per bedroom were omitted as not representative of a standard residential design flow.

Local Board of Health regulations can increase Title 5 design flow. Several towns have increased the minimum to 165 gallons per bedroom. The actual flows shown here reflect an economy of scale and statistical averaging of individual home maximums within a multi-family community having a shared wastewater treatment facility and/or community well. These numbers further support the lack in justification for this type of local increased regulation.

Section 4

Other States

Each state has a unique set of rules to regulate the installation and maintenance of on-site wastewater treatment systems. These rules can cover the gamut of regulation: some states set a very low regulatory threshold, while others use an alternative means to properly design an effective treatment system. Let's look at a few of these states and see how they compare to Massachusetts.

Wisconsin

Wisconsin has a design flow limit of 12,000 gallons per day before a state-issued pollutant discharge elimination system permit must be obtained. The state uses a peak flow of 150 gpd per bedroom, which results in 80 bedrooms at the threshold. However, Wisconsin code states that "12,000 gpd shall be deemed equivalent to 85 bedrooms for residential dwellings."[13] Despite this five-bedroom increase, the state faces a gap in development sizes much like Massachusetts.

Indiana

Indiana has set a threshold of 750 gpd, which equates to a five-bedroom home. Any development above this limit is considered a commercial on-site sewage system and is subject to additional permits and monitoring systems. Indiana allows a decrease in the absorption area if secondary treatment is used.

Maine

Maine has one of the simplest set of regulations to follow. Their basic rule is that any system can be proposed for any sized development "as long as it works."[14] If the design flow exceeds 2,000 gpd, it must be designed by a licensed engineer. Towns are allowed to place more stringent regulations.

Arizona

Arizona uses two thresholds to determine the level of treatment, permitting and monitoring required. A relatively simple treatment facility is allowed for design flows under 3,000 gpd, while a more-regulated system is required for flows up to 24,000 gpd. Beyond that, an Individual Aquifer Protection Permit is required.

Pennsylvania

Pennsylvania, like Massachusetts, has a design limit of 10,000 gpd. Clustered systems are allowed, and local municipalities cannot create stricter regulations. Pennsylvania does not allow any provisions for increased flow.

New Hampshire

New Hampshire controls the size and household density of their developments by using a lot loading capacity (2,000 gpd per acre) instead of a cumulative flow threshold. This allows developers to design a series of simple wastewater systems to treat a large

[13] Wisconsin Administrative Code SPS 383.22(2)(b)6.b.
[14] Glenn Angell, State Site Evaluator, Maine Department of Health and Human Services

subdivision, as long as there is enough land. New Hampshire does, however, require a groundwater discharge permit for design flows above 20,000 gpd.

A few states have similar regulations to Massachusetts and find themselves with a similar financially-inspired gap in development sizes. But, most states have avoided that gap by allowing a higher threshold or by using another appropriate measuring stick. MassDEP can learn from the successes of those states and do away with sizing gap while maintaining a leading environmental standard.

Section 5

Recommendations – A Middle Ground

It is clear from the information presented herein that an extreme difference in cost exists on either side of the regulatory threshold contained within Title 5. The public health and environmental protections afforded through more intense analysis, higher technical requirements for treatment and extremely higher levels of operation, monitoring and oversight that are necessary for these complex systems seem extreme when observed from the perspective of those projects just under the thresholds. Below are a few recommendations to avoid the gap.

1. Implement a framework of analysis, design and oversight that provides adequate public health and environmental protections while being sensitive to the financial feasibility of projects between 10,000 and 20,000 gallons per day. Implementation of primary treatment with a focus on water quality at the property line or limit of a sensitive receptor rather than at the outlet of the treatment device and a relaxation of the inspection and operation requirements from daily to monthly or even quarterly could result in substantial savings. Remote monitoring could also be implemented, where operators would be alerted if system issues arise. These requirements could even be applied to very large systems below 10,000 gallons in situations that warrant providing protection that does not now exist. See Section 6 for a suggested regulatory change that might be considered.

2. Raise the 10,000-gallon-per-day (GPD) maximum design flow of a Title 5 system to 15,000 GPD in Section 15.004 (c). The original version of Title 5 in 1978 had the maximum at 15,000. It was changed in the 1986 revision to the regulations.

   310 CMR 15.004(1) The Approving Authority shall not approve the construction, upgrade, or expansion of an on-site subsurface sewage disposal system unless it is: (a) a system serving or designed to receive only sanitary sewage from a facility where the total design flow generated on the facility, is less than 15,000 gallons per day;

3. Include a graduated design flow rate for multi-family projects based on the total number of bedrooms in Section 15.203. This recommendation could be implemented alongside the ones listed above. Based on the data review by the MassDEP working group in 2012, the following could be supported:

Number of Bedrooms	Recommended Design Flow	Maximum Flow
1-18	110 GPD	1,980 GPD
19-48	95 GPD	4,560 GPD
49-90	85 GPD	7,650 GPD
91-200	75 GPD	15,000 GPD

4. Have MassDEP provide definitive guidelines to local Boards of Health for the implementation of local septic regulations and a process for review of these regulations to ensure compliance with the intent and purpose of Title 5. The Department can verify the scientific support for local requirements exceeding those in Title 5. MassDEP offers model regulations for local well regulations, but currently offers no guidance for local septic regulations. Since this proposal impacts rights granted to cities and towns by the legislature per The Massachusetts Home Rule Amendment (Article 89) and a state statute known as the Home Rule Procedures Act.2 (MGL Ch. 43B) that were adopted in 1966, we will leave it up to the lawyers to craft appropriate statutory and/or regulatory revisions to address this recommendation.

Section 6

Another Suggested Regulatory Change – Recirculating Sand Filters

On September 9, 2008, MassDEP issued a Certification for General Use for recirculating sand filters (RSF) in accordance with Title 5. The certification details the applicability, design criteria and monitoring regulations for an RSF system, that is, an on-site sewage disposal system that includes an RSF.

A recirculating sand filter significantly reduces the levels of Biological Oxygen Demand (BOD), Total Suspended Solids (TSS), and total nitrogen in the wastewater effluent. Currently, an RSF system is recommended for developments in a Nitrogen Sensitive Areas (NSA), like Interim Wellhead Protection Areas and Zone II areas. Like any system under Title 5, the design flow must be under 10,000 gallons per day. With an RSF system, the regulations allow a 50% reduction in the soil absorption system if the flow is less than 2,000 gallons per day (there is no such reduction for flows between 2,000 and 10,000 gallons per day). Title 5 also allows a loading rate increase in an NSA from 440 to 550 gallons per day per acre.

Given the effectiveness of the recirculating sand filters, why not expand the applicability of an RSF system? MassDEP can stipulate that the use of an RSF system in a non-nitrogen sensitive will increase the design flow up to 20,000 gallons per day. Operators can follow the monitoring schedule stated in the certification, as opposed to the daily inspections and monitoring required for a wastewater treatment facility.

310 CMR 15 could be revised in Section 15.202 with the addition of subsection (4) as follows:
(4) A recirculating sand filter ("RSF") or equivalent alternative technology approved by the Department in accordance with 310 CMR 15.280 through 15.288 may be used as component of all systems designed to serve a facility or facilities with a design flow of 10,000 to 20,000 gpd when the subject site is ***not*** *located in a Nitrogen Sensitive Area.*

The use of a successful alternative technology like the recirculating sand filter to increase the design flow for on-site disposal systems would immediately remove the sizing gap that Massachusetts encounters. This regulatory change can be combined with the recommendations in Section 5, to provide developers an even greater ability to maximize developments while maintaining superior water quality standards.

Section 7

Conclusion

It is clear there is a point of economic feasibility when looking at what the residential development community has built over the last 20 years in the Commonwealth under current regulations. Regulations should allow for a full range of project sizes while protecting the public health and the environment. A gap exists caused by a combination of regulatory and financial factors in the Commonwealth between 90 and 200 bedrooms.

MassDEP should investigate the matter and provide opportunities across the full range of project types and sizes. Developable land in Eastern Massachusetts is scarce and expensive, and the development community can ill afford to waste land or miss chances to provide housing in order to meet the current and future needs of our citizens.

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8. Ground Water Discharge Permit Program, 314 CMR 5.00

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National Onsite Wastewater Recycling Association
Model Code Framework for the Decentralized Wastewater Infrastructure

– 1st Edition[1]
August 2006

Executive Summary

Introduction

The National Onsite Wastewater Recycling Association (NOWRA) Model Code Framework is intended to serve as a guide and to facilitate the following activities within states and localities.

- Promote the rationalization of regulations across political boundaries with performance and science based code provisions.
- Establish an efficient method with which to evaluate and deploy new onsite wastewater treatment processes.
- Create a methodology to integrate decentralized wastewater treatment standard setting mechanisms within the U.S.E.P.A Total Maximum Daily Load (TMDL) program.
- Advance the professionalism of industry participants through education, training and certification.

The documents within the Framework were developed over a five year period beginning in 2001 by a team of experienced team of industry professionals. Participants included volunteers from the regulatory, service and manufacturer segments in all geographic regions of North America. The resulting Framework documents evolved through ten drafts that were reviewed and discussed at model code committee meetings, held in all regions of the country. Committee resources were provided by self-funded volunteers, grants from the US Environmental Protection Agency, and contributions from business, industry and state onsite associations.

The Framework comprises several related documents that can be used either independently or in concert. At the same time, several documents remain under development

1. The Guidance Document -- includes the core principles and structures of the Model Code Framework and recognizes regulation as a form of risk management. It is written to inform businesses, citizens, policy officials and other related industry groups about the use and regulation of decentralized treatment systems. The Guidance Document was approved by the NOWRA Board of Directors, June 9, 2006

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[1] The NOWRA Model Code Framework for the Decentralized Industry was adopted by the NOWRA Board of Directors, June 9, 2006. The adoption of these documents represents a milestone in a five year effort to complete this work. Additional information can be found at www.modelcode.org.

2. The Model Code Framework -- presents a written structure with policy options for each major subject of a code. The Framework is not a model code that can be adopted directly. Instead it contains policy options to be considered when adopting a state or local code. Code language is provided to implement the selected policy choices. Code committee guidance and supporting rational is offered on each of the policy options. This guidance is intended as a tool to evaluate proposed or existing regulation. It was approved by the NOWRA Board of Directors, June 9 2006

3. Appendices provide additional resources for use in writing codes/
   - Appendix A: Classification Matrices. This document provides a matrix for use to classify treatment components on the basis of effluent quality and variability for constituents of design and regulatory interest. It is useful for designers assembling treatment trains and regulators setting effluent requirements for pretreatment and final treatment components. The classification matrices are to be used in conjunction with Appendices C and D.

     Currently, the State of Florida Department of Health, in cooperation with NOWRA, is beta testing the classification matrices (Appendix A) and the procedure for evaluating confined treatment components (Appendix D) NOWRA Board approval is waiting for results of the beta test.

   - Appendix B: Is reserved for states to list the results of component classification decisions in the matrices.

   - Appendix C: Soil evaluation component is still in development.

   - Appendix D: Procedures for Administering the Confined Treatment Components Database and Matrix. This information gives the method in which to evaluate confined treatment component data by the quality of the protocol used to collect the data and to use acceptable data to list components in the classification matrices. This document is being beta testing by Florida DOH..

   - Appendix E: Tank Standards -- establishes the requirements for watertight and structurally sound tanks. Methods for testing tanks are not specified. Instead, the document relies on using material specific evaluation protocols that have been adopted by other standard setting organizations. Treatment requirement standards are not specified because the performance of the device is highly dependent on the influent characteristics and because performance and assessment tools are still under development by other groups. The document has been approved by the NOWRA Board of Directors.

   - Appendix F: Do Not Flush List Guidance– identifies substances that may cause problems with the operation of pretreatment devices and the traditional septic system if flushed into the household wastewater plumbing system. The document has been approved by the NOWRA Board of Directors.

Framework Objectives

The Model Code Framework is intended to overcome significant structural and attitudinal barriers to industry modernization. The information within the documents enables the regulatory community and policy officials to change the style of regulation from prescriptive to performance. The performance of specific regulatory functions and services is also changed to the organizational level that can most efficiently and effectively perform the function; local, regional or state government and national organizations that evaluate and certify people skills and treatment components. More specific changes in code construction and style occur in the following components.

- Prescriptive codes to performance based codes. The shift implies both a change in the construction of codes and in the processes by which they are administered.
    - The term "prescriptive code" means an administrative regulation that specifies the means of achieving an objective and excludes other means of achieving the same objective. Approval of new methods requires a code change which has occurred as infrequently as every 10 to 25 years in the states. The use of a prescriptive treatment design is presumed to produce an acceptable quality of effluent despite large variation in site risk conditions and system performance in the field.
    - The contrasting term "performance code" means an administrative regulation that specifies the end or result of a process or activity. It allows the general use of solutions that demonstrate achievement of the objective requirement or standard without a code revision. The deployment of treatment and dispersal methods creates a link between demonstrated performance and site risk. Performance of treatment components and skilled personal is assessed by the creation of measurable standards and an evaluation tool to assess compliance with the standard. This process can be applied to treatment components and skilled personnel and is intended to allow their deployment across multiple political jurisdictions.

- Treatment/dispersal designs and industry professionals to national level evaluation programs. Promote national evaluation systems that evaluate to multiple levels of performance to allow state and local jurisdictions to link performance with the appropriate level of risk management. Under current regulatory practices a treatment technology or method is subject to unique specifications and evaluation procedures in each state/province and often in each county. The result of this unique evaluation process, coupled with the inflexibility of prescriptive codes means that proven methods and technologies employed in one jurisdiction are either banned in a neighboring jurisdiction or are not offered by the manufacturer because of the time and money cost of the approval process.

- The establishment of performance requirements to the jurisdiction best suited to match site or area risk conditions with performance requirements – local, regional or state level government. The common practice in most state codes is to establish statewide standards that are not sensitive to site or area risk. This results in a standard that is too strict at some sites, resulting in unnecessary costs to homeowners, and too lenient in others, resulting in excessive health and environmental risk. Instead, the Framework suggests that performance requirements be set by the level of government that best understands local risk conditions, the local tolerance for risk relative to cost of managing that risk and the enforcing authority's capacity to administer the code provisions. This political/technical cost/benefit evaluation provides value to citizens affected by the regulation.

- Promote reasonable rules by causing a close link between the establishment and enforcement of a code requirement. The assumption is that code provisions are written to be enforced and that enforcing a provision evaluates the body politic's determination of reasonableness of the rule. Enforced unreasonable rules are quickly modified as a result of the political feedback mechanism. Unreasonable rules tend to be selectively enforced to ensure political survival of the rule and the discretionary power of the enforcing agency, violating the concept of equitable application of laws. Selective enforcement also creates the opportunity for corruption and invidious discrimination.

- Shift regulatory attention to operational management of treatment systems.

- Promote the education and certification of industry participants.

The Model Code Framework does not provide clear solutions for several issues facing the decentralized industry; either because the solutions need to be determined by organizations with a broader scope than the industry or the definition of the problem remains undefined.

- Risk assessment –the code does not provide a methodology to assess the actual risk of utilizing decentralized wastewater treatment at a site or in an area.
- Risk management, not risk elimination – no wastewater treatment system reduces risk to zero at an acceptable cost. Therefore the regulatory portion of the industry is charged to manage risk by balancing benefit and cost of the regulation. Since benefits are linked to risk reduction and sensitivity to costs vary greatly, this balance is largely a local political decision.
- Risk management relative to other sources - each health or environmental issue likely has multiple sources. Risk management can only occur within the context of a broad regulatory program covering all sources. The USEPA TMDL program can provide a reasonable methodology to manage the multiples sources of environmental pollution. The NOWRA model code is designed to facilitate implementation of the TMDL program.
- Abuse of regulatory discretion – to establish requirements for reasons other than requiring the treatment levels needed to protect the human and natural environments.

- Use the code to manage land use in lieu of appropriate zoning. The objective of decentralized regulation should be to provide a safe wastewater management methodology for every site deemed buildable by other regulations. It is not uncommon that regulatory agencies set unreasonable standards, deny access to treatment technology or increase the land or money cost of using a treatment system to discourage or otherwise manage development outside the service area of central treatment works.
- Discriminate between treatment and dispersal technologies/methods on the basis of personal or institutional bias instead of performance relative to reasonable performance standards and evaluation programs.

Conclusion

The first edition of the NOWRA Model Code Framework is designed to accelerate the process of industry maturation. Regulation largely shapes the industry and can promote or inhibit the development of more effective and efficient technologies and methods.

The model code needs to evolve along with the service and manufacturing segments of the industry as new research better defines the risks of decentralized system utilization and improves on the technology.

To accomplish this work, the NOWRA Board has directed the Model Code Committee to meet annually to review and update the code and guidance. This meeting will occur during NOWRA's annual conference with the purpose to review and propose appropriate revisions to the Framework Documents and new materials. Additional meetings will occur through teleconference to address ongoing activities.

To facilitate the use of this work NOWRA has developed and will conduct an Education and Outreach Program for regulators and policy officials. The purpose is to assist the states/provinces and local government regulators and policy officials in the use of the code documents. This program, funded with a grant from the US EPA, includes a series of four workshops to be held in different geographic regions of the US, and where code changes are being planned. They are scheduled to begin January 2007. Information about these activities and their results will be posted on the Model Code website – www.modelcode.org. Additional updates on the work of the Model Code Committee will also be posted on this website.

Strategic Framework For Unsewered Wastewater Infrastructure

INTRODUCTION

The National Onsite Wastewater Recycling Association (NOWRA) was founded in 1992. Its principal purpose is to educate and serve its members and the public by promoting sound federal, state, and local policy, improving standards of practice, and advancing public recognition of unsewered wastewater infrastructure. To achieve this mission, NOWRA has developed and adopted a model framework to serve as a guide for future national policy on onsite systems and for NOWRA's programs and activities.

THE GOAL OF THE MODEL FRAMEWORK

Achieve sustainable development while protecting human health and environmental quality.

NOWRA believes that attaining this goal will provide enduring opportunities to our members and enhance the quality of living for the public. Traditional "prescribed" models cannot achieve the goal of sustainability. In fact a "prescribed" model is detrimental to achieving such a goal because it largely ignores local environmental sensitivities and thwarts innovation. Furthermore, a "prescribed" model approach is unable to adequately balance human health and environmental protection with economic development pressures.

WHAT IS THE MODEL FRAMEWORK?

The Model Framework contains critical components necessary to achieve the Goal. It is based on performance of all components affecting the onsite wastewater treatment system; performance of the treatment system, system owners, system practitioners (site evaluators, designers, installers, pumpers, operators, and regulators), and system regulatory agencies.

The Model Framework consists of seven components:

1. Performance requirements that protect human health and the environment;
2. System management to maintain performance within the established performance requirements;
3. Compliance monitoring and enforcement to ensure system performance is achieved and maintained;

4.Technical guidelines for site evaluation, design, construction, operation and acceptable prescriptive designs for specific site conditions and use;

5.Education/training for all practitioners, planners, and owners;

6.Certification/licensing for all practitioners to maintain standards of competence and conduct; and

7.Program reviews to identify knowledge gaps, implementation shortcomings and necessary corrective actions.

Collectively, these elements constitute a total system capable of excellence in performance. Each element is important and must be included for the goal of sustainable development to be realized. Therefore, NOWRA is promoting this framework and each of the principles equally.

HOW THE ELEMENTS WORK

Performance Requirements: The Model Framework recognizes that onsite wastewater treatment systems are not 'disposal' systems but systems that discharge treated wastewater to ground and/or surface waters. This model also recognizes that sensitivities of water resources to treated wastewater discharges vary and that water quality standards, therefore, should reflect the specific site characteristics. Further, performance requirements must be specific and measurable to allow credible performance compliance monitoring of all systems. Methodologies for determining appropriate water quality performance requirements must be established by regulatory agencies based on risk management procedures.

System Management: To maintain system performance within the established performance requirements, perpetual management of all systems must be provided. Management may be provided by the owner or through third parties that may be private, quasi-public, public/private, or public. Ultimately, all treatment systems should be maintained on an equivalent basis. Perpetual management should be provided in a manner that the treatment system and its servicing is transparent to the user.

Compliance Monitoring and Enforcement: A governmental regulatory agency must have continuous oversight of the performance of all onsite wastewater treatment systems. The system owner (either property owner or management district) is responsible for maintaining compliance. Renewable operating permits issued to the responsible party (property owner, management district, or sanitary/utility district) by the governmental agency occurs only after acceptable performance is documented, and is the more reliable method of regulatory surveillance of performance.

Technical Guidelines: Guidelines for site evaluation, design, construction, and operation are critical aids to owners and practitioners to inform them of acceptable methods for achieving compliance with performance requirements. These should include prescriptive designs that are capable of meeting the performance requirements under specific site conditions and intended uses. However, they are only optional designs and are not intended to be required designs. Owners may submit alternative and/or innovative designs for approval provided the owner assures performance to meet the established requirements.

Education and Training: The most critical element to ensure that consistency is achieved is Education. Education of the public and college and technical school students is needed. Also, a training component to ensure that all practitioners are knowledgeable in standards of practice is essential.

Licensing/Certification: Licensing/certification of all practitioners is the fundamental link to maintain high standards of competence and conduct. Continuing education is a central tenet of this Model Framework for licensing and certification programs. The licenses/certifications should be limited in term but renewable following documentation of minimum continuing education requirements. Also, they must be revocable if the holder is found to be negligent or fraudulent.

Program Reviews: This Model Framework must be grounded in good science, engineering, appropriate statu-tory authorities and sound management practices. Shortcomings in the management programs must be identified to direct needed and appropriate research, enabling legislation, education, etc., necessary to implement appropriate corrective actions to achieve our goal of sustainable development.

NOWRA'S DIRECTION

NOWRA intends that this Model Framework be advanced as the "national" ideal for building and maintaining an onsite wastewater infrastructure within the U.S. NOWRA is using this framework to identify and plan programs and actions that will be beneficial to its members and the public.

ADOPTED BY THE NOWRA BOARD OF DIRECTORS AND MEMBERSHIP, OCTOBER 1999

Model Code Framework for the Decentralized Wastewater Infrastructure

VOLUME II

CODE DESIGN PHILOSOPHY AND GUIDANCE

NOWRA
National Onsite Wastewater Recycling Association

March 2007

IMPORTANT NOTE

The Model Code Framework for the Decentralized Wastewater Infrastructure remains a work in progress. Its three major elements are code structure, user guidance, and evaluation of treatment components. While each element can stand alone, the three are intended to work together. Volume I and Volume II—essentially completed at this time—represent, respectively, the first two elements; they are particularly important because they address specific code issues and policy options. The tools for evaluating the performance of confined treatment components (pretreatment) and the unconfined-soil component remain in development.

The protocol for evaluating the pretreatment components—currently under beta testing by the Florida Department of Health (FDOH)—is near completion. The joint objectives of NOWRA and FDOH are to (1) perfect the evaluation protocol and the performance classification matrices, (2) have FDOH and NOWRA jointly administer the protocol, and (3) have FDOH incorporate the protocol into the Florida state code.

The protocol for evaluating the unconfined-soil component has been more difficult to develop and is about half-way to completion. Work on documents concerned with the scientific aspects is complete; the implementation document is still in development. The completed soil-evaluation/classification documents should be available at the next NOWRA Annual Conference.

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Produced and published by
National Onsite Wastewater Recycling Association, Inc.
3540 Soquel Ave, Ste A, Santa Cruz, CA95062
831-464-4884
nowra@nowra.org • www.nowra.org

www.modelcode.org

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* * *

DOCUMENTARY SUPPORT

The following United State Environmental Protection Agency (U.S. EPA) resources should be used to supplement the information in this volume. They can be downloaded or ordered through the National Center for Environmental Publications at http://www.epa.gov/ncepihom/ordering.htm or from the specific agency as follows:

U.S. EPA Onsite Wastewater Treatment Systems Manual (2002)
http://www.epa.gov/ORD/NRMRL/Pubs/625R00008/625R00008.htm

U.S. EPA Voluntary National Guidelines for Management of Onsite and Clustered (Decentralized) Wastewater Treatment Systems (2003)
http://www.epa.gov/owm/septic/pubs/septic guidelines.pdf

U.S. EPA Management Handbook (Draft 2003)
http://www.epa.gov/owm/septic/pubs/septic_management_handbook.pdf

CONTENTS

CHAPTER 1

INTRODUCTION

BACKGROUND

In July 1999, the National Onsite Wastewater Recycling Association (NOWRA) adopted the *Model Framework for Unsewered Wastewater Infrastructure* (see Appendix A) to identify the critical components necessary to achieving the goal of "sustainable development while protecting human health and the environment." The paper identified seven critical components:

1. Performance requirements that protect human health and the environment
2. System management to maintain performance within the established performance requirements
3. Compliance monitoring and enforcement to ensure system performance is achieved and maintained
4. Technical guidelines for site evaluation, design, construction, operation, and for acceptable prescriptive designs for specific site conditions and use
5. Education/training for all practitioners, planners, and owners
6. Certification/licensing for all practitioners to maintain standards of competence and conduct
7. Program reviews to identify knowledge gaps, implementation shortcomings, and necessary corrective actions.

In 2000, the NOWRA Board of Directors authorized work to proceed on addressing the seven components identified in the 1999 paper. The specific purpose of the continuing work was to craft a comprehensive framework on which state-level codes for decentralized wastewater-treatment systems should be written. *Model Code Framework for the Decentralized Wastewater Infrastructur*e is the outcome of that mandate. It comprises two documents: Volume I – *Workbook for Writing the Code* and this document, Volume II – *Code Design Philosophy and Guidance.* Hereinafter, those documents will be referred to concisely as follows:

- The whole work will be referred to as: Model Code Framework
- Volume I will be referred to as: Workbook
- Volume II will be referred to as: Guidance book

An Executive Summary of the work is available, separately.

The Model Code Framework provides the tools and the knowledge to propel to a new level the performance-based regulation of onsite, cluster, and other systems for decentralized wastewater treatment. Its two volumes apply the principal of "informed choice" to addressing the performance issues applicable to wastewater-management solutions. "Informed choice" means that policy makers and citizens at all affected levels participate in setting and applying regulations; they understand the regulatory options and the benefits and costs associated with each option. In the subject case, it means specifically that they have the knowledge to shape the management of human and environmental benefits and risks that are associated with using decentralized wastewater recycling in their community. This process maximizes the value of regulation by balancing benefits, costs, and risks at levels appropriate to the immediate community The Workbook applies the principal and process of "informed choice" in three ways, with many opportunities for its use to be found within each category:

1. Jurisdictions adopting a performance-based code have choices of requirements and language for (a) varying levels of management and quality assurance, (b) the varying health and environmental risks associated with varying local conditions, and (c) the varying capabilities of regulatory authorities and service providers.
2. Classification Matrices allow state and local jurisdictions to choose from a range of output performance measurements to deliver the desired level of risk reduction necessary to protect human health and the natural environment.
3. System designers can choose treatment components that are rated in the Classification Matrices and use Soil-Component parameters to meet the required output performance specified for the site. Alternatively, they can propose systems designed to meet specified performance requirements and quality-assurance requirements in the adopted code.

The Workbook and this Guidance book will continue to evolve with the increased understanding of both micro- and macro-scale impacts of wastewater-management practices. The field of decentralized wastewater treatment is becoming integrated with other efforts in water-resource management, including storm water management, water reuse and recycling, and watershed planning. All those efforts will influence "informed choice" related to wastewater management. As technology advances and scientific research is applied to treatment and dispersal mechanisms, approaches to wastewater management will acquired more "informed choices."

The two volumes are intended to be used in tandem to inform and support state-level regulatory personnel in their crafting of codes that are responsive to local environmental conditions, priorities of local communities, and priorities of local government entities. The realistic assessment of the local capacity for wastewater-infrastructure management is a critical component of the code-writing process. A rational evaluation of risk factors and of the extent to which community interests and capacities can be focused on protecting human health and the environment is the foundation of a reasonable and effective code.

GUIDANCE FOR REGULATORS, POLICY MAKERS, AND THE GENERAL PUBLIC

The purpose of a regulatory code for decentralized wastewater-treatment systems is to protect human health and the environment. It must be reasonable if it is to be effective. The evaluation and reduction of risk should be the basis for code development decisions, but choices must be made in the context of a variety of potentially competing resource-protection issues.

To determine the reasonableness of a proposed regulation, all segments of the population must be invited to assess its impact, with the intent to affect an alignment of aims (i.e., align community interests and capacities to achieve the selected or required level of performance and protection). Provision of the resources and support for the regulatory capacity necessary to enforce the regulation must be a critical part of this alignment. A code cannot meet its purpose without political and community support.

Code adoption is a method of risk management. The evaluation of *risk* related to wastewater treatment can and should be conducted in an objective and deliberative manner. The adoption of performance *requirements* based on the level of risk that society is willing to accept is a more subjective process. All parties need to understand that it is impractical to expect total elimination of risk (i.e., adopting a numerical performance goal of zero). The cost of assuring that an adopted performance provision can be met must be understood and balanced against the value of the reduced risk. If the value of the reduced risk is high enough, then it may be expected that the resources necessary to enforce the adopted provision will be provided. If those resources are not provided, there can be no assurance that risk will be abated.

Under the Model Code Framework, performance requirements for differing localities are established based on the differing levels of evaluated or perceived risks to human health and the environment. Within the decision-making structure, there are critical elements and levels of management practice that may be adopted as quality assurance provisions to achieve the desired performance. In aligning support for the adoption of a code based on performance requirements and quality management practices, regulators need to weigh the demands of implementing the code against the value of improved water quality, reduced public health risks, preservation of property values, and protection of investments in decentralized wastewater infrastructure. Local officials, industry practitioners, and the general public need to be informed and involved in identifying those benefits if they are to be expected to support the imposed requirements, including the education and enforcement elements.

GOALS, PURPOSES, AND INTENT

A critical first step in the development of a performance-based code is the formulation of purpose statements that will direct decision making. In the subject context, the overriding purpose is to protect human health and the environment. That goal can be restated more precisely: “The code is intended to reduce to an acceptable level the risk of harm to public health and the natural environment.” That statement can be extended with sub-statements that guide the code-writing process more specifically.

Statements of intent are discussed in more detail in Chapter 6, "How to Use the Model Code Framework," but could include statements such as the following:

- The risk-reduction goals of the governmental body writing a code reflect an obligation to protect citizens and to meet applicable environmental and public health regulations.
- Recognizing that decentralized wastewater-treatment systems are only one of many contributors of risk to human health and the natural environment, efforts to reduce the share of the impact from these systems shall be balanced on a cost/benefit basis through integrated water-resource management strategies.
- The code shall provide a range of performance-based requirements and management practices with related guidance to allow governmental units the ability to make informed choices when adopting code provisions that reflect the level of risk associated with varying conditions.
- The code shall support the planning and zoning intentions of local governments by helping to ensure that decentralized wastewater-treatment systems are available to support the structure envisioned by zoning decisions. The code shall ensure that decentralized wastewater-treatment systems can provide sustainable and cost-effective solutions within a continuum of wastewater infrastructure options, including integration with larger wastewater-collection and -treatment facilities.
- The authority and responsibilities of various practitioners in the decentralized wastewater-treatment industry shall be clearly articulated in the code with associated quality-assurance requirements to achieve conformance with the applicable standards of practice.
- Adopted code provisions have the force and effect of law. Enforcement shall be equitable and reasonable. Education will be the primary focus of enforcement to promote compliance, reserving punitive enforcement action for cases where education and notification of compliance requirements do not achieved adequate performance.

PERFORMANCE-BASED AND PRESCRIPTIVE ELEMENTS OF A CODE

A code must approach the issue of performance-based requirements versus prescriptive requirements in a systematic manner, recognizing that use of some prescriptive requirements can be an integral part of a performance-based code. The Model Code Framework provides a hierarchical sequence of code-development steps that moves from purpose statements to performance-based requirements to prescriptive requirements. The following is an example of this sequence:

1. High-level purpose statement: Protect public health and natural environment
2. Statement of intent: Protect estuaries from nutrient overload
3. Drainage basin TMDL for nitrogen: All sources contributing nitrogen in the drainage basin shall not exceed a cumulative total load of X lb/yr (mass loading standard)

4. Performance-based requirement for decentralized wastewater-treatment systems in specified basin: <20 mg/l TN and <15 mg/l N-nitrate in 90% of effluent samples from a pretreatment component
5. Prescriptive requirements for achieving compliance with performance-based requirements: Evaluation and listing of pretreatment components that are "deemed to comply" with the adopted performance-based requirements.
6. Non-prescribed designs for achieving compliance with performance-based requirements: Plan review and assessment of engineered designs (those not conforming to the listed prescriptions under Step 5) with respect to the performance-based requirements
7. Quality Assurance: Monitor installed systems to assure their compliance with adopted performance-based requirements and to assure that the applicable management practices are being followed.

Step 5 is an example of a prescriptive solution within a performance-based code. Historically, prescriptive codes allow only specified system designs or listed components; they do not recognize defined purposes or performance-based requirements; and they provide for only limited design options. Alternative design options need to proceed through a lengthy and sometimes costly approval process. A performance-based code can allow for non-prescriptive solutions (those not specifically prescribed in the code or not listed as "deemed to comply") as described under Step 6. Finally, a performance-based code must include the quality assurance requirements.

Without acknowledged purposes and established performance-based requirements, innovation is thwarted and compliance becomes mere comparison of solutions to prescriptions. The goal "to reduce to an acceptable level the risk of harm to the public health and the natural environment" cannot be achieved in the most effective and cost efficient manner under those constraints. Jurisdictions are cautioned not to limit solutions to "deemed to comply" prescriptions that meet adopted-performance-based requirements.

The example used here only relates to system design. Similar opportunities for more responsive regulations are realized when this approach to purpose and performance are applied to the full range of people and organizations associated with a sustainable decentralized wastewater infrastructure.

Development of the NOWRA Model Code Framework

The transition of state and local codes from the prescriptive type to the performance-based type is an evolutionary process. Many jurisdictions have made significant progress and shared in the development of the two volumes of the Model Code Framework. NOWRA members regularly met at various locations around the country and worked together on the multiple tasks involved in developing the Model Code Framework. Many other partners shared their state and regional experience with performance-based code development efforts through formal interviews and through participation in code meetings held from May 2001 through 2004.

The Model Code Framework is intended to promote the adoption of performance-based codes by state and local jurisdictions. It provides resources supported by the best available data, science, and expert opinion. (Many current codes contain restrictions that are only supported by opinion and tradition.) The content of the two volumes of the Model Code Framework challenges these traditions and attempts to expose the myths associated with many current practices and regulatory structures.

No governmental unit is required to adopt the precise structure or language of the Workbook. However, the fact that it was developed with industry-wide support, the best knowledge available from experts in the field, and significant regulator participation creates a strong argument for its use. The resources, processes, and code provisions of the Workbook are realized in the following interrelated components and development structures:

- **Classification Matrices** – Successively more stringent output parameters of wastewater constituents are arrayed in matrices—output parameters on the vertical axis and probability values on the horizontal axis. The matrices serve two functions:
  - ***Classification.*** The matrices provide a method for classifying the outputs of treatment-train constituents. The purpose is to classify (as opposed to judge) designs or components.
  - ***Performance Measures.*** Classification categories serve as performance measures that can be adopted as performance-based standards in state or local codes.

  Another resource—related to the matrices—classifies the performance of the Soil Component, which may be referenced in the code.

- **Evaluation** – The Workbook resource provides an avenue for classifying treatment-train designs and components into the categories defined by the matrices. The protocol includes an application process, content requirements for submitted specification manuals, and the proofs needed to support applicant claims and classification in the matrices. Listed design/specification manuals contain maintenance and monitoring requirements. NOWRA evaluation processes could also be applied to certification of individuals and organizations.

- **Guidance** – This Guidance book was developed to assist state and local jurisdictions in the development, adoption, and implementation of performance-based provisions. Guidance is provided to support the process of aligning desired levels of risk reduction to appropriate performance-based requirements and quality assurance management provisions.

- **Code Language** – The code language is provided to support and implement selected performance-based requirements. Code language options address both the selection of quality assurance management practices that are often absent in current codes and the administration/enforcement issues common to all codes. A checklist of necessary authorizing ordinances and statutes is also provided.

- **Design Manuals** – Design manuals are prescriptive solutions to performance-based requirements. Specification manuals for commonly used designs can be created, evaluated, and listed. To "prime the pump," NOWRA encourages the submission of generic design manuals for evaluation and listing and may develop sample manuals as needed for small-volume applications. Proprietary component manuals may be developed and submitted as described in Item 2 above.

There are numerous factors within the industry that make this national approach to code writing a highly important endeavor. When applied, there tend to be minimal variations between codes adopted by the multiple local jurisdictions and by the many states. Less variation increases market size for new products and designs and fosters innovation, higher quality, and lower costs.

The need to secure local approval in thousands of jurisdictions for every new product and design makes innovation and deployment of effective decentralized wastewater-treatment systems very difficult. Many regulating agencies do not have the technical expertise available to do adequate evaluation. The Model Code Framework classifies systems and components against performance measures in the matrices and lists the categories that can be met within specified outcomes and probability values. If local and state regulators have confidence in the NOWRA classification process, they are likely to approve the use of listed systems and components without requiring additional product testing.

Codes currently being used often ignore the status of maintenance and monitoring of installed systems as well as other quality assurance management practices. This has resulted in large numbers of uncorrected system malfunctions or failures that increase risks to the public health and the natural environment. The variations among state and local codes also create many problems for homeowners, realtors, and builders. It is time to finally resolve these long standing problems to properly support the growing demand for managed decentralized wastewater-treatment infrastructure.

CHAPTER 2

CORE PRINCIPLES

ALIGNMENT OF AIMS

The Model Code Framework promulgates a process of code development that results in an adopted code that pleases, or at least aligns the aims, of all the groups affected by its provisions. If this alignment of aims is achieved during the code development process, the code will be adopted with broad community support. The Model Code Framework provides for alignment of aims in the following manner:

- ***Code options are provided*** – The Model Code Framework provides for use of a range of regulatory options that allow the most appropriate government jurisdiction to match code requirements to risks of harm to public health and the natural environment. Where its knowledge of local conditions is a paramount factor, a local jurisdiction decides the level of regulation necessary to provide an acceptable level of protection.
- ***Purpose of provisions are clear*** – Each requirement is developed in a three-part process that lists the purpose of the requirement, provides a range of performance options that achieve the purpose, and code language that defines a measurable performance-based requirement. Guidance is provided to assist in making choices on code requirements.
- ***Requirements* are based on science** – The requirements suggested in the Model Code Framework were developed by national experts from all areas of the decentralized wastewater-treatment industry, including scientists, engineers, regulators, contractors, manufacturers, soil evaluators, and academic researchers. The requirements are backed by current science; where the science is not settled, the expert opinion of the group is used.

The Model Code Framework provides options for as many levels of system performance and quality-assurance management practices as are needed to match state and local conditions, capabilities, and politics. The written code should reflect the community's capacity to implement requirements intended to reduce the health and environmental risks associated with decentralized wastewater-treatment systems. It is recognized that states and local communities have different capabilities to administer and enforce codes. The Model Code Framework informs and supports code development processes and provides options that allow adopting jurisdictions to choose code requirements appropriate to their circumstances.

There are benefits to be gained from using an informed-choice approach to the selection of performance-based code requirements over the traditional prescriptive code requirements that often limit choice. Since risks vary with human and natural environments, options should be available to match choices for regulatory solutions to the level of desired risk reduction. When applied to local communities in their local environments, an informed-choice approach facilitates the alignment of aims among politicians, regulators, industry, homeowners and the general public. Code requirements that meet the objectives of the community and assure protection of public health and the natural environment tend to be readily adopted and enforced.

BALANCED CODE PROVISIONS

The core philosophy of the Model Code Framework is to minimize reliance on statewide requirements and prescriptions in code design. A statewide approach tends to be of the "one size fits all" type, although, in fact, that one size actually fits very few. As a result, statewide requirements are inevitably over specified (too strict for the risk) in some environments and under specified (risk ignored, no code provision) in others. Those circumstances can result in political opposition to a proposed code when a substantial number of statewide provisions make no sense relative to local risk factors. They can also result in the inability to pass codes that are appropriate in some situations. For example, a code provision to reduce nitrogen in onsite wastewater may be judged appropriate when a high density of onsite systems near a shoreline have been shown to contribute to pollution, as may be demonstrated through a Coastal Zone Management Plan. The same provision may gain little or no support for scattered housing in agricultural areas where tons of nitrogen are applied as crop fertilizer and there is no evidence of impacts from the dispersed onsite systems.

Local jurisdictions often resolve an overly restrictive statewide code provision by ignoring it, by granting selective variance approvals, or by creating de facto substandards:

1. *Simply ignoring a provision of statewide code or omitting it from the local code.* The resulting total lack of enforcement of a statewide code provision creates a general disrespect for the law and undermines the expectation of voluntary compliance with all regulations, whether these are required through federal, state, or local code provisions.

2. *Enforcing the provision for some circumstances or individuals and not for others, as in selective variance approvals or case-by-case enforcement action by a regulator.* Some jurisdictions attempt to address a statewide standard in a politically acceptable manner by granting variances and applying selective enforcement so as not to create a local political or legal backlash.

3. *Creating de facto substandards, such as applying a local nitrate standard of 25 mg/l when the statewide code requires a maximum standard of 10 mg/l.* Creating de facto law and enforcing substandard provisions shifts the power to make law from formal lawmaking processes by the legislature or designated authority (subject to hearings and legal standards) to informal creation by individual regulators or local departments.

To avoid these types of local responses to unreasonable statewide provisions, the Model Code Framework encourages the adoption of code provisions that are responsive to local conditions and can be applied in a fair and equitable manner. Balanced code provisions promote fair application and enforcement of the code as well as increased respect for and compliance with the code.

Elements of a Performance-based Code

Prior to discussing elements of a performance-based code, the differences between prescriptive codes and performance codes need to be clarified:

> "Prescriptive code" means an administrative regulation that specifies the means to achieve an objective and excludes other processes that achieve the same objective.

Some prescriptive codes contain "performance provisions" that link the output of a specific system design to a "performance requirement." Absent performance-based requirements for all treatment systems and the general ability to utilize alternate designs without first securing a code change, both the provision and the code remain prescriptive.

> "Performance code" means an administrative regulation that specifies the ends or results of a process or activity and allows the general use of solutions that demonstrate achievement of the objective requirement or standard.
>
> "Performance-based standard" means a clear statement, either numeric or narrative, of a measurable, achievable condition or output of a process that is applied at a specific point or place, that permits a clear pass/fail determination, and that allows multiple solutions. "Performance-based requirement" is a substitute term.

Performance-based standards/requirements can be applied to:

- Treatment, conveyance, and distribution systems
- Certification of people and organizations
- Quality-assurance and administrative processes

A fully developed performance-based code contains the following elements as applied to the regulation of treatment systems:

1. Performance-based requirements are adopted or authorized in code language that sets the output requirements for treatment systems. The Model Code Framework creates a mechanism for local adoption of performance-based standards either by proposing a standard or by providing a mechanism for doing so.
2. An evaluation process is used to determine compliance of the component or system design with the applicable standard. There are generally three methods for evaluating systems or components. One or all can be employed in an evaluation program.

a. Deemed to comply – The system is evaluated by performance testing and then listed as complying with a specific performance-based standard or with a designer's or manufacturer's claim of performance. With proper operation and maintenance, it is expected that the systems will perform in the field as it did during the evaluation period.

b. Process monitoring – The system components are routinely checked during operation to see if each is functioning properly, with adjustment or repair as needed. A properly operating system is expected to produce output that meets the standard.

c. Output monitoring – The output of the installed system is evaluated against the appropriate standard. Monitoring can be continuous or based on periodic sampling, but should be required to meet a statistically valid sampling protocol if an expectation of performance is based solely on this method of evaluation.

3. Adopted performance-based standards reflect the level of risk associated with the site and the surrounding environment or conditions. The first two elements establish the link between the individual system and the adopted performance standard. This third element establishes the link between site risks and the adopted standards. Because risk varies by area, adopted performance-based standards should also vary. This de-emphasizes adoption of countywide or statewide standards except when a minimum level of acceptable risk is being established.

4. The capacity and delivery of services by regulators and industry professionals are assessed and linked to the utilization of system designs and processes. This element is related to the performance of people versus systems and becomes especially critical when more complex system designs are used in areas with high risk conditions. Failure to provide the necessary level of professional support increases the risk and jeopardizes the purpose and goals of performance-based requirements. Capacity and responsibility issues are discussed below.

5. The least-studied element of a performance-based code is the alignment of aims between the decentralized wastewater-treatment industry and the general public served by the industry and its regulatory structures. Regulation delivers a public-safety service at a cost. The service is risk reduction. The cost is time, money, and constraints or conditions placed on citizens' use of their land. The alignment of aims between the public, industry professionals, and regulators relative to risk reduction and cost is critical to successful adoption and implementation of performance-based codes.

Capacity for Implementation of Code Provisions

When considering the various provisions in the code structure, it is essential that the adopting jurisdiction evaluates the available capacity for implementation. Beyond matching performance-based provisions with the varying levels of risk to human health and the environment, the selection process must also take into account the resources available to support each provision under consideration. If resources are inadequate, or if there is insufficient support to expand capacity to meet the provision, then it should not be adopted.

Areas where "capacity" is an issue include regulatory staffing levels and competencies, professional training opportunities and requirements, qualified practitioner availability and licensing / certification programs, data management systems for permitting and monitoring records, residuals-management options, financial assistance for system repair and replacement, and effective program auditing and oversight. That list is not exhaustive and reflects components of the Model Code Framework and program elements of the *U.S. EPA Voluntary National Guidelines for Management of Onsite and Clustered (Decentralized) Wastewater Treatment Systems* (2003). These capacities are explored in greater detail in Chapter 5, Quality Assurance through Management.

It is expected that an adopted code will include a significant number of provisions related to quality-assurance-management practices that are considered prerequisites to the implementation or application of other code provisions. Ideally, a state-level code would incorporate such prerequisite provisions to provide local authorities with clear direction on the capacities needed to adopt and implement each portion of the state code at the local level. The Model Code Framework strongly promotes such capacity considerations in the selection of code provisions and performance-based standards.

Responsibility Placed on Regulators and Industry

Regulators at the state and local levels are increasingly challenged to enhance their knowledge and expertise in order to provide effective oversight of a widely diverse and dispersed wastewater infrastructure. In many cases, regulatory agencies are severely understaffed, providing little time or opportunity for staff training and professional development. Often, state-level staff members working in related areas of water-resource protection are not engaged in an integrated approach that includes decentralized wastewater-treatment infrastructure. In addition, many regulators perform duties that could be handled, and should be handled, by non-regulatory professionals.

The Model Code Framework Committee spent significant time reviewing the issues of regulator/contractor responsibilities and professional conflict of interest. Table 2-1 was developed to reflect the Committee's position on these issues. The Committee clearly stated that a regulator should conduct only those activities and responsibilities defined as regulatory roles. Regulator performance of activities that are the responsibility of non-regulatory professionals was determined to be a significant conflict of interest to be prohibited in adopted codes.

The Model Code Framework was developed with a strong philosophical basis in classification and informed choice. Given this philosophy, it contains very few outright prohibitions. Consequently, the Committee's decision to place such a definitive prohibition on the role of the regulator is evidence of the strong sentiments concerning that issue.

TABLE 2-1. Conflict of Interest for Individuals Serving Multiple Roles.

ROLE	Owner	Site Evaluator	Designer	Constructor	REGULATOR Inspector	REGULATOR Plan Reviewer	REGULATOR Monitor	Operator	Pumper	Vendor
Owner	X	1	1	1	2	2	2	1	1	1
Site Evaluator		X	1	1	2	2	2	1	1	1
Designer			X	1	2	2	2	1	1	1
Constructor				X	2	2	2	1	1	1
Inspector					X	1	1	2	2	2
Plan reviewer						X	1	2	2	2
Monitor							X	2	2	2
Operator								X	1	1
Pumper									X	1
Vendor										X

Scale:
1 = Potential conflict. A consumer protection issue that can be avoided by practices such as disclosure and information.
2 = Significant conflict that should be prohibited by rule.

Both the competency and integrity of the regulator role is recognized as being of extreme importance to the advancement of the professional capacity of all segments of the Decentralized Wastewater-Treatment industry and integrated approach to water resource management. The primary regulator roles of code implementation and oversight, along with outreach, technical assistance, and education for system owners, industry professionals, and public officials, are seen as sufficiently critical to demand resource allocations that adequately support a high level of regulatory capacity free from conflicts of interest.

Likewise, there are significant capacity issues related to industry professionals and other non-regulatory personnel working in water-resource management areas. Public-sector personnel need to become familiar with interrelated water-quality and -quantity issues and actively support integrated water-resource management solutions. Demonstration of professional integrity, adherence to professional codes of ethics, and compliance with standards of practice need to become the norm for the industry. Industry professionals also have a role in the education of system owners, other industry professionals, and public officials, including regulators. Assurances of professional competency through education/training and licensing/certification are addressed in Chapter 5.

CHAPTER 3

CORE STRUCTURES

The Classification Matrices and the Soil Component are critically integral to the Model Code Framework. Both were developed in adherence to the philosophy of classification and informed choice. Classification is inherent to the study of soils, but the usefulness of its application in establishing performance measures is less evident. This chapter describes and justifies the classification approach to development of these core structures of the Model Code Framework.

CLASSIFICATION MATRICES

A basic task of the Model Code Framework Committee was the development of performance-based provisions. The task was divided into two approaches:

1. Numeric performance matrices that classify treatment components by measures of system output and output variability
2. Narrative performance-based requirements that define (1) the range within which output parameters are acceptable and (2) management practices that ensure compliance with that output range.

The numeric performance provisions are incorporated in the Classification Matrices used to categorize a range of performance measures for constituents of interest. The relationship of the Classification Matrices to the Soil Component is explained in the related support document for the soil-component resource. The narrative performance provisions are addressed in Chapter 5, Quality Assurance through Management.

The two axes of a matrix define the system output for each constituent as follows:

- The vertical axis presents discrete values of constituents that cover the full range of output values from raw sewage to drinking water.
- The horizontal axis presents probability values, in the form of percentages, that categorize the variability in the system component's output performance.

Vertical Axis (y-axis): Constituents of Interest. The destination of the waste stream determines the constituents of interest. The two primary discharge destinations are subsurface and surface and reflect the output of the treatment train. Seven constituents of interest are identified in Table 3-1.

TABLE 3-1. Y-axis Constituents and Classification Levels by Destination of Final Effluent.

Constituent	Effluent Destination		
	End of Treatment Train Discharge		Classification Levels
	Subsurface	Surface	
Fecal Coliform	X	X	<1, $<10^1$, <200, $<10^3$, $<10^4$, $<10^5$, $<10^6$, and $>10^6$ cfu/100ml
Total Nitrogen	X	X	0, <2, < 10, <20, <60, <90, <120, >120 mg/L
Nitrate	X	X	0, <2, < 10, <20, <60, <90, <120, >120 mg/L
Total Phosphorus	X	X	0, <1, <5, <10, <35, >35 mg/L
BOD_5		X	0, <1, <5, <10, <20, <30, <200, <350, <500, <1000, and >1000 mg/L
Total Suspended Solids		X	0, <1, <5, <10, <20, <30, <200, <350, <500, <1000, and >1000 mg/L
pH		X	7, 6 or 8, 5 or 9, 4 or 10, 3 or 11, and <3 or >11

Horizontal Axis (x-axis): Output Variability. The quality-assurance/quality-control features of a product design and maintenance program attempt to control performance variability. The horizontal axis of the matrix classifies the quality-assurance/quality-control performance results, expressed as probabilistic values, each stated as a percentage of occurrence—50%, 75%, 90%, 95%, and 99%.

As an example, Figure 3-1 shows the numeric matrix for nitrate with an evaluated nitrate-reducing component listed in the various classifications. The shaded blocks represent the classification pattern of the component. This classification example

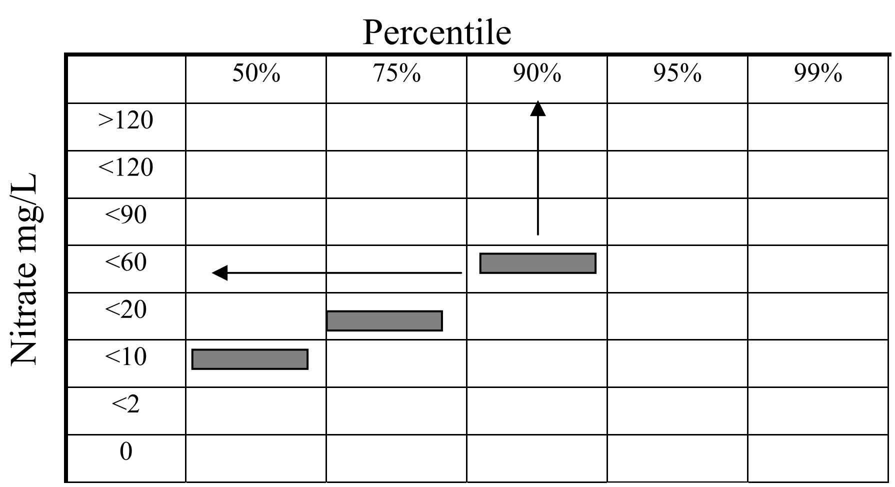

FIGURE 3-1. Numeric matrix for nitrate and an evaluated nitrate-reducing component.

shows performance levels for nitrate below 10 mg/L, 50% of the time, below 20 mg/L, 75% of the time, and below 60 mg/l, 90% of the time. When qualifying in one box, a component automatically qualifies in all boxes to the left and above, as shown by the arrows. The classification matrices are included as Appendix A in the Workbook.

The percentage values in the Classification Matrix relate directly to the reliability of the component performance—the higher the percentage, the greater is the level of reliability that can be expected.

There are many factors that contribute to system and component reliability; the Component Evaluation Process in the Model Code Framework assesses some of them. Quality assurance management practices also contribute significantly to the reliability level.

COMPONENT EVALUATION

A major purpose of the Model Code Framework is to help in standardizing the industry, especially in the area of product development. Since performance-based codes may require that components or system designs meet specific output-performance standards for constituents of concern in designated areas or under identified risk conditions, it is important to be able to qualify and quantify component or system performance. The standardizing process is critical if the decentralized wastewater-treatment industry is to advance. The Procedures for Administering Confined Treatment Component Database and Matrix and the subsequent listing of components to the Classification Matrices can address this industry need.

Historically, state and local jurisdictions have independently developed codes for decentralized wastewater-treatment systems without reference to a national model. For example, differences among state codes make it difficult to develop and market treatment products. In response to this, the Non-Soil Treatment Technology Database and Matrix (under development as an Appendix to the Workbook) will serve to classify components and bring them into a national forum, thereby avoiding the continual "re-invention of the wheel" in each jurisdiction.

Product verification and certification programs attempt to provide a level of assurance for the reliability of an evaluated component. While it is very challenging to provide assurances of reliability over long periods of time under variable operating conditions, that is what must be achieved to establish national acceptance of a "deemed to comply" solution to evaluation of system compliance with performance-based requirements. A system or component is considered to be robust when it can meet or exceed an adopted level of performance over time and variable operating conditions. The soil is a good example of a treatment component that has proven to be very robust when used appropriately.

THE SOIL COMPONENT

Decentralized wastewater-treatment systems are composed of a series of components, each with influent specifications and effluent expectations. The last component in the treatment train produces the final output of the system. Defining the necessary effluent quality for this output is the primary regulatory target of a performance-based code.

In the case of subsurface systems, the final effluent quality, after passing through the soil-treatment component, is difficult to measure. To avoid the necessity for measuring performance after the soil component, the Model Code Framework inserts a Soil-Component element that assigns treatment values to various soil characteristics. Once the final output effluent quality requirements are defined and integrated with the treatment information provided by the Soil Component, the system design decisions are directed to the upstream distribution system and pretreatment components to assure that the influent to the soil component has the appropriate characteristics.

Since the pretreatment components provide easier access for measurement of output performance than the soil component, those upstream components can be evaluated for treatment capabilities with given influent requirements. A system designer will then be able to link compatible components into a treatment train that includes the specific soil characteristics as a definable part Additional guidance and support documents are provided for using the Non-Soil Treatment Technology Database and Soil Component of the Model Code Framework.

POINT OF STANDARDS APPLICATION

In the case of subsurface systems, performance-based requirements are expected to be met following treatment within the soil component. While the defined soil-treatment boundary is the point of standards application, the Soil Component provides a mechanism to design backward from that final treatment boundary in the soil. In the case of surface discharge, where there is no expectation of soil treatment, the point of standards application is the system effluent from the final non-soil-treatment component.

Depending on the receiving environment for a surface discharge or a reuse/recycle system, or the influent requirements for distribution to a soil treatment component, the constituents of interest will vary. They may include the additional three noted in Table 3 (BOD_5, total suspended solids, and pH), other constituents such as FOG (fats, oils, and grease), and constituents of unique concern to a local receiving environment or the tolerance of a manufactured component. In all cases, the performance-based standard must be defined along with the point in the treatment train at which the standard is to be applied.

When performance-based standards are adopted, the point at which the standards are to be applied must be defined.

CHAPTER 4

SELECTING PERFORMANCE-BASED STANDARDS

One of the most critical objectives of the Model Code Framework is to encourage state and local authorities to use "informed choice" in the selection of performance-based standards. Performance-based standards for decentralized wastewater-treatment systems established at the state level are influenced by broad public health and environmental concerns related to the protecting the quality of drinking water, surface water, and groundwater. Yet those standards may be too restrictive or too lenient given local conditions. Statewide standards are often adopted with very limited information on the actual contribution and relative impact of contaminants from decentralized wastewater-treatment systems.

It is reasonable for states to establish performance-based standards for decentralized wastewater-treatment systems to achieve generalized levels of protection related to bacteria in swimming, contact and other public waters. On the other hand, numeric performance-based standards adopted and applied statewide for other constituents such as nutrients would likely be unreasonable due to the wide variation in local risk factors. The Model Code Framework anticipates that local performance-based standards for nitrogen and phosphorus would be adopted as needed for areas such as watersheds with established TMDLs for specific nutrients or targeted Coastal Zone Management goals, where there is community interest in protecting local resources at risk of nutrient impacts. It is considered appropriate that a local jurisdiction would adopt performance-based standards that reflect the level of risk or prioritization of resource protection within its area of jurisdiction.

A number of factors must be taken into consideration when selecting numeric performance-based standards. These include clear goals with realistic and achievable standards, responsiveness to local risk conditions, balance between risk reduction and costs, and practical means of measuring and assuring performance.

CLEAR GOALS AND REALISTIC PERFORMANCE-BASED STANDARDS

Goals must be clearly defined with a primary focus on public health and environmental protection. The process must serve to reveal ulterior motives—such as increasing/decreasing development—that should be addressed through other regulatory means. Many of these potentially divisive issues should be addressed through the alignment of aims discussed earlier in this volume.

Wastewater-treatment goals, and any proposed numeric performance-based standards, must be realistic and achievable. Are there reliable and affordable treatment systems available to meet the standards? Does the responsible regulatory authority have the capacity to assure owner accountability for system performance? It is important to consider these and other "reality checks" early in the process of considering the adoption of numeric performance-based standards.

RESPONSIVENESS TO LOCAL RISK CONDITIONS

In reality, the process of an informed-choice selection of performance-based standards will involve many other considerations. The U.S. EPA *Onsite Wastewater Treatment Systems Manual* (2002) devotes an entire chapter to establishing performance-based requirements for treatment systems. Many of the evaluation methods and tools for assessing resource vulnerability and the capacity of the receiving environment discussed in Chapter 3 of the U.S. EPA manual are technically complex. Two less complex approaches (Hoover, 1998 and Otis, 1999) are also presented and are more easily applied at the local level where there may be limited resources for dealing with risk.

The Hoover approach uses a vulnerability-assessment method that emphasizes public input. This approach is well suited to aligning the aims of the community during the process of selecting performance-based standards. The following three components of risk assessment and management are involved in the process:

1. Identifying ground-water and surface-water resources and the relative perceived value of each resource to the community
2. Assessing vulnerability of each resource with designations of low, moderate, high, and extreme vulnerability due to conditions such as soil properties and depth to limitations in the soil profile
3. Developing management-control measures dependent upon the value and vulnerability of each resource.

The second step reinforces the importance of small-scale risk consideration associated with site and soil evaluation for the proper siting and design of treatment systems. The third step emphasizes the importance of stricter quality-assurance requirements in response to a community's agreed need for increased protection of a vulnerable and valued local resource.

In another approach, Otis provides a simplified method of assessing the probability of environmental impact in the absence of extensive detailed data to support informed choices. This approach is presented in the form of a decision tree for estimating the relative probability of wastewater sources impacting water resources. The process allows decision makers and other community members to progress through a series of environmental-sensitivity assessment to assign a qualitative estimate of the relative probability of impact. Limitations on the data available to assess building density, well construction, travel time of treated wastewater, fate of groundwater discharge, and impacts to aquifers, surface water, and point-of-use resources will certainly affect the ultimate determination of relative impact. However, the process itself should assist participants in understanding the relative impacts and the rationale for varying performance-based standards.

Whether simple or complex, the processes for evaluating local risk and resource-protection priorities require that decision makers have access to adequate technical expertise to support those processes. That support may be in the form of a paid consultant, an experienced person from a nearby jurisdiction that has successfully adopted and implemented performance-based standards, an academic with access to the technical resources of a local college or university, or other knowledgeable personnel.

While the selection of performance-based provisions related to quality-assurance management practices (narrative performance-based standards) may require less technical support, a local jurisdiction considering the adoption of numeric performance-based standards for decentralized wastewater-treatment systems must access the necessary expertise to explore contributing factors and relative impacts.

Decision-makers need to have a good understanding of the conditions in their local community that will impact risk evaluation and the prioritization of resource-protection goals. The following is a short list of the types of conditions that may warrant local adoption of numeric performance-based standards or the application of state-level numeric performance-based standard:

- Shallow soil over rapidly permeable coarse sand, gravel, or bedrock
- Vulnerable unconfined or sole-source aquifer used for drinking water
- Shellfish harvest area bordering a high density of decentralizes wastewater-treatment systems
- Risk of contamination to surface waters that serve as recreational or economic resources for the community.

These or other types of conditions would need to be identified to evaluate risk and to identify resource-protection priorities. If there is a known or perceived impact to prioritized resources, it is important to establish reasonable evidence that decentralizes wastewater-treatment systems are a significant contributor. This step may involve some form of sanitary survey or system inventory for existing systems, or projections of increased risk or impacts from future development on available lots or large parcels of undeveloped land. In the latter case, the goal may be to manage impacts from anticipated higher densities of decentralized wastewater-treatment systems in sensitive areas.

When adoption of performance-based standards is under consideration, complementary or alternative management options need to be considered also. It may be that selection of alternative management practices would be more cost effective than establishing strict performance-based standards. If it is decided that numeric performance-based standards are necessary, assuring that adopted standards can be met will still require additional management practices. A full range of options needs to be considered as to effectiveness and capacity for implementation.

The guidance offered in the Model Code Framework cannot provide a step-by-step process for considering the adoption of numeric performance-based standards, since the process must be tailored to the resources of the local jurisdiction. The Hoover and Otis approaches provide relatively simple structures for such a process, and there are examples and case studies for both simple and complex approaches available from U.S. EPA and other resources. Considering the local adoption of numeric performance-based standards needs to be a well-informed and deliberative process with adequate resources and expertise available to evaluate risk, prioritize resource protection goals, provide a reasonable estimate of current and future impacts, and assess management options and capacity for implementation.

BALANCING RISK REDUCTION AND COSTS

There is an inherent desire to eliminate risk, but zero risk is economically impractical, as is selecting a numeric performance-based standard of zero. In reality, health and safety regulations attempt to reduce risk to a reasonable level at an acceptable cost. This balancing of risk reduction and cost cannot and should not be avoided in the process of considering performance-based standards.

Just as there are cost limitations and technical limits to the detailed determination of risk conditions, likewise there are cost and technical limits to the selection of performance-based standards. For example, it is not known if selecting 10 mg/l Nitrogen-Nitrate as an influent standard for soil treatment components in vulnerable areas will protect drinking water sources better than a standard of 20 mg/l, yet there are definite cost penalties associated with selection of the more stringent standard. Similarly, various levels of standards may be selected with small relative differences, such as TSS/BOD standards of 30, 20, 10, and 5 mg/l for new treatment systems used in defined areas of relative assumed risk. If existing systems, meeting only the least stringent 30 mg/L standard, are not shown to be causing an impact in the highest risk areas and the new systems meeting the various standards are not producing quantifiable improvements in the areas of concern, can the higher treatment system costs be justified?

Also of great importance in considering costs and benefits is the issue of relative contributions of contaminants from sources of pollution. If the nutrient contribution from decentralized wastewater-treatment systems is minimal relative to other sources of nutrient loading to the environment, it is not likely to be cost effective to implement nitrogen or phosphorus standards for these systems. On the other hand, a community whose economy is dependent on the harvest of local shellfish may be very willing to bear the cost of a strict pathogen standard for local wastewater-treatment systems if shown to be a major source of bacteria contamination and cause for closing the shellfish beds. When costs, benefits, and sources of pollution are being considered, the cost of a scientifically sound watershed study to identify and quantify contributing sources may be a worthwhile investment prior to adopting more stringent pathogen and nutrient standards for wastewater-treatment systems in a given area of concern.

If the cost is too high for protection against an unproven level of risk, the more stringent standard will be revoked, ignored, or selectively enforced. If costs related to stricter performance-based standards provide benefits related to a proven level of need for public health, environment, and local-resource protection, the added costs are very likely to be accepted. Concerns and issues related to fairness and equity in the adoption and enforcement of regulations were discussed earlier in this volume. Some of these issues can be resolved through a reasoned and balanced consideration of performance-based standards and supporting management options.

MEASURING PERFORMANCE

In the process of selecting performance-based standards, it is necessary to consider how compliance with the standards will be measured. Treatment-system performance can be measured or monitored in the various ways described earlier in this volume. Projecting and measuring impacts of selected performance-based standards at the watershed level, drinking water source, or other vulnerable resource is not as easily addressed.

When dealing with nutrients such as nitrogen and phosphorus, the measurement of greatest interest is mass loading, particularly when dealing with TMDL limits in stream segments or watersheds. When performance-based standards are selected based on nutrient concentrations (mg/l), those selected standards should be related to the anticipated mass load over a period of time. The volumes associated with the nutrient concentrations must be considered, as well as issues related to water conservation that may increase nutrient concentrations in effluents, yet not increase the nutrient mass loading to the environment. In addition, when reuse and recycling are being considered and those nutrients are being used as resources, the selected performance-based standards may not be applicable in measuring large-scale nutrient impacts from the systems.

More complex considerations also must be addressed when performance-based standards related to pathogen reduction are being selected. If decentralized wastewater-treatment systems are targeted as potential sources of bacterial contamination, as could occur in a TMDL study, it is important to have some assurance that other possible sources of pathogen or bacterial contamination have been considered. If decentralized wastewater-treatment systems are a minor contributing source, applying aggressive and expensive standards to those systems may not significantly reduce the contaminant load. Assessment of the sources of contamination and the sensitivity of the receiving environment, along with water-quality attainment and preservation goals, are critical to the selection of performance-based standards for wastewater systems.

PROMOTION OF AN INTEGRATED PROCESS

The complexity of an informed-choice process should not be a barrier to the selection of performance-based standards and adoption of performance-based provisions. As many working in watershed protection programs and integrated water resource efforts have come to realize, it is only through the exploration of interrelated issues by multiple affected and interested parties that truly effective solutions can be developed and supported. Approaches such as those presented in the U.S. EPA manual, as well as other approaches designed to address local conditions, provide a means for community members to evaluate their resources and align the aims of the community in the process. The Model Code Framework encourages and builds on this alignment of aims, providing the Classification Matrices, Evaluation Process, and Soil Treatment Tables as tools for the development and implementation of performance-based requirements and decentralized wastewater-treatment codes that protect human health and the environment.

The quality of management practices is as important as the quality of performance-based standards in assuring acceptable system performance—management practices, too, must be selected with consideration for existing or attainable local capacity and support. Chapter 5, Quality Assurance through Management, addresses that additional area where informed choice and the alignment of community aims are critical. Chapter 6, How to Use the Workbook, summarizes the code-writing process to manage risks to public health and the environment while beneficially aligning the interests and capacities of local jurisdictions and communities.

CHAPTER 5

QUALITY ASSURANCE THROUGH MANAGEMENT

Selection of adequate system performance-based requirements and allowing deployment only of systems that are expected to meet those requirements do not assure that the desired performance level will be met in practice. How the systems are operated and maintained—i.e., how they are managed—significantly affects the quality of their performance.

Quality assurance through management supports the primary regulatory premise that decentralized wastewater-treatment systems can provide a high level of public health and environmental protection if properly planned, sited, designed, and installed—and if operated and maintained with a proper degree of management oversight. "Management oversight" is used here in the broadest sense and should not be equated merely with maintenance oversight. The following quotation provides a comprehensive description of what management entails

> "Management of decentralized systems is implementation of a comprehensive, life-cycle series of elements and activities that address public education and participation, planning, performance, site evaluation, design, construction, operation and maintenance, residuals management, training and certification / licensing, inspections / monitoring, corrective actions, recordkeeping / inventorying / reporting, and financial assistance and funding. Therefore a management program involves in varying degrees, regulatory and elected officials, developers and builders, soil and site evaluators, engineers and designers, contractors and installers, manufacturers, pumpers and haulers, inspectors, management entities, and property owners. Establishing the distinct roles and responsibilities of the partners involved is very important to ensuring proper system management."
>
> —*Voluntary National Guidelines for Management of Onsite and Clustered (Decentralized) Wastewater Treatment Systems (U.S. EPA, 20030*

Ideally, regulation should serve as a method of risk reduction and risk management. The Model Code Framework offers a flexible and responsive process that supports adoption of provisions for quality-assurance management that allow for risk-reduction decisions associated with decentralized wastewater treatment and the local environment. That structure clearly defines roles and responsibilities and provides mechanisms for accountability in terms of level of quality-assurance management and risk reduction. A comprehensive management program requires both community support and adequate regulatory/private sector capacity and professional competency.

Benefits derived from an effective management structure are first and foremost the protection of public health and the environment. A further purpose for adopting and implementing robust quality-assurance management is to ensure system performance and a sustainable decentralized wastewater-treatment infrastructure. A significant benefit to focusing on sustainability is the protection of property values through life-time investment in wastewater infrastructure by communities and individual property owners. Local jurisdictions may have many other reasons and anticipated benefits from the adoption of management practices that address the needs of their communities.

Voluntary National Guidelines for Management of Onsite and Clustered (Decentralized) Wastewater Treatment Systems (U.S. EPA, 2003), provides five model management structures, each dealing with roles and responsibilities within a series of thirteen program elements. An in-depth review of those thirteen elements is provided in Chapter 2 of *Handbook for Management of Onsite and Clustered (Decentralized) Wastewater Treatment Systems* (U.S. EPA, Draft 2003). Referred to here as the U.S. EPA Management Handbook, this resource should be considered as a companion document to this chapter.

This chapter continues with discussions of quality assurance within the context of those thirteen subjects.

QUALITY ASSURANCE BY SUBJECT

1. Public Education and Participation

This Guidance book has previously addressed the importance of alignment of aims, which would be an expected outcome from a thorough program of public education and community participation. Public education should have a wide focus and target audiences, including outreach to the general public, policy makers, and those listed in the previous quotation concerning management. The benefits of an informed public are many, including the consumers' ability to make decisions regarding wastewater alternatives, to better maintain their systems, and to access competent service providers. An informed public is more likely to understand the need for management of quality assurance matters and consequently to support the adoption of regulatory provisions concerning such management.

Broad topics such as roles and responsibilities need to be openly presented to the community at large, clarifying the extent and limits of responsibility for each of the various parties. Presentation of such broad topics can lead to more specific discussions with targeted groups. An example of an outcome from these more targeted discussions would be the development of templates for disclosure language or disclaimers applicable to the varying service-provider roles.

Other topics, such as the importance of proper site selection and subsequent site protection for locations of decentralized wastewater-treatment system, should be addressed broadly but also targeted as critical responsibilities to property owners, developers, and contractors. While site selection, evaluation, and protection would be specifically addressed in the adopted code, early public education serves to create an understanding of the related code provisions and their importance to system performance. Many other methods of addressing this first element are detailed in the U.S. EPA Management Handbook.

2. Planning

Planning, land use, and environmental protection have recently found many common intersection points within communities facing water, wastewater, stormwater, and land-resource decisions. Even though wastewater treatment is a critical factor in land development, planners typically have had very little to do with determining how and where a community's wastewater treatment will occur. Planners are frequently left to react to municipal decisions on sewer-line extensions, connection policies, and allocation of new capacity. In unsewered communities, planners have historically relied, for better or for worse, on the ability of land to support conventional septic systems as a de facto method of regulating development.

The Model Code Framework attempts to neutralize this traditional use of septic systems for land-use control by supporting desirable land-use patterns that determine infrastructure decisions, instead of the reverse. For communities around the country working to achieve desirable land-use patterns, environmental goals, and sustainable infrastructure policies, managed decentralized wastewater-treatment options provide flexible tools for integrating wastewater treatment with land-use planning and environmental protection. This approach also challenges communities to first define community goals, and then consider wastewater-treatment solutions that best serve those goals, instead of allowing the infrastructure to determine land-use outcomes. Land-use plans supported by effective wastewater regulation allow the private sector to explore creative development patterns that meet defined communities goals.

For planners, and communities overall, the management of decentralized wastewater-treatment systems presents opportunities and challenges. Implementing managed decentralized wastewater-treatment solutions that serve community land use goals first requires adjusting traditional financial, regulatory, and administrative viewpoints established around centralized sewer systems. It also requires extensive work in educating citizens, officials, regulators, and funding agencies about alternative approaches, including potential benefits from reuse, recycling, watershed recharge, and the potential for integrating wastewater treatment with water-resource management. This education must start with recognition of all wastewater systems, ranging from publicly-owned collection-and-treatment systems to privately-owned individual onsite systems, as components of a community's infrastructure that should be responsibly managed to protect the environment and public health and to achieve water-quality goals.

It must be recognized also that desirable or undesirable development patterns may exist with centralized or decentralized wastewater options depending on the community's land-use regulations. While management of onsite and cluster systems offers a new tool for achieving land-use and environmental goals, major advances in wastewater-treatment technology have the potential to undermine those very same goals. Onsite technologies that treat wastewater to a very high degree can result in an extremely clean effluent that can safely be dispersed on almost any parcel of land. Some state and local codes may permit wastewater to be dispersed in areas much smaller than required by a conventional septic system. In the absence of adequate land use regulation and zoning, planners and local officials may see this as a threat to their communities rather than a benefit.

If used in a coordinated manner, the Model Code Framework can address existing and future wastewater-treatment needs through integrating wastewater-treatment approaches with other community planning and land-use goals. To maintain community support, there should be assurance that property owners' investment in managed decentralized wastewater-treatment systems is long term, with little risk of having to invest in central sewer within the expected life of the decentralized systems. There must be a commitment to adopting code provisions that promote investment in sustainable wastewater-treatment infrastructure and support community resource-protection goals but do not substitute for land use, planning, and zoning regulations.

Ideally, the adopted code would include quality-assurance management provisions that effectively interface with comprehensive community planning. Planning documents related to wastewater-treatment infrastructure must include or identify institutional mechanisms to insure that management programs will be in place to support development. Oversight, funding, and fiscal responsibilities must be addressed in such plans to provide a structure for the adoption of quality-assurance management provisions in local wastewater regulations.

3. Performance-based Requirements

Chapter 4 addressed selection of performance-based requirements. Previous discussions of regulatory and industry performance expectations are expanded in this chapter. Since performance-based requirements are at the core of the Model Code Framework, the reader is referred to related areas of the guidance for more in depth coverage of that subject.

The overarching issues that must be confronted when considering provisions for managing quality-assurance related to performance-based requirements are briefly discussed in the following paragraphs. In jurisdictions involved with Coastal Zone Management, TMDL implementation, or NPDES Phase II Storm Water regulations, these issues may already be familiar territory. However, the Model Code Framework can help any community establish priorities in both the planning and implementation of solutions for wastewater-treatment management that will help assure that performance-based requirements are met.

If regulation serves to reduce and manage risks associated with wastewater treatment, there must be some consensus as to what constitutes a risk before code provisions are adopted. In many areas "a little sewage on the ground" from a poorly performing system produces little cause for alarm until a nuisance complaint is filed during a neighborhood feud or a property transfer is delayed or canceled due to "onsite wastewater system malfunction." Often efforts to more fairly assess system performance through routine operational inspections are rebuffed as intrusive, or, when accepted, the resulting inventory of system failures becomes a bewildering problem that the community is unprepared or unwilling to address.

On the other hand, efforts at risk reduction can be taken to the extreme, where the standards established attempt to eliminate risk rather than manage it, resulting in unnecessary expense, inability to achieve unrealistic performance-based standards, probable backlash from affected parties, and potential loss of community support. It is critical to build consensus for performance-based requirements that are protective of public health and the environment, and then codify quality-assurance management provisions that will equitably assure the their attainment. Where sensitive environments or conditions warrant stricter performance-based standards and the value of this added protection is understood by the community, more comprehensive quality-assurance management provisions will likely be accepted.

4. Site Evaluation

A site evaluation for a decentralized wastewater system should clearly define the conditions of both the site and the surrounding area to assess the level of risk. The site may range in size from a single lot for an individual home, to a subdivision for multiple homes, to a large parcel designated for a cluster system, to a small community or village assessing a decentralized wastewater-treatment system as an option. Assessment of the surrounding area should consider watershed-scale issues and related concerns such as source-water protection as well as relevant planning and zoning requirements. The extent of the site evaluation should be determined by the anticipated wastewater characteristics and the sensitivity of the site and surrounding area to impact from that wastewater. Since the level of risk will vary, the site evaluation process must be thorough enough to identify localized and surrounding risk factors in order to effectively direct the level of quality-assurance management.

Often with prescriptive codes, the site evaluation is merely an assessment to verify that local conditions comply with the requirements of a code that allows a prescribed or accepted system. It is assumed that compliance with code requirements will assure protection of public health and the environment. From state to state, there is wide variation in prescriptive siting requirements, such as vertical and horizontal setbacks. Also there is a growing body of evidence that such prescriptive provisions do not always provide the expected protection. This is of particular concern in more vulnerable populations and environmentally sensitive areas where local risk factors are not detected through a prescribed site-evaluation process.

In the case of a performance-based code, the site evaluation is the basis for the design of a system that meets the performance-based requirements dictated by the site, local area, and water-quality objectives. When performance is prioritized, the quality and breadth of the site evaluation is recognized as the critical foundation for system design and permit-approval decisions. Thus, quality-assurance provisions related to site evaluation in a performance-based code are of critical importance.

Adopted code provisions must address both the level of detail required in the site evaluation and the competency of the evaluator. The Model Code Framework committee determined that the use of the Soil Component for system design must be conditioned upon the level and quality of both the site evaluation and the soil evaluation. Specific guidance is provided with the options for site and soil evaluations and the performance of qualified professionals.

5. System Design, Treatment Component Selection, and Regulatory Review

The design of a system should be conducted in the context of site evaluation and performance-based requirements. This context must also serve as the basis for the regulatory review of a design, with the designer providing a clear justification for design choices based on the projected performance of the system related to regulatory risk-reduction goals. At the same time, there is need for design-review criteria that allow for designer flexibility and innovation.

A major dilemma facing the decentralized wastewater-treatment industry is the lack of understanding and agreement on the performance of natural, constructed, and manufactured treatment components. The wastewater-treatment capacity of natural systems, such as the Soil Component, is difficult to quantify due to inherent variability and the limited amount of scientific research conducted to support both regulatory and design decisions. The Model Code Framework provides a Soil Component measure that estimates soil treatment performance for varying conditions and distribution designs. It is important that both designers and reviewers understand the rationale and related science used to estimate soil-treatment performance when using the Soil Component.

Likewise, designers and reviewers need to understand the limitations and capacities of constructed and manufactured treatment and/or dispersal components selected for a proposed system design. For the most part, standards and evaluation protocols for an array of constituents of interest are not yet widely accepted or incorporated into state codes. Even in cases where a standard such as ANSI/NSF Standard 40 has been widely adopted for manufactured aerobic treatment units, actual field performance is still questioned, particularly in the absence of adequate quality-assurance management, and due to results from regulatory sampling programs that often do not apply statistically valid protocols.

The Classification Matrices and Component Evaluation process for treatment components and systems offers a mechanism for supporting existing and developing evaluation protocols and test centers, and allows for consideration of all available data. The variability and reliability of data need to be better understood in order to predict performance norms for existing and new treatment technologies. Predicting performance trends is important to insure that performance levels align with risk-reduction goals. Preliminary research to develop a statistical model to assess data along with a decision-support system to classify the quality of data sources was used in the development of the Component Evaluation process.

The Classification Matrices and Component Evaluation process do not establish performance standards, but rather provide information related to the level and reliability of performance data. The resulting constituent-specific matrices for an evaluated component or system provide a higher level of component-performance information for both industry and regulatory personnel. The underlying Evaluation Process database does not remain static, but allows for continuing input of performance data.

It should be recognized that standardization can limit design flexibility and potentially thwart innovative treatment solutions that may be provided through non-prescribed designs. There is a tension and potential barrier to implementing regulatory criteria for review of performance-based designs when the customer's interest in having maximum flexibility is presumed to be in conflict with the regulator's interest in assuring performance and protection of public health and the environment through standardization. Greater regulatory capacity and competency is needed to accommodate the review of non-prescribed designs. This also requires consumer and community support for the added costs to support an effective design-review process. In addition, adopting higher level quality-assurance elements related to operation permits, licensing, inspections, compliance monitoring, and reporting mechanisms can support the use of less-standardized non-prescribed designs.

6. Construction

System performance issues related to construction are primarily affected by the quality of the installation and thus the competency of the installer. Traditional pre-cover regulatory inspections have very limited value in assuring performance, and can only partially verify compliance with any prescriptive installation requirements. The U.S. EPA Management Handbook provides an overview of broader construction-related considerations including more thorough and flexible approaches to inspection. Other tools related to construction assurances include legal approaches such as contracts, insurance, and performance bonds. Of particular importance is the installer's attention to professional standards of practice and a system of accountability to assure adherence to those standards. NOWRA supports Standards of Installation Practice and national certification including the U.S. EPA-funded development of an installer credential program by the National Environmental Health Association (NEHA).

7. Operation and Maintenance

Ultimately, the homeowner or property owner is responsible for system operation and maintenance (O&M), whether by conducting duties personally, by contracting directly with a service provider, or paying service fees to a Responsible Management Entity (RME). Owner performance-based requirements must not be overlooked or relegated when evaluating quality-assurance code provisions related to O&M responsibility. While owner accountability is politically challenging, both at the state and local levels, it must be addressed if performance-based code provisions are to be effective in protecting public health, the environment, and the property values of all owners.

O&M must be considered in the design and construction of systems, with code provisions requiring safe and accessible maintenance and monitoring components such as risers, inspection/sampling ports, alarms, and control panels. As with construction, service-provider standards of practice and licensing/certification requirements are important quality-assurance tools. Quality-assurance provisions should require designers and manufacturers to provide effective O&M and monitoring components and training of service providers in their use. Manufacturer-qualified, designer-qualified, and/or management-program-qualified service providers could be an additional licensing/certification requirements for specified systems, components, or designs. They should be mandatory for non-prescribed system designs.

An operation permit is another quality-assurance management tool that is particularly important with advanced treatment systems and non-prescribed system designs. For effective O&M programs, operation permits must be renewable and revocable, and should be applicable to all systems permitted in a performance-based code. A time frame for operation-permit renewal linked to the frequency of inspection and/or monitoring should correspond to the level of risk associated with the system and site. The necessary compliance monitoring, corrective action, record keeping, and reporting associated with effective use of operation permits and other management tools are discussed under the quality-assurance elements that follow.

8. Residuals Management

For managed systems, it might be expected that more domestic septage and other residuals will be collected for treatment, reuse, or disposal than would otherwise be collected when property owners are not encouraged or required to have residuals removed from their systems. Planning for the projected volume of residuals to be managed and the availability of facilities or sites for treatment, reuse, or disposal must occur early in the process of considering quality-assurance management options. Also, the variation in the volume of the residuals generated by different treatment processes may be significant and should be assessed when technologies are evaluated. Stakeholders should be engaged in discussions concerning the responsibility for properly managing the residuals generated by their wastewater-treatment systems.

For example, a very questionable but well-intentioned requirement for septic-tank pumping every 3 to 5 year can result in significant and unnecessary increases in collected residuals, high costs for collection, and misuse of a limited capacity for treatment, reuse, or disposal. A more reasonable and equitable plan might be mandatory monitoring of scum and sludge volume, with collection required only if the sludge and scum layers exceed or are calculated to exceed (prior to the next monitoring event) specified limits based on tank design. This would result in lower volumes of collected residuals, lower maintenance and transportation costs, and less demand on the limited capacity of residuals receiving facilities or sites. Residuals management provides a good example of the need to project the impact of quality-assurance-management options in advance of selecting code provisions.

9. Training and Certification/Licensing

The importance of establishing measures of competency for site evaluators, designers, installers, O&M service providers, and inspectors is repeatedly discussed in the related management-program elements. The U.S. EPA Management Handbook provides details on various approaches and identifies national organizations, including NOWRA, that are engaged in training and certification/licensing efforts. The success of these efforts should be measured by the level of accountability attained—that should help to assure continuing public confidence in the performance of decentralized wastewater-treatment professionals.

Competency issues related to safety, ethics, and evolving standards of practice can be effectively addressed with oversight structures such as state licensing boards supported by national certification programs. To the extent that those resources are available, code provisions should require licensing and certification for all professionals so as to reduce the level of local regulatory responsibility in this area. That step would not reduce or remove local management responsibility for reviewing professionals' performance and subsequent reporting of misconduct or non-compliance with certification or licensing requirements.

Any system of accountability for professional performance must include code provisions that allow for revocation or suspension of a license or certification and enforcement of prohibitions or limitations on the scope of professional practice. Limitations should address such issues as owners conducting installation and O&M services, and prohibitions on professional practice in the absence of manufacturer, designer, or management training or qualification requirements. It is critically important that adopted code provisions define clear roles, responsibilities, and certification/education requirements for all parties, including owners and regulators, as well as industry professionals.

10. Inspection and Monitoring

Inspection and monitoring can be synonymous terms, but they are frequently viewed as describing, respectively, different levels of performance assessment. Inspection can be broad in application: regulatory-compliance review of system installations and operational-performance review, which is commonly associated with monitoring. Monitoring is sometimes considered to be limited to sampling for component-effluent quality, groundwater contamination, or watershed impacts, but it can include operational inspections for assessing system performance and/or performance of O&M service providers.

The use of sampling as a monitoring requirement for system performance should be limited because of the high cost of conducting effective protocols. When used as a compliance tool, great care must be taken in the selection of target parameters and the reasonableness of their application to performance. System designs with sampling requirements should only be permitted where there is a high level of regulatory and industry professional competency and accountability. Additional quality-assurance-management provisions and monitoring covering reuse of treated wastewater are addressed under Code Provisions and Code Language Options, Water Use Standards in the Model Code Framework.

In adopting code provisions related to inspections and monitoring, consideration should be given to their application to broader water quality regulations such as NPDES permits and other federal, state, and local water-program requirements. (Federal programs are detailed in the U.S. EPA Management Guidelines.) The code provisions should focus on proper operation and preventive maintenance to assure long-term system performance rather than on the more traditional evaluation for system failure or malfunction.

11. Corrective Actions and Enforcement (Accountability)

A code requirement or a program for quality-assurance management is only as effective as its provisions for assuring compliance. Compliance is often viewed narrowly as it relates to monitoring and inspections or to defined enforcement mechanisms such as nuisance-abatement and property-transfer provisions as described in the U.S. EPA Management Handbook. In developing and implementing an effective performance-based code, the issues of compliance, corrective action, and enforcement must be viewed in their broadest senses and must provide for systemic accountability in all matters covered by the code.

Two of the seven components underlying the Model Code Framework (See Chapter 1, Introduction) address both the broad and narrow issues of accountability:

3. Compliance monitoring and enforcement to ensure system performance is achieved and maintained;

7. Program reviews to identify knowledge gaps, implementation shortcomings and necessary corrective actions.

Some statutes and codes adopted at the state level incorporate broad accountability through state audits of local programs. In the absence of or in addition to the state oversight, local provisions should be adopted to establish an audit function. Building on the community involvement necessary for an alignment of aims in adopting a local code, it might be effective to assign this review function to a local advisory committee.

12. Record Keeping, Inventory, and Reporting

For an effective audit, there must be adequate records and reporting mechanisms that document the performance of the systems and their management. Record-keeping and reporting capabilities are even more critical in the day-to-day implementation of quality-assurance provisions. Tracking of owner/service provider/inspector compliance with monitoring and inspection requirements and recording system-performance information in an easily retrievable and useable format are necessities. Interactive web-based computer software is available for these purposes, but significant cost, capacity, and privacy concerns must be adequately addressed.

A more basic issue that, currently, is not adequately addressed is the actual inventory of systems by responsible jurisdictions. While absence of a basic inventory does not have to be an absolute barrier to considering performance-based code provisions, the deficiency must be addressed if potential risks associated with current conditions and practices are to be identified.

If quality assurance provisions are intended to reduce and manage risks to human health and the environment and address community interests or concerns, there must be an evaluation of the existing wastewater-treatment infrastructure at least in terms of its impact on the local community and surrounding environment. System inventories and lot-by-lot assessments can provide a strong foundation for local consensus building.

13. Financial Assistance and Funding

This last program element of the thirteen addressed in the U.S. EPA Management Handbook is related to the second element, Planning, in that it is essential to the issues of financial assistance and funding. The existence of an up-to-date, comprehensive wastewater management plan can significantly affect the allocation of limited resources to support a management program or to fund infrastructure projects involving decentralized wastewater-treatment systems. Good planning that results in access to funding will encourage public support for code goals.

A wide range of financial issues are associated with adopting performance-based provision. Since financing issues related to system management are addressed in the draft U.S. EPA Management Handbook, this discussion will focus on the need to assess economic impacts related to system performance-based standards and the inequity in the allocation of public funds for wastewater infrastructure. Both of these are public policy issues that need to be an integral part of the community-involvement process prior to code adoption.

A proposed statewide performance-based standard or code provision could be subject to formal cost-benefit analyses through statute, but it is more likely that an informal analysis will occur for code provisions that are adopted locally. This process may be a gross estimate of the costs of implementation balanced against the socio-economic gains from improved public health and environmental resource protection. As discussed previously, if the benefits are identified in advance of code adoption and serious effort is made to align the aims of the community, acceptance and financing of code development and implementation should be forthcoming.

A related financing issue is the inequitable manner in which public funding for wastewater infrastructure is applied. While significant tax dollars continue to be allocated for centralized wastewater-treatment infrastructure, institutional mechanisms are just starting to develop for allocating tax dollars to decentralized infrastructure. These mechanisms need to be explored and expanded at both state and local levels with attention to legitimate investment in private infrastructure that is providing public benefit. For example, an inspection program and system upgrades funded by homeowners in an older subdivision bordering a recreational water reservoir could provide significant benefit to the wider community in maintaining water quality. Had a sewer system been installed for those homes, a comparable level of water quality protection would likely have been paid for by some form of public funding. Public dollars channeled through local economic-development programs and state revolving-loan programs should support private infrastructure initiatives where public benefit is derived.

NOWRA AND U.S. EPA MANAGEMENT MODELS

One of the positive outcomes of local decision making is the creativity and home-grown solutions that can result. Many of the decisions related to the consideration and adoption of provisions for quality-assurance management will be strongly influenced by local capacity, but the process itself allows the local community to reevaluate that capacity. The range of options in the Model Code Framework and the the U.S. EPA Management Models provide decision makers with room to grow from more limited but manageable prescriptive codes to more flexible performance-based codes requiring more complex provisions for quality-assurance management.

The use of the terms “models” and “framework” is critical to understanding the intended application of the U.S. EPA Management Models and the NOWRA Model Code Framework. Neither is intended to provide a management program or code provisions that can be adopted wholesale with little adjustment to local conditions and capacities. It is expected and appropriate that performance-based requirements and quality-assurance provisions will vary even within local jurisdictions in relation to risk-reduction goals. It is through the process of fully considering the wide range of options presented in the guidance literature that true progress is made in understanding the value of a code and the benefits it will provide.

The remaining chapter of this Guidance book provides general guidance on the critical process of adopting state and local performance-based codes. The more specific guidance provided in the resource on Code Provisions and Code Language Options also assists in that process. The overall process challenges decision makers to clearly identify the roles and responsibilities of all involved parties and to give very careful consideration to the intended and unintended consequences of selected code provisions.

CHAPTER 6

HOW TO USE THE MODEL CODE FRAMEWORK

The Model Code Framework is both a process and a variety of resources offered by NOWRA to advance the field of decentralized wastewater-treatment through regulatory evolution and integration into broader water-resource management goals. Since those goals vary widely across regions and within states, the Model Code Framework process and its resources must be flexible and widely applicable. Building upon the principles discussed already, this final chapter suggests approaches to the use of the *Framework for a Code* processes and resources. NOWRA recognizes that the development, adoption, and implementation of a performance-based code versus a traditional prescriptive code will be a unique process for each state and local jurisdiction.

NOWRA, through the Model Code Framework, is (1) promoting state-level regulation that recognizes national resources for certification and performance verification of products and professionals and (2) suggesting a statewide structure for local adoption of performance-based requirements and code provisions. The ultimate goal is to achieve more responsive and integrated regulation that focuses on performance and supports sustainable wastewater-treatment infrastructure that is protective of human health and the environment.

FRAMEWORK IN ACTION

The challenge of implementing a flexible, locally responsive performance-based code will require regulators to be more engaged in horizontal community involvement processes versus more traditional vertical chain-of-command approaches. The Model Code Framework creates opportunities for involvement by regulators, decentralized wastewater-treatment professionals, the general public, local officials, and many others engage in the development, adoption, and implementation of performance-based codes. An alignment of aims is at the core of a successful performance-based code both in its initiation and its ongoing evolution. Just as the Model Code Framework has and will continue to evolve with input from participants in the process, state and local regulatory processes aimed at the adoption of performance-based provisions will only succeed and flourish with a strong foundation of stakeholders aligned and committed to the process. Ultimately they form the constituency that is required to gain the necessary political support for implementation.

Requirements for stakeholder participation should be adopted in a performance-based code.

There are numerous examples and potential mechanisms for engaging stakeholders in the regulatory process. They range from statutory requirements with explicit advisory-group responsibilities to informal education meetings in local communities. Certainly some methods are more effective than others, but a key function of any method must be the identification of common aims and purposes. Those decisions should be reached in the context of broader water-resource management and wastewater-infrastructure goals. The formal establishment of goals, purposes, and statements of intent is a critical precursor to the adoption of performance-based provisions (see Chapter 1, Goals, Purpose, and Intent).

Purpose statements must be incorporated into a performance-based code and provide a context for integration with other related water-resource and infrastructure-management goals.

PRINCIPLES IN ACTION

Integration of purpose statements with other related goals can only occur when the stakeholder base is broad and decisions-makers are well informed. The Model Code Framework is founded on "informed-choice" but recognizes that all of the necessary information for decision-making is seldom available, including much of the science or data for risk evaluation and models for predicting the outcome of risk-reduction strategies. In the absence of all the facts, it is necessary to make defensible decisions that are derived from a reasonable rational process aimed at meeting established goals. Unfortunately, these conditions set the stage for strong competing interests providing contrary "facts" that can stall or subvert the decision-making process. This is where a strong stakeholder group and committed regulatory personnel, with aligned aims and clear purpose statements, can be prepared to face the political pressures that will likely be brought to bear.

Purpose statements must be widely distributed early in the process and must remain in the forefront to focus the discussions and decisions in the code-development process.

Decisions related to effluent standards or performance requirements for wastewater-treatment systems are ripe for these types of controversies, and are complicated by the need to consider both local impacts and broad scale or even global impacts. A locality, for example, might experience a very low risk of nitrate contamination to local groundwater resources due to soil and geological conditions, yet nitrogen "runoff" may have a cumulative impact downstream. This is dramatically demonstrated by the nutrient impact from upstream watersheds in the "dead zone" expanding into the Gulf of Mexico from the mouth of the Mississippi River. Though wastewater systems are not likely to be a major contributor of nutrients in that case, some stakeholders may feel that any contribution needs to be considered. It is very important that the broad range of potential risks and impacts from multiple sources are considered, but it is just as important to ensure that the comparative risk and impact associated with decentralized wastewater-treatment infrastructure are not overstated.

Decisions on performance-based requirements are often made with incomplete information on impacts, risks, and all sources of potential contamination. The decision-making process demands transparent and balanced deliberation.

Any deliberation process that is crippled with insufficient information will arrive at imperfect decisions, resulting in regulations that will need continuous revision. Even with the implementation of performance-based provisions, installation permits will continue to be issued and wastewater treatment systems will continue to operate under imperfect performance management of systems, professionals, and regulatory oversight structures. Effective management systems will only evolve with a concurrent evolution in regulation, requiring a feedback mechanism that supports capacity building and accountability.

Performance-based codes must specify prerequisite capacity requirements for implementation of performance-based provisions. They must establish a mechanism for accountability at all levels—from treatment system and system owner, to treatment component and industry professional, to regulation and regulator.

NATIONAL, STATE, LOCAL IMPLEMENTATION

Table 6-1 provides an outline for the following discourse on the adoption of state and local regulation as it relates to the Model Code Framework and other national resources. The orientation of the decentralized wastewater-treatment field toward performance-based codes and management is clearly evident in the three U.S. EPA publications listed under ACKNOWLEGEMENTS on page ii and noted in Table 6-1. Such national guidance and related national initiatives under the Clean Water Act and other federal regulations recognize or support the use of managed decentralized wastewater-treatment systems as sustainable infrastructure that can help achieve goals for water quality, public health, and environmental protection. In most cases, those federal regulations and initiatives related to sanitary wastewater are implemented at regional U.S. EPA, state, tribal, or local levels of government.

The Model Code Framework focuses guidance on state and local jurisdictions. The first column of Table 6-1 lists items related to federal, state, and local jurisdictions that are applicable to the development of performance-based codes. The last box in that column lists three regulatory functions related to implementation, all of which will be discussed with emphasis on the accountability necessary for an effective performance-based code.

TABLE 6-1. From National Guidance to State Framework to Local Implementation.

REGULATORY LEVELS	RESOURCES
<u>National / Federal</u>: High Level Purpose Statements and Guidance Resources • Public health and environmental protection • “Fishable, swimable, and drinkable” waters • Protection of source water • Watershed approach to solutions • Integrated water resource management • *Onsite Wastewater Treatment System Manual* • *Voluntary National Guidelines for Management of Onsite and Cluster (Decentralized) Wastewater Treatment Systems* • *Draft USEPA Management Handbook*	• NOWRA Framework for a Cod*e* for Decentralized Wastewater-Recycling Infrastructure • National Credentials for Professionals (ex. NSF Inspector, NEHA Certified Installer, etc.)
<u>State Level</u>: Purpose Statements, Performance Requirements, and Regulatory Framework • State level advisory groups • Recognition and promotion of performance requirements • Adoption of state level code provisions • Recognition and adoption of national resources such as certification programs • Roles and responsibilities defined for all parties • Framework for local adoption of performance requirements and code provisions options • Promotion of local water resource planning (ex. Coastal Zone Management, State-certified 208, and Watershed plans) • TMDL development and implementation Implementation *****	• National Product Testing – Verification and Certification • Matrices and Evaluation Process in NOWRA Framework for a Cod*e* for Decentralized Wastewater-Recycling Infrastructure
<u>Local Level</u>: Statements of Intent; Local Adoption of Performance Standards and Code Provisions within State Framework • Ongoing outreach and public participation • Statements of intent as foundation for action • Risk considerations and local resources • Selection of performance standards and requirements • Assessment of capacity for implementation • Adoption of code provisions (within a state regulatory framework as applicable) Implementation *****	• • Support Document for the Soil Component in NOWRA Framework for a Cod*e* for Decentralized Wastewater-Recycling Infrastructure
*** Permit Review / Management Oversight** *** Education / Enforcement** *** Accountability / Feedback**	• Provisions and Language Options with Guidance NOWRA Framework for a Cod*e* for Decentralized Wastewater-Recycling Infrastructure

The second column of Table 6-1 provides a list of resources in the Model Code Framework and related national resources that can significantly support both state and local code-development processes. More detailed information on the Matrices and Evaluation Process, Soil Component Treatment Calculations, the Code Provisions, and Language Options is provided in other documents of the Model Code Framework and on NOWRA website. These resources have also been briefly introduced and discussed in earlier sections of this Guidance book. (Note: The Matrices and Evaluation Process and the Soil Component Treatment Calculations are still in development.)

All of these Model Code Framework resources and related national resources can be used to develop and implement state and local performance-based codes. The resources are expected to provide common ground for advancing the industry and regulatory structures that are necessary to support a well-managed decentralized wastewater-treatment infrastructure. The societal and economic benefits that can be derived from effectively managed decentralized wastewater-treatment infrastructure cannot be fully realized until the industry matures and regulations support an efficient management system.

STATE-LEVEL REGULATION

Just as states apply federal regulations and initiatives in a manner that takes into account the unique conditions within each state jurisdiction, it is reasonable to apply state regulations in a similar manner to accommodate the unique conditions found in local jurisdictions or regional areas within a state. While large watershed impacts reach beyond most political boundaries as noted earlier in the example of runoff to the Mississippi River, impacts from small-scale, localized wastewater-treatment systems are often most effectively addressed at the local level. Consistent with a local watershed approach, state-level regulatory requirements related to TMDL implementation and source-water protection can inform a state framework for adoption of local regulation.

> *A state-level performance-based code would include a framework of requirements to support the implementation of locally adopted regulations. They would include local effluent standards to manage decentralized wastewater-treatment systems, and thereby reduce their impacts on public health and the environment to a level of risk acceptable to the state and to local citizens.*

By adopting a regulatory framework that allows for locally adopted treatment standards, a state may appear to be relinquishing its responsibility and authority for water resource protection. That is not the case if the state framework includes provisions for a state oversight role that ensures local accountability. In many cases, the arrangement should enhanced water-resource protection due to the ability to apply stricter performance criteria locally if driven by higher localized risk conditions or identified sources of impact.

> *Strict effluent-performance standards applied statewide are inappropriate and often politically unacceptable, yet a statewide framework can support a state's water resource and public health protection goals though the over-*

sight of locally adopted performance-based requirements based on identified risk factors, existing impacts, and local resource protection goals.

The major wastewater constituents listed in the NOWRA Matrices include fecal coliform (bacteria), total nitrogen, nitrate, and total phosphorus. Most states have established performance-based standards related to bacteria using either or both fecal coliform and E.coli as indicator organisms. Given the proven public health risks associated with pathogens in wastewater, it is reasonable that statewide bacterial standards be established. In the case of phosphorus and the nitrogen constituents of wastewater, the aspects of beneficial use, varied soil-treatment capacities, and limited understanding of impacts and risk factors make it very unlikely that a statewide standard can be justified.

The Model Code Framework promotes limiting statewide performance-based standards for wastewater constituents to only bacterial or pathogen indicators. It recommends establishing a state-level requirement for local jurisdictions to identify local risk factors or known impacts from nutrient constituents of wastewater and to adopt local performance-based standards for specific nutrient constituents as necessary.

The West Central Florida Coast is one of the largest shellfish harvesting areas in the world. In many areas, Clearwater to Panama City Beach, the depth increases by only about 1 foot per mile. The city of Cedar Key in Levy County was just beginning to develop a subdivision and the shellfish industry wanted assurances that their industry would not be shut down as a result of excessive fecal contamination. In addition, the Florida Department of Health (FDOH) had added concerns about nitrogen in the springs emerging from the Suwannee River system. Levy County adopted an ordinance for onsite wastewater systems based on the following recommendations from FDOH:

- **Fecal Coliform (FC)**—The FC standard for shellfish harvesting areas is ≤ 14 FC colonies/100 ml. The goal should be BDL (below detectable limits).
- **CBOD5 (carbonaceous biological oxygen demand) and TSS (total suspended solids)**—FDOH Advanced Secondary Treatment Standards require that these pollutants each be maintained at equal to or less than 10 mg/l. Fecal coliform is a major concern in the shellfish harvesting environment. The lower the BOD and TSS of the effluent entering into the onsite wastewater system drainfield the better the chance of attaining very low fecal coliform colonies.
- **TN (total nitrogen) and TP (total phosphorus)**—It is unclear as to what levels of nitrogen and phosphorus would be detrimental to the shellfish harvesting environment. In confined estuaries excessive nitrogen and phosphorus can contribute to excessive underwater plant growth that will eutrophy under certain weather conditions, resulting in reduced dissolved oxygen and the potential to kill off other organisms. The treatment method designed to remove the CBOD5 and the TSS should also be designed to reduce the Kjeldahl nitrogen (ammonia and organic nitrogen) to nitrate. By recirculating the nitrate effluent back to the primary treatment the nitrate is driven off in the gaseous form and the TN is reduced. Nitrogen exists in normal domestic residential wastewater at levels of between 35–45 mg/l. Fifty percent reductions can be achieved by recirculation, and many of the advanced secondary treatment systems are designed to achieve between 10 and 20 mg/l of TN.

Phosphorus exists in normal domestic residential wastewater at levels between 6 to 10 mg/l. Phosphorus removal requires the addition of another treatment component and adds significant cost to the system. Unless proven necessary, it is not recommended that treatment for phosphorus be required. Since the treatment module is added to the system, it could be added at a later date if found necessary. Plant uptake will further add to the reduction of both nitrogen and phosphorus.

—Excerpts from Recommendations for OSTDS in Shellfish Harvesting Areas. Florida Department of Health - July 31, 2003

FIGURE 6-1. Florida Department of Health recommendations in shellfish harvesting areas.

Figure 6-1 presents an example of state-level regulation from the Florida Department of Health. It is not necessarily representative of the Model Code Framework approach, but does provide a context for this guidance topic. In the example, state-level standards for three wastewater constituents are discussed.

Other state regulations may specify BOD and TSS standards as indicators of pollution or, more often, as limits (e.g. < 30 mg/l of BOD/TSS) for soil-absorption-area sizing reductions based on allowable increases in soil loading rates. Even lower incremental BOD/TSS limits such as <5, <10, <15, and <20 mg/l have been adopted in some codes as performance-based standards for pretreatment-component effluent applied for variations in marginal soil or site conditions. In reality, variability in component performance may well exceed a 5 to 10 or even 20 mg/l BOD/TSS range. Moreover, it is not proven that a 30 mg/l of BOD/TSS effluent will significantly impact soil treatment any more than a 5 mg/l of BOD/TSS effluent, yet the cost to consistently meet a 5 mg/l standard could be very high.

When establishing state or local performance-based standards for effluent applied to soil, it is important to assess the benefit to be derived from adopting a very strict standard or incremental standards for wastewater constituents.

In any regulatory process, a legitimate mechanism for feedback and accountability for the purpose of the regulation must be established. Often a legislative statute will establish the scope of state regulation but will seldom specifically acknowledge the underlying intent or purpose. Advisory groups or technical panels may be established by statute or through agency ad hoc committees. These formal mechanisms for guiding or soliciting input into the state regulatory process must include defined roles and responsibilities that are accountable to a stated purpose. Establishing a legitimate means for assessing varied or conflicting positions can circumvent single-interest issues that may undermine the intended purpose of the regulation.

Formal feedback mechanisms, such as state advisory groups, provide accountability and responsiveness to stakeholder input and concerns and are a necessary component of a performance-based code.

Another mechanism for regulatory accountability at the state level is integration of regulations that have a common purpose, such as Coastal Zone Management plans, TMDL development and implementation, source-water protection efforts, and 208 wastewater planning. Codes for decentralized wastewater-treatment systems should support the broad goals of water-resource protection and water- and wastewater-infrastructure plans, but should also aim to inform these related regulatory processes of the potential benefits derived from the use of decentralized wastewater-treatment infrastructure.

A state-level performance-based code should be developed and implemented in a manner that clearly defines and establishes its contribution and relevance to broader water-resource and public-health goals and should incorporate code provisions that are consistent with related state-level regulations.

State-level regulation can recognize and utilize national resources that will provide efficiencies in areas related to the performance of products and professionals. The Matrices and Evaluation Process in the Model Code Framework provides a classification resource that can be used as a screening mechanism in state-level product approval. National certification and training programs can supplement and support state professional credentials requirements.

Incorporation of national programs that complement state performance and accountability requirements for products and professionals is strongly recommended to conserve limited state funds.

A state-level framework needs to establish clear roles and responsibilities for decentralized wastewater-treatment system owners, management entities, service providers, regulators, and any other parties engaged in complying with a pertinent performance-based code. Often homeowners, property owners, or off-site system owners are not held accountable for the ongoing performance and operation of the wastewater-treatment system—they are only held accountable when a failure or malfunction is identified. Likewise, the ongoing performance of industry professionals, including private and public-sector individuals, is seldom reviewed unless a significant problem occurs.

A mechanism for ongoing or periodic performance review of wastewater-treatment systems, system owners, and industry professionals (including regulators) must be included in a state-level performance-based code.

The structure of requirements for supporting implementation of locally adopted regulations was introduced in the first paragraph of this section, State-Level Regulation. A state structure should promote code options that allow local jurisdictions to adopt code language that meets the purpose and intent of the state regulation. A series of code options, such as those suggested in the Model Code Framework, establishes a potential progression of local regulations that could be adopted according to available management capacity and level of risks in the local jurisdiction. With a performance-based code, the state structure must promote local flexibility but not to the extent that rigid prescriptive language finds its way into local code elements, limiting solutions for effective decentralized wastewater treatment.

A state structure should be flexible enough to accommodate local amendments to code provisions so long as they promote the purpose and intent of the state code. A state code must be responsive to local conditions yet prohibit local prescriptive requirements that would undermine the benefits and cost-effective use of decentralized wastewater-treatment infrastructure.

State jurisdictions could expand on existing state level code provisions by adding or allowing multiple options or means to meet performance goals or requirements that are responsive to purpose statements incorporated in the state code. State codes can incorporate criteria that would allow local jurisdictions to adapt applicable state code provisions as needed, conditional upon state goals and requirements being met and demonstrated local capacity to implement the adapted code provisions. When allowing local flexibility, state statute and state codes must establish state oversight responsibility and authority for local code review and local program audits. Such mandatory accountability mechanisms are necessary to assure that the broader water-resource and public-health responsibilities of state and federal regulatory authorities are being met.

> *State regulatory performance-based requirements should be clearly stated in the code and should allow for local flexibility in meeting state requirements subject to demonstrated local capacity and mandatory state review and audit.*

LOCAL ADOPTION OF REGULATIONS

Much has already been said about the importance of stakeholder involvement. Ongoing outreach and public participation efforts at the local level are most critical and effective at reaching the regulated community. Informed citizens become more receptive and responsible customers in communities where added cost may accompany implementation of a decentralized wastewater-treatment infrastructure. A receptive, informed community is more likely to adopt a long term view where anticipated benefits may justify added costs. It is important that these benefits be well defined at the start of a performance-based code process and that clear statements of intent include the value of those benefits to the community at large. Local stakeholder groups will always consider the costs associated with proposed regulations, and will likely demand that "any extra cost" be proven necessary.

> *Well defined and clearly articulated statements of intent that address anticipated costs and benefits and are aligned with community interests and resource-protection goals must serve as the foundation for successfully adopting and implementing local performance-based codes or provisions.*

The statements of intent must remain in the forefront of all subsequent code-adoption processes and serve as the benchmark for decision-making. Attention to cost does not detract from decisions if it serves to identify real barriers to successful implementation of proposed code provisions and supports resource allocation for necessary capacity building. The cost of added capacity to implement an adopted code will ultimately come from the consumer either directly as operation permit fees, service contracts, or responsible management entity charges or indirectly though tax-supported budget allocations.

> *Local capacity must be integrated into the cost/benefit decision process and balanced against the stated intent of proposed regulation. In this way, more creative approaches to implementation, such as an expansion in a managed private sector role, can be explored.*

Nowhere is it more critical to have stakeholder participation than in the evaluation and relative ranking of risk, impacts, and local resource-protection goals. Methods of gathering input and assigning levels of concern are varied, with some described earlier in this Guidance book. Whatever the method used, it must be a broad-based, inclusive process that is recognized as legitimate to the participants and the community at large.

The outcome of an evaluation and ranking process must be specific enough in identifying risks, impacts, and resource-protection goals to allow for subsequent decisions on proposed performance-based requirements and to determine if there is a need for the adoption of local performance standards for constituents of concern.

The evaluation and ranking process must include scientifically defensible data from varied sources, such as TMDL and other watershed studies, documented sewage nuisance locations and densities, soil and geological conditions, source-water protection boundaries, water and wastewater infrastructure needs, and recreation and economic values associated with local water resources (i.e. lakes, rivers, streams, wetlands, and groundwater). Tools such as GIS can help participants visualize a complex integration of factors that will affect decisions. In some areas, there may be sufficient data, financial resources, and expertise available for development of a computer model to project potential impacts from wastewater constituents.

In gathering and analyzing available data on potential sources of wastewater impacts, attention must be given to the relative level of risk compared to other sources of contributing pollution. In other words, care must be taken to not overemphasize the impacts and risks associated with decentralized wastewater-treatment systems in order to implement provisions or standards where none are needed.

Nutrients provide an example of a sometimes misplaced concern and overreaction in addressing impacts from decentralized wastewater-treatment systems. Even though nitrogen, particularly nitrate, and phosphorus are getting much more attention in the research on component- and soil-treatment capabilities, there are areas of the country where those constituents do not pose a risk. Where the risks and impacts are real or highly probable, as in localized phosphorus loading to inland lakes bordered by porous soils, nitrogen loading in coastal areas, and nitrate contamination of vulnerable groundwater resources, adoption of appropriate performance-based requirements should occur.

In cases where constituent-specific performance-based standards are adopted, code provisions must be very clear about the purpose of the performance-based standard and assure that it is applied only in areas with identified risks or impacts.

As noted in the previous section on state-level regulation, local code-development and -adoption processes should ideally occur within a state framework. In some cases, a state structure may not exist, such that local jurisdictions may chose to apply directly a national framework such as the Model Code Framework and refer to performance-based codes that are developing in other states and locales.

When a state performance-based code is in place, consistent accountability across the local jurisdictions and effective recognition of local variations in risk and capacity is likely to occur, along with a reciprocal flexibility and responsiveness at the local and state levels.

THE CODE IN ACTION

No matter how well state and local codes are developed and adopted, the true test of their effectiveness is in their application. While jurisdictional authorities and owner and professional responsibilities may be well defined, it is the ultimate performance of each individual—reviewing a design, manufacturing a component, providing service, or complying with a permit—that will determine the overall success of a decentralized wastewater-treatment infrastructure.

Regulation must establish the individual level of accountability within a structure that will not overburden the process.

Permit Review / Management Oversight

Individual permit review is often identified as a regulatory bottleneck or a barrier to legitimate design approval. In the former case, where regulator reviewers are overloaded and public budgets will not support more regulatory staff, there are ways to utilize private-sector resources to assist in permit review. To avoid the latter case where the process is a barrier, permit review must incorporate flexibility and competent reviewers so that both non-prescribed designs and those with components "deemed to comply" can receive legitimate consideration in a timely manner. Very prescriptive regulatory design criteria can be a cause for delay of permit approval or can result in outright denial. As an example, strict application of conservative design-flow rates can create a barrier to permit approval for cost-effective legitimate designs.

Figure 6-2 relates to the foregoing example and suggests an approach that could allow for more flexible review criteria. The Model Code Framework Committee had numerous discussions concerning alternative approaches to the determination and designation of daily design flow. While "Guided Prescription" is not a term or approach specifically addressed in the Model Code Framework, the summary provided in Figure 6-2 promotes the use of rational criteria for design review.

Responsibilities associated with design review require more expertise and judgement (i.e., human resources) than management-oversight responsibilities that are amenable to implementation through the use of computer database programs, internet interfaces, and system telemetry resources. These tools are becoming more common in applications for management of decentralized wastewater-treatment systems and will be critical to the implementation of a responsive regulatory structure.

Both the availability of information-technology resources and the competency and capacity of human resources need to be assessed in advance of adoption and implementation of code provisions intended to assure the fair and effective application of oversight and management requirements necessary for the implementation of performance-based codes.

This approach parallels other aspects of the Model Code. For example, a "prescription" for a certain type of treatment unit could be approved, but it would be based upon a rational analysis of how a system meeting that "prescription" would perform under managed conditions. In a similar fashion, design flow rates could continue to be set by an adopted prescriptive formula, but the adopting authority would provide an analysis of the factors to be input to the prescription. The selection of design flow rates would then become an "informed" decision rather than merely following a prescription for which the original rationale may be lost over time. A "Guided Prescription" approach to setting design flow rates would require that a designer provide a review and discussion of what might be reasonably expected to be the contributing population related to facility characteristics and what might be reasonably expected to be the per capita flow rate. The following criteria could be adopted by the regulatory authority:

- A designer can use the adopted prescriptive formula for daily design flow or offer an analysis on the probability of a designer-recommended daily design flow being sufficient under prescribed specifications for occupancy and per capita flow rates. For example, one could show that if the occupancy prescription was that the number of people is presumed to be one plus the number of bedrooms, statistically this occupancy would be exceeded X% of the time, or if there is a prescribed per capita flow rate, statistically this rate would be exceeded X% of the time. The designer would need to make a case that the designer-recommended daily design flow would very infrequently exceed the prescribed values or formula for daily design flow. The adopting authority would determine what level of risk (probability of exceeding daily design flow) should be accepted versus the cost of over-sizing some portion of the system. This approach could allow for design flow rates that are not so routinely excessive, as is often the case with inflexible daily design flow volumes prescribed in many codes.
- It would be important for the adopting authority to have criteria for peak flow versus average flow because it impacts upon risk. A system that provides flow equalization could be fully or partially immune (depending on the details of the flow equalization scheme) to flow peaking, so that any "safety factor" for peaking would be less relevant. A system where the flows are simply passed through as received would not only need to consider the average flows, but also a multiplier for peaking. Thus, the designer's case for the selected daily design flow must include a discussion of how the system design can or cannot cope with peak flows, and what that implies for the proposed design flow rate.

Under this approach to setting design flow rates there would need to be a caveat that the designer is always responsible for taking into account any information available that may indicate flows from the facility in question that would be "out of bounds" relative to the prescribed design flow rates.

—Summarized from a discussion of the NOWRA Model Code Framework Committee, September 2003

FIGURE 6-2. A "Guided Prescription" approach to setting design flow rates.

Education and Enforcement

Education and enforcement are complementary regulatory responsibilities, both being necessary to ensure implementation and compliance. The process in the Model Code Framework promotes education and "informed choice" as effective proactive approaches, reserving enforcement action as a method of last resort that is critical to preserving a fair and equitable application of regulation. An educational process that explains the purpose and requirements of regulations to the appropriate responsible parties can foster cooperation and compliance. While "ignorance of the law" may not be a defense, it most certainly is a reflection on the regulatory authority's efforts to educate the regulated community.

> *Targeted educational campaigns that "inform" the regulated groups of their roles and responsibilities followed by mechanisms to assess overall accountability and compliance set a foundation for fair and equitable enforcement.*

Manageable mechanisms for accountability in areas such as system-operation oversight and professional-credential requirements must be in place to support effective enforcement programs, but just as important is the commitment to exercise enforcement responsibility. The Model Code Framework holds that the local adoption of code provisions promotes enforcement because it is more likely that the regulations will be perceived as reasonable and applicable to the local jurisdiction conducting enforcement. This certainly is contingent upon an early alignment of aims, an ongoing public participation process, and educational efforts to "inform" the regulated community.

> *Failure to enforce code provisions, whether from lack of resources or lack of political will, undermines public trust in the regulatory process and reduces the value of community-engagement efforts.*

As expected in the adoption of local code provisions, methods of conducting oversight and enforcement also must pass a "reasonableness" test. One failing example is the regulatory use of statistically invalid sampling programs for compliance monitoring of installed systems. Not only is there significant cost associated with such an inappropriate approach, but its use is not "reasonable" because it does not accurately judge performance. The monetary cost can extend well beyond sampling and analysis when results lead to expensive unjustified enforcement action and unnecessary system upgrade or replacement. The non-monetary cost is the loss of public support and credibility in an adopted management program.

> *To be sustainable and meet community public health and environmental protection goals, oversight and enforcement mechanisms must balance costs and benefits and be judged fair and reasonable by the regulated community.*

Accountability / Feedback

Just as a state regulatory structure that allows adoption of local code provisions should incorporate processes for auditing local jurisdictions, so too must it include a feedback mechanism for local jurisdictions to propose changes to the state regulations. In turn, the local jurisdiction should gather input from its local stakeholders and share this feedback with state regulatory authorities.

> *Local lessons learned must be included in a formal feedback loop to better inform the process for periodic review and improvement of state and local regulations. Feedback should specifically address management goals for decentralized wastewater-treatment systems and related regulations governing public health, environmental protection, water quality, and water-resource infrastructure.*

It is becoming more common for governmental bodies to establish accountability and feedback processes for judging the effectiveness of regulation. This positive step supports the intent of a performance-based code to be responsive to advances in technology, management systems, and professional skills. More importantly, effective political and regulatory processes for feedback and accountability are needed to respond to any evidence of new impacts or emerging health and environmental risks.

> *The real value of a performance-based code rests in the necessity for accountability and a responsive regulatory structure that addresses treatment systems, professionals, and organizations for the purpose of managing risk to public health and environmental resources.*

By way of conclusion and summary, recommendations to be found in the Model Code Framework for the assignment of national, state, and local responsibility related to the regulation and management of a sustainable decentralized wastewater-treatment infrastructure are presented in Figure 6-3.

The Model Code Framework provides a process and resources for advancing the management of decentralized wastewater-treatment infrastructure and promoting its regulatory evolution and integration into broader goals for water-resource management. Within the primary goal of protecting public health and environmental resources, the Model Code Framework focuses on the following objectives:

- Provide an affordable decentralized wastewater-treatment method and management structure for any site where local and state law allow development

Responsibility	National	State	Local
Code Framework Development and Implementation	NOWRA Code Framework Committee	Adopt Code Framework provisions and resources, making state level choice decisions	Adopt Code Framework provisions and resources within state framework, making local level choice decisions
Professional personnel classification, evaluation and certification	National Organizations: NOWRA, NEHA, NSF, etc.	Require certification for major skill areas statewide. Adopt and recognize national certifications statewide	Accept state adopted national certifications – modifications at local level prohibited by state code.
Evaluation, classification and listing of treatment components	National centers for evaluation and certification (ETV, NSF, etc.) & NOWRA Component Classification Matrices	Recognize NOWRA classification program for treatment components	Accept state recognition of treatment components – no modification at local level permitted
Adoption of treatment performance requirements	NOWRA Classification Matrices, Soil Treatment Tables, and guidance documents serve as resources	Set minimum performance requirements for risks that are statewide & support integrated approach (watershed, TMDL, etc.) for local risk consideration	Adopt treatment performance requirements based on site and area risk factors including capacity for implementation

FIGURE 6-3. Recommendations for assignment of responsibility.

- Assess local risk and cost/benefit of decentralized wastewater-treatment solutions
- Include management assurances to extend system life and preserve property values
- Support adoption of reasonable and responsive state and local performance-based codes
- Ensure professional competency through national certification programs and training
- Provide a classification process for treatment components at the national level to replace unique local and state product-evaluation programs.

In recognition of variation across regions and within states, the process in the Model Code Framework is intended to be flexible and its resources widely applicable. The process and resources will evolve over time.

APPENDIX A

The National Onsite Wastewater Recycling Association, Inc.

Web Site: http://www.nowra.org

MODEL FRAMEWORK FOR UNSEWERED WASTEWATER INFRASTRUCTURE

INTRODUCTION

The National Onsite Wastewater Recycling Association (NOWRA) was founded in 1992. Its principal purpose is to educate and serve its members and the public by promoting sound federal, state, and local policy, improving standards of practice, and advancing public recognition of unsewered wastewater infrastructure. To achieve this mission, NOWRA has developed a model framework. This framework is structured as a guide in which to establish future national policy for onsite systems and NOWRA's complimentary programs and activities.

THE GOAL OF THE MODEL FRAMEWORK

Achieve sustainable development while protecting human health and environmental quality.

NOWRA believes that attaining this goal will provide enduring opportunities to our members and enhance the quality of living for the public. Traditional "prescribed" models cannot achieve the goal of sustainability. In fact a "prescribed" model is detrimental to achieving such a goal because it largely ignores local environmental sensitivities and thwarts innovation. Furthermore, a "prescribed" model approach is unable to adequately balance human health and environmental protection with economic development pressures.

WHAT IS THE MODEL FRAMEWORK?

The Model Framework is a number of critical components necessary to achieve the Goal. It is based on achieving performance excellence in all components affecting the onsite wastewater treatment system; performance of the treatment system, system owner, system practitioners (site evaluators, designers, installers, pumpers, operators, and regulators), and system regulatory agencies.

The Model Framework consists of seven components:

1. Performance requirements that protect human health and the environment;
2. System management to maintain performance within the established performance requirements;
3. Compliance monitoring and enforcement to ensure system performance is achieved and maintained;
4. Technical guidelines for site evaluation, design, construction, operation and acceptable prescriptive designs for specific site conditions and use;
5. Education/training for all practitioners, planners, and owners;
6. Certification/licensing for all practitioners to maintain standards of competence and conduct; and
7. Program reviews to identify knowledge gaps, implementation shortcomings and necessary corrective actions.

Collectively, these components create a total system of performance excellence. While each stands alone in its own function, NOWRA believes diminution of one within the system prevents the goal of sustainable development from being realized. Therefore, NOWRA is promoting this framework inclusively and each of the principles equally.

HOW THE COMPONENTS WORK

Performance Requirements: The Model Framework recognizes that onsite wastewater treatment systems are not 'disposal' systems but are systems that discharge treated and cleaned wastewater to ground and/or surface waters. This model recognizes that sensitivities of water resources to treated wastewater discharges vary and that water quality standards therefore should reflect the specific site characteristics. Further, performance requirements must be specific and measurable to allow credible performance compliance monitoring of all systems. Methodologies for determining appropriate water quality performance requirements must be established by regulatory agencies based on risk management procedures.

System Management: To maintain system performance within the established performance requirements, perpetual management of all systems must be provided. Management may be provided by the owner or through third parties that may be private, quasi-public, public/private, or public. Ultimately, all treatment systems should be maintained on an equivalent basis. Perpetual management should be provided in a manner that the treatment system and its servicing is transparent to the user. It should not matter to the user what type of system or management is needed for the property.

Compliance Monitoring and Enforcement: Governmental regulatory agencies must have continuous oversight of the performance of all onsite wastewater treatment systems. The system owner (either property owner or management district) is responsible for maintaining compliance. Renewable *operating permits* issued to the responsible party (property owner, management district, or sanitary/utility district) by the governmental agency occurs only after acceptable performance is documented, and is the more reliable method of regulatory surveillance of performance.

Technical Guidelines: Guidelines for site evaluation, design, construction, and operation are critical aids to owners and practitioners to inform them of acceptable methods for achieving compliance with performance requirements. These should include prescriptive designs that are capable of meeting the performance requirements under specific site conditions and intended uses. However, they are only optional designs and are not intended to be required designs. Owners may submit alternative and/or innovative designs for approval provided the owner assures performance to meet the established requirements.

Education and Training: The most critical element to ensure that consistency is achieved is Education. Education of the public and college and technical school students is needed. Also, a training component to ensure that all practitioners are knowledgeable in standards of practice is essential.

Licensing/Certification: Licensing/certification of all practitioners is the fundamental link to maintain high standards of competence and conduct. Continuing education is a central tenet of this Model Framework for licensing and certification programs. The licenses/certifications should be limited in term but renewable following documentation of minimum continuing education requirements. Also, they must be revocable if the holder is found to be negligent or fraudulent.

Program Reviews: This Model Framework must be grounded in good science, engineering, appropriate statutory authorities and sound management practices. Shortcomings in the management programs must be identified to direct needed and appropriate research, enabling legislation, education, etc. necessary to implement appropriate corrective actions to achieve our goal of sustainable development.

NOWRA'S DIRECTION

NOWRA intends for this Model Framework to be the "national" Model in building and maintaining onsite wastewater infrastructure. NOWRA intends to use this framework to identify and plan programs and actions that are beneficial to its members and the public.

"Making the Difference in Onsite"

Model Code Framework for the Decentralized Wastewater Infrastructure

VOLUME I

WORKBOOK FOR WRITING THE CODE

National Onsite Wastewater Recycling Association

March 2007

IMPORTANT NOTE

The Model Code Framework for the Decentralized Wastewater Infrastructure remains a work in progress. Its three major elements are code structure, user guidance, and evaluation of treatment components. While each element can stand alone, the three are intended to work together. Volume I and Volume II—essentially completed at this time—represent, respectively, the first two elements; they are particularly important because they address specific code issues and policy options. The tools for evaluating the performance of confined treatment components (pretreatment) and the unconfined-soil component remain in development.

The protocol for evaluating the pretreatment components—currently under beta testing by the Florida Department of Health (FDOH)—is near completion. The joint objectives of NOWRA and FDOH are to (1) perfect the evaluation protocol and the performance classification matrices, (2) have FDOH and NOWRA jointly administer the protocol, and (3) have FDOH incorporate the protocol into the Florida state code.

The protocol for evaluating the unconfined-soil component has been more difficult to develop and is about half-way to completion. Work on documents concerned with the scientific aspects is complete; the implementation document is still in development. The completed soil-evaluation/classification documents should be available at the next NOWRA Annual Conference.

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Produced and published by
National Onsite Wastewater Recycling Association, Inc.
3540 Souqel Ave, Ste A,Santa Cruz, Ca 95062
831-464-4884
nowra@nowra.org • www.nowra.org

www.modelcode.org

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Jean Caudill, Vice Chair
Marie-Christine Ballanger
Allison Blodig
Linda Hanifin Bonner
Fred Bowers
Steve Branz
Ben Burks
Matt Byers
Mike Hines
Mark Hooks
Anish Jantrania
Roman Kaminski
Bob Lee
Brian McQuestion
Del Mokma
Bob Pickney
Rodney Ruskin
Michael Stidman
Tony Smithson
Larry Stevens
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PREFACE

Including establishment of critical definitions and concepts

The philosophical and technological Framework envisioned by NOWRA to mold a regulatory code for decentralized wastewater infrastructure is realized in the *Workbook for Writing the Code* that starts on page 1 of this volume. A Volume II, *Code Design Philosophy and Guidance*, supports the Workbook volume. Encapsulations of material from Volume II appear throughout the Workbook, appropriately placed to serve as immediate guidance on the subject matter. (See "secondary element" below.)

The *Workbook* is a tool intended to be used by state regulatory personnel for writing their state's **Code for Decentralized Wastewater Infrastructure**. It guides them through the process of writing a code that regulates the performance and management of decentralized wastewater infrastructure and promotes the achievement of ultimate goals of water-resource management.

In the context of the code's generic title suggested in the preceding paragraph, the following definitions apply:

- "Decentralized" means, with reference to, the wastewater collected, treated, and returned to the environment near the point of origin.
- "Infrastructure" means physical components and systems and the management thereof.

Details of water-resource management ideally will vary in goals and practice across the relatively large geographical area (the whole state) to which the code will apply. As a means of working toward achieving that ideal, the traditional "prescriptive" approach to code design is defective—it tends to promote state-wide prescription of fixed remedies based on the statewide problems. Furthermore, the prescriptive approach inhibits deployment of new technologies because code revisions are needed to permit their general use. Time between prescriptive code revisions is often in the range of five to twenty-five years.

To address these defects, the NOWRA Framework's approach to code design embraces the principle of "informed choice" and the flexibility in code writing and delegation of authority that it promotes. "Informed choice" means that policy makers and citizens at all affected levels participate in setting and applying regulations; they understand the regulatory options and the benefits and costs associated with each option. In the subject case, it means specifically that they have the knowledge to shape the management of human and environmental benefits and risks that are associated with using decentralized wastewater recycling in their community. This process maximizes the value of regulation by balancing benefits, costs, and risks at levels appropriate to the immediate community. Moreover, it tends to facilitate alignment of the sometimes contentious agendas of politicians, regulators, industry leaders, homeowners, and the general public. The performance code design also promotes the establishment of performance standards. Treatment systems are evaluated; if they meet the standard, they are authorized for general use without the need for a code revision.

With the overall end of protecting public health and environmental resources effectively and efficiently, the *Workbook* focuses the code writers on the following specific objectives:

- Providing access to an affordable wastewater-treatment method and management structure for the owner of any site that meets the local and state laws governing development;
- Assessing the local risks and cost/benefit ratios associated with the use of decentralized wastewater-treatment systems;
- Adopting reasonable and responsive performance requirements for decentralized wastewater-treatment systems;
- Adopting management practices that prolong the life of decentralized wastewater-treatment systems and preserve property values;
- Ensuring professional competency through national certification programs and local training programs for personnel engaged in the decentralized wastewater-treatment industry; and
- Using a national uniform classification process for components of decentralized wastewater-treatment systems instead of using local and state evaluation programs.

The *Workbook* has two elements: a primary and a secondary.

The **primary element** is the suggested standard text, numbered by Chapter and Section and interspersed with places for the insertion of nonstandard text peculiar to the writer's jurisdiction or optional code language. Square brackets [ ] in the text denote places where nonstandard text is to be inserted. The nature of that text is identified within the brackets. The primary element is set in serif type with flush-right margins, using the full page width —similar in appearance to this paragraph.

> The **secondary element** comprises, as a whole, a series of explanatory, instructional, or background notes. Each discrete note is inserted immediately after the text to which it refers in the primary element. The notes are set in sans-serif type with a ragged right margin, indented on both sides, with a grey bar in the left margin—similar in appearance to this paragraph.

WORKBOOK

FOR WRITING THE CODE

[*name of state*] Code
for
Decentralized Wastewater Infrastructure

Effective Date: [*effective date*]

[*Name of writing agency*]

[*Address, contact information, etc.*]

LIST OF CHAPTERS AND SECTIONS

CHAPTER 1

INTRODUCTORY TOPICS

1.1 TITLE

These regulations shall be known as the [*name of state*] Code for Decentralized Wastewater Infrastructure (the code).

1.2 AUTHORIZING LEGISLATION

The code is authorized under the provisions of [*enabling legislation*] and created, administered, and enforced by the state Department of [*name of the department*] (the Department).

1.3 PURPOSE AND INTENT

The purpose of the code is to regulate the treatment, dispersal, and reuse of wastewater from structures not served by centralized treatment systems. It is intended to serve the best interests of the citizens. To that end, it manages risk to public health, public safety, and the natural environment and promotes public welfare in a manner acceptable to the public.

> The term “manages risk” is used rather than “eliminates or minimizes risk” because complete risk elimination is impracticable and risk-reduction measures cannot be deployed without regard for cost. The term “in a manner acceptable to the public” is included because the degree of risk reduction is a function of the public’s perception of the costs and benefits of the code.
>
> “Costs” are regulatory fees, time delays, visually objectionable features, installation and operating costs, and restrictions on property use experienced by the affected property owner and neighbor.
>
> “Benefits” are the perceived and actual risk reductions to human and natural environments in areas such as nuisance control, health protection, and environmental protection. Protection of the owner’s and neighbor’s property values is another important benefit.
>
> The extent of applied regulation is largely determined by a process whereby the body politic weighs perceived costs and benefits and selects the optimum combination. Like setting speed limits on city streets, that process does not result in a

> no-risk condition—just an acceptable-risk condition. "Body politic" means the combined interaction of individuals and groups within the political process that influences the contents of the code and the administrative and enforcement practices. Because the creation of the code and enforcement of the code are functions of different political forces, gaps between the law and the enforcement frequently emerge. While in practice those gaps may be politically useful for moderating the effects of overzealous or poorly constructed code language, they tend to create disrespect for the law and conditions for corruption and selective enforcement. An objective of the code must be to create conditions that minimize those gaps.

1.4 STATE/LOCAL RESPONSIBILITIES

The code is intended to be a **state** code in all matters that it regulates, except that **local governments** are granted certain discretionary responsibility for setting regulatory requirements and policy on a locality-by-locality basis in the following areas (see also Section 1.13.1, Delegation of Authority):

- Performance standards for effluent from decentralized wastewater-treatment trains
- Levels of system inspection, preventive maintenance, and monitoring required to manage the risk of the occurrence of a system malfunction that results in the release of non-compliant effluent.

Exercise of these discretionary powers shall not result in jurisdiction-wide pollution abatement that is less than that required by the code.

The burden of documenting the risk and effectiveness of the risk-reduction measures imposed by the code lies with the regulatory agency.

> The code is structured to support the Total Maximum Daily Load (TMDL) process whereby government regulates various sources of pollution affecting surface waters. The sources of pollution that should be considered for regulation include, but are not limited too, municipal wastewater, stormwater, human induced atmospheric deposition, agricultural- and urban-applied fertilizers, farm-animal manure, crops that fix nitrogen, soil erosion, and decentralized wastewater-treatment systems. Because the mix of sources varies from area to area, the intent of this provision is to allocate responsibility for determining performance and management standards for decentralized wastewater-treatment systems to the level of government that will be most effective in making and enforcing decisions regarding TMDL pollution-abatement allocation. In most states, that level of government is municipal, county, or regional. However, those decisions may have ramifications that impinge on neighboring jurisdictions—watersheds do not respect lines of political jurisdiction. Consequently, state-level government will often play a coordinating role.

1.5 FOCUS

The code is focused on the output performance of individual wastewater-treatment systems in terms of effluent quality. Required output performance is linked to the risk conditions associated with individual sites.

> A site's risk condition is partly determined by the requirements set by local or area governments based on the expected quality of surface and subsurface water. Since the sources of pollution of water are many, those government entities must allocate responsibility for pollution reduction to the various sources through imposition of performance requirements. Whether decentralized wastewater-treatment systems are a minor or major contributor of a specific pollutant may vary from one area to another. Because of this possibility, the government body that has the responsibility for allocating reduction requirements among the different sources must control the adoption of quality standards for decentralized wastewater-treatment standards.

1.6 COSTS

The state recognizes that the code may have cost implications for the public and may restrict citizens' choices and opportunities. Consequently, the code's requirements will be established at minimum levels consistent with their achieving the necessary reduction in risk to health and safety for the targeted human and natural environments.

> Cost is one half of the political calculation of cost/benefit value that influences the level of code requirements and applied enforcement. For any level of benefit, as costs increase, the political resistance increases, reducing the likelihood that the requirement will be adopted or, if adopted, will be enforced. In other words, minimizing costs maximizes the likelihood that the benefits goal will be achieved. A code that applies state-wide standards rather than focused applications and uses inefficient methods for evaluating/approving designs and products will increase costs relative to benefits. For example, if risk conditions determine that only 25% of a state's wastewater-treatment systems require nitrate-reduction processes but state imposes that requirement statewide, resistance to the unneeded costs from the 75% innocent property owners is likely to block passage of the rule.

1.7 REASONABLENESS

The provisions of the code and their enforcement are intended to be reasonable. To that end, the following standards are set:

1. The requirements imposed will be minimally necessary to manage the known or reasonably anticipated risks to human and natural environments.
2. Each code provision will be drafted in a manner that makes the obligation clear to the regulated persons.
3. Each code provision will be accompanied by a statement of its purpose in language that facilitates communication and the development of alternate methods of compliance.
4. Code requirements will be based on accepted management, science, and engineering principals. In cases where the science and engineering considerations are not settled, the code will be based on the best judgment of committees of experienced and expert persons in each area of practice.

> Administrative codes have the full force and effect of law. The reasonableness of rules is a serious consideration for several reasons:
>
> - Under reasonableness and equal-protection standards, the Constitution requires that laws be clear and enforced without discrimination.

- In a democracy, a law's reasonableness is subject to review by the political process. Reasonable rules are accepted politically; unreasonable rules, if enforced, are modified as a result of political feedback. Unreasonable rules can remain unchallenged if not enforced or if enforced selectively or weakly.

The task then is to define "reasonable rules." Basic standards for reasonable rules as applied to decentralized wastewater-treatment codes are as follows:

- Rules must be in written form and formally promulgated.
- Rules must be clear. The persons that are required to comply must be able to read the rules and must be able to understand the actions needed to comply.
- Rules must be enforced without invidious discrimination—equal treatment.
- Decisions to enforce must be based on clearly determined violations.
- Rule enforcement must emphasize education to ensure that the rules are known and understood. Punitive actions must be reserved for non-compliance after an obligation is known.
- Time for processing applications and permits must be short—within the range of that needed by service vendors operating in a competitive market.
- The authority, accountability, and responsibilities of participants in the decentralized wastewater-treatment industry must be clearly articulated.
- Regulatory personnel must have no conflict of interest in the performance of their duties.

1.8 WASTEWATER-TREATMENT OR -MANAGEMENT OPTIONS FOR EVERY SITE

The code is intended to provide decentralized wastewater-treatment or -management options for all owners of building sites that are not served by any other system of wastewater conveyance and treatment.

The objective of the decentralized wastewater-treatment industry is to ensure that an effective and efficient method of wastewater management is available to every site where construction of a building is allowed under law. In some communities, access to treatment technology is formally or constructively denied to citizens for the purpose of preventing construction of buildings. This tactic is commonly invoked in the name of land-use control. Constructive denial includes regulation that unnecessarily drives the cost of installing and operating the system to a level that most citizens are unwilling to pay. That practice subverts the intent of both land-use regulation and decentralized wastewater-treatment regulation. It prevents the construction of homes on land that planning and zoning agencies deem appropriate for construction. De facto zoning through manipulation of the decentralized wastewater-treatment code denies citizens access to the process and appeal rights that accompany zoning laws. The development of a broad range of onsite treatment technologies and the deployment of cluster designs means that all land areas can be provided with service.

1.9 EQUIPMENT EVALUATION

Recognizing that standard designs and components for decentralized wastewater treatment systems are deployed in regional and national markets, this code supports a national evaluation program and a multi-level classification system based on performance. The purpose is to eliminate duplicative product-evaluation and -approval programs at state and county levels, while supporting state and local government discretion in selection of performance standards to match local risk conditions.

> The purpose of a national evaluation and listing system is to improve the effectiveness and efficiency of the process of gaining product approval. Currently, many states operate product- and design-approval evaluations that are unique to the state. They often require the applicant to install and test systems in the state under a state experimental protocol, ignoring both the product and use approvals already granted in other states and the data collected to support those approvals. They may require a five-year evaluation program for systems that have been in long-term use in other states. The consequent high equipment-approval costs and choking of robust competition combine to reduce the overall affordability of a treatment system and increase political resistance to regulation.

1.10 ESSENTIALITY OF MAINTENANCE

The code recognizes that decentralized wastewater-treatment systems need to be maintained in a manner that assures that they continue to provide effective treatment over their predicted lifetimes.

> Capable maintenance is critical to the satisfactory performance of a wastewater-treatment system. Failure to provide it negates the intent of the code by which the system was approved and wastes the regulatory effort.

1.11 SUSTAINABLE PERFORMANCE

The code recognizes that decentralized wastewater-treatment systems are part of the continuum of water provision, conditioning, conveyance, and waste treatment for the communities that they serve. They are the permanent infrastructures for wastewater treatment for about a quarter of the population and nearly a third of new construction. Consequently, it is critical to the welfare of a large segment of the population that the performance levels of decentralized wastewater-treatment systems be sustainable for as long as the sites they serve are occupied.

> Decentralized wastewater-treatment systems support buildings that can have life expectancies of a century or more. The treatment systems must provide corresponding longevity, first by quality maintenance, then by repair, rejuvenation, or replacement as the situation dictates.

1.12 COMPONENT LOCATION

To allow for flexibility in design, the code recognizes that decentralized wastewater-treatment and -transfer components can be located inside or outside the structure served.

> There are advantages and disadvantages to locating components of decentralized wastewater-treatment systems inside the structures they serve. The advantages of interior location are:
>
> - Components are not subject to the external pressures of buried structures.

- Material degradation caused by chemical and electrical reactions with the soil environment is reduced or eliminated.
- Components are not subject to groundwater and stormwater infiltration.
- Components in tempered spaces are not exposed to the cooling effect of contact with cold or freezing soil. (Higher wastewater temperatures promote treatment and reduce the potential of freezing of external components.)

A disadvantage of interior location is the requirement that materials and venting conform to a plumbing code.

1.13 DELEGATION OF AUTHORITY

Governmental and private-sector organizations or persons may be authorized as agents of the state to administer and enforce the code.

Many state codes are administered by governmental entities (e.g., county government) or private-sector entities. Delegation needs to be explicit.

1.13.1 Governmental Entity

The following governmental entity:

[*General class of government (e.g., local; county; township) or full legal name (e.g., Board of Commissioners of Xyab County, Maryland)*]

is granted authority as agent of the state in the following matters:

- **Adopting the Code**. The agent may adopt, administer, and enforce the code by means of employees or appointed agents who possess the qualifications required by the code.
- **Adopting More Stringent Requirements**. The agent may selectively adopt more stringent requirements than those prescribed in the code in limited code areas and use them in focused application in the following regulatory matters:
  – Final effluent performance standards (requirements may be adjusted to reflect the particular human and natural conditions occurring within selected localities of the jurisdiction).
  – Operational, maintenance, inspection, and repair requirements to enhance risk management (requirements may be adjusted to reflect the particular levels of risk and other circumstances occurring within selected localities of the jurisdiction). [*Name specific areas where discretion is allowed.*]

The option for adopting "more stringent" requirements than those of the state code is included to allow local governments to focus their pollution-abatement tactics most efficiently and equitably in the localities they know to be the highest contributors to the total pollution load of their jurisdiction

This is one of several intertwined topics addressed in other sections of this document. The issues include:

- Which regulatory topics should be applied statewide or countywide and which should be applied in a focused manner?

- Which level of government should have the authority to write rules on the various code topics?
- Which level of government is best able to focus requirements that address differing site and regional risk conditions?
- Should state codes adopt statewide requirements based on managing statewide minimum-risk conditions or should they adopt statewide requirements based on managing high-risks conditions found at a few sites in the state? In both situations: How does the code manage risk at sites that do not have the same risk conditions as those targeted by the statewide standards? Where the statewide standard targets the higher risk level, does the state permit local codes to adopt lesser standards for low risk sites?

The recommendations in this Workbook and reflected in Volume II, *Code Design Philosophy and Guidance*, concerning generalized application versus focused application, are summarized as follows:.

- In generalized application, statewide topics should include:
  - The evaluation and certification of treatment components, people, organizations, and processes.
  - Rules governing the scope, administration, and enforcement practices of local units of governments authorized to enforce the state code.
  - Determination of minimum requirements for effluent performance of decentralized wastewater-treatment systems to manage the risks to human and natural environments that exist at all sites within the state.
- "Focused application" means the differential application of requirements based on the varied site risk conditions and the political and resource capacity of the enforcing governmental unit—the choice is between state government and local government. For treatment requirements, the focused application should be flexible enough to apply different performance requirements based ideally on individual site risk. This level of focused application of requirements is important because the cost impact of rules on individual households can be severe. Marginal cost differences can be in the range of $5,000 to $15,000 per household depending on requirements for enhanced levels of treatment.

The recommendations do not prescribe the answer to the question, "Which effluent-performance standard should be adopted for any given statewide or focused application issue?" They do not say definitively which level of government can best deliver discrete application of site-based risk-management standards. They do suggest that in many cases local units of governments are best suited to make the focused application decisions for the following reasons:

- Local governments enforce state codes in most states; they largely determine the level of applied enforcement, occasionally not enforcing the state rules with the vigor intended by the code's authors. This relaxed enforcement creates gaps between state rules and their enforcement. On the other hand, when the governmental level that enforces performance requirements is the same level that wrote them, those gaps will be smaller because the performance requirements are more likely to reflect the local political consensus.
- The level of government that determines the allocation of pollution-reduction responsibilities under the TMDL program between the various local sources of pollution should be able to determine the level of treatment required of decentralized wastewater-treatment systems. If the state makes that determination, the local governments are less able to make the political tradeoffs necessary to resolve the many issues. For example, Community A's nitrogen contribution to Local Lake could be 90% from housing, 3% from agriculture, and 7% from other sources; community B's contribution could be

90% from agriculture, 3% from housing, and 7% from other sources. If the objective is to reduce nitrogen mass loading to the lake by 20%, the two communities would likely arrive at different solutions if left alone. However, if the state dictates an 80% reduction of onsite nitrogen in a statewide standard, then the homeowners in Community B will be forced to spend many thousands of dollars per household to reduce the total nitrogen load to their lake by 2.4%. Local sources of pollution will vary and may include different mixes of the following sources: agricultural fertilizers, farm-animal wastes, urban storm water, wildlife, soil erosion, leaking municipal collection systems, atmospheric deposition, and effluent from municipal treatment works.

- Different areas of the state have different tolerances for risk and for acceptance of the costs needed to reduce that risk. Local units of government are likely to be more responsive to those considerations.

State statutes define the authority of state agencies and local governments to regulate these matters. States have variously taken three different code approaches under generic names such as uniform code, minimum code, and default code (see definitions in Chapter 2).

The regulatory philosophy behind state minimum codes is that the state should adopt requirements at the minimum level needed to manage the statewide risk level. Then local governments are permitted to adopt more stringent provisions where local conditions warrant the additional protection. Some states ignore the minimum-code design philosophy and instead adopt a "maximum code" designed to manage the enhanced risk conditions existing at a minority of sites. Such behavior by the state agency frequently causes local governments and the state itself to ignore or under-enforce the state provisions in areas where the risk conditions do not warrant the severe requirements.

A problem with granting local governments discretion to modify the state code is the opportunity it gives them to set standards that affect issues other than health, safety, and environmental protection. A frequent ulterior motive for setting relatively severe requirements for lot size, setbacks, and waste-water effluent is the desire to control land use and the income profile of residents.

In light of these circumstances, the recommended way to manage the code-creation process for the best benefit of the citizens is as follows:

- State codes should set minimum effluent and operational-management requirements. They should give local governments the authority to adopt more stringent requirements for focused application where warranted by local risk conditions. This code follows those suggestions.

  This does not permit adoption of local ordinances that modify state product-approval processes and state certification programs for individuals, organizations' and processes.
- As a checks-and-balances mechanism, local government changes to the code should be approved or reviewed for reasonableness by the state agency before they are adopted (see the following section). The state government also influences local government behavior by the manner in which it conducts the TMDL regulatory process.
- A checks-and-balances mechanism for the state agency's establishment of its minimum requirements for waste-water effluent is a more difficult subject. Full disclosure of the rationale for the proposed minimum requirements and involvement of local government, industry, and citizens in their establishment will provide the best likelihood of reasonable rules being developed.

- Adopting Modifying Language — Governmental entities modifying state code language in areas where such modification is permitted must first submit the language to the Department for approval [*optional: "comment"*] and may not implement until such approval [*optional: "comment"*] has been received.
- Imposing Fees — Governmental entities may be granted authority as agents of the state to adopt fee schedules for permits, reviews, inspections, and other related administrative functions.
- Establishing Application Procedures — The department will establish a uniform permit-application form and procedure. Local government entities may be granted limited authority as agents of the state to establish modifications to the procedures, provided the modifications are first approved by the Department.

> A uniform application form and procedures facilitate statewide efficiency for state regulators and for designers, installers and service providers that operate in multiple jurisdictions. The procedures for application in each jurisdiction should be as uniform as is reasonable. The code recognizes that the procedures may be modified to account for exceptional conditions at the local governmental level.

1.13.2 Private-Sector Entities

The Department or its delegated governmental agents may appoint qualified nongovernmental entities or persons as agents to perform regulatory duties required by the code. Those agents are subject to the direct supervision of the appointing authority.

> Many state codes are enforced by persons who are not employed by the state—usually local-government employees, but also employees of private code-enforcement agencies.

1.14 WITHDRAWAL OF DELEGATED AUTHORITY

The Department may discipline or revoke the authority of an agent to administer or enforce the code for good cause. "Good cause" in the case of a governmental entity is defined as any of the following transgressions: failure to enforce the provisions of the code as required by the Department; failure to provide timely service to citizens; failure to adequately supervise the performance and qualifications of employees and private-sector agents; malfeasance; and conflict of interest.

"Good cause" in the case of a private-sector agent is defined as any of the following transgressions: failure to maintain required credentials, failure to conduct required inspections, failure to maintain accurate records of inspections, malfeasance, and conflict of interest.

> Delegation of authority must be accompanied by a mechanism by which to withdraw the authority. Otherwise, the state abdicates its authority and responsibility to administer its rules and state laws.

1.15 CONFLICT OF INTEREST

Employees of the state, employees of agent-government entities, and private-sector agents and organizations who are engaged in administrating or enforcing the code are prohibited from engaging in activities that create a conflict of interest between those regulatory responsibilities and their private interests, professional responsibilities, or other duties. Specifically, other than their official regulatory services, they may not provide any person or organization with compensated services related to decentralized wastewater treatment, such as, but not limited to, soil evaluation, site evaluation, and system design, construction, installation, operation, or maintenance.

> Table 1 and related text in Volume II, *Code Design Philosophy and Guidance*, provide the position of the NOWRA Board and Code Committee on conflict of interest as it applies to regulatory personnel. Conflict of interest creates serious issues of law enforcement, equal protection, and fairness for citizens. The conflict occurs even if the services in question are provided outside the employee's regulatory jurisdiction.
>
> Several arguments are advanced in support of (1) regulatory agencies' providing design work and (2) individual regulatory staff's moonlighting as service providers in neighboring jurisdictions.
>
> With respect to item (1): Some argue that the local population is too poor to pay for the work, that private service vendors do not exist in the area, or that, if they do exist, they are not sufficiently qualified. Reply: If parts of the population are really too poor to pay private practitioners, then government subsidies should help to pay the costs. If private contractors are not available, they have probably been excluded or priced out of the market. If private service vendors really are insufficiently skilled to do the work, then the state should develop a training and certification program.
>
> The primary reason for the no-conflict-of-interest provision in the code is that a government agency should not be in the position of conducting the site assessment, designing the system, approving the design, and enforcing the rules against the owner if the system fails or is otherwise non-compliant with the rules
>
> With respect to item (2): The argument is that individuals have a right to work in private-sector employment. Reply: Agreed, but they do not have a right to a public-sector job at the same time if the combination creates a conflict harmful to the public interest. A staff member of a regulatory agency who moonlights in a neighboring jurisdiction may be supervising the work of his/her competitors when acting as a regulator in his/her home jurisdiction. This is not an insignificant issue, because many designers and installers work in multiple jurisdictions.

1.16 SCOPE

These regulations shall apply to:

1. The structure and components referred to as a decentralized wastewater-treatment system, including its design, its manufactured, site-constructed, or in-situ components, its location, its operation, and its effluent quality.

(OPTIONAL:

2. Activities and personnel involved in evaluating the site and soil associated with the installation of the wastewater-treatment system.
3. Activities and personnel involved in designing, manufacturing, constructing, installing, repairing, modifying, maintaining, monitoring, inspecting, and regulating the wastewater-treatment system.
4. The qualifications and training of personnel referred to in Items 2. and 3.)

> As a minimum, the code should regulate the object of interest—the decentralized wastewater-treatment system. The code may regulate objects, activities, and individuals, provided authority is granted under applicable law.
>
> *Recommendation:* Scope should include all four items listed, if permitted by law.

1.17 APPLICABILITY

1.17.1 Effective Date of Code

The effective date of the code is [*date*].The code applies to decentralized wastewater-treatment systems installed or modified on or after the effective date.

1.17.2 Uniform Code

The code is a Uniform Code. All matters regulated by the code are subject to its specific requirements, except in cases where authority is granted to delegated government agencies to modify the requirements or adopt alternative ones. The delegated authority must be exercised only with respect to matters specifically identified in the code as subject to that prerogative and exercised in accordance with any concurrently specified limitations.

More stringent requirements may be adopted in the following areas:

- Determination of final effluent performance standards
- Determination of operational, maintenance, inspection, and repair standards

(See Section 1.13.1; also notes following that section discussing code types.)

> The intent of the code is to give local governments discretion in areas that affect the quality of the local human and natural environments, specifically control of the effluent-performance requirements. The code grants no local discretion in requirements for product evaluation and approval, licensure or certification of personnel, organizations, processes, and methods.

1.17.3 Application of the Code to Existing Facilities

A decentralized wastewater-treatment system that existed prior to the effective date of the code is subject to the regulations in existence at the time the system's permit was first issued or, if no permit was issued, at the time the system was first used, except that operation of a decentralized wastewater-treatment system under any of the following circumstances is prohibited:

- Operation results in wastewater with a fecal coliform content that exceeds [*matrix standard, e.g.,* $<$ *10^5, 50% of the time*] being discharged to surface waters or to land surfaces in a manner that permits direct human contact.
- Operation results in discharge of wastewater to groundwater from soil treatment components deemed to generate fecal coliform exceeding [*matrix standard*].
- Change in the principal use of the structure has caused the effluent loads and flows to exceed the limits of the design parameters of the system's components.
- Changes to the structure have caused the effluent loads and flows to exceed the limits of the design parameters of the system.
- Changes to the loads and flows of a cluster system have caused the design capacity of the system to be exceeded

This topic is politically sensitive and regulators will need to engage the support of the public and the body politic if an environmentally effective outcome is to be achieved.

Retroactive provisions that cause the modification of existing systems have a major detrimental effect on owners and should be applied only when such systems present a significant and immediate threat to the human and natural environments.

Judicious retroactive application of provisions of the code may be deemed reasonable for addressing problems in the following areas of existing systems:

- Operational maintenance and inspection
- Direct discharge of untreated sewage to the land, groundwater, or surface water.
- Localized discharge of polluting agents.
- Unsafe conditions such as collapsed or failing structures and unguarded access points.
- Service-access discrepancies, such as inadequate risers.

Retroactive application of code requirements in the following areas is considered less acceptable and would likely raise significant opposition if not presented under the mantle of public-welfare imperatives:

- Increased vertical and horizontal separations
- Increased size of components
- Changes to design requirements in general
- More stringent or new effluent-performance standards

Recommendations:

- Include language emphasizing that the regulations in effect at the time that a system was installed govern the system.
- Limit retroactive application of the new code to the circumstances deemed "reasonable" above. Focus them on areas of perceived major problems.
- Avoid retroactive application to provisions deemed "less acceptable" above unless critical health or environmental issues are involved—and then focus the application on the most severe problems. The burden of proof of critically is on the regulatory agency, which must accept the responsibility of convincing the public.
- Decisions should be based on research findings, not arbitrary numbers, and applied in a manner commensurate with site risk.

1.18 SEVERABILITY

Should any provision of this code be held by a court of competent jurisdiction to be invalid, void, or unenforceable, the remaining provisions shall remain in full force and effect.

1.19 LIABILITY LIMITATION

Liability of the state and its employees, agents, and deputies, when acting within the scope of their authority is limited by the provisions of [*state statute and section on limitation of liability*].

1.19.1 Exception to Liability Limitation

State agencies, local governments, and individual agents providing services deemed to be a conflict of interest in Section 1.15 are subject to tort claims in the same manner as private persons and organizations offering the same services.

Except as provided in the preceding paragraph, regulatory approval of any authorized activity of this chapter may not be construed as an assumption of responsibility by the agency or its agents for any decisions, errors, and omissions in the execution of its duties. The responsibility for the design, construction, repair, and operation of any decentralized wastewater-treatment system is ultimately the responsibility of the owner. The performance of duties by any other person is the responsibility of that person.

> The purpose of this language is to reduce agency and staff liability for errors and omissions and other sources of liability.
>
> Authority to limit liability by code is problematic without specific authority to do so in the law. Most states have statutes that cover this issue.
>
> Liability is a component of responsibility. A goal of a performance code is to assign responsibility for the quality of discrete portions of the work to individuals and organizations.The question here is the responsibility of government for the quality of the work performed. A reasonable position is that a government agency should not take on a task unless it intends to perform it adequately. If the work is important, it should be done well. If it is not important, the requirement should not be enacted. If the work is important, but internal budget and political restraints prevent adequate staffing, the option to shift the work function to third parties needs to be explored. The state agency staff can then concentrate on consultation and audits of third party service providers.
>
> *Recommendations:*
>
> State statutes should limit liability, not the code. Where such state liability limitation exists, it should be noted.
>
> Provision of non-regulatory services for homeowners such as soil and site assessment, design, construction, and maintenance services that are provided by government staff should be subject to the same liability as if the work were performed by the private sector. If the statute otherwise limits liability, the regulation should reapply it. At least one state provides state-level liability reduction to county agents providing regulatory services but removes state liability protection from county agents providing private-sector services. Further, the code should prohibit regulatory staff from performing non-regulatory decentralized wastewater-treatment services normally provided by the private sector. If they perform these services, the work will be outside the scope of authorized work and subject the agency or person to the full scope of tort action.

1.20 CODE AND POLICY ADVISORY COUNCIL

The Department shall appoint a Decentralized Wastewater-Treatment System Policy Advisory Council and may create technical subcommittees as appropriate. No member of the Department may be a voting member or officer of the Council.

The council shall have [*number*] members.

Council membership shall be balanced with proportional representation between local government regulators, manufacturers of decentralized wastewater-treatment equipment, service providers of the decentralized wastewater-treatment industry, users of decentralized wastewater-treatment systems, and citizen interest groups, as follows:

Regulators	[*numbe*r]
Manufacturers	[*number*]
Service Providers	[*number*]
Users	[*number*]
Citizen Interest Groups	[*number*]

(OPTIONAL language to expand the scope of Council)
The council, upon request of citizens affected by a Department decision or a dispute over application of the code at the local or state level, may conduct a hearing and provide an advisory opinion [OPTION "a final decision"] on the matter.

> The purposes of creating an Advisory Council are (1) to provide advice and technical expertise to the Department and (2) to provide communication channels between decentralized wastewater-treatment entities, interest groups, and the Department.
>
> Advisory council members provide two forms of advice: policy and technical. At the policy level the council should represent a broad base of interest groups. Appointees do not need to be technical experts, but should be familiar with the topic. The Department and the council should have access to technical experts to serve on technical subcommittees.
>
> A major role of advisory councils is to approximate the interests of the citizens in deciding the balance between the cost and benefit of the regulation. To do so, the committee membership should be balanced and represent a broad range of interest groups, essentially the same groups that would attempt to influence the legislature.
>
> Interests groups by their nature represent the private interests of the groups, often to the detriment of the overall citizenry. Regulatory agencies are also interest groups and if allowed to unilaterally write rules would tend to serve their interest, just as would interest groups of installers, designers, or pumpers. The broad based council creates a structure where conflicting special interests can approximate the interests of the citizenry.
>
> There are two forms of councils. In some states the councils decide Department policy and in others the matter is determined by statute. In most states the councils advise the Department. Where the council is advisory, Department representatives should serve as advisors, not as voting members, for several reasons. 1) There is a conflict between giving and taking advice. 2) If Department staff sat on the committee as voting members, the Department would be advising itself. 3) As voting members the Department representatives would be the most powerful members of the committee because they would be giving advice and then accepting or rejecting the advice of the council. 4) The Department might find itself in the embarrassing position of reversing decisions that its representatives proposed and voted for.
>
> As staff to the council in most states, state regulators still maintain significant influence over council activities.
>
> Local regulators, as users of the code, should be assigned to the committee as voting members as a part of a balanced membership. The total number of regulatory personnel should not exceed 1/3 of the committee and may be limited to a smaller share depending on the breadth of other interest groups represented. Note: This 1/3 regulatory membership cap is employed under the balanced-committee requirements of the American National Standards Institute (ANSI).

If the council has the power to decide the policy and technical issues, then it is more appropriate to have a Department representative as a voting member because the department is just another interest group among many.

A key feature of the deployment of advisory councils is that the Department should follow the advice of the council most of the time and when it does not, it should explain the reasons to the council before announcing the decision publicly. Failure to do so can convert the council from an ally of the Department to a powerful political opponent.

Recommendation: Establish broad-based, balanced advisory councils for policy issues, either by rule or law. Policy includes code development, administration, enforcement and integration with related regulations. Balanced means that major interests are represented with no single interest allowed to dominate or control the process. Establish technical committees of experts to advise the councils. Do not appoint Department staff as voting members of the policy councils.

CHAPTER 2

DEFINITIONS OF TERMS

WITH SPECIFIC REFERENCE TO THEIR USE IN THIS VOLUME

NOTE: The definitions contained in [*name of dictionary*] apply to words or terms not included herein.

Accepted engineering practice means the norms by which components and treatment trains are (1) designed in accordance with all relevant factors influencing safety and performance and (2) manufactured, installed, built, and verified in a manner that ensures their operational safety and performance during their intended life spans when used in reasonably foreseeable conditions.

Acceptance rate is the maximum flow and load rate acceptable for treatment or conveyance by any component of the system, measured in [*unit/time*].

Black water means wastewater contaminated by human body waste, toilet paper, and any other material intended to be deposited in a receptor designed to receive urine or feces.

Capacity means

- The maximum liquid volume able to be accommodated without effluent surfacing or backing into the structure.
- The maximum flows and loads as specified by the design manual or permit for the treatment train of component.

Cluster system means a wastewater collection and treatment system that is under some form of common ownership and management and provides treatment and dispersal/discharge or reuse of wastewater from two or more homes or buildings but less than an entire city or metropolitan area.

> There is significant overlap between decentralized clusters and centralized systems. The divide between the two is often a function of design and engineering style and the state law that assigns the respective regulatory functions to different agencies.

Decentralized means a generalized class of wastewater-treatment applications that includes onsite and cluster systems that discharge their treated wastewater near the point of origin. The contrasting term "centralized" refers to the extensive collection-and-treatment works serving large geographic areas such as a cities.

> The historical concept of the term "decentralized" proposed that cluster and onsite systems should be under active management. The current use of the term includes both managed and unmanaged systems. EPA has various definitions of the term, some with and some without the management inclusion.

Deemed to comply means that a system is assumed to comply with pertinent effluent- performance standards during operation without effluent-sample monitoring, provided the system is operated and maintained in a manner specified in the approval document.

Default code means a state code whose provisions concerning given subject matter(s) are, by state statutes, applicable to a political subdivision only if that subdivision has not adopted regulatory provisions applicable to the same subject matter(s). The subdivision's provisions may impose greater or lesser levels of regulation than the state's code. If the subdivision imposes no requirements, the state's requirements apply by default—whence the term "default code."

> State statutes define the relative powers of state agencies and local governments to adopt regulations for decentralized wastewater-treatment systems. Default codes assign the bulk of the power to write codes to the local governments. In contrast, a state with a Uniform Code assigns the sole power to draft regulation to the state agency, which then has the authority to grant discretion to local governments to supplement or revise the regulations. Minimum Codes split the power between the state and local governments with the state agency being authorized to adopt minimum health, safety, and environmental-protection provisions and local governments being authorized to adopt more stringent requirements

Department means [*name of the state department with authority to regulate decentralized wastewater-treatment systems*].

Engineered design means the design of an onsite or cluster system created to meet specific performance requirements for a particular site as certified by a licensed professional engineer or other qualified and licensed or certified person.

Experimental system means a type of system component or treatment train that does not conform to an evaluated design and whose processes are not based on confirmed science or engineering practices. These are systems for which valid and reliable data are being sought to demonstrate compliance with the intent of the code.

Final effluent means the wastewater at the point it leaves the treatment train.

Grey water means any putrescible wastewater discharged from domestic activities including, but not limited to, washing machines, sinks, showers, bath tubs, dishwashers, or other sources except toilets and urinals.

Habitable structure means a permanent or semi-permanent structure intended for human habitation.

Holding component means a vessel designed to hold sewage or wastewater without leaking to the immediate environment while awaiting transportation to a treatment and dispersal facility.

Imminent threat to human health and safety means a substance, activity, or condition that poses an unacceptable risk to public health and safety and requires immediate abatement.

Load and flow means:

- Load—the total weight of individual wastewater constituents of interest entering a pretreatment component over a given period of time or applied to a given area of soil over a given period of time (unit of weight / time).
- Flow—the volume of liquid entering a pretreatment component over a given period of time or applied to a given area of soil over a given period of time (unit of volume / time).

Long term acceptance rate means the acceptance rate of a component after the break-in period is complete. The break-in period may include the development of a suitable level of biological activity. The break-in period for a soil dispersal component may also include the time to develop ponding of the surface caused by the development of a hydraulically restricting biomat.

Major repair means the replacement of a component such as a septic tank or other treatment component including the dispersal system.

Management Model IV means the situation wherein a decentralized wastewater-treatment system is owned by the property owner and managed by a third party organization. (See EPA Voluntary Management Guidelines.)

Management Model V means the situation wherein a decentralized wastewater-treatment system is owned and operated by a third party organization, such as a utility. (See EPA Voluntary Management Guidelines.)

Minimum code means a state code that, in accordance with state statutes, may be amended by sub-units of government in a manner that equals or increases its health, safety, and environmental requirements. This term is contrasted with "uniform code" and "default code."

> The purpose of a minimum code is to allow the state regulatory agency to adopt minimum requirements to manage the risk conditions existing at all sites statewide and local governments to adopt additional requirements to manage higher risk levels existing within the jurisdiction.

> Several problems may occur with minimum provisions:
>
> - Some states adopt statewide "minimum" provisions based on the highest risk found at a minority of sites. This practice leaves little room for local code revision to address discrete problems. Instead, local governments are placed in the position of enforcing state provisions at individual sites where the risk is not perceived. Their alternative is to under-enforce the code by ignoring the provision or applying selective enforcement.
> - Local regulatory agencies may choose not to address the higher risk areas because the local population may have a different tolerance for risk than state officials.
> - Designers tend to design to the code requirement without regard to site conditions which may pose a greater risk than that contemplated by the code.
>
> Also, see the discussion of "uniform" code provision.

Minimum daily flow means the minimum flow required to maintain the level of biological activity necessary for treatment.

Minor repair means the replacement of subcomponents such as a switch, pipe, pump or valve. Servicing of the system by cleaning, tank pumping tank, filter replacements, and adjustments is not considered a repair.

Modification means to substantially alter the design or use of a component or group of components in an existing wastewater-treatment system.

New construction means the installation of a wastewater-treatment system on a parcel that did not previously have such a system installed.

Non-treatment component means a wastewater confinement, holding, or transfer device that is not intended to provide wastewater treatment.

NOWRA means National Onsite Wastewater Recycling Association.

Onsite wastewater-treatment system means a system that (1) collects wastewater from as single structure, treats it, and disperses it to the surface or subsurface environment on one or more legal parcels near the source of the wastewater generation or, alternatively, (2) stores the collected wastewater or the collected and treated wastewater in a holding component until transported to another location for the necessary final step(s).

Onsite system means an onsite wastewater-treatment system.

Operating permit means a document or certificate issued by an authorized government agency giving permission to operate a decentralized wastewater treatment system.

OWTS means onsite wastewater-treatment system.

Performance code means an administrative regulation written in terms of ends or results that are required to be achieved by application of a process. It allows the general use of designs or components that achieve the objective requirements or standards without a code revision.

> Performance codes contain measurable requirements, a method of evaluation of alternate design specifications or manufactured components to the specified requirements and a method to allow the general use of the designs or manufactured components once approved without first necessitating a code revision. Performance codes often create lists of acceptable designs or manufactured components available for general use. The listed design specifications and manufactured components are prescriptive solutions to the adopted performance requirements. This is contrasted with "prescriptive" codes in that the latter specify the details of one or more processes and disallow the general use of other processes until the code is revised. The prescriptions are assumed to meet the objectives of the regulation, often without first listing the specific objectives or conducting an evaluation of the prescriptive design's performance.

Performance requirement means a clear statement, numeric or narrative, of a measurable and achievable condition or output to be achieved at a specific point in a process. The requirement must allow for multiple solutions and a clear pass/fail determination of compliance.

Performance standard is a substitute term for "performance requirement."

Point of standards application means the specific location, depth, or distance from a regulated facility, activity or practice at which the concentration of a substance in the system effluent plume must comply with the specified performance standard.

Point of standards application, design means the point where the wastewater leaves the last treatment zone. This may be the same as the point of standards application or some point prior to reaching that point.

Prescriptive code means an administrative regulation that specifies the process of achieving an objective and excludes or limits the use of other processes that achieve the same objective.

> The objectives of prescriptive codes are usually stated as high-level purpose statements such as "protect public health and the environment." Specific requirements, such as allowable fecal coliform in final effluent, are often missing. The primary objections to traditional prescriptive codes are that they offer limited design choices and require a code change to allow use of additional designs. Code revisions seldom occur more often than 5 years and frequently take 10–25 years between substantial revisions. This inflexible structure frequently resulted in unbuildable residential lots and no authorized design to replace failing systems.

Quality assurance (QA) means an integrated system of activities involving planning, quality control, quality assessment, reporting' and quality improvement to ensure that a product or service meets defined standards of quality with a stated level of confidence.

Repair means to restore a system to a functional condition without substantial modification.

> "Major repair" means the replacement of a component, such as the septic tank or replacement of other treatment components, including the dispersal system.
>
> "Minor repair" means the replacement of sub-components, such as switches, pipes, pumps, and valves. Servicing of the system by cleaning, tank pumping, filter replacements, and adjustments is not considered a repair.

Requirement. (See "Performance requirement.")

Responsible management entity (RME) means a legal entity responsible for providing various management services. It must demonstrate managerial, financial, and technical competence and capacity sufficient to ensure long-term, cost-effective management of onsite or clustered wastewater-treatment facilities in accordance with applicable regulations and performance criteria.

System means a decentralized wastewater-treatment train.

Sewage means wastewater containing fecal matter that exceeds the adopted performance standards for bacteria in the final effluent of a wastewater-treatment train.

> Currently many states regulate and define sewage in ways not appropriate to a performance code. Terms like "water carried wastes" or "untreated wastes" do not describe a measurable boundary between the state of the water being sewage and not sewage. This *Workbook* relies on fecal coliform bacteria counts for the definition of sewage and indicator of treatment quality. Other indicators or direct measurements could have been used, but none of those processes have the historic body of information that currently exists for fecal coliform.
>
> Wastewater containing nutrients can be a valuable resource or a serious threat to citizens' health and welfare depending on site conditions and use. Consequently, the presence of nutrients alone is not a basis for classifying wastewater as sewage.

Standard. (See "Performance standard.")

System construction inspector means a person who observes construction of wastewater-treatment systems for compliance with code specifications and the approved design.

System designer means a person who matches site and soil characteristics with appropriate wastewater-treatment technology and prepares system designs and installation plans for the site.

System installer means a person who constructs and assembles the components of a wastewater-treatment train to the designer's specifications.

System maintainer/operator means a person who provides operational, maintenance, and service activities to assure the effective and continuous operation and performance of a system.

System operation inspector means a person who inspects the system for compliance with the code and permit specifications.

System plan reviewer means a person who reviews required documents for compliance with the code prior to issuance of a construction permit. The documents may include but are not limited to the permit application form, site and soil evaluation report, management plan, and system-construction plans.

System soil evaluator means a person who makes the determination of soil morphology by defining its physical constitution as exhibited by the types, thickness, and arrangement of the horizons in its profile and by the texture, structure, consistence, and porosity of each horizon. (Modified EPA)

Treatment means the intended transformation of specific properties of wastewater from one state or condition to another.

> "Treatment" modifies the mass or concentration of a pollutant or other wastewater constituent of interest. Concentration is often reduced by means of dilution. Mass can not be reduced by dilution.

Treatment component means a discrete portion of the wastewater-treatment train within which wastewater treatment is intended to occur. It may be located within or outside the structure and is defined by specifically identified points of influent and effluent.

Treatment train means the total assemblage of wastewater treatment, transfer, and holding components beginning with the first wastewater treatment component within or outside the structure and ending at the point where the effluent is dispersed from the last treatment or conveyance component. The term "system" is often use synonymously with "treatment train."

Type I compliance violation means discharge of sewage to the ground surface or surface water or within a structure where such discharge is not otherwise intended or permitted.

Type II compliance violation means the dispersal of sewage to the groundwater measured at a point of standards application for the regulated constituent where such discharge is not otherwise intended or permitted.

Type III compliance condition means the performance or operation of a treatment or conveyance component in a manner that does not comply with an applicable standard or specification but which is not a Type I or II compliance violation. The expected response to a Type III condition is maintenance of the component by an authorized person.

> The terminology used in the three previous definitions is intended to shift the classifications away from the term "failure." The "Type III compliance condition" is differentiated from Types I and II violations because Type III conditions are issues that do not immediately cause a compliance violation. For example, a blower on a pretreatment device may fail but the downstream components are capable of continuing to treat the wastewater for a period of time without creating a Type I or Type II violation.

Unconfined treatment component means the volumetric area of land and water that is not within a confining structure with a discrete point of effluent discharge and which has been evaluated for treatment capacity by a person or organization authorized to do so by the code.

> The treatment component can include in-situ and engineered soils and surface and groundwater where permitted by rule. The definition includes saturated soils and surface water as potential treatment areas because nitrate reduction in soil requires anoxic conditions provided by saturated soils (groundwater by most definitions.) Further, ground and surface water provides dilution as a treatment mechanism.

Uniform code means a state code that reflects provisions in state statutes prohibiting subordinate levels of government from adopting ordinances that add to, delete from, or otherwise modify the regulations contained in the code except where the state code specifically permits such modifications. This term is contrasted with "minimum code" and "default code."

> Some provisions are appropriately standardized across political jurisdictions. This code promotes the uniform application of provisions in the area of evaluation and certification of equipment, standard designs and personnel. A design approved at the state level should be available statewide if it meets local effluent performance requirements. An installer certified to install conventional systems by the state should not be subjected to a separate evaluation in each local jurisdiction. On the other hand, this model code promotes minimum state code provisions for final effluent quality and the level of management attention paid to a system, leaving the local governments to regulate their various local risk conditions affecting their unique human and natural environments.

Wastewater means:

- Wastewaters associated with dwellings, business establishments, institutions, and other structures or places used for human habitation, employment, or congregation. It may be further characterized as domestic wastewaters normally discharged from or similar to those discharged from plumbing fixtures, appliances, and other devices dedicated to, but not limited to, sanitary, bath, laundry, dishwashing, garbage disposal, water conditioning, and cleaning purposes.
- Storm and clear-water wastewater generated in or near buildings or other site improvements, when commingled with domestic wastewater.

> Storm and clear-water wastewater treatment is included in the scope of the "decentralized wastewater treatment" definition because states are beginning to require the treatment and onsite infiltration of stormwater under Phase II of the EPA Stormwater Regulations. The processes for flow management, treatment, and dispersal for both are similar and can be combined if properly designed.

Water reuse means any specific beneficial use of the treated wastewater in place of releasing it to the surface or subsurface environments.

CHAPTER 3

GENERAL REQUIREMENTS

3.1 DEPLOYMENT OF DECENTRALIZED SYSTEMS

An onsite or cluster wastewater-treatment system or holding component shall be provided where a permanent or semi-permanent structure discharges wastewater through a plumbing system whose effluent is not conveyed by sewer to a centralized municipal treatment facility other than a cluster system.

(OPTIONAL requirements if allowed by law)

A wastewater treatment or holding component shall be provided at habitable structures that do not have wastewater plumbing.

An approved wastewater collection and treatment system or a holding component shall be provided at property or locations where people routinely congregate or are employed, such as construction sites, fairs, carnivals, revivals, agricultural workers' field locations, encampments, and other locations where the public congregates for short temporary periods.

> The above requirements are intended to ensure that approved systems are provided to safely remove, treat, and recycle sanitary waste from structures where such removal is not provided by another method such as a municipal collection and treatment system. This can include a requirement to provide systems for structures that do not have plumbing. However, the scope of this code does not extend to the requirement to install plumbing itself, which must be left to a plumbing code or building code.
>
> *Recommendation:* The first requirement should be adopted. The two "options" should be addressed at the local level by the health department.

3.2 ABANDONMENT

3.2.1 When?

The system shall be properly abandoned in the following circumstances:

- When the system is permanently disconnected from the structure served and has not been approved for subsequent use by another structure.

- When the building sewer has been connected to a sanitary sewer that is part of a municipal treatment works.
- When the system has been condemned by the regulating authority

3.2.2 How?

The procedures for abandonment of external vaults and tanks are as follows:

- The property owner or agent shall apply for a permit to abandon the system if the system contains tank or vault components.
- The contents of tanks or vaults shall be pumped and equipment removed.
- Pipes or plumbing attached to the tanks or vaults shall be disconnected or sealed.
- Electrical connections shall be disconnected.
- Tanks or vaults shall be EITHER:
  - Removed and the void leveled to the surrounding grade with sand or other suitable inert material and completely covered with soil or material similar to that at the surface in the immediate area,

  OR

  - The covers of tanks or vaults shall be removed, the bottoms ruptured, and the void leveled to the surrounding grade with sand or other suitable inert material and completely covered with soil or material similar to that at the surface in the immediate area.

(Instead of removing the tank covers, the tank may be completely filled with material such as concrete, sand, or pea gravel smaller than #1 stone.)

> The purpose of requiring use of approved abandonment procedures is to protect the population from injury associated with residual pollution and from collapsed tanks, child access, and other unintended/unauthorized entry.

3.3 EMERGENCY REPAIR

Notwithstanding any provision requiring a permit to commence repair to a system with a Type I or Type II compliance violation, if a Type I or Type II compliance violation poses an imminent threat to public health or safety, the owner or agent may commence corrective action immediately without securing such permit. The owner or agent must then notify the regulatory authority within 2 workdays of commencement of the action and apply for any required permit.

Where an imminent threat to human health and safety exists, the regulatory agency may cause the abatement of the threat by:

- Issuing a directive to the owner to abate the threat
- If the owner does not abate the threat in the time specified in the directive, the agency may abate the threat and bill the owner for the cost.

> Authority to abate an imminent threat is important for application in the rare cases when the owner will not take action. The authority must not be abused. Its use must be reserved for major problems and exercised in accordance with uniform triggering criteria, lest accusations of unequal treatment arise.

3.4 RIGHT TO INSPECT

Staff and agents of the regulatory authority may enter the property of a permittee to inspect the system during reasonable hours and with appropriate notice to the owner and occupants. The right to enter does not include the right to enter an occupied private residence or associated structure absent permission or an inspection warrant.

The owner or agents shall produce permit documents and required records at the request of the regulatory agent inspecting the system.

> The purpose of an inspection is to reduce the risk that a code violation will pose a threat to the human or natural environments.
>
> Inspection activity raises difficult issues because the government's right to enter private property is restrained by state and Federal law. Furthermore, even when lawfully established, the authority can be restrained politically if perceived to be abusive in its application. Care must be taken to ensure that individual regulators are thoroughly aware of the constraints on their rights in areas that are limited by law and custom. Likewise, care must be taken to ensure that the public is not misinformed regarding its rights to bar government entry.
>
> A different conceptual approach may be useful here. While the citizen's ability to limit government entry to private property is protected by the Constitution, no such protection is afforded to the right to operate a wastewater-treatment system. If the issuance of a permit is conditioned on the right to inspect the facility, then failure of the owner to allow such inspection may be a sufficient basis to suspend the permit. In other words, the individual has the right to bar entry absent a warrant of the court, but not the right to operate a treatment system.
>
> To protect the regulatory agency and the regulator personally, the best practice is to (1) announce the visit to the occupant(s), (2) request permission to conduct the inspection, (3) if refused, leave the site, and (4) secure an inspection warrant from the appropriate authority or revoke the permit.

3.5 FINAL-EFFLUENT REQUIREMENTS

The system design selected for a site is required to comply with the final-effluent requirements adopted in Chapter 5 or determined by local ordinance.

3.6 COMPATIBLE SYSTEM COMPONENTS

Components listed in NOWRA Matrices may be selected to create a treatment train if they have complementary influent and effluent parameters as specified. A treatment train designed by site-specific engineering or an experimental design is considered to be a single, discrete treatment component and is evaluated at the time of the application for a permit.

3.7 DOMESTIC WASTEWATER FLOW— DETERMINATION

3.7.1 Systems Designed to Serve One To Eight Households

The owner or owner's agent of a residential system designed to serve one to eight households may select one of the two following methods for calculating the estimated wastewater load and flow from a structure for the purpose of determining the system's minimum design flow.

3.7.1.1 ***Prescriptive Determination.*** Determination of minimum design flow for systems treating or containing domestic wastewater wherein black water is present shall be based on [*Gpd or Lpd value selected from* OPTIONS *below*] per defined two-person bedroom and half that amount for a defined one-person bedroom.

OPTIONS FOR INSERTION ABOVE

– High risk avoidance: 150 gpd [568 Lpd)
– Moderate risk avoidance: 100 gpd [379 Lpd]
– Low risk avoidance: 75 gpd (284 Lpd).

For plumbing systems that separate grey water from black water, an estimated 60% of the unseparated flow is considered to be grey water and the remaining 40% is considered to be black water.

3.7.1.2 ***Adjusted Base Flow Determination.*** The designer of the treatment system may adjust the minimum design flow determined in accordance with paragraph 3.7.1.1 based on, but not limited to, the following:

- Incorporation of water-conserving features within the structure
- Utilization of flow-management techniques
- Use of actual occupancy values and flow rates

The adjusted design flow in [*units/time*] for the structure must be recorded as provided in paragraph 3.7.1.4.

> The designer of the system needs to consider the fact that reduced flow achieved by water conservation increases the strength of the constituents in the wastewater.

3.7.1.3 ***Determination Waiver.*** The designer may specify a treatment design of a given capacity (in gallons/liters per day) without regard to the design features of the structure, provided the actual use is equal to or less than the design flow and provided notice is provided as required by paragraph 3.7.1.4.

3.7.1.4 ***Recording of Adjusted Flow Rate***. For system designs that invoke the provisions of 3.7.1.2 or 3.7.1.3, the design capacity in gallons/liters per day maximum flow shall be declared and, along with the prescriptive design flow specified in paragraph 3.7.1.1, (1) filed with the regulatory agency, (2) recorded with the deed, and (3) displayed on a permanent placard mounted in clear view near the primary electrical distribution box of the structure. The notice shall also contain the estimated number of occupants the system will support based on an average daily use of 60gpd (227L) per person.

3.7.2 Systems Designed to Serve More than Eight Households or More than Twenty People

Design flows and loads for multifamily structures and cluster systems designed to serve more than eight households or more than 20 people shall be determined by a professional engineer or other qualified designer who shall be responsible for the design. The design flow shall be filed with the regulating agencies and recorded with the property deed. The owners of the structures served shall be presented with notices that inform them of the capacity of the treatment systems. The notices shall explain that, in the event of the capacity's being exceeded, either the capacity of the system must be increased or the total flow must be limited.

3.7.3 Systems Designed to Serve Commercial Structures

Design flow and loads from commercial structures shall be determined by a professional engineer or other qualified designer who shall be responsible for the design. Such determination shall be recorded with the property deed.

> Estimation of flows from single-family structures is very difficult because of differing occupancy levels, water-use habits, hours of occupancy, use of water-conservation devices and practices, amounts and types of cooking, and other activities. Two identical 3-bedroom houses may be occupied in one case by a single retiree who spends the winters in Arizona and, in the other case, by a year-round family of eight. So, hourly, daily, and seasonal flows vary widely.
>
> As the number of households and individuals using a single treatment system increases, the variation in flow decreases. As the population served by a treatment system approaches 20 persons, the variation in daily flow drops significantly. Based on the 2000 Census statistic that the average number of persons per household is 2.59, that 20 persons translates roughly to eight households.
>
> Over estimating flows and loads has the following consequences:
>
> - Greater costs for the owner.
> - The soil component may not fit in the space available or may restrict the use of significant areas of land.
> - Longevity of some components may be increased, lengthening the times until/between their need for servicing, repair, or replacement.
> - The larger components may provide better treatment results.
> - Performance of some components may be degraded by inadequate flows—some components, such as aerobic pretreatment devices, require minimum levels of influent to maintain the bacterial colonies upon which the treatment process depends.
>
> Under estimating flows and loads has the following consequences:
>
> - Performance of some treatment components may be degraded.
> - Longevity of some components may be decreased, shortening the times until/between their need for servicing, repair, or replacement.
>
> Most prescriptive codes estimate flow based on one or more features of the structure. The concept assumes that larger structures mean more people and higher flows. This may or may not be accurate—housing sizes and occupancy statistics are heading in opposite directions. According to census data, between 1970 and 2000, the average household size decreased by 16% (from 3.1 to 2.6 persons), while the average home size increased by 46% [from 1500 sq. feet (139.35 sq. meters) to 2,200 sq. feet (204.4 sq. meters)].

The three most common factors used for estimating flows are: number of bedrooms, assumed occupancy per bedroom, and assumed per-capita water use. Typical values assigned to those estimators are:

- 3 bedrooms
- 2 people per bedroom—therefore a three-bedroom home would generate 6 people for flow-calculation purpose. (In actuality, the 2001 census reports that only 3% of all households have 6 or more members, providing an actual average occupancy of about 0.9 persons per bedroom.)
- 75 gallons per day (gpd) per person, i.e., 150 gpd per bedroom. Some states estimate 100 gpd per bedroom.

The estimated 75 gpd per person for water use is at about the 70th percentile of actual use. Table 3-4 in the EPA Onsite Wastewater Treatment Systems Manual indicates that the 75 gpd estimate is low for about 30% of the population. The average per capita use indicated by the graph is about 60 gpd. (Note: 60, 75, 100 and 150 gallons are 227, 284, 379 and 568 liters respectively.)

The common code-design practice tends to over-estimate household occupancy by a factor of 2 but undersize the drainfield for the corresponding loads and flows estimates. The result is frequent early failure for 3-bedroom homes occupied by 6 persons.

The NOWRA soil component treatment calculations will determine the size of a dispersal area accurately by basing them on estimates of influent loads and flows—but only if those influent estimates themselves are accurate.

These factors should allow the sizing of systems to be undertaken with more flexibility than is possible under traditional prescriptive codes.

Recommendations:

- Allow multiple methods for determining estimated flows.
- If prescriptive sizing is used, give notice to the owner explaining the actual gallons per day that the system can handle, the range of likely per capita use, and the option to use alternate flow-estimation processes.
- For designer-determined loads and flows, record the information as required in paragraph 3.7.1.4.

3.8 OPERATIONAL RESPONSIBILITIES

3.8.1 System Owner and System Operator

The owner of the system is ultimately responsible for the proper installation, operation, and maintenance of the system, unless otherwise provided in the code. A designated system operator shall comply as a minimum with the operational and maintenance requirements contained in applicable component manuals and the code.

The purpose of the above paragraph is to clearly identify the person responsible for the system and to provide for alternate methods of providing management. The concept of a responsible management entity (RME) provides for third-party management.

3.8.2 Licensed and Certified Person

Licensed or certified personnel involved in the regulation, design, installation, and monitoring of decentralized wastewater-treatment systems shall perform their functions in conformance with the code and the standards of practice of their occupation.

> Pertinent professional personnel are linked to the continuation of a system's license or certification. They can be held liable in a tort action for design errors even if the design is code compliant. A professional designer may be responsible for safety requirements incorporated in published standards even if the code has not adopted the standards. Furthermore, it is the professional's responsibility to design a system that is fit-for-use under the owner's pattern of water use. As far as the owner and designer are concerned, the code is a minimum specification, and they must exceed the code requirements if necessary to meet individual needs and expectations.
>
> Disciplinary action against a licensed or certified person for violations of the code or standards of practice should be the responsibility of the certifying or licensing organization in addition to the regulatory agency.

3.9 TIME LIMITS FOR REPAIR

A system deemed to have a Type I or II compliance violation not an imminent threat to health and safety shall be repaired or replaced within the following time limits:

- Type I compliance violation—Plan of action within 30 days; remedial work completed within 90 days.
- Type II compliance violation—Plan of action within 30 days; remedial work completed within 120 days.

If weather conditions prevent timely repair, the time periods for correction of Type I and II violations may be extended by the regulatory agency.

> The purpose of setting repair time limits is to protect the human and natural environments from the effects of malfunctioning systems. If the malfunction poses an imminent threat, it must receive attention, such as pumping, immediately.

3.10 POINT OF STANDARDS APPLICATION

The performance standards applicable to the system's final effluent quality must be equaled or exceeded as the wastewater exits the treatment train. The unconfined treatment component terminates at the edge of the assessed volume of soil.

> Some states have adopted specific locations where adopted performance standards must be achieved, such as a drinking-water well or property line. This code applies the performance standard at the end of the design treatment zone because treatment beyond the assessed area is unknown. This code does not limit the extent of the treatment zone, an area that could include on-lot and off-lot surface and ground water where treatment, such as dilution and nitrate reduction, are likely to occur.

3.11 DEEMED-TO-COMPLY DETERMINATION

Treatment components that have been evaluated and classified by approved field or test center evaluation protocols to specific performance requirements are deemed to comply with those requirements without sample monitoring of the effluent provided that:

1. The influent characteristics comply with those listed in the component's specification manual.
2. There is no Type I or Type II compliance violation.
3. The system is in compliance with the adopted operation and maintenance requirements.

The purpose of this section is to allow the use of treatment systems without effluent-sample monitoring for the vast majority of installations that are located in low-risk environments.

Effluent monitoring in performance-based codes is the alternative regulatory approach to "deemed to comply." Ideally, effluent monitoring is the most appropriate and direct measure of compliance with a performance standard. If employed, many of the common, costly prescriptive and QA/QC requirements can be eliminated. The problem with effluent monitoring is that it is technically difficult for the soil component and very expensive for all treatment components if conducted to accepted statistical confidence levels, performed by persons without a conflict of interest, and performed in compliance with standard sampling methods. For the most part, those sample-monitoring costs are not justified for the risk posed by small individual onsite treatment systems.

Effluent sample monitoring of installed systems is deployed by regulatory agencies for two reasons: to enforce standards against individual system owners and to evaluate the performance of a manufactured component or a standard design. A common practice in some states is to combine both programs by using the information from the enforcement program to evaluate the component or design. The programs need to be separated because the protocols for the two purposes are different.

- Enforcement of mean-based standards against individual homeowners requires many samples of the individual system to estimate its mean to a reasonable degree of confidence to support an enforcement action. Because the number of samples needed increases as variability increases, it may take more than 100 samples of an individual system to adequately estimate the mean. The cost of this level of sampling is too high for the risk at most sites and is not justifiable.
- The effective evaluation of a component/design in field conditions may need about 35 homes in the study with about 4 samples from each system. Collecting data from hundreds of sites does not significantly improve reliability of the test protocol and is very expensive to homeowners. See the following paper for information on field evaluation of treatment components:
  Groves, T.W, F. Bowers, E. Corriveau, J. Higgins, J. Heltshe, M. Hoover. 2005. *Variability and Reliability of Test Center and Field Data: Definition of Proven Technology from a Regulatory Viewpoint.* Project No. WU-HT-03-35. Prepared for the National Decentralized Water Resources Capacity Development Project, Washington University, St. Louis, MO, by the New England Interstate Water Pollution Control Commission, Lowell, MA.
- Influent values are needed to evaluate the component/design and are not needed for enforcement purposes. Including data from an undersized system (system designed for 600 gpd receiving 1,000 gpd) in the evaluation of the component is inappropriate.
- Current state field-enforcement and product-evaluation programs frequently do not employ third-party evaluation or use standard methods for sampling and testing. Field sampling for the purpose of design evaluation should be designed to the same quality standards as test-center evaluation.

- Some states require field evaluation of manufactured products within their jurisdiction even though the product/design may have been evaluated in similar conditions in other states. That process is inefficient in the extreme because of the high cost of the evaluations and the barriers it creates to the deployment of new technologies and methods.

Recommendations:

- Code enforcement for installed systems. For onsite systems and small cluster systems, rely on site evaluation and evaluated designs supported by mandatory operational maintenance to promote compliance. Discontinue effluent sampling except in high risk situations. If sampling is conducted, collect sufficient samples to establish the degree of statistical significance needed to support enforcement.
- Field evaluation of standard designs and equipment. Create a national installed-system evaluation program using strict evaluation protocols that collect sufficient data concerning conditions that affect treatment. That might entail 35 systems tested 3–4 times a year each, selected by the evaluation agency, and scattered in the various regions of the country. Until such a program is created, accept evaluation data from other states and provinces, and, if the data are sufficient, do not require in-state field evaluation.

3.12 CODE VIOLATIONS

Installation or operation of a system in violation of the code is unlawful. Notice of a code violation from the regulating authority to the responsible party shall be in writing and shall identify the nature of the violation, the code provision violated, amount of time permitted for correction, and potential penalty if not corrected.

Prosecution of unsatisfied corrective orders is provided by [*name of government unit*].

3.12.1 Penalties

Penalties for violations of the code are identified in the following schedule:

- [*penalty schedule or reference thereto*]

3.12.2 Imminent Threat Abatement—Enforcement

Enforcement action to abate imminent threat to human health and safety or to the natural environment from Type I and Type II compliance violations consists of one or both of the following.

- Issuance of a compliance order to repair the system in a specific period of time or to discontinue use of the system until repaired.
- Issuance of a citation. Authority to issue citations is provided by [*name of the government unit*].

Issuing citations is an enforcement tool that is less difficult to deploy administratively than other enforcement techniques. In most states, the provision usually requires specific authority by ordinance or statute.

> Citations increases citizen attention to the law and ease the administrative burden associated with prosecution. Most people comply with the requirements of the citation and pay the fine(s) without appearing in court. However, it does not force the owner to repair the system, only to pay the fine and be subject to further citations. Depending on the size of the fine, the persistence of the regulator, and the cost of the repair, the owner may choose to ignore the fine and/or not repair the system, forcing the matter into court. Once in court, the burden of proof rests with the regulatory agency to defend the code provision and the agency's administrative practices and to prove the violation.

3.13 APPEALS TO REGULATORY DECISIONS AND ORDERS

A person affected by an order or decision of the regulating authority may file a Level I or Level II appeal. The appeal shall be sent to [*name and address*] .

3.13.1 Level I Appeal

A person receiving an order or decision from the department may appeal the order or decision by filing a written appeal within 30 calendar days of receipt. The appeal shall be signed by the appellant and contain a clear statement of the issue(s), reasons for the appeal, a proposed alternate decision, rationale for the proposed alternate decision, and the applicable fee (see schedule available from [*name and address where fee schedule is available*]). At the request of the appellant, the department may conduct a meeting with the appellant and representative(s).

The department shall consider the appeal and issue a determination within 15 working days of its receipt. The 15-day period may be extended by mutual consent. If the agency does not answer in writing within the 15-day period or any extension thereof, the fee shall be returned to the appellant and the complaint deemed to be denied. The appellant, after denial or receipt of an answer deemed to be unsatisfactory, may, within 30 days, file a Level II appeal.

In the event the appellant desires to skip the Level I Appeal stage, he/she may file a Level II appeal in the first instance.

3.13.2 Level II Appeal

A person receiving an order or decision of the department may appeal the order or decision by filing an appeal within 30 days of receipt of the order or decision. The appeal shall be signed by the appellant and contain a clear statement of the issue(s), reasons for the appeal, a proposed alternate decision, rationale for the proposed alternate decision, and the applicable fee (see source of fee schedule in paragraph 3.13.1). The department shall schedule a contested-case hearing within 30 calendar days and issue a determination within 30 working days after the hearing. Failure of the department to respond to the appellant within 15 calendar days to schedule a hearing or failure to answer the complaint with a decision within the 30 days shall be deemed a denial of the appeal and the appellant may appeal the decision to court. Failure to schedule a hearing or to render a decision within the time limits shall cause a return of the fee to the appellant.

Level I Appeal. The purpose of the Level I Appeal is to provide the regulatory authority with the opportunity to re-examine the issue and allow the appellant an opportunity to express his/her views in an informal, relatively inexpensive process. It also provides the agency's top management with an audit of the quality of the code language and the staff's interpretation thereof.

Level II Appeal. The more formal Level II Appeal requires a formal hearing before an independent hearing officer with sworn testimony, formal exhibits, and a precedent-setting decision (or, if not precedent-setting, a decision that could sway the case before a circuit-court judge at the next appeal level.)

The appeal process should have short timelines because of the continuing injury to the appellant if the appeal has merit. Return of the fee for tardy work is an incentive for efficient delivery of services.

3.14 VARIANCES

Any person affected by the code may apply for a variance to a code provision for a specific application. The regulatory agency that adopted the provision shall consider the variance request. If both the local and state agency adopted the provision, the state has primary jurisdiction and shall consider the position of the local government in the determination.

The variance request shall be in writing. It shall identify the code provision(s) for which the variance is requested, state the requested variance, identify the proposed application, and state the rationale for the request. The variance request shall be sent to [*name and address*] with the required fee (see source of fee schedule in paragraph 3.13.1).

The standard for approval is that the variance substantially achieves the purpose of the provision(s) and provides a degree of protection equal to or greater than that afforded by the provision(s).

The regulatory authority shall render a decision on the variance request within 30 working days of receipt of the application, unless the applicant agrees to an extension. Failure to answer the variance request within the 30 working days or within the period of extension shall be considered a decision to deny and the fee shall be returned to the applicant.

The agency granting all or part of the variance request shall include in its decision a declaration as to whether the decision is nonprecedent-setting or precedent-setting. Precedent-setting variances shall be published [*frequency*].

The following circumstances highlight the need for variance provisions and increase the frequency of requests to apply them:

- Inflexible prescriptive codes that do not provide sufficient design or other options for the range of likely circumstances.
- Performance codes that set performance standards that are stricter than warranted by site risk.

The need for variance provisions diminishes under performance codes. If performance standards are determined commensurate with site risk, the need for variances largely disappears. The deleterious affects of statewide performance standards that are over-specified relative to site risk are ameliorated by variance provisions.

> The process for issuing a variance must be formalized to provide equal treatment and to create a record of the action. A busy variance docket is a signal to code writers that the code needs to be adjusted. Vague provisions and provisions with standards that do not accurately reflect level of risk invite variance applications.
>
> Timely response is a measure of and agency's performance..
>
> *Recommendation:* Include a variance provision in the code.

3.15 WRITTEN RECORDS

Administrative codes, policy statements, code interpretations, compliance directives, and agency determinations shall be in written form or, if maintained in electronic form, shall be capable of being converted to written form upon request.

CHAPTER 4

APPROPRIATE SOURCES

4.1 STANDARDS, PROTOCOLS, AND LISTS

The following protocols, standards, and lists are recognized as appropriate sources for supporting a claim of compliance with performance standards or requirements:

4.1.1 NOWRA Classification Matrices (Appendix A)

4.1.2 NOWRA List of manuals for evaluated components that meet the various performance-classification levels within the NOWRA Classification Matrices

4.1.3 NOWRA soil-treatment credit tables and calculations. (Appendix C)

4.1.4 NOWRA protocol for component evaluation (Appendix D)

4.1.5 NSF Standard 40 and listed components

4.1.6 ETV-NSF protocol and reports

4.1.7 The publication of Bureau de normalization du Québec (BNQ) entitled: *Wastewater Treatment — Stand-Alone Wastewater Treatment Systems for Isolated Dwellings — Certification Protocol*

4.1.8 NOWRA tank standard (Appendix E)

4.1.9 20th Edition of *Standard Methods for the Examination of Water and Wastewater*, a joint publication of the American Public Health Association (APHA), the American Water Works Association (AWWA), and the Water Environment Federation (WEF).

> The third-party standards, protocols, and lists are incorporated into this volume by reference for the sake of efficiency and because some or all are protected by copyright or trademark.
>
> It is advantageous for both safety and efficiency reasons to be able to recognize evaluated designs without having to wait for a code change to be adopted. Code revisions can take years to accomplish; timelines as long as 5–12 years are not uncommon, especially when dealing with prescriptive codes. It is unreasonable to require citizens to wait years for access to evaluated, suitable technology and methods that could immediately solve existing problems such as a failed treatment system or an unbuildable lot.

CHAPTER 5

EFFLUENT AND SITE REQUIREMENTS

5.1 EFFLUENT REQUIREMENTS

5.1.1 Characteristics of Final System Effluent

The final effluent of a decentralized wastewater-treatment system as it leaves the final treatment component shall achieve the treatment levels prescribed in paragraph 5.1.2. by constituent. The following methods may be used to determine whether compliance with the final-effluent minimum requirements has been achieved:

- ***Deemed to Comply.*** The whole system is deemed to comply with the final-effluent requirements if it is operated and maintained in accordance with the permit-approval documents. The system may consist of components evaluated according to methods contained in Appendices C and D (see paragraphs 4.1.3 and 4.1.4) or it may be designated as having a site-specific engineered design. A treatment component individually classified as "deemed to comply" is assumed to comply with the requirements without effluent sampling during system operation.
- ***Experimental.*** The treatment train or one or more of its components is (are) defined as experimental and appropriate safeguards are in place at the time the permit is issued to ensure that the requirements are met.
- ***Effluent Monitoring.*** The final effluent is evaluated under an approved sampling protocol.

5.1.2 Final Effluent Minimum Requirements

The system effluent shall meet the following requirements as it leaves the final treatment component:

- **Land surface discharge**
  - Fecal coliform: [requirement *]
  - [other constituent] [requirement]
  - Etc.

- **Land subsurface discharge**
  - Fecal coliform: [requirement *]
  - [other constituent] [requirement]
  - Etc.
- **Surface water discharge**
  - Fecal coliform: [requirement *]
  - [other constituent] [requirement]
  - Etc.

* Example: <200 colony-forming units per 1000mL, 95% of the time.

SECTION 5.1.3 IS FOR OPTIONAL USE BY LOCAL REGULATORY AGENCIES ONLY

5.1.3 Final Effluent Minimum Requirements — Local Agency

At the locations severally identified in paragraphs [*numbers* (e.g., 5.1.3.1, 5.1.3.2 . . . 5.1.3.n)], the requirements for system final effluent and operational management shall be as set forth in the respective paragraph, notwithstanding the requirements set forth in section 5.1.2.

5.1.3.1 Property at: [*location, reference to appended map, etc.*]

- Special Circumstances: [*circumstances prompting need for special requirements*]
- System Final-Effluent Requirements: [*requirements* (see para. 5.13 for sample presentation of requirements.)]
- System Operational-Management Requirements: [*requirements*]

5.1.3.2 Property at: Etc. …….

5.1.3.n Etc. …....

> The *Classification Matrices* in Appendix A are designed to provide policy options for effluent performance standards.
>
> Statewide minimum requirements are intended to manage the risk conditions that prevail statewide. Higher levels of risk should be handled by focused application of more stringent requirements at the local government level.
>
> *Recommendations*:
>
> The state code should adopt minimum final-effluent requirements for fecal coliform. The state code generally should not adopt final-effluent requirements for nutrients unless required by statute. The reason for this is that risk associated with nutrients from household wastewater vary significantly by site and the presence of other sources. Decisions to reduce onsite nutrients should be made as part of an evaluation of all pollution sources and the efficiency and effectiveness of managing each. For example, these decision processes should be deployed to implement the determination of a TMDL for a body of water. Private and public resources may be more efficiently and economically deployed in reducing nutrients from other sources.
>
> See Volume II, *Code Design Philosophy and Guidance*, for more information on the selection of performance standards.
>
> In areas where site risk levels raise concern, local governments should consider adopting more stringent requirements than those contained in the state code. Local governments should try to focus application of additional and enhanced requirements at the site, neighborhood, or watershed levels. In all circumstances, requirements should be set at levels that the enforcing government agency is able and willing to enforce.

5.1.4 Requirements for Reused Water

The following requirements pertain to treated non-industrial, domestic wastewater, including gray-water, that is reused above the soil. The requirements shall be met both at the discharge point and a point prior to a transmission line.

5.1.4.1 ***Potable Water.*** Refer to the USEPA potable water standards

5.1.4.2 ***High-Contact-Risk Water.***

- Fecal coliform shall have a median level of <1 colony-forming units/100 mL. (<2.2 mpn/100 mL), with a single sample not exceeding 14 colony-forming units/100 L.
- Turbidity shall be < 2 NTU (continuous monitoring)
- No odor shall be detected

5.1.4.3 ***Low-Contact-Risk Water.***

- Fecal coliform shall have a median level of <200 colony-forming units/100 mL (<200 mpn/100 mL.), with a single sample not exceeding 800 colony-forming units/100 mL. (<800 mpn/100 mL).
- Turbidity shall be < 5 ntu (continuous monitoring).
- No odor shall be detected.

> The most prominent documented cause of disease transmission by water-delivery systems (including wells) is infrastructure failure. Because we do not have equipment, tests, and processes capable of determining instantaneously whether pathogens are present in our water, we use surrogates to indicate the extent to which human waste is present. However, even these tests (Coliform and E-coli) are not instantaneous; they take days to run. Accordingly, several other tests are used to provide assurance that the risk-reductions requirements are likely to have been met. Those include testing for turbidity, pH, BOD/CBOD, suspended solids, odor, and disinfectant concentrations (e.g., chlorine residual or UV intensity). Some of those tests are instantaneous and are used as measures of process quality control.
>
> The U.S. Environmental Protection Agency has set Potable Water standards that cover a host of parameters. Anyone intending to treat wastewater to produce potable effluent must conform to those standards.
>
> The standard for high contact risk is to be used for water-reuse applications at residential or office buildings where the public is likely to come in direct contact with the water—above-ground irrigation, car washing, laundry work, and landscape impoundments, for examples.
>
> The turbidity standard is to facilitate disinfection; the odor standard is for aesthetics. Adhering to those standards along with the following requirements can help to assure that the infrastructure is performing satisfactorily: BOD <15 mg/L, pH of 6 to 9, and chlorine residual of >1 mg/L after 30 minutes. Use of other disinfectant processes such as Ultra Violet disinfection is permissible. Although technology may be able to meet the standard without a disinfectant, reliability and quality assurance normally dictate its use.
>
> The standard for low contact risk is intended to be used with reuse applications where the public is unlikely to come in direct contact with the reuse water—toilet and/or urinal flushing and subsurface irrigation, for examples. Use of aesthetics control in these circumstances will depend on the application and user but is not required.

Absence of odor is one indicator that a system is functioning properly, and, together with the following, can help to assure that the infrastructure is performing: BOD and SS <30 mg/l; pH of 6 to 9; and a Chlorine residual after 30 minutes of > 1 mg/l or other disinfectant equivalent such as that for Ultra Violet disinfection which monitors the intensity (253.7 nanometers/sq cm) which is the wavelength that is the most effective for killing bacteria. Again, although technology may be able to meet the standard without a disinfectant, reliability and quality assurance may dictate its use, or backup availability.

The following are additional infrastructure vulnerabilities:

- ***Cross connections.*** A common cause of pollution in water supplies is cross connections. Often, they occur because of plumbing errors or lack of signage on tanks and connections. All reuse-water connections should be marked with a permanent sign, and pipes and faucets should be color-coded. Pipes carrying reuse water can be identified by an electronic signature to distinguish them from soil and water-supply lines. Where possible, air-gaps should be provided to prevent cross connections. Inspection by a third party will help to reduce pollution-causing errors.
- ***Parts and supplies on hand.*** The on-site stocking level of parts and supplies should be commensurate with the contact-risk level and the importance of maintaining the supply of reuse water. Where those factors are high, parts and supplies should be available within one day.

Sizing/duplication of the system. Communal systems should have the capacity for at least one day's storage to continue product supply when the system is shut down for repairs. Also there should be a mechanism (with air gap) for inserting potable make-up water during those periods of shut down. Duplication is a function of critical-unit availability and the demand for the product. The greater the product need, the greater is the need for duplication.

Additional treatment requirements. Proposed reused of treated water may dictate adding facilities necessary for the treatment of such things as heavy metals, sodium, salinity, calcium, magnesium, oil, grease, etc. Car washes, laundry, irrigation, and industrial use are examples of where additional-treatment needs should be evaluated.

Monitoring. Monitoring of parameters that can be measured with automated equipment, and consequently capable of being alarmed, is most effective when used on a continuous basis. A disinfectant system should be tested anywhere from daily to weekly depending on the magnitude of the contact risk, meaning not only the immediate potential for contact but also the potential for contact's spreading beyond the immediate user area.

5.2 SITE REQUIREMENTS

5.2.1 Horizontal Setback Requirements

The horizontal setback requirements between system components and other features shall be determined by the system designer by use of one of the two options presented respectively in paragraphs 5.2.1.1 and 5.2.1.2:

5.2.1.1 Compliance with the prescriptive requirements provided in Table 5-1.

5.2.1.2 Compliance with the following performance requirements:

- Released effluent may not pond around the structure's footings or reenter the structure

- Released effluent may not cause a violation of the applied water quality standards at a drinking-water well.
- Released effluent may not pond in the trench of a utility service or suction-pump discharge line.

TABLE 5-1
Required horizontal separation distance in feet (meters) between a system component and a site feature*

Feature	Dispersal component	Exterior septic tank or holding tank	Servicing, suction lines and pump discharge lines
Structure	[number]	[number]	[number]
Property line	[number]	[number]	[number]
Ordinary high water mark of navigable waters	[number]	[number]	[number]
Swimming pool	[number]	[number]	[number]
Water service	[number]	[number]	[number]
Well	[number]	[number]	[number]

*Distances assume that site soil evaluation was properly conducted.

Horizontal setback is intended as a design safety factor, on the assumption that all components will fail to perform as expected.

Setback requirements were originally established in a time of hand-dug wells and privies. Regulated distances have tended to expand under recent codes despite advances in design as cautious regulators tended to set uniform separation distances based on largely unknown or unmeasured risks.

Traditional prescriptive application of setback distances has not been reflective of actual site conditions or risk. For example, the statewide setback requirement for a well often is identical in widely disparate circumstances, such as:

- Karst or clay conditions
- Managed or unmanaged sites
- Well up- or down-slope of the system
- Ten- or a thousand feet to groundwater
- Advanced pretreatment used or not used
- Site and soil professionally evaluated or not

Consequently, setback distances are too great in many instances and too short in others relative to the risk.

> Excessive safety factors are not a problem if the cost of implementation is low, but the cost of severe set-back requirements is high in terms of monetary and opportunity costs. Excessive requirements cause sprawl because of the large lots needed to accommodate the requirements. Replacement systems may not be possible under current setback requirements. Neighboring lots may become unbuildable because of the location of surrounding wells and systems. A doubling of a setback distance from a well increases the sequestered area by a factor of 4.
>
> *Recommendations:* This code should allow setback distances to be based on performance requirements and not on traditional uniform prescriptive requirements. Table 6-1 should be filled in at the local level, where the following questions should be answered:
>
> - What problem is being solved by this provision of the code?
> - How do we know that it is a problem?
> - Do we know that our proposed solution will solve the problem?
>
> With respect to the applied separation between a well and drainfield, it is recommended that the determination be made according to site and system risk conditions in terms of the following factors:
>
> - The overall risk reduction desired for a point of drinking water use.
> - The direction, depth of flow and the location of the drinking water source.
> - The velocity of the vertical and horizontal flow.
> - The time needed for sufficient reduction of pathogens under saturated and unsaturated flows.
> - The amount of dilution expected.
>
> If use of a prescriptive table has been dictated, it is recommended that the foregoing performance factors be utilized for justification of an alternative method for determining setback requirements.

5.2.2 Service Accessibility and Safety Requirements

5.2.2.1 ***Access Ports—New Systems.*** Service access ports to components shall be located to be accessible to service personnel as follows:

- The location of the access port, if not visible at the surface, shall be marked in a manner that the service personnel can determine its location. Methods may include a physical marker, a marker on the site plan, or other acceptable indicators.
- Service ports that, according to the management plan, are to be accessed more frequently than once every [*period*] shall be accessible to the surface without digging. Access ports may be covered by ornamental or other coverings provided the cover can be easily removed.
- Service ports that are buried shall be located within 6 inches (15.2 cm) of the surface and shall be accessible by use of hand tools.

5.2.2.2 ***Access Ports—Existing Systems.*** Access ports of existing systems shall be made to conform to the requirements presented in paragraph 5.2.2.1 at the first scheduled service or repair event following adoption of the code.

5.2.3 System Access by Service Equipment

In new construction, access ports for system component shall be accessible to service vehicles as follows:

- The horizontal distance between a component's pumping-access port and the closest parking point for a truck weighing 60,000 pounds (27,216 Kg) shall not exceed 200 feet (61 meters). For a holding tank, the parking point shall be suitable for truck access in all weather conditions during periods of occupancy.
- The vertical elevation difference between the parking point and the bottom of the tank to be pumped shall not exceed 20 feet (6.1 meters) for truck-mounted vacuum pumps.
- For individual systems, the vertical and horizontal requirements may be waived if other suitable transfer methods for enabling servicing of the components are demonstrated to the regulatory authority.

> Pump trucks weighing up to 60,000 pounds (27,216 Kg) need to get close enough to the components to perform their task. Two frequent barriers are the lack of all-weather access or physical barriers like landscape planting or fencing. For scheduled pumping of septic tanks, seasonal access conditions can be accommodated by scheduling the service during dry weather. Holding tanks need frequent pumping, so all-weather access is needed for year-round use.
>
> Access barriers like fencing can be removed at cost to the homeowner.
>
> Regulatory restrictions to landscaping for truck access is very intrusive on the homeowner and should be avoided if possible. The extra time and expense of getting to the components is a private matter between the pumper and owner. For cluster systems and other Management Model V conditions, access can be achieved by an easement created during the platting stage of development.
>
> *Recommendation:* For holding tanks, all weather access should be provided. For other components, dry-weather access only may be required. Access conditions should be incorporated into the management plan approved for the system.

5.3 PROHIBITED SUBSTANCES

No person may introduce any substance into a decentralized wastewater-treatment system that would cause the system's effluent-safety requirements imposed by this code to be violated or cause a violation of law if discharged to the ground surface or to surface waters.

> The list of banned substances is too large to be included in the code. Instead the regulatory agencies should publish a notice of common substances that should not be put into a decentralized wastewater-treatment system or should be limited in volume. See the "Don't flush" list in Appendix F.

5.4 ADJUSTMENT FOR POTENTIAL LEAKS

System components such as, but not limited to, septic tanks and connections, that are not watertight shall be sized to accommodate unintended infiltration of stormwater, ground water, water from high water tables, and other sources.

> The term "unintended" is used because some systems are sized by design to accommodate and treat stormwater and because some components are not intended to be watertight—drainfields, for example.

5.5 COMPONENT STRUCTURAL INTEGRITY

Components of a wastewater-treatment system shall be capable of bearing the live and dead loads applied when installed and operating. The standard applied should be determined base on site risk conditions. Optional standards that might be considered for adoption, depending on site risk, include:

- . . . shall be acceptable under expected soil load as determined by testing or suitable calculation.
- . . . shall be acceptable under expected soil and human traffic loads, including light lawn tractors, as determined by testing or suitable calculation.
- . . . shall be acceptable under expected soil load and the weight of a pickup truck as determined by testing or suitable calculation, unless physical barriers to such traffic protect the area.
- . . . shall be acceptable under expected soil load and weight of a pumper truck as determined by AASHTO H-10 standard for a 16,000 lb/axle load, unless the area is protected from such traffic

5.6 SAFETY OF ACCESS PORTS

Ports provided to give access to system components shall not create a safety hazard. All exposed access openings shall be guarded. Openings larger than 4 inches in diameter shall be secured by bolted or locking lids or by lids that are set to prevent sliding and weigh at least 59 lbs in accordance with ASTM C 1227 – "7.6.1." If the foregoing requirements will not prevent access, a physical barrier shall be erected to prevent access to the site of the opening. Covers, risers, and lids shall be capable of bearing the expected live and dead loads.

> See tank standards in Appendix E

5.7 SOIL-COMPONENT EVALUATIONS—LIMITATION OF USE

System designers may apply the soil-treatment and hydraulic-conductivity capabilities of the unconfined-soil component only to the extent that the characteristics of the site soil have been evaluated. Table 5-2 provides the amount of credit that may be claimed based on the extent of evaluation.

> The soil analysis determines the soil-treatment credits and the pretreatment requirements of the treatment train. Failure to do the analysis thwarts the appropriate use of the treatment tables.

TABLE 5-2
Soil Treatment Credit Available by Type of Soil Evaluation
(Uniform, Known Area Conditions)[1]

Soil and Site Evaluation Type		Hydraulic Conductivity	Nitrogen	Phosphorus	Bacteria	In situ Organic	Dilution	Comments
		X = Credit can be taken, subject to any applicable footnote						
Observation of site[2]		X	X	X	X	X	X	
NRCS Map–Scale[3]	1:400	X	X	X	X	X	X	
	1:20,000	X	X	X	X	X	X	
Percolation Test								Should be used only as a source of supplemental information if there are questions relative to water movement in area soils
Soil Evaluation								Not necessary if area soils evaluated
Ground Water Characterization								
Perched								Not necessary if area soils evaluated
Seasonal								Not necessary if area soils evaluated
Permanent								Not necessary if area soils evaluated
Vegetative								Not necessary if area soils evaluated
Soil Climate								
Temperature								Not necessary if area soils evaluated
Moisture								Not necessary if area soils evaluated

[1] Some dispersal component sites are in soils that have relatively homogenous characteristics across broad areas. If the characteristics of the area are known, the site evaluator can rely on that information. Reliance on maps and general observations should be avoided at the edge of the map classification area and at the margin of a design classification breakpoint—example if the maps indicated GW depth is at 38 inches and the code requires 35 inches, do not rely on the map. Maps should only be used in conjunction with a specific site observation.

[2] Must be used in conjunction with a suitable soil map.

[3] Must be used in conjunction with suitable site observation.

CHAPTER 6

QUALITY ASSURANCE AND QUALITY CONTROL

6.1 CONSTRUCTION AND REPAIR PERMITS

Performing construction or repair of a decentralized wastewater-treatment system may require that a permit be obtained before work begins. When such a permit is required by the state or local regulatory agency, the language in this section applies.

6.1.1 Construction Permit

Construction, installation, modification, or add-on work shall not be performed on a decentralized wastewater-treatment system unless the owner has first obtaining a permit for the work to be performed from [*name of agency*].

6.1.2 Repair Permit

No major repair of a decentralized wastewater-treatment system may be performed unless the owner has first obtaining a permit for the work to be performed from [*name of agency*]. Minor repair and normal servicing does not require a permit.

(ALTERNATE LANGUAGE: No person may repair a decentralized wastewater-treatment system by replacing components or parts unless the owner . . . . etc.)

> An application for a construction permit gives the regulatory agency notice that a regulated activity is about to commence, allowing the agency to ensure that related regulations are met.
>
> *Recommendation:* Construction permits should be required for initial construction, modifications, and replacement.
>
> An application for a repair permit gives the regulatory agency notice that a regulated repair is about to be performed. Inspection requirements sometimes can be reduced when repair personnel are identified as certified practitioners. Obtaining a permit is costly to the owner, and the requirement is often ignored, especially for minor repairs where the cost of the permit exceeds the cost of the repair.

> *Recommendation:* Permits should be required for major repairs. Waive permit requirement for minor repairs if personnel are certified or licensed.
>
> Construction and repair permits facilitate scheduling of inspections and provide easy vehicles for collecting fees.

6.1.3 Posting

The construction or repair permit shall be posted conspicuously in a place on the building or other location that is visible from the street. The permit shall remain posted until the construction or repair activity is completed and final inspection has occurred.

6.1.4 Expiration

The construction and repair permits shall expire [*number of years/months*] from the date of issuance or when the work is complete. If work is commenced within the specified period, the permit may be extended for an additional [*number of years/months*]. The code in effect at the time the permit was issued shall be applicable during the period that the permit remains active. The permit may be renewed at the discretion of the permitting authority at any time. If significant changes have occurred in the code since the permit was issued, the renewal permit may be made subject to any pertinent new requirements,

> The term of a permit should be generous—in the range of 2–4 years, depending on the nature of the project. If significant changes have occurred in the code since the permit was issued and the agency intends to apply the changes to existing permits, the revised code should specify the new requirement.

6.1.5 Transfer

Upon application by a new system owner, a construction or repair permit shall be transferred to the new owner.

6.1.6 Revocation

The permit may be revoked for the following reasons:

- An imminent threat to human health and safety or to the environment would occur if the work subject to the permit continues.
- The permit application contains false information that is material to the decision to grant the permit

6.2 OPERATING PERMIT

6.2.1 Issue

A decentralized wastewater-treatment system shall not be operated unless an operating permit has been issued by [*name of agency*] to the owner or jointly to the owner and operator when the operator is not the owner but a certified responsible management entity (RME).

6.2.2 Duration

The operating permit continues in effect until its expiration date or until it is revoked for cause. The permit expires [*number*] years after issuance or upon property transfer, whichever occurs first. (OPTION: The term of the permit is indefinite.)

> The operating permit is a legal instrument that makes it easier for the regulatory agency to enforce the maintenance requirements of the code. The primary effect is to put owners on notice that the government is interested in the operation of the system. The secondary effect is to increase the chance of a successful court action because the charge of "operating without a permit" can be added to the "failure to properly maintain" charge.
>
> The implied threat of the provision is that a system without an operating permit may not be operated and, therefore, the home must be abandoned—a politically unrealistic action in most cases.
>
> The operating permit creates obligations on the part of the regulatory agency as well as the homeowner. The regulatory agency needs to have the skills, personnel, support systems, and the political will to enforce the requirement.
>
> Statewide operating-permit programs are more difficult to adopt and enforce than local requirements focused on areas of perceived high risk. A major problem with statewide application of these provisions is the failure to enforce the provision by local governments where the risk of health and environmental effects is perceived to be minimal.
>
> *Recommendations:*
>
> - Do not establish statewide operating permits initially unless the state is assured that the enforcing agencies are able and willing to enforce the provision. Instead, first establish a focused operating-permit program in areas of perceived substantial risk of harm from failing systems, and where the regulatory capability exists to administer and enforce the provision. Linking the operating-permit program to high risk areas increases the political viability of the requirement. The question is: who should adopt the provision, the state or the local governments? The key is who is in the better position to identify focused areas of perceived risk and to secure enforcement.
> - Do not conduct regulatory inspection of individual systems if service-tracking programs are in place. Do conduct regulatory audits of service providers.
> - If operating permits are issued, they should be for a fixed period of time and linked to the risk of failure of the design.

6.2.3 Revocation

The operating permit may be revoked for the following reasons:

- Existence of a Type I or Type II compliance violation beyond the authorized repair period.
- Existence of a Type I or Type II compliance violation that is an imminent threat to human health and safety or to the natural environment.
- Persistent failure to perform required inspections and maintenance.
- Change in use or increase in the size of the structure that significantly increases the wastewater loads and flows.

6.3 PERMIT ADMINISTRATION

6.3.1 Application Submittal

- ***Person.*** The owner of the decentralized wastewater-treatment system, the owner's agent, the owner's assigned operator, or the person performing the work shall apply for the permit.
- ***Application Form.*** The permit application shall be filed on a form supplied by (or by other method acceptable to) the [*name of agency*].
- ***Attachments.*** The following documents shall be attached to the permit application:
    – [*List of documents (plot plan, soil report/certificate, system plan, etc.*)]
- ***Addressee.*** [*name and address of agency*]

> *Recommendation:* The state agency should establish a uniform permit for use in the local jurisdictions.

6.3.2 Retention of Documents

Records pertaining to construction and operating permits shall be retained in the following manner:

- ***By the owner or operator.*** Construction and repair permits and attached documents shall be retained at the worksite during the course of the work until the system is allowed to be operated. They shall be produced when requested by the inspector.

  The operating permit and related documents, for example [*names of documents*], shall be retained by the owner or operator while the permit is active and shall be made available to the inspector within a reasonable time of their being requested..
- ***By the regulatory agency.*** Construction and repair permits and attached documents shall be retained during the course of the work until the system is allowed to be placed in operation (OPTIONAL TIME PERIOD: . . . until the system is abandoned).

  The operating permit and related documents, for example [*names of documents*], shall be retained while the permit is in effect (OPTIONAL TIME PERIODS: . . . retained until the system is abandoned, . . . retained indefinitely).

> *Recommendations:* Construction and repair permits should be retained at the work site and by the regulatory agency during the work. A copy of the permit documents, especially the approved plan, should be retained by the regulatory authority until the system is properly abandoned. It is unrealistic to expect the owner to retain the records because of the turnover of owners.
>
> If there is an operating permit, the records should be retained by both the owner/operator and the regulatory agency during the period of operation of the system.

6.3.3 Application Processing Time

The regulatory agency shall process a permit request, perform a plan review (if required; see section 6.4) and issue an approval or denial of the completed permit application within [*number*] business days of receipt. The process time may be extended by agreement of the applicant. Failure to issue a determination within the required time shall cause the agency to rebate [*number*] percent of the application fee for each day the reply is late.

6.3.4 Written Response

The agency response to a permit and application shall be in writing. If the permit application or plan approval is denied, the agency shall state the specific reasons for the denial in the response.

> Performance standards can apply to the work or individuals and organizations in addition to the effluent of wastewater systems. An important performance element to citizens is timeliness of code administration. Long permit-review times delay home building projects, increase costs, and harm the citizen. The review-time performance standard should approximate the best practices in similar regulatory agencies or that provided by competitive service agencies for similar processes.
>
> *Recommendation:* Since most permit and plan reviews are bench reviews and require an hour or two of labor at most, a target permit-turnaround time should be in the range of 1 to 3 working days. Some review agencies return plans in one day with an appointment.
>
> Some agencies conduct a field audit along with the plan review; longer review times of a day or two can be expected.
>
> Agencies with insufficient staff to meet the required response time should consider authorizing third-party reviewers or waiving the review process for plans prepared by Master Designers. Third-party review options range from using peer review to directing overflow work to other public or private review organizations.

6.4 DESIGN PLAN REVIEW

A design plan shall be submitted with the permit application for construction of any new decentralized wastewater-treatment system or modification of an existing system. The plan shall contain the information specified in paragraphs 6.4.1 and 6.4.2.

[OPTIONAL ADDITIONAL LANGUAGE: Plans submitted by a Master Designer are not subject to mandatory review prior to issuance of a permit, but they may be audited for the purpose of confirming the designer's continued rating as Master Designer.]

6.4.1 Information Required for an "Onsite" System

The following information shall be provided with the design plan for an "onsite" system (as distinct from a "cluster" system):

- A scale drawing showing the property boundaries, the location of existing and proposed structures (including those associated with the subject system's components), current and proposed easements, driveways, below-ground water and utility lines, public and private wells, and surface waters. Off-site property that potentially affects the placement of system components because of setback requirements shall be shown, but not necessarily to scale. On large lots, those features that are more than twice the distance of the largest setback requirement from any system component may be omitted. If the system's components are on a legal parcel other than that of the structure served, the site plan must include all parcels with interconnected system components.

- Soil- and site-evaluation reports, (OPTIONAL . . ., for example, NOWRA's Certificate of Performance Standard Compliance for the unconfined-soil component and non-soil component evaluation(s) issued by NOWRA within the preceding 100 calendar days.)
- Operation and maintenance manuals for the system components, including the unconfined-soil treatment/dispersal component. If the design is based on a design manual that has been approved by NOWRA, the manual's name and approval number may be provided in lieu of the manual.

> The utility of a design plan's being reviewed by a regulatory agency is determined by the value added to the process. The value of regulatory review is conditioned on the following:
>
> 1. Is the quality of the regulatory review sufficient to ensure that the plan is code compliant? Can the contractor and the code-compliance inspector rely on the approved plan?
> 2. Does the review agency assume responsibility for the quality of the review? Responsibility means compensation to harmed parties for errors or omissions. Harm to individuals may include reconstruction costs and time delays in construction or occupancy of the structure.
> 3. Is the agency review timely? Optimal review times are in the range of 1–3 work days. Acceptable time may be less than 10 work days. Unacceptable permit turn-times are likely longer than 10 days. The appropriate permit turn-time is determined by benchmark regulatory agencies with rapid turn-times and service organizations operating in a competitive service environment.
> 4. Does the desk review requirement divert agency resources that could better be deployed in field inspection, consultation, or training?
> 5. Does the field inspector feel pressure to approve a non code-compliant system to cover for agency errors in plan review?
>
> *Recommendation:* If any answer to items 1–3 is "no" or if the answer to item 4 or 5 is "yes," the agency should consider one of two options:
>
> - Reform the program to make the answers to items 1–3 "yes" and the answer to items 4 or 5 "no."
> - Drop the mandatory plan-review function and shift staff resources to site inspection, certification audits, consultation and training. Plans should still be submitted and available at the work site for inspector review.
>
> The primary benefit of a design-plan review is a quality control audit of the designer's work—to reduce or eliminate errors in construction. The quality control service can be provided by any competent person, public or private. The cost of plan-design errors to the homeowner, designer, and installer is a noncompliant system, reconstruction costs, and time delay.
>
> The ultimate determinants of code compliance are trained and certified private- and public-sector personnel and construction inspection by a trained and certified inspector.

6.4.2 Information Required for a "Cluster" System

If the decentralized wastewater-treatment system is a "cluster" system, a single cluster-system design plan may be submitted for review and permitting. The plan shall include the cluster system's maximum influent design loads and flows and a detailed specification and drawing of the standard connection between a structure's plumbing system and the last off-lot or first on-lot treatment component, whichever is applicable. Further plan reviews of the cluster system for individual structure connections are not required provided design flows are not exceeded. Hook-up of an individual structure shall be subject to any plumbing-permit process pertinent to that structure. The cluster system's construction permit shall be in effect until the development served by the approved cluster system is completed, unless revoked for cause.

An easement shall be recorded for the cluster system's components.

6.4.3 Information Required for an REM-Owned and -Operated System

If a decentralized wastewater-treatment system serving a single structure is owned and operated by a certified Responsible Management Entity (RME), the plan review and inspection provisions contained in paragraph 6.4.2 apply to the individual on-lot system.

> Traditional rules were developed to deal with the one-lot systems owned and operated by the individual building owners. Cluster systems owned and operated by certified RME organizations should be regulated more like utilities, with the regulatory attention shifted to the RME rather than system installation.
>
> Cluster or other systems serving 20 or more people are defined as Class V injection wells under federal and state Underground Injection Control programs and need to be registered with the appropriate authority.

6.4.4 Submittal of an "As-Built" Plan

A permit for system construction or modification is issued pursuant to approval of the design plan. If unexpected site conditions or other circumstances are encountered that require that the system be installed in a manner other than in conformance with the approved design plan, an "As-Built" plan shall be submitted to the approving agency.

6.5 SITE SUSTAINABILITY PLAN

The designer shall provide a site sustainability plan to the regulating agency and the owner. The plan shall describe the procedures for maintaining the decentralized wastewater-treatment system at the site in successful operating condition for the expected life of the structure(s) served. The presumed life of the structure(s) is 100 years unless stated otherwise. If the site is expected to be connected to a non-onsite wastewater conveyance- and treatment-system in the future, the sustainability plan may be limited to that period. The plan shall assume that all components will fail and require repair or replacement during the life of the system unless the designer can demonstrate indefinite operating life for the components. For the unconfined-soil treatment/distribution component, the plan may prescribe, but is not limited to:

- Use of rejuvenation techniques.
- Relocating the component to areas reserved for the purpose.
- Using alternating drainfields or pretreatment to eliminate the formation of a clogging layer.

> Most structures will last in excess of 100 years if properly maintained. Many will rely on decentralized wastewater-treatment systems for their lifetimes. The designer should provide a contingency plan to maintain a system on the site either with repaired, rejuvenated, or replaced components.

6.6 INSPECTION

6.6.1 Construction Inspection

Except as provided in paragraph 6.6.1.1, systems and system components that have been newly installed [OPTION . . . , modified, or subjected to major repairs] shall not be covered or placed into service until inspected and approved by the [*regulatory agency's name*] construction inspector. The contractor performing the work shall contact [*regulatory agency's name*] to schedule an inspection. If the inspector is unable to inspect the facility within [*number*] days, or verbally waives the inspection, the contractor may cover the components.

> If the risk of faulty installation has been reduced by training, certification, and demonstrated installer performance, the regulatory agency should recognize the training and reduce or eliminate the "call for inspection" requirement.
>
> Late inspections can substantially slow construction and tie-up contractor work crews at large cost. The agency should be able to provide inspection no later than the day following an inspection request in at least 80% of the cases. If budget or political constraints prevent hiring sufficient inspection staff, the state should consider licensing private inspection staff to do some or all of the work. Many private inspection contractors work in both building inspection and real-estate inspection; they should be capable of adding decentralized wastewater-system inspection to their line of services.

6.6.1.1 ***Inspection Waiver.*** An installer who holds a Master Installer certificate shall notify [*regulatory agency's name*] that the work is complete. The system/component(s) then may be covered and placed into service without inspection unless the agency or the inspector specifically requests otherwise. The Master Installer shall inspect the system/components(s) prior to covering and certify that the system was installed per code and permit requirements.

6.6.2 Grading Inspection

The inspector may require an inspection of final grading and landscaping to ensure that the system is not subject to storm-water erosion or ponding over the components.

6.7 MAINTENANCE

6.7.1 Operational Maintenance

The owner shall have the system and its components serviced during its operational lifetime in accordance with the requirements of the code, the operating permit, and the components' service manuals.

6.7.2 Maintenance Oversight

[*Regulatory agency's name*] shall verify that the system and its components are being maintained in compliance with the requirements of the code, the operating permit, and the components' service manuals. A combination of maintenance-record inspections and physical inspections may be employed in a manner appropriate to the operator's history.

> Regulatory agencies should have a method of monitoring compliance with system maintenance requirements. Some agencies maintain a database of required service events and either monitor for compliance themselves or contract with a service firm to do it. Where the owner's/operator's system maintained behavior exhibits a pattern of noncompliance with requirements, the agency should take measures to enforce the requirements.
>
> *Recommendations:*
>
> - If scheduled maintenance is being performed routinely, the agency should rely on the maintenance records to verify compliance and forego routine regulatory inspections. Spot inspections may be productive.
> - If scheduled maintenance is not being performed routinely, the agency should establish routine regulatory inspections
> - The agency should not rely on the maintainer to perform regulatory inspections because of conflict of interest issues. The maintainer should be required to notify the agency of significant service events.
>
> Effluent quality monitoring—Some agencies require that effluent samples be taken to measure the system's performance against adopted standards. Those standards are often stated as measures of central tendency—average or mean values. Because of the natural high variation of effluent quality, numerous samples are needed to establish the average or mean performance levels of decentralized wastewater-treatment systems—as high as 100–200 samples to establish the 95% confidence level that often is needed to sustain an enforcement action. Because adequate sample monitoring is very expensive, it is not reasonable, relative to risk, to require it for the vast majority of small treatment systems.
>
> *Recommendation:* Do not require effluent samples from small systems. Instead, rely on evaluated designs and operational maintenance enforcement.

6.7.3 Existing-System Assessment Protocol

Inspection of an existing system shall determine whether the system is operating in compliance or not in compliance with pertinent requirements. The authority having jurisdiction shall determine the level(s) of inspection required based on risk conditions.

- Level I. The system is operating with a Type I compliance violation.
- Level II. The system is operating with a Type III compliance condition

- Level III. The system is operating with a distribution component that conforms with the pertinent design specifications or, alternatively, the distribution component functions hydraulically and provides the intended level of treatment.
- Level IV. The system is operating with a Type II compliance violation.

Determination of compliance or level of noncompliance shall be achieved by either of the two following methods:

1. Deemed-to-Comply Method. The soil-component design features are in conformance—OR are not in conformance—with the prescriptive design requirements in effect at the time the component was constructed or last modified. If those design requirements have been superseded by those of a subsequent code with retroactive application, the new design requirements apply.
2. Treatment-Evaluation Method. Treatment performance evaluated by testing the effluent as it leaves the treatment train. Sampling protocol and evaluation shall conform to recognized protocols.

> The regulatory agency needs to determine the depth of the evaluation to be conducted. The inspector's questions might be:
>
> - Is the system currently failing or showing evidence of recent failure (surfacing)? (Type I violation)
> - Does the system have the required vertical and horizontal separation distances? (Possible Type II violation)
> - Has the use of the structure changed so that it is no longer compatible with the design?
>
> The following general language expands on the code language but is not intended to be more than a guide to the development of an inspection protocol.
>
> - A Level I inspection looks for surfacing of sewage where it is not intended. This can be observed by walking the site and inspecting for discharges in buildings.
> - A Level II inspection looks at the mechanical, hydraulic, structural, and control functions of the system components. The tanks are evaluated for needed pumping.
> - A Level III inspection determines the hydraulic capacity of the distribution component without discharge to the surface.
> - A Level IV inspection determines the status of the drainfield relative to prescriptive performance standards covering the system.
>
> Inspection of an existing system frequently occurs along with a home inspection during a property sale. The information collected is intended for the private use of the buyer, seller, bank, and the realtor. Regulatory agencies should not require that the inspection report be submitted to the agency for purposed of enforcement because it creates a conflict of interest for the inspector and would otherwise discourage voluntary inspection.
>
> The results of Level III and IV inspections need careful consideration.
>
> - A ponded drainfield absent surfacing is not a failed system. In fact, it is likely to be providing an optimal level of treatment because of added treatment in the trench and equal distribution.
> - States that employ prescriptive vertical-separation requirements should consider establishing a reduced separation requirement when evaluating mature systems.

- Level IV inspections may create a political backlash unless directed in a focused manner to a publicly perceived problem. Requiring that the drainfield be replaced when the system has a 30-inch separation instead of 36 inches may be politically and scientifically unsupportable, because the system is probably performing better than a new conventional system.

Note: An inspection checklist needs to be developed for each level of inspection.

The inspection levels above describe the options for a regulatory compliance inspection. Non-regulatory inspections frequently occur as part of a home inspection during a property sale. The information collected is intended for the private use of the buyer, seller, bank, and the realtor. Regulatory agencies should not require that these private inspection reports be submitted to the agency for purposes of enforcement because the requirement creates a conflict of interest for the private inspector and would otherwise discourage voluntary inspections, which frequently lead to system repair and improvement.

6.7.4 Reporting a Malfunctioning System

The owner or operator of a decentralized wastewater-treatment system shall report the occurrence of a Type I or Type II compliance violation to [*name of agency*] within [*number of days*].

A homeowner reporting a system as failing is likely to get it fixed without a regulatory order. If a repair permit is required, making the permit application will also fulfill the reporting requirement.

A person who fails to report a failing system, is guilty of "operating a system in violation of the code."

Recommendation: Do not adopt this requirement if the agency has a maintenance-monitoring or regulatory-inspection program in place. Otherwise, adopt it.

6.8 CERTIFICATION

6.8.1 Areas of Certification

An individual or organization employed at a decentralized wastewater-treatment system to perform the services and core tasks associated with the following occupations or functions must possess current certification from the indicated organizations:

Individuals

- Construction Inspector
  [*name of certification and issuing organization*]
- Designer
  [*name of certification and issuing organization*]
- Installer
  [*name of certification and issuing organization*]

- Maintainer/Operator (OPTION: excluding homeowner)
  [*name of certification and issuing organization*]
- Plan Reviewer
  [*name of certification and issuing organization*]
- Site Evaluator
  [*name of certification and issuing organization*]
- Soil Evaluator
  [*name of certification and issuing organization*]

Organizations

- Responsible Management Entity (RME)
  [*name of certification and issuing organization*]
- Regulatory Agency
  [*name of certification and issuing organization*]

Persons holding professional licenses that nominally permit them to perform the services and tasks associated with the occupations/functions listed above must comply with their license restrictions that permit them to work only if qualified in the specific area of practice.

> The state has three options in establishing a certification program:
>
> - Issue state certification without reference to third-party certification
> - Issue a state certification contingent on the applicant's possession of a third-party certification. The terms of the certifications would need to be the same.
> - Require third-party certification but no state certification—oversee the issue by requiring production of certificates at time of contact (at plan review and site inspection, for examples).
>
> The term "certification" as used here refers to programs that issue either certifications or licenses. Some states provide certification programs but do not *require* certification to enter the workforce. A requirement for certification prior to performing commercial work is functionally the equivalent of requiring possession of a license.
>
> The purpose of certification is to reduce the risk that service providers will make errors that degrade system performance. Certification provides a mechanism for screening applicants concerning their skills, knowledge, and history, and thereby protecting the industry from the introduction of unsatisfactory individuals.
>
> The certification function can be based on either prescriptive or performance requirements. There are issues with both approaches:
>
> - Prescriptive pre-application requirements such as prior experience and possession of other licenses or degrees (engineer, plumber, for examples) tend to screen out otherwise qualified personnel.
> - Evaluation based on knowledge, skills, and ability to perform a task is an excellent screening approach that does not tend to eliminate qualified persons. The process is expensive to develop and implement, but national certification programs may have sufficient economies of scale to to warrant its use.
> - Certification programs can be abused in the following ways:
>   - Setting high pass points or requirements. This tactic may be partially intended to reduce the labor supply and thereby drive up wages.
>   - Preventing performance of minor ancillary tasks of one classification from being performed by another, causing more staff to be assigned to a task.

In general, certification programs are useful tools for improving the level of service to the public. They also are useful as base programs for structuring continuing-education programs. Both certification and training programs are primary tools for advancing the service level of the industry.

Many regulatory agencies are unable or unwilling to fund the development of performance-based evaluation procedures. Low-cost, marginal-value certification programs deployed by many regulatory agencies make robust certification programs uncompetitive. They reduce the job mobility of skilled personnel because of the cost and hassle involved in crossing political boundaries to a new job.

Recommendations:

- State codes should require certification of service providers for the key classifications listed in paragraph 6.8.1.
- State codes should recognize national certifications.
- State codes should recognize persons holding the national certificates as persons meeting state certification requirements. States can add an examination for knowledge of the state code if deemed necessary.
- Local government should accept state certifications without additional examination.

6.8.2 Prior Qualifications for Initial Certification

When initially applying for certification, applicants engaged in the following occupations/functions must demonstrate the prior training and experience shown after each listed item:

- Construction Inspector: [*requirements*]
- Designer: [*requirements*]
- Installer: [*requirements*]
- Maintainer/Operator (option: excluding homeowner): [*requirements*]
- Plan Reviewer: [*requirements*]
- Site Evaluator: [*requirements*]
- Soil Evaluator: [*requirements*]
- Responsible Management Entity (RME): [*requirements*]

If there are subclassifications in an occupation (e.g., Installer I and Installer II), it is particularly important to recognize them in connection with Prior Qualifications, so as to minimize the risk of unfairly screening out qualified persons.

Recommendations:

- Prior qualification should be avoided at the entry level.
- National certification programs should provide two levels of certification for each general classification group.
  – Entry level–common and simple elements of the task
  – Journey level— broad and complex elements of the task
- States should adopt a third classification—Master level— to identify persons, either entry level or journey level, who have demonstrated reliability in their trades at their respective levels to an extent that permits substantially reduced regulatory attention.

The purpose of multilevel certification is to allow persons with narrow but expert skills, such as ability to install conventional systems but not site-constructed sand filters, to contribute their particular expertise to the benefit of the industry.

6.8.3 Display of Certificate

A person performing work requiring certification must produce the certification document when requested by an inspector or other government agent with jurisdiction. A regulatory inspector must produce his/her certification when requested by any individual with whom the inspector is interacting as an agent of the state.

6.8.4 Duration of Certification

Certificates issued by the state expire in accordance with the following schedule:
[*List of certificates (see para. 6.8.1) with duration of each*]

> Expiration dates keep the certification list current and serve as a mechanism for enforcing the obligation to obtain continuing education. A reasonable duration is three years.

6.8.5 Continuing Education

Persons holding current certifications must successfully complete approved education programs after the effective date of the current certification and prior to applying for certification renewal.

6.8.5.1 ***Course Approval.*** Education programs shall be approved by the agency issuing corresponding certification. The content of the course shall be focused on improving the knowledge, skills, and abilities of certificate holders in the performance of the work covered by the certification.

6.8.5.2 ***Credits Hours.*** One hour of training equals one credit hour. The credit hours required for each certification are as follow:

[*List of certificate titles with credit hours required for each*]

6.8.5.3 ***Reporting Credit Hours.*** The entity conducting the approved continuing education shall perform the following functions:

- Provide mechanisms that ensure that the individual pursuing the continuing-education credit actually attends the complete program and is attentive to the subject material.
- Record the attendance and issue a corresponding certificate to the individual. If direct notice is required by the certifying agency, a list of attendees and other information required by the agency shall be provided to the agency.

6.8.5.4 ***Failure to Report Required Credit Hours.*** Persons who fail to report sufficient credit hours for certification renewal shall be denied a new certification, with the following exceptions:

- The applicant may apply for the current certification to be extended for a four-month period to provide time to earn the necessary credits hours or resolve disputes concerning awarding/reporting of credit hours.
- The agency may grant a second extension upon the applicant's request showing good cause for such extension. The determination of "good cause" shall be solely at the discretion of the agency.

> *Recommendation:* Continuing education should be required as a condition of renewal of certification. Eight to sixteen hours of approved courses is reasonable for renewal.

APPENDIX A

Classification Matrices

Pending beta testing by Florida Department of Health.

APPENDIX B

Listed Components

Reserved for list of evaluated and classified components.

APPENDIX C

Soil Component

Under development.

APPENDIX D

Procedure for Administering the Confined Treatment Component Database

Pending beta testing by Florida Department of Health.

APPENDIX E

Tank Standards

GUIDANCE

Decentralized wastewater treatment systems employ various buried structures such as septic, pump, holding and treatment tanks. While the majority of this guidance addresses the septic tank, it also applies to the other uses of the tank.

The primary purpose of the septic tank is to clarify the wastewater; to separate constituents that float and sink from the other wastewater constituents. A second benefit is that decomposition of organic material begins in the septic tank. Raw waste is reduced to sludge, scum, gases, and effluent with the aid of beneficial microbes that reduce the organic material without outside energy sources. In this regard, the septic tank is extremely beneficial at a nominal cost when compared to the overall system cost.

FIT FOR THE INTENDED USE AT THE SITE

The septic tank system needs to be fit-for-use in its operating environment. The operating environment of most septic tanks is: buried below ground, in or above ground water, empty or full of sewage. The septic tank system consists of the tank, riser and inlet/outlet ports. The common performance standard in many state codes is that the tank system is watertight and structurally sound while installed and operating.

- Watertight – Inflow of groundwater or storm water. Onsite wastewater treatment systems are designed to return a predetermined volume and quality of wastewater to the environment. A septic tank allowing inflow of water can permit large unintended volumes of ground water into the treatment and disposal system. This can overwhelm the capacity of the downstream components which may not be able to handle the extra water and provide adequate treatment. Also surges of inflow can displace solids from the tank adversely affecting the operation and operating life expectancy of downstream components. Groundwater and soil often have compounds such as sulfur, iron and manganese which can severely impact the septic tank and treatment components downstream.
- Watertight – Outflow of sewage. Leaking tanks can pollute groundwater in circumstances where there is a lack of suitable soil treatment between the tank and the groundwater.
- Structurally sound – The buried tank needs to be structurally sound to withstand the live and dead loads experienced at the site to prevent cracking or collapse.

The potential impacts include safety of people in the area of the tank, the operation of the treatment system and the formation of cracks or other openings that cause leaks.

In many jurisdictions, the watertight, structurally sound requirements have not been aggressively enforced. Because the manufacture and installation of truly structurally sound, watertight tanks are marginally more expensive, and because the customers are very cost sensitive, this lack of enforcement gives a price marketing advantage to vendors of poor quality tanks. This problem is compounded because the tank is "out-of-sight" and "out-of-mind" of homeowners so they may not know that the tank system is leaking or structurally unsound.

The intent of the NOWRA code is that the treatment system be sustainable for the expected period that the treatment system needs to serve the structure. For most systems that is the expected life of the structure. Sustainable means that the system components can be maintained in operating condition through maintenance, repair or replacement. This model code guidance does not suggest that an installed tank be designed to last for 100 plus years, the expected life of many structures. Obviously, the actual life will vary depending the waste stream influent, timely inspection, pumping and other operational factors. Robust components require less maintenance and repair and have a longer life expectancy. The determination of the targeted design life of the system can be determined by the designer/owner and/or the regulating jurisdiction.

DETERMINATION OF THE WATERTIGHT AND STRUCTURALLY SOUND REQUIREMENTS

In a performance code, the determination can be made by the inspection of an installed system during its operational life. The performance standard for a structurally sound tank with watertight connections is simple: it leaks or it does not; and it remains intact when installed and operating, or it does not. If the tank is not leaking and is not showing signs of structural collapse, the tank satisfies the two requirements. However, there are several issues to be considered in this matter:

- The inspection of an installed, operating tank may be technically impractical or too expensive.
- Pressure testing can be dangerous if the tank fails. Such tests must be done in a manner that complies with OHSA safety standards. If the test is conducted in the excavation, entry into the excavation is also subject to OSHA shoring and excavation rules.
- Most regulations are designed to prevent the non-compliant condition from occurring with health and safety rules establishing minimum design requirements and implementing construction/manufacturing inspection programs.

It is useful to be able to determine if the tank design will meet the requirement before it is placed in operation. Two methods are typically employed to verify watertightness and structural capacity, respectively:

- The tank is tested by filling with water or by applying a vacuum or pressure test.

- The tank design and construction satisfies engineered standards and approved industry quality control methods.

The tank should be designed to withstand all likely conditions with an appropriate safety factor and remain watertight and structurally sound for the intended life of the component. There are several methods to test a tank. Each tank, or a random sample of tanks can be tested at the factory and/or each tank can be inspected and tested at the site after it is installed and/or after it is placed in operation. The installed tank must meet the appropriate standards.

TANK STANDARDS

The NOWRA model code provides a series of successively more stringent performance requirements and code language. Following are the options for each of the major issues:

STRUCTURALLY SOUND

Purpose: Prevent tank collapse; protect public safety and protect the internal components and processes.

Policy Options: standard and code language

- No adopted standard
- The installed tank shall be structurally sound, capable of bearing all anticipated live and dead load conditions exerted on a buried tank. Those conditions may include: tank empty and full, and tank installed above and below the water table, as determined by the following language:

  The tank shall be structurally sound as determined by Engineering Design with appropriate safety factors, and watertight verified through appropriate testing and compliance monitored by local authority. All tanks shall be designed and certified by a Professional Engineer, licensed and qualified to perform structural design. Design should contemplate all reasonably expected loading conditions, including burial depth, tank full to top of riser, an empty tank installed with water table at top of ground and any other reasonable expected loading conditions. Manufacturer should be required to certify that all tanks manufactured meet the engineer design.

> Structural integrity of a tank is important to protect against dangerous collapsing. Septic tanks are subjected to many varying loads and stresses. In some areas tanks may be buried deep below ground to prevent freezing, in others, water tables are often above the top of the tank for extended periods of time. All tanks must be designed to withstand all anticipated structural loads. Since septic tanks are buried and usually forgotten, structurally sound requirements must be implemented, enforced and monitored by the authority having jurisdiction.
>
> Since tanks are made from several types of materials, no one industry adopted standard is available. Fortunately, all tanks of all materials can be analyzed by engineers to determine structural soundness including appropriate safety factors. Many industry standards are available for use in determining the exact requirements based upon the onsite system and conditions.

ACCESS GUARDED

Purpose: Prevent injury or death caused by child or unintended adult entry into the system components while maintaining ease of access by maintenance personnel.

Policy Options: standard and code language:

- No provision
- All exposed access openings shall be guarded. Openings larger than 4 inches should be secured by bolting or locking lids or by lids that weigh a minimum of 59 lbs (from ASTM C 1227 – "7.6.1") and are set to prevent sliding. Covers, risers and lids shall be capable of bearing the expected live and dead loads.

> This is an important safety issue. Guidelines may be found by consulting available standards: ASTM C1227, ASTM C 890, CSA B-66, and IAPMO PS-1. Potential loads could include people, lawn equipment, or vehicles.

WATERTIGHT TANKS

Purpose: Prevent unintended leaks to protect the tank's function of clarification and to protect downstream components from excess flows and loads.

Policy Options: standard and code language:

- No provision
- Tank shall be watertight to the outlet hole
- Tank shall be watertight, including inlet and outlet pipe penetrations, to a point 2 inches into the riser
- Tank shall be watertight, including inlet and outlet pipe penetrations, to and including the riser assembly
- Testing [SEE TESTING OPTIONS BELOW]

> For tanks where leaks out of the tank need to be controlled, the minimum standard should be "watertight to the outlet hole." For tanks where inflow waters are a concern, the minimum recommended standard is for all tanks and associated components to be watertight into the riser assembly. Any other standard will permit periodic uncontrolled leaking into or out of the tank. Downstream components cannot be practically designed to handle unintended flows. Post installation testing of tanks is the best method to assure this standard is met.
>
> Post-installation testing: A testing program is essential to ensure compliance. The level of testing will depend heavily on the value placed on achieving the recommended standards. A minimum should be random periodic testing of installed tanks. The most comprehensive program would require testing of every tank installed. Local conditions—availability of water and/or other testing equipment and monitoring personnel will have to be considered when setting this standard. OSHA safety standards for shoring, excavating and confined space entry also need to be considered when selecting an evaluation protocol. Testing responsibility may be other than the local regulator.

EVALUATION PROTOCOLS

The objective of quality assurance (QA) and quality control (QC) procedures is that the installed tank be "fit-for-use" as a component in an installed wastewater treatment train. The QA and QC processes focus on the safety of the tank structure and the wastewater loads and flows exiting the tank. Two key components of that process are ensuring that tanks are structurally sound and watertight when installed. Evaluating the tank assembly at the site is an important component of a QA program. However, site evaluation for structural soundness and watertight condition of the installed tank (buried in both the full and empty state) is sometimes difficult and may increase cost of system. Cost is always an important consideration along with the risk posed by failure to perform to performance requirements. As a result, alternative QA and QC processes are often employed such as evaluating the tank at the site before it is buried, certifying the personnel doing the work, certifying the manufacturer to accepted industry standards. Because tanks are made from materials that have different strengths and weaknesses, different test methods will affect the designs differently. Further, various testing methods have different time and money costs.

Adoption of existing evaluation protocols - Different tank systems and materials may require different evaluation protocols for watertight and structurally sound requirements. Where an accepted evaluation protocol for the material or tank assembly exists, the entity specifying the evaluation requirement should first consider adopting that protocol.

Listed below is a general explanation of the procedures and a rationale for selecting the testing procedure.

Watertightness Testing Procedure

- ***Water Test Procedure:*** A water test is performed by installing tank, connecting inlet and outlet piping (with caps), installing risers, and filling tank to required depth. Some materials, such as concrete, may require a period of time for natural absorption into the material prior beginning the watertight test. Backfill may or may not be in place depending on whether the backfill is integral to the structural design. Mark the level of water in the tank "or riser." After a predetermined "test time" applicable to the material or assembly, make a visual check on the outside of the tank for leakage (if possible), and check water level in the tank (or riser). If no visual evidence of leaking and water is at mark, tank passes.

  ADVANTAGES: This test is easily and quickly administered, and pass/fail is fairly obvious. A small leak will have evidence (a wet spot). The weight of the water also provides a test on the foundation under the tank. If bedding under the tank is uneven or has rock protruding, tank may crack causing failure of test.

  DISADVANTAGES: Water may not be available on site, and will have to be transported to the tank.

- ***Pressure Test Procedure:*** A pressure test is usually performed by capping inlet and outlet piping, sealing access openings, and then pressurizing tank to 5 PSI. Pressure in the tank is held for a given period of time, depending on the adopted protocol. If leaks are discovered and repaired, the test may be run again. In the final test, any leakage is considered a failure.

ADVANTAGES: This test is easily and quickly administered, and pass/fail is fairly obvious.

DISADVANTAGES: Installer/tester must purchase and maintain testing equipment.

- ***Vacuum Test Procedure:*** A vacuum test is usually performed by plugging inlet and outlet piping, installing risers and using a vacuum pump to pull a negative pressure of 4 inches of Mercury. The tank must hold this vacuum for a given period of time, depending on the adopted protocol. Any leakage is considered a failure.

  ADVANTAGES: This test is easily and quickly administered, and pass/fail is fairly obvious.

  DISADVANTAGES: Installer must purchase and maintain testing equipment.

When selecting the method of testing, the manufacturer/engineer should be required to approve the test method procedure to insure that the actual test loading condition does not exceed the "engineered design" loading condition.

The longer a test is performed, the more accurate the result to identify relatively small leaks. Length of test must be balanced with the increased cost of the longer test.

Repairs can be made to tanks failing watertight test provided the structural integrity has not been compromised.

TANK EFFLUENT CHARACTERISTICS

Designer must ensure that the various components of the treatment train are compatible. This edition of the model code does not provide an evaluation scheme to classify effluent quality from the septic tank component. Like other treatment train components, the quality and volume of the influent are major determinants of effluent quality characteristics.

Septic tanks should be sized to minimize the required maintenance. Smaller tanks will require pumping more often than larger tanks with the same flow. Effluent filters, screens or other methods are strongly encouraged to prevent large solids from passing to downstream component during operation. Care should be taken to prevent solid flows during servicing.

Provide Access to Components

Proper maintenance and repair are important to the long-term success of all systems. If maintenance workers cannot easily or adequately access components, maintenance will either be ignored or put off until a crisis happens. Access at ground level or above is highly recommended for all tanks and/or components contained therein. Openings should be of adequate size to facilitate maintenance. See the code document for language and guidance on tank access.

APPENDIX F

Don't Flush Listing

ITEMS TO AVOID FLUSHING INTO AN ONSITE SYSTEM

The following guidance is a collaborative effort of wastewater professionals within the National Onsite Wastewater Recycling Association (NOWRA). The purpose is to identify common issues that can cause problems with the operations of newer onsite treatment and traditional septic systems. Many operational problems exist today because owners are either unaware of the results of daily practices to these systems. NOWRA's goal is to ensure that owners are educated and informed about the safe practices for their treatment systems in order to avoid costly repairs and to protect groundwater quality. The items listed below are known to have caused failures of onsite treatment systems and must be considered if waste generated by/from a particular site will contain them in excessive quantities. Since excessive is a subjective word, it is highly recommended by NOWRA that you share concerns with your Wastewater Professional to come up with a treatment strategy for your particular needs.

A list of NOWRA wastewater system professional services is found on www.septiclocator.com

Inert Materials: Plastic, rubber, scouring pads, dental floss, kitty litter, cigarette filters, bandages, hair, mop strings, lint, rags, cloth and towels do not degrade in an onsite treatment system. Inert materials will build up solids and lead to system malfunction, clogging or increased pump out frequency.

Paper Products: Disposable diapers, paper towels, baby wipes, facial tissues, baby wipes, lotioned, scented or quilted Toilet tissue, moist toilet paper, do not dissolve readily in an onsite treatment system. Excessive amounts of toilet tissue will also not decompose. All can lead to system malfunction, back-up or increased pump out frequency.

Food Wastes: Do not put animal fats, bones, grease, coffee grounds, citrus and melon rinds, corn cobs, egg shells down the sink. Garbage disposal use should be limited to waste that cannot be scooped out and thrown in the trash. Spoiled dairy products and yeasts from home brewery or baking may cause excessive growth of microbes that do not degrade sewage.

Household Products: Do not flush baby wipes, lotioned, scented or quilted toilet tissue, female sanitary products, cotton balls or swabs, or condoms. antimicrobial soaps and automatic disinfection tablets (blue, clear or otherwise) may kill the organisms needed to consume waste.

Medications/Aliments: Normal use of over the counter medications does not affect the performance of onsite systems. Do not flush expired medicines/antibiotics into an onsite treatment system. Prescriptions for the following medical conditions are known to cause biological disruption in the treatment system: bulimia, severe infections (including AIDS), chronic diarrhea, intestinal/colon by- pass, or other gastrointestinal conditions and cancer. Oral or intravenous chemotherapy is known to cause serve disruption to the treatment process and will require more frequent pump out intervals or the use of biologically based additives.

Commercial Additives: Both the U.S. Environmental Protection Agency and the Small Flows Clearing House have reported that there is no evidence to support the use of additives with normally functioning Onsite Treatment Systems. Some Septic Tank additives have been shown to do more harm than good. A normally functioning system should not require additives.

Chemicals & Toxins: The following materials kill the microbes necessary for the biological treatment to occur: paint, paint thinner, solvents, volatile substances, drain cleaners, automotive fluids, fuels, pesticides, herbicides, fertilizers, metals, disinfectants, sanitizers, bleach, mop water, floor stripping wastes, excessive use of household chemicals, and backwash from water softener regeneration.

Laundry Practices: On-site systems must process the water as it enters the system. Laundry should be spread out over the week, not all run at one time. Excessive use of detergents, especially those containing bleach, can affect system performance. Liquid detergents are recommended over powders. Fabric softener sheets are recommended over liquid softeners. Bleach should be used sparingly and at half the rate indicated on the container.

Clear Water Waste: From air conditioning discharge lines, floor drains, gutters, whole house water treatment systems and sump pumps can increase the flow to your treatment system. These flows can at least disrupt, if not destroy your treatment process.

Remember—if you have additional questions, consult your wastewater professional. NOWRA has a new online service available at NOWRA's Septic Locator to help you with these questions.

Thank you for the invitation to participate in the Stakeholder Group. I think there are some great opportunities to improve the regulatory approaches to wastewater and improve water quality protection. Here are my questions and comments:

1. Starter Homes and Uniform Code: I support the concept of providing greater density through zoning amendments to allow for more affordable housing. However, I oppose diminishing the regulatory powers of local boards of health. Given the highly variable hydrogeologic environments throughout the Commonwealth and the prevalence of on-site septic systems and private on-lot well I believe that there are enough unique circumstances to warrant local jurisdiction. Most of my experiences working with local boards indicate that they have invested considerable effort in developing local codes that are customized to local conditions. Adding another regulatory step that might require MADHCD and/or MADEP oversight will present an additional burden on communities in getting local regulations adopted. Furthermore I believe that it would place a significant additional burden on MADEP staff in reviewing local regulatory proposals and the local conditions that they are based upon.

2. New Category: I believe that the existing Title 5 threshold of 2000 gallons/day should be further strengthened and clarified. At this flow level significant contaminant plumes (including nitrogen, phosphorus, and pathogens) develop from on-site septic systems that can threaten dowgradient private wells and other resources well beyond the current 100-foot separation. Systems of this size should be required to meet drinking water limits at the downgradient property boundary. While the existing Nitrogen Loading guidance document provides some approaches to this issue, it does not clearly identify the requirement for this type of analysis for projects that do NOT propose credit land. The existing policy seems to apply only to those cases, although I think the intent was to meet this standard in all cases for flows exceeding 2000 gallons/day.

3. Additional Tie-Ins: This could be a significant benefit to places like Cape Cod in addressing their TMDL requirements. There are many private sewage treatment plants with extra capacity that could provide a net reduction in nitrogen loading by allowing the connection of surrounding homes. I believe that the legal/responsible entity issue has been solved in the issuance of GWDPs to private facilities. Perhaps this allowance could be focused on nitrogen-sensitive watersheds and limited to connecting existing homes, possibly allowing for some growth to the on it that a net nitrogen reduction can still be realized.

4. Allowing Compost Leachate (including Urine Diversion) to be applied for a landscaping fertilizer: Ecotoilets were identified as a nontraditional approach in the Cape Cod 208 Plan. This Plan has been certified by the Massachusetts Governor. I would suggest broadening this policy change to include urine diversion toilets in addition to composting toilet. Both technologies provide possible low-cost, source reduction alternatives to reducing nitrogen loading. The State of Vermont has permitted the application of collected urine as a fertilizer. For more information visit the website: http://richearthinstitute.org

Thank you for the opportunity to provide these comments. Scott

Scott Horsley
Principal
Horsley Witten Group, Inc.
www.horsleywitten.com

508-364-7818

Attached is a copy of the nitrogen removal study we have going, and the results of the first year of data (2016). Since the bacteria that do the nitrifying and denitrifying work in the treatment components are slow growers and have slower metabolisms at colder temperatures, we expected a slow start-up period that first winter. I was actually pleased to see the performance we acheived after the first 6 weeks. Note the average removal rates at the bottom that were achieved during the first year of operation with 2 - 3 days (started with 2, changed to 3 at mid-year) of empty-bed residence time.

Larry

Stephens Consulting Services, P.C. &
SCS Systems LLC
P.O. Box 708
Haslett, MI 48840
Phone: (517) 339-8692

WASTEWATER TREATMENT CONCEPT
SILVER LAKE PROPERTIES
Craig Cihak

BACKGROUND

Several commercial properties in the Silver Lake area are owned by a series of companies of which Craig Cihak is a partner/member. These properties are now served with onsite septic systems owned and maintained by these companies. The Silver Lake resort area is part of Golden Township of Oceana County.

As the Silver Lake community continues to grow, a need has developed for an improved wastewater collection and treatment system. Many believe that the continued use of simple septic tanks and soil-based systems will eventually impact the quality of Silver Lake. In fact, this very matter is the subject of an extensive ongoing study of the factors that influence the water quality of Silver Lake. Of course, Silver Lake and the dunes surrounding it are the main attraction that brings so many resort lovers to this area every summer. So for all in the area, protecting this resource is of prime importance. Previous efforts to construct a community sewer system have not yet been successful, primarily due to cost.

For the businesses in the area, the lack of public sewer is sometimes a barrier to their growth; and sometimes maintenance of their existing systems has been troublesome.

CONCEPT UNDER CONSIDERATION

Mr. Cihak has purchased two parcels of land on Hazel Road in Section 28, Golden Township for the purpose of constructing a community wastewater treatment system for his properties. A substantial amount of planning was previously put into the use of one of these properties several years ago for this very purpose. Engineering and hydrogeological studies were conducted and some permits and approvals were obtained from regulatory agencies having jurisdiction. The project was dropped at that time, primarily because the company became a victim of the economic downturn. Mr. Cihak has purchased that property (about 20 acres) and a 40-acre parcel nearby.

Mr. Cihak proposes to now build with private funds a wastewater collection and treatment system to treat the wastewater from his own businesses on these parcels of land. The wastewater treatment facilities will be privately designed, constructed and operated to treat the collected wastewater to a very high quality, and then dispersed back into the ground on these properties that are remotely located. All of this will be done without cost to the Township or other local units of government. All necessary and appropriate permits and approvals will be obtained for these facilities in accordance with state and local law, codes and ordinances.

ADVANTAGES OF THIS PROPOSAL

This proposal presents several advantages to the community as a whole as follows:

1. This proposal will collect and transport the wastewater from several existing commercial properties along Hazel Road to a remote location for treatment well away from Silver Lake.

2. The wastewater will be treated to a very high quality, including the removal of nutrients like nitrogen and phosphorus, and then dispersed back into the soil to be returned to the groundwater through the soil as the final treatment component.

3. All collection and treatment facilities will be built with private financing without the need for public financial commitments.

4. The collection system that is planned will be a S.T.E.P. (Septic Tank Effluent Pumping) system with a common pressure sewer. This is the type of system that can easily be extended to other properties in the future should the need arise. Other properties along the sewer route will also be able to tap and use this sewer if appropriate arrangements are made with the system owner.

5. At some point in the future, the owner may consider selling the system to the Township, should Golden Township desire to take over the system and make it public.

6. As long as this system is privately owned and operated, operation and maintenance of the treatment system will be privately funded through user fees charged back to the properties served. Operation of the system will be under the oversight of a DEQ Certified Operator with the appropriate credentials.

7. The system owner will obtain and maintain the appropriate MDEQ permits required for this system.

8. As required by the MDEQ, an escrow fund will be established and maintained with access by either MDEQ or the Township for funding of emergency repairs or system operations if the need arises.

DETAILS OF THE PROPOSED COLLECTION SYSTEM

As mentioned above, the collection system proposed is a S.T.E.P. system. This particular type of system involves three primary components: 1) A septic tank or tanks on each property served, the purpose of which are to trap and store the large solids in the wastewater; 2) A high-head pump with controls to pump the clarified septic tank effluent to a common forcemain (pressure sewer) normally located in the street R.O.W.; and 3) A pressure pipe, or network of pipes, in the street to carry the septic tank effluent from each property served to the treatment site. Such a pressure sewer can be designed to transmit the wastewater from any number of properties for great distances to a remote treatment site. Pressure collection sewers are very cost-effective and can be installed using trenchless technologies, eliminating the need for dewatering, and keeping surface restoration to a minimum.

PRELIMINARY DETAILS OF PROPOSED TREATMENT SYSTEM

The treatment system under consideration consists of the following components:

- Aerated lagoons with about 30 days of residence time to aerate and oxidize organic matter in the wastewater. Carbon constituents in the wastewater will be oxidized here, along with the conversion of organic nitrogen compounds and ammonia to nitrate (nitrification).

- At the outlet of the primary aerated lagoon cell(s), alum or ferric chloride will be added to the treated effluent on its way to a smaller aerated/mixing cell with about 15 days of residence time. In this cell, gentle agitation of the wastewater will cause contact between the phosphorus compounds in the wastewater and the metal salts that are added, forming a floc that will tend to settle out of solution.

- From the mixing cell, the wastewater will flow into a small settling pond with no aeration. The purpose of this cell (with about 15 days of residence time when full) will be to provide a quiescent zone for the phosphorus compounds to settle out of solution.

- In the dike of this settling pond will be located a dosing tank with pumps to deliver the treated effluent to the bottom of an upflow, saturated filter filled with wood chips or coarsely shredded wood mulch. The purpose of this filter is to create an anaerobic/anoxic environment with a carbon source (wood chips) that will serve as a de-nitrification reactor to reduce the nitrate in the wastewater to nitrogen gas, and thus remove nitrogen from the effluent.

- The overflow from the top of these de-nitrification filters will then be designed to flow into an effluent storage pond. In the dike of this storage pond will be located a dosing tank with pumps and controls. These pumps will be timer-activated to dose the open sand beds for discharge of the finished effluent back into the soil. Open sand beds are chosen as the method of choice because they can be easily maintained. It is expected that the quality of the effluent discharged onto these sand beds will meet the effluent requirements of the DEQ groundwater discharge permit. Nevertheless the soil component beneath the sand beds will provide the final tertiary treatment of the wastewater. A system of groundwater monitoring wells will be maintained and periodically sampled to assure that the groundwater quality is not diminished.

MAJOR DEQ PERMITS REQUIRED

Part 22 Groundwater Discharge Permit – Authorizes the discharge of treated wastewater to the groundwaters of the state and sets the performance requirements for treatment works design and operation. This permit is site-specific, and must be renewed every 5 years. An annual fee is required to maintain the discharge permit, and is determined by the type of permit issued and size of discharge.

Part 41 Construction Permit – This is a construction permit required before the construction of either a collection or treatment system serving the public (more than one user). This requires the preparation of a system design by an engineer, and submittal of the detailed construction plans and specification to the MDEQ for approval. The permit is issued upon approval of the construction plans, and authorizes the construction of the facilities as shown on approved plans and specifications.

PROPOSED PILOT STUDY FOR "PROOF OF CONCEPT" FOR NITROGEN REMOVAL

Background – The processes involved in total nitrogen removal from a wastewater stream have been well known for decades (Advanced Wastewater Treatment, Culp and Culp, 1971). In fact, this writer wrote a paper on the subject while in graduate school in the 1970's. A quick summary of this 2-step process is as follows:

Nitrogen in raw wastewater is predominately in the forms of organic nitrogen and ammonium. Well developed aerobic treatment processes (like the proposed aerated lagoons) biologically convert these forms of nitrogen to nitrates, the oxidized form of nitrogen. This part of the process is called the "nitrification" step. Aerated lagoon cells are capable of nearly 100% conversion with adequate residence time. The only exception to this is when the water temperature drops below 45 to 50 degrees F. Colder temperatures slow the bacterial action significantly. Fortunately, incoming flow during the winter months at Silver Lake will be next to zero. This will allow flow to be stored for treatment when the temperature warms in the spring.

After the nitrification step, the proposal for this treatment system is to create a denitrification step. Denitrification requires the wastewater containing the nitrate to pass through an environment low in dissolved oxygen (anaerobic/anoxic) with a food source (in the form of carbon) for denitrifying bacteria. The wastewater following the aerobic nitrification step will not contain enough remaining carbon to feed the bacteria, so a food source must be added. There are other ways to accomplish denitrification, but this proposal is to accomplish nearly 100% denitrification with an inline, up-flow, anaerobic reactor/filter. After the nitrification, the wastewater will be delivered to the bottom of the upflow denitrification reactor using pumps controlled by programmable timers. In this way, the feed pumps can be adjusted from time to time to maintain the desired flow and contact time in the reactor. The media in the reactor is to be shredded bark mulch. This media is to serve two functions: 1) Serve as a carbon source for denitrifying bacteria; and 2) Provide surface area for denitrifying bacteria to attach themselves. Research has shown that shredded bark has been found as a good material for this purpose. The reactor is also to be an up-flow reactor to provide a saturated, anoxic environment forcing the bio-culture to utilize the oxygen attached to the nitrate molecules and release nitrogen gas to the atmosphere.

Attached are copies of three documents to support this concept:

Minimizing Nitrogen Discharges from Onsite Wastewater Systems, Pipeline, Summer, 2012

Batch Test Evaluation of Four Organic Substrates Suitable for Biological Groundwater Denitrification, Chemical Engineering Transactions, 2014

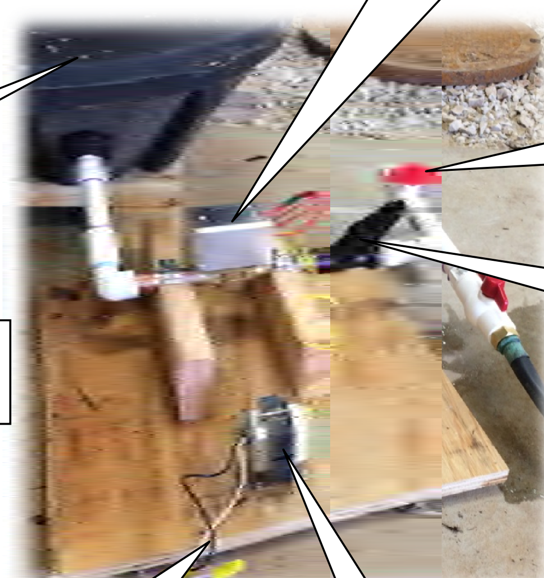
Enhanced Nutrient Removal – Nitrogen, EPA Onsite Wastewater Treatment Systems, Technology Fact Sheet 9, EPA Onsite Wastewater Systems Manual, February, 2002

<u>PILOT STUDY</u> – (In progress)

SCS Systems, LLC operates a wastewater treatment facility for Brookfield Township, Eaton County. This treatment facility uses recirculating aerobic packed-bed filters to highly treat septic tank effluent from a S.T.E.P. collection system serving homes around Narrow Lake. The wastewater is highly nitrified in the process. This pilot study is taking this nitrified effluent and passing it through an up-flow shredded bark mulch reactor/filter using a timer activated supply pump and valve assembly. The volume of the empty bed is known (~75 gallons), and the nitrified effluent feed is controlled by a programmable timer activating a motorized valve on the feed line. The source of the nitrified effluent is a pressure tank fed by a pump in an effluent storage tank. It was designed to supply wash-down water for the treatment facility.

The reactor chamber is a round H.D.P.E. cylindrical container of approx. 24" in diameter and about 4 feet tall, manufactured as a pump vault. It has a hopper bottom that forms the bottom 10" to 12" of the vault. A ¾" threaded bulkhead fitting was placed in the side of the hopper bottom for the wastewater feed location. Another ¾" threaded bulkhead fitting was placed near the top of the container as the overflow point. A sampling tap was installed in the feed plumbing so that samples can be drawn before the reactor. A P-trap was plumbed with a sample tap in the overflow piping so that a sample of the overflow can be collected at any time. Below are some pictures of the pilot study apparatus.

VIEW OF THE TEST APPARATUS SHOWING THE TEST CONTAINER AND THE FEED CONTROL VALVES



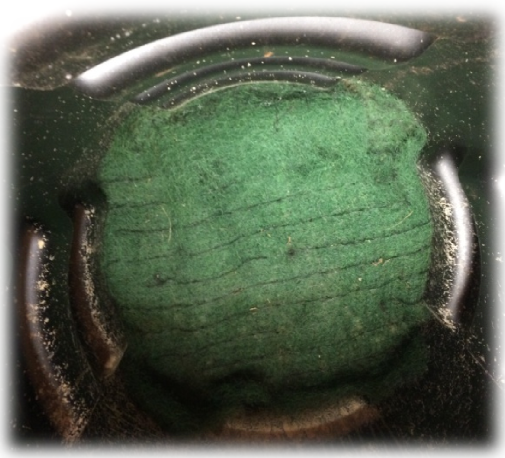
WASTEWATER FEED CONTROL APPARATUS

VIEW OF DISCHARGE PLUMBING WITH SAMPLING POINT

SOURCE OF NITRIFIED WASTEWATER EFFLUENT FROM EXISTING TREATMENT WORKS AT NARROW LAKE

FILLING OF THE TEST CONTAINER

Hopper bottom filled with 6A stone
(Stone used as a distribution media)



FILLING OF THE TEST CONTAINER

Porous plastic geotextile mesh placed
over stone as a separator

FILLING OF THE TEST CONTAINER

Shredded bark mulch place over
plastic mesh and stone

FILLING OF THE TEST CONTAINER

Test container filled with bark mulch up to just below the overflow – a total media depth of 2.75' (33")

Ball Point Pen

FILLING OF THE TEST CONTAINER

Media Size

Overflow bulkhead fitting

FILLING OF THE TEST CONTAINER

Another layer of plastic mesh placed over bark mulch, and then covered with a thin layer of stone on top (to hold down mulch)

PROPOSED SAMPLING AND TESTING SCHEDULE

This pilot study has been up and running since the first week of December, 2015, but no samples have yet been drawn. It is expected that the denitrification bio-culture will slowly develop in the media as time passes, and that nitrogen removal will increase with time. Sampling will begin the first week of January, and depending upon the results, continue on a twice per month schedule. Grab samples will be drawn for both influent and effluent from the test apparatus, and tested for the following parameters:

- TKN
- Ammonia
- Nitrite
- Nitrate
- BOD
- Phosphorus

In addition, D.O. and pH will be carefully measured in the pool of effluent on top of the test container during the collection of each sample.

CONTACT TIME TO BE EVALUATED

Various contact times can be evaluated throughout the course of this study. Initially, the programmable timer will be set to provide an empty bed contact time of 48 hours. It is anticipated that this will provide adequate time for denitrification to occur in a mature reactor. A lot of the research that has already been done in similar situations has used shorter contact times with good results.

KEEPING THE RESULTS OF THIS PILOT STUDY IN PERSPECTIVE

It is important to understand and keep in mind what this pilot study means to our Silver Lake Wastewater Treatment project. We know from extensive past research and experience that aerobic treatment in facilities using aerated lagoons will do an excellent job of nitrifying wastewater (converting the nitrogen to nitrate) if properly sized, particularly during the warmer three seasons of the year. We also know it is a well-established fact that an anaerobic/anoxic environment with a carbon source will remove nitrate from wastewater. We are not doing this pilot study to prove those facts.

What we do hope to gain from this pilot study is some guidance as to the amount of residence time needed for the nitrified wastewater to be in that environment in order to achieve the degree of denitrification necessary to achieve our desired effluent quality. This information will dictate to some extent the ultimate sizing of the denitrification reactors/filters that will be necessary when our treatment facilities reach full capacity. Our ultimate goal is to reduce the total nitrogen content of the effluent to less than 5.0 mg/l in the groundwater below the recharge area. While all of this removal does not have to occur at the treatment site prior to application to the sand beds, it would be reassuring if that did happen. We can count on significant dilution in the groundwater beneath the recharge area, and can monitor that concentration in monitoring wells on the property where the sand beds are located. The Michigan groundwater discharge rules do permit dischargers to prove compliance with the groundwater quality standards in the groundwater near the point of discharge.

Furthermore, the design of the treatment works is intended to provide a great deal of flexibility to the operator to make process adjustments in order to achieve the highest level of treatment. Here is a summary of those options:

1. The first and foremost benefit provided this treatment system is the fact that the area served is highly seasonal in nature. Silver Lake is a recreational resort area that is almost entirely comprised of summer recreational activities. Almost 100% of the local businesses close for the winter months, and most of the residential dwellings are occupied only during the warmer summer months. The group of businesses to be served initially by this system will all be closed for the winters. The benefit of this type of community is that the incoming flow will diminish to near zero for 6 to 8 of the coldest months. This presents the option of storing any winter flow for treatment in the spring before incoming flow picks up again. It also offers the choice of operating the system into the low-flow fall period after incoming flow has diminished. It may not be necessary to discharge onto the sand beds during the coldest months.

2. The ability to avoid a groundwater discharge in the winter months when the biology of the system slows down means we will not need to discharge when the system is not operating at its optimum efficiency.

3. With regard to the denitrification “filters”, the system is to be designed to allow recirculation of the filter effluent back through the filters a number of times, if necessary. This will mean that the biology in the filters would have several opportunities to remove nitrogen from the treatment flow stream. This will be an adjustable parameter controlled by the programmable timer on the denitrification filter dosing pumps, and a control valve mechanism on the treated flow diversion assembly. Treated final effluent will actually be stored in a small lagoon cell and can be monitored for quality prior to discharge to the sand beds.

SYSTEM START-UP PERIOD WILL BE LENGTHY

In addition to all of the flexibility options listed above, there will be a lengthy start-up curve for the use of this system. Because of the fact that this system will initially be constructed as a private investment to serve only the properties owned by Craig Cihak, the initial incoming flow is anticipated to be no more than about 20,000 GPD. The initial system design will be for 50,000 GPD, but may not be limited at that after system performance can be monitored for a period of time.

Operating at only 40% ± of design capacity there will be extensive time for performance testing of the full-size facilities . . . including the denitrification facilities. Knowledge gained during this initial pilot study can be added to and supplemented by experience gained during the first few months and perhaps years of actual performance by the initial components of the full-size system. Multiple adjustments can be made as the performance of the full-size system is optimized, and future sizing requirements are further solidified. During this ramp-up period, adjustments can be made with regard to:

- Best seasonal start-up/ramp-up date
- Best seasonal shut-down/ramp-down date
- Performance of aerated lagoon cells under seasonally varying flow rates
- Optimum residence time for denitrification filters
- Need for recirculation in denitrification filters, and best recirculation rate
- Sustainable loading rate for highly treated effluent on sand beds

CONCLUSION

We believe that the combination of information gained from this pilot study and from the performance gained during the first two years of performance testing of the actual treatment works will prove that this proposed system will meet the expected performance requirements to be set by the Michigan Department of Environmental Quality.

A RATIONAL METHOD FOR DETERMINING DESIGN FLOWS FOR CLUSTER SYSTEMS

Larry D. Stephens, P.E.*

BACKGROUND

One concept in the design of sewer infrastructure for new developments (and sometimes communities of existing homes) in Michigan and elsewhere in the United States is to provide one or more smaller collection and treatment systems for small groups or “clusters” of homes, rather than one large centralized system. This concept sometimes represents the most cost-effective method of wastewater management for the community. Because these clusters of homes vary in size from a very few homes to dozens or more, they present some interesting challenges for the designer and regulatory community with regard to predicting the wastewater flow quantities. Smaller numbers of homes can be expected to exhibit larger flow variability than larger numbers of homes where periods of peak usage from individual homes tend to mitigate one another. The goal of this paper is to set forth a rational method of predicting expected wastewater flow from clusters of homes of different sizes, and accompany that projection with statistical confidence.

Many studies have been performed and much has been written concerning what the per capita wastewater flow is from residential communities. The conclusions of many of these studies indicate per capita daily flows of 50 to 55 GPD --- some as high as 60 GPD (McEachin and Loudon, 2002, U.S.E.P.A., 2002). There seems to be widespread agreement on the use of these numbers for design purposes, particularly for homes built after 1994 with water-efficient fixtures and appliances. However, when it comes to estimating the population of a home or group of homes there appears to be less agreement. Both the expected number of people living in a neighborhood and the flow per person are necessary parameters in estimating the total design flow if you happen to be a decision-maker in the design of the wastewater system to serve a new community. Little has been written with regard to the proper sizing of systems serving smaller communities of homes. Is the size of the homes a critical factor? Is the number of bedrooms or bathrooms a factor?

FACT OR FICTION?

Most codes for onsite wastewater treatment systems are written with prescriptive language that requires the system to be sized based upon the number of bedrooms in the dwelling. Two common flow formulas set forth in codes are:

> 150 GPD for the 1st bedroom + 100 GPD/each additional bedroom, or
> 150 GPD per bedroom

Do either of these represent an accurate estimate of the actual flow? Is there any relationship between these numbers and household occupancy? How do these formulas relate to the actual flow from a group of homes? Some would argue that these numbers should still be used to allow for

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* Larry D. Stephens, P.E., President, Stephens Consulting Services, P.C., P.O. Box 708, Haslett, Michigan, 48840 Phone: (517) 339-8692, Email: scscons@yahoo.com

peak flow conditions because you can't control the number of people living in a home. Those arguing the contrary point of view would say that the peak flow conditions are mitigated by larger numbers of homes, with actual flows coming closer to the averages. What are the facts?

CENSUS INFORMATION

The 2000 Census information is readily available online for any jurisdiction in the U.S. For any community it is possible to obtain household size and population information. Using the census data for the state of Michigan, the following facts are interesting:

- The average household size for Michigan is 2.56 people.
- Less than 4% of households have more than 5 people living in them.
- Less than 11% of households have more than 4 people living in them, even though more than 17% of households have more than 3 bedrooms.

So, if one were designing a central wastewater system for the entire population of the state of Michigan, and used the numbers found in many codes, it would appear that it would be considerably over-designed! Similarly, it may be true that smaller systems for communities of homes are over-designed if these same code formulas are used.

SOCIAL AND ECONOMIC FACTORS

Some would argue that social and economic factors have a large affect on the expected wastewater flow. For instance, the larger the home --- the more people likely to reside there, and the more wastewater is likely to be generated. Or, the more affluent the neighborhood, the larger the homes and families likely to be living there; or some might argue the opposite. How significant are these factors? Or, are they factors at all?

The author analyzed the 2000 census data for 12 communities in Michigan. The 12 communities were selected because they represented somewhat of a cross section of the Michigan population. Some were small --- some were large. Some were lower income communities --- some were wealthy. Some were urban, and some were rural. The goal of the analysis was to determine whether household income and home size had any affect on the household occupancy.

Table 1 shows the results of this demographic comparison. Figures 1, 2, 3 and 4 graphically show the trends as median household income increases. The communities have been ordered from 1 to 12 from the lowest to highest household income. As expected, the size of the homes and the number of bedrooms increases as household income increases. It is, however, somewhat of a surprise that the average number of bedrooms does not even reach 4 in the higher income communities. And, I think most would be surprised to know that the average household occupancy remains almost constant at around 2.5 people per household, regardless of income. In fact, the trend is slightly downward with increased income.

So, since we know that ***people produce wastewater, not bedrooms or bathrooms***, it would seem logical that we should make use of this readily available information in the sizing of our waste treatment works. Census data is available for any local jurisdiction by going to the following website: http://www.factfinder.census.gov/home/saff/main.html. With a series of steps to define your local census district, one can then obtain census findings on the percentage of homes with

1 occupant, 2 occupants, etc., up to 7-or-more occupants. By using these percentages to compute the expected population in any particular size community, and plugging in the flow per capita to be used, one can easily compute the design flow to be used for the treatment works. From there, the designer can use a safety factor of his or her choosing to allow for peak flow conditions.

Figure 5 is an example of a spreadsheet calculation using census information for a new housing project of 41 homes in Handy Township, Livingston County, Michigan. The upper section of the spreadsheet lists the 2000 census data downloaded from the website mentioned above for Handy Township. A township in Michigan is a generally rural governmental jurisdiction with a typical size of 36 square miles. In this example Handy Township has a total of 2,477 homes according to the 2000 census.

The lower section of the spreadsheet applies the percentage of homes with the various occupancy numbers to the total number of homes in the proposed development (41) to estimate the number of homes that will have 1, 2, 3, etc. occupants. The spreadsheet uses these numbers to then estimate the anticipate population in the new development. For our example, the estimated population of the 41 home development is 113 people, or 2.76 people per household.

The last two lines of the spreadsheet simply allow the designer to then use a per-capita average and peak flow number of his or her choosing to calculate the average and peak design flow for the project.

FLOW VARIABILITY

We must always keep in mind that illustrated here is a method of estimating the likely population of a new community; and, from that estimated population, determine an anticipated wastewater flow. It could also be used to estimate current flow from an existing community, but would not be as accurate as an actual population survey and/or actual flow measurement. This method assumes that the new development will have a population that mimics the characteristics of the larger surrounding community. Designers are cautioned to decide if that is a valid assumption for any particular project.

Certainly, there is variability in statistical data, so we must recognize the limits of our procedure. With regard to methods listed here, the following cautions are in order:

- The methods discussed here are appropriate for calculating the wastewater quantity generated at the source. If one is to use of the same quantities for design decisions at the downstream end of the collection system, the collection system must be watertight. Any infiltration, inflow or exfiltration has not been accounted for.
- No attempt has been made in the methods suggested here to accommodate different lifestyles. As examples, recreational communities may have significantly different occupancy patterns; home schooling of children may increase flows from homes; and significant hot tub and home spa use could result in increased volume.
- Some professionals express a legitimate concern that a characteristic of more affluent lifestyles is more frequent entertaining, resulting in higher wastewater flows. Designers

need to be conscious of this factor as they choose safety factors for their system component sizing, particularly for systems serving smaller communities. Peak flows in portions of the system are mitigated to some extent as the size of the system grows. So, in general, the author suggests that designers use a larger factor of safety for systems serving smaller communities.

However, with regard to the census data, we can draw some statistical conclusions. As an illustration of how this would be done, the census data for household size was obtained for a typical township in southeast Michigan. This township happens to be one of the communities in which 5 of the 14 communities for which existing flow information is shown in Figure 8 are located. It has a population of about 6,000 households. The census data obtained for this township was used to plot confidence intervals for different size populations using a standard spreadsheet program. In this way we can determine with 90% or 95% confidence what the expected population will be for any particular size community. Therefore, flow differences based upon population variability can be factored into the safety factor chosen for the design. Figures 6, 7 and 8 illustrate how this data can be useful in projecting a design flow per household, or for an entire community. For the purpose of this illustration, a per capita flow of 60 GPD was used.

Note that statistically this data becomes much less useful with small numbers of homes because the sample size is too small to be statistically predictable. Notice from Figures 6 and 7 that as the number of homes approaches zero the confidence intervals widen off the chart. For instance, for a sample size of only one home, an accurate statistical prediction cannot be made. In such cases the designer may get some design guidance from census information as to how many homes in that community have a household occupany of say 5 or more people to help him or her in quantify the risk for design purposes.

COMPARISON WITH ACTUAL PROJECTS

So, how does this method of predicting project flows stack up against actual field measurements? To answer this question, the actual flow records from 14 different residential projects located in southern Michigan were obtained. Each of the projects had a means of measuring the actual wastewater quantities being treated at the treatment site. The type of collection system varies --- some with grinder pumps and pressure sewer, some with S.T.E.P. systems, and some used gravity sewers. With two exceptions, the data available was only the total annual flow that could be averaged to estimate the average daily flow. Two of the projects were equipped with telemetry panels that logged daily flow information.

Table 2 lists the actual measured data from these 14 sites, ranging in size from 7 homes to 272 homes. The average daily flow from the total project is listed, together with a calculated average daily flow per home. The right side of Table 2 illustrates a comparison of the actual recorded flows with the flow that would have been predicted using the census methods described above. The population of the development is first estimated using the census data of the surrounding community. This number is multiplied by 60 GPD per capita (the flow chosen for this illustration) to obtain an estimated average daily flow for that size community. This table then shows the difference between the actual and the estimated flows. A red number in that column indicates the actual measured flow was larger than what the predicted average flow would have been based upon our assumed per capita flow and estimated population. A black number indicates our predicted flow was higher than the actual measured flow. Readers should keep in mind that this table does not illustrate confidence intervals, nor does it illustrate peaking factors. It is a simple comparison of predicted and measured averages.

Superimposed on Figure 8 are the data points from a full year of data from each of the 14 operating facilities. Some of the numbers from existing facilities are so close that the points actually overlap and hide one another at this scale. One of the projects was too large for this graph, so the information is listed below Figure 8.

As stated above, the projects listed had a variety of collection systems. The systems that used gravity collection, or otherwise were vulnerable to infiltration and inflow, would have measured flows that included the extra leakage. In addition, some of the systems utilized uncovered recirculating sand filters at the treatment works. These components do allow precipitation to enter the system prior to flow measuring devices, and the extra water would be recorded as flow. Without some investigative effort (considered beyond the scope of this paper), it is not possible to quantify the extra infiltration and inflow. Obviously, the designer must consider these extra sources of flow unless they are somehow prevented from entering the system by design.

As one compares the actual recorded flows with the statistically predicted flows shown on Figure 8, a casual observer could get the impression that the smaller systems generated flows closer to the average predicted numbers than the larger systems. The author suggests that system infiltration and inflow may be an explanation for this phenomenon. Remember --- a per capita average daily flow of 60 gallons per person was used to generate Figures 6, 7, and 8. This number is on the high side of numbers found in the references, and seems to over-estimate flow experienced in the larger systems mentioned here. But, proportionately, flows recorded for the smaller systems seem to meet or exceed this number. In other words, smaller systems seemed to produce more flow per capita than do the larger systems. The author suggests that the observation can also be explained by the fact that infiltration and inflow may have a larger impact on recorded flow for the smaller systems than for the larger systems. This is supported by a more detailed analysis of the daily flow records of two of the systems that have recirculating sand filters. Brooks River Landing and River Rock Landing are projects located near Lansing, Michigan, for which the author has several years of daily flow records. Flow spikes are readily observable in these flow records during precipitation events.

As one can see, the actual data from all 14 of these existing communities falls within the expected flow range (using 60 GPD/capita) predicted by the methods described earlier. It would appear from this information that the predicted average flow could safely be used for projects of over 20 homes with a safety factor allowance of the designer's choice for peak days.

SAFETY FACTORS

Described above is the author's suggestion for estimating a design average flow for projects based upon probabilities. The choice of choosing a safety factor for any particular component of the collection or treatment works should follow the same type of rational analysis. Designers should ask themselves one key question: "What would happen if the flow through any particular component is greater than the design flow for that component?" The follow-up analysis of that answer should take a rational path as follows:

- Those components that would cause a system "failure" in the sense that the system would be incapable of performing within compliance limits need to be sized substantially larger than the highest expected flow, leaving room for predictive error.
- Those components that would still perform, but would result in some reduced system performance under higher flow conditions may or may not need to be up-sized. The designer needs to analyze how often and how long the higher flow conditions might occur, and balance that against the buffering ability of the system to handle such flow conditions. He or she also needs to consider the cost-effectiveness of enlarging the capacity of that component.
- Those components that would have negligible impact on overall system performance when experiencing occasional higher-than-expected flow conditions do not normally justify up-sizing for peak flow conditions, particularly if those higher flow conditions are rare occurrences.

Table 3 is an example of the ratio of measured peak flow compared with the average measured daily flow for one cluster system located near Lansing, Michigan. This is one of the facilities that the author has logged daily flow data over several years via telemetry at the treatment site. Shown in Table 3 are two full years of data from the third quarter of 2002 through the second quarter of 2004. Also shown is the highest daily flow measured during each quarter, and the ratio of that one-day high, to the quarterly average.

This system is comprised of a recirculating sand filter, followed by an intermittent sand filter. While the collection system in this housing development is watertight, any precipitation on the R.S.F. is captured in the system and included in the measured flow. A careful review of precipitation records shows a strong correlation between rainfall events and the peak flow occurrences. Designers are cautioned to consider such characteristics when interpreting and applying this information to other projects. One might note, however, that if 60 GPD per capita were used for the design flow from this typical residential neighborhood in southern Michigan, the peak daily flow exceeded that number by a factor of 1.6, or less, for these two full years of record!

CONCLUSIONS

The use of Census data from the smallest local jurisdiction in which a new residential community is to be located can be helpful information in predicting the expected population of that new community. Using that predicted population with the appropriate per capita flow is a rational way of determining projected wastewater flows from a watertight collection system for that community. Designer care should be taken to account for any expected lifestyle differences from the surrounding community being used as a comparison. The appropriate safety factor should be used to accommodate daily flow variations that will normally occur.

Table 1. Demographics of various communities with a range of income levels

No.	Community	Population	Median Household Income	Avg. No. of Rooms	Avg. No. of Bedrooms	Avg. Household Size
1	Flint	124,943	$28,015	5.2	2.5	2.51
2	Detroit	951,270	$29,526	5.5	2.5	2.77
3	Lansing, MI	119,128	$34,833	5.2	2.4	2.39
4	Sanilac County	44,547	$36,870	5.6	2.7	2.60
5	Southfield	78,296	$51,802	5.2	2.4	2.27
6	Bath Twp.	7,541	$53,881	5.9	2.9	2.68
7	Meridian Twp.	39,116	$55,203	5.6	2.6	2.36
8	Grand Blanc Twp.	29,827	$59,858	5.9	2.8	2.50
9	Rochester Hills	68,825	$74,912	6.2	2.9	2.59
10	Grosse Pointe	5,670	$81,111	7.0	3.1	2.37
11	Grosse Pointe Twp.	2,743	$114,863	8.4	3.6	2.69
12	Bloomfield Hills	3,940	$170,790	9.0 +	3.6	2.45
	Total Population	1,475,846			2.8	2.52 (Avg.)

Figure 1.   Median household income by community

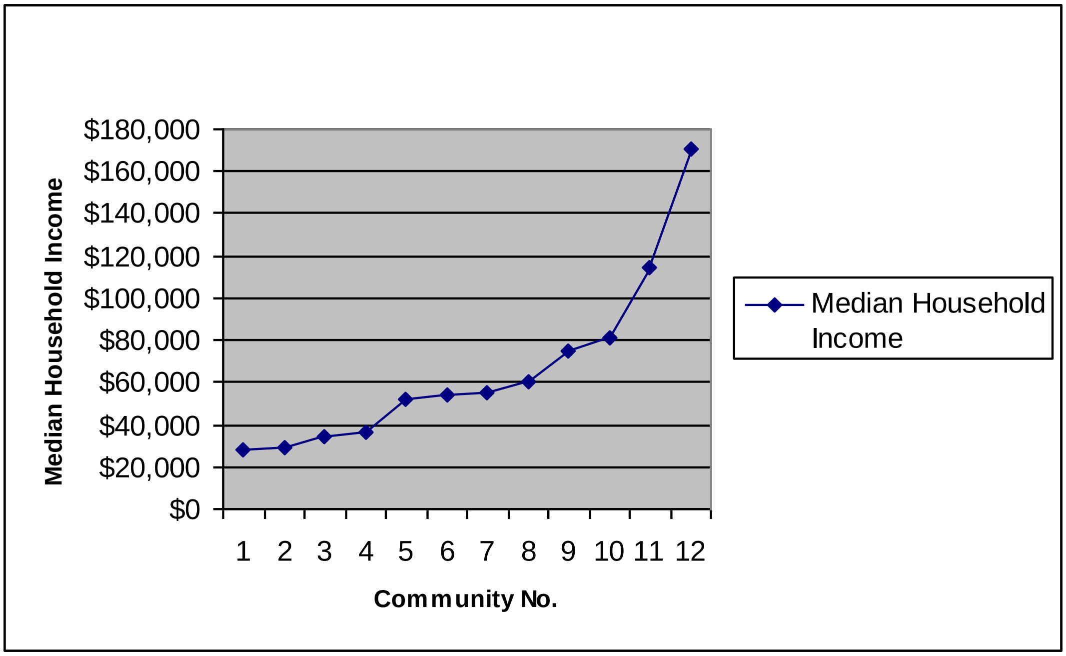


Figure 2. Average number of rooms per home by community

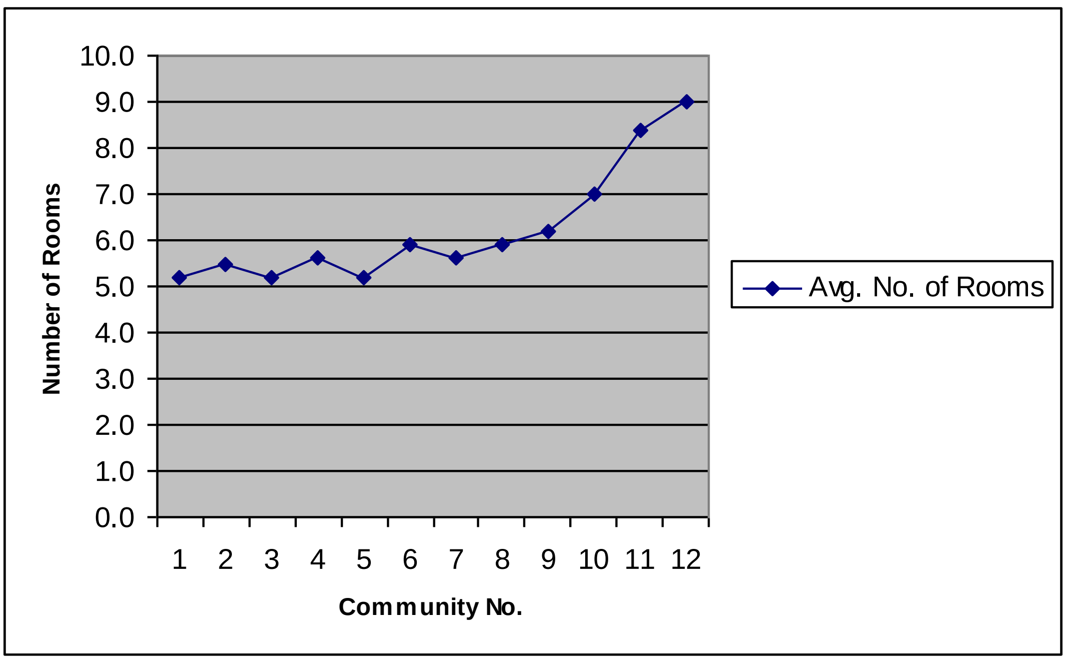


Figure 3. Average number of Bedrooms per home by community

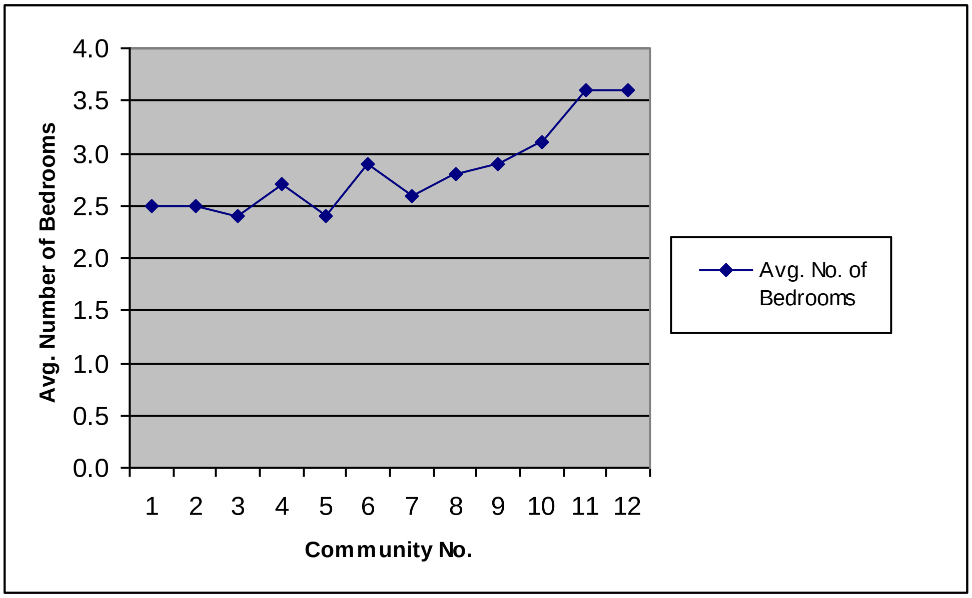


Figure 4. Average household size by community

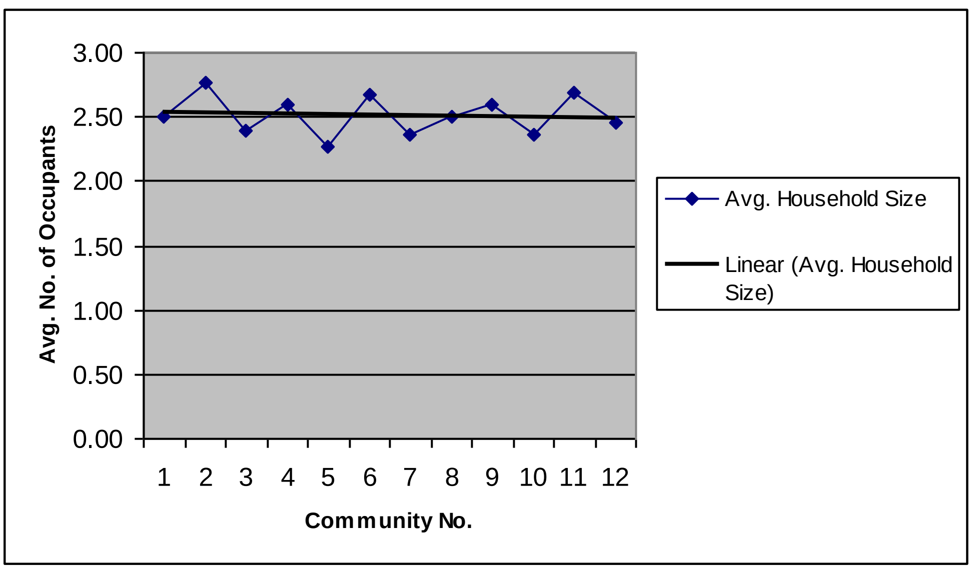


Figure 5. Spreadsheet used in applying census data to a project.

Livingston County - Handy Township

Household Size - 2000 Census

	Number	
1-person household	547	**22.1%**
2-person household	726	**29.3%**
3-person household	453	**18.3%**
4-person household	427	**17.2%**
5 -person household	219	**8.8%**
6-person household	51	**2.1%**
7-or-more person household	54	**2.2%**
Total Households	**2477**	**100.0%**
Average Household Size	2.83	

Applying This Information To Summerbrooke

Using Handy Township Data

	Number		People
1-person household	9	22.1%	9
2-person household	12	29.3%	24
3-person household	7	18.3%	22
4-person household	7	17.2%	28
5-person household	4	8.8%	18
6-person household	1	2.1%	5
7-or-more person household	1	2.2%	6
Total Households	**41**	100%	

Total Anticipated Population **113** **2.76** **People per household**

Total Anticipated Average Flow = 113 x 60 GPD/Capita = 6798 GPD

Total Anticipated Peak Flow = 113 x 75 GPD/Capita = 8498 GPD

Table 2. Comparison of Actual Measured Flows with Predicted Flows using Census Data for the Surrounding Community

Site Information			Measured --- 2003			Estimated based upon Census Information			
Sewer District	Type	Initiated	No. Homes	Meas. Average Daily Flow	Daily Flow/Home	Flow Estimate Using Census Data 60 GPD/Cap	Difference from Predicted @ 60 GPD/Cap.	Est. Population	Est. of Meas. Flow per capita
Deer Creek	GRAVITY/SAND FILTER/BED	1997	7	1,779	254	1227	-552	20	89
Eagle Ravines	GRAVITY/BED	1992	8	1,509	189	1402	-107	23	66
Greenock Hills #3	GRINDER/BED	1990	8	1,679	210	1341	-338	22	76
Hidden Ponds	GRINDER/BED	1995	14	3,748	268	2493	-1,255	42	89
Brooks River Landing	STEP/RSF/TRENCHES	1994	15	1,051	70	2311	1,260	39	27
River Rock Landing	STEP/RSF/SURFACE WATER	1997	19	1,935	102	2928	993	49	39
Highland Hills	STEP/BED	1994	19	2,534	133	3329	795	55	46
Long Lake Pines	GRAVITY/SAND FILTER/BED	1996	19	2,730	144	3420	690	57	48
Orchard Estates	GRINDER/BED	1989	23	3,034	132	3902	868	65	47
Oaks At Beach Lake	STEP/SAND FILTER/BED	1995	23	4,651	202	3855	-796	64	73
Portage Bay Highlands	STEP/SAND FILTER/BED	1995	27	3,206	119	4731	1,525	79	41
Sandy Creek	GRINDER/SAND FILTER/BED	1996	34	5,082	149	5542	460	92	55
Runyan Lake	STEP/BED	1987	183	23,250	127	32588	9,338	543	43
Tyrone Lake	STEP/BED	1985	272	31,252	115	47102	15,850	785	40
		Totals	671	87,440	130				

Note: Numbers in red above indicate projects where measured flows would have exceeded the estimated average daily flows using 60 GPD/capita and a population estimate based upon census data.

The number in black in the "Difference" column is the amount the estimated daily flow using a census estimate would have been larger than the actual average measured flows.

Figure 6. Statistical probability of household size for a sample community

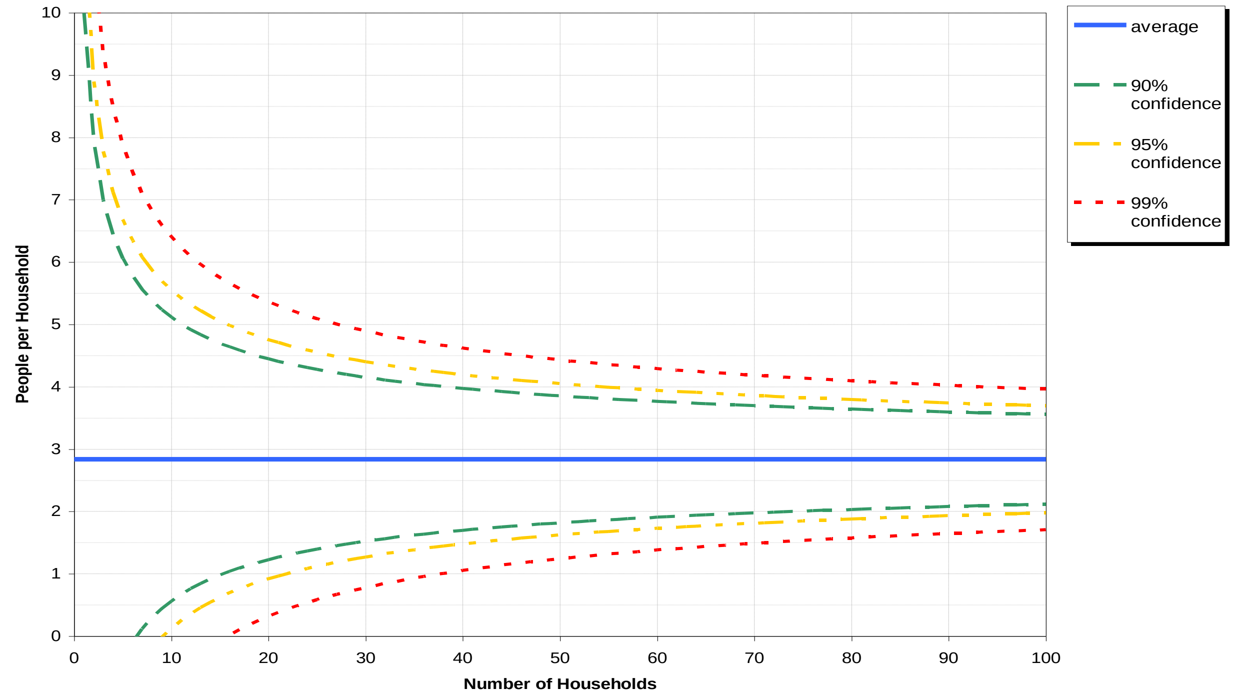


Figure 7. Statistical probability of flow per household for a sample community

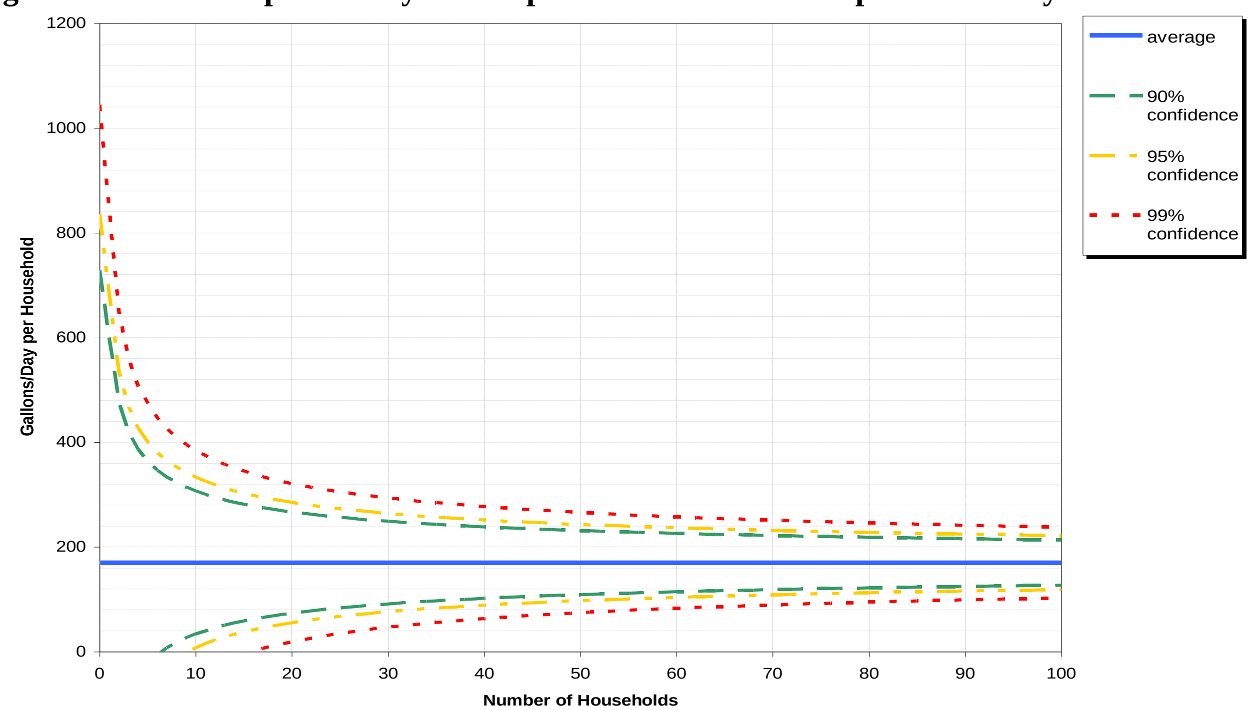
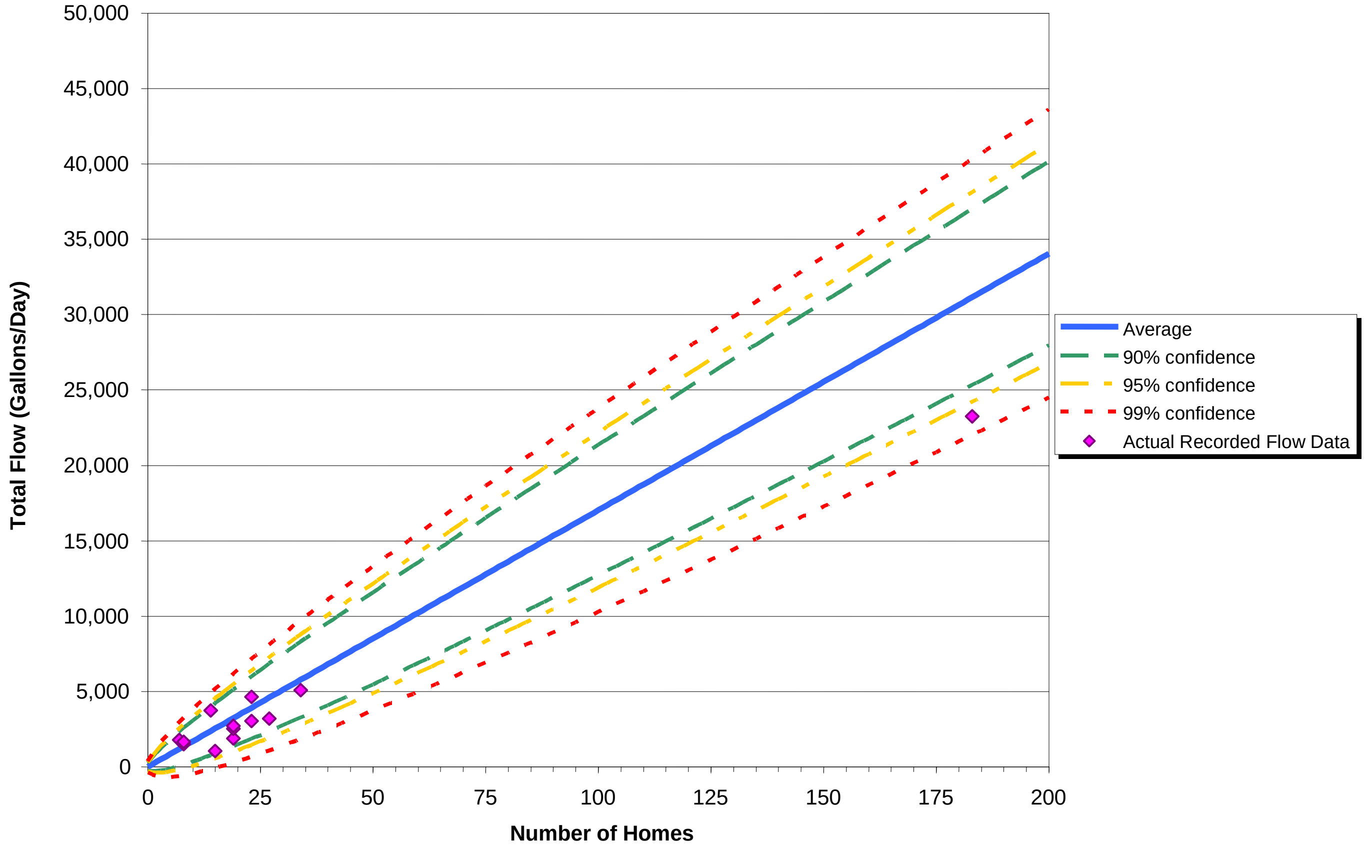


Figure 8. Statistical estimate of total projected flows for a sample community



Note: One existing project with 272 homes and an average daily flow of 31,252 gallons is not shown.

Table 3. River Rock Landing - Windsor Twp., Eaton County, Michigan

Flow Analysis, Treatment Type --- Sand Filters

Quarter	Year	Average total flow per day	No. of occupied homes	Estimated population	Average daily flow GPD/person	High daily flow	Ratio of High flow to average	Peak daily flow GPD/person
2nd	2004	1935	19	49	39	4138	2.14	84
1st	2004	1769	18	46	38	3046	1.72	66
4th	2003	1695	17	44	39	3482	2.05	79
3rd	2003	1349	15	39	35	2090	1.55	54
2nd	2003	1247	13	34	37	2558	2.05	75
1st	2003	1468	11	28	52	2590	1.76	93
4th	2002	546	9	23	24	1056	1.93	46
3rd	2002	544	9	23	24	1468	2.70	64

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SILVER LAKE NITROGEN REMOVAL REACTOR PILOT STUDY RESULTS

PARAMETERS

Date	Ammonia - N (mg/l)			Nitrate - N (mg/l)			Nitrite - N (mg/l)			TKN (mg/l)			TIN (mg/l - Calc.)				TBOD-5 (mg/l)		Total P (mg/l)			Total SS - (mg/l)		Effluent D.O. (ppm)	Effluent pH	Effluent Temperature		
	Influent	Effluent	% Removal	Influent	Effluent	% Removal	Influent	Effluent	% Removal	Influent	Effluent	Change	Influent	Effluent		% Removal	Influent	Effluent	Influent	Effluent	% Removal	Influent	Effluent	Effluent	Effluent	°C	°F	
12/30/15				23.4	11.2	52.1%																						12/30/15
1/5/16				23.8	14.0	41.2%																		0.53		6.0	42.8	1/5/16
1/11/16	6.50	3.00	53.8%	21.9	5.4	75.3%	0.0	0.0	NA	7.6	5.4	2.2	28.4	8.4		70.4%	11.0	10.0	5.4	5.2	3.7%	3.0	6.0	0.76	6.72			1/11/16
1/18/16				23.9	2.3	90.4%								5.3	*													1/18/16
1/25/16	0.06	0.15	-150.0%	28.4	9.1	68.0%	0.0	0.0	NA	0.7	1.7	-1.0	28.5	9.3		67.5%	ND	6.7	5.8	5.6	3.4%	1.0	9.0	0.93	6.70	9.3	48.7	1/25/16
2/1/16				24.9	3.7	85.1%								3.9	*									0.79	6.69			2/1/16
2/8/16	0.14	0.10	28.6%	24.6	2.2	91.1%	0.0	0.0	NA	0.8	1.5	-0.7	24.7	2.3		90.7%	ND	11.0	7.0	6.1	12.9%	1.0	9.0	1.05	6.66	11.1	52.0	2/8/16
2/16/16				23.0	10.9	52.6%								11.0	*									1.01	6.86	7.5	45.5	2/16/16
2/23/16	0.04	0.19	-375.0%	27.9	5.8	79.2%	0.0	0.0	NA	0.1	1.7	-1.6	27.9	6.0		78.6%	ND	5.0	7.9	7.3	7.6%	1.0	1.0	1.11	6.77	9.8	49.6	2/23/16
3/1/16				32.5	8.4	74.2%								8.6	*									1.41	6.78	10.3	50.5	3/1/16
3/9/16	0.05	0.20	-300.0%	31.9	5.6	82.4%	0.0	0.0	NA	0.7	2.1	-1.4	32.0	5.8		81.8%	ND	4.8	8.0	7.8	2.5%	ND	ND	1.25	6.75	16.2	61.2	3/9/16
3/14/16				38.0	1.3	96.6%								1.5	*									1.46	6.80	15.6	60.1	3/14/16
3/21/16				23.6	2.8	88.1%								3.0	*									0.51	7.27	13.8	56.8	3/21/16
3/31/16				20.5	2.0	90.2%								2.2	*									0.23	7.03	15.2	59.4	3/31/16
4/4/16	2.51	0.81	67.7%	15.3	1.0	93.5%	0.0	0.0	NA	2.9	2.6	0.3	17.8	1.8		89.8%	5.8	23.0	3.2	3.0	6.5%	ND	14.0	0.46	6.90	12.9	55.2	4/4/16
4/11/16				12.0	2.1	82.5%								2.9	*									0.38	7.21	13.0	55.4	4/11/16
4/19/16				23.3	0.0	100.0%								0.8	*									0.33	7.09	17.6	63.7	4/19/16
4/26/16				28.3	1.1	96.1%								1.9	*									0.37	7.58	13.0	55.4	4/26/16
5/10/16				22.4	0.0	100.0%								0.8	*									0.64	7.37	12.3	54.1	5/10/16
5/16/16				23.2	0.7	97.0%								1.5	*													5/16/16
5/24/16				30.9	0.7	97.7%								1.5	*									0.50	7.42	14.6	58.3	5/24/16
5/31/16				30.9	0.0	100.0%								0.8	*									0.23	7.16	17.7	63.9	5/31/16
6/7/16	1.98	0.33	83.3%	24.9	1.7	93.2%	0.0	0.0	NA	2.1	1.5	0.6	26.9	2.0		92.4%	4.7	21.0	5.2	5.1	1.9%	ND	9.0	1.26	6.63	16.4	61.5	6/7/16
6/20/16				39.1	7.6	80.6%								7.9	*									0.30	6.95	20.5	68.9	6/20/16
7/11/16				44.5	9.0	79.8%								9.3	*									0.53	6.51	20.5	68.9	7/11/16
7/19/16	2.26	0.51	77.4%	44.3	7.5	83.1%	0.0	0.6	NA	2.0	2.0	0.0	46.6	8.6		81.5%	6.0	9.0	9.3	8.2	11.8%	NA	NA	0.49	6.74	21.5	70.7	7/19/16
7/29/16	0.54	0.39	27.8%	48.2	10.1	79.0%	0.0	1.7	NA	0.3	1.6	-1.3	48.7	12.2		75.0%	0.0	0.0	9.4	8.5	9.6%	NA	NA	0.54	6.73	22.5	72.5	7/29/16
8/15/16				38.0	4.2	88.9%								6.3	*									1.19	7.56	22.9	73.2	8/15/16
9/7/16				26.8	1.8	93.3%								3.9	*									0.75	6.66	22.3	72.1	9/7/16
10/26/16				30.1	1.4	95.3%								3.5	*									0.92	6.36	15.6	60.1	10/26/16
11/11/16				32.1	5.9	81.6%								8.0	*									0.38	6.71			11/11/16
11/21/16				28.2	10.4	63.1%								12.5	*									0.75	6.90	12.0	53.6	11/21/16
	Average - all data			28.5	4.7	83%							31.28	5.12		81%												
	March and April Averages			25.0	2.7	89.2%							24.9	3.2		86%												
	After March 15th Average			29.3	3.5	88.1%					After March 15th Average			4.6														

* Used last available values for ammonia and nitrite

Septic Systems for Groundwater Protection: A Literature Review

University of Minnesota

Introduction

Millions of people rely on septic systems for wastewater treatment and dispersal. Properly designed, installed and maintained septic systems are reliable and effective in providing quality treatment. One distinction of these systems is that they discharge treated wastewater to ground water. Since ground water is often used as a source of drinking water without any treatment, it is essential that these systems be designed to protect ground water for this use. This paper is intended to provide a short but thorough summary of key scientific literature related to this topic.

Waterborne Disease Hazards from Septic Systems

Household wastewater contains a variety of disease causing organisms. The potential for polluted water to cause illness has been understood for thousands of years and water treatment processes have been used for at least 4,000 years (Hoff and Akin, 1983).

The effects of these diseases range from short-term discomfort and nuisance (e.g. 24-hour flu symptoms), to chronic disability, to death. For example, "Brainerd Diarrhea" is a relatively new health threat with symptoms that include dramatic, urgent watery diarrhea persisting for many months and a failure to respond to antibiotics. (Osterholm et al., 1986; Levine et al., 1991) In the first recorded outbreak, the illness lasted at least one year for 75% of the patients. Sanitation for the prevention of disease is increasingly important as we enter what has been described as the "post anti-biotic era" with emerging diseases that do not respond to antibiotics.

Viral Pathogens

It is arguable that any virus pathogenic to humans could be found in wastewater. (Slade and Ford, 1983).

Protozoal Pathogens

Disease causing protozoa include *Giardia lamblia* and *Cryptosporidium*. *Cryptosporidium* became famous when an outbreak in Milwaukee in 1993 caused over 400,000 people to get sick and dozens of people to die. (Moore et al., 1993; Gurwitt, 1994) *Giardia* has been the most commonly identified source of waterborne disease outbreaks in recent years. Prominent symptoms include diarrhea, abdominal cramps, fatigue, weight loss, flatulence, anorexia, and nausea. Removal of protozoa is an essential part of wastewater treatment.

Evidence of Pathogens from Septic Systems Contaminating Ground Water:

Because of the high cost and difficulty of testing for a wide range of potential pathogens, indicator organisms have historically been used to indicate the level of disinfection of water. Counts of total coliforms, fecal coliforms, and fecal streptococci are commonly used. However, there have been a number of waterborne disease outbreaks from contaminated drinking water that met the drinking water standard of zero fecal coliforms. (Goyal, 1983; Hoff and Akin, 1983; Levine et al., 1991;

West, 1991) These include cases of Giardia, Cryptosporirosis, and Hepatitis A virus. The isolation of viruses from 10 of 23 (43.5%) samples of" bacteriologically safe" potable water supplies further shows that bacteriologic indicators are not adequate to monitor for viruses in water. (Goyal, 1983) There is not a close correlation between bacterial counts and viral levels. (Hoff and Akin, 1983; Slade and Ford, 1983)

Fecal coliform will always be present in wastewater containing feces. However, for virus to be present there must be an infected host. For municipal wastewater treatment systems, there is a higher probability of any given virus being present due to the larger population being serviced by the system. However, there will be a higher concentration of virus particles in a septic system serving an individual home when there is an infected person present because there will be no dilution from others who are uninfected.

Viruses vary greatly in their ability to survive treatment processes. However, it has been repeatedly established that many viruses are more resistant to environmental conditions and sewage or water treatment processes than the indicator organism fecal coliform.

The protozoa *Giardia lamblia* and *Cryptosporidium* are also particularly resistant to conventional treatment methods and it is even more common for these to occur in the absence of the indicator fecal coliform. For the years 1991-92, for waterborne disease outbreaks with bacterial, viral, or unknown causes, coliform testing was positive 88% of the time. However, for protozoal outbreaks, sampled water contained coliforms in only 33% of the cases.

Direct evidence of health impacts:

The U.S. Center for Disease Control in cooperation with the U.S. Environmental Protection Agency has maintained the Waterborne Outbreak Surveillance System to investigate, document and report waterborne disease outbreaks since 1971. Illnesses reported by the Waterborne Outbreak Surveillance System probably represent only a small proportion of all illness. (Levine et al., 1991) Outbreaks associated with small individual water systems are the most underreported because they generally involve small number of persons.

Failed septic systems have historically been a major, and possibly the leading cause, of waterborne disease k associated with contaminated ground water. (United States Environmental Protection Agency, 1977) For the years 1971-82, overflow or seepage of sewage through soil, limestone, and fissured rock, primarily, from septic systems was responsible for 43% of the outbreaks caused by the use of contaminated, untreated well water. (Craun, 1985) In another 35% of these outbreaks, insufficient information was available to determine a definite source.

Some specific examples of the many documented disease outbreaks either definitively or possibly associated with failed septic systems include an outbreak of diarrhea associated with Norwalk virus among 181 of 331 participants in an outing held at a South Dakota campground on August 30 and 31, 1986 (Center for Disease Control, 1988), an outbreak of Norwalk gastroenteritis in Tate, Georgia in 1982 where approximately 500 persons became ill (Center for Disease Control, 1982), an outbreak of typhoid fever occurred in May 1972 in Yakima County , Washington, involving

Salmonella typhi (McGinnis and DeWalle, 1983). Numerous other disease outbreaks have been recorded. (Craun, 1979; Bloch et al., 1990; Lawsonetal., 1991)

Other evidence of ground water contamination:

In some regions of the country, ground water contamination from failed septic systems is very prevalent. A study in South Carolina found that 92.5% of 460 wells sampled in a three county area tested positive for total coliforms, fecal coliforms or fecal streptococci. (Sandhu et al., 1978) Failed septic systems were implicated as the most common source of contamination.

A summary of bacterial transport through soil, adapted from Crane and Moore (1984), with additions. It may be accurate to rename this table, "A summary of studies of bacterial transport through wet or saturated soils." The first five studies listed were of dispersal systems that were in direct contact with ground water. The travel distance was probably underreported in early studies due to limitation& in laboratory techniques of the time. For instance, in Caldwell (1938), B. coli was only found to move about 10 feet, but pungent manurial odors could be detected in the ground water to a distance of over 300 feet.

Vaisman studied gross contamination of a water supply by cesspools installed in contact with a highly permeable aquifer with rapid ground water flows of 30 to 60 m/day. Anan'ev and Demin (1971) studied the impacts of a municipal wastewater pond built in sands with gravel and pebble. Allen and Morrison (1973) studied the movement of bacteria through fractured bedrock above and below the level of saturation.

In summary, these studies show that bacteria can move considerable distances under saturated conditions in the saturated zone of soils.

Data on the movement of viruses through soils and ground water are much more limited, but Table 4 summarizes some travel distances that have been recorded in the literature. It is clear that under certain conditions, viruses can travel significant distances through the subsurface.

Treatment Variables:

By far the most important factor in treatment is the soil water content. To be more specific, unsaturated flow is essential to effective treatment. The predominance of this variable has been reported and discussed by numerous authors. (Baars, 1957; Griffin and Quail, 1968; Romero, 1970; Schwartz and Bendixen, 1970; Bouma, 1975; Ziebell et al., 1975; Wong and Griffin, 1976; Bicki et al., 1984; Crane and Moore, 1984; Lance and Gerba, 1984) (Reddy et al., 1981) Despite this, a number of examples could be found in the literature, which indicates an incomplete understanding of the importance of this factor on the part of the writers.

There are several reasons unsaturated soil is essential including: 1) better soil contact with the wastewater for better adsorption and reaction of pollutants with soil; 2) greater detention time in the soil; and 3) improved soil aeration for aerobic treatment.

The Biomat

The biomat is a layer of organic matter where wastewater soaks into the soil. It is extremely beneficial in removing potential pathogens from the wastewater by providing both a physical filter and biological barrier. (Magdoffand Bouma, 1975) If this layer becomes too dense or thick, it will cause the system to fail to receive wastewater.

This layer's formation and degradation are concurrent processes that result from the input of organic matter into the anaerobic trench and the degradation of the layer because of aerobic decomposition on the side of the biomat facing the unsaturated soil. These processes are very complex and are a function of many variables (Jenssen and Siegrist, 1990; Siegrist et al., 1991), including: the amount and strength of the waste entering the soil treatment system (Siegrist, 1987a); dosing and resting (McGauhey and Krone, 1967; Converse et al., 1975; Siegrist, 1987b) (Otis et al., 1977) (Hargett et al., 1982); both soil and wastewater temperatures, the shape of the soil absorption area, soil depth, texture (Hantzsche et al., 1982), and particle and pore size distributions (Bouma et al., 1972; Jenssen and Siegrist, 1990), and structure (Tyler et al., 1991).

Depth to water table

If the water table is too close to the soil treatment area, it will moisten the soil below the biomat and slow flow into the soil. A number of studies have shown that a separation is needed from the water table to provide adequate drainage. (McGaughey and Krone 1967; Winneberger et al., 1961, 1962; Klein et al., 1962; Hendixen et al., 1963). For typical agricultural soils in California, this distance was found to be 2.5 to 3.0 feet. Schwartz found a direct relationship between depth to water table and the life of drainfields (Schwartz and Hendixen, 1970). Mahuta and Hoyle, 1991, also studied the effects of the water table on soil aeration. In summary, an adequate separation to the water table is needed to allow aeration of the soils to prevent the biomat from becoming overly restrictive to the flow of the wastewater.

Wastewater application frequency

Another important factor that affects the biomat and its resistance to flow is the dosing frequency of the wastewater. Hargett et al. studied the influence of the loading rate and application pattern, on soil clogging. (1982) They concluded that dosing results in higher infiltration rates as long as the application rate is not so high as to create persistent ponding. Another study using very high loading rates, had found that soil treatment systems dosed six times per day had approximately one-half the hydraulic life expectancy of those dosed daily, and one-third the life expectancy of those dosed weekly; again showing that more frequent dosing with the same amount of wastewater will increase hydraulic resistance of the biomat. (Schwartz and Hendixen, 1970) Design recommendations for four doses per day for rapidly permeable soils where an enhanced biomat is needed for improved treatment, and once per day or less for other soils to prevent the formation of an excessive biomat, were recommended by Houma. (EPA, 1978)

Otis et al. discussed the issues of biomat formation at length and made specific design recommendations to account for the effects of application strategies. (Otis et al., 1977) They also discussed some earlier work by Kropf et al. (1975) that reported that the total flow through continuously ponded columns was more than in columns subjected to intermittent flooding. Similar results were reported elsewhere. (Perry and Harris, 1975; Jawson, 1976) These researchers found that columns characterized by short-term aerobic and anaerobic conditions might result in reduced infiltration due to the formation of an intense biomat. This indicates that frequent dosing may form a denser biomat more quickly than continuous ponding. At least three to four weeks of resting was required to restore infiltration capacity. (Perry and Harris, 1975)

Long term resting has been found to restore the infiltrative capacity of soil treatment systems. Jenssen and Siegrist propose that the design of soil treatment systems view hydraulic failure of the soil treatment area as a planned for event such that a second soil treatment area is available to use while the first soil treatment rests and recovers. (Jenssen and Siegrist, 1990)

One form of long term resting is seasonal use. This is a common phenomenon in Minnesota at lakeshore properties. The intermittent use of these properties, not only seasonally, but also often only on summer weekends, inhibits the formation of the biomat. The treatment effectiveness of seasonally used systems was studied by Postma et al. (1992) Biomats were not found in systems that were dissected at the end of summer occupancy. It was found that although these systems had more than 1.5 m of unsaturated soil beneath the bottom of the soil treatment system, elevated numbers of indicator organisms were found both 2 m and 6 m away from these systems in the ground water. These findings again highlight the importance of the biomat to effective treatment.

Wastewater strength

The growth of the biomat is also a function of the strength of the wastewater.

Regarding which wastewater characteristics are likely to be the most important, Okubo and Matsumoto reported soluble organic carbon (SOC) to be a key factor. They also reported organic suspended solids concentrations to be directly related to biological clogging rates. Siegrist discussed the importance of various factors, and suggested that total kjeldahl nitrogen (TKN) and total biochemical oxygen demand (ultimate carbonaceous and nitrogenous, tBOD) as well as the sum of tBOD and total suspended solids (TSS) are key factors in soil clogging. (Siegrist, 1987a)

Temperature

Generally speaking, higher temperatures will increase break down of the biomat. Lower temperatures will allow the biomat to form more quickly. (Otis, 1985) (Kropf et al., 1975; University of Wisconsin, 1978; Simmons and Magdoff, 1979)

Treatment Processes:

Physical treatment processes:

Physical straining, gravity and interception effect treatment in the soil. These processes can be better understood in the context of the relative size of the various particles and of the soil pores (Matthess and Pekdeger, 1985). Bitton gives a typical virus size as 18- 25 nm versus the 20 to 250 nm size given below(Bitton, 1980). An EP A publication states that "viruses linked to waterborne disease have protein coats that provide protection from environmental hazards and range in size from 0.02 to 0.09 um" or 20 to 90 nm (Burke, 1993). This same publication states that pathogenic bacteria range in length from approximately 0.4 to 14 um and range in width from 0.2 to 1.2 um. It should be remembered that viruses and bacteria are commonly adsorbed to wastewater solids, or aggregate to themselves (bioflocculate) under many environmental conditions.

It appears that smaller bacteria and viruses will not be readily filtered out of the solution by the soil even at lower moisture contents. Cogger arrived at this conclusion based on his evaluation of field data of microbial treatment in soil treatment areas. (Cogger, 1988) It should be recognized that bacteria can flocculate, and that bacteria and viruses can and do associate with solids in the waste stream, making these microorganisms more subject to straining. (Hoffand Akin, 1983; Matthess and Pekdeger, 1985; McDowell-Boyer et al., 1986; Vilker et al., 1978) In addition, the biomat contains polysaccharides and polyurinides, which will cause the layer to be sticky to microorganisms.

Infiltration of rainwater can dislodge and move previously adsorbed viruses. (Rao and Melnick, 1986) Organic substances such as humic and fulvic acids make viruses more subject to leaching. (Vaughn and Landry, 1983) (Powelson et al., 1991)

Flow rate has a major effect on treatment. In one study, increasing the filter rate from 0.2 m/hour to 0.4 or 0.5 m/hour resulted in a ten-fold decrease in virus removal in a soil column. (Hoff and Akin, 1983) Similarly, Green and Cliver found that shallow ponding for even a short period of2 minutes, resulted in 61% retention versus 96% retention under a drip method that prevented ponding in a sand column study. (Green and Cliver, 1975) Huysman reported lower rates of virus adsorption with higher flow rates. (Huysman, 1993) Lance and Gerba found that saturated flow through loamy sand resulted in 7% recovery of poliovirus at a depth of 10 cm, but unsaturated flow resulted in only 0.5% recovery. (Lance and Gerba, 1984) Gerba et al. (1991) provided a summary of the factors controlling viral survival and transport in the subsurface.

Jansons et al. showed the variation in treatability of different viruses. They found that indigenous echovirus from treatment plant effluent was found at a depth of9.0 m in ground water 14 m from a recharge basin, whereas seed poliovirus was not isolated beyond a depth of 1.5 directly below the basin. (Jansons et al., 1989a) It was found that other strains of echovirus as well as coxsackievirus type 84, untyped adenovirus and adenovirus type 3 also were more subject to leaching than the seed poliovirus. These studies indicate that indigenous or naturally occurring viruses can be more resistant to treatment compared to virus populations that are generated in a laboratory. This finding brings into some question the applicability of findings from much of the research to date on the treatability of viruses under field conditions.

It should be kept in mind that virus adsorption does not mean virus destruction. In fact, virus association with particles enhances virus survivability. (Hoff and Akin, 1983) Thus, at least some proportion of adsorbed viruses may be susceptible to leaching. This has been documented in a number of field studies, an early one being of a site used for irrigation of sewage. (Wellings et al., 1975; Yates, 1987a) After a period of heavy rain, viruses were found in ground water that had previously not had detectable virus.

Microbial die-off in soil:
The treatment of potentially pathogenic organisms in soils is related to both the retention and survival of those organisms. Reddy et al. (1981) provided a literature review and reported that the most important factors controlling the rate of die-off were temperature, moisture, pH, and method of waste application. (Many of the studies cited were regarding surface application of organic

wastes.) The general principle that higher temperatures and lower moisture contents induce higher die-off rates was shown.

Crane and Moore (1984) summarized die-off time for various bacteria. It has been reported elsewhere that pathogenic bacteria and viruses can survive in soils for up to five years under unusual conditions. (Romero, 1970; Bitton, 1975; Gerba et al., 1975; Reneau et al., 1989) In studies that are more recent it has been shown that after one year of exposure at 4°C, the inactivation of both Hepatitis A virus (HA V) and poliovirus 1 in mineral water was negligible. (Biziagos et al., 1988; Nasser, 1994) After 300 days at room temperature, HA V was still infectious.

Microbial activity has been found to influence the survival of bacteria and viruses in soil. In an early study, Kliger found that specific bacterial pathogens survived longer in sterile soils than in natural soils, indicating a biological role in treatment. (Kligler, 1921) Vaughn et al. (1983) noted studies by Sobsey et al. that showed that the survival of poliovirus 1 and reovirus 3 depended upon the microbial activity in the soil. They observed that viruses persisted longer in sterile soils than in non-sterile soils. In a comparative study of the survival of enteric viruses in soil under sterile and non-sterile conditions and aerobic and anaerobic environments, it was found that virus survival was much longer under sterile conditions in aerobic environments, but not under anaerobic conditions. (Hurst et al., 1980; Gerba, 1985) This shows that aerobic, but not anaerobic, soil microorganisms treat viruses. This finding further emphasizes the need for an adequate separation to the water table to maintain aerobic.

A key early study on factors affecting virus survival in soil was that of Hurst et al. (1980) Factors that were found to affect virus survival were temperature, soil moisture content, presence of aerobic microorganisms, degree of virus adsorption to soil, soil levels of resin extractable phosphorus, exchangeable aluminum and soil pH. Overall, temperature and virus adsorption to soil appeared to be the most important factors affecting virus survival. Virus survival was lowest near but not at soil saturation, with higher survival under extremely dry or supersaturated conditions.

The importance of temperature on virus survival is supported by many studies. Hoff reported a dramatic reduction in virus removal at lower temperature. (Hoff and Akin, 1983) A study to determine whether measurable chemical and physical factors, such as pH, nitrate concentration, turbidity, and hardness affected virus persistence at various temperatures found that the only variable that significantly effected the survival of all three viruses, was temperature. (Yates et al., 1985)

Building on this finding, Yates developed a model to find safe setback distances from septic systems to wells, using only ground water flow and ground water temperature data. (Yates and Yates, 1989) They estimated safe septic system setbacks to range from 15 m to over 75 m based on the variation in ground water temperatures and transmissivity .This study was done in the Phoenix area. The greatest required setbacks were for areas with relatively cool ground water with a temperature of 19° C. By comparison, ground water temperatures in Minnesota have been reported to average 9.9° C, with a standard deviation of 2° C. (Minnesota Pollution Control Agency, 1987) Ground water temperatures as low as 3° C were reported in this study. Wintertime temperatures of 13.5°C in the septic tank and 2.5°C in a mound system have been measured in Minnesota. (Machmeier and Mattson, 1978) Temperatures of 1.5°C were measured in Wisconsin. (Bouma et al., 1975) Similar temperatures have been measured in other studies. (Seabloom and Engeset, 1980) The temperature dependence of virus survival clearly has implications for septic system designs in northern climates.

Biochemical treatment processes:
Wilhelm et al. published an excellent analysis and description of the biochemical treatment of domestic wastewater in septic systems. (Wilhelmet al., 1994) They describe the treatment of wastewater as being driven by various microbially driven reactions. The capacity of the soil treatment system to treat wastewater can be evaluated in terms of the mass balance of wastewater oxygen demand and the supply of oxygen. The apparent correlation between biological clogging of sands and a decline in the measured oxidation-reduction potential in sands was noted some time ago. (Avnimelech and Nevo, 1964; Mitchell and Nevo, 1964; Nevo and Mitchell, 1967) (Jones and Taylor, 1965) This is more easily understood in the context of these biochemical reactions. Given the typical range of wastewater O2 demands (400 to 1500 mg/l) and application rates of wastewater of 1 to 5 cm/day, drain fields receive loads of approximately 4 to 75 g O2 demand/ M2 /day. This demand is reported similar to the O2 uptake of surficial soils and much higher than is usually found deeper in the horizon. (Hoff and Akin, 1983; Glinski and Stepniewski, 1985) This demand can also be compared to soil respiration rates that have been measured under field cropping conditions of approximately 8 g O2 demand/ M3 /day. (Hillel, 1980) The depth to water table is a major factor in how much oxygen can get to the wastewater. (Mahuta and Boyle, 1991)

Pathogen Removal
Because the mechanisms for removal differ, the treatment efficiencies of septic systems with respect to various types of pathogens will be reported separately.

Bacteria
The EPA Report, "Management of Small Waste Flows" (University of Wisconsin, 1978) is a compilation of an extensive series of studies of the Small Scale Waste Management Project of the University of Wisconsin--Madison. This project included the work of Bourna et al. (1972) on the soil absorption of effluent. Treatment of septic tank effluent was studied in 20 systems in 12 major soil types. The summary report from 1978 is often cited to show the treatment efficiency of soil treatment systems for bacteria. (University of Wisconsin, 1978) .This sandy soil did contain a biomat at the time of sampling.

The importance of the biomat in getting this level of treatment can be seen from a concurrent laboratory study using undisturbed 60 cm soil cores of Almena silt loam loaded with septic tank effluent at 1 cm/day. At that loading rate without a biomat, wastewater short-circuited through the larger pores and channels in the soil and significant numbers of bacteria were found in the column effluents. The loading rate was reduced to 0.3 cm/day and the bacteria counts decreased dramatically to below 2/100 ml. When the loading rate was restored to the 1 cm/day rate, high counts of bacteria in the effluent were found again.

The importance of larger pores in the transport of microorganisms was also shown by Smith et al., who found that 22- 79% of the added E. coli penetrated 28 cm of various intact soil cores compared to only 0.2- 7% penetration through the same thickness of sieved and repacked soil. (Smith et al., 1985) The importance of macropores, if a biomat is not present, can also be seen in the work of

Brown et al. (1979), who also found that treatment improved with time. This is in agreement with both the principles described above and with historic studies of these same issues of bacterial movement from soil treatment systems. For instance, Caldwell described a soil defense mechanism which was not explained, but which resulted in a decreasing distance from the privy that fecal bacteria were found in the ground water with time after a privy aged. (Caldwell, 1937, 1938; Caldwell and Parr, 1937) The formation of a biomat would fit with this finding.

The importance of both an adequate separation from the water table and of unsaturated soils for treatment of fecal bacteria has long been recognized by researchers, (though ignored too often in practice). Kligler published an excellent study including a thorough literature review of movement and survival of bacteria from privies, cesspools and septic systems in 1921. (Kligler, 1921)[1] He cited work by Dempster (1894), who concluded that moisture is the important factor in the persistence of indicator bacteria in soil, with organisms surviving much longer in moist than in dry soil. Also cited was the work of Pfuhl (1902) who reported that Bacillus typhosus survived for 88 days in moist soils and only 28 days in dry soil, and that Bacillus dysenteria behaved similarly, remaining alive for 101 days in moist soils and only for 12 days in dry soil. Firth and Horrocks (1902) as well as Sedwick and Winslow (1902) also published results and conclusions in agreement with the conclusion that moisture is an important factor and that the bacilli persisted for longer periods in damp than in dry soil.

Kliger went on to site the work of Whipple who studied the relation of pit privies to well pollution on the sandy soil of Long Island. (Whipple, 1902) He found that the "soil below a depth of 5 feet contained very small numbers of bacteria and was in fact almost sterile below a depth of 3 or 4 feet B. coli was invariably absent." He concluded that the distance of the base of the latrine from the water table is of greater importance than the distance of the well from the privy. Where contamination reached the water table, he found little reduction in wells 50 feet from the source compared to 10 feet from the latrine.

Kliger further cited the work of Eijken and Grijns (1917), who found that under tropical conditions in dry soil, B. coli was absent at 1/2 meter, but that during rain they can penetrate to a depth of 1.5 meters. This report also emphasized the importance of the water table not being "too high". Kliger went on to agree with Whipple in making the following conclusions. "The vertical distance between the source of pollution and the groundwater is the significant factor. The horizontal distance between the source of pollution and the well is of relatively slight importance except when there are underground channels or cracks in the soil."

In some regions of the country, the southeast in particular, these findings appear to have been historically ignored. For example, South Carolina was reported to have a required six-inch separation distance to the water table and only one foot from bedrock. (Burks and Minnis, 1994) This may give some insight into the widespread ground water contamination in some counties of South Carolina discussed earlier based on work by Sandhu et al. (1978)

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[1] This study may well have been the basis for the almost mythical recommendation for three feet of separation from the drainfield to the water table

Cogger et al. (1988) studied the performance of trench systems at 30 cm and 60 cm from the seasonal water table at loading rates of 1, 4, and 16 cm/day. It was concluded that the 60 cm design provided adequate microbial treatment throughout the study. This writer disagrees with this assessment in that the systems had measurable fecal coliform counts at all loading rates. The paper also concluded that separation to water table was more important than loading rate in achieving adequate treatment.

In previous work, Cogger and Carlile (1984) investigated 15 conventional and alternative septic systems in soils with high water tables. Inadequate treatment was again documented. There was a definite correlation between the percent of time the system was in the water table and the water quality. It was also concluded that vertical movement of waste constituents into deeper ground water is possible when gradients are small and there is no restriction to vertical movement.
This is by no means a complete list of studies regarding this topic. However, these show the effectiveness of bacterial removal under various conditions.

Viruses

Environmental virology is a relatively young discipline. Much more research has historically been done for bacteria than viruses. This is due to the high cost and difficulty of testing for viruses. Despite these challenges, there have been a handful of studies of virus movement in soils and ground water. Unfortunately, there has historically been relatively little work in the area of virus movement through unsaturated soils. (Gerba et al., 1991)

According to Vaughn et al. (1983), the first evidence of viruses in ground water, based on virus recovery rather than Mack et al. (1972) who found poliovirus type 2 from a 30.5 m deep well located 91.5 m from a septic system gave epidemiological evidence. Vaughn et al. (1983) found virus particles at a depth of 18 m, 67 m from a septic system in a shallow sandy aquifer. Virus concentration was not correlated to season nor was it correlated to the presence of indicator bacteria. The septic system used "leaching pools" that were located 3 m below grade. The depth of the system and the leaching pool design likely inhibited aeration of the system.

In another Texas study, enteric viruses were isolated from a well 25 m from a septic system. (Wang et al., 1981)

A key study of note was the work of Stramer as part of the Small Scale Waste Management Project at the University of Wisconsin -Madison, which was summarized by Yates, (1991) who is quoted extensively in the following summary. (Stramer, 1984; Yates, 1987b) Four septic systems were studied.

The first system consisted of a modified conventional septic tank serving a family of six. Poliovirus was introduced via an inlet baffle of the septic tank. Twelve days later, viruses were found in the seepage bed 53 m away. (The summary by Yates (1991) cited earlier, reported that the viruses moved at a rate of 4.5 ml/day implying that this was in ground water, which was not the case.

The second septic system was in saturated soils located on a lakeshore. The system received intermittent use, mainly on weekends. Poliovirus particles were put in the septic tank through the inlet baffle. Eight days later, poliovirus was isolated from ground water 12.3 m and 20.6 m from the septic system. One week later, viruses were found in greater numbers in these wells and in a well 28.8 m from the septic system. On days 43 and 71 after the virus was introduced, poliovirus was isolated from the lake water, 46.2 m from the septic system. Viruses were isolated from the lake sediment on day 109.

In the third system poliovirus was found 9.1 m from the drainfield thirteen days after being put in the system. No correlation could be found between the presence of indicator bacteria and the detection of viruses. On some occasions, bacteria were present but not viruses and visa versa. The fourth system was a mound system serving a family of four. Viruses were recovered in only one well, located 1 m from the point of wastewater application in the mound, on days 105 and 119. Here again, indicator bacteria did not correlate with the presence of viruses.

A more recent study, Anderson et al. (1991) investigated the movement of viruses from septic systems in Florida. The field study of septic systems in subdivisions was conducted in two phases. The first phase of work-involved ground water monitoring near relatively large densely populated residential subdivisions using conventional septic systems. Two subdivisions were monitored for viruses in different hydrogeologic regimes in the state. Monitoring did not yield detectable virus in any of the 112 ground water samples of 1134 and 2268 liters each, collected over a period of one year. The monitoring did indicate that other ground water impacts, namely nitrogen, phosphorus, carbon and fecal coliforms. No spiking of viruses was done, but sampling of 175 stools from children indicated that enteroviral infections were relatively common in the subdivisions.

The second phase of the study was a more detailed study of eight individual systems in the same subdivisions. Detailed monitoring around one of the study homes was done after the enterovirus Coxsackievirus A9 was detected in stool and septic tank effluent samples. Virus was detected directly below the drainfield on two occasions, but not in wells 10 feet down gradient of the system. One possible reason for this was that the wells in the drain field area were sampled first, extracting relatively large volumes of ground water, with the other wells being immediately sampled thereafter. It may also be that their results are more favorable than those of Stramer (1984) are due to temperature affects, with the warmer Florida temperature enhancing viral inactivation.

Other references of note include: Gerba et al., (1975); Reneau and Pettry, (1975); Lance et al., (1976; 1982); Burge and Enkiri, (1978); Landry et al., (1979); Keswick and Gerba, (1980); Gerba, (1984); McDowell-Boyer et al., (1986); Jansons et al., (1989a, b); Bloch et al., (1990); Gross and Mitchell, (1990); Yates et al., (1990); Lawson et al., (1991); Levine et al., (1991); Powelson et al., (1991; 1993); Hedberg and Osterholm, (1993).

Protozoa

Protozoans and parasitic worms are of lesser concern than viruses or bacteria since they are larger and therefore are more easily removed by filtration. However, saturated flow can transport these organisms to ground water if macropores are present. The difficulty of treating Cryptosporidium in conventional sand filters for potable water highlights this possibility. It is not unreasonable to conclude that if Cryptosporidium can be passed through a water treatment facility in the form of ocysts, that it could also be transported to ground water through a failing septic system. Giardia could likewise be transmitted. However, due to their size, protozoa can be expected to be more readily removed from wastewater than bacteria or viruses in soil treatment systems, and therefore should not be considered the limiting factor in the design of such systems.

Other Pollutants

This is only a reminder that there are other pollutants of concern from septic systems including nitrogen, which is typically transformed to nitrate and phosphorus, which is readily adsorbed by most unsaturated soils.

Hazardous or Priority Pollutants
Priority pollutants can be expected to be present in typical household effluent. (Ver Hey and Woessner, 1987) A Connecticut study concluded that if volatile organic compounds (VOCs) and hydrocarbons (HC) are present in wastewater going to aseptic system, the contaminants do make their way to the groundwater. (Kolega et al., 1987) This is an oversimplification in that many toxic organics are biodegradable and the rate of treatment for various compounds at various concentrations has been the subject of considerable research effort. (Namkung et al., 1983) The biomat is a major site for the treatment of these types of pollutants. It should be noted that many of these compounds do break down more slowly than other wastewater carbon sources, and may not be treated thoroughly.

Research in Florida showed that VOCs (with the exception of one, 2 dichlorobenzene at one sample) were completely removed from soils beneath active drainfields before or immediately after passage through the infiltrative surface. (Sherman and Anderson, 1991)

Higher levels of these compounds, as are found in wastewater from service stations, can pollute ground water. (Sauer and Tyler, 1994)

Heavy metals
Heavy metals can be expected in, and have been found to be removed from wastewater in soil absorption systems. Most of the heavy metals can be expected to accumulate at the infiltrative surface. In the study previously cited by Sauer and Tyler, it was found that heavy metal concentrations in soil beneath beds receiving service station effluent were less than or within the range of background. (Sauer and Tyler, 1994) However, it was also estimated that mass loads of heavy metals over the life of such systems could be such that a hazardous waste site may be created. Therefore, waste streams with significant levels of heavy metals, (e.g. service stations) should not use septic systems to treat their wastewater.

Pesticides
A study in Illinois of treatment of pesticides in septic systems at concentrations likely to be encountered in the laundering of pesticide-contaminated clothing, found that once the biomat formed, septic systems effectively remove these contaminants at these concentrations. (Bicki and Lang, 1991) The same study showed the importance of the biomat in this function in that the system failed to treat these contaminants until the biomat effectively formed.

Summary and Conclusions:

Properly functioning septic systems provide excellent treatment of virtually all wastewater constituents except for nitrate, any excessive doses of priority pollutants and possibly some viruses. While the physical, chemical and biological processes of this treatment are generally well understood, this knowledge is not always applied properly. The importance of an adequate separation to the water table has been documented in scientific literature for more one hundred years. Yet, there are some units of government that have ignored this knowledge with the result that there are many unsafe septic systems in use that do not have this required separation.

Waterborne disease is still a threat to public health in the United States. Though outbreaks are not as common as in many parts of the world, serious waterborne disease outbreaks continue to occur. A leading cause of such disease outbreaks is faulty onsite sewage treatment.

Pathogenic viruses and bacteria can survive for extended periods in ground water. Therefore, prevention of pathogenic contamination of ground water is essential for public health.

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APPALACHIAN TRAIL CONFERENCE

Backcountry Sanitation Manual

Science knows now
that the most fertile and
effective manure is the
human manure. Do you
know what these piles of
manure are, those carts
of mud caried off at night
from the streets, the frighful
barrels of the nightman,
and the fetid streams of
subterranean mud which
the pavement conceals
from you? All of this is a
flowering, it is green grass,
it is the mint and thyme
and sage, it is game, it is
cattle, it is the satisfied
lowing of heavy kine,
it is the perfumed hay,
it is gilded wheat, it is
bread on your table, it is
warm blood in your veins.
—Victor Hugo,
Les Miserables

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Preface

What This Manual is About

Pete Ketcham, Field Supervisor, Green Mountain Club

The ATC Backcountry Sanitation Manual addresses the management of human waste in the backcountry. Proper management of human waste protects hikers, the environment and trail maintainers.

Resolving problems of backcountry sanitation is a continuous challenge for Trail clubs and land managers. This manual was created in the belief that all remote recreation areas will benefit from an expanded discussion of backcountry sanitation. The Appalachian Trail Conference (ATC) hopes it will offer a step up for those who operate composting systems, as well as for those Appalachian Trail (A.T.) clubs and land managers who have reached a crossroads in backcountry sanitation decisions.

This manual introduces a new, simpler and often safer method of composting human waste in the backcountry—the moldering privy. It is a design that saves money and—even more importantly—labor. Whether volunteer or paid, labor has always been in short supply on the A.T. The moldering privy is suitable for the majority of sites that need better waste management than pit privies or catholes, and it is cheaper and easier to implement than other alternatives.

See: Section 8, "The Moldering Privy" in Part 3—Descriptions of Systems.

The approaches recommended here are distilled from the experiences of several hundred people operating composting toilets and other systems that have successfully resolved human waste problems at backcountry sites along the A.T. Primary emphasis has been placed on composting systems, because they have been the most successful in the majority of backcountry situations. However, other systems receive some attention, especially to provide comparisons with composting systems.

The Green Mountain Club and the Appalachian Mountain Club began using composting systems in the late 1970s, and their systems have undergone continual evolution and improvement. Several other A.T. clubs and land managers have used different composting systems with varying success. The most successful systems are presented in this manual.

If you read this manual through, you will discover a lot of repetition. This is intentional, because the manual is being posted on the Web, where readers may download only the chapters that interest them. Therefore, each chapter must be self-contained, with as much relevant information as possible. Inevitably, this leads to repetition, although we have tried to minimize it by the use of cross-references to other chapters where appropriate.

The first four sections provide background for sanitation management. Section 1 covers the history of sanitation on the A.T;Section 2 explains why managing sanitation issues is important; Section 3 outlines the science of composting; and Section 4 discusses the health and safety issues associated with composting. Much of the information on the science of composting and health and safety issues in sections 3 and 4 was written by Pete Rentz, a Trail volunteer who is also a medical doctor.

See Appendix D for contact information for the ATC regional field offices.

Sections 5 and 6 cover the regulatory and permitting process, including compliance with ATC policy and local management plans. This is as important as health and safety considerations. Local and state sanitation codes and permit requirements *do* apply to almost all new sanitation systems and old systems in trouble. Even though many are written for municipal or residential waste water discharges, sanitation officials apply them to backcountry situations. It is extremely important that you check with your regional ATC field office, local A.T. club officers, local land managing agency, and relevant local and state officials to learn how these regulations are interpreted in the backcountry in your region.

Section 7 addresses the aesthetics of sanitation systems in the backcountry. The chapter is short, but the issue is vital, in view of the fact that hiking the Trail is, as much as anything, an aesthetic or even spiritual experience. An unattractive or obtrusive toilet facility can ruin the feeling of an otherwise pleasant overnight site.

Sections 8 through 10 form the bulk of the text. Section 8 focuses on the mouldering privy system, Section 9 and 10 describebatch-bin systems in use on or near the A.T. Topics include collecting, storing, and composting human waste; sanitary procedures; spring and fall operations; and record keeping. Section 11 presents case studies of individual installations. Section 12 guides the process of deciding which system best matches your needs and resources. Section 13 covers management of gray water (wash water) and food waste.

This manual is *not* an installation or operation manual for the systems described. Each system, especially each commercially produced system, has its own manual for installing and operating it correctly. This manual reviews each system to help maintainers decide which is best for them. The Appendix tells how to get more information on that system.

This brief manual does not cover some backcountry waste problems, such as illegal garbage dumping and managing pack stock and pet wastes. In addition, it does not cover some methods of handling human waste in the backcountry that have been used in other parts of the country, such as vault toilets, incinerating toilets and chemical toilets. Finally, some remote recreation areas can still rely on pit toilets or catholes. The capabilities of each backcountry site, the impacts imposed by visitors, and the capabilities of the managing entity must be carefully evaluated. Only then can a solution tailored to a specific site be developed.

As composting systems and techniques improve, so will this manual, which is why ATC chose to publish it on the Internet. As readers experiment with different systems, new information and techniques will develop. ATC plans to add to this manual as each field season produces new information, and to revise it periodically.

Much of the information and experience with composting systems has been developed on the Appalachian Trail in the Northeast, but I have tried to make this manual useful to all A.T. clubs. In April 2000 I traveled to several sites along the A.T., from Tennessee to Pennsylvania, to meet with regional ATC staff and volunteers. I saw composting efforts of other clubs and agency partners in operation in the field, and I learned something of the strengths and challenges of various A.T. clubs. If your questions are not addressed or your knowledge is omitted, I hope to hear from you so I can improve future revisions.

Never Apologize, Just Explain

Dick Andrews, Volunteer, Green Mountain Club

Trail maintainers should resist any suggestion that backcountry waste disposal systems are somehow substandard, but tolerable because they are in remote locations. If this attitude is accepted, it will diminish the Trail's prospects for continuing as a practical and enjoyable entity for future generations of hikers, since that will make the Trail dependent on continued tolerance of what is imagined to be substandard. Maintainers who do a conscientious job of managing human waste need not apologize for the results of their efforts.

No practical way of disposing of human waste in the backcountry is perfect, if perfection is defined as zero chance of pollution or dispersal of pathogens. However, when applied appropriately, all of the systems covered in this manual are adequate, even when compared to household-sewage systems in rural and suburban areas.

By way of comparison, a septic system serving flush toilets, which is commonly considered the "gold standard" of sewage treatment away from central sewage treatment plants, often leaves a lot to be desired. A septic tank does not actually treat sewage. It liquefies some solids, and separates the remaining solids from water. But, the water leaving a septic tank and entering a leach field is as contaminated with pathogens as the sewage going in. Treatment, if it takes place at all, occurs in the biologically active soil of the leach field, where the septic tank effluent is supposed to be exposed to air and organisms that prey upon and compete with pathogens. Dissolved solids are supposed to be taken up as nutrients by plant roots.

However, in actual septic systems, conditions often prevent proper treatment; inadequately treated sewage percolates down to the ground water or out to the surface. Many leach fields are too cold in winter for biological treatment, and dormant plants take up no nutrients in winter. Some leach fields are too deep for plants to reach, even in summer. Waterlogged soil, which prevents aerobic treatment, is common, either from weather-related flooding or from large inflows of water from extravagant use of toilets, showers, washing machines and dishwashers. In private conversation, sanitary engineers estimate that more than half of all septic systems fail to work properly at least part of the time, even if the septic tanks are pumped when they should be and soils in the leach field have not become clogged.

Few people worry about these shortcomings, probably because the malfunctions are out of sight. Only in locations like Cape Cod, where large numbers of inadequate septic systems threaten an important aquifer, is notice taken of the problem.

It is unreasonable to insist on perfection in the backcountry when it is not required anywhere else. Many systems treating human waste in the backcountry are actually more effective than rural and suburban systems people live with every day, partly because human waste is not mixed with such a huge volume of water in the backcountry. We should strive to improve backcountry sanitation even further, but we can be proud of the progress already made.

Acknowledgments

Development of the sanitation systems described in this manual owes much to the work of hundreds of individuals over many years.

The initial design and testing of the batch-bin composting system was done by the Backcountry Research Program of the Northeastern Forest Experiment Station in Durham, N.H., under the leadership of Ray Leonard in the mid-1970s. The system has been further developed and refined by the Appalachian Mountain Club (AMC) and the Green Mountain Club (GMC) since then.

The moldering privy is the design of Appalachian Trail Conference (ATC) and Green Mountain Club Volunteer Dick Andrews. Dick developed the idea of using red worms in a simplified composting toilet after he successfully used them in his Clivus Multrum at home. The first moldering privy was installed under Dick's supervision at Little Rock Pond Shelter on the Appalachian Trail in southern Vermont in 1996. Thanks also go to Scott Christiansen, Gilbert Patnoe, and Cheryl Vreeland of the Green Mountain Club's Laraway Section and Leo Leach and Jeff Bostwick of the Burlington Section for their help and assistance in the additional development and testing of the moldering privy, and in the moldering privy description in this manual.

This manual reflects changes and innovations along the Appalachian Trail since the last edition of GMC's *Manual For Bin Composting* was published in 1995.

Special credit is due to former Green Mountain Club Field Supervisors Ben Davis and Paul Neubauer, without whom the previous editions of the *Manual for Bin Composting* would not have happened. Much of the development of the GMC's composting toilet installations was due to Ben and Paul, and their interest in keeping the GMC at the forefront of backcountry sanitation technology. Largely because of the foundation their work provides, the GMC and ATC dare to hope that Trail volunteers and land managers will find the *ATC Backcountry Sanitation Manual* the best guide currently available.

See: GMC *Manual For Bin Composting*

I must extend special thanks to David Del Porto and Carol Steinfeld of the Center for Ecological Pollution Prevention (CEPP) of Concord, Mass. Their book, *The*

See: *The Composting Toilet System Book* (see Appendix E, "Bibliography" and Appendix C, "About the Organizations Behind this Manual.)

See: Appendix D, "State-by-State Regulatory Contact list."

See: *The Humanure Handbook: A Guide To Composting Human Manure,* in Appendix E, "Bibliography"

Composting Toilet System Book , is at the forefront of information on composting human waste, including much that is useful in the backcountry. Many other references were dated, so the publication of their book in 1999 was very timely. Many illustrations, components of several chapters, and the State-by-State Regulatory Contact list in the Appendix come from *The Composting Toilet System Book*. I can't recommend this book highly enough to complement the *ATC Backcountry Sanitation Manual*.

I'd like to thank Joseph Jenkins, author of *The Humanure Handbook: A Guide to Composting Human Manure*. The book and e-mail correspondence with the author, who has twenty-four years of experience composting human waste, significantly enhanced the *ATC Backcountry Sanitation Manual*. *The Humanure Handbook* should be on the bookshelf of anyone maintaining backcountry campsites and facilities.

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This manual would not have been possible without my editor, Dick Andrews, originator of the mouldering privy system. Dick was *the* perfect editor for this project—not only because of his professional skills (he is a free-lance writer and editor by trade), but because of his twenty-seven-years of experience composting human waste at his home in southern Vermont. He was an invaluable source of technical information and ideas on this subject. He has also been a long-time ATC and GMC volunteer, and he was able to apply the volunteer perspective to the manual to make it as useful as possible to A.T. club volunteers. Thank you, Dick.

Finally, credit for this manual must be given to the many unnamed ATC maintaining club volunteers, ridgerunners, and caretakers who have toiled with few thanks to make composting on the Appalachian Trail work.

—Peter S. Ketcham, Waterbury Center, Vermont (March 2001)

Part 1
Background for Sanitation Management

1—A Brief History of Northeastern Backcountry Use and Backcountry Sanitation Management

2—The Importance of Backcountry Sanitation Management

3—The Decomposition and Composting Process

4—Health and Safety Issues

1

A Brief History of Northeastern Backcountry Use and Backcountry Sanitation Management

Pete Ketcham, Field Supervisor, Green Mountain Club

In the late 1960s and early 1970s there was a surge in use of backcountry facilities unlike anything land managers had ever seen. The number of people seeking primitive recreation in the mountains, particularly along the Long Trail in Vermont and the Appalachian Trail along the East Coast, had increased about ten times since the 1930s. By the mid 1970s, the most popular overnight destinations, such as upper-elevation and backcountry pond sites, were receiving as many as seventy overnight visitors each week during the six-month hiking season. The volume of human waste increased proportionately from about one gallon per week per site to fourteen gallons per week, or more than three hundred gallons per season at some sites.

Many backcountry facilities in New England were developed between the 1920s and 1940s on upper mountain slopes to provide scenic views, refuges near summits or idyllic getaways near the shorelines of mountain ponds. When many of these facilities were built, the number of visitors was low, averaging five persons per week per site. At these low levels of use, wastes in pit privies could probably be safely decomposed and assimilated by soil.

However, the severe limitations of these mountain sites became evident as the number of visitors increased. Most ridgeline campsites had poor, thin soils that precluded frequent digging of new pit toilets. Most campsites near ponds were located very close to shorelines, and locating new sites for pit toilets a safe distance from water was difficult without moving entire campsites. At some sites, helicopters were used to fly waste out, but many people considered this practice too expensive and intrusive.

Watersheds were being polluted, human health was at risk, and the recreational experience at managed backcountry facilities was being eroded by unmanageable amounts of human excrement. These problems prompted the development of alternative waste management systems.

In the mid-1970s, the Backcountry Research Program of the USDA Forest Service Northeastern Forest Experiment Station in Durham, N.H., led by Ray Leonard, developed the batch-bin composting toilet system as an inexpensive and practical means of waste disposal for high-use backcountry sites. Since 1977, batch-bin systems have operated continuously at selected sites in the White Mountains of New Hampshire and the Green Mountains of Vermont, as well as in other areas. Along other parts of the Appalachian Trail, as use has increased, land managers and maintaining clubs have also begun to study and implement alternative waste management systems at the more fragile and popular campsites.

Backcountry sites in New England were subject to a combination of especially wet and cold weather, thin and acidic soils, and a flood of backcountry recreationists from nearby urban areas, since the Green Mountains of Vermont and the White Mountains of New Hampshire were within a day's drive of 70 million people. In retrospect, it is no surprise that the inadequacy of traditional pit toilets became apparent there sooner than on many other sections of the Appalachian Trail. Consequently, the Green Mountain Club (GMC) and Appalachian Mountain Club (AMC) have played an active role in the evolution of alternative waste management systems. Between them, the GMC and AMC now manage thirty-eight composting toilet systems among their more than eighty-six backcountry campsites.

The success of the two clubs' composting toilet systems rests largely in the hands of dedicated and knowledgeable field staff and volunteers. Organizational commitment by the GMC, AMC, the Appalachian Trail Conference (ATC), and their agency partners has ensured the continued success of this effort.

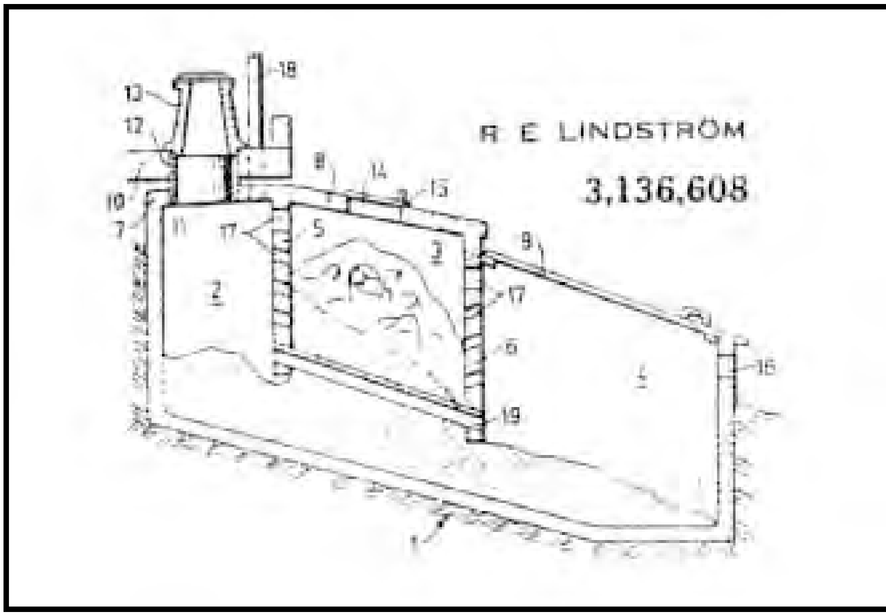


Figure 1.1—Original Clivus Multrum Toilet designed by R.E. Lindstrom of Sweden in the 1930s. Drawing From Stop the Five Gallon Flush (1980) taken from The Composting Toilet System Book by David Del Porto and Carol Steinfeld.

2

The Importance of Backcountry Sanitation Management

Pete Ketcham, Field Supervisor, Green Mountain Club

2.1 BASIC QUESTIONS

Almost all backcountry facilities can benefit from sanitation management. Improper disposal of wastes at fragile, heavily used remote recreation sites causes pollution of soil, ground water and surface water, and it degrades the experience of the backcountry user.

Ask the following questions when considering new or improved sanitation facilities:

- Is your organization governed by a Local Management Plan (LMP) or a Forest or Park Master Plan (Such as National Forests and Parks have)?

- If the answer is yes, does your organization's LMP specify a role for backcountry facilities and sanitation systems?

For example, as a member of the Appalachian Trail Conference (ATC), the Green Mountain Club (GMC) has an LMP to guide its management of the entire 445-mile Long Trail System in Vermont, which includes the Appalachian Trail. The GMC plan guides the development of overnight facilities and sanitation facilities in language derived from the ATC's *Local Management Planning Guide*. The guide says:

> *Managing overnight-use areas constitutes an important part of club effort. Numerous factors must be considered in locating and designing overnight-use areas, including soils, vegetation, topography, expected visitor use, proximity to water, distances to roads and other overnight sites, and use of adjoining lands. Ideally, shelters and campsites should be spaced a modest day's hike apart, and they should be designed to contain the social and environmentalimpacts of overnight visitors within a confined area. Provisions should also be made to for dependable water supplies andsanitation at each site. Regardless of whether privy or dispersed disposal area is used to accommodate human waste, the site should be monitored to ensure that human wastes does not create environmental or health problems.*

From *Local Management Planning Guide*—Chapter 2 (G) *Overnight Use—Shelters, Campsites, and Privies,* Appalachian Trail Conference, Revised 6/90. See Appendix E.

See Section 7, "The Aesthetics of Backcountry Sanitation Systems," and Section 9, "The Decision Making Process."

All A.T. maintaining clubs are bound by ATC policy to provide for backcountry sanitation. However, the type of system is left to individual clubs, subject to standard decision-making criteria. Your organization may be guided by a similar policy, or it may be governed by a state, county, municipality, or land management agency.

See Section 5, "Following Policies and Regulations."

Land managers and Trail clubs should carefully consider the following goals when establishing a designated overnight facility and providing for its sanitation.

- *Protection of Water Quality*—This is a primary concern. Overnight facilities should ordinarily be located near a dependable source of drinking water. It is vital not to compromise the water source by improper disposal of human wastes.

- *Prevention of Resource Damage*—Central waste systems reached by designated trails prevent the formation of bootleg trails and damage to vegetation. Sites with no facilities often have a myriad of bootleg trails to poorly chosen spots (for example, next to the shelter or tent site or near water supplies).

- *Protection of Aesthetic Quality*—Nothing makes an overnight facility less appealing than untreated sewage on the ground. Even where a toilet area is designated for disposal of human waste by the hiker in a cathole, waste is likely to surface unless there is a human presence (for example, a caretaker or ridgerunner). Also, if a privy smells bad, some hikers will avoid it and deposit their waste on the ground, often in improper or undesirable locations.

To tailor a solution to a particular site, it is necessary to evaluate the site's capabilities and the impacts of visitors.

2.2 OVERVIEW OF HUMAN WASTE IN THE BACKCOUNTRY

Humanwaste in the backcountry takes four basic forms: Sewage (fecal waste, urine, pet waste, and nonorganic contaminated trash), food waste, trash and litter, and fire waste.

Sewage—Sewageis the highest priority because it can spread disease. Traditional disposal methods such as pit privies and catholes often contaminate water, but they can be managed to minimize risks.

1. HUMAN FECAL WASTE—Human fecal waste in the backcountry is commonly deposited in the soil in pit-toilets and/or cat-holes, and to a lesser extent on the ground surface. The following methods for dealing with it are commonly employed:

Pit toilets—The traditional repository. (A pit toilet with no privy shelter is called a chum toilet.) Because anaerobic waste breakdown in a pit is slow, pathogens may remain viable for years. The waste in poorly placed privies can leach contaminants into the surrounding area years after use has ceased. However, pits work well when properly sited and not overused. The level of use must match local soil characteristics. If you are considering a pit toilet, contact your regional ATC office for information on siting and installation.

Modified pit toilets—These attempt to avoid anaerobic decomposition in favor of aerobic decomposition. Modifications include:

- Regularly digging out pits to prolong their life. Wastes are then shallow-buried or composted.

- Half-filling newly dug or newly emptied pits with dry leaves and duff. Users throw in additional organic matter after use. The outhouse is periodically tilted aside, providing access to mix and aerate the wastes if needed.

Catholes—These are almost always used where established toilet facilities are not provided. The user digs a small hole, about six inches deep, then covers the waste with soil.

Catholes are often improperly made, and wastes do not break down quickly, despite the old adage "bury it and it will be gone in two weeks." Studies by Temple and others have shown human pathogens remain viable for up to two years in catholes.

See studies by Temple, *et. al.* (1982), in Appendix E.

For the cathole method to be effective, users must break up wastes with a stick, mixing them thoroughly with duff within the cathole before covering with a mound of leaves and duff. This creates a mini-composting pile in the top layer of forest soil. This will only work well if the soil that the cathole is dug in is biologically active and diverse with decomposer organisms. At higher elevations, many of these organisms may be absent.

Catholes are usually unsatisfactory as the sole means of waste disposal at designated facilities. Most users make them improperly, despite educational efforts either on- or off-site. Some users even deposit wastes on the surface. If you choose to designate cathole use at certain campsites, consult your regional ATC office for more information.

Temporary pit latrines—These are typically used by groups, may also create health hazards in heavily visited overnight sites, due to slow waste breakdown and poor placement. As with cat-holes, temporary latrines should be shallow, and wastes should be well-mixed with leaves and duff before being covered with a mound of leaves and sticks. Many groups mistakenly assume that the deeper the hole, the better.

Snow holes—These simple holes in the snowpack are a special situation. Although fecal wastes on snow are subject to solar breakdown and other effects of weathering, they may contaminate spring runoff, especially at sites next to water. Individual knowledge and willingness to make snow holes away from water can reduce adverse impacts. However, provision of usable winter toilet facilities at sites with high winter use is the best option.

Composting toilets—These are a major improvement over the above methods of disposing of fecal waste. Site limitations such as shallow soils or high water tables, coupled with heavy use, have led to the development of batch-bin composting and moldering privies, as well as more expensive manufactured aerobic composting toilets.

In a composting toilet, raw wastes are held apart from the surrounding site until sufficiently decomposed to be spread over the forest floor. However, waste policy on federal land in the west frequently dictates that even treated waste be transported out of the backcountry.

Dehydration and incineration toilets—These are commercially available. Results have been mixed. Provision of fuel (usually propane) can be expensive and disruptive, and offensive odors have been reported in some cases.

Removal of wastes—Typically by helicopter, truck or mule train, must be done where on-site management is not possible. Removal prevents contamination of a site, but is expensive and can be disruptive.

2. URINE—Urine is usually a hidden waste problem, aside from toilet paper and yellow snow. The urine of healthy individuals is ordinarily sterile, so the health hazards associated with urine in the backcountry are comparatively low.

Overnight users tend to urinate in the immediate vicinity of a backcountry facility or campsite. Some use privies and some do not. Urine in anaerobic systems such as a pit-toilets substantially increases offensive odors. Depending on the design, urine can be either an asset or a liability in aerobic composting systems, but odors are much less of a problem in either case.

Day users tend to urinate next to the trail and at privies at overnight sites.

3. DOG WASTE—This is a problem whenever dog owners do not clean up after their pets. Canine feces should be disposed of using the cathole method. Tracking of dog feces into water supplies on hikers' shoes may contribute to the spread of waterborne pathogens such as *Giardia lamblia*.

See Section 4—"Health and Safety Issues."

4. NONORGANIC CONTAMINATED TRASH—Nonbiodegradable items, such as feminine hygiene products, are thrown into privies by careless visitors. In pit toilets such trash is generally left in the pit, taking up space and shortening the life of the pit. In composting systems it is generally retrieved and allowed to weather before being packed out.

Food waste—Food waste is tossed into the woods, dumped into privies, buried, burned, rinsed into surface water, or packed out, in the absence of on-site disposal systems. Ineffective disposal of food waste can offend other hikers, attract nuisance animals and insects, and pollute water. Trail clubs and land managing agencies should aggressively teach Leave No Trace outdoor ethics to hikers and backpackers and thus promote a Carry In-Carry Out Policy for all non-sewage waste, including food.

Disposal by scattering—Can cause excessive nutrient loading to the water table where shallow soils provide little absorption of nutrients, and attracts nuisance animals. This practice should be discouraged by land managers.

Disposal in pit toilets—Undesirable due to putrefaction odors, fly attraction, and animal visitation (particularly bears).

Burying—Can promote decomposition of food wastes when they are actively mixed with soil in the hole. However, it is a not an ideal solution, because animals may dig up wastes.

Burning food wastes—Can be effective, but a wood fire must be very hot to completely consume the waste and avoid offensive odors;d most hikers do not have the skills or tools to accomplish this. In addition, wood is scarce at most campsites, and managers often discourage or prohibit wood fires to avoid scarring trees or the site.

Rinsing food wastes—Rinsing into surface waters obviously pollutes the water, and should be prohibited.

Trash and litter—Problems with these are declining with widespread education about carry-in, carry-out practices.

Clean trash: Paper, plastic, foil, cans, and bottles. It is most prevalent in areas visited by day hikers and non-hikers.

Fishing lines and hooks: These present cleanup and wildlife entanglement problems at heavily used backcountry fishing areas.

Unsorted trash: Food, paper, non-organic trash, etc. It is principally a problem at trailheads. Hikers often carry out food waste, but then put it in trailhead garbage cans, attracting animals that scatter garbage. Hikers should be instructed to take food waste home.

Washing wastes: Food, soap, toothpaste and other hygienic wastes. They contaminate surface and ground water. The installation of washpits, coupled with Leave No Trace education about low-impact washing practices, has done much to alert hikers to the growing scarcity of pure drinking water and the need to keep water sources as clean as possible.

- Dish washing in surface water is a widespread and undesirable practice. The use of washpits has done much to focus hikers attention away from the water source as the place to wash. However, washpits that are inappropriately sited, poorly constructed, or improperly maintained pollute surface and ground water at medium- to high-use overnight sites.

See Section 13, "Gray Water Management in the Backcountry."

- Hygienic wastes, particularly from hand washing after privy use, are a sanitary hazard. The waste system should separate privy users from surface water as much as possible. Sites with the privy and shelter on opposite sides of a watercourse are most prone to water contamination from hand washing.

- Bathing, shaving, and toothbrushing: These pose contamination problems at all areas with surface water.

Fire wastes—These appear wherever fires are built. Fires built in undesignated places, such as on the ground, against tree trunks or in unauthorized fireplaces, cause additional damage. Cutting of live trees, excessive wood-gathering, peeling of birch bark, along with scorched inorganic trash, burn-scarred rocks, and charred wood, are other adverse impacts associated with backcountry fire use.

2.3 SUMMARY

New or improved waste management systems must be chosen after analysis of site characteristics, available financial and labor resources, and current or projected use.

Continuous educational efforts are essential for effective waste disposal. Backcountry users should have on-site information, from stewardship signs or field personnel, or information such as guidebooks or pamphlets to instruct them in proper backcountry waste management techniques.

3

The Decomposition and Composting Process

Pete Ketcham, Field Supervisor, Green Mountain Club

Pete Rentz M.D., Trails Chairman, Massachusetts A.T. Committee of the Appalachian Mountain Club—Berkshire Chapter

3.1 INTRODUCTION

Ever since land animals appeared on Earth, feces and urine have been deposited on the ground. Microorganisms in the soil have evolved to take advantage of these nutrients. This process may be observed in any well-drained cow pasture where cattle eat grass, urinate, and defecate. Urine immediately sinks into the soil, and is no longer evident minutes after it is deposited. Manure stays on the surface for several days or weeks, eventually decomposing and also disappearing, nourishing the grass in the process.

When this natural process occurs in a human-controlled environment, we call it *composting*. Composting is a method of waste management in which materials of biological origin are decomposed by common soil microorganisms to a state where they can be applied to the land with little environmental stress. By using compost as a soil amendment, soil properties are improved, and nutrients are reclaimed by plants. Composting requires a container, oxygen, proper moisture, proper temperature range, aerobic organisms, and time.

Mechanisms of Decomposition—Decomposition can occur either under *aerobic* conditions (in the presence of oxygen), or under *anaerobic* conditions (in the absence of oxygen).

Aerobic decomposition is the primary decomposition process in porous upland soils, such as the cow pasture described above. The goal of composting is to ensure aerobic conditions as completely as possible. Rapid breakdown, moderate-to-high temperatures, lack of odors, and effective pathogen destruction typify well-managed backcountry aerobic-composting operations.

Anaerobic decomposition in the backcountry is characterized by slow decomposition, comparatively low temperatures, foul odors, and high pathogen survival.

The key to an effective composting process is oxygen, which powers aerobic bacteria and poisons anaerobic bacteria. With oxygen, aerobic bacteria thrive and outcompete anaerobic bacteria, which have slower metabolisms.

3.2 VARIABLES AFFECTING COMPOSTING

The physical and chemical properties of material being composted, and the temperatures attained, directly affect the rate and extent of microbial activity in the composting process. The most significant variables affecting the composting of human waste in the backcountry are listed here.

Size of substrate particles—The size of the substrate particles determines the surface area accessible to microbial attack. Smaller particles expose more surface to bacteria, leading to faster and more complete decomposition. Mixing wastes with ground bark or a similar bulking agent and breaking up clumps of raw sewage creates small compost fragments. This results in finished compost that is composed mostly of fine crumbly particles.

Voids between particles—Voids between particles comprise a significant fraction of compost volume. These air spaces are the main source of oxygen for the microorganisms which cause decay. Turning of the compost mass can reduce clumping and compaction, and bring fresh air into the interior of the pile.

Moisture content—The moisture content of compost is critical. Water is the solvent in which organic and inorganic constituents of cells are dissolved, and it serves as the medium for movement and interaction of various cellular substances.

A moisture content around 60 percent by weight is best for rapid aerobic composting. Below this, compost becomes too dry for rapid microbial growth, the compost process slows considerably, and pathogen encapsulation (conversion to a temporarily inactive form protected by a durable coating) is likely. Much above 60 percent, water begins to collect, and portions of the pile become anaerobic.

Maintaining a suitable moisture content in a system is not difficult, as drainage of excess liquid tends to make the pile self-regulating.

All of the systems described in this manual can do or can offer drainage of liquids. Pit toilets and moldering privies discharge their liquid directly into the soil. Moldering privies, however, have the advantage allowing the liquid effluent to pass through both aerobic portions of the compost bed and the top biological layer of the soil, providing a high degree of treatment.

Batch-bin systems isolate liquid from the ground and absorb it with a bulking agent, generally bark mulch. A portion of the liquid is evaporated from the bin by the heat of the composting process. The remainder gets evaporated in the drying process.

See Section 9.

The *beyond-the-bin* system drains liquid from the toilet, and treats it in a filtering barrel before releasing it into the ground. Any remaining liquid is managed the same way as in the batch-bin system.

See Section 10.

See sections 11 and 12 .

The three commercial *continuous composters* and the one homemade version described in the manual all have provisions to collect, store, and ultimately treat and discharge liquid, ideally by running it through a beyond-the-bin filter barrel.

Temperatures—*Temperatures* attained in composting depend on the configuration, size and composition of the compost mass, its moisture content, and on its manipulation.

Some water is necessary for aerobic bacteria, but too much moisture inhibits them and retards composting, which reduces the temperature.

Mesophilic composting, which occurs in moldering toilets, takes place when waste materials are added slowly. Temperatures may range from 10 degrees C. to 45 degrees C. (50 degrees F. to 112 degrees F.).

Thermophilic composting can follow mesophilic composting in a mass of uncomposted material large enough to conserve the warmth generated by mesophilic composting. Thermophilic, or heat-loving, bacteria take over, and temperatures may rise well above 50 degrees C. (120 degrees F.), to as much as 75 degrees C. (167 degrees F.). Thermophilic composting is the goal of batch-bin composting operations.

Every organism has a heat tolerance limit, above which it perishes. Bacteria flourishing in the mesophilic range warm the pile to their own tolerance limits, and are replaced by thermophilic bacteria. Redworms and many other invertebrates that thrive in meosphilic composting generally do not tolerate temperatures in the thermophilic range. Eventually the upper limit of the thermophiles is reached, and activity slows and ceases. The temperature falls, and if oxygen and nutrients are again made available (*e.g.* by turning the pile), the temperature will rise again. Nutrient and oxygen availability, ambient temperatures, and pile insulation affect the rate and extent of heat buildup.

See McKinley, Vestal, and Eralp, 1985, in Appendix E.

It is often assumed that the highest temperatures in the thermophilic range produce the highest rates of microbial activity. However, the range of greatest bacterial activity is between 35 degrees C. and 45 degrees C. (95 degrees F. to 112 degrees F.). This range corresponds with adaptation to the soil environment in hot climates. Up to 55 degrees C. (130 degrees F.) the rate of growth and reproduction is still very high, but it falls off markedly above 60 degrees C. (140 degrees F.), the limit of the range of thermophilic bacteria.

Sun and wind have little direct impact on the temperature in a composting chamber, but are worth considering for other reasons.

In most of the backcountry overnight sites along the Appalachian Trail, the sun is either obscured by mountain fog or by a dense canopy of trees. If selected shading trees can be removed, it may improve a composting area by keeping it dry and odor free, and it will help dry compost in a drying rack, but it probably will not enhance the composting process itself significantly.

At some sites in Pennsylvania, the canopy has been reduced around continuous composting toilet systems. The sloping tank and vent stack are painted a dark color to help absorb heat. The Mountain Club of Maryland has reported that solar gain helps to create draft the vent stack, which helps draw fresh air into the pile and moisture and odor up the stack.

Wind can help keep a composting area dry and to dry finished products. It also enhances the draft in manufactured continuous composting toilets, which can be desirable, but also can lower the temperature in the composting chamber too much.

The container is critical to reaching thermophilic composting temperatures. It must hold at least 160 gallons for self-insulating thermophilic composting. It is possible that an insulated container could be smaller, but this has not been established. Insulation is of no value in mesophilic composting, since heat is produced at a negligible rate.

Nutrient Elements—Microorganisms utilize a wide array of *nutrient elements*, most of which are present in human fecal wastes. Those used in larger amounts are called macro-nutrients, and include carbon (chemical symbol C), nitrogen (N), phosphorus (P), and potassium (K).

Nutrients are used in fixed proportions by any particular class of organisms, so a shortage of one nutrient may cause microbial activity to cease before other available nutrients are consumed. Destruction of pathogens is most effective when nutrients are approximately balanced so the composting process can utilize most or all of them. When composting human waste, an optimum balance is created by adding a bulking agent (*e.g.* hardwood bark) high in carbon, since human waste contains the other macro-nutrients in appropriate proportions.

The ratio of carbon to nitrogen—the carbon:nitrogen (or C:N) ratio—is the key to nutrient balance. Understanding the C:N ratio is critical to the selection of bulking material, but achieving an effective C:N ratio is not difficult.

If the excess of carbon over nitrogen is too great (high C:N ratio), cell processes slow down. In that case, nitrogen is limiting. That happens when a bulking material of very high C:N ratio, such as sawdust, is used exclusively, or when too much of a bulking agent with a more moderate C:N ratio, such as hardwood bark, is added to the wastes. Given enough time, nitrogen is recycled and the excess carbon is metabolized to carbon dioxide, but the time required can be too long to be practical for batch-bin operations.

If the carbon is limiting (low C:N ratio), excess nitrogen is converted to ammonia until the nutrient balance is restored. That happens when not enough bulking agent (such as hardwood bark) is added. A low C:N ratio typically encourages anaerobic conditions, and accounts for the odor of ammonia associated with anaerobic breakdown.

A C:N ratio between 25:1 and 30:1 is optimum for aerobic composting of human wastes. There is no convenient test to determine whether the C:N ratio is in this range. Fortunately, however, this is the approximate ratio which occurs when ground hardwood bark (C:N ratio of 100:1 to 150:1) is added in the quantity needed to regulate the moisture level of the compost. Modest departures from the ideal ratio will slow composting, but will not stop the process. If your compost has an earthy odor, it is close enough to the ideal ratio.

The C:N ratio of human urine is about 0.8:1, and that of raw sewage is about 7:1. The C:N ratio of food scraps is variable, but tends to be less than 15:1.

pH range—The *pH* of the compost is important, because decomposer microbes are intolerant of both acidic and alkaline conditions. The optimum pH range is between 6 and 7.5 (7.0 is neutral).

Fortunately, pH normally is not a concern for the compost operator if an appropriate bulking agent is used. Altering the pH of a compost pile by adding lime to the crib, tank, catcher, or composting bin (which makes the compost more alkaline) *is not recommended*. The result is an increase in ammonia production with its resultant loss of nitrogen. Use of peat moss to soak up excessive water tends to make the pile too acidic. Bark, wood shavings, leaves, and duff should be added if peat moss is used.

3.3 DECOMPOSER ORGANISMS

Aerobic bacteria, molds, fungi, and even protozoa found in soil use enzymatically moderated chemical processes requiring oxygen to progressively break down feces into water, carbon dioxide, nitrogen, and minerals. Antibiotics are produced by some of these microorganisms (actinomyces species) in a microscopic form of germ warfare. There is even a bacterium in soil (Bdellovibrio bacteriovorus) which attacks E. coli, a potential pathogen found in feces, and destroys it.

See Section 4—"Health and Safety Issues."

The process of transforming raw wastes to finished compost is the job of three major forms of soil organisms: bacteria, fungi, and actinomycetes. The aim of composting technology is to optimize conditions for growth of these organisms.

Dindal (1976) found soil invertebrate populations in composted material to be the same as those in the surrounding forest system. Most are active burrowers and improve aeration.

All three excrete enzymes which break down the large molecules of energy rich organic compounds of sewage; smaller organic molecules and inorganic ions are then absorbed over the entire microbe cell surface. Energy is released, raising the temperature of the surroundings. The smaller absorbed molecules, such as sugars, alcohols, organic acids, and amino acids, provide usable energy and food for cell growth and reproduction.

Bacteria are single-celled organisms found everywhere. In terms of numbers, bacteria are the most prevalent organisms in the compost pile—a gram of compost can contain more than one trillion bacteria. They are responsible for the initial

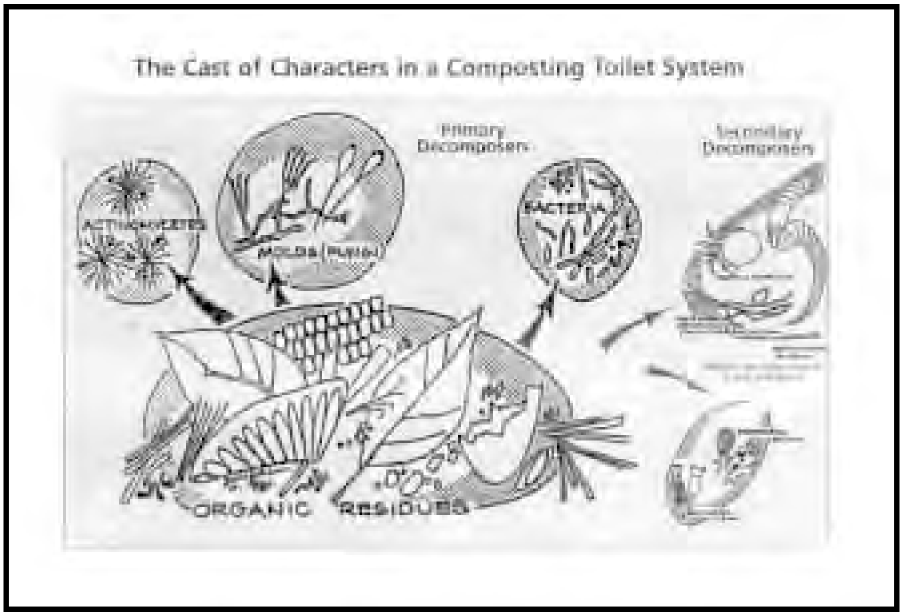


Figure 3.1—Types of decomposing organisms found in a composting toilet. Key organisms include actinomycetes, bacteria, and fungi. Red worms are a secondary player, and must be added by the operator." Drawing from The Composting Toilet System Book by David Del Porto and Carol Steinfeld. Drawing originally published by D.L. Dindal, Soil Ecologist, SUNY College of Environmental Science and Forestry, Syracuse, NY.

breakdown of a wide variety of compounds in the wastes, and for most of the heat released into the compost pile.

Fungi are multicellular organisms with extensive networks of branching filaments. They may make up the bulk of the compost mass during later stages of the compost process. They grow intermingled with actinomycetes, and they utilize similar substrates for energy and nutrient sources. Mature mushrooms often appear in compost. Like bacteria, both fungi and actinomycetes are most active at temperatures below 55 degrees C. (130 degrees F.).

Actinomycetes are single-celled, mostly aerobic organisms, closely related to bacteria, but structurally similar to fungi. They function mainly in the breakdown of cellulose and other organic residues resistant to bacterial attack. Several, such as *Streptomyces*, produce antibiotics. Actinomycetes are detectable visually as a silvery blue-gray powdery layer in the compost, and by their faint earthy odor.

Many common *soil animals* invade the compost pile as decomposition proceeds. Dindal (1976) found soil invertebrate populations in composted material to be the same as those in the surrounding forest system. Most are active burrowers and improve aeration. They feed on organic residues and microorganisms, in addition to each other, and further reprocess the wastes through digestion and defecation.

Some of the larger creatures commonly seen are beetles, collembolas (springtails), isopods, millipedes, mites, and slugs. Worms may burrow in compost at moderate temperatures. Second-phase decomposition in a drying rack or moldering crib that has been capped provides the most favorable habitat for these larger invertebrates.

3.4 CHARACTERISTICS OF HUMAN WASTE AFFECTING DECOMPOSITION

Feces are rich in anaerobic organisms, such as E. coli, Bacterioides, Lactobacillus, and Klebsiella, which typically account for about one-third the weight of the feces. These bacteria produce mercaptans and other volatile compounds that account for the unpleasant odor of feces.

Medical literature indicates that feces are produced by an adult at a rate of about 150 grams (5 ounces) per day, a figure which agrees well with the records of the Green Mountain Club (GMC). At our overnight sites with caretakers and batch-bin composting toilets, each person has produced 0.03 gallons (3.85 ounces) of waste per day, or 0.2 gallons per week.

GMC backcountry shelter-use data tabulated by Davis & Neubauer (1995) showed that some overnight sites were collecting 14 gallons a week of waste, or more than 300 gallons a season. In 1999 Stratton Pond, GMC's most heavily visited site on the Appalachian Trail in southern Vermont, collected an average of 11 gallons of sewage per week. In the 20-week caretaker season, corresponding to the traditional five-month hiking season, this totaled 220 gallons of waste.

See Davis & Neubauer (1995), in Appendix E.

Urine is mostly water. Of the 1,200 grams produced daily by an average person, only 60 grams are solids, mostly nitrogen as urea. Though this urea is a fairly small percentage of urine by weight, it can be a major source of nitrogen in a compost operation.

Healthy people produce sterile urine. If, however, urine is allowed to percolate through feces, it becomes a contaminated witches' brew called leachate. Properly designed composting toilets can adequately treat this leachate if it percolates slowly through an aerobic portion of the compost mass. But if a composting toilet is poorly designed, operated without enough bulking agent, or overloaded, leachate will be inadequately treated. It can then foul ground water and actually harm plants, so it requires special handling.

3.4 DECOMPOSITION IN TYPICAL BACKCOUNTRY TOILETS

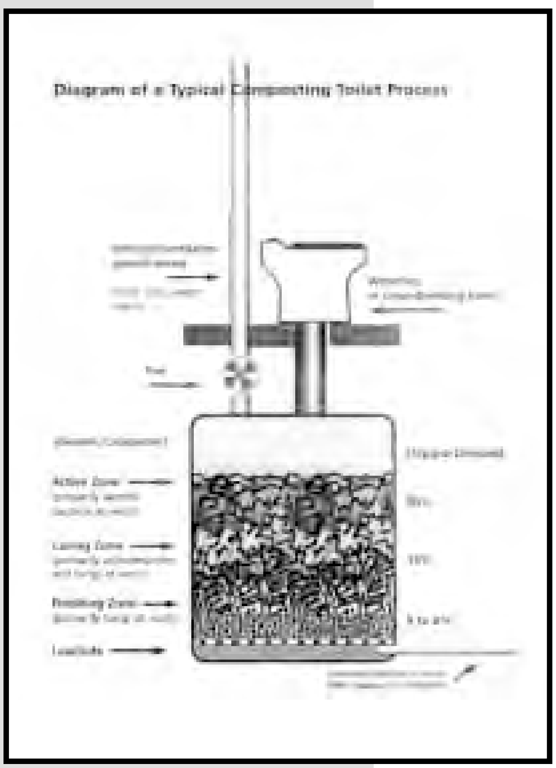
Traditionally, people have used pit toilets or pit privies (commonly called outhouses) in the backcountry. Returning to our cow pasture comparison, this practice is an attempt to keep popular backcountry sites from resembling septic barnyards, or the even more objectionable feedlot. Outhouses protect privacy and keep feces in one spot, but the mass of feces and urine in the pit usually is anaerobic. Pit privies are appropriate and effective in a low-use situation where a new pit may be required every 4-6 years, although there is still the risk of groundwater contamination.

See Franceys, R. et al. (1992), in Appendix E.

According to Franceys, pollution from a pit toilet can travel 15 meters (50 feet) from the pit in the direction of groundwater flow. In dry soil, Rybczynski tells us that pollution can travel from a pit toilet 3 meters (10 feet) vertically and 1 meter (3 feet) laterally. Complete decomposition of feces in an underground pit may require decades. Human pathogens may remain viable for decades in the cool, anaerobic conditions of the pit. If soil is shallow, or groundwater high, pathogens and nutrients can be transported from a site for many years after a pit has been abandoned. These facts preclude the use of pit toilets in many areas of the backcountry.

See Rybczynski et al. (1982), in Appendix E.

Composting systems, including composting toilets, require that feces remain aerated and in contact with soil organisms which can use oxygen to produce rapid decomposition. If there is too much moisture, oxygen cannot reach aerobic bacteria, and they perish. If the volume of the fecal mass is too large compared to its surface, the same thing happens; the center of the pile "goes anaerobic," and malodorous, slow, anaerobic decomposition occurs.



With insufficient bulking agent, urine can saturate compost, causing anaerobes to take over. Anaerobic decomposition of the nitrogen in urine produces unpleasant chemicals such as ammonia, which is poisonous in high concentrations and accounts for some of the noxious odor of a traditional outhouse.

The nitrogen in urine requires a great deal of bulking agent to provide the additional carbon to achieve the optimal carbon:nitrogen ratio for composting of 25:1, and to avoid saturation. Unless the nitrogen is desired as a fertilizer, it is often undesirable to prematurely fill the chamber of a composting toilet or privy with the large volume of carbonaceous material needed at a high-use backcountry site.

To minimize the labor of handling bulking materials and emptying compost chambers, or if there is any uncertainty over the capacity of a composting toilet or privy to treat leachate, it is best to separate urine and feces by providing urinals or asking users to urinate in the woods.

Figure 3.2—Typical composting toilet process (moldering style) - Not a specific unit mentioned in this manual. Drawing from The Composting Toilet System Book by David Del Porto and Carol Steinfeld.

4

Health and Safety Issues

Pete Ketcham, Field Supervisor, Green Mountain Club

Pete Rentz, M.D., Trails Chairman, Massachusetts A.T. Committee of the AMC Berkshire Chapter

> *"Proper Sanitation is defined by the World Health Organization as any excreta disposal facility that interrupts the transmission of fecal contaminants to humans." From The Humanure Handbook, by J.C. Jenkins, 1999*

4.1 OVERVIEW OF PATHOGENS

Various harmful disease-causing organisms, called pathogens, can be present in feces. Even the normally occurring *E. coli* can behave as a pathogen if it is ingested in large volume, or if it contaminates a wound. Pathogens include diarrhea-causing Salmonella or Typhoid bacteria, polio and hepatitis viruses, protozoa such as *Giardia lambia* and Entomoeba histolyticia, and parasites such as hookworm and Ascaris (roundworm).

Most of these pathogens are killed by composting for several months, although Ascaris eggs can be resistant to composting conditions, and may remain viable for years in favorable soil conditions. If aerobic decomposition is so fast that the temperature in a composting mass rises substantially, destruction of pathogens is more rapid, and Ascaris eggs do not survive.

Hikers infected by Ascaris are probably rare in this country, though it would take a very expensive study to determine this with certainty. However, there is no control over who uses the backcountry toilets, and there is no practical method of monitoring the temperature in all parts of a composting chamber. Therefore, field workers must assume that Ascaris eggs are present in compost even after high-temperature decomposition, and they must follow the safety precautions and procedures outlined below.

Parasitic worms other than Ascaris are either tropical in habitat or not transmitted through feces, and are of little concern in temperate climates. Giardia and their cysts, amoebas, viruses, and pathogenic bacteria do not last long in the composting environment.

4.2 CONDITIONS THAT DESTROY PATHOGENS AND PARASITES

Substantial elimination of human pathogens, including parasites, is the primary goal of composting. A variety of interacting factors destroy pathogens; their importance differs in *mesophilic* (low temperature) and *thermophilic* (high temperature) composting.

The design and operation of a composting system depends on which type of composting is expected to dominate. Batch-bin and beyond-the-bin systems rely primarily on thermophilic composting for pathogen destruction, while moldering, or continuous-composting systems rely on mesophilic composting.

The following conditions destroy pathogens in composting systems:

1. *High temperatures* generated in the interior of a compost pile in thermophilic composting that exceed the upper limits of human pathogen tolerance.

   Human pathogens, adapted to a narrow range centered around body temperature (37 degrees C. or 98.6 degrees F.), are killed by exposure for several hours to temperatures in the range of 50 to 60 degrees C. (122 to 140 degrees F.), or by exposure for several days to temperatures in the range of 40 to 50 degrees C. (104 to 122 degrees F.).

   A properly managed compost pile, well-supplied with fresh material and large enough to retain its own heat, will have enough nutrients and oxygen to warm quickly into the thermophilic range. For specific information on optimum pile size and management of thermophilic composting, see the description of Batch-Bin Composting in Section 9.

   Thermophilic conditions are reached only in the interior of a pile. Therefore, in any system that depends on high temperatures for pathogen destruction, the pile must be turned to transfer the outside material to the interior. The greater the

See Section 9, "Batch-Bin Composting.

Typical Pathogen Survival Rates at 20° to 30°C in Various Environments*

	Survival Time[a] in Days		
Pathogen	Freshwater and wastewater	Crops	Soil
Bacteria			
Fecal coliforms[b]	<60 but usually <30	<30 but usually <15	<120 but usually <50
Salmonella spp.[c]	<60 but usually <30	<30 but usually <15	<120 but usually <50
Shigella	<30 but usually <10	<10 but usually <5	<120 but usually <50
Vibrio cholerae	<30 but usually <10	<5 but usually <2	<120 but usually <50
Protozoa			
E. histolytica cysts	<120 but usually <15	<10 but usually <2	<20 but usually <10
Helminths			
A. lumbricoides eggs	Many months	<60 but usually <30	Many months
Viruses			
Enteroviruses[d]	<120 but usually <50	<60 but usually <15	<100 but usually <20

*Adapted from Feachem et al. (1983).
[a] Includes polio-, echo-, and coxsackieviruses.
[b] In seawater, viral survival is less, and bacterial survival is very much less than in fresh water.
[c] V. cholerae survival in aqueous environments is a subject of current uncertainty.
From Crites and George Tchobanoglous, Small and Decentralized Wastewater Management Systems (United States: McGraw-Hill, 1998)

Figure 4.1—Typical Pathogen Survival Rates at 20 to 30 Degrees Celsius in Various Environments" From The Composting Toilet System Book by David Del Porto and Carol Steinfeld.

volume of waste, the better the pile self-insulates, and the higher the proportion of material that undergoes thermophilic conditions after each turning.

2. *Aerobiosis:* Most human gut pathogens are "obligate anaerobes" (organisms that live only in the absence of oxygen). Aerobic conditions contribute to a lethal environment for them. Small particle size and thorough mixing ensure maximum oxygen exposure.

3. *Competition:* Hardy local soil microbes are better able to utilize the rapidly changing conditions in composting material in the competition for nutrients and attachment sites.

4. *Destruction of nutrients:* Human pathogens are generally more fastidious in their nutritional requirements and choice of substrate than non-pathogenic organisms. They are at a competitive disadvantage as nutrients to which they are adapted are consumed, oxidized or otherwise altered.

5. *Antibiotics:* Produced by actinomycetes and fungi, these hinder the growth of many pathogens. Antibiotics play a larger role in the later stages of thermophilic composting processes, when the pile has cooled and stable mesophilic conditions favor fungi and actinomycetes.

6. *Time:* The length of exposure to inhospitable conditions takes a toll on human pathogen populations.

   Time is critical in a moldering toilet or privy, and in commercially produced continuous-composting systems like the Bio-Sun or Clivus Multrum, since the temperatures in these systems are in the mesophilic range. The agents and mechanisms of low-temperature pathogen destruction need ample time to take effect. In a properly functioning compost pile, bacteria and viruses are generally inactivated over periods ranging from a few days to a few weeks. However, moldering systems generally provide a large factor of safety by holding wastes in aerobic conditions for months or even years.

   Although composting occurs faster in batch-bin and beyond-the-bin systems, time is still necessary. In the first (thermophilic) stage, wastes are exposed to rapid aerobic composting conditions for three to six weeks. Most of the breakdown of waste materials and destruction of pathogens occurs in this phase. Aging at ambient temperatures on a drying rack provides a secondary decomposition period ranging from one month to one year, in which the compost stabilizes and shrinks further. If more time is allotted to the primary phase, less is needed in the secondary stage.

See Section 9.6—"Batch-Bin Composting: The Finished Product, and "Spreading Finished Compost."

4.3 SAFETY PRECAUTIONS AND PROCEDURES

Although the ideal is to eliminate handling of raw sewage or reduce it to a minimum, compost operators often work with raw sewage. Even finished compost cannot be considered absolutely safe, although it typically has pathogen concentrations comparable to those in ordinary forest soil. Strict sanitary procedures are essential. If caution and common sense are used, the likelihood of infection or illness is extremely low.

The following precautions and procedures are essential in any operation composting human waste:

- Regardless of what type of system you are using, hang a special wash jug near the outhouse, away from the shelter and washpit, and well away from surface water. Label the jug "FOR COMPOSTING ONLY." That wash jug should *never* leave the site.

- The best container for a wash jug is a one-gallon plastic milk jug with a small hole punched near the bottom. Put a small twig in the hole. When the jug is capped and the twig is in place, leakage is slow. With the cap loosened and the twig removed, a small stream comes out. That system allows you to wash and rinse hands thoroughly.

- Use a clean jug to pour wash water into the wash jug *before* you begin any aspect of the composting operation; never touch this clean jug after the point in the work in which your hands may have become contaminated.

- The best soap is liquid antibacterial soap in a small squeeze bottle, although dish washing soap also works well. Bar soap easily gets dirty. If bar soap is used, keep it in a plastic soap dish. Do not leave soap outside on the ground, or critters may chew a hole in the bottle or dish. Use your composting soap only for cleaning up after composting operations. Label it "FOR COMPOSTING USE ONLY."

- After handling any sewage container or performing any mixing or turning, always wash your hands well with soap. Allow soapy water from your hands to fall directly on the ground.

- Do not put soap into clean water. Rather, let a small stream of clean water run over your hands while sudsing up. Then rinse with clean water. This keeps the wash container free of soap.

- Some compost operators follow their handwash and rinse by a rinse with a 3 percent hydrogen peroxide solution. This is a good precaution, since one never knows whether people infected with pathogens have been using the toilet. A dilute solution of liquid chlorine-based bleach (1 tablespoon per quart of water) also can be used.

- Some people use the waterless hand sanitizer available from drug stores. While useful, this is not a substitute for vigorous handwashing with water and antibacterial soap.

- Wear long pants.

- Long-sleeved shirts can be a problem, because the sleeves may be soiled by brushing against soiled objects. Roll the sleeves up snugly before you begin. Tuck in your shirttails so they won't dangle into or against a bin while you are turning compost. The same goes for long braids. Any clothing used for composting should be laundered in hot water separately from other clothing.

- During bug season, plan to do all work with your system early in the morning. Swatting bugs or scratching insect bites with soiled hands is foolish. Wear a bandanna to keep bugs out of your ears.

- Use rubber gloves. The Green Mountain Club (GMC) and U.S. Forest Service (USFS) use heavy-duty rubber gloves, available from medical-supply stores. Wash your hands even when you have used gloves.

Figure 4.2—Things to always do when handling composted waste—Safety always comes first." From the Center for Clean Development. Taken from The Composting Toilet System Book by David Del Porto and Carol Steinfeld.

- Keep your fingernails short.

- Wear eye protection. Safety glasses are the least-expensive option.

- Cover small cuts and blisters with Vaseline and a Band-Aid before you handle any potentially contaminated objects, such as tool handles or handles on collection and storage containers. Remove Band-Aids and wash thoroughly when you are done. Larger cuts are best covered with gauze and disposable gloves.

- If you cut or nick yourself while handling buckets or tools, *stop* and wash well with soap and water. Bandage before finishing the job. Do not risk infection.

- Once you have begun interacting with your composting system, treat your hands as if they are completely soiled. No adjusting of clothes, resting of hands on hips or in pockets, folding of arms, etc. Keep your hands off your body, and touch nothing but tools, containers, and bulking agent.

- If you accidentally splash raw sewage on yourself, wipe it off with dry bark powder or powdered charcoal, taking care to not scratch your skin. Then rinse with a stream of water. Keep a small, open container of finely powdered bark or charcoal with you while you are working. Raw sewage can be removed the same way from shoes or clothing, which should later be washed.

- Be careful if small, springy branches, or underwear with elastic gets into the sewage containers. This does happen occasionally. Elastic can slingshot sewage at you with uncanny accuracy and alarming consequences.

- Keep your mouth closed while dumping sewage from one container into another. If sewage does splash in your mouth, rinse immediately with copious quantities of water, and do not swallow.

- Do not lean against any part of the composting system for leverage. Turn the compost in the bin without touching the bin at all.

- Be careful to keep tool handles away from the sides of the toilet or any container.

- Keep all tool handles clean by rubbing them with bark or duff after use. Mark all tools “FOR COMPOSTING USE ONLY” with paint or another permanent marker. It is best to lock composting tools away from visitors.

- Stand tools up carefully to keep the handles clean. As an extra precaution, hold tools well above where the metal tool head attaches to the wooden handle. The metal portion of the turning fork and shovel will become contaminated during each use.

- As a final precaution, *never touch finished compost*, no matter how “done” it appears. It is safe if properly handled. Areas where compost has been properly spread should pose no health risk to the operator. However, take reasonable precautions in moving through those areas (such as not walking in bare feet).

Additional safety equipment can be used. For example, the Randolph Mountain Club, which operates the Bio-Sun continuous-composting toilets in the White Mountains of New Hampshire, requires its volunteers and staff to wear heavy duty, elbow-length, industrial-rubber gloves; plastic face shields, Tyvek shirts, and heavy-duty rubber gowns.

See Section 11.6.

Part 2
Regulatory and Aesthetic Issues

5

Integrating Backcountry Sanitation and Local Management Planning

Jody L. Bickel, Associate Regional Representative for Central and Southwest Virginia, Appalachian Trail Conference

Since 1983, the Appalachian Trail Conference (ATC) has promoted local management planning among Trail-maintaining clubs and agency partners. The *Comprehensive Plan for the Appalachian Trail* and the *Memorandum of Understanding between the National Park Service and ATC* (which delegated certain management responsibilities to ATC and the clubs) assume that local management plans will be the cornerstones for cooperative management of the Appalachian Trail.

In 1987, ATC initiated the development of a local planning guide, with the intent of providing the Trail-maintaining clubs with a comprehensive reference document to aid them in the process of local planning. The *Local Management Planning Guide* has evolved from this initial concept to with two purposes: (1) to consolidate existing ATC and federal policies affecting Trail management into a single reference for clubs and cooperating agencies, and (2) to answer questions on how to prepare a local management plan and what to include in a plan. In other words, the *Planning Guide* is designed to be used as both an active tool and as a permanent reference of current policies for management of the Appalachian Trail.

Each of the 31 Trail-maintaining clubs prepares a local management plan, following the guidelines in the planning guide, for its section of the Trail. The most current edition of the Planning Guide was revised in 1997. Each club plan is reviewed by the ATC Board of Managers and updated approximately every five years.

See Appendix D.

When making decisions about backcountry sanitation management, volunteers should refer to the maintaining club's local management plan to ensure compliance with local standards and Trail-wide policy. For more information contact your ATC regional office.

6

Introduction to the Regulatory Process

Pete Irvine, Appalachian Trail Coordinator, USDA Forest Service

6.1 OVERVIEW

Providing adequate facilities for the disposal of human waste along the Appalachian National Scenic Trail is a complex issue. Factors including the number of users, type of users (day hikers, overnighters, long-distance hikers), length of the annual use season, availability of nearby off-Trail facilities, type of terrain, availability of suitable overnight sites (both shelters and campsites), and other variables, all contribute to this complexity.

In many locations along the Trail, dispersed individual cat-holing of human waste in accordance with the principles of Leave No Trace is the current sanitation practice, and is expected to be adequate and acceptable for the foreseeable future. In other locations, concentration of use, particularly overnight use, on a limited number of sites—especially in fragile or sensitive ecosystems—dictates the need for more developed sanitation facilities.

6.2 CURRENT POLICIES ADDRESSING BACKCOUNTRY SANITATION

See: *Local Management Planning Guide* (1997 Edition), in Appendix E.

There is no "standard policy" among the various Appalachian Trail cooperative management partners addressing backcountry sanitation facilities. The current Appalachian Trail Conference (ATC) policy, as stated in the *Local Management Planning Guide* (1997 Edition) is that sanitation facilities should be provided at high-use shelters and popular campsites. Some clubs (*via* their local management plans) or regional management committees have additional policies.

For example, the mid-Atlantic regional management committee has resolved that all overnight shelter sites in its region should have developed sanitation facilities. Trail clubs in that region (Shenandoah National Park in Virginia through New York) have worked for several years to develop waste facilities at existing shelters that do not have them.

The policies of federal and state agency partners vary, and often include general, agency-wide policy direction (for example, USDA Forest Service manuals and hand-books, National Park Service director's orders, and state agency equivalents). They often include additional, more specific policy for particular units (forests or parks), or for the Appalachian Trail (for example, national forest land management plans, national park general management plans, and state agency equivalents).

Both Forest Service and Park Service policies state that wastewater facilities will be in compliance with the federal Clean Water Act. Both agencies strongly recommend involvement of appropriate specialists (such as a public health service consultant or sanitary engineer) in determining the appropriate type of facility type, its design, and its siting. According to Park Service policy, the following are suitable backcountry waste systems:

- Flush toilets
- Composting toilets
- Barrel toilets
- Evaporator toilets
- Incinerator toilets
- Pit privies

The overriding legislation dealing with backcountry sanitation is the Clean Water Act of 1977, as amended. This law gives the United States Environmental Protection Agency (EPA) the authority to regulate wastewater facilities in order to restore and maintain the integrity of the nation's waters. EPA delegates many of the permitting, administrative, and enforcement aspects of the law to state governments, who in turn work through local (county, township, or municipal) sanitarians and health departments. While federal agencies are not bound by most local and state laws and regulations, they are bound by the federal regulations pursuant to the Clean Water Act which are administered by state and local agencies for the EPA.

6.3 CURRENT PROCESSES FOR PROPOSING SANITARY FACILITIES

A proposal to develop a human waste facility at a site may be advanced by any of the cooperative management partners—individual maintainer, local maintaining club, ATC, or land-managing agency partner. Often, a proposal for a human waste facility is part of a larger proposal to construct or reconstruct an overnight site. Once a proposal is advanced, all cooperative management partners should be involved in the decision: first, whether a human waste facility is necessary or desirable; and second, what facility is best suited to the location.

Once a proposal for a sanitary facility has been developed by the management partners, land ownership determines the direction that the approval process will take.

On federal lands, an environmental analysis of the proposal must be conducted in accordance with the National Environmental Policy Act of 1969 (NEPA), which requires activities be analyzed to determine their impacts on natural resources and the public.

In increasing order of complexity, the three levels of analysis are: (1) *categorical exclusion*, (2) *environmental assessment*, and (3) *environmental impact statement*. Most simple actions, like relocating or improving an existing privy, can be done under the easiest procedure, a categorical exclusion. Involvement of program-area specialists is usually required to ensure that the project will not adversely affect cultural resource sites or threatened or endangered species, and that it is compatible with other activities. Investigation of agency, state and local requirements should be completed early in the NEPA process.

The Park Service and the Forest Service have developed different policies to implement the requirements of NEPA that depend, in part, upon site-specific factors and the risk assessment of the decision maker (such as the district ranger, the forest supervisor, the park manager, or the park superintendent).

On non-federal lands, analyses and approvals may be required by other agencies, and coordination with other state and local regulatory agencies may be necessary. The applicable state and local regulatory agencies vary from state to state.

For example, state regulations in Maryland and Pennsylvania, which prohibit the direct ground contact of human waste in a constructed facility, preclude new pit privies. Concrete vault toilets and composting toilets with waterproof composting chambers meet the regulations.

Construction of a replacement shelter and composting toilet in Pennsylvania in 1997 required approval of the concept and design of both the shelter and the toilet by the land manager, the Pennsylvania Game Commission, and separate approval of a permit for the composting toilet by the local sanitary engineer.

In 2000, the Green Mountain Club (GMC) in conjunction with the University of Vermont and the Vermont Department of Forests, Parks, and Recreation restored the historic Butler Lodge on Mt. Mansfield. This project also included an upgrade of the batch-bin composting toilet system to a beyond-the-bin liquid management system. The project required submitting a wastewater permit application to the State of Vermont Agency of Natural Resources Department of Water Supply and Wastewater Disposal. The GMC submitted an application and a thorough explanation of the system, based on the report developed by the Appalachian Mountain Club (AMC). A permit was issued. This is the first time the GMC has had to apply for such a permit. (See Appendix for the permit.)

See Appendix N for the permit.

The Appalachian Mountain Club is planning to install red worm moldering privies at several sites on the A.T. in Connecticut. In order to begin the process of getting regulatory acceptance of these systems, AMC wrote a letter to the State of Connecticut Department of Public Health. The club was placed in contact with the supervising sanitary engineer of the Environmental Engineering Section. The AMC submitted a letter of request accompanied by a detailed description of the moldering privy. The state approved the installation as long as several criteria were met. The state's letter served as the AMC Trails Committee's means of notifying local health agencies of the acceptability of the system and to solicit their involvement in the review, testing, and approval of the units where applicable.

See Appendix N for the state's letter.

The Appalachian Trail Conference and its local maintaining clubs for the Great Smoky Mountains National Park area are working to install moldering privies along the A.T. in 2001. They are working closely with the National Park Service to make sure that all applicable regulations are met. For example, in the national park, regulations concerning introduced and exotic species will bar the ATC and clubs from using red worms in the moldering privies.

Determine all of the regulatory stakeholders that need to be involved in your proposed sanitation project!

The importance of this cannot be emphasized strongly enough. Management of the Appalachian National Scenic Trail is a partnership. Volunteers have always been—and continue to be—the cornerstone of the A.T., but they do not work alone. Since the 1920s, the Forest Service, the Park Service, the states and local communities have worked together to complete, preserve, and maintain the Trail.

The 1978 amendment to the National Scenic Trails System Act authorized the A.T. land acquisition program, which dramatically broadened and deepened this partnership. Today, volunteers work in a partnership that includes the Appalachian Trail Conference (ATC), Trail maintaining clubs, and multiple government landowning agencies (NPS, USFS, state parks, Department of Transportation, local Trail communities, *etc*.).

Contact your ATC regional office for more information; addresses are in Appendix D. Also see Appendix C for regulatory contacts, which can inform you of all of the stakeholders involved with permitting a sanitation system.

Even more partners are involved in backcountry sanitation. These included state, county, and local health departments, state agencies in charge of natural resources and environmental conservation and protection, and state, county, or town-contracted engineers. Contact your ATC regional office for more information; addresses are in the Appendix. Also see the Appendix for regulatory contacts, which can inform you of all of the stakeholders involved with permitting a sanitation system.

Some volunteers feel challenged by working in this larger partnership. Government and state agencies must comply with many laws, which sometimes slows approval of a project. However, this partnership creates a system of checks and balances that ensures the overall best trail management. It also provides the trail management community access to a vast pool of talent and experience. Without everyone's commitment to work together, the health and preservation of the trail could be threatened.

How do you learn what you need to know? The best way is from your club's leadership. The partners' rights and obligations are in each club's local management plan, itself authorized by federal agencies under the *Comprehensive Plan for the Management of the Appalachian Trail*. If you are not part of a club, consult the Appalachian Trail Conference. ATC develops policies that ensure consistent and thoughtful management of the trail and its corridor lands. ATC alternately supplies the bond to hold everything together and the lubricant to make the partnerships along the trail work smoothly.

Appalachian Trail Design, Construction, and Maintenance, Second Edition, by William Birchard, Jr. and Robert D. Proudman, published by the Appalachian Trail Conference, Harpers Ferry WV 2000, pp. 10-11.

In any case, don't start any backcountry sanitation project on your own. Trail work on the A.T. often requires a formal authorization from the Park Service, Forest Service or state, so always work with the blessing of your club and the ATC.

For more information, see *Appalachian Trail Design*, *Construction*, *and Maintenance*, Second Edition,by William Birchard, Jr. and Robert D. Proudman.

6.4 ADDITIONAL REGULATORY CONSIDERATIONS

To go along with the usual regulatory process for sanitation projects along the A.T. described above, the following situations require additional consideration before work begins:

Congressionally designated Wilderness—New structures are prohibited in most designated federal Wildernesses, in keeping with the Wilderness Act of 1964 and other Wilderness legislation. Existing Appalachian Trail structures in Wilderness are generally allowed to remain and be maintained, but complete reconstruction or new construction may be prohibited. It is prudent to consult the legislation establishing each Wilderness, because the legislation (and the committee language used to assist in its interpretation) usually varies from one Wilderness to another. Even if construction or reconstruction is permitted, use of vehicles and other motorized equipment generally is prohibited. Helicopter delivery of material and removal of waste may be permitted, but if so, it is strictly regulated.

Special areas designation—Designation of state or federal land areas as roadless areas, research natural areas, or other specially designated areas may limit the options for construction of facilities, or vehicular or air access to waste management facilities for maintenance.

Design approvals—Most agency land managers require that construction plans be developed for agency approval. Agency resources, including engineers and landscape architects, may be available or required to assist in design. Efforts spent on design approval, including accessibility and confined space considerations, can prevent or reduce problems during construction and operation of the facility.

Accessibility—Accessibility for people with disabilities must be considered in planning and designing all facilities on federal or state land, regardless of remoteness or difficulty of access to a site. Applicable legislation includes the Architectural Barriers Act of 1968, the Rehabilitation Act of 1973, and the Americans with Disabilities Act of 1990. Any facility constructed using federal funds must be made accessible, and all federal programs must provide for reasonable accommodation for persons with disabilities in all program areas. Accessibility requirements should be researched early in the development of a facility.

At the time of publication of this manual, new regulations on access for disabled persons in outdoor environments, including backcountry settings, were being developed by the Architectural and Transportation Barriers Compliance Board, but were not yet finalized. Agency land managers are the best source of current accessibility information.

Confined spaces—A backcountry sanitation facility with an access hatch, ladder, steep stairs, low head room, or other egress or exit restriction is a "confined space" as defined by the Occupational Safety and Health Administration (OSHA), and special regulations apply. Sanitation facilities, especially composting systems, may present these situations. The OSHA regulations are difficult to follow in backcountry situations, and the best practice is to avoid confined spaces when designing a backcountry sanitary facility.

Agency land managers are the best source for information on confined space requirements.

Disposal of compost—The disposal of composted material is regulated by the EPA. In general, composted material should be considered "domestic septage," like that from a septic tank, unless temperature is monitored throughout the composting process, or pathogen tests of the finished compost categorize it as "Class A sludge." EPA regulations require that domestic septage be incorporated into the soil when placed on the land, while Class A sludge may be surface-applied without restriction. Remote backcountry composting toilets have been shown capable of producing Class A sludge even in the absence of high composting temperatures, and it is possible to obtain waivers from domestic land application requirements from the EPA-designated regulating agency.

Maintainer health and safety—Personnel, whether volunteer or employee, involved with the maintenance of backcountry sanitation facilities should be aware of current agency standards and use standard practices and appropriate protective equipment. Standards and practices vary by agency, and local land managers are the best source of current standards and practices.

For more information on regulatory processes, contact your ATC regional office.

7

The Aesthetics of Backcountry Sanitation Systems

Jody L. Bickel, Associate Regional Representative for Central and Southwest Virginia, Appalachian Trail Conference

7.1 OVERVIEW

Managers of the Appalachian Trail are increasingly challenged to provide both adequate sanitation facilities and a primitive experience. An overnight backcountry site can be overwhelmed by an imposing waste management system that can destroy the sense of solitude and isolation from civilization.

Trail managers should carefully consider the aesthetics of each potential sanitation system, along with issues such as user types and seasonal use patterns. Factors such as location, design, installation and maintenance affect aesthetic impacts directly, and also indirectly through their effects on user compliance. Designated "toilet areas" and throne-like toilets with large buildings and extensive equipment should be avoided if possible.

High use, particularly in fragile ecosystems, has encouraged development of more effective, but also more elaborate, waste management systems. These include commercially produced continuous-composting toilets (sometimes with solar-assisted warming and ventilation) and batch-bin composting systems. Such systems generally require a larger structure footprint, additional tools, compost bulking materials, and extraneous system supplies. Appropriate tools and supplies are necessary for system management, but an overabundance can create adverse aesthetic impacts.

7.2 GUIDELINES ON AESTHETICS

The Appalachian Trail Conference (ATC) provides guidelines on aesthetics in several documents, which should be used in addition to this manual.

Chapter 2(I) of The *Local Management Planning Guide* (1997 edition), which details ATC and federal policy on Trail management, provides some guidance on aesthetics. It is quoted below.

In 1995, ATC's Board of Managers adopted the following policy on managing the A.T. for a primitive experience:

The Appalachian Trail Conference should take into account the effects of Trail-management programs and polices on the primitive and natural qualities of the A.T. and the primitive recreational experience the Trail is intended to provide. Although these guidelines are intended to apply primarily to the effects of actions or programs on predominantly natural, wild, and remote environments along the Trail, they may apply to certain pastoral, cultural, and rural landscapes as well.

Trail improvements, including shelters, privies, bridges, and other facilities, should be constructed only when appropriate to protect the resource or provide a minimum level of public safety. Design and construction of these facilities should reflect an awareness of, and harmony with, the Trail's primitive qualities. Materials and design features should emphasize simplicity and not detract from the predominant sense of a natural, primitive environment. The Trail treadway, when constructed, reconstructed, or relocated, should wear lightly on the land and be built primarily to provide greater protection for the Trail footpath or Trail resource values. Trail-management publications should include appropriate references to the potential effects of Trail-management activities on the primitive qualities of the Trail.

In developing programs to maintain open areas, improve water sources, provide sanitation, remove structures, and construct bridges, signs, Trailheads, and other facilities, Trail managers should consider whether a proposed action or program will have an adverse effect on the primitive qualities of the Trail, and, if such effects are identified, whether the action or program is appropriate.

Trail clubs also should consider the effects of individual management actions (such as bridges, relocations, or other developments) on the primitive character of the Trail. The remote recreational experience provided by the Trail and the resources that enhance this experience should be carefully considered and protected. The following questions can be used to help evaluate the potential effect of a policy, program, or project on the primitive quality of the Trail:

- *Will this action or program protect the A.T.?*
- *Can this be done in a less obtrusive manner?*
- *Does this action unnecessarily sacrifice aspects of the Trail that provide solitude or that challenge hikers' skill or stamina?*
- *Could this action, either by itself or in concert with other actions, result in an inappropriate diminution of the primitive quality of the Trail?*
- *Will this action help to ensure that future generations of hikers will be able to enjoy a primitive recreational experience on the A.T.?*

— Local Management Planning Guide (1997 edition), Chapter 2(I)

7.3 FACTORS IN LOCATING SANITATION FACILITIES

The *Checklist for the Location, Construction and Maintenance of Campsites and Shelters on the Appalachian Trail* is a listing of important factors to consider when locating and building new campsites and shelters, or for operating and maintaining older sites. Since most backcountry sanitation facilities are located at designated overnight-use areas, this document can serve as a useful planning tool.

See: *Checklist for the Location, Construction and Maintenance of Campsites and Shelters on the Appalachian Trail.*

Consider the following factors that affect the aesthetic impact of sanitation facilities:

Toilet location—If possible, choose an unobtrusive location, so the toilet will not dominate the site. To encourage user compliance, choose a dry site with a dry access route, and consider distance from camp area(s), rodent pests, and wind and sun exposure. Prevent numerous access trails to the toilet by clearing and marking one defined route.

Number of toilet facilities per site—One managed facility is adequate for most shelters and campsites. Consider consolidating multiple existing systems. However, bear in mind that overloading a single facility during peak season may actually reduce user compliance.

Toilet design—Use rustic design and materials, subject to the need for durability (for example, use galvanized hardware and nails). When items such as plastic or metal bins and plastic pipe must be used, camouflage or disguise them through creative construction and installation. Stain or paint structure(s) with colors that harmonize with the site, such as brown, dark green or gray at forested sites. Do not use glossy paint. Assure that the roof and flashing are flat, muted and non-reflecting. Avoid over-building the structure and sanitation area with unnecessary items, such as windows and benches.

Contamination prevention—Small wild animals, such as mice, voles, and squirrels, as well as domestic pets, are tempted to explore sanitation management areas. Mice, in particular, like to use toilet paper—new and used—for nesting material, and will carry it into a nearby shelter. Install hardware cloth to block access to raw waste. Do not provide toilet paper for users. Although complete access prevention is not possible, keeping a clean, managed toilet located a decent distance from camp and cook areas will help.

People are often very curious about structures in the backcountry. Generally, the less obtrusive a sanitation system is, the less attention it will attract. Although most people will keep their distance from the inner workings of a toilet, managers should guard against system disturbance by Trail visitors. Typical problems include use of bulking material (such as shavings or bark mulch) for fires, use of shovels and other sanitation tools around campsites, and disturbance of equipment (unlatched bins, *etc.*). Post low-impact signs at the management area explaining the hazards of the waste system. Cover tools and supplies with earth-toned tarps out of sight of the area. In high-use areas, consider padlocking all sanitation tools in a storage locker attached to or included in the toilet structure.

See Appendix D.

For more information, contact your ATC regional office.

Part 3
Descriptions of Systems

8

The Moldering Privy

Pete Ketcham, Field Supervisor, Green Mountain Club

Dick Andrews, Volunteer, Green Mountain Club

8.1 INTRODUCTION

The moldering privy is experimental, but it has great promise for disposal of human waste in the backcountry, and even in some frontcountry locations. It is much cheaper than commercially manufactured composting toilets. The moldering privy requires less labor and exposes maintainers to less risk of infection than bin composting systems, and is much less polluting than pit toilets. It also eliminates the need to dig new pits, and it can serve a higher volume of users than pit toilets. The maximum use capacity of the moldering privy has not been established, but it may approach or equal the capacity of commercial composting toilets and batch-bin composting systems.

The moldering privy could serve as the perfect middle ground for maintainers. It combines the resource protection benefits of composting with less maintenance, expense and risk than earlier systems.

Project background—The moldering privy was developed in a continuing research project by the Green Mountain Club (GMC) in conjunction with the Appalachian Trail Conference (ATC), the National Park Service Appalachian Trail Park Office (ATPO), and the Vermont Department of Forests, Parks, and Recreation (VT FPR). The goal was to develop a waste management system to replace the traditional pit toilet and designated toilet (cathole) area with a system that manages human waste with less maintenance than other composting systems.

GMC drew upon the concept for the moldering privy from Dick Andrews (a GMC volunteer, composting toilet owner, and the editor of this manual) as well as existing composting technologies and literature on the subject of sanitation in remote backcountry areas. Dick conceived of, and built, the first moldering privy on the Long Trail/Appalachian Trail at Little Rock Pond in the Green Mountains of Vermont in 1997.

In 1999, with the assistance of the GMC's agency partners, the club created a refined version of the moldering privy with plans for a lightweight outhouse suited to backcountry applications, and built four units on the Long Trail in northern Vermont. The GMC also produced a draft *Moldering Privy Manual and Design* in 1999.

In 2000, the GMC designed a double-chambered moldering privy, and installed three experimental double units on the Long Trail. The lessons we have learned and the improvements we made are presented in this chapter.

Other clubs have also been experimenting with the moldering privy concept. For information on the AMC-Berkshire A.T. Committee's experience, see Chapter 8—Case Studies, Moldering Privy on the A.T. in Massachusetts.

Chapter 8—Case Studies, Moldering Privy on the A.T. in Massachusetts.

> *Note: A word of caution*—The GMC moldering privy system is still experimental. Composting in our moldering privies has been so effective that no composting chambers have yet filled, so we have not completed a full composting cycle. It may take several more seasons to fill our current systems and finish composting their contents.
>
> Therefore, GMC suggests considering all the waste management systems in this manual that have proven track records. If the alternatives to the moldering privy do not work for you, experimenting with the moldering privy may be your best option. Please keep in touch with the GMC periodically to see how our systems are working.
>
> A moldering privy built by the Appalachian Mountain Club (AMC) Berkshire Chapter's Massachusetts A.T. Committee has completed more than one full composting cycle, with excellent results. For details, see Chapter 8—Case Studies, Moldering Privy on the A.T. in Massachusetts.

For details, see Chapter 8—Case Studies, Moldering Privy on the A.T. in Massachusetts.

8.2

RATIONALE FOR DEVELOPMENT OF THE MOLDERING PRIVY

Batch-bin composting has worked well in many sites, but it requires a lot of labor, both by well-trained and sturdy people to manipulate the process, and by porters with strong backs to haul in the large amounts of bark mulch or other bulking agent needed to absorb liquid. Batch-bin composting also requires field personnel to handle raw sewage. With care, this can be done with reasonable safety, but it still poses a risk that is better avoided. In addition, batch-bin composting kills pathogens very effectively in waste that has reached a high temperature, but if part of the waste in a batch fails to heat sufficiently, pathogens will survive. In practice, the odds are high that part of the waste will escape high temperatures. The practice of finishing compost on drying racks was developed to address this limitation.

The moldering privy was inspired by commercially manufactured ambient-temperature, continuous-composting toilets designed for households, with the realization that in most backcountry settings the soil—though sometimes thin—is adequate to absorb the extremely low volumes of liquid deposited in a waterless toilet. Thus, the watertight, bulky and expensive composting chambers characteristic of household composting toilets are not needed in the backcountry.

8.3

WHAT A MOLDERING PRIVY IS

Jenkins (*The Humanure Handbook*, 1994)

What moldering is—Moldering means slow, or cool, composting. This is in contrast to quick, or hot, composting, which is the process on which a batch-bin composting system relies. As defined by Jenkins (*The Humanure Handbook*, 1994), to molder means "to slowly decay, generally at temperatures below that of the human body."

The temperature range of a moldering pile of waste is between 4 degrees C. and 37 degrees C. (between 40 degrees F. and 99 degrees F.). Temperatures below 4 degrees C. (40 degrees F.) do not accommodate the invertebrates and microorganisms that process fecal material. Temperatures above 37 degrees C. (99 degrees F.) are in the thermophilic range of composting, which is generally not possible without a large amount of fresh organic material and a lot of human manipulation of the pile. Waste is added too slowly in a continuously moldering toilet to provide enough fresh organic fuel to reach a high temperature, and the moldering privy aims to avoid the labor of frequent manipulation of the pile.

Below 20 degrees C. (68 degrees F.), decomposition slows as the temperature drops, until the pile is dormant below 4 degrees C. (40 degrees F.). The pile does not freeze at 0 degrees C. (32 degrees F.), because it contains dissolved salts and other minerals, but it does freeze below about -2 degrees C. (29 degrees F.). Composting organisms survive freezing, or they leave eggs or spores that survive freezing. When the temperature rises above 4 degrees C. (40 degrees F.) again, the organisms become active again, or their eggs and spores hatch, and composting resumes.

How it is designed—A moldering privy consists of:

- A conventional privy shelter, or outhouse, on a crib.
- The crib sits above a shallow depression, only a few inches deep, which confines urine so it will percolate into the biologically active layer of the soil.
- The pile of human waste mixed with bulking agent in the crib is above ground, so it cannot become waterlogged.
- Gaps between timbers in the cribbing are covered with screening, forest duff, or both, to exclude flying insects and sunlight, but to allow infiltration of air. Hardware cloth or other barriers may be desirable to exclude rodents, which sometimes take toilet paper to dry structures and use it for nesting material. This can be a problem with any toilet other than a flush toilet.
- Native microorganisms and invertebrates, possibly supplemented by introduced red wiggler worms (also known as redworms or manure worms), do the real work of composting.

Many design variations are possible, and creative thinking will yield one to suit almost any condition. A single crib with two or more sections can support a shelter that can be slid back and forth among the sections on skids. In high-use sites, a shelter can be moved among three, four or more cribs to allow a year or more for complete composting before returning the shelter to the first crib.

The crib can be built in many ways, but it there are some advantages to constructing it with a pyramidal form, wider at the base than at the top. This shape is more stable; it holds more volume for a given height; it provides more soil surface at the base to absorb liquids; it facilitates banking duff or straw against the sides (which blocks light and drying breezes while admitting adequate air and helping to keep

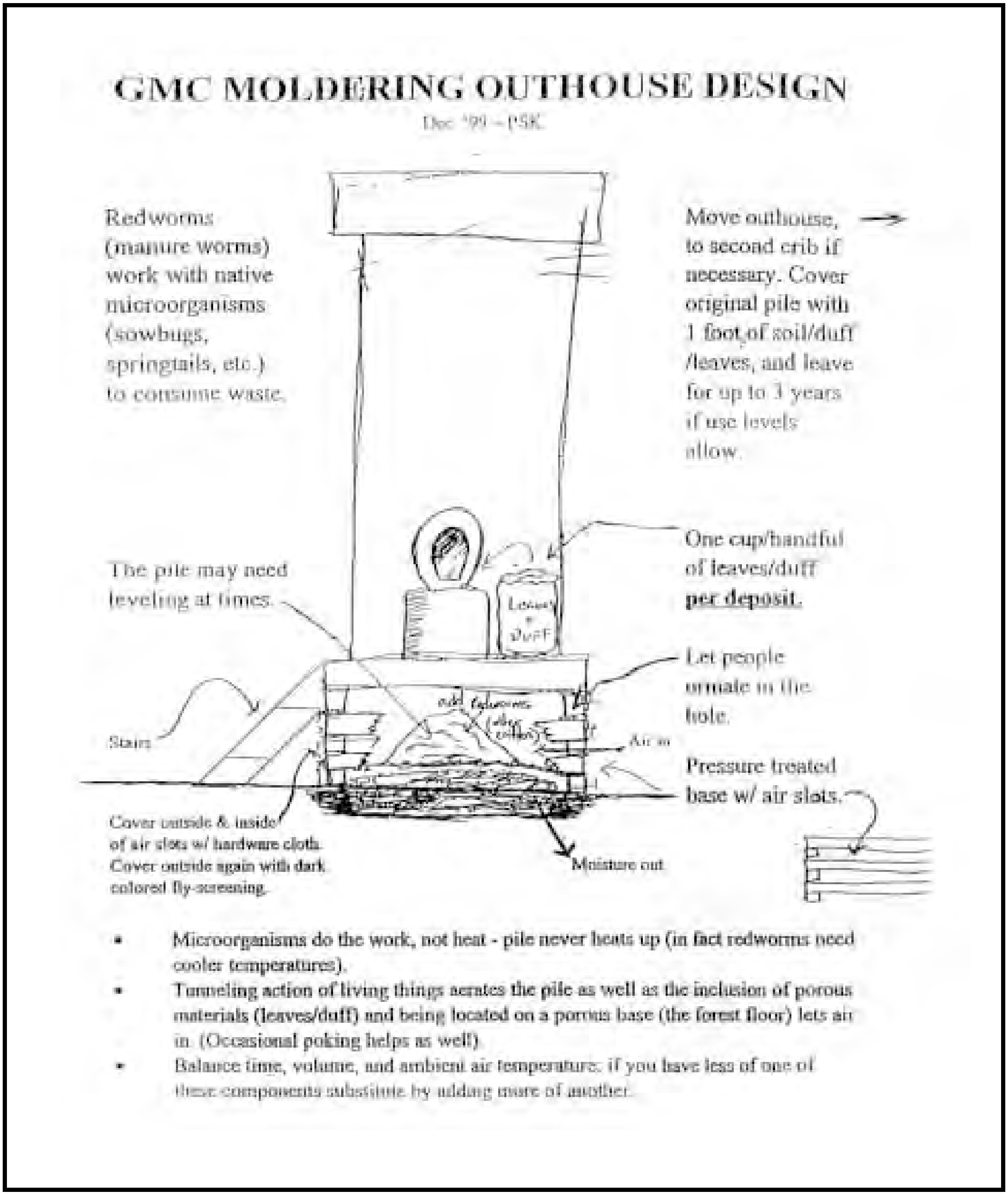


Figure 8.1—Conceptual diagram for the Green Mountain Club moldering privy. Not to scale. This diagram shows only one composting chamber. Current Green Mountain Club design utilizes a double-chambered system. When one chamber is full in the new design, it is capped with a lid, and the outhouse building is shifted over the empty chamber.” Drawing from Lars Botzojorns, Pete Ketcham, and the Green Mountain Club.

the pile warm in cool weather); and it reduces contact between the crib and the compost pile, which prolongs the life of the crib. However, a crib with vertical sides is somewhat easier to build, and this advantage may be most important to some builders.

How it is used—Users are asked to add a small amount of *bulking agent* with each use. The bulking agent need not be kept dry since, unlike batch-bin composting, it need not absorb liquid. If users add too much bulking agent, it will do no harm, except that the crib will fill faster. Occasional stirring of the pile, adding bulking agent if necessary, plus regular light watering to keep it moist, is the only manipulation required to optimize composting. Moderate overwatering will do no harm, since excess water will simply seep into the soil.

Unlike pit privies and batch-bin composting operations, which usually ask users to urinate in the woods (to reduce odors and to minimize the amount of bulking agent needed to absorb liquid), at all but the highest use levels, separation of urine from the compost mass is unnecessary in a moldering privy, which actually benefits from the liquid provided by urine.

A generous layer of bulking agent (six inches to a foot) is spread on the bottom of the privy crib when it is built, to insure that liquids will filter through an aerated layer before reaching the soil. This layer is topped with some decomposed leaf litter, or forest duff, to introduce local decomposer organisms. Liquid that seeps through the pile will be contaminated with pathogens from feces, but if it percolates slowly enough through aerobic and active regions in the lower part of the pile, it will be treated by contact with air and aerobic micro-organisms. If pathogens are not entirely eradicated in the composting pile, liquid receives further treatment in the biologically active upper layer of soil into which it seeps.

Capacity—The crib can easily be made to enclose substantially more volume than the pit of a typical backcountry pit privy, and composting reduces the volume of waste, so moldering privies fill more slowly than most pit privies. In low-use sites, composting may be fast enough to keep up with use for many years, or even indefinitely.

If and when the crib does fill, a new crib is built nearby, and the privy shelter moved to it. The old compost pile is covered with light and porous organic material, typically half a foot or more of duff, straw, or shavings, possibly topped by a layer of hardware cloth (to exclude rodents). At some sites, the cover may need secure fastening to exclude curious people. The cover is intentionally porous to admit rainwater to keep the pile moist; it is lightweight to avoid compacting the pile. In humid climates, the pile may stay damp enough to finish composting even if it is fitted with a solid cover. In dry climates, the covered pile may need occasional watering.

See Section 11.8—Case Studies, “Prototype Wood-Fired Compost Incinerator.”

Recycling compost—When the second crib is full, typically after several more years, the finished compost in the first crib can be removed and applied to the forest floor, either on the surface away from human traffic and water, or by shallow burial. If required by local regulations, compost can be dried and removed from the backcountry. With the right equipment, it can also be incinerated on the spot, yielding a small amount of sterile ash. The shelter is returned to the first crib, and the second crib is covered for further composting and aging.

An incidental advantage of a privy on a raised crib rather than at ground level is that the outhouse door can be opened without clearing snow for much or all of the winter, so it is more likely to be used in winter. The pile will freeze in winter, but composting will resume when it thaws.

Use of bulking agent—Because there is no need for the bulking agent to absorb urine, much less bulking agent is necessary than in batch-bin composting. At many sites, enough forest duff is available to supply the bulking agent for a moldering privy. Of course, duff should be collected from various spots in rotation to avoid adverse impacts on the area's soil natural community.

Even when duff is scarce, carrying in bulking agent is much less arduous than with batch-bin composting. Shavings have been found to work well, since they are light to carry and resist compaction. Both hardwood and softwood shavings work, although some people consider hardwood shavings superior. Feed stores sell baled shavings as bedding for horses and other livestock, or shavings may be available free or inexpensively at lumber mills. Sawdust (unless very coarse), hay, straw, and unrotted leaves or conifer needles all tend to compact and form impermeable layers, so they are less satisfactory. Conifer needles also are likely to be too acidic; so is peat moss. Wood chips are usually insufficiently absorbent, and are hard to mix with hand tools.

Monitoring—The composting process in a moldering privy takes place at ambient temperature, so there is no need for monitoring and management of the process, except possibly for some turning and watering of the pile. It is useful to build the toilet bench or stool with a hinged top, so the whole top can be flipped up to make stirring or watering the pile easier. It is even better to build the shelter with a removable toilet stool and chute, such as many National Forest privies have, since it is easier to manipulate the pile through a hole at floor level.

Venting—There is no need to install a vent stack in a moldering privy shelter, since the permeable sides of the crib admit plenty of air, and obnoxious gases are not produced in aerobic composting. Vent stacks in pit privies normally do nothing useful anyway, since there is nothing to create a draft. They are installed in a tradition that began in the days of anaerobic urban cesspool privies that encountered such high levels of use that they produced large volumes of explosive methane (the principal constituent of natural gas). Methane is much lighter than air, so it readily rises up a vent stack and dissipates. Backcountry pit privies produce insignificant amounts of methane, so the vent stacks we are accustomed to seeing on them are ineffective and superfluous.

Redworms in moldering privies—Experience in household composting toilets has shown that adding red wiggler worms substantially speeds and improves low-temperature composting, and this is true in backcountry moldering privies as well. The worms consume waste, aerate the pile, and spread microorganisms and spores throughout the pile. Worms also can tunnel through and aerate compacted layers if they develop in the pile.

There is not yet enough experience to know whether redworms or their eggs can survive winters in a privy, although they normally do in large manure piles. Therefore, clubs experimenting with them have been re-introducing them each spring.

Predators such as shrews may sometimes eliminate introduced worm populations. Fortunately, composting will proceed even without worms, although it may be slower and require more manipulation of the pile.

Trash—If trash tossed into a moldering privy is inconvenient to remove, it can simply be left there until composting is complete, and then removed. Since material in a moldering privy needs little or no handling until composting is finished, trash does not hinder the process as it does in batch-bin composting. Of course, trash takes up space in the crib, so it should be discouraged.

Earthworms

In the last 10 to 15 years, vermicomposting—using earthworms to hasten the breakdown of organic matter—has become popular.

Worms transform organic material in their digestive tracts, so that their fecal matter, called "castings," is rich in nutrients that are ready for plants. Equally important, by virtue of their ability to burrow deep and come to the surface often, earthworms provide deep aeration for soils and prevent compaction.

Earthworms are not very happy at the high temperatures that can occur in composting (over 100°F), nor can they tolerate low or high moisture levels, highly acidic (low pH) environments, or being in material that is often mixed, tumbled or chopped. So they will not be happy in many of the small composters. In large composters, they should help, especially in continuous composters, because of the compaction problems in these systems. Keep in mind that worms prefer kitchen scraps to excrement.

Some claims have been made that pathogens are killed by the enzymatic activity in worms' digestive tracts. Alas, it's not so. In fact, worms are potential carriers of certain pathogens, although this is uncommon in healthy populations.

The manufacturer of the AlasCan composting toilet system likes to use two or three types of worms found in compost piles: red worms (*Lumbricus rubellus*), brandling worms, or "red wigglers" (*Eisenia foetida*), and white worms (Enchytraeidae). It's the red wigglers—sometimes called sewage worms—that are commonly used in larger-scale composting of organic wastes.

Culturally, advocating adding worms to your processor may turn off many people. You might think twice before mentioning the worms in your system to guests.

Worms from a composter

And, no, worms will not crawl up through your toilet stool and surprise you. Worms don't like light, and will not leave moist organic matter for the cold, dry world of your bathroom.

Bottom line: Consider worms a compost helper but not a key player in your composting toilet system.

Worms can be purchased through many mail order garden suppliers as well as from worm growers that specialize in fast-acting worms. They usually run about $20 for two pounds. You may also find some regular earthworms in your yard waste composting pile.

Resources

Worm Digest is a newsletter that features all kinds of information on composting with worms, including suppliers: Worm Digest, Box 544, Eugene, OR 97440-9998 www.wormdigest.com.

Worms Eat My Garbage, a book by Mary Appelhof, discusses worm composters for kitchen wastes. (Flower Press, 1982)

Figure 8.2 —Diagram and text from The Composting Toilet System Book by David Del Porto and Carol Steinfeld.

Food scraps introduced in a moldering privy actually would improve the composting process, by providing a more diverse nutrient supply for the composting organisms. However, they attract pests—flies, rodents, possums, skunks, raccoons and bears—so they are undesirable, and should be prohibited by stewardship signs.

8.4

ABOUT THE RED WIGGLER WORM

The red wiggler worm (*Eisenia foetida*, also called the redworm or manure worm) is the worm of choice to augment the biological robustness of your moldering privy. It is known throughout the country for the best attributes and habits for consuming organic waste.

For many years, people have kept worm bins in their homes to compost kitchen and other food waste year-round. Red wigglers are readily available by mail order from firms that supply gardeners and bait shops, and once you have worms, you can easily raise as many as you need. Red wigglers reproduce quickly, and have a voracious appetite. Their castings (their own waste product) are a nutrient-rich, humus-like substance sought after by gardeners. The worms are excellent burrowers, and when introduced into the moldering privy, they help delivery of oxygen to aerobic bacteria by tunneling and churning the waste pile. Other worm species also can be beneficial, and local worms may infiltrate your moldering privy spontaneously, but based on its experience, GMC recommends introducing the red wiggler because it is so effective.

Note: red wiggler worms as an exotic species—Check with your ATC Regional Office and your local land managing agency to learn whether redworms are considered an exotic species that cannot be introduced. In the Great Smoky Mountains National Park, for example, the National Park Service considers redworms an introduced species, so moldering privies can not use them. Fortunately, the moldering privy relies on many indigenous organisms to break down waste, and the worms are an enhancement, not a requirement for successful operation.

8.5 COMPARISON OF THE MOLDERING PRIVY WITH OTHER COMPOSTING TOILETS

The majority of the maintaining clubs along the Appalachian Trail have limited money and manpower, and their need for an alternative system to the pit toilet is becoming increasingly apparent. Shelter use is increasing once again, and some members of the trail management community feel we are in the midst of a second backpacking boom that could surpass the use levels seen in the 1970s.

Several kinds of composting systems can replace pit toilets, but the moldering privy is especially useful in the backcountry.

- *Batch-bin systems* require a high level of oversight to function correctly. Despite what some bumper stickers suggest, much of composting doesn't just "happen." Batch bin systems require many hours of work each season by dedicated field staff and volunteers to ensure the process succeeds. Experience has taught us that an active presence at the site is needed weekly throughout the season. In addition, hundreds of pounds of hardwood bark mulch must be packed in to batch-bin system sites each season, a very arduous task.

  Organizations without paid field staffs or extremely committed volunteers with lots of time cannot meet these requirements. There may be volunteers willing to get involved with batch bin composting, but there are generally not enough to meet the high demands of this system.

  In addition, batch-bin systems are best suited to sites with a high volume of use. Starting a run in thermophilic (high temperature) composting requires a generous quantity of fresh waste, so it may not operate well at low- to medium-use sites.

  Batch-bin composting systems cost significantly more than pit toilets, and this cost may be out of reach to some clubs and organizations.

- *Continuous-composting systems*—Commercially manufactured composting toilets are even more expensive to install than batch-bin composting systems, although they can be cheaper in the long run at very high-use sites because of reduced labor requirements. Even in the long run, however, they are still substantially more expensive than the moldering privy.

Key advantages of a moldering privy—Compared to other composting systems, the moldering privy offers several substantial advantages:

1. *Convenience*—The moldering privy eliminates the need to search for new pit sites and move the toilet frequently (sometimes a great distance).

   Many clubs have found that at old backcountry sites the best places for holes have already been used. More often than not, they are still contaminated, and can't be re-used. Pits can be contaminated and unpleasant for three to five years—or more—after being closed. Locating a new pit far enough away from the water source, yet not too far away from the facility to discourage use, is a big challenge. The moldering privy solves this problem. The toilet can remain at the best site indefinitely. With a moldering privy, you can create a permanent spot for sanitation management, independent of soil depth.

2. *Reduced pollution*—The moldering privy reduces the likelihood of water pollution and groundwater contamination.

   Many backcountry privies are in areas with seasonal high water tables, and consequently will have their pits filled with water for a third of the year, or more. That results in anaerobic conditions (which favor the propagation of human pathogens) and groundwater contamination that can be a threat to public health.

   The moldering privy sits on top of the surface of the soil, and eliminates the need for a pit altogether. The composting mass cannot become waterlogged, so any liquid that drains through the pile is exposed to aerobic treatment before entering the soil.

3. *Reduced maintenance*—The moldering privy reduces labor and maintenance needs and costs.

   Once moldering privies are installed, most maintenance can be accomplished by one volunteer visiting the site three to four times a year, although more frequent attention may be needed at high-use sites.

   The moldering privy relies more on natural processes than human manipulation of the excrement to facilitate its breakdown. Liquid separates by gravity out of the pile, so it requires no attention or effort.

   Except where prohibited, the maintainer adds a cup of red worms to the pile once or twice a season to speed decomposition. He or she waters the pile if it is dry. (Adding a drop or two of liquid biodegradable detergent to the water helps water penetrate a dry pile rather than run off the surface.) The maintainer and users add bulking agent to improve the porosity of the pile, balance the carbon to nitrogen ratio, and introduce organisms and funguses that will assist in the breakdown of the pile. The maintainer may keep a container full of duff or other bulking agent inside the outhouse to encourage people to deposit it on the pile.

   The maintainer stirs the pile if it appears that the excrement and bulking agent are segregated. Stirring is usually required infrequently, especially if redworms are active (as opposed to every three or four days with other systems).

   At longer intervals, the maintaining organization moves the outhouse when the crib is full to another crib. Four people can easily move an outhouse from one freestanding crib to another; one person can do the job with some multichamber crib designs. Moves are seldom needed, except at high-use sites.

   See Section 9—"Batch-Bin Composting," for detailed information on spreading compost.

   When waste is fully composted, the maintainer spreads it on the forest floor or buries it in a secluded area well away from water and the shelter or campsite. The procedure is the same as for batch-bin composting systems. See Chapter 7—Descriptions of Systems, Batch-Bin Composting, for detailed information on spreading compost.

4. *Reduced odor*—The moldering privy reduces offensive odors.

   Pit toilets are anaerobic, and anaerobic bacteria produce strong odors when they break down waste, particularly when the waste mass is saturated with urine. Some hikers refuse to use pit toilets because of the odor.

   In contrast, the moldering privy is aerobic. It is not completely odorless, but when working properly its odor is not strong, and the primary component of the odor is earthy, which improves the experience of the hikers and campers. Thru-hikers stopping at Little Rock Pond Shelter, the site of the GMC's first moldering privy, regularly noted in the shelter log that the privy was the most pleasant one they had encountered since leaving Georgia.

5. *Reduced cost*—The moldering privy is comparatively inexpensive.

   A complete batch-bin style composting system (with or without a beyond-the-bin liquid filter) can easily cost $1,000 to $5,000. The moldering privy designs described in this chapter can be built from $200 to $500, depending on whether pressure-treated lumber is used and whether the toilet building itself is replaced.

   Manufactured composting-toilet systems, with the buildings housing them, can cost from $10,000 to as much as $80,000. (See Chapter 8—Case Studies, Appalachian Mountain Club Clivus Multrum Composting Toilet, and Randolph Mountain Club Bio-Sun Composting Toilet.)

(See Chapter 8—Case Studies, Appalachian Mountain Club Clivus Multrum Composting Toilet, and Randolph Mountain Club Bio-Sun Composting Toilet.)

8.6 FREQUENTLY ASKED QUESTIONS ABOUT RED WIGGLER WORMS AND MOLDERING PRIVIES

The Green Mountain Club's experience using moldering privies has generated a good deal of interest in the technology. Here are some basic questions frequently asked of the system's developers:

Q: *Where can I get red wiggler worms?*

A: GMC buys them from Gardener's Supply Inc. of South Burlington, Vermont (800) 863-1700; <www.gardeners.com>.

As of March 2001, the worms (Item #02-232) were selling at $29.95 for two pounds. If you are a non-profit Trail club, you may be able to get a discount. The worms are shipped via UPS. When you receive your worms, transfer them to a bin and give them food. Gardener's Supply recommends giving them melons, but they will consume any vegetable garbage.

If you do it right, you should only have to purchase worms once. If you provide enough food and the right environment, the worms will reproduce and give you an annual harvest.

GMC's goal is to maintain a supply of worms at our headquarters to be dispersed to various moldering privy sites along the Long Trail/Appalachian Trail. Given the size of our trail system, we may seek volunteers to host regional worm farms to reduce travel expenses.

Q: *How do I care for and maintain my supply of worms?*

A: We created two worm bins made of five-gallon food-grade plastic buckets with lids. Buckets were available free or inexpensively from restaurants such as Dunkin

For more information on raising redworms, consult *Worms Eat My Garbage* by Mary Appelhof, 1982, Flower Press, 10332 Shaver Road, Kalamazoo MI 49002.

Donuts, or from some hardware stores. We drilled holes in the lids for air, and in the bottoms for drainage (without drainage, worms will drown). Other people who raise worms prefer shallower containers than five-gallon buckets, but the buckets have worked for us.

We lined the bottoms of the buckets with shredded newspaper, and filled the buckets two-thirds full of garden soil. Commercial potting soil or other bedding materials may be preferable if your local soil tends to compact excessively.

We feed the worms food waste, placing it on the surface of the soil. Be careful not to supply too much food waste with high water content (many fruits and vegetables) at once. Water can accumulate faster than it can drain, and the worms will drown.

For more information on raising redworms, consult *Worms Eat My Garbage* by Mary Appelhof, 1982, Flower Press, 10332 Shaver Road, Kalamazoo MI 49002.

Q: *How many worms do I need to put in a moldering privy, and how often*?

A: We have not counted worms; you don't need to, either. Worms tend to cluster in balls in the worm bin. Each moldering privy should get a ball of worms about the size of a baseball. This ball of worms conveniently fits into an eight-ounce yogurt cup, which is an ideal container for transporting worms into a backcountry site, as long as transportation is quick.

You should only have to introduce worms once a season, in early spring when the pile has thawed out, unless the population dies. At low-elevation sites, moles, voles, mice and other predators may eat some or all of your worms. This may be prevented by lining the bottom of the crib with hardware cloth. Since the composting environment is corrosive, the hardware cloth may need replacement when finished compost is removed from the crib.

Q: *If the bottom of the moldering privy is open to the soil, won't the worms leave?*

A: Only if conditions in the pile become unfavorable. The waste pile in the toilet will probably be the best habitat for worms in the area of the toilet. This should entice them—as well as attract other local desirable organisms—to stay,.

Q: *Will the worms survive over the winter in the field?*

A: Probably not. In a cold climate, the waste mass will probably freeze all the way through. Unless there is enough soil so the worms can burrow below the frost line, they will die. Unless you see active worms in the spring, you should introduce worms each year.

Q: *Can hikers and campers put food waste into the moldering privy?*

A: They could, but this would take up valuable space and attract flies and other pests (including big ones like raccoons and bears) to the privy. Stewardship signs should instruct users to deposit nothing but human waste and toilet paper in a moldering privy.

Q: *What else do I need to know about keeping worms alive and working in a privy?*

A: Redworms are fairly self-sufficient creatures. The key to their survival is a favorable environment. Moisture in the pile and aeration provided by forest duff or other bulking agents must be monitored regularly. Since it is protected from rain by an outhouse, parts or all of the pile may dry too much, especially if air can blow freely through the privy crib or the privy is in the sun, so occasional light watering is helpful. Adding a drop or two of liquid biodegradable detergent will help water penetrate a dry pile rather than run off the surface.

If you keep the compost pile conditions favorable, the worms will thrive and increase their level of consumption of waste, reducing the need to service the unit as often.

8.7 COMPONENTS OF THE GMC MOLDERING PRIVY SYSTEM

Primary Components—The GMC moldering privy system has two components:

1. *Moldering crib*—The crib, made from dimensional lumber or landscaping timbers, creates the above-ground chamber where waste is stored and composted. The toilet shelter, or outhouse, sits on top of the crib. The crib confines the waste pile while allowing air and digesting organisms in and letting liquid drain out.

   GMC's crib is 48 inches long by 48 inches wide by 30 inches deep. That provides 40 cubic feet, which is a lot of storage space. Two cribs, or more if use levels dictate, are constructed. They may be either freestanding cribs, or a unit with two or more chambers along which the outhouse can be slid.

   After the first crib is full, the outhouse is moved onto the second crib. Each season, red wiggler worms are introduced into the pile by maintainers to speed decomposition. While the second crib is being filled, the first crib is capped—that is, covered with a layer of hay or similar material, followed by a protective cage attached to the top of the crib to prevent tampering. Thus covered, it continues to compost until the second crib is full.

   The time required to fill the second crib ensures waste is fully composted, as long as it is more than a year. If cribs fill in less than a year, more than two cribs are needed. The operator can enhance the composting process in filled cribs by turning piles with a spading fork periodically, adding additional carbon-based bulking agents like wood shavings, and continuing to introduce red worms each spring.

   The outhouse is returned to the first crib after its composted material has been spread on the forest floor or given a shallow burial in a dry, unfrequented spot.

2. *Outhouse*—GMC uses a lightweight outhouse, or privy shelter, with a 3-by-4 -foot floor to make it easier to move it, both to the backcountry site and from crib to crib.

8.8 SOURCES OF MATERIALS

Different regions of the Trail present different challenges for obtaining materials to use in construction of moldering privies. The Green Mountain Club used the following sources:

1. *Moldering crib*—GMC bought cribbing material at a local lumberyard. We made our first moldering crib of 6-by-6-inch untreated cedar landscaping timbers, which were light to carry and easy to work with. Later we decided that a pressure-treated crib would last longer and reduce maintenance costs. However, the cedar crib has shown no signs of deterioration in three years.

2. *Outhouse*—GMC has bought lumber for outhouses at local lumber yards in Vermont. Our outhouses are not built of pressure-treated (PT) wood. That was the choice of the volunteers who built them. Using PT lumber for the floor and lower parts of the outhouse would lengthen its life and might save money in the long run, despite its greater cost.

3. *Stewardship signs*—An excellent waterproof and tear-resistant plastic paper, with the trade name of *NeverTear*, made by Xerox, was employed at GMC sites. This or similar products should be available at your local office supply store, or the store can order it from Xerox. Paper signs created on a personal computer can be photocopied onto NeverTear, which also can be photocopied.

4. *Miscellaneous components*—GMC bought screening, hardware cloth, poultry staples, galvanized spikes, angle brackets, door handles, hooks and eyes, toilet seats, flashing, roofing, drill bits *etc*. at a local hardware store. Be sure to tell the store if your organization is tax-exempt.

8.9 CONSTRUCTION SPECIFICATIONS

Our current design of moldering privy cribs units is 4 feet square, with vertical sides. The crib is built of 6-inch-by-6-inch dimensional pressure-treated timbers, except some parts of the lowest course, which are 4-by-6-inch PT lumber. The finished height of the crib is about 30 inches. The inside dimension is about 3 feet square (4 feet minus the width of two 6-inch timbers).

The outhouse set atop the crib is 3 feet wide by 4 feet deep, and therefore spans the whole depth of the crib front to back. The base of the outhouse typically overlaps the sides of the crib by an inch or so, but the primary support of the outhouse is the front and rear of the crib. The top course of timbers is adjustable, so the crib can be used with existing outhouses of varying dimensions. Gaps can be covered by PT plywood if necessary.

If the size of the top course of timbers is varied to fit an outhouse with smaller dimensions by trimming some of its parts, this will affect the pilot hole layout described below. For a larger outhouse, it is best to build a larger crib. However, we recommend against larger cribs and outhouses because the components are difficult to transport to backcountry sites. For simplicity, our standard square crib is described.

The jury is still out on the effects PT lumber on soil, which might absorb toxic compounds from treated wood. Biologically healthy soil absorbs liquid from a moldering privy and provides backup treatment if necessary, so PT lumber might provide durability and long-term economy at the expense of effective waste treatment.

GMC has built experimental cribs entirely of untreated hemlock; of a bottom course of PT lumber with a hemlock top; and entirely of PT lumber, to investigate the factors of toxicity, longevity and cost. We will observe these cribs closely for differences in the apparent effectiveness of the biological community in consuming waste, factoring out other variables such as use levels and climate as well as we can. We may also test soils for residues from PT lumber.

If untreated cribbing lasts long enough, it would be a viable option for clubs with limited financial resources. For example, if the hemlock crib lasts for fifteen years, replacement of both the crib and the toilet could be done at the same time, allowing for one-time fund acquisition at each replacement cycle.

8.10

ADVANCE PREPARATION

GMC employed the following steps in advance of final construction of the privy:

1. *Cutting the cribbing*—Untreated green hemlock was rough cut a full 6 inches square, weighing about 11 pounds per linear foot. The stock pieces ran between 12 and 13 feet long and were generally clear of knots, wane and twist.

   The "6-by-6" (actually 5½-inch square) or "4-by-6" (actually 3½-inch by 5½-inch) PT lumber was 0.40 CCA treated for full ground contact, and varied greatly in weight depending on its storage conditions. After storage outside it can weigh twice as much as green hemlock. The lighter the material, the better, so we recommend covered storage. Both eight-foot and twelve-foot stock were used as available. This material rarely had as much as ¼ inch overage in length.

   The stock was laid out on blocking on the ground for cutting. For some of the hemlock material it was necessary to scribe and cut an end square before laying out the other pieces to be cut from the timber. The PT material was always square. The stock was cut freehand with a chain saw, and was scribed on two adjoining sides to give the sawyer both a square line and a plumb line to follow. The chain saw was a fairly rough cutting tool, having a ⅜-inch kerf, but cribbing pieces were generally within ½ inch to ¾ inch of the desired length. If greater precision is desired, a skilled person with a sharp bow saw can cut to much closer tolerances without spending much more time.

   The PT 4-by-6-inch stock, as well as other miscellaneous pieces (stair treads, cleats) were cut with a 12-inch miter saw when available. This produced very square ends, which helped assure a square shape for the base of the crib during assembly.

2. *Pilot holes for spiking*—Two systems were used to fasten the cribbing. In the early designs, every course of cribbing material was nailed to the course below using 10-inch galvanized spikes. In later designs, the corners of the crib were pinned in place atop each other using concrete reinforcing bar (rebar) set in pre-drilled holes. The second system was much faster to assemble in the field, but it required some additional drilling and more careful layout ahead of time. The rebar method of fastening cannot be used with a crib that is wider at the base than at the top, which is a major advantage of cribs with vertical sides.

   In both systems, the base square is made of two 4-foot-long "6-by-6" pieces and two 3-foot-long "4-by-6" pieces. Those must be spiked together to provide a stable, rigid, bottom course. In addition, the two shorter members of the top course (36 inches long) are spiked to the course below to hold them in place. *It is always necessary to drill pilot holes for spikes to avoid splitting the lumber!* We also countersank the spikes about 1 inch for more equal penetration of the two pieces.

   Pilot holes for spikes were always centered on cribbing pieces. The countersink for the spike head was first drilled using a ⅞-inch spade bit, to a depth of about one inch. A 12-by-5⁄16-inch twist shank bit was then used to finish the pilot hole through the piece.

   - NOTE 1: Only the countersink and pilot of one member were drilled in advance. The corresponding 5⁄16-inch pilot on the second member was drilled in the field at the time of assembly.

   - NOTE 2*:* The ⅜-inch spike shank was 1⁄16 inch larger than the 5⁄16-inch pilot.

- NOTE 3*:* If the entire crib is to be spiked together, pilot holes in successive courses must be offset so that the spikes in upper courses will not hit the spikes in the course below.

3. *Pilot holes for rebar supports*—The rebar system requires that holes be drilled through both ends of each 4-foot piece of cribbing. These holes must align well enough that the pieces of cribbing may be dropped on top of the standing rebar without bending or binding. Half-inch rebar was used, and ¾-inch holes were drilled. The ¼-inch overage accommodated some misalignment during assembly, but the finished product locked together very tightly.

   Lay out holes as follows: Measure 3 inches in from one end of the timber, and draw a square line. Mark the center of the timber on this line. This will be the location of the first hole. If all the timbers were *exactly* 48 inches long, you could simply repeat the process at the other end of the same timber, and the distance between the holes would always be 42 inches. However, it is essential to keep the distance between the holes the same, despite variations in the length of the timbers as large as ¾ inch. Therefore, measure 42 inches from the center of the first hole (or 45 inches from that end of the timber) and make another square line. Find the center point of the timber on that line, and it will be the location of the second hole. Drill pilot holes for rebar with a ¾-inch spade bit, lengthened if necessary with a 6-inch hex-keyed extension so it will drill all the way through the timber. A ½-inch chuck electric drill speeds the process. Be sure to drill holes square to the top and bottom surfaces of the timber. Block timbers so the drill bit will not hit dirt or rocks.

   When drilling rebar pilot holes it is useful to pre-assemble the crib. Begin by laying out the bottom pieces: two four-foot "6-by-6" pieces and two three-foot "4-by-6" pieces in a tight square. Note that the four-foot pieces will require *horizontal* countersinks and pilot holes for spikes (into the three-foot pieces) as well as *vertical* rebar pilot holes. Once these two four-foot pieces are prepared, mark them clearly, because they will be required early in the construction process. Continue the pre-assembly by reforming the base square and setting up the rebar. Carefully fit successive courses of four-foot timbers on top of the base. Note that the next four courses of cribbing (eight pieces total) are all the same in forming a square crib with vertical sides.

   - NOTE: If the topmost course is to be square with the other courses, no modification is necessary. However, if the top course is to be stepped-in to accommodate the outhouse, modification of the pilot hole measurements in the two topmost timbers will be required.

4. *Cutting the rebar*—Cut four pieces of half-inch rebar 30 inches long, using a hacksaw.

Tools used in the workshop—The following tools were used off-site to prepare the material for field assembly:

- Chain saw
- Speed square
- Tin snips (for cutting hardware cloth)
- Cordless drill and standard A.C. electric drill
- 12" Miter saw (standard A.C.)
- Cordless circular saw
- Hacksaw

8.11

FIELD ASSEMBLY

Field assembly of prepared materials consists of finding a site for the unit, assembling the crib, providing screening, attaching the stairs, attaching the outhouse, and completing the finishing touches.

1. Siting the unit—Locate a spot with a reasonable balance of the following factors:

   Topography: A level spot is important. The moldering privy allows urine to drain into the soil below the crib, where it will be cleansed by the biologically active layer of the soil (the top six inches). Too much slope could cause urine to stream on the surface, which is unappealing and a potential health hazard. However, avoid places vulnerable to flooding.

   Water table: If possible, dig test pits to determine the seasonal high water table at spots you are considering. Soil below the seasonal high water table usually has a tell-tale mottled appearance. Pick a spot with as much soil above the seasonal high water table as possible.

   Sun and shade: Keeping the privy shaded in summer will increase the productivity of the worms and other soil creatures who prefer a dark, moist environment. (Banking duff, hay or straw against the outside of the crib can also help maintain the optimum temperature and moisture.) If possible, site the privy under deciduous trees so it is shaded during the summer and sunlit in winter, which will help prolong the life of the structure by melting snow and keeping it dry. Winter sun exposure also helps keep snow from blocking the door.

   W*ater sources:* Make every effort to stay at least 200 feet from all water and downhill from where hikers will collect drinking water.

   A*esthetics*: If possible, place the privy far enough away from the camp site to protect the camping experience, but not so far that people will not use it. This requires judgment, and possibly observation of camper and hiker behavior. The optimum distance is affected by things such as slope and footing of the approach trail (people often do not wear boots at night, so the approach trail should be relatively easy). Separation from the campsite also helps discourage winter vandals from considering it an easy source of firewood (this is no joke).

   Prevailing winds: Try to locate where wind will usually carry odor away from the shelter and tenting areas. Locate away from areas prone to drifting snow in winter.

   Privacy: Take advantage of trees or other forms of shielding from the shelter or tent site, but provide directional sign(s) to the privy and a map inside the shelter. Face the outhouse door away from shelter opening and trails, unless the location is well shielded.

   Logistics: Try pick a place near a source of leaves and duff.

2. Assembling the crib—The process in the field is simple once materials are on site and sorted.

   Begin by locating the bottom course pieces. Stand the “4-by-6” pieces on end, and set a piloted “6-by-6” member atop them. Holding the assembly square, finish the spike pilot hole into the three-foot timber using the 5⁄16-inch drill bit, then spike this corner. Repeat the process for the other three corners. Check the assembled base for squareness by ensuring both diagonal corner-to-corner measurements are identical. Set the squared base onto the prepared site, check it again, insert the rebar, and add the remaining courses of four-foot timbers. Repeat the piloting and spiking process for the short pieces in the top course.

Remove a couple of inches of soil from the bottom of the crib, to create a depression to retain liquid long enough for it to seep into the soil. Pile this soil around the outside of the bottom of the crib.

If you plan to introduce redworms and you wish to prevent predation by mice, voles, and the like (a problem more likely at lower elevations), line the bottom of the depression with hardware cloth.

3. Screening—The inside of the crib is lined with ½-inch mesh hardware cloth, secured with ¾-inch poultry staples. The hardware cloth may be cut into eight-inch strips, which will cover the openings between timbers and use less material. The outside of the crib is covered with both the half-inch hardware cloth and dark-colored fly screening. The dark color helps shade the pile, keeping worms and other organisms active.

4. Attaching the stairs—Stairs to the outhouse are made of commercial three-step pressure-treated stringers, and treads of either 2-by-8-inch or 2-by-10 inch PT lumber, 28 inches to 32 inches wide, depending on availability. Secure stringers and treads with 2.5-inch galvanized deck screws. Screws are better than nails, because they permit disassembly and attachment to another crib later. Support the stringers with a 2-by-4-inch pressure-treated cleat, or galvanized joist hangers or framing anchors. It may be necessary to enlarge holes to accommodate screws if the hardware was designed for nails.

5. Attaching the outhouse—Use galvanized angle brackets or framing anchors to fasten the outhouse to the top course of timbers. Use galvanized screws (lag screws or deck screws work well) to facilitate future removal. Again, it may be necessary to enlarge holes to accommodate screws if the hardware was designed for nails.

6. Finishing touches—A tube of aluminum flashing attached to the underside of the toilet seat acts as a splash guard and ensures the waste does not get caught on the cribbing or screen.

   A stewardship sign on the inside and outside of the door should explain the system to the user and provide instructions. Maintainers may also want to keep a small can, waste basket, or bucket inside the privy filled with duff or other bulking agent, and encourage hikers to keep it filled.

Tools used in the field—The following tools were used on-site to for field assembly:

- Cordless drill
- Drill bits:
  Spade bits:
  ¾" (nail head countersinks)
  ¾" (rebar holes)
  Standard twist shank drill bit:
  5⁄16" x 10" (nail shank)
- Two-pound hand sledge
- Hammer
- Shovel
- Tape measure
- Level
- Weatherproof paper (for the outhouse stewardship signs)
- Staple gun (to attach screen and hardware cloth into place before nailing with poultry staples; also used to post outhouse stewardship sign)

9

Batch-Bin Composting

Pete Ketcham, Field Supervisor, Green Mountain Club

9.1 BACKGROUND

The batch-bin system was introduced to the Green Mountains of Vermont and the White Mountains of New Hampshire as a pilot project in waste management in the mid 1970s. The design and prototype were created by Ray Leonard of the U.S. Forest Service's Backcountry Research Project at the Northeastern Forest Experiment Station in Durham, New Hampshire.

The system was designed to provide forest, park and trail managers with a method for human-waste management at remote recreation sites, generally high in the mountains. Thin and frequently saturated soils at many of these sites are unsuitable for pit toilets, which release untreated wastes that leach into groundwater. Disease-causing organisms, called pathogens, can travel up to five feet in fine, sandy soil and as far as 200 feet in soil of coarser fragments (McGauhey and Krone 1967)—even farther if the soil is very moist. The batch-bin system permits on-site disposal of human waste after safe decomposition in a leakproof container.

Since their introduction, batch-bin composting systems have evolved somewhat differently in the Green Mountains and White Mountains, although the techniques are similar in both places and the results are the same.

The Green Mountain Club (GMC) system uses one large composting bin, and employs storage containers to accumulate enough waste to fill the bin. The Appalachian Mountain Club (AMC) system uses two smaller composting bins in sequence, and it uses no storage containers to accumulate sewage before a composting run starts. The GMC system uses a wooden drying rack to dry and age compost before sifting it through a screen, whereas the AMC system in the White Mountains dries compost right on a sifting screen. All AMC systems also incorporate beyond-the-bin liquid separation, which keeps the mixture of sewage and bark mulch comparatively dry and reduces its volume.

The following text describes the GMC system, and notes points at which it differs from the AMC system.

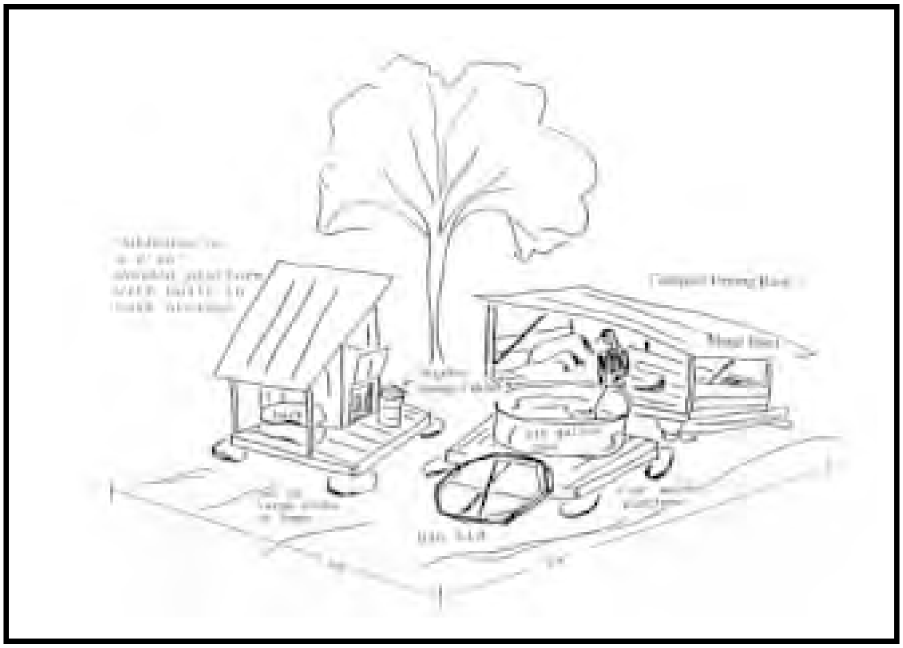


Figure 9.1—Diagram of Green Mountain Club batch-bin composting toilet systems depicting all of the system's components. Note that the outhouse design depicted is only one of several options. Not shown are the two 32-gallon storage cans the Green Mountain Club uses as part of their system. The Appalachian Mountain Club uses two 150-gallon stainless steel composting bins instead of storage cans." Diagram from the Green Mountain Club.

9.2 HOW THE BATCH-BIN COMPOSTING SYSTEM WORKS

How it functions—The batch-bin system functions as follows:

1. Wastes accumulate in a 70-gallon Rubbermaid or similar polyethylene leakproof container, called a "catcher," under the seat of a conventional outhouse with a modified bench. In the GMC system, the catcher is periodically emptied into one of two 32-gallon rectangular garbage containers for storage. In the AMC system, a compost run is started when the catcher is full.

   Each time people use the toilet, they add a handful of ground hardwood bark mulch (available from lumber mill debarking operations). Hardwood bark has the best carbon-to-nitrogen ratio and structural shape for composting. Other organic materials, such as peat moss, work, but poorly.

2. When both storage containers and the catcher are full, all of the sewage and bark mixture is transferred to a composting bin of 160 to 210 gallons. In Vermont, GMC uses a cylindrical 210-gallon plastic composting bin originally designed for aquaculture. It weighs about 45 pounds, and is four feet in diameter and 2.5 feet high. It costs about $175. The custom-fabricated lid costs about $135.

   In the White Mountains in New Hampshire, the Appalachian Mountain Club uses a custom-made rectangular stainless steel composting bin of 150 gallons. The bin weighs 150 pounds empty. It is three feet high at the back, two feet high at the front, four feet long and three feet wide. It costs about $1,000.

3. The wastes are thoroughly mixed with enough additional hardwood bark, and recycled compost if available, to soak up excess liquid. The material is completely

mixed, broken up and aerated with a turning fork, and the bin is almost full. This results in a carbon-to-nitrogen ratio of approximately 30:1 by weight, which is optimum for the composting process.

4. Now a "compost run" begins. During the run, no new wastes are added to the compost bin, and the pile is turned every four to five days. Waste breakdown occurs as local soil bacteria and fungi proliferate in the compost. Human pathogen destruction results from temperatures higher than 90 degrees F. (32 degrees C.) competition with hardy local microorganisms, and from processes such as oxidation and antibiosis, intrinsic to rapid aerobic decomposition (for more details, see Chapter 3—The Decomposition Process).

   A GMC run lasts four to six weeks, depending on ambient temperatures and operator skill and energy. The compost then goes to a storage platform, or drying rack, to further decompose and dry for six months to a year. An AMC run lasts two to four weeks in each composting bin (four to eight weeks total), and then the compost is put on a screen for drying, aeration and sifting.

5. After the material has sufficiently aged and dried, the mixture of humus and bark is sifted to capture bark chips that can be reused in the next run. Screening also catches any chunks of material that escaped decomposition. These can be broken up and placed in the next run. The screen is a five-by-four-foot wooden frame on legs three or four feet off the ground. The best screening material is heavy gauge diamond patterned expanded sheet steel. However, a double layer of ¼-inch hardware cloth also works.

6. Finally, some of the finished compost is recycled into the next run, which helps inoculate the run with beneficial organisms. The rest is scattered thinly over selected spreading sites, or buried if necessary to satisfy regulations.

For more details, see Section 3—"The Decomposition Process."

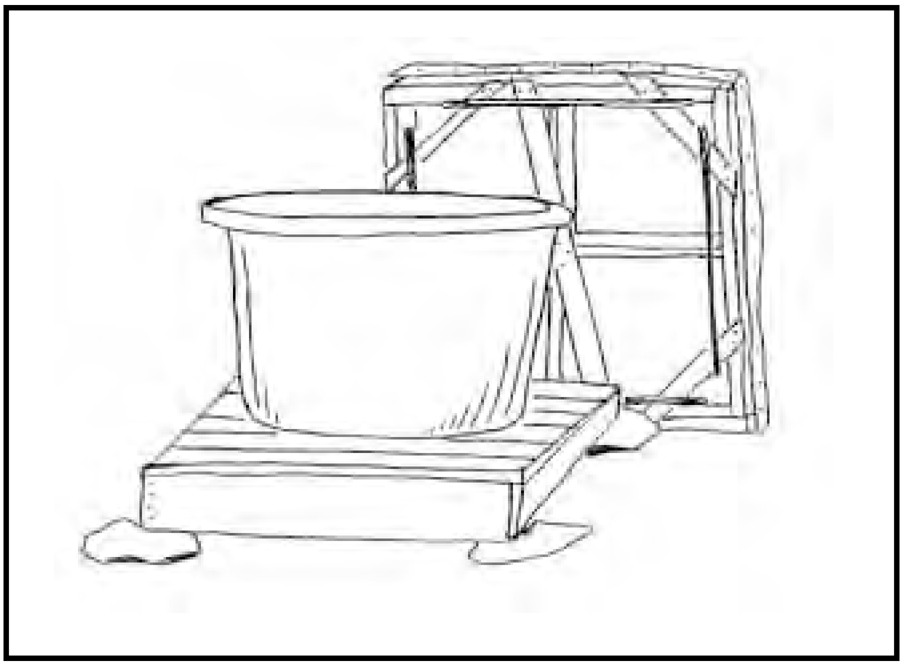


Figure 9.2—Diagram depicting the Green Mountain Club batch-bin compost system bin and lid. The lid is constructed of dimensional lumber. The Green Mountain Club recommends using manufactured plastic lids whenever possible because they have a longer life expectancy in the field and are less likely to leak. If cost is a factor, a wooden lid may be the best option. Diagram from the Green Mountain Club."

9.3

COMPONENTS OF THE BATCH-BIN COMPOSTING SYSTEM

Operator—The operator of the batch-bin composting system is its most important element. Mastery of the process requires resourcefulness. The operator must maintain an optimal aerobic environment for composting, which requires sensitivity to the variables inherent in a biological waste management system, and he or she must be prepared to deal with unforeseen difficulties.

Operating a compost pile is a continuous experiment. Try different handling procedures to see which are the most effective in the conditions where you work. Turn the compost pile with co-workers to ease the burden and share insights. Refer to the manual as you go. Keep accurate records so the next operator will know what to expect.

Above all, keep a level head. No problem is insurmountable if you are patient, thoughtful and inventive.

Outhouse—The batch-bin system uses an conventional outhouse, with the design modified to accommodate a 70-gallon catcher under the seat. The rear has a hinged door for removing the catcher, and the outhouse needs a solid platform extending far enough behind it to slide the catcher out easily. An existing outhouse can be used if it can be properly modified.

Regulations may require screened vent stacks in some areas; otherwise, they can be omitted. Screened vent stacks normally do nothing useful in a backcountry privy,

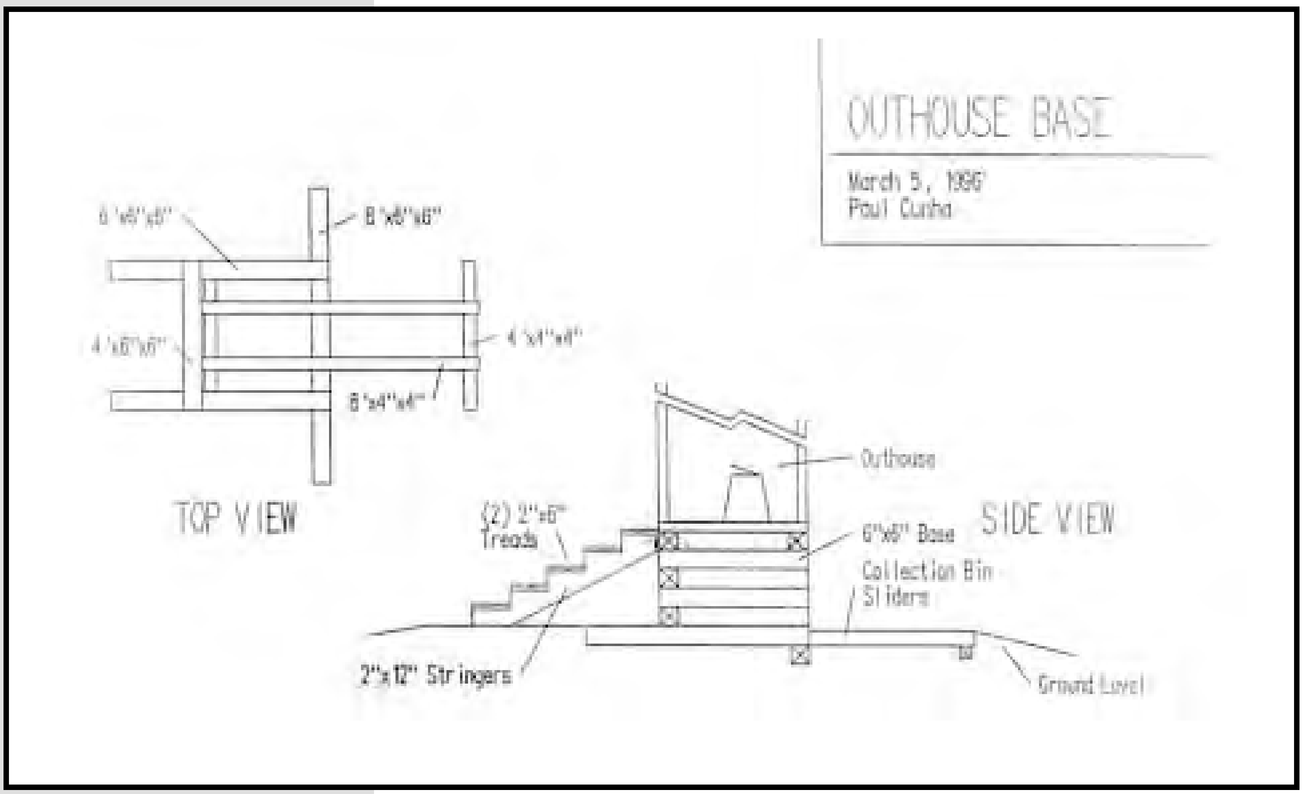


Figure 9.3—This diagram shows how to construct a chamber to house a 70-gallon sewage catcher in either a batch-bin or beyond-the-bin system. This plan is particularly useful for converting an existing outhouse. However, a new outhouse can accommodate a 70-gallon catcher without an elevated foundation requiring a ramp or stairs." Plans from Paul Cunha and the Appalachian Mountain Club Trails Department.

since there is nothing to create a draft from the catcher or pit. They have been installed habitually because of a tradition begun in the days of urban anaerobic cesspool-style privies that produced high levels of dangerous methane. Methane is much lighter than air, so it readily rises up a vent stack and dissipates. Backcountry privies produce negligible amounts of methane. So the vent stacks we are accustomed to seeing on backcountry privies are ineffective and superfluous.

If you are building a new outhouse, plan it with a solid wooden floor and a platform extending behind the rear access door far enough to allow the catcher to slide all the way out of the outhouse. This makes moving and working with the catcher much easier. If an existing outhouse does not have a sturdy platform, it can be firmly secured to one.

If the distance from the underside of the privy bench to the top of the catcher is more than six inches, attach a short piece of metal flashing to the underside of the bench to guide waste into the catcher. This prevents waste from running down the inside of the front wall.

Winter access and maintenance are easier if the outhouse is elevated, so its front door and rear access door are off the ground and the catcher can be emptied if need be without interference from deep snow. In the White Mountains, operators make a point of composting as early and as late in the season as possible, and 70-gallon catchers have not required emptying during the winter. GMC also has found that 70-gallon catchers will not require emptying in the winter, as long as they are emptied before winter starts.

The outhouse should be kept clean and attractive, so visitors will use it rather than the woods. Keep a broom for sweeping the outhouse, and cleaning supplies for its seat. A small can of paint or stain is useful for covering graffiti as fast as it appears. Graffiti begets more graffiti.

Catcher—In the past, 20-gallon heavy plastic cans were used as catchers at most GMC sites. However, 20-gallon catchers fill too fast at the heavily used backcountry campsites that need batch-bin composting, particularly in winter and by large groups. Twenty-gallon catchers often overflow during the winter and leave a mess for shelter maintainers in the spring. So AMC and GMC now use 70-gallon high density polyethylene (HDPE) tubs, and we recommend them, especially for any site receiving off-season use.

A 70-gallon catcher weighs more than 550 pounds when full, so it must be set on rails or on a platform extending at least five feet behind the outhouse so the operator can pull it all the way out without help.

The catcher should be low and wide rather than tall and narrow, because it is hard to shovel out a tall container and keep the shovel handle clean. The 70-gallon Rubbermaid stock tank used by AMC and GMC is 40.5 inches long by 32 inches wide by 24 inches high.

Industrial-grade HDPE is corrosion proof and durable. Rubbermaid stock tanks have built-drain plugs, which make it easy to attach a beyond-the-bin (BTB) liquid management system (See the Beyond-the-Bin section of this chapter for a diagram of the catcher with strainer plate attachment.) If not broken, plastic will last 10 years or more. Twisting and lifting often breaks thin plastic containers, and they tend to crack in cold weather, so it is best to avoid inexpensive polyvinyl chloride (PVC) garbage cans or any plastic other than HDPE. (See the Appendix for Sources of Material and Equipment.)

See Section 10 for a diagram of the catcher with strainer plate attachment.

See Appendix G, for "Sources of Material and Equipment."

Most metal containers are poor choices. Stainless steel is good, but expensive. Catchers of other metals should be completely coated with roofing cement or some other durable coating. However, even a coated metal catcher will last only two to three years. Metal catchers with rounded bottoms are better than catchers with seams. Mixing wastes in metal catchers or storage containers other than stainless steel is not recommended, because scraping will remove the coatings and accelerate corrosion.

In Great Smoky Mountains National Park, the Appalachian Trail Conference and local trail clubs have tried using plastic garden wheelbarrows as catchers in privies. This makes it easier to transport waste to storage containers. But the wheelbarrows don't hold much, so they must be emptied frequently, and they can overflow in winter or if subjected to large groups. Liquid tends to slosh out when the shallow wheelbarrows are moved. If liquid is to be drained for separate disposal, it must be filtered, because the urine is contaminated from being in contact with fecal matter. Wheelbarrows would be most effective at low-use sites visited often by a adopters or other attendants.

A catcher larger than 70 gallons is too heavy for one person to slide out of the outhouse. It also may allow more sewage to accumulate than the compost bin can accommodate. In addition, the catcher may sit in the outhouse so long that it causes problems with flies and odors in the summer. Adding fresh and recycled bark, knocking over the "cone" of bark and feces, and keeping fresh feces covered with a thin layer of bark helps reduce flies and odors. However, there is no substitute for the routine transfer of waste from the catcher to a storage container (in the GMC system) or the first composting bin (in the AMC system) when necessary.

Emptying catchers—If a site has received high off-season use, the pile in the collection container may be mounded into a cone. It may be necessary to push the pile down before sliding the container out, using a stick through the privy seat. Wash the privy seat well if it becomes contaminated. It is best to design the privy with a flip-up bench seat to provide more sanitary access to the catcher. It is also good to provide a rear door high enough so the catcher can be slid out of the outhouse to manipulate its contents.

Once waste is in a storage container, do not add bark or turn it. The waste should remain inert until you are ready to compost it.

Once most of the sewage has been shoveled out of the catcher, you may want to dump the rest of the sewage and liquid into the storage container. But if sewage is poured from the catcher to the storage container, it may splatter, especially if urine has not been separated from feces. To reduce the chance of getting splashed, stand behind the collection container. Rest the edge of the catcher gently on the storage container. Pour carefully.

To help keep flies down, clean the catcher with several shovels full of fresh bark before replacing it in the outhouse. Put the bark used for cleaning in the storage can (in the GMC system) or the compost bin (in the AMC system).

Always double-check the catcher position after replacing it in the outhouse. Position the container as far forward as possible to keep urine from running over the front edge. Line the bottom an empty catcher with three to four inches of fresh or recycled bark mulch to help to absorb liquids and reduce odor.

Storage containers—The AMC system does not use storage containers. Wastes from the catcher are mixed with bark a bit at a time in a mixing bin, and then placed directly in the first composting bin. Therefore, what follows applies only to the GMC system.

Storage containers accumulate waste for a compost run, and provide storage for fresh waste during a run. They should be close to the outhouse, to ease transfer of waste and minimize spillage. Set storage containers on a level, secure dry base, such as short boards. Stay away from sharp stones, which can puncture the bottoms. Avoid rolling the storage container on an edge, which can cause the plastic to split. It is best to leave the storage container in one place, adjacent to the outhouse and compost bin.

Sometimes people or animals investigate or knock over storage containers. In the Smoky Mountains, black bears have knocked over storage containers. ATC and local clubs have solved the problem by surrounding the composting areas with electric fences. In Vermont, GMC has had more trouble with people, who often think the storage containers are trash containers, and open them to deposit trash. Occasionally someone will maliciously knock over a container, spilling its contents. To counteract this, GMC has been building secure, ventilated lockers for storage containers and the bark-mulch supply.

Storage containers must be leakproof, with secure lids. The GMC uses rectangular, 32-gallon Rubbermaid HDPE garbage containers. Their square shape resists warping under weight and pressure, their lids fit tightly, and their rims resist cracking when tipped over.

Galvanized steel garbage cans have been used extensively in the past, but they rust quickly. Fifty-five-gallon plastic or metal drums with tightly fitted lids work, but wastes in the bottom are difficult to remove, and the drums make the compost area look like a hazardous waste site. The volume of waste in storage also tends to be too great.

At least two storage containers are needed to hold the mixture of sewage and bark before and during a run. GMC has found that the contents of two 32-gallon containers plus the 70-gallon catcher, plus added bark to adjust the moisture content, are the ideal volume of sewage for composting in a 210-gallon compost bin. We try not to have many storage containers at the site, because this allows a backlog of sewage to develop, and increases the risk of animals or hikers knocking over the storage containers.

Keep storage container lids tightly secured with string or bungee cords to discourage the casually curious or litterbugs from lifting them. Label storage containers clearly with paint or marker: RAW SEWAGE—KEEP OUT! Check regularly for leaks, and replace leaking containers immediately.

Before any wastes are placed in a storage container, put several inches of bark and/or finished compost in the bottom to absorb liquid and reduce odors.

Do not mix bark mulch with sewage when transferring it to storage containers. However, you can put a layer of bark mulch and/or recycled compost on top of sewage to control odors. The goal is to prevent sewage from starting to compost before the planned start of a run, so there will be a large enough mass of fresh sewage and bark to create a good, hot run. Therefore, every effort should be made to keep the waste in the storage containers inert. This can be done by not mixing waste when transferring it from the catcher, not adding bark mulch, and by packing the storage containers as full as possible to reduce availability of oxygen.

If non-biodegradable trash has been thrown into the catcher, storage container, or compost bin and is contaminated, leave it there and let it go through the compost run. Then allow it to weather in a protected spot before packing it out.

See Appendix G, "Sources of Material and Equipment," for more information on storage containers.

Compost bin—The bin is the key element, and the largest one, in the composting operation. A bin of 160 to 210 gallons is optimal to create self-insulating composting conditions. AMC and GMC have not used insulated bins, but they may be useful in some places.

The bin or bins should be near the outhouse and storage containers, if any, to facilitate waste transfer and minimize spillage. GMC has found that one large bin ordinarily is enough at an overnight site, especially if a beyond-the-bin system or another method separates liquid from solid waste. AMC always uses two bins, partly because usage at its sites is typically high and partly because the bins are smaller.

Initially, bins were built of marine grade plywood, laminated inside and out with fiberglass and resin, but industrial HDPE bins are cheaper and better. Stainless steel is even more rugged, but also heavier and more expensive. Building a leakproof plywood bin is difficult. In addition, fiberglass resin is a health hazard and requires approved breathing masks. HDPE is less likely to be consumed by porcupines than plywood coated with fiberglass, and porkies cannot damage stainless steel at all. Persistent porkies will chew through a fiberglass coating to get to the plywood inside.

- NOTE: PORCUPINES—Because of their love of salt, porcupines can be a problem even with HDPE bins. If they are, removal of the offending animals is the best solution. If porcupines must be eliminated, check with your regional ATC field office and the local land manager before taking any action. Removal of any creature may not be permitted in your area. Elimination options include live trapping or removal by hunting. If you cannot remove the porcupines and they continue to be a problem, you can enclose your composting system components inside a metal cage.

Aeration tubes once were thought necessary for composting, but they actually provide minimal aeration, and they hinder turning the compost. Do not add them to bins. The tube holes in the bin walls are points of weakness, and the edges are ideal places for animals to begin chewing into the bin.

The original bin design used a sliding front door, but it let water into the bins. Modern HDPE bins are only accessed from the top.

See Appendix G, "Sources of Material and Equipment."

Compost bin lid—Many HDPE bins are available, but few are designed for use with lids. The GMC has located a supplier who will custom fabricate snugly fitting black plastic lids for the 210-gallon bin. (See the Appendix, Sources of Material and Equipment.) The GMC reinforces these lids to withstand winter snow loads, and we hope the black color will provide some solar warmth.

If you can't get a plastic lid, you can make a wooden lid. All the AMC's stainless steel bins are fitted with framed plywood lids, which are covered with plastic for waterproofing when left through the winter. A lid should be sturdy to withstand falling branches and snow. A lid of marine-grade plywood, reinforced with slats to prevent warping, will last many years, but is heavy to pack in and maneuver.

Two sheet-metal roofing panels, overlapped and screwed to a two-by-four lumber frame, make a sturdy top. Crimp and nail or screw down all exposed edges. Reinforce with diagonal bracing. Secure with rocks to prevent the wind from lifting it off.

See Appendix G, "Sources of Material and Equipment."

Fiberglass and plastic solar panels are not recommended, because they crack easily under snow loads, a sharp blow, or a sudden twist, and they provide only a small amount of heat from the sun in comparison to the heat generated by microbial growth.

Transporting the compost bin to the site—AMC has flown all of its compost bins to its sites. HDPE compost bins weigh only 60 to 100 pounds, but they are awkward to pack to remote sites. Since the tubs are cylindrical, they can be rolled on easy terrain. Two to four people can carry a bin upside down or lashed to a homemade stretcher. One person can carry a bin on a wooden packboard by resting the rim on the top of the packboard and grabbing the sides with his or her arms.

Positioning the compost bin—Stainless steel bins have strength enough to sit directly on leveled ground.

An HDPE compost bin may be placed directly on flat level ground; on pressure treated two-by-six-inch boards; or on a sturdy platform of pressure-treated two-by-six-inch lumber. Note that a full bin can weigh more than 1,700 pounds.

It is convenient to put the bin on a raised platform of wood or earth, and this is especially useful if the site is wet. Pack the ground on which the bin or wooden bin platform will sit with mineral soil or fine stream gravel to provide a solid base. Set the empty bin or platform on the ground and try to rock it back and forth. Then tilt it aside to look for compressed soil indicating high spots that could weaken a bin. Shave these down until the impression of the bin or platform on the ground is uniform, if it will sit directly on the ground. It is better to set the corners of a platform securely on large, flat rocks.

Drying rack—The drying rack (or “screen” for the AMC process) is the third stage in composting. On GMC’s rack, composted sewage dries for six months to a year, and any surviving pathogens are destroyed by continued exposure to unfavorable environmental conditions. In both systems the drying process also enables the operator to sift material to reclaim bark mulch and remove trash from it.

The drying rack gives the operator a great deal of control over composting. Uncertainty whether the compost is done—that is, whether pathogens have been reduced to an acceptable level—is eliminated by aging the material on the rack.

The compost drying rack should be near the composting bin to make transfer easier. The best shape for the drying rack is that of a small three-sided lean-to. (See the Appendix, Drying Rack Plans.) For a site that does one to two runs a season, a six-by-four-foot rack is good. The rack can be made from untreated lumber, since the compost has no liquid draining from it. Two-by-six-inch boards make a long lasting platform deck.

See Appendix J, “Drying Rack Plans.”

Higher walls in the back of the rack increase storage capacity. The front should be open. You can use local logs for the base, but rot-resistant or pressure treated dimensional lumber is better. Provide a sturdy roof, sloped to shed water, with ample room beneath for air flow. Metal roofing is inexpensive, easy to pack in and install, and lasts 25 years or more.

Do not use plastic sheeting to cover the platform: it punctures, rips, and scatters, and it traps moisture on the surface of the compost.

Examine the deck for repair whenever the rack or a portion of the rack is emptied. Replace rotted boards or resurface the deck if needed. When resurfacing the deck of the rack, nail new boards directly on top of old boards, giving a double thickness.

Use only a designated and labeled or color-coded shovel (red is recommended for potentially contaminated tools) to transfer compost to the drying rack at the end of a run. Turn compost on the rack *regularly* with a designated fork to enhance further breakdown. Adding leaves and duff at this stage introduces additional soil invertebrates to the compost, which helps speed it toward maturity.

Sifting screen—AMC makes the base of its drying rack from a screen, so material sifts as it dries. The screen is elevated on legs, and has a frame above it so it can be covered by a tarp in wet weather. The tarp is removed in dry weather to speed drying.

GMC uses a separate sifting screen before spreading finished compost in the woods. The GMC screen is a simple wooden frame approximately five by four feet, three or four feet off the ground, covered with a double layer of heavy gauge quarter-inch hardware cloth or heavy gauge diamond patterned expanded sheet steel. A tarp beneath the screen captures screened compost. Locate the sifting screen on dry, level ground adjacent to the drying rack.

In the GMC system, compost is sifted when it has been sitting in the drying rack for six months to a year and appears dry. Use a shovel designated for clean material (a green handle is recommended) to place compost on the screen. In the AMC system, compost dries quickly because it is exposed to air both above and below, and is raked frequently. Drying and sifting are complete in two to four weeks.

Rake compost gently back and forth with an ordinary garden rake to cause the finer compost particles to fall through the screen. Bark mulch and any chunks of uncomposted sewage that managed to make it through the system remain on the screen. Place sewage chunks back in the composting bin with the catcher/storage container shovel (red handle), and break them up so the sewage will be adequately composted in the next run. Bark mulch to be recycled can be placed back into the drying rack. This composted bark mulch has a pleasant earthy odor, and it is useful as a substitute for fresh bark when lining the catcher after emptying it.

Screened compost is ready to be spread in the woods (See 9.x below: The Finished Product) or recycled into the next run if room permits.

The remaining chips are thoroughly dried, and bagged with special color-coded labels to indicate they are to be recycled by the caretaker. They should *not* be placed in the outhouse for users to add to waste.

Transport containers—Two five-gallon plastic buckets with handles are useful for transporting finished compost to be spread. The buckets need not be leakproof, as they will hold compost only. Keep them labeled and removed from the site, or trash will magically appear in them.

Composting tools—Each of two phases of the composting process requires its own set of tools to prevent spreading pathogens to finished compost.

> *Phase One:* This shovel and fork are used for material in the catcher and the storage container, for starting a run, and for transferring the material from composting bins. Tools used in each of these steps contacts waste potentially contaminated with a significant level of disease-causing pathogens. Therefore, these tools should have a red handle or should be wrapped with red tape. Red is a universal sign of danger. Ideally, these tools should be stored by hanging them from a branch or nail on a tree exposed to the weather near the rear of the outhouse. If you have a problem with hikers using or disturbing the tools, they can be stored in a secure locker.

Phase Two: This shovel, rake and fork are used for material in the drying rack and the sifting screen, and for spreading finished material from the transport buckets. This material has been through a compost run with high temperatures and/or has sat on the drying rack or screen, so it is either lightly contaminated or free of pathogens. These tools should have a green handle or be wrapped in green tape;green is a universal sign of safety. These tools also should be stored by hanging them from a branch or nail on a tree near the drying rack, unless hikers tend to use or disturb them.

To avoid contaminating the finished compost, tools must not be mixed up. If you break a tool, suspend operations until you can replace it.

The *turning fork* is the flat-tined spading fork variety, as opposed to the round-tined type. Flat tines let you pick up the waste and compost for mixing. Take care not to puncture the containers or the bin with the points.

A *long-handled shovel* is very useful for mixing raw wastes, because it can more easily chop the wastes than the turning fork. It is also used for transferring wastes from the collection container to a storage container and from the storage container to the bin.

An ordinary *garden rake* is useful for sifting finished compost.

Clean the red tools after every use by wiping them with bark or finished compost, holding them above the compost bin. Hang them outside (handles up) if possible to facilitate cleaning by weathering. Wipe wood handles at least once a year with boiled linseed oil.

Bark mulch (bulking agents)—Bulking agents are materials that provide carbon, aeration and structure to the compost pile. Hardwood bark mulch is the best bulking agent for composting human wastes in the batch-bin composter.

Fine bulking agents such as peat moss, sawdust or ground dried leaves and duff are unsatisfactory because they compact and exclude air. Bark mulch is durable, and its chips are the right size to break up sewage and create air channels throughout the compost pile. The structure provided also creates good surface areas for decomposer organisms to thrive on.

The carbon-to-nitrogen (C:N) ratio of hardwood bark varies, depending on the type of tree and the age of the bark. Fresh hardwood bark has a C:N ratio in the range of 100:1 to 150:1. Older, dried bark has a C:N ratio of between 150:1 to 350:1, due to nitrogen loss. At the C:N levels in old dry bark the compost process is generally not impeded, because the bark is drier and less is needed to soak up water. In contrast, sawdust has a C:N ratio of nearly 500:1—high enough to bring decomposition to a standstill.

Bark for composting works best when fresh from the sawmill. However, it is much more convenient to bag and store bark in the fall to have on hand for the spring, and to distribute bark when personnel and transportation are available. Bark stored under cover over the winter is drier, and thus lighter to pack to compost sites.

Selecting bark at the mill requires judgment. The size of the bark chips is the most important criterion. Look for chips at least an inch to two inches long, which break up sewage well, but less than four inches, because longer chips are hard to turn in the compost bin.

Also, find the conveyor carrying fresh bark from the debarker. Fresh bark is often the lightest, because it has not sat outside soaking up water. If the pile is wet, try digging down a few inches. You may find a drier layer beneath. If you can't find chips of the right size in the fresh bark, look elsewhere in the storage pile, even if you have to take wet bark.

Often, a foot or so into the pile, the bark is vigorously decomposing. Although this decomposing bark is fairly moist, it works very well for composting human wastes.

Use a turning fork to scoop bark into bags. Shovels work, but are difficult to push into the bark pile. Tie the bags off with string or plastic lock-ties. Use slip knots that can easily be untied in the field: no one wants to dig out a pocket knife in the middle of a composting operation.

GMC has found that used coffee bags or feed bags are great for mulch. They are durable, and allow mulch to breathe and dry. They hold 40 to 60 pounds of bark, or about 75 pounds of damp bark, which is the maximum weight for packing into a backcountry campsite.

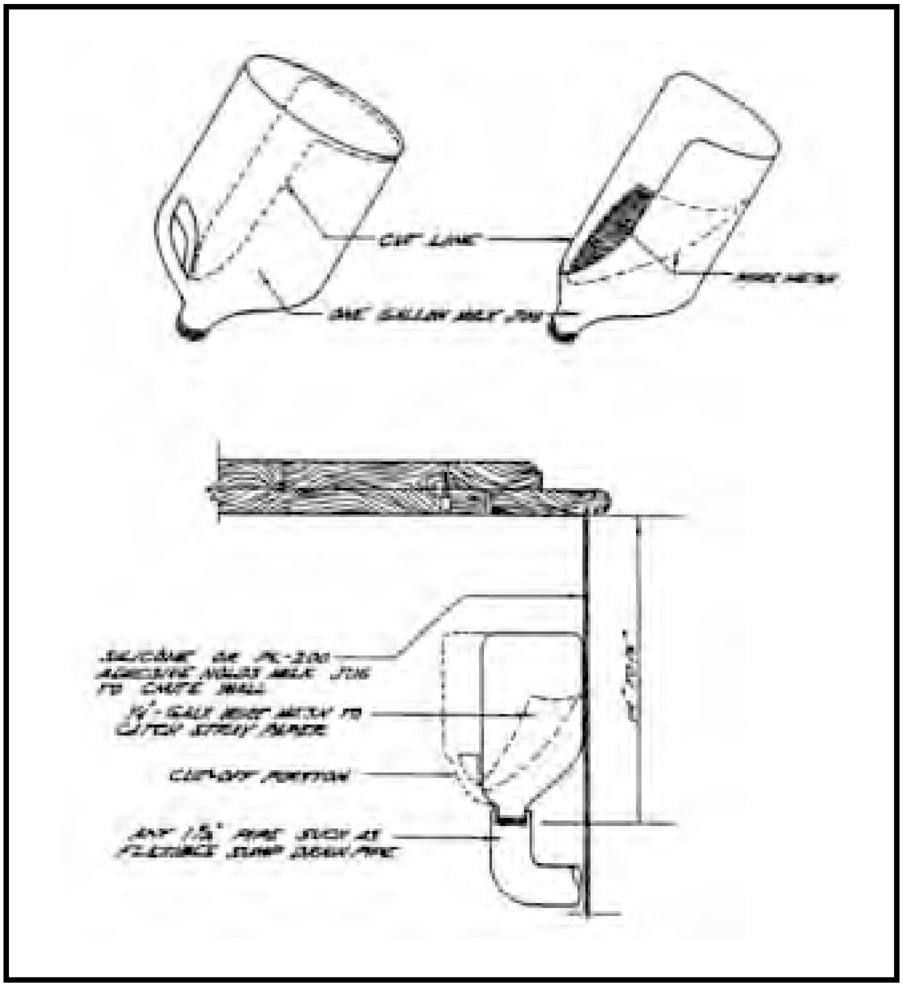


Figure 9.4—An example of a simple, home-made, urine diverting device that could have many applications with a variety of systems, both those described in this manual and others in use on the A.T. The drain pipe could lead to a beyond-the-bin liquid management system or a simple rock-lined dry well. State and local regulations may dictate how the liquid is managed." From The Composting Toilet System Book by David Del Porto and Carol Steinfeld.

Estimating the amount of bark to supply to a site depends on the level and type of use. Day use means more urine in the catcher if urine is not separated from solid waste. The volume of bark needed also depends on the moisture level of the bark. Dry bark will absorb more waste water than damp bark. Keeping an accurate record of bark use in all phases of the operation will help you plan your bark supply in the future.

The following table is based on varying use levels at several Green Mountain Club sites with batch-bin composters:

VISITORS/YEAR	GALLONS OF WASTE	POUNDS OF BARK
100	15	125
200	50	300
500	100	750
850	250	850
1,200	400	1,600

Table 9.1—Bark Amounts at GMC Sites

As you can see, bark use and sewage quantity are not directly proportional to overnight use. Day use, bark moisture content, liquid input, and the quantity of old compost and bark recycled back into the system affect the amount of bark needed.

Keep a supply of bark on the site under cover: in the shelter, under the outhouse or the drying rack, or raised off the ground and covered with roofing. This allows the bark to dry as water vapor escapes through the porous bag. If bark can not be not stored under cover, line the feed bags with plastic garbage bags to keep the bark from absorbing more moisture. Do not place bags of bark on plastic sheeting, which will tend to collect moisture that will soak into the bark.

Stay several bags ahead of what you need. Leave several bags over winter at the site for use in the spring. Hide your stored bark supply or prominently label it “Fecal Compost Material” to prevent disturbance by visitors. See 9.4 below for information on transporting bark to the site.

Keep a container of bark in the outhouse at all times. GMC has found that at sites with an attendant, it is best to keep a small can of mulch in the outhouse and fill it each day. This takes less space than a feed bag, is more convenient for users (floppy bags are awkward to empty), and encourages users to throw in the right amount of mulch.

Post a sign instructing users to throw in a handful of bark after each use of the privy. At high-use sites, the operator should add bark during the day if more is needed.

Thermometer—A long probe thermometer is useful for monitoring the compost process. The AMC records the temperature in both compost bins daily at approximately the same time each day, and tracks this data during a compost run. This is helpful, but not necessary. There are many other composting indicators a maintainer can easily detect without a thermometer. However, to guarantee maximum pathogen reduction it is helpful to be sure temperatures are reaching the thermophilic range frequently.

Store thermometers under cover to keep water from seeping into their housings. Recalibrate occasionally, following the manufacturer’s instructions.

Wash Station—On the first visit to the site each year, bring two one-gallon plastic milk jugs and a pump bottle of antibacterial soap to establish the wash station for the season.

See Sanitary Procedures, Section 4—"Health and Safety Issues," for a complete discussion of soap, wash jug, and hand-washing procedures.

Punch a small hole in the side of one milk jug near the bottom. Place a small twig or nail in the hole to stem the water leak. Tie the jug to a tree. When the cap is loosened and the twig is removed, a small stream of water comes out, allowing hand washing without touching the jug.

Rinse off the soap bottle after each use.

9.4 BULKING AGENT TRANSPORT OPTIONS

One of the main challenges of operating a batch-bin or beyond-the-bin composting system is transporting bulking agent to the site. The pros and cons of each option are discussed below.

- *Pack it in:* Volunteers or seasonal field staff pack mulch to the site on packboards or pack frames.

  The *main advantage* of this method is low cost, if volunteers are available. Paid seasonal staff are not an option for most clubs. Packboards cost from nothing (old pack frames) to $300, and last a long time. Packing is the easiest system to institute, and all sites are accessible on foot.

  The *main disadvantage* is that it is a lot of hard work, so bark mulch at the site may run out. Many excellent trail and shelter volunteers can not carry loads of mulch. Even vigorous club members may refrain from volunteering to avoid the possibility of being solely responsible for supplying bark mulch.

  If you depend on volunteers, and they are unable or unwilling to support your composting system, it will fail. The GMC uses large volunteer groups (typically a camp or college group) to pack in bark mulch. This keeps individual shelter volunteers happy, and the packers can carry lighter loads and make fewer trips.

  Some clubs sled mulch during the winter, and report that it is easier and more pleasant than backpacking. To our knowledge, A.T. clubs have not tried pack animals, dogsleds, wheeled game transporters, canoe portage buggies, wheelbarrows, garden carts or jogging strollers. Wheeled devices, even muscle powered, are illegal in federally designated Wilderness areas and on A.T. lands owned by the Park Service. They may also be illegal on other classifications of federal or state land. Check with your regional ATC office and with your land owning agency.

  - *Drive It In:* If you have legal road access, an ATV or a four-wheel-drive vehicle and the money to run it, getting bark to the site is easy. Snowmobiles may be feasible in some locations. The *main advantage* is that it saves work, making it easier to recruit and keep volunteers.

  The *main disadvantage* of vehicle transport is the potential to destroy the primitive experience of the A.T. Nothing degrades a hiker's experience more than the arrival of a motor vehicle. In addition, regular vehicle access may encourage drivers of ATVs or vehicles to use the route illegally. Maintaining the route and the vehicle can be expensive, unless provided by volunteers or the land manager.

  To minimize disruption, schedule vehicle visits when use of the site is lowest and disturbance of plants and animals will be least. *Be sure to contact your regional ATC field office and the local land manager to see whether vehicle access is legal and feasible*.

- *Fly It In:* The easiest (and the hardest) way to get bulking agent to a site is a helicopter. The only A.T. club to use this method is the Appalachian Mountain Club in New Hampshire. With 90,000 members, AMC is the largest A.T. club. The club has a full time trails department staff to manage the airlift budget and the split-second logistics required to use a helicopter efficiently. AMC is fortunate to have the means to use a helicopter, because the exceptionally high use of their campsites and the rugged terrain of the White Mountains make it impossible to pack in enough bark even with volunteer groups augmenting their paid seasonal staff.

The *main advantage* of airlifting is the ability to supply a season's bulking agent in one shot. If your sites have extremely high use, too little soil for a moldering privy (which can use lightweight shavings or local forest duff), and are very hard to reach, airlifting could be your best or even only option. A small club could afford an airlift if it could get the use of a helicopter donated by a helicopter company or the local National Guard.

The *main disadvantage*, of course, is high cost. Helicopters can cost $800 to $1000 an hour. There also may be legal restrictions. *If you are considering airlifting any materials or supplies, contact your regional ATC field office and the local land manager to see if it will be legal and feasible*.

9.5 OPERATION OF THE SYSTEM

A compost run with three thermophilic temperature cycles and six turnings takes four to six weeks. Climate determines the maximum number of runs per year. At mountain sites in the Northeast, the compost season runs from mid-May through mid-September, generally 15 to 18 weeks.

Capacity—Capacity depends on the number of compost bins and the available labor, bark, and spreading areas. One 210-gallon bin can compost 130 gallons of bark and sewage mixture per run, although skilled composter operators may be able to boost capacity to 160 gallons per run.

The number of compost bins needed at a site depends on:

1. The number of overnight and day visitors per year.

2. The liquid content of the wastes collected. High day use results in a higher proportion of urine, unless urine is separated from solids.

3. The length of the compost season.

4. The capacity of the drying rack. A sewage backlog may force a shortening in the length of a run, calling for more time on the drying rack. Hence, more storage capacity for secondary decomposition can increase overall capacity. (In the AMC system, the use of two composting bins in sequence permits frequent composting runs, and eliminates the problem of sewage backlogs.)

5. How often the site and the system are maintained. If there is less maintenance and oversight, an extra bin may be needed to provide adequate storage of wastes and to allow a longer retention time for waste in the system. A system with less

maintenance will not reach thermophilic temperatures as reliably, so it will need a longer period of secondary treatment in a second bin and then on the drying rack.

At mountain sites with an 18-week composting season, one bin and one drying rack should be adequate for 450 to 500 overnight visitors per season. A site in the southern Appalachians, with a longer composting season and higher temperatures during the season, could handle more visitors with one bin.

With a beyond-the-bin (BTB) system or another way of segregating urine, the number of visitors one bin can accommodate is greatly increased because the amount of bark mulch needed to absorb liquids is reduced. AMC uses BTB systems at every site; that, plus daily attention to the process and the use of two compost bins, accommodates high volumes of visitors.

Where two or more bins are required, they should be located side by side to facilitate waste transfer from bin to bin.

Filling the bin—If the compost bin is empty or new, add several inches of finished compost, recycled bark, fresh hardwood bark, crumbled dry leaves, or peat moss to the bottom. That absorbs liquid, and reduces odor. Including forest duff or recycled compost or bark chips inoculates fresh waste with decomposer organisms.

If a run has been completed, leave the bottom six inches of material in the bin. AMC and GMC compost operators call this bottom layer the “mank” layer. It is generally too wet, potentially still pathogenic, and not decomposed enough to be transferred out of the compost bin. Instead, it must be thoroughly mixed into the waste to be composted in the next run. Add some duff or recycled compost or barks chips to inoculate the fresh waste with decomposer organisms.

If a liquid separation method such as the beyond-the-bin system is used, there should be little or no mank layer. In this case, leave the bottom three inches of finished compost to help inoculate and start the next run.

Add sewage to the bin. In the bin, mix it with recycled compost, recycled bark mulch and fresh bark mulch to the point where the wastes will not drip. The sewage bark mixture should be glistening, not dripping.

Do not pour wastes into the compost bin. It is most efficient to have one person add a shovel full of sewage and another person add a shovel full or two of bark or a shovelful of old compost, and chop and mix the wastes well. Each new addition of fresh wastes is thus broken up and mixed with bulking agent as it is added. All mixing must be thorough.

Do not heap a large quantity of waste in the bin and then try to mix the entire batch. This saves no time, mixing is less thorough, and more moisture drains downward.

In the AMC system, sewage from the catcher is mixed with bark mulch a little at a time in a separate mixing bin, and then transferred into the first compost bin. This enables very thorough mixing of the material, insuring a fast start and a high temperature during the composting process.

At low-use sites with infrequent attendance, wastes tend to dry as water settles to the bottom of containers or is absorbed by bark mulch. When transferring such dry waste, mix it with recycled compost from the drying rack rather than bark. Compost usually has a higher moisture content than fresh bark, so this will help keep the mixture moist.

It is essential to break up any clumps of raw sewage during the waste transfer. If small clumps of raw sewage are allowed to tumble around in the bin, they will dry slightly on the outside, and resist decomposition. Then pathogens can survive to contaminate the finished compost. Be alert and break up any remaining clumps during the first two turnings, while the pile is still moist and before the clumps harden.

Shake each forkful of fledgling compost when starting the run to find any sewage clumps. Small balls of sewage will generally roll down any slope in the compost pile. Use the side of the fork or side of the shovel to crush and cut these up.

Plan ahead: Make sure your compost bin is ready to receive sewage and start a run when both storage containers are filled and the catcher begins to fill up.

Turning the compost pile—Thorough mixing gets the pile off to a good start and assures aerobic conditions. Adequate mixing at any stage is not difficult if the waste has the right moisture content. Don't rush. Spend enough time when turning the compost pile, breaking up clumps and regulating moisture.

Add bark mulch or dry finished compost if the pile is too wet, or add water if it gets too dry. Keep the pile moist and steaming. *Usually, the pile will self-regulate to the proper moisture level as excess moisture drains to the bottom and forms the mank layer.* Keep the moisture level at the point where water only saturates the bottom six inches of mank. This is the ideal moisture level. If the pile is too wet, you can remove the lid on dry sunny days to let the pile dry.

Do not allow the pile to get too dry. Under dry conditions the process slows way down, and some harmful micro-organisms may "encapsulate," forming durable hard outer coatings that protect them from attack by environmental conditions. *Dry compost does not equal done compost*.

Guard against adding too much bark. After a few days, wood splinters in the bark begin to soak up moisture in the compost, and the pile will become slightly drier. In addition, an actively turned pile will also lose moisture as water vapor escapes.

After the first few turnings of a full bin, leave the mank layer alone. *Do not mix the lower region of the bin where moisture has collected into the upper part of the pile—you will contaminate it with pathogens*.

To turn the pile, dig out a corner, taking care to leave the mank layer intact, and heap material in the back of the bin. Dig a new hole next to the first, turning and fluffing the compost as you fill the original hole. Work your way around the bin, digging and filling as you go. Include the center of the pile. During a run, all portions of the pile, including the center, are actively mixed together. Add more bark, recycled compost or recycled bark as needed. Turning may be a challenge if the bin is nearly full, but it is essential to expose the pile thoroughly to air.

Turn the pile early in the morning to avoid blackflies and mosquitoes, or turn during a light drizzle. Slapping bugs or scratching bites is unsanitary once composting operations have begun. Wearing long pants, a long-sleeved shirt rolled to the elbows, and a head net also helps.

The compost run—A compost run converts raw sewage to a finely textured humus-like material. Add no more new sewage to the compost bin after a run starts, because that would recontaminate the compost.

See Section 3—The Decomposition and Composting Process, for details.

A progression of changes mark the run. The temperature of the compost moves into the upper reaches of the mesophilic range, or 35 degrees C. to 45 degrees C. (95

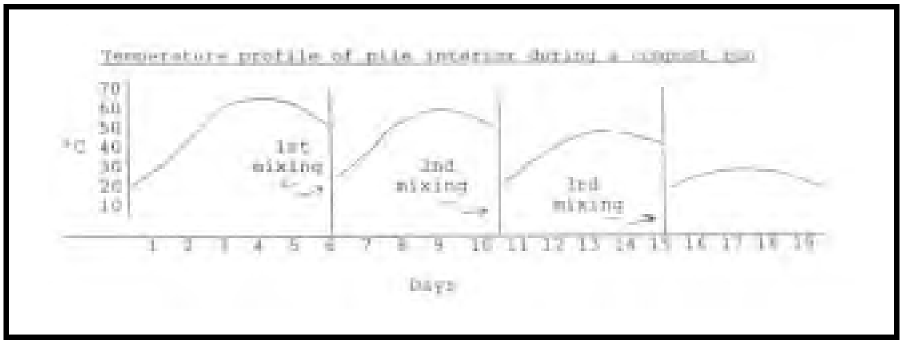


Figure 9.5—Temperature profile of compost pile in a batch-bin system during a compost run." From the Green Mountain Club.

degrees F. to 112 degrees F.), where the most intense microbial activity takes place. The temperature then passes into the range of thermophilic microbes (chiefly bacteria)—45 degrees C. to 75 degrees C. (112 degrees F. to 167 degrees F.). As the upper temperature limit is reached, oxygen and readily available nutrients are depleted, and the temperature falls. Mesophilic fungi and actinomycetes begin to decay the most resistant compost components.

Turning the pile every four to five days exposes new nutrient sources, and brings oxygen again to the pile interior. Bacterial growth is reinvigorated, and the temperature climbs again until nutrient and energy supplies are exhausted. Nutrient and energy sources in the compost are depleted more rapidly with successive turnings. The temperature peaks get lower and lower as the pile stabilizes.

The C:N ratio begins to decline as carbon is lost as carbon dioxide. The volume of the pile diminishes due to loss of carbon—a 30 percent reduction in pile size is not uncommon under favorable conditions. Nitrogen is largely recycled. Although some is lost as ammonia, the rate of loss is much less than that of carbon.

The formation of humic acids and related organic molecules darkens the color of the pile noticeably as the process advances. Due to adsorption and assimilation of waste compounds, unpleasant odors disappear early in the process.

Starting the compost run—A run can be conducted by one person, especially if the operator is trained and experienced. Generally, though, it is better to have two or more people. Two people are more likely to mix materials thoroughly without becoming tired. In addition, a helper can tend many jobs while the other person is mixing—for example, spreading finished compost, raking compost on the drying rack or screen, replacing the sewage catcher, cleaning the outhouse and supplying it with bulking agent, and setting up the wash station. Finally, doing the job with two people enables one of them to stay clean and uncontaminated if a job requires a clean pair of hands.

See Appendix B, "Troubleshooting and General Composting Tips."

To ensure rapid waste breakdown and high temperatures, start a run with a large addition of fresh wastes and hardwood bark. A full catcher (50 to 70 gallons of sewage) works well in the GMC system. In the AMC system, a run is always started with a full bin of new material. Once the catcher of raw sewage is mixed with bulking agent, the compost run has begun, and no new sewage wastes are added during the run.

Stored waste—Significant decomposition can occur while sewage is stored before the start of a run. Sometimes high temperatures are reached several times during storage. Premature composting depletes many nutrients, so the final run may not get hot enough without a large batch of new sewage. The result of trying to conduct a run without enough new sewage will be incompletely composted and contaminated material. This problem does not arise with the AMC system, which does not employ storage containers.

Large quantities are easier to compost than small ones. Pathogen destruction is more reliable, because a large pile self-insulates and achieves high temperatures. GMC uses 210-gallon bins to insure a high temperature, and AMC uses 160-gallon bins. In either case, the key is to compost one large batch of sewage—as much of it fresh as possible—at a time.

At low-use sites, too little waste may accumulate in a season for a compost run. That is why the GMC began to use storage containers. Now, by using the 64 gallons worth of storage and the 70-gallon catcher, a high temperature batch run can be done even if it takes more than one season to collect enough waste.

Quantities—Using a 210-gallon composting bin, up to 160 gallons of sewage can be composted in one run, using several hundred pounds of bark or a mixture of bark, recycled bark and compost. Breaking up clumps, regulating moisture, and ensuring thorough mixing is more time consuming with higher volumes, but it produces a better result. With less than 100 gallons, reaching thermophilic conditions may be difficult, unless the volume of use at the site is high enough that all of the sewage in the catcher is fresh enough to mix with ample bark mulch.

Once the storage containers and catcher have been emptied, the compost bin should be full to within several inches of the top. For slightly smaller quantities of sewage, older compost can be added as an insulating layer around the outside of the bin. The temperature of the pile should always be monitored if possible to make sure it is reaching thermophilic range.

Mixing—After the final addition of raw sewage and bark, turn and mix the material to be composted very thoroughly when starting the compost run. This provides good starting conditions.

The AMC system requires no initial mixing in the compost bin, since sewage is mixed with bark in a mixing bin as it is transferred to the compost bin.

Allow the compost to sit through the first temperature rise, which will probably take about five days. Active aerobic composting will create a rapidly changing environment unfavorable to human pathogens. As oxygen and nutrients in the pile interior are exhausted, the pile will settle slightly. If possible, use a probe thermometer to observe and confirm the temperature rise, peak, and decline. Turn the pile again when the temperature begins to drop to reinvigorate the compost process. If you do not have a thermometer, turn the pile after five days.

Turning the pile "inside out"—The outer layers of compost will not be exposed to the high temperatures of the interior, and they will need to be switched with the compost in the center. This is called turning the pile inside out. The sides and top layer are heaped into the center as the old center material is built up around them as the new sides.

The following technique works well:

1. Dig a hole in the outer layer to within six inches of the bottom.

2. Heap this compost to one side.

3. Dig an adjacent hole in the center portion of the pile and use this compost to fill the outside hole.

4. Dig a new outside hole to fill the center hole.

5. Continue working around the bin until all the center is moved to the outside. The goal is to turn the entire pile inside out after each composting cycle. Since some mixing of outsides and center compost does occur, repeat inside out mixing as many times as the run permits.

   Six turnings of the compost during a run should be the minimum. The longer the wastes can be decomposed in the bin, the shorter will be the time needed on the drying rack for additional decomposition. A shorter run requires a longer rest on the drying rack for the compost.

Thermophilic conditions—Achieving thermophilic conditions is *not* essential to reducing the volume of waste, but it *is* crucial to pathogen destruction. If thermophilic temperatures are not achieved during a run, or it is uncertain whether they have been achieved, compost should sit on the drying rack at least a year.

The AMC has found that reaching thermophilic conditions is assured at high-use sites where the ample supply of fresh sewage is thoroughly mixed with bark mulch before placing it in the first composting bin. Under these conditions, a separate rack for drying and aging is not necessary.

Two bins permit a variety of strategies to manage large volumes of wastes. A run can start in one bin, while the second is completing a run. And, as in the AMC system, transferring material from bin to bin can simplify turning inside out.

9.6 THE FINISHED PRODUCT

When is compost done? Unfortunately, definitive tests are expensive laboratory procedures, and composting, being a natural process, does not lend itself well to simple field tests. However, a little experience in watching changes in temperature, color, odor and moisture content enables an operator to reliably judge completion of the process.

For more information on these processes, see Section 4—"Health and Safety Issues."

Heat, competition, aerobiosis, antibiosis, destruction of nutrients, and time are the main agents and mechanisms of pathogen destruction. A well-managed compost pile goes through several heat cycles during a run. The best on-site determination of compost stability is a final drop in temperature after thermophilic conditions have been reached several times.

A final drop in temperature may be difficult to detect, because each run behaves differently. Fortunately, the smell and visual appearance of the compost are excellent indicators of stability and safety.

See descriptions of actinomycetes in Section 3—"The Decomposition and Composting Process," and in the Glossary in Appendix A.

At the end of a run, the compost should be loose and crumbly, with a uniform texture. There should be no clumps or balls of sewage. The odor should be faintly earthy, indicating the presence of actinomycetes Its color should be the dark brown-black of rich humus. The compost should be moist, not wet or dry. In general, it finished compost looks like rich organic soil mixed with partially decayed bark mulch.

Spreading Finished Compost—Finished and sifted compost can be spread carefully on the forest floor. The top six inches of the soil acts as a dynamic living filter made up of plant roots, decaying plant matter, abundant soil microorganisms, and active invertebrate populations. Nutrients and residual energy-rich compounds in the compost are quickly assimilated into this soil layer during the warmer months.

Because there is always some chance of pathogen survival, select spreading sites and handle compost with caution. Try to avoid nutrient loading of the water table, surface water contamination from runoff, and human contact with spreading sites. Fortunately, bin composting (and aging on a drying rack if conditions require it) normally create stable and safe compost, which, if properly managed and disposed of, presents little environmental stress or hazard to human health.

- *NOTE: Check with your local Trail club, ATC field office, and land management agency to learn of any constraints on disposing of compost. Some states may prohibit surface spreading, so compost must be trench-buried or packed out. GMC is developing a compost incinerator that may make it easier to comply with this kind of restriction.*

See Section 11.8—“Prototype Wood-Fired Compost Incinerator.”

Keep an area map showing compost spreading zones, to enable new operators and volunteers to locate the areas used for spreading.

When you choose an area to spread compost, look for flat ground or a gentle slope with at least one foot of well-drained soil and actively growing herbaceous ground plants. Avoid areas with compacted soil such as old tent sites. Water generally flows off the surface of such sites, which should first be revegetated. Cover with leaves, duff, and branches to initiate recovery.

Be prepared to carry compost well away from the overnight site. Some sites may require carrying the compost for several tenths of a mile for spreading.

Do not spread compost within 500 feet of ponds and streams. Avoid natural drainages, even if they appear dry. They are often indicators of subsurface flow, and they will be wet if it rains. Avoid marshy areas, as groundwater will be near or at the surface. Never spread within 1,000 feet upslope of any drinking water source.

Spread compost only in the summer. Dissolved minerals and residual pathogens are much more likely to be leached into water at other times of year. Try not to spread compost during or immediately before a rainstorm. This will allow extra time for assimilation into the soil.

Spreading compost, like starting a run, is best done with two people, both to facilitate carrying the compost to the spreading site, and to speed the process. Five-gallon grout buckets are good for carrying compost. A 20-gallon can is the largest container two people can carry any distance. It is better to use smaller containers and avoid fatigue, which creates temptation not to travel far enough.

Feed sacks or coffee bags can also be used, either filled with compost or used as slings carried by two people on each end. However, moving compost with bags is not as clean as transport in a can or bucket.

Set the can or bag with compost on the ground at the edge of the selected spreading area. Scoop up a shovelful at a time and scatter it thinly over the ground to prevent overloading any spot with nutrients. Throwing the compost into the branches of small trees helps scatter it. Do not dump compost, fling a large quantity from the container, or drop shovelfuls on the ground in small heaps. Ensure clean working procedures.

See Section 4—“Health and Safety Issues.”

9.7

COMPOSTING RECORDS

Accurate record keeping is important, both to the success of a long term operation and to orienting new operators. Many problems can be easily avoided if information is passed along in a useful manner.

In addition to filling out the record forms, each operator should write a report summarizing the operation and problems encountered during the season, and recording the status of compost system at the start of winter.

How to fill out the composting record form—Composting record forms indicate the actions taken regarding the compost bin and drying rack. It is not necessary to record each time you empty the collection container into a storage container, although this can be useful for scheduling visits to composting sites. Record actions such as mixing the wastes in the storage container in the "Comments" column.

1. *Date*—The record form should be filled out only when something is done to the compost bin or drying rack, such as adding sewage or bark, turning and mixing, removing compost, *etc*.

2. *# Visitors*—This should not be a cumulative figure. Record the number of overnight visitors from date to date, including the site attendant(s), if any. Note in the comments the approximate number of day users.

3. *Sewage Input*—This is the volume of raw sewage added to the bin, in gallons or liters. Estimate the quantity by the fullness of the catcher and storage containers. Subtract the volume of bark that you have added to the catcher or storage containers, so you have computed the net volume of raw sewage.

4. *Bark Input*—Again, this is the amount of fresh bark added to the bin, by the operator when a run was begun. Estimate the weight and record in pounds or kilograms.

5. *User-Added Bark*—Record the quantity added by users in the outhouse, and the amount added to the collection container by the operator. This column is totaled up and added to the total bark input column when a run begins. Record it as often as necessary—generally as a bag is used up in the outhouse.

6. *Recycled Compost Input*—Record here the quantity of old compost or recycled chips added to the bin and mixed with the fresh wastes.

7. *Date Full*—This is the date that a run begins. After this, no fresh sewage is added until the completion of the run.

8. *Total Sewage Input*—Add up the number of gallons of new sewage collected since the end of the last run. Do not include mank left in the bin from the previous run.

9. *Total Bark Input*—Add up the pounds of fresh bark added to the bin when the last run was begun plus the pounds of user added bark which have also been added to the catcher. Again, do not consider recycled compost or bark mulch used as bulking agent or mank left over from the last run.

10. *Pile temperature*—If a thermometer is used, record temperatures daily. If no thermometer is used, estimate temperature and record as thermophilic (*thermo*) or mesophilic (*meso*).

11. *Turning Dates*—Record each date the pile is turned during the run.

12. *Date Complete*—This is the date the run is over and the finished compost is transferred out of the bin. Fill the entire line to give a summary of the run. Under “Turning Dates,” record the number of turnings. If a second run is begun on the same day, begin a second line to record this new operation.

13. *Compost Transferred to Drying Rack*—Record in gallons or liters the approximate volume of compost which is transferred to the drying rack.

14. *Observations and Comments*—Be as specific as possible. Things to record here include: pile turned and mixed; pile moisture, color, and odor; temperature status; amount of old compost added to the process; problems encountered; presence of fungi or actinomycetes; presence of invertebrates; status of compost on the drying rack; information on spreading compost (where, how much—an area map is helpful), *etc*.

9.8 SPRING START-UP PROCEDURES

Before the hiking season begins, the project leader should visit each site with field personnel or volunteers to empty the catcher and plan for the composting season.

Generally, all that is needed on the first visit, if the storage containers were left empty the previous fall, is to empty the catcher and scour the site for wastes deposited on the snow by thoughtless winter users. Use the red-handled shovel to add this waste to the storage container.

Take antibacterial soap and a wash jug with you on the first trip, because there may be none at the site.

See sanitary procedures in Section 4—“Health and Safety Issues.”

Typical problems to be dealt with in the spring may include a large amount of accumulated wastes to be composted; fecal wastes from snow holes on the snow and the ground; and the bin lid knocked off during the winter, letting water into the bin.

Securely fastened lids should stay on bins. However, they can still be knocked off by falling trees, and determined vandals can defeat any fastening system, so it is best not to leave material in composting bins over the winter.

You may find a soupy mess if storage container lids were knocked off during the winter, or the storage containers were knocked over. You may find bark burned or thrown in the snow over the winter, trash in the storage container or collection container, and so forth.

Review the records and the report of the previous operator for existing problems. Look for new problems. Develop a waste handling and management timetable with the individual operators.

The plan of action for each site should address:

The catcher: Does it need to be emptied immediately? (It generally does in the spring.) Does it need replacement? When? *Etc*.

The compost bin: Is it full? (It is best to leave it empty the preceding fall.) Is compost ready for transfer to the storage platform? Does it need more wastes before starting a run? Does it need bark? Turning? *Etc*.

The storage containers: Are they full? When will they be full? Do they need replacement? When? *Etc*.

The drying rack: When will space on the rack be needed? Is compost ready for sifting? Does it need new siding, bottom boards, roof? *Etc*.

Evaluate all other components of the composting system, including shovels, other tools, plastic wash jug, antibacterial soap, probe thermometer.

An example of a spring action plan might be:

- Spread last year's compost from half of the storage platform
- Repair platform
- Turn and mix remaining compost on the drying rack for further aging
- Begin a run with the new wastes

Plan a follow-up visit by the project leader, particularly for first-year compost operators. Problems at the site may require immediate attention.

Overwintered compost from a drying rack can be recycled into the catcher and compost bin to minimize bark use. Turn and aerate it directly on the drying rack with the green fork to speed aging. Remember that compost absorbs less moisture than fresh ground hardwood bark.

Evaluate and anticipate compost accumulation on the drying rack, and plan a spreading schedule. Rapid plant growth and actively growing ground microbes and soil flora and fauna create optimum spreading conditions in midsummer. Plan ahead.

In the Northeast, mud season is generally a month of low waste accumulation, so try to get as far ahead as possible. If large volumes of waste are anticipated at a medium- to high-use site, try to run the previous winter's waste with enough new sewage to have a four-week run done by the July 4 weekend.

Use June to get a few extra bags of bark on site. Stay several bags ahead at all times, so extra bark will be on site at the end of the season for the next year.

Never panic; just get the job done.

9.9

END-OF-THE-SEASON PROCEDURES

Because the AMC system uses two bins, one will be available to start composting in the spring, or as a repository for sewage if the catcher fills during the winter, even if the other bin has been left full during the winter. Freezing of the comparatively dry compost does not damage composting bins. However, with any system it is best to leave all bins empty during the winter. Otherwise, users of the site are apt to find a way to remove lids, allowing a nicely finished bin of compost to become waterlogged and mixed with trash. The bins are covered with watertight lids tied in place. The drying screen is left empty, with the tarp flat on the screen and held in place with rocks.

In the GMC system, schedule your last run of the season so the compost bin can be emptied before winter starts.

Leave the catcher empty to allow for late fall and winter accumulation. Disconnect the beyond-the-bin or other liquid separation system if one is present before temperatures fall below freezing.

Late fall is not a good time to spread compost. Leave it on the drying rack or screen—or the second bin in the AMC system—until the next summer.

In the GMC system, provide space on the drying rack to accept compost from a fall run, so the compost bin will be empty (except for the mank layer) through the winter. To do that, spread compost from the rack as early in the fall as possible, but no later than mid-September. Compost stored over the winter on a rack is generally ready for spreading or recycling as early as mid-June if it is turned several times.

Outhouses, particularly those depending on composting, benefit from attention in winter, unless there is no winter use. Regular visits to batch-bin composter sites in the winter are desirable. Solicit shelter adopters or other volunteers to check the storage containers, shovel snow from the outhouse door and the rear access door, and empty the catcher if it fills. Often former caretakers will be willing to do this, and some hikers also may be willing. Demonstrate procedures to volunteers in the fall, and post signs at the outhouse with instructions.

In the GMC system, at least one of the storage containers should be left empty. That will allow the catcher to be emptied in the fall, winter and spring.

Leave several bags of bark on site, under cover if possible. The GMC has found six bags is the ideal amount to get things rolling in the spring: two for use in the outhouse by hikers, and four for use in starting the first run of the next season. There is enough to do in the spring without having to pack in six bags of bark to deal with winter wastes.

A brief report should be added to the compost records and sent to the shelter adopter, if there is one, and to the maintaining club. Point out problems encountered, how they were dealt with, and what to expect. Evaluate all parts of the batch-bin system.

Secure the compost-bin lid with rope and stakes or with several heavy rocks. If the area is subject to high winter use, consider placing hooks on the lid or locking it down with carriage bolts to keep the curious and litterbugs from peeking inside. GMC has learned that secure fastening of lids is vital. Looking for the dumpster they have been hoping to find all along the Trail, hikers often do not realize what is in the bin, despite signage. When they finally pry the lid off, they are horrified by the contents and leave without replacing the lid. Then the bin fills with contaminated water which must be bailed in the spring and carefully dumped in a sump hole away from water, facilities and trails.

Be sure the roof on the drying rack is intact and secure. Scan the area for dead trees that could fall on the composting operations and outhouse, and, if necessary, remove them.

Store composting tools where they may be easily retrieved: hanging from trees near the drying rack and outhouse, unless experience indicates they must be in a secure locker. Record where the tools are stored. Bring the thermometer indoors for the winter.

9.10 WINTER OPERATING PROCEDURE (USUALLY OPTIONAL)

Winter is a time of suspended decomposition. Human fecal waste in pit privies, catchers, and storage containers breaks down extremely slowly, if at all. No composting is done in winter, but if a site receives heavy winter use, a midwinter emptying of the catcher may be necessary.

GMC and AMC have found that their new 70-gallon catchers do not overflow during winter if they are emptied in late fall, so their sites no longer need winter visits. If a site has such high winter use that a 70-gallon catcher is overwhelmed, winter attention will be necessary, unless it is possible to convert to an even larger catcher.

When checking shelters or campsites used in the winter, check for defecation on the snow and in snow holes near or above the water supply, and shovel any feces found into a storage container. Make sure the outhouse door is free of snow and ice and that the catcher has not overflowed, driving people outside. Make sure there is enough bark in the outhouse.

Wastes left on top of snow are partially broken down by weathering and sunlight, but wastes left in deep snow holes will emerge in late spring. When the snow melts, human wastes may directly enter surface water. Spring runoff contamination potential is highest at overnight shelters next to water.

For emptying the catcher in winter, you need old leather work mittens, a snow shovel, a one-quart tin can, soap, and a small camping stove. The can, soap, and stove are for hand washing (a Thermos of hot water can be substituted for the stove). Find the composting tools, both red and green. They should be hanging on trees near the drying rack and the outhouse. Check the records before you start.

Shovel a path to the outhouse, shovel out the outhouse, and shovel a path to the storage containers. Check the storage containers to see whether they will hold more waste. If not, check the bin to see if wastes can be placed directly in the bin. This is a last resort, because it complicates emptying the bin and starting a run early the next season.

If you are alone, boil a can full of water, and place it in the outhouse for washing up afterward. Bringing it to a full boil assures it will be warm when you are done. If the weather is extremely cold, cover the can with a spare jacket or something else to conserve its warmth. If you're not solo, have your companion take charge of the hot water. Soap dissolves poorly in ice water, so washing hands in cold water is ineffective as well as uncomfortable.

Put on your pair of old leather mittens, which you will drop in a plastic bag to be cleaned at home when you are done. Remove the catcher from the outhouse, being careful not to twist it or bend it. If urine has run down the front, the catcher may be frozen in. If so, use the tip of the red shovel to pry it up. Several sharp blows with a board to the gap between catcher and outhouse will generally free it. Be careful: Plastic breaks easily when very cold. Hot water can be used to melt the troublesome ice, if you can make enough of it.

Check to be sure the bottom of the catcher is intact. (If it is not, transfer all accumulated waste to a storage container. Leakage should be mopped up with bark mulch and also placed in a storage container. Use a five-gallon bucket as a temporary substitute catcher, and plan to replace the catcher immediately. Place the old catcher in a secluded spot in the woods to weather for a year before packing it out.)

Place the catcher next to the storage containers. Transfer the waste to the storage containers. If the material is not entirely frozen, it can be shoveled directly into the storage container. Otherwise, use the red shovel (not the fork) to shave the wastes, one thin layer at a time. This generally works well, but it is time consuming (one-and-a-half to two hours for 70 gallons of waste). Sometimes, if plenty of bark was left in the bottom of the catcher, the block of waste will slip right out.

Pick up any shavings or chips of waste from the snow with the red shovel, and put them in the storage container. Re-secure the covers of the storage containers to keep out hikers' trash.

Replace the catcher in the outhouse, taking care to line it up properly. Usually it should be as far forward as possible, to keep urine from running over the front edge and freezing the catcher to the outhouse. Close the rear door securely. Loosen the bark in the container in the outhouse, and line the bottom of the catcher with three inches of bark to absorb liquid and reduce odor.

Replace the red shovel. Wash up. Record data in the record book. Post new signs if needed.

10

Liquid Separation in Composting Systems (AMC's Beyond-the-Bin System)

Hawk Metheny, Shelters Field Supervisor, Appalachian Mountain Club

10.1 WHEN TO USE A BEYOND-THE-BIN-SYSTEM

One of the biggest drawbacks to a conventional batch-bin composting system is the challenge of transporting bark mulch to a backcountry location. Backpacking, helicopters, and pack stock involve labor and expense that rise to formidable levels at remote sites that encounter high use.

The beyond-the-bin (BTB) system was developed by the Appalachian Mountain Club in 1995 to reduce the amount of hardwood bark being flown or packed to its fourteen remote backcountry campsites, all of which use composting toilets. Those sites collectively average more than 20,000 users per year. Two BTB systems were installed in 1995, four in 1996, four in 1997, and two in 1998, for a total of twelve. The remaining two sites still use the conventional batch-bin system. One is in a federally designated Wilderness area, where airlifting is not allowed and getting conversion materials to the site would be problematic; the other site sees comparatively low use and does not warrant the conversion.

With twelve sites using the BTB system there has been a reduction in bark consumption of 30 to 35 percent. In 2000, the AMC shelter program airlifted more than 400 fifty-pound bags of bark. Some sites use more than 40 bags per season. Without the BTB, demand for bark would have been more than 600 bags (15 tons), with the most popular sites needing more than 60 bags. The Bell Jet Ranger helicopter used for airlifting carries 800 pounds and costs $800 per hour. Saving more than 200 bags of bark has reduced airlift costs by about $2,400 a year, and has also reduced noise and visual impact on backcountry visitors.

10.2 OVERVIEW

Traditional batch-bin composting systems collect urine and feces in a collector vessel, or catcher, under the outhouse seat. In the BTB system, a sturdy strainer plate is installed in the collector as a false bottom, so solids remain on top and liquids pass through the strainer. A fitting and drain hose at the bottom of the chamber below the strainer carry the effluent to a filter barrel filled with anthracite coal and septic stone, where it is treated safely and dispersed into the soil through perforations. (See Figure 10.x). That substantially reduces the amount of liquid in the collector.

The ideal moisture content for composting is around 60 percent. Coincidentally, the average moisture content of human fecal matter is 60 to 70 percent. But urine raises the moisture content, so additional bark is needed to absorb the liquid.

In addition, the ideal carbon-to-nitrogen ratio (C:N ratio) for composting is thirty parts carbon to one part nitrogen by weight, or 30:1. Fecal matter has a C:N ratio of about 8:1, and hardwood bark has a C:N ratio of about 150:1. When mixed in the

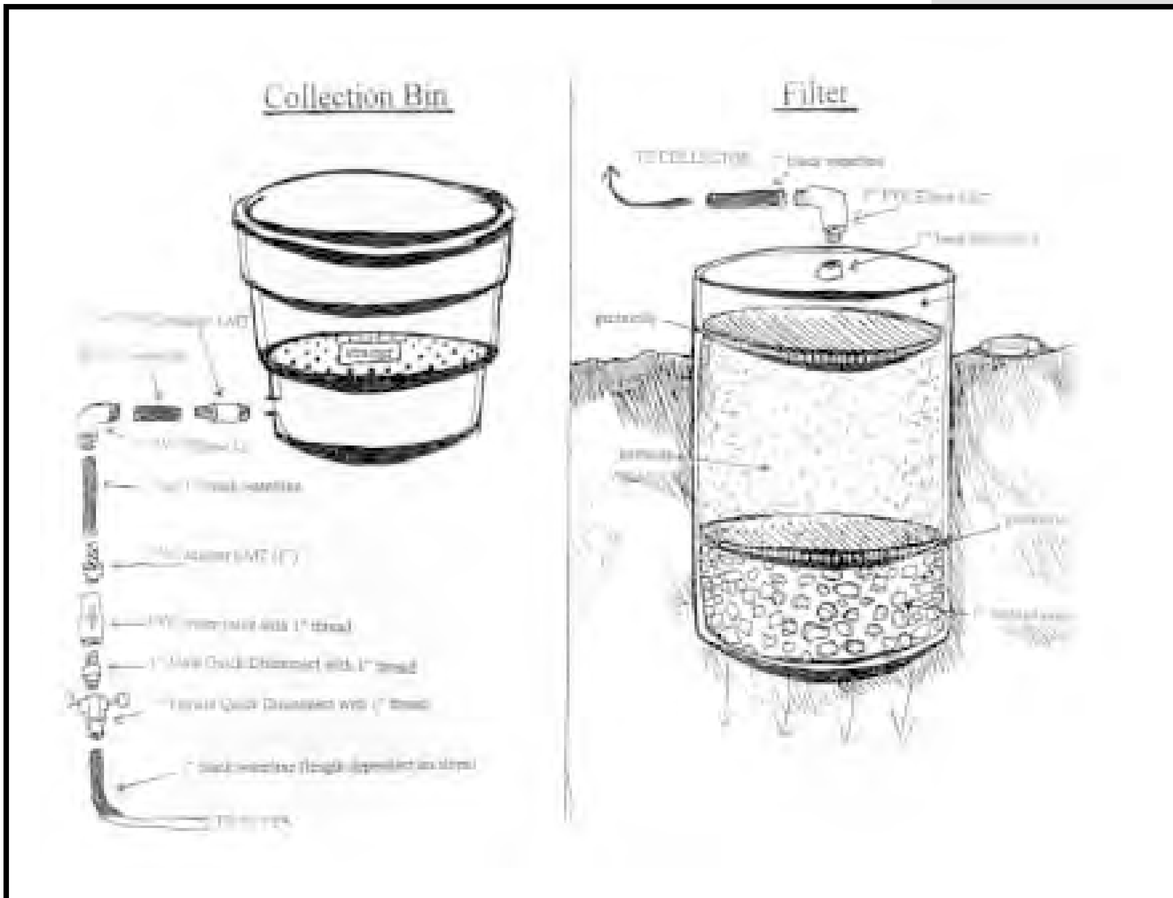


Figure 10.1—The beyond-the-bin liquid management system designed by the Appalachian Mountain Club's Trails Department. This system is an improvement to the Green Mountain Club and Appalachian Mountain Club batch-bin system. Not shown in this diagram is a second barrel that can be attached beyond filter barrel to store filtered effluent. This allows the system to be located near water or in places where drainage is poor. Treated effluent drains into the storage barrel, and is transported to a site with better characteristics for disposal in the ground." Diagram from the Appalachian Mountain Club Trails Dept.

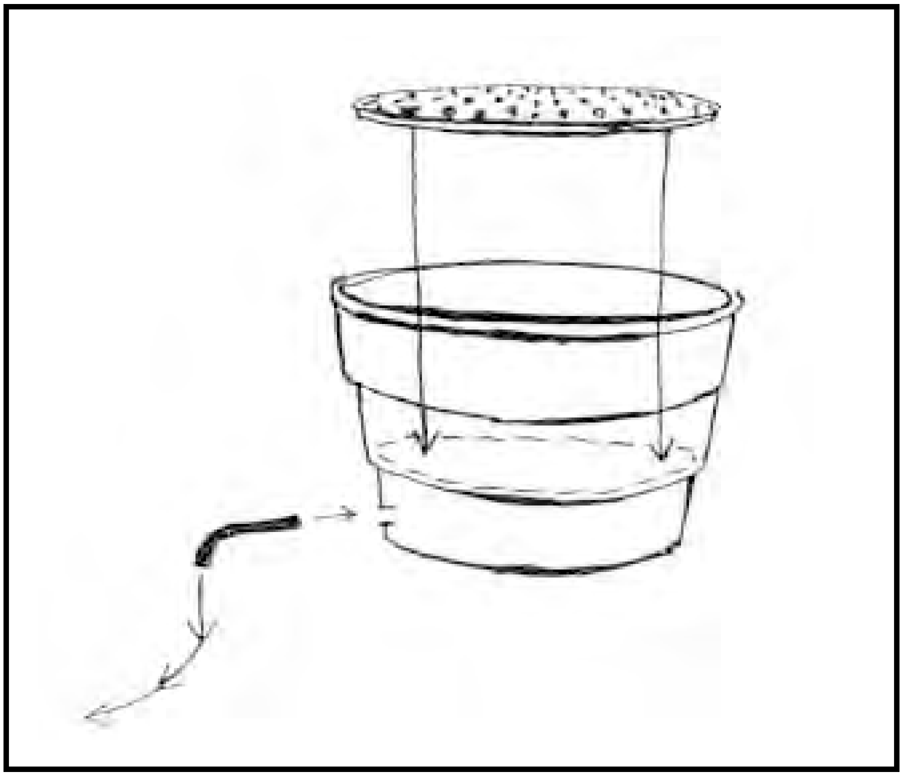


Figure 10.2—Diagram illustrating the placement of a perforated stainless-steel strainer plate in a 70-gallon sewage catcher. This is the first step to attaching a beyond-the-bin liquid management system. The hose leads liquid away for treatment. Diagram from the Appalachian Mountain Club Trails Department."

ratio of about two parts bark to one part waste, the desired C:N ratio of 30:1 is achieved. Excessive urine raises the nitrogen ratio so that more bark, with its higher carbon ratio, is needed to offset the urine's higher nitrogen level. Traditional batch-bin composters generally require three parts bark to one part waste to achieve the desired 30:1 C:N ratio.

Signs and on-site managers asking users not to urinate in the outhouse help achieve some reduction in the amount of urine. Even then, however, human biology and anatomy, combined with the preference of some users to urinate in private, inevitably add some urine to the catcher, especially in high-use areas.

10.3 BENEFITS AND DRAWBACKS

Additional benefits—The beyond-the-bin system has benefits beyond conserving bark. Handling raw sewage is inherently unpleasant and risky, and excessive liquid makes it much worse. Removing liquid lessens spillage, reducing risk to both the operator and the environment.

Another advantage is improved recycling of mulch. The BTB system creates drier compost, so less bark decomposes and more is recovered by sifting.

Separating liquid also reduces odors. Most offensive odors are due to ammonia and other products of anaerobic decomposition, especially when urine is mixed with feces. The BTB systems have a slightly musty odor that is not nearly as offensive as pit privies or the occasional catcher in traditional bin-composting systems. That encourages hikers and campers to use the outhouse rather than the forest floor as long as the toilet seat, hopper, and outhouse floor are kept clean.

Installing a BTB system is not complicated, and it requires only basic carpentry and plumbing skills. Fortunately, the slight slope needed to make liquids flow downhill is usually available with little or no modification to the landscape. Since the system is driven by gravity, only the plumbing parts require routine maintenance and repair.

Unless the compost in a traditional composter has the perfect water content, which is not often the case, the bottom of the bin accumulates a layer of wet, non-composted sewage with a distinctive odor that operators call “mank.” After the compost layer above is removed, bark is mixed with this layer to absorb the liquid and restart proper composting. Mank seems to accumulate because liquids settle through the pile, and it is virtually eliminated in the beyond-the-bin system.

Drawbacks—Moderately higher initial investment is the biggest drawback to the BTB system. It requires a collection tank, strainer plate, plumbing parts, and filtration system. However, the saving in labor and mulch transport soon offset these expenses.

If funds are limited, the system can be set up in stages. The strainer, plumbing, and filtration system can be installed later in a batch-bin composting system as long as clearance for the collection tank is provided in the initial construction, and a 70-gallon Rubbermaid catcher is installed.

One other drawback is that the compost may be harder to mix. When solids and liquids are combined, the liquid helps soften the solids, sometimes even dissolving them completely. In the BTB system, clumps of sewage tend to stay bonded, so breaking down solids is more laborious, and diligence and attention to detail are required to properly mix the material. However, the compost pile requires fewer turnings. Therefore, the total work of turning the pile is about the same for the two systems.

The BTB system has slightly higher visual impact because of the drain pipe and filter barrel, but careful design and attention to detail during construction can help. Pipes can be buried or routed through brush. The filter barrel can be almost completely buried, since only the cover need be accessible for monitoring and periodic replacement of the filter medium.

Special Considerations—A sturdy portable intermediate mixing container is a useful component in the beyond the bin system for proper mixing of sewage and bark. In traditional batch-bin composters, sewage is usually mixed in the compost bin. Since extra effort is needed to break up sewage balls and clumps in a BTB system, the mixing container must be strong to withstand vigorous shovel and pitchfork handling. Stainless steel and thick plastic containers work well, and there may also be other possibilities.

As with most compost systems (the moldering privy is an exception), dry bark is vital. Thorough drying before bagging and dry storage on site are crucial. Store your dry bark in synthetic feed bags lined with plastic bags under a tarp.

The filtration system should be disconnected after the final compost run of the season to prevent freezing and splitting the drain pipe in winter. A quick-disconnect fitting on the pipe simplifies this.

Filter materials may eventually need replacement. AMC has had its systems in place for five years, and testing the effluent from the first system shows it still met the standards required for backcountry dispersal. We recommend testing effluent every five-years.

10.4

DRYING THE END PRODUCT

Screens dry and sift the finished product. Raised four-foot-by-eight-foot screens made of half-inch-by-#18 expanded stainless steel or galvanized metal are mounted on a frame of pressure-treated “2-by-4” lumber. Compost is spread on the screens from the second compost bin and allowed to dry for several days. Next, the material is sifted using shovel, spading fork, or gloved hand, so the fine humus falls through the screen and intact bark stays on top.

For details on proper procedure, see “Spreading Finished Compost” in 9.6 above in the chapter on Batch-Bin Composting.

The humus is gathered in buckets or feed bags and carried away from the campsite for dispersal and broadcast on the forest floor. Bark remaining on the screen is allowed to dry further, and then bagged in plastic-lined feed bags to be re-used in subsequent compost runs. (Incidentally, do not put recycled bark in the outhouse; use only new, clean bark there.) The drying screens are covered with tarps nightly and during inclement weather. The tarp is supported by a raised ridgepole of 2-by-4 lumber.

Screens increase the re-usability of bark significantly, further reducing the need to transport more bark to remote sites.

10.5

INSTALLATION

Three or four people can install a BTB system in a couple of days. Following is a brief description of the installation. More detailed instructions are available from AMC. (See Appendix TK for contact information.)

Elevation Change—First, determine whether your site has adequate slope for a gravity-fed filter system; it must be at least ⅛ inch per foot, though a steeper angle is better. If necessary, the outhouse base and collector support rails can be raised to gain elevation.

Size of collector housing—AMC uses 70-gallon catchers in its privies to accommodate a high volume of visitors. Some of our sites in the White Mountains of New Hampshire average twenty visitors per night, with peak nights over sixty. The catcher is 24 inches tall, and weighs more than 550 pounds when full, so it requires a substantial housing. Our outhouse bases sit on a foundation of pressure-treated “6-by-6” lumber. The catcher sits on a pair of rails of pressure-treated “4-by-4” lumber for easy extraction through the access hatch. If the BTB system is to be installed in an existing composting system, outhouses can be retrofitted, or a collection unit with a lower height might be adapted or modified.

We have designed a base to fit a standard four-by-four-foot outhouse supported by timbers of 6-by-6 lumber stacked in five or six layers and secured with hundred-penny nails. All lumber can be cut in the frontcountry and then transported to the site. The timbers are best cut with a sharp chain saw by a skilled sawyer.

Plumbing parts are readily available, and some pre-assembly can be done in the shop to insure all pieces are accounted for and fit together. The filter barrel perforation holes are also best drilled before transporting to the backcountry, although they can be drilled on site with a cordless drill. Approximately 75-100 pounds of septic stone is required, along with five or six 50-pound bags of fine grade anthracite coal. These materials are widely available.

The majority of the installation time and effort will go into building the outhouse and its base.

Distance from Water—The filter should be at least 100 feet from any pond, lake, or stream, and more is better. If this is not possible, install a second barrel connected by a hose to the filter barrel (which must not be perforated) to collect liquids, which can be pumped or bailed for disposal in a better spot. Use sturdy capped jugs to carry the filtered effluent.

Regulations—Local and/or state authorities may call for specific designs for final distribution of liquid effluent that should not be required for a BTB system. It is important to remember the very small flow being treated. Most authorities are accustomed to flows in the hundreds of gallons per day generated by conventional flush systems, not the quarts per day from a waterless composting system. Be sure to clearly explain this fact and to describe the BTB system as a vast improvement over the pit privy being replaced.

10.6 CONCLUSION

The beyond-the-bin composting system is a substantial improvement over a conventional batch-bin composter, especially in high-use areas. The moderate initial financial investment will be quickly repaid through reduced bark transportation, higher quality end product, less odor and a safer and more pleasant experience for composting personnel.

Part 4
Installations

11

Case Studies

11.1

MOLDERING PRIVY ON THE A.T. AT LITTLE ROCK POND, VERMONT

By Dick Andrews, Volunteer, Green Mountain Club

The first experimental moldering privy was installed at Little Rock Pond Shelter on the Long Trail/Appalachian Trail in the Green Mountain National Forest in Vermont in September 1997, under the supervision of Dave Hardy, field supervisor for the Green Mountain Club (GMC), with help from me.

The moldering privy replaced a pit privy located on a steep slope—actually, an ancient talus slope with thin soil, where finding new places to dig pits was extremely difficult. The outhouse at the site was in poor condition, so we replaced it with a new one prefabricated by a GMC volunteer. A large group of volunteers on a freshman orientation outing from Harvard College helped carry materials about three quarters of a mile up a stiff grade on a side trail to the site, and helped build the privy.

After removing the old outhouse, we backfilled the pit to within a few inches of the top. We then built a crib over the original pit, using six timbers of white "8-by-8" cedar landscaping lumber, in three courses of two timbers per course, resulting in horizontal gaps of eight inches in the crib. The timbers were excellent for the purpose: light to carry and easy to work, but sturdy and decay-resistant. They were fastened with long spikes without pre-drilling holes.

The timbers varied in length from four feet long to somewhat more than six feet long. To maximize the volume in the crib and minimize waste of the timbers, we built the crib in the form of a stepped truncated pyramid, wider at the base than at the top. It was two feet high, providing somewhat more than two vertical feet for waste accumulation, counting the depression below the crib and the elevation of the floor of the outhouse above it. Total volume in the crib was about 40 cubic feet.

After sending volunteers far and wide for forest duff and stapling hardware cloth and insect screening over the gaps in the crib, we placed about eight inches of duff in the bottom of the crib, and banked duff against its sloping sides. We assembled the outhouse on top of the crib, lightly toenailing it in place to ease removal when the crib filled. The design of the outhouse was conventional, with a seat on a wooden bench at the rear of the structure. We did not install a vent, since the porous duff banked against the crib allowed ample ventilation while excluding light and insulating the compost pile somewhat against temperature variations. The last step was the installation of a few steps to reach the door of the elevated outhouse.

Little Rock Pond has a caretaker in summer, and the caretaker keeps the privy supplied with bulking agent. We started with bark mulch, but switched to softwood shavings (eastern white pine, available at agricultural supply stores), which were lighter to backpack to the site, easier to manipulate in the pile, and easier and more attractive for users to handle. A nine-cubic-foot bale, compressed to a package 12-by 18-by-28 inches, weighed 35 pounds and cost about $3. It was enough for more than 1,000 uses, at one cup per use. Users were asked to add a handful of shavings each time they use the privy.

See Appendix F for a copy of the stewardship sign with instructions for users.

The caretaker keeps an eye on the compost pile, stirring with a stick and watering with a garden watering can through the toilet opening as needed to keep the pile aerated and moist. Each season the GMC has introduced an eight-ounce container of redworms to enhance composting in the pile. The club propagates its own worms in plastic buckets at headquarters in Waterbury Center, Vermont.

Composting has worked well in the moldering privy, and as of the end of the 2000 hiking season, the crib had plenty of room for additional use. In the privy's first full season (the summer of 1998), A.T. thru-hikers repeatedly wrote in the shelter log book that the moldering privy was the nicest smelling outhouse between there and Georgia. Reviews have continued to be complimentary. The privy is not odorless, but the odor is usually earthy, as long as the pile is at least lightly covered with shavings.

When the crib does fill, a second crib will be built and the outhouse will be moved to it, an easy job for four people using a couple of 2-by-4s temporarily nailed to the walls of the outhouse as handles. The first crib will be covered with a layer of forest duff (protected from dogs or other animals by a hardware cloth cover) and left to weather and finish composting until the second crib is full. Then it can be emptied and the compost scattered on the forest floor at an appropriate distance from water, trails and the shelter site.

11.2 MOLDERING PRIVY ON THE A.T. IN MASSACHUSETTS

By Pete Rentz, M.D., Trails Chairman, Massachusetts A.T. Committee of the AMC-Berkshire Chapter

The ideal composting system would be safe for users, safe for maintainers and the environment, easy to use, durable, and lightweight for ease of transport. It also would be economical, and the composting process would use a readily available bulking agent. In Massachusetts, we have been experimenting for several years with a design for a moldering privy that attempts to achieve those goals.

We started with our basic four-foot-by-four-foot privy, which we know how to transport and build, and placed it on a cribwork of 6-by-6 timbers that form two composting chambers. We have found that even in a high-use situation, a nine-cubic-foot chamber will require more than a season to fill with feces, organic material, and toilet paper. When this occurs, the privy is simply shifted to the empty adjacent chamber. Thus, composting occurs for a minimum of one year, and in some cases two or three years. During that time the volume of compost typically halves, and the end product is not much different in appearance and smell from the original carbon-rich forest duff (partly decomposed leaf litter) that we use for a bulking agent.

We use duff for the carbonaceous composting material because it is free, it is available everywhere in the woods without need for transport, and it does not introduce foreign substances into the natural environment. Duff is also desirable because it is finely divided and fluffy, and because it contains a rich assortment of aerobic soil bacteria, molds, and fungi.

Since the composting crib is in contact with the soil, earthworms will be found in the compost. We have tried to introduce red wiggler manure worms (*Eisenia foetida*), but have not seen any indication that they speed the composting process. In fact, they disappear soon after they are introduced, and may only serve as a feast for shrews.

We have tried urine diversion, and have found that it is important for our high-use moldering privies to prevent saturation of the compost pile. The composting chamber of a low-use moldering privy fills only every two years; in this situation, the urine appears to evaporate or percolate through the compost pile to the soil satisfactorily.

Urine diversion is accomplished by creating a “two-holer,” with one seat for urination only. The urine basin is a six-quart stainless steel mixing bowl fitted with a sink drain that is plumbed to a length of ½-inch internal diameter thick-wall clear plastic tubing. The end of the tubing is perforated and is placed in a small leach pit containing landscape fabric, gravel, and anthracite coal. The urine diversion apparatus adds about $100 to the cost of our privy.

There is no odor associated with the leach pit. However, it is good to flush the basin and tube periodically with a quart of clean water. Beyond this ordinary cleanliness, disinfection of the plumbing with chlorine solutions has not proven necessary. The urine diversion feature mainly serves women; men are encouraged to urinate on trees at a decent distance from the shelter.

We have tried covering the composting chamber with a weather-resistant board, but it has proven to be unnecessary. The cover doesn’t seem to make much difference to the composting process. Rain and evaporation seem to balance each other in our uncovered chamber experiment. The cover is mostly for aesthetics, and a layer of dry leaves appears to be equally good for this purpose.

Mixing is performed yearly with a spading fork. This aerates the compost, and breaks up tree roots that might otherwise infiltrate the compost. The final product, about four cubic feet of humus, is carried a short distance in five-gallon plastic buckets to a disposal area where it is buried in a spot away from foot traffic and downhill of any water source.

Those procedures require about one hour of maintenance activity each year per privy, not counting the harvesting of duff, which is usually performed by the users in accordance with simple instructions. Compare tht to the three to four man-hours necessary to re-dig a pit privy and move it.

We ask users to deposit one handful of duff per use of the toilet. An instructional sign directs hikers to places to collect duff, and asks them to try to collect duff with deciduous leaves that have begun to decay and are rich in decomposing organisms.

It directs them not to dig deep enough to create holes that could cause erosion. It is good to keep a small rake for collecting duff, since that encourages harvesting the renewable upper layer rather than digging into the soil. The sign also instructs hikers not to harvest in a spot already harvested.

Flies and other vectors have not been a significant problem. The composting privy is sweeter-smelling than the pit privy it replaces, and appears to attract fewer insects.

11.3

THE APPALACHIAN MOUNTAIN CLUB CLIVUS MULTRUM COMPOSTING TOILET

By Chris Thayer, Huts Manager, Appalachian Mountain Club

The Appalachian Mountain Club (AMC) has increasingly relied on Clivus Multrum technology in recent years to provide sanitation at our high-elevation huts in the White Mountains of New Hampshire. The eight huts, spaced about a day's hike apart, are located near or above timberline, where there is little or no soil. The White Mountains have such a severe climate that they have pockets of permafrost and have recorded the world's highest surface wind velocity. The staffed and fully enclosed huts provide meals and bunkroom-style shelter.

Since 1997, we have installed Clivus Multrum continuous composting toilets at Carter Notch, Mizpah Spring, Galehead, and Lonesome Lake Huts with great success. The success of this innovative technology at backcountry locations serving 36 to 60 guests per night is promising for applications in the frontcountry as well.

Construction costs varied, depending on the size of the system and whether it could be installed in an existing structure. Costs ranged from $60,000 at Carter Notch, Galehead, and Lonesome Lake (for four toilets at each hut), to $85,000 at Mizpah

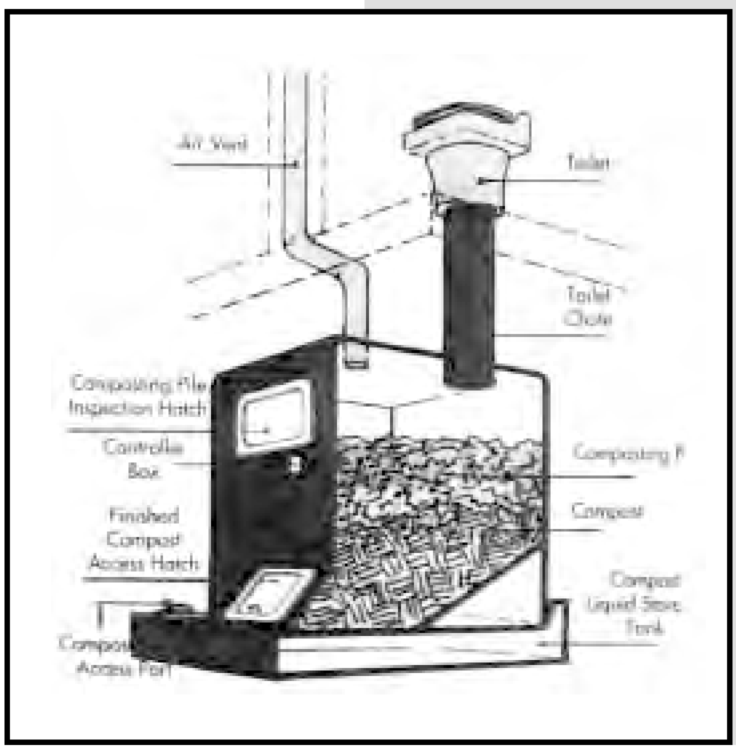


Figure 11.1—Example of large, commercially designed, continuous composting toilet. This example is a schematic cutaway view of a Clivus Multrum system, showing features common to most models. (Contact Clivus Multrum New England for specific model information. See Commercial Systems contacts in the Appendix.) As waste composts, it becomes light and crumbly, and slowly migrates via gravity down the sloped bottom to an access port, where finished material is removed. Provisions are made to remove and treat liquid effluent separately. This step is essential to the proper composting of material in a large continuous composting system, especially in backcountry settings. In backcountry and mountain environments, cold temperatures and high humidity usually prevent most liquid from evaporating." Diagram from Clivus New England and The Composting Toilet System Book by David Del Porto and Carol Steinfeld.

Spring (for six toilets). Though there is significant investment upfront, we have found these systems cheapest to operate at high-use sites in the long run.

The schematic *(Figure 11.x)* shows a cutaway view of the composting chamber. The waste mass is similar to a garden compost pile. Shoveling out a small amount of composted final product each year creates a void that causes the waste in the pile to slowly slide down the inclined back of the bin as it decomposes. The chambers are sized so that waste is completely composted in the two or more years it takes to appear in the lower hatch.

That end-product, reduced to only 5 percent of its original volume, has the odor, appearance, and bacterial content of topsoil. Liquid that appears in the sump reached by the lower hatch has changed biochemically to a stable fertilizer and salt solution safe enough to meet quality standards for swimming water!

The vent on the composter, assisted by a solar-powered electric fan, creates a draft that pulls air into the compost, up the air ducts, throughout the waste pile, and out the stack. Oxygen in the air reaches the middle of the pile and supports the slow decomposition process and the treatment of the liquids. Air is also drawn down the fixtures, especially when a toilet is opened. That oxygen supports the rapid breakdown that takes place at the surface of the pile. The downdraft also prevents odors from entering the toilet room.

The caretaker sprinkles planer chips (produced as a byproduct by mills that plane lumber) on top of the pile each day, and turns the pile periodically. That adds bulk, surface, and keeps the pile "fluffy" so aerobic organisms will grow. Once a month in the summer, our construction crew adds a commercially produced "bacterium" solution. That is intended to help the naturally growing soil bacteria, mold, and other organisms thrive. The organisms consume the waste and produce mostly carbon dioxide (CO_2) and water vapor, which is carried away by the draft.

From the user's point of view, the Clivus works just like an outhouse. However, the continuous flow of air can sometimes dry the surface of the pile, so there is a danger of fire from a match or cigarette dropped into the compost chamber. Also, people may be tempted to use the toilet to dispose of garbage instead of carrying it out. Signage and the diligence of staff help avoid those problems. We have also found the unit must be cleaned daily to ensure guest satisfaction as well as proper functioning of the system.

11.4

RANDOLPH MOUNTAIN CLUB BIO-SUN COMPOSTING TOILET

By Paul Lachapelle, Volunteer, Green Mountain Club; Doug Mayer, Vice President and Trails Chairman, Randolph Mountain Club; Anne Tommaso, former Field Supervisor, Randolph Mountain Club

About the Randolph Mountain Club—Founded in 1910, the Randolph Mountain Club (RMC) maintains a network of 100 miles of hiking trails and four shelters on the northern slopes of the Presidential Range on the White Mountain National Forest in New Hampshire, and on the Crescent Range in the town of Randolph, New Hampshire. The club has approximately 500 members, and is managed by an active volunteer board of directors. The RMC is funded by dues and donations from members, cost-challenge trails contracts with the U.S. Forest Service, and other state and local grants.

RMC's four shelters consist of two cabins near treeline on Mount Adams: Crag Camp, with a capacity of twenty, and Gray Knob, with a capacity of ten. There are also two Adirondack-style shelters, The Perch and The Log Cabin, each with a capacity of ten. Overnight fees, ranging between $5 and $8, are set to cover the basic operating expenses of the cabins. The RMC is dedicated to keeping fees as low as possible.

Two caretakers, based at Gray Knob and Crag Camp, manage the four shelters during the summer. During the rest of the year, one caretaker is in residence at Gray Knob. The club also has two trail crews, which perform basic maintenance and erosion control projects. In the summer, a Field Supervisor oversees the caretakers and trail crews, and acts as a liaison to the Board of Directors.

11.4.1 — **HISTORY OF RMC SANITATION EFFORTS**

RMC has used several techniques to dispose of human waste. Pit toilets were used at all camps until visitation began to rise in the 1980s. In 1977, the club had 2,272 visitors among its camps. By 1995, that number had more than doubled to 4,923.

A thermophilic batch composting system, based on methods tested and used at several Appalachian Mountain Club (AMC) and Green Mountain Club (GMC) sites, was adopted at Crag Camp in the early 1980s. It was satisfactory for a few years, but required well-trained labor and a large volume of wood chips. Visitors were asked to not urinate in the toilet, but instead to use the nearby woods. During the '80s, as Crag Camp became increasingly popular year-round, the system was eventually overwhelmed.

At Gray Knob, a dehydrating toilet had been installed in the mid 1980s, replacing a pit toilet. The toilet dehydrated solids while draining untreated blackwater onto the soil surface. Within a few years, however, the toilet was nearing its capacity, the system was not adequately dehydrating the solids, and the toilet was serving only as a collection and storage system. Thus, the RMC faced the prospect of routinely flying out untreated solids, which would prove expensive and intrusive. Therefore, the RMC decided a new toilet system was required at Gray Knob.

Evaluation of options—Beginning in 1994, RMC undertook a study of all available waste management options for its facilities. RMC's study was headed by Paul Lachapelle, then a caretaker for the club; options included flying out raw waste *via* helicopter, continuing direct burial, propane-fired systems, and thermophilic or mesophilic composters.

The club faced a major challenge: to effectively and affordably manage increasing volumes of human waste throughout the year, with minimal skilled supervision and intrusion in the wilderness in a notoriously harsh environment. RMC settled on a continuous-composting toilet to manage waste on-site because it would eliminate costly and intrusive helicopter flights and the transport of the large amounts of wood chips required for a batch-composting system.

Selection of a properly sized composter was critical, since the cold climate allows composting only between May and September. The remainder of the year, the composter would function essentially as a containment device.

Continuous-composting toilets (also termed *mesophilic* systems, because temperatures in the composting pile are lower than in *thermophilic* systems) operate on the principle that the waste in the tank, given enough air and time, will decompose into a soil-like material. Natural oxygen-using bacteria, or aerobes, consume some harmful organisms, or pathogens, in the waste. Pathogens are also eradicated over time when exposed to oxygen, or as a result of the competition between organisms, or the loss of nutrients and warmth. The volume of the pile is reduced as some of its mass is converted to carbon dioxide and water vapor by the aerobes. Like any composting technology, the aim is to optimize conditions for microbial activity.

The essential ingredients of a compost pile are organic material, microorganisms, moisture, oxygen and heat. The process of transforming raw waste into finished compost depends primarily on natural soil microorganisms such as bacteria, fungi, and actinomycetes. Soil invertebrates such as springtails, mites, millipedes, and beetles also contribute to waste decomposition. Adding wood chips increases the amount of carbon, absorbs moisture and odors, and provides air space and structure within the pile. This carbon source (also called bulking agent), preferably hardwood shavings, must be added periodically in order to support aerobic decomposition.

For more information on composting processes, see Section 3—The Decomposition and Composting Process.

In contrast to thermophilic batch composting, continuous composting is a long-term method that can take years to effectively reduce or eliminate pathogens, and it requires much less carbon. The compost pile must be regularly mixed to increase aeration.

RMC decided to install a continuous-composting toilet manufactured by Bio-Sun Systems of Millerton, Pennsylvania. Although there are numerous commercial composting toilet manufacturers, this model was chosen for several reasons: First, it has a large access door to facilitate maintenance of the pile. Second, more air contacts the waste surface, since the waste is suspended on a perforated liner, and air can circulate below the waste pile as well as above. Lastly, its one-piece tank is made with 5/16" rib-reinforced, high-density polyethylene, so it is extremely sturdy.

The volume of the tank is 1000 gallons, or 130 cubic feet. The toilet seat is directly above the sealed tank. A fan powered by a solar panel in an exhaust vent draws air through the system. During construction, RMC stained the box around the tank black, in order to increase heat absorption. A thermometer mounted in the tank monitors the ambient air temperature, and another thermometer in the waste pile records temperatures there.

Installation and modifications of the Bio-Sun toilets—The Crag Camp Bio-Sun toilet was installed in 1995. Two other Bio-Suns, at The Perch and Gray Knob, were added over the ensuing three years. The average cost of the units, including materials, construction, helicopter time, and installation, was $12,000. Funding came primarily from RMC member dues, donations, and overnight fees collected at the facilities. Generous grants from the Appalachian Trail Conference's Grant-to-Clubs Program, the Davis Conservation Foundation, and the Reavis Foundation enabled RMC to bridge a financial gap, and complete the projects.

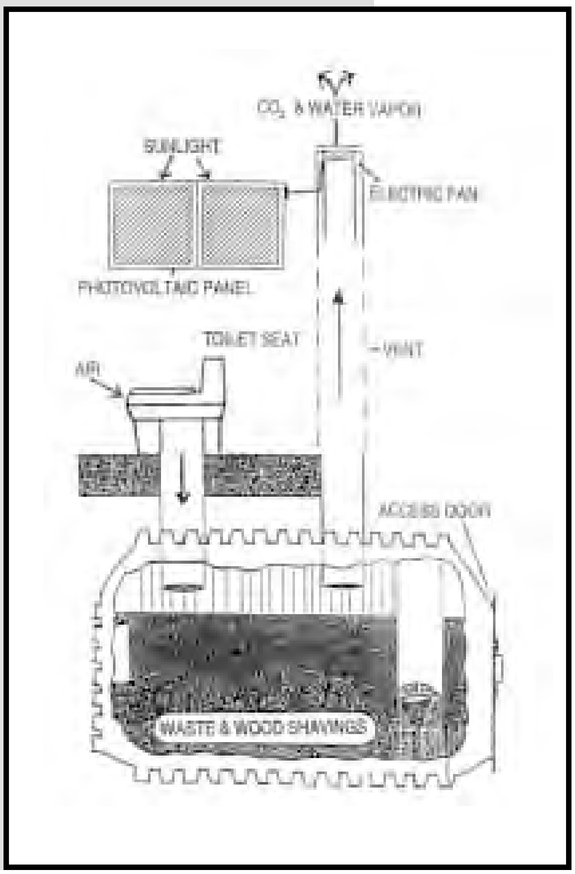


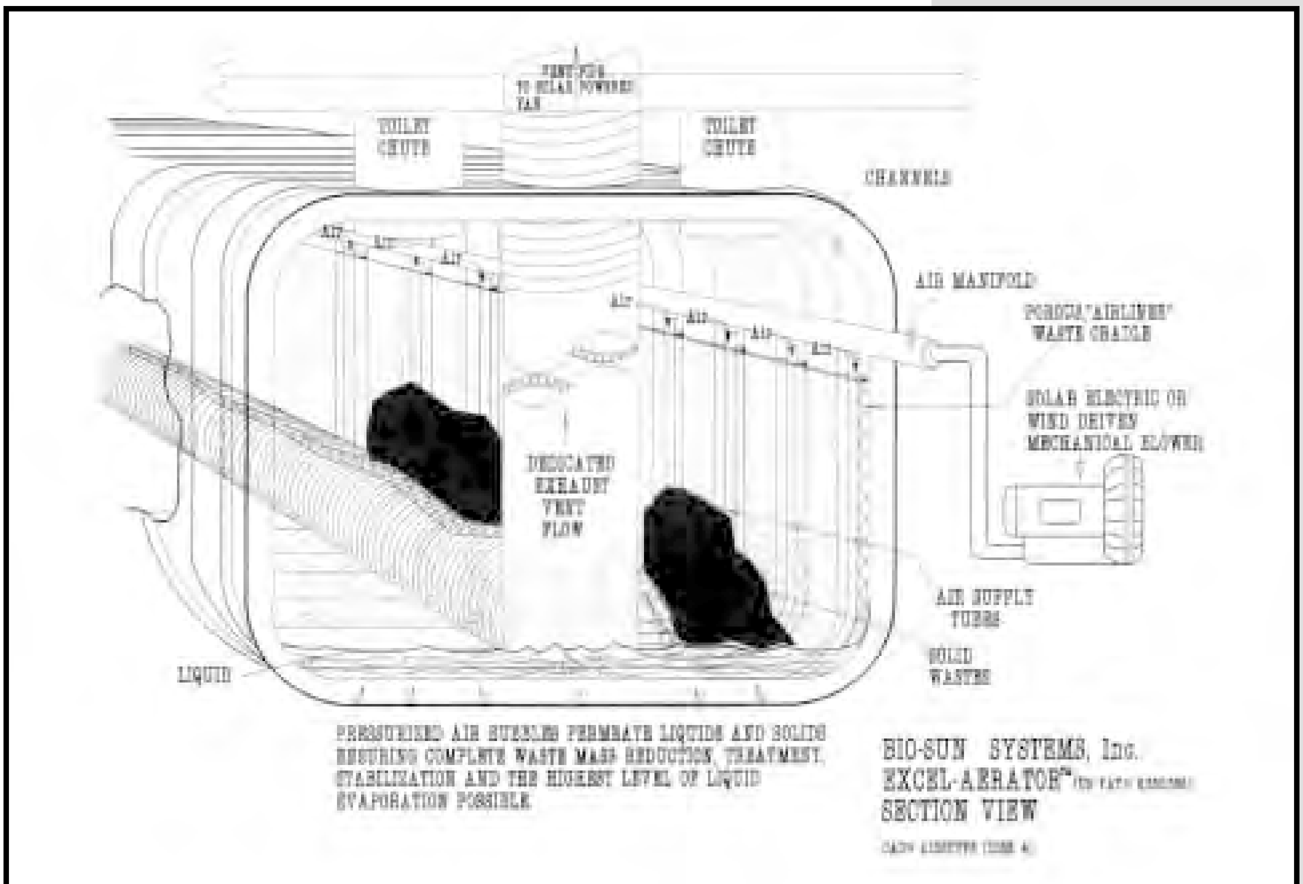
Figure 11.2—A cutaway view of a Bio-Sun WRS 1000, the model installed at the Randolph Mountain Club's Gray Knob Cabin in the northern Presidential Range of the White Mountains in New Hampshire. Note that the bottom of the tank does not slope. Aged compost must be raked towards the rear access door by the operator, and newer waste must be pushed forward. Schematic from Bio-Sun Systems, Inc. and the Randolph Mountain Club.

During the first year with the Crag Camp Bio-Sun, liquid levels slowly began to climb in the composter. RMC installed several high-tech solutions to reduce liquid accumulation, including a "Vapor Core" system, in which a solar-powered motor spun an impeller that created droplets that could be vaporized in the exhaust stack. The system worked when installed, but was almost immediately plagued with breakdowns in the harsh mountain environment.

Due to the consequent liquid accumulation, there was minimal aerobic composting, and anaerobic conditions led to increased odors. The following summer, RMC added a "beyond-the-bin" liquid treatment system, in which liquids flow out of the composter into a 55-gallon plastic drum, where they are filtered through alternating layers of activated charcoal and gravel. The liquid problem was resolved immediately, and the waste started composting. Beyond-the-bin systems were incorporated into the design of the Bio-Sun toilets when they were subsequently installed at the Perch in 1996 and at Gray Knob in 1997.

In 1999, RMC added a galvanized-screen drying rack to the process, further refining the system. The rack enabled caretakers to isolate the end product and finish it on the rack. In 2000, drying racks were added to the Bio-Suns at The Perch and Gray

Figure 11.3—This is another example of a large, commercially made, continuous composting system—the Bio-Sun. The model shown here requires more electrical power than the one in use in the northern Presidential Range of the White Mountains of New Hampshire by the Randolph Mountain Club, so it may not be practical in many backcountry situations. Note: This diagram shows two toilet chutes accessing the same compost chamber. For more information, contact Bio-Sun Systems, Inc. See Commercial Systems in the Contact List in the Appendix.



Knob. The design for the racks was taken from the AMC shelter facilities, and has been fairly effective. Older, composted material is removed from the bin and spread out on the rack for two to three weeks, depending on the weather. It is then buried in the woods, 200 feet or more from the cabin.

See contact list in Appendix D.

- NOTE: Many state regulations require burial of finished compost at a depth that varies from state to state, so check with your local ATC field office and state agency. Most rules say the material must be buried under six to 12 inches of soil in a dry, well drained area at least 500 feet from campsites, shelters, trails, and water supplies.

  Because the pathogen content of finished product is seldom checked in the field, it is always possible that some pathogens survive composting. Therefore, all precautions listed in Chapter TK should be taken when returning compost to the environment. When selecting a site for burial, always consider all potential contamination avenues, including water, trails, and animal transport to water or shelters.

Current operation of the Bio-Sun toilet—Two summer caretakers are responsible for all routine maintenance on the Bio-Suns. The toilets are checked daily to assure that the solar powered fans are operating and the debris-collecting screen leading to the beyond-the-bin system is not clogged.

A check sheet is kept in the toilet to keep track of usage. Every twenty-five uses, a handful of bark chips is added. Any garbage found in the tank is removed and double-bagged. The waste is then packed out of the backcountry, and disposed of in a sanitary landfill.

The pile is mixed once a week. We have yet to find the ideal tool for this task. Currently, a ten- to twelve-foot-long 2-by-4 seems to work best. Mixing entails knocking down the accumulated cone and thoroughly mixing and aerating the pile. Care must be taken to keep the older, advanced material to the front of the bin, and the new, fresh material to the rear.

Packets of bacteria claimed by their sellers to reduce odor and speed composting are also added once a week. RMC is uncertain how effective they are.

Conclusion—Use of the club's facilities continues to increase. Overnight visits have exceeded 5,000 in recent years, and day use has also grown, indicated most visibly by overflowing trailhead parking areas in the valley. Much of the increase has come during the colder months, when composting toilets can act only as storage bins, and by the end of the 1990s use was distributed almost uniformly through the year.

Winter is a challenge for composting toilets. Below 40 degrees F., there is essentially no biological decomposition. The system must be large enough to accommodate an entire winter's accumulation of waste with no reduction in volume until spring, because it is impractical to remove frozen waste. Winter maintenance consists of knocking down the frozen cone below the toilet chute and continuing to add bulking agent.

In 1999, overnight visits broke down as follows:

27 percent in Winter (December, January and February)
22 percent in Spring (March, April and May)
23 percent in Summer (June July and August)
28 percent in Fall (September, October and November).

As of 2000, the club had three operating Bio-Suns systems. The Log Cabin, due to its low use numbers, still had a traditional pit toilet.

Initially, results with the Bio-Sun toilets were mixed. RMC had hoped for a largely maintenance-free system, but that goal remains elusive, particularly with high usage in a harsh environment with high humidity, low temperatures and essentially no sunlight.

Following the addition of the beyond-the-bin system and drying racks, the composters have worked fairly effectively, as long as caretakers check the system regularly. The screen filter leading to the beyond-the-bin system tends to clog, requiring prompt cleaning to avoid liquid accumulation. Maintaining a proper chip-to-waste ratio has also been a challenge, because it is difficult for caretakers to accurately gauge the usage of the toilets.

Plans include the addition of a mechanical counter to track usage and enable us to add the correct amount of wood chips. The club also hopes to experiment with the addition of red wiggler worms to speed composting.

Finally, the RMC hopes to test the material for pathogens to determine whether it could be spread on the forest floor, reducing the environmental impact and labor of burying waste.

11.4.2 — **GRAY KNOB: A COLD, DARK PLACE**

Welcome to the Randolph Mountain Club's Gray Knob cabin—Nestled under a craggy outcrop of rocks, at treeline at 4,481 feet on the side of Mount Adams, RMC's Gray Knob cabin is the only enclosed structure in the Presidential Range open to the public year-round. The Gray Knob caretaker welcomes an assortment of overnight hikers, day hikers, climbers and even die-hard backcountry skiers, all headed

Figure 11.4 The Randolph Mountain Club's Gray Knob Cabin in the northern Presidential Range of the White Mountains in New Hampshire. Drawing by Eric Scharnberg, from the Randolph Mountain Club.

Figure 11. 4— Imagine trying to compost in a remote location with an average temperature of 36 degrees Fahrenheit, fog 270 days annually, a northern exposure with no direct sunlight for more than a month every year, and its highest usage in mid-

up Mount Adams. Just 1.3 miles off the Appalachian Trail, the cabin is also frequently used by thru-hikers seeking refuge from the wild weather of the Presidentials. In 1999, Gray Knob had nearly 2,000 overnight guests, and at least as many day-hikers—most of whom eventually find their way to the Bio-Sun toilet.

Using the knowledge the club gained from installing and operating Bio-Sun toilets at Crag Camp and The Perch, a Bio-Sun was added to Gray Knob in the fall of 1998. Funding came from Gray Knob overnight fees, RMC members, donations, and a generous grant from ATC.

The system uses a beyond-the-bin liquid filtration system. A solar panel powers an electric fan in the exhaust stack, removing odors from the toilet, and moving moisture-absorbing fresh air over the waste pile. Atop the exhaust stack, a passive, venturi-effect cap (which uses wind to create suction) adds to the draft created by the fan.

From late September through early May, the toilet is essentially a containment bin, with little or no composting. During these frigid winter months, the only maintenance is the dreaded "knocking down the cone." When May arrives, however, the caretaker literally has his or her hands full, with composting in full swing. A drying rack is used to isolate and finish the end product.

So—how's it going? As of 2000, pretty well. Come up on Lowes Path and see for yourself. And if the urge strikes, make your contribution to our composting work-in-progress.

For more information, please refer to the contact list in Appendix D for RMC and ATC addresses.

11.5 AT HOME WITH THE CLIVUS MULTRUM

By Richard Andrews, Volunteer, Green Mountain Club

The Clivus Multrum is a commercially manufactured, self-contained, continuous-composting toilet. It relies on mesophilic, or low-temperature, composting, which some people call moldering to indicate that it takes place with no significant temperature rise. Developed in Sweden, the design was licensed to Clivus Multrum USA for manufacture and sale in this country in the early 1970s.

I have had extensive experience with the Clivus Multrum, since I installed the fifth one manufactured in the United States (serial #005) in my home in 1974, and have used it continuously since. I also sold Clivus Multrums for several years, and have observed many installations, both successes and failures.

Although the Clivus Multrum has worked well for me, I consider it unsuitable for most backcountry situations. Of course, its shortcomings in the backcountry also apply to some degree to all composting toilets that resemble it.

At several thousand dollars a unit, the Clivus Multrum is too expensive for many backcountry situations. More important, it must be sheltered from the weather, and it requires warm temperatures to have reasonable capacity. The rate of activity of the decomposing organisms in a Clivus Multrum approximately doubles with each 20-degree Fahrenheit increase in temperature. Thus, the capacity of a Clivus Multrum doubles from 40 degrees Fahrenheit to 60 degrees, and doubles again from 60 to 80 degrees. The building required to shelter and warm a Clivus Multrum multiplies the cost of an installation. Insulation alone cannot provide warmth, because the decomposition process creates insignificant heat.

Although the designers of the system intended it to evaporate all liquid, in practice this happens only under ideal conditions, such as installations in the warm and dry climate in the American Southwest. In most other places, evaporation is less complete, so liquid accumulates in the bottom of the tank, and must be dealt with. Since a Clivus Multrum composting tank is an impervious container, the system requires a good draft in its ventilation stack to work properly, and this is often difficult to ensure in the backcountry. The composting tank is bulky and hard to transport. Finally, if users ignore instructions and introduce trash, it is difficult to reach and remove.

Design of the Clivus Multrum—The Clivus Multrum is a large (approximately four feet wide by ten feet long by seven feet tall in our case) fiberglass-reinforced resin tank with a bottom sloping at 30 degrees. Early versions of the tank were not insulated, but modern versions include a layer of foam plastic insulation to conserve warmth. However, material that can be biologically metabolized to produce heat is introduced into continuous composting toilets at a low rate, so the generation of heat occurs at a low rate. In addition, the minimal heat of decomposition is steadily removed by evaporation and ventilation. As a result, there would be no significant temperature rise even if the tank were perfectly insulated, and this insulation is of questionable value.

Air channels built into the tank ensure that no part of the compost pile is far from air. A vertical chute connects to a toilet seat on a floor above the highest portion of the tank. A bulking agent, such as wood shavings, is added through the toilet chute regularly to keep the pile aerobic. A vent with a fan removes odors, water vapor and other gases produced by composting, such as low concentrations of carbon dioxide (and methane and ammonia if parts of the pile become anaerobic). A second vertical chute may be included for food waste in homes where the kitchen is conveniently located.

The tank must be placed on a platform sloping at 30 degrees, an angle intended by designers to cause compost to tumble in slow motion toward a cleanout door above the lowest portion of the tank. Most users find that the compost does not move by itself, but the slope does make it easier to pull compost toward the cleanout door for removal.

Water that does not evaporate and dissolved solids collect in the bottom of the tank, and must be drained or pumped periodically. Since some evaporation does take place even under unfavorable conditions, the liquid is a concentrated solution of the salts contained in urine, plus whatever else is leached out of the compost pile. Research by Clivus Multrum indicates that the liquid is bacteriologically benign as long as it has percolated slowly through aerobic portions of the compost pile, and the company says that lack of odor in the liquid indicates it is stable and has been adequately treated. This is only possible if use of the toilet does not exceed its capacity. Since use levels may exceed capacity without continuous monitoring and control, it is generally considered wise to handle the liquid as if it were black water (untreated sewage).

Small portions of the compost pile in a Clivus Multrum may become anaerobic from time to time. This is not considered a problem as long as most of the pile is aerobic, because material will generally move out of the anaerobic region into aerobic conditions, where pathogens will be attacked and largely eliminated.

Clivus Multrum has arranged for analysis of compost produced by its composting toilets. The results indicate that elimination of pathogens is not perfect, but the concentration of pathogens in the finished product is comparable to that in typical soil. Blind bacteriological tests cannot distinguish the compost produced by a properly functioning Clivus Multrum from a soil sample.

Flies are sometimes a problem, especially in a new installation in which a balanced ecosystem has not established itself. Once a Clivus Multrum is working properly, soil invertebrates consume fly eggs before they can hatch, although the predators may occasionally fall behind if a lot of food waste contaminated by fly eggs is introduced at once. Flies may also be a problem if the surface of the compost gets too dry, which can be cured by occasional light spraying with water.

Our experience—My wife and I installed our Clivus Multrum in 1974, 26 years ago. It has been used by an average of two people. Our house has sometimes been vacant for a month or two, but we also have visitors, and occasionally as many as three other people have lived with us for several months at a time. Often the house is occupied all day, while most overnight backcountry sites are vacant much of the day—and 24-hour occupation produces more human waste than a simple overnight. Thus, our average usage has been equivalent to a campsite with a use level of 800 to 1,000 overnights annually.

The toilet and food waste chutes are on the first floor of the house. The composting tank is in an unheated basement. We had no electricity other than that provided by a small wind generator for fifteen years, and the temperature in the basement varied between 34 degrees F. in midwinter and 58 degrees F. in midsummer. Clivus Multrum said the composting tank should be in a space averaging at least 60 degrees F., a temperature our basement never even reached for that first fifteen years. An average annual temperature of 60 degrees or more will not be reached outdoors in the backcountry except in the warmest locations. However, since our tank was sized for continuous use by four people, the composting process worked fast enough to keep up with input. In mesophilic composting, time, warmth and volume can substitute for each other.

Clivus Multrum said a fan in the vent stack was essential, but with such a small supply of electricity, natural ventilation was our only possibility. I installed a stack reaching the peak of our story-and-a-half house, giving a vertical rise of about twenty-three feet from the top of the composting tank. This provided excellent draft in winter, when the basement air was warmer than the outdoors, but little or no draft in summer, when the basement was cooler than the outdoors. Yet in midsummer the basement was as warm as it would get, so the composting process would be at its annual peak, requiring the maximum supply of air. Something had to be done.

I installed a rotating turbine ventilator designed to enhance draft from wind, which worked well in summer. But water vapor from the tank formed unbalanced accumulations of ice on the turbine in the winter, causing a terrible racket when the wind came up. Our house is on an exposed location at an elevation of 2,000 feet, and the climate was colder twenty-five years ago than it is now, so ice accumulated for long periods: we experienced intervals as long as three weeks of subzero weather, with almost constant wind, and periods of windy subfreezing weather much longer than that. A stationary draft-enhancing chimney cap was quieter, but ice still formed in the downwind portions of the cap, eventually plugging the exhaust route. When this happened, the wind drove through the open upwind passages of the vent cap and down the vent stack, reversing the draft, chilling the composting tank and forcing odors into the house. The only cure was to plug the vent stack until a thaw arrived. This caused no problem, because the composting process was largely dormant in such chilly conditions, so it required next to no air.

After fifteen years, we connected to the electric grid. This made it possible for us to have running water and a water heater. As a result of the water heater and a warmer climate, the basement is now 10 degrees F. warmer throughout the year than it was. I vented the propane-fired water heater into the Clivus Multrum vent stack, which warms the stack and provides draft for reliable ventilation in summer, and also prevents ice accumulations in the vent cap in winter.

In the first couple of years we had the Clivus Multrum, flies were occasionally a problem. A few times they got so bad that I reluctantly hung pesticide strips above the compost pile in the tank. As biological activity in the compost pile increased and became more diverse, flies became less of a problem. The surface of the compost pile is now a seething busyness of sowbugs, rotifers and other composter's helpers. Flies are also controlled by using ample bulking agent and keeping the surface of the compost pile moist, which I do by spraying it with a little water once a week. The tank produced some moths when we went on a two-month vacation in the very dry summer of 1999, but they were gone within a week of thoroughly wetting the pile upon our return.

Liquid has always accumulated in the lower end of the composting tank. In the early years, I bailed it, carried it outdoors in buckets, and poured it on the lawn. For a while I installed a hand-powered bilge pump sold by Clivus Multrum to transfer the liquid into buckets, but it plugged easily, and soon broke. When we got electricity, I bought an electric sump-and-bilge pump that can handle salt water, installed it in the tank, and piped the liquid into our septic tank, which disposes of gray water from our sinks, shower and washing machine. I operate the pump once a week, and it has worked well since its installation. We no longer garden, because our next-door neighbor has poor fences and livestock that devour a garden in fewer than five minutes, but acquaintances who do garden sometimes ask for jugs of "Clivus tea," which they say is a super fertilizer.

We have tried various bulking agents: partially rotted leaves from the forest floor, sawdust, and pine shavings. Leaves tend to form mats, and sawdust also tends to compact. The same is reported of grass clippings, hay and straw. Pine shavings have been the best of the things we have tried, remaining comparatively loose and aerated even when wet. We add about one quart per day of pine shavings, so a nine-cubic-foot bale, costing $3, lasts nine months. The shavings also are fragrant and not objectionable even if some spill on the bathroom floor. Some owners of Clivus Multrums use peat moss as a bulking agent, but I have had no experience with it. Some composters find hardwood shavings better than softwood, but pine shavings have worked for us, and they are available locally at agricultural supply stores, which sell them as bedding for livestock.

In the early years, I removed compost through the clean-out door once a year or once every other year. The material is, as Clivus Multrum advertises, brown, crumbly and odorless. Peach pits and fragments of bone survive composting, but eggshells, corncobs, peanut shells and toilet paper vanish. I have disposed of the compost by dumping it in our fifteen acres of woods. I did not keep good records of the amount of compost produced, but I typically removed six five-gallon buckets in a cleaning.

In 1992, I bought a pound of red wiggler worms (also called redworms or manure worms) and put them in the Clivus Multrum. In addition to consuming organic material themselves, the worms aerate and mix the pile, and carry fungus spores and other micro-organisms around the pile. They have made a remarkable difference. In fact, I have not removed any material from the compost tank in the eight years since I introduced the worms. I keep telling myself I ought to get around to it, but the pile has not reached a crisis point.

Despite the slope of the bottom of the tank, material does not move from the top of the tank to the lower end by itself. It builds up beneath the toilet chute, and about once a month I use a long stick to shove fresh material down into the lower portion of the tank. This would probably be a less frequent chore if I removed some of the compost from the lower end of the tank, thereby increasing the slope of the top surface of the pile. But shoving material with a stick is less work than removing compost, so human inertia wins, and the status quo endures.

11.6 AIRLIFT HAUL-OUT SYSTEM

By Chris Thayer, Huts Manager, Appalachian Mountain Club

The Appalachian Mountain Club (AMC) still uses an airlift haul-out barrel method of waste management at Zealand Falls and Greenleaf Huts in the White Mountains in New Hampshire. AMC's eight huts, spaced about a day's hike apart, are located near or above timberline, where there is little or no soil. The White Mountains have such a severe climate that they have pockets of permafrost and have recorded the world's highest surface wind velocity. The staffed and fully enclosed huts provide meals and bunkroom-style shelter for 36 to 90 people.

Haul-out systems evolved from predecessors such as cesspools and pit toilets, and came about through recognition that use levels at our high-elevation huts were too high for the old methods. We hope to phase out these systems soon, because, although they are simple and the cheapest to install in the short term, with initial cost of about $10,000 to $20,000 per hut, maintenance expenses rise as the numbers of users increase.

In our haul-out systems, waste is airlifted to a local sewage plant, where it is treated for a fee. The caretaker, the primary maintainer of the system, keeps a close eye on levels in the barrels, winches them out of the iron holding vaults when full, caps them, and removes them from the hut to a holding field until airlift, replacing them in the holding vaults with empty barrels.

Maintenance includes buying and retrofitting suitable barrels and buying equipment for safe removal of barrels. A good relationship with a local treatment facility is essential. It is important to keep seasonal vegetation trimmed in the area to facilitate the loading and storage of waste barrels and for safe airlift operations. The ground must be kept level to prevent barrels falling over, especially in winter. In winter the caretakers must keep the loading and storage area shoveled so that when the snow melts and thaws, it doesn't cause the barrels to fall over. Caretakers must monitor each barrel for leaks or other signs of weakness, so they can be replaced when necessary.

11.7 FLUSH TOILETS WITH LEACH FIELD AT HIGH MOUNTAIN HUTS

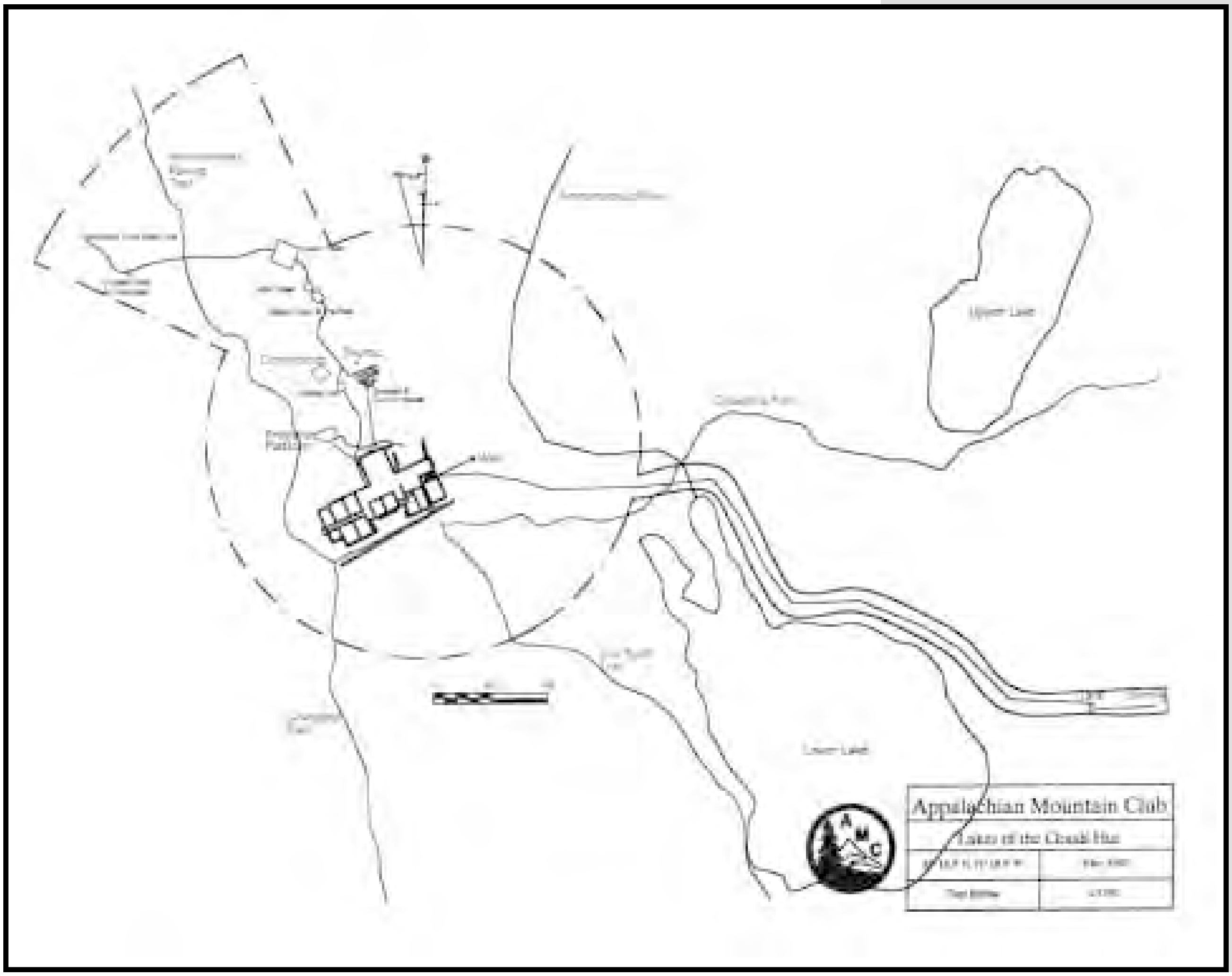
By Chris Thayer, Huts Manager, Appalachian Mountain Club

Two of the highest huts maintained by the Appalachian Mountain Club (AMC), Lakes of the Clouds Hut (5,012 feet) and Madison Spring Hut (4,825 feet), use flush toilets with leach fields. The AMC's eight huts, spaced about a day's hike apart, are located near or above timberline, where there is little or no soil. The White Mountains have such a severe climate that they have pockets of permafrost and have recorded the world's highest surface wind velocity. The staffed and fully enclosed huts provide meals and bunkroom-style shelter for thirty-six to ninety people.

The cost of implementing these systems over a period of years has been estimated at $80,000 for each hut. Lakes of the Clouds Hut has eight toilets, and Madison Spring Hut has four. Each system has low-flow toilets that empty into a feces-separator strainer, which separates and retains solids from the waste water, and allows liquids to continue through the system. The strainer keeps the majority of the solids from entering the septic tank, so the tank doesn't have to be serviced as often, and it allows solids to dry completely, making them lighter and much less costly to airlift out.

After the strainer, wastewater goes to a septic tank, where more solids are separated. Some float on the surface and are held back by baffles in the tank, and other solids sink to the bottom. Active and significant bacterial decomposition also takes place. The tank has an automatic doser to insure that all portions of the leach field are used. When the appropriate water level is reached in the tank, the doser dumps the contents of the tank onto the leach field.

Figure 11.5—Map of the Appalachian Mountain Club's Lakes of the Clouds Hut on the A.T. in the White Mountains of New Hampshire. From the Appalachian Mountain Club.



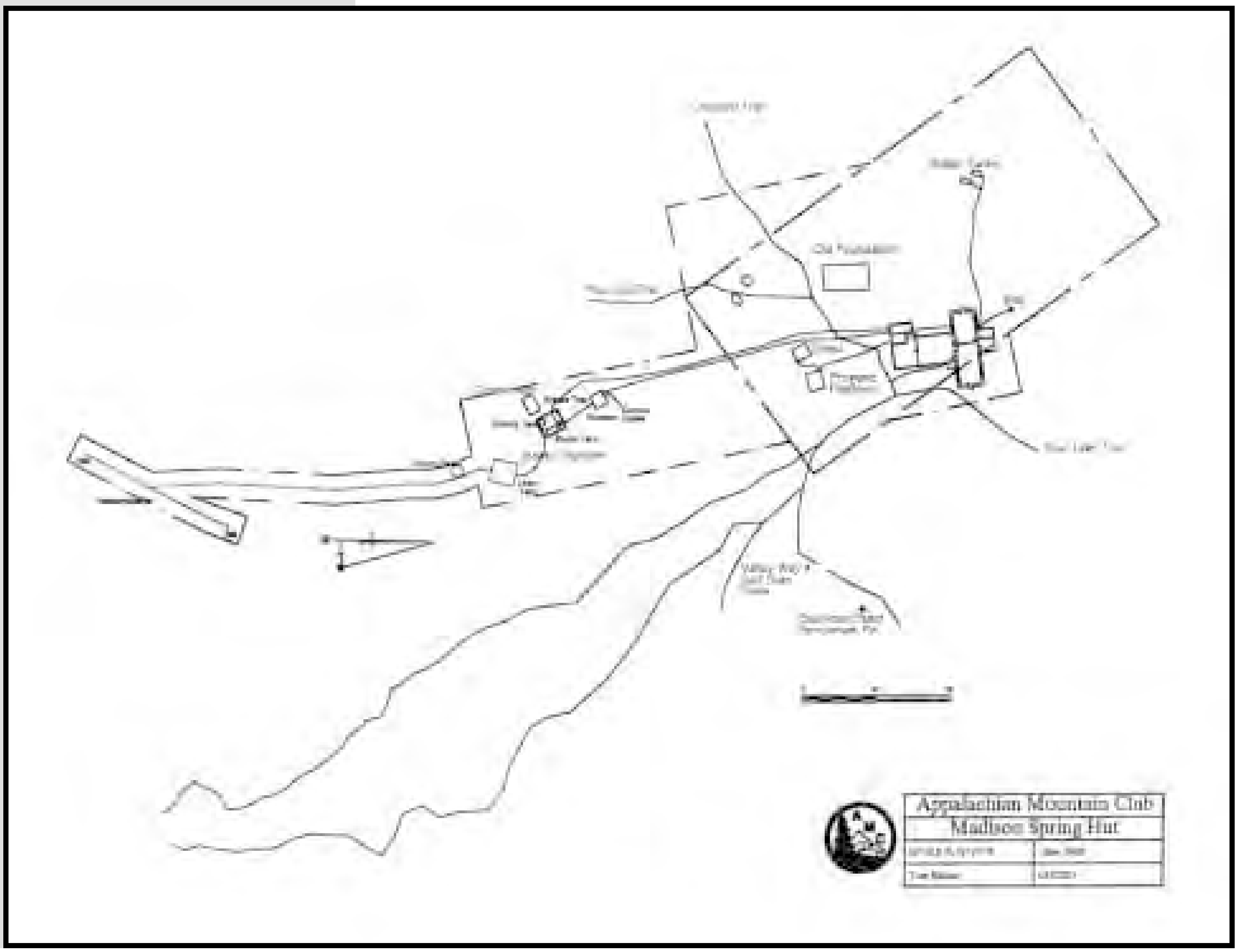
Our first leach fields were filled with sand, but new ones use black anthracite coal flakes instead. The grains of coal are more uniform in size and offer more surface area per grain, and coal is much lighter to airlift in to the location. The wastewater is sprayed on the top of the field, and as the water settles through the filtering medium, the remaining solids are removed. Pick-up pipes in the bottom of the leach field gather the filtered, treated water and carry it on down the system. Bacterial decomposition is active and important here also.

The final disposal system, which discharges the treated water, varies system by system. Some use plain perforated pipe; others use a chlorinator, doser (manual or automatic), and perforated pipe to disperse the liquid into the soil.

Cleanliness of the toilet area and the rest of the system, and diligence in maintenance, are essential. Every day, the caretaker cleans the system and walks the entire line to ensure function and integrity. Annual maintenance by our construction crew includes periodic changing of the septic field leaching materials (we typically change an inch or two of filter material each year) and close monitoring of every component, including the amount of water used and the quality of the discharge.

Solids also must be shoveled from the septic tank at the start of each season and once midway through the season, for removal and disposal at a sewage treatment plant.

Figure 11.6—Map of the Appalachian Mountain Club's Madison Spring Hut on the A.T. in the White Mountains of New Hampshire. From the Appalachian Mountain Club.



11.8

PROTOTYPE WOOD-FIRED COMPOST INCINERATOR, APRIL 2001

By Richard Andrews, Volunteer, Green Mountain Club

Some jurisdictions do not allow composted human waste to be applied to land. In those places, the product of composting systems must be removed from a site. Unfortunately, that requirement offsets much of the potential advantage of treating human waste by composting at backcountry sites. To make composting useful while meeting such requirements, incineration of compost is an obvious possibility. No pathogen could survive combustion at high temperatures. Many biological nutrients would be destroyed as well, and if the remaining ones were a concern, a small amount of dry ash is much easier to transport away from a backcountry site than a large amount of damp compost.

Incineration of human waste has been done at some backcountry sites, particularly at heavily used sites in the West. However, manufactured incinerators are expensive and intrusive, and require large amounts of liquefied petroleum fuel (propane or butane), which is a continuing expense, a questionable use of a nonrenewable resource, and a transportation and aesthetic headache. Reports indicate the incinerators can be smelly as well, although this objection would probably disappear if an incinerator were used for compost rather than fresh sewage.

In contrast, a practical wood-fired incinerator is an appealing prospect for forested backcountry sites in the East, where modest or even ample amounts of downed wood are often available nearby—especially if the incinerator can use damp or green wood.

In the fall of 2000, I built an inexpensive, lightweight prototype compost incinerator that successfully burned compost from my household Clivus Multrum composting toilet, using green wood as the supplementary fuel. Except for a short time immediately after ignition, the smoke was either invisible or largely steam, indicating reasonably clean combustion. The product was a fine, white ash. Even bones could be crumbled to white powder between one's fingers after going through the incinerator (the Clivus Multrum composts kitchen garbage as well as human waste). The cost of materials for the prototype was about $30.

However, the prototype was not problem-free. The chief difficulty was that compost and wood sometimes jammed in the vertical, gravity-feed fuel magazine. A tapered fuel magazine, wider at the bottom than at the top, would probably solve this problem—but only further testing can confirm this guess. It might also be solved by using wood chunks of a different shape as supplementary fuel.

The incinerator also must be scaled up to a larger size than the prototype, which was too small to be practical in the field. However, that is unlikely to be a problem, since the chief goal is high-temperature combustion, which is easier to achieve in a large fire than a small one.

The incinerator consisted of three concentric lengths of stovepipe. The combustion chamber was two two-foot sections of eight-inch diameter pipe (four feet long overall), standing vertically and stayed with three guy wires to prevent tipping over. Air inlets with a total area of about ten square inches were cut in the sides at the bottom, and a woven wire grate was installed six inches above the bottom.

One section of ten-inch diameter pipe (two feet long) stood outside the combustion chamber, so incoming air had to travel down through the one-inch space between the two pipes before entering the air inlets in the combustion chamber. That preheated the combustion air and reduced heat losses from the combustion chamber, creating a very hot fire on the grate.

A four-foot length of six-inch stovepipe was suspended centered in the combustion chamber, with the bottom six inches above the grate. That was the fuel magazine.

To use the incinerator, I dropped wads of crumpled paper down the fuel magazine until it was about half full, and then dropped in a flaming wad of paper, followed by dry kindling and then a few sticks of dry wood, cut to a length of about three inches. Once that was burning well, I followed it by dropping in sticks of green wood, also about three inches long. Once a good fire was established, I scooped in a fuel mixture consisting of equal weights of green wood chunks and damp compost. That mixture fed by gravity into the fire as fuel burned away on the grate at the bottom. Ash fell through the grate onto the ground below. After I stopped adding fuel, the fire burned until the fuel was consumed—as long as the wood-and-compost mixture did not hang up, or jam, in the fuel magazine.

Smoke from the fire traveled up through the one-inch annular space between the fuel magazine and the combustion chamber. Thus, the fuel magazine was surrounded by hot stack gases, which partially dried and preheated the compost-fuel mix before it reached the fire. I covered the top of the fuel magazine with a small piece of sheet steel to prevent smoke from smoldering portions of the fuel load from escaping without going through the hottest part of the fire.

After the snow melts, I intend to build and test a larger prototype. For information on the progress of those experiments, contact the Green Mountain Club.

12

The Decision-Making Process

Pete Ketcham, Field Supervisor, Green Mountain Club

J.T. Horn, New England Regional Representative, Appalachian Trail Conference

Chris Thayer, Huts Manager, Appalachian Mountain Club

Paul Neubauer, former Field Supervisor, Green Mountain Club

This chapter has three portions.

- Section 12.1 is a general discussion of the process of determining the best option for disposal of human waste at a backcountry site.
- Section 12.2 is a case study showing how a particular consideration—the feasibility of depending on volunteers for operating a demanding sanitation system—affects the choice of a system.
- Finally, Section 12.3 is a matrix listing the characteristics of various backcountry sanitation systems. The matrix is intended as a systematic guide to deciding which system is best for your site.

12.1 DETERMINING THE BEST OPTION

The decision to provide sanitation facilities at a backcountry campsite is a major one for Trail maintainers, clubs and land-managing agencies. Providing sanitation facilities requires a substantial expenditure of time and resources, both financial and human, for maintenance during the life of the system as well as for its planning and installation.

The challenge is to choose which system best balances the needs and limitations of the site, the needs and limitations of the maintaining organization, and any related impacts.

Sites for advanced sanitation systems—Any site where wastes accumulate faster than they break down in catholes or pit privies is a candidate for an enhanced backcountry sanitation system. The site must be able to absorb wastes left by hikers and campers, or wastes must be removed from the site, to ensure that the natural resource is not damaged and public health and safety are not compromised.

An enhanced sanitation system is recommended for sites that receive more than about ten overnight visitors per week, or the equivalent, and that have any of the following conditions:

1. Soils that are shallow (less than four feet to bedrock, hardpan or seasonal high water table).

2. Soil that is poorly drained—that is, it is fine textured (such as silt or clay) or a bog soil.

3. A location that is closer than 200 feet to ponds or streams.

An enhanced backcountry sanitation system may also be advisable for sites where soils are adequate for pit privies, but use is high enough that pits are filled and the toilet is moved frequently, and where the number of pits threatens groundwater—or where it is becoming difficult to find unused sites for pits.

Advanced backcountry sanitation systems are unnecessary if use is very low (less than 100 persons per season). A simple enhanced system, such as a moldering toilet, could succeed with attention only once or twice a year. However, it is inadvisable to attempt a more complex sanitation system without enough volunteers or field personnel to operate the system. Some enhanced systems require maintenance at least two times a month, unless usage is very low. Weekly or even daily attention may be required with some systems at high- to very high-use day and overnight sites.

Site Examination—A site must first be evaluated to consider access to the site, placement of facilities, suitability for handling of sewage and compost and for storage of bulking agent, tools, and other items, and for its capacity to absorb finished compost with acceptable impact.

Examine and map the surface water flow on the site, and try to identify subsurface flows. Identify areas suitable for spreading composted sewage.

Topography may limit where you can put certain kinds of toilets, and that may influence or determine which type of system is appropriate. Toilets should be as far from the water source as possible, which dictates siting them in the opposite direction from water. System components should be near but behind the outhouse, so hikers will not have to walk past composting operations to use the privy.

If the site is wet, the outhouse and any components should be placed on platforms. A consistently wet site precludes some systems, particularly a moldering privy. The area should be ditched to direct surface and shallow subsurface flows around and away from installations such as an outhouse, bin, and storage platform. The trail to the outhouse should be hardened, and large flat rocks or other firm surfaces should be provided for mainteners to stand on while working on the system.

12.2

CASE STUDY: THE ROLE OF VOLUNTEERS AND FIELD STAFF IN MAINTENANCE OF A REMOTE BATCH-BIN COMPOSTING SYSTEM ON VERMONT'S LONG TRAIL

By Paul Neubauer, former Field Supervisor, Green Mountain Club

On the Appalachian Trail in southern Vermont, the Brattleboro Section of the Green Mountain Club (a section is a semiautonomous chapter of the club) maintains a batch-bin composting system at Spruce Peak Shelter. The section has managed to maintain the system, but it has been a challenge. Another club considering installing a demanding sanitation system should consider carefully whether its members are up to the job.

The arrangement at Spruce Peak Shelter could be replicated elsewhere on the A.T., especially where ridgerunners employed by the Appalachian Trail Conference (ATC) or the land-management agency patrol nearby. The Mountain Club of Maryland and the Blue Mountain Eagle Climbing Club in Pennsylvania have established such relationships to maintain batch-bin and Clivus Minimus composting systems.

Spruce Peak shelter has become increasingly popular with both thru-hikers and day- hikers, so the sewage volume has surged. To cope with this, GMC's field staff helped the section install a 70-gallon catcher in the outhouse to avoid overflows when the volunteer operator can't get to the site frequently. The section cooperates with GMC's seasonal field staff, which is stationed nearby, to ensure that the batch-bin system is checked and serviced properly.

This experience has shown that getting a system up and running is daunting for a volunteer group, partly because most of the members generally do not have prior experience with such installations. After installation, it is a major group effort to maintain the structures and transport the bulking agent (bark, shavings, and/or other materials).

However, if no major repair work is required and there is storage for a large stockpile of bulking agents to accommodate the irregular availability of volunteers, a batch-bin composting system can be maintained by a dedicated individual volunteer or group, provided use of the site does not exceed 100-150 overnights per season. There also must be a large catcher in the privy and reasonable access to the site.

The big challenge comes when a batch of compost is being run through the process, and the pile should be turned every three to five days. If a maintainer cannot visit the site regularly during a run, he or she must allow more composting time to assure effective treatment of the sewage. This may require ample storage capacity to accumulate sewage awaiting the next run.

Turning at longer intervals increases the chance that some sewage will not be subjected to a sufficient period of high temperatures. However, if a system at a low- to medium-use campsite is well-managed, lengthening the compost run period and increasing the time the compost is retained on drying racks can compensate for this.

Of course, volunteer operation of a batch-bin composting system is impossible if a club chooses to prohibit volunteers from handling sewage.

12.3

BACKCOUNTRY SANITATION SYSTEM DECISION MATRIX

Definition of terms—The matrix on pages TK-TK is a guide to the process of deciding which sanitation system is suitable for a backcountry site. Each system is discussed according to the following terms:

Principle at work—The biological process operating in the system. See Section 3 of this manual, "The Decomposition Process." On the A.T. there are two types of anaerobic systems, four types of low-temperature aerobic systems (moldering, or slow composting), and types two-high temperature aerobic systems (thermophilic, or rapid composting).

Site preferences—Topographical and other site factors affecting the choice of system: size, slope, ground type (e.g. ledge or boulders) and moisture content, tree cover, orientation requirements (e.g. facing south), road access. See Section 3 of this manual, "The Decomposition Process," along with Sections 7-11 and the listings of clubs and manufacturers in the Appendix.

Environmental limitations—Limiting weather conditions, soil qualities, or energy requirements such as wind or sun. See Sections 7-11 of this manual, and the listings of clubs and manufacturers in the Appendix (except for Pit Privy, Vault Toilet, and Penn. Composter).

Level of use tolerated—System capacity, the factors that affect it, and how system effectiveness may change with increasing use. See Sections 7-11 of this manual, and the listings of clubs and manufacturers in the Appendix.

Breakdown process—The effect of the principle at work on the system's operation. For example, whether the system requires a short or long retention time of composting material. See Section 3 of this manual, "The Decomposition Process."

Regulatory issues—Permits and environmental assessments (e.g., National Environmental Protection Act (NEPA)) required by local, state, and federal authorities; approvals required from local clubs, land managers and ATC. See Section 5 of this manual, "The Regulatory Process."

Sanitation issues—Risks of contamination to the operator, the hiking public, and the area's natural resources. Tolerance for error in operation. Requirements for handling raw material and removing finished material. See Section 4 of this manual, "Health and Safety."

Aesthetic issues—Impacts of the system on the experience of site visitors. See Section 6 of this manual, "Aesthetic Issues."

Installation issues—Complexity of installation and skills required. Transportation requirements (such as helicopter, truck, pack stock, backpacking). Structures required for housing components. Auxiliary components, such as a liquid management system or drying rack. See Sections 7-11 of this manual, and the listing of clubs and manufacturers in the Appendix.

Cost of installation—The basic cost of the components of each system. Additional costs of permits, labor, transportation and construction also must be considered. See Sections 7-11 of this manual, and the listing of clubs and manufacturers in the Appendix.

Labor for installation—Requirements for paid and volunteer labor for installation of the system. See Sections 7-11 of this manual, and the listing of clubs and manufacturers in the Appendix.

Operation issues—Frequency and type of attention required. See Sections 7-11 of this manual, and the listing of clubs and manufacturers in the Appendix.

Cost of operation—The daily, weekly, monthly, and yearly costs. These might include additives, biological accelerants (e.g., enzymes or red worms), and bulking agents (e.g., bark mulch, shavings or duff); energy (e.g., solar systems or batteries); and replacement parts (e.g., fans, mixing blades, pumps, etc.). See Sections 7-11 of this manual, and the listing of clubs and manufacturers in the Appendix.

Labor for operation—Requirements for paid and volunteer labor for operation; need for a service provider from the manufacturer of the system. See Sections 7-11 of this manual, and the listing of clubs and manufacturers in the Appendix.

Decision Matrix

Pit Toilet—Standard pit privy, not detailed elsewhere in this manual.

Principle at work—Dig as deep a hole in the ground as possible. However, the bottom of the pit should be 18-20" above the seasonal high for the water table. Some states may have regulations regarding pit construction, check with your ATC regional office. Then mount a simple structure on top. Waste collects in the pit. When the pit fills, the privy is moved and the hole is covered. Pathogens take years to be destroyed, the principle in effect is the amount of time pathogens are exposed to unfavorable conditions

Site preferences—A dry site in which to dig the pit, with deep soils and a low water table.

Environmental limitations—Environmental factors that challenge use: Little or no soil, a ledge, a high water table, soils that don't drain well, and steep slopes; extreme cold (where the average mean temperature never gets above 40 degrees Fahrenheit; clay soils that do not drain at all.

Level of use tolerated—Varies with size of pit and levels of use. Climate influences the rate at which wastes decompose. The higher you go, the colder and wetter the climate, and the slower the decomposition. Every 1,000 feet in elevation gained means it will be 3 to 5 degrees Fahrenheit cooler. Climate will vary with the elevation of your site, latitude, and other factors.

Breakdown process—Anaerobic and malodorous. Slow breakdown in pit that may take decades to fully decompose.

Regulatory issues—Some states do not permit pit toilets. The USDA Forest Service and National Park Service must comply with NEPA.

Sanitation issues—May cause ground water contamination. Pits must be closed when waste reaches within one foot of the original grade. Pits must be properly capped with three to four feet of soil when full. There is some tolerance for error in operation.

Aesthetic issues—Can have unpleasant odors if not vented properly. Flies and vermin are possible if not maintained well.

Installation issues—Basic carpentry is needed. Requires transportation of materials to site, digging a substantial pit.

Installation costs—From $200-$600 in lumber and supplies.

Installation labor—Two to three days of labor to build the structure. A day's work to dig the pit. Transportation to the site.

Operation issues—Must be well vented and screened to prevent odor and flies.

Operation costs—Free. Except for labor to move periodically and for repairs/replacement with regards to the structure.

Operation labor—Privy must be moved periodically. The size of the pit and the frequency of use determine the need to move pit.

Vault Toilet—Standard container-style toilet, not detailed elsewhere in this manual.

Principle at work—Waste goes into a sealed vault made of concrete or other impervious material. Waste is pumped out when full. Pathogen reduction is achieved by "treatment" of the effluent at a municipal sewage treatment plant.

Site preferences—Road access is required. Other possibilities could be the removal of waste from vaults with aircraft or ATV. Those two would require a trail or clearing of an area for landing a helicopter.

Environmental limitations—Environmental factors that challenge use: ledges and steep slopes; could require major excavation and blasting to overcome those limitations.

Level of use tolerated—High, depending on use levels, size of vault, and frequency of cleaning.

Breakdown process—None. Waste is removed and disposed of regularly.

Regulatory issues—Must be an approved design. Federal agencies must comply with NEPA.

Sanitation issues—Should be an approved design that is totally contained.

Aesthetic issues—A substantial structure that may be intrusive in backcountry. Requires road access.

Installation issues—Heavy equipment is required to dig hole and install tank.

Installation costs—Several thousand dollars.

Installation labor—Must be done by contractor with experience and heavy equipment.

Operation issues—Must be well vented to prevent odors. Regular pumping must be scheduled.

Operation costs—Must be pumped regularly. Several hundred dollars each time.

Operation labor—Routine pumping by a licensed septic hauler.

Mouldering Privy—Described in Section 8 of this manual.

Principle at work—An above-ground chamber (crib) is constructed to collect the waste. Liquids drain through the pile and into the soil, thus allowing oxygen to access the waste and liquid so aerobic decay can take place. Pathogen reduction is achieved by retention time in the system, not heat. Breakdown and pathogen reduction is enhanced by local decomposers and red wiggler worms.

Site preferences—A dry, level site is preferable. If some soil depth (4-6" or more) can be found, locate the unit there to help absorb liquids. Trees are helpful to shade the unit and keep the pile moist and the worms happy.

Environmental limitations—Environmental factors that challenge use: ledges, swampy or wet ground, high water table, nearby water sources (nearer than 200 feet); extreme cold (where the average mean temperature never gets above 40 degrees Fahrenheit; clay soils that do not drain at all.

Level of use tolerated—These units are designed to be used at low- to medium-use sites. They could be used at a higher-use site if enough cribs were constructed (NOTE—see Section 6, "Aesthetics"). GMC defines a low- to medium-use site as one receiving no more than 500 overnight visitors during the typical hiking season of 20 weeks.

Breakdown process—Slow aerobic ("moldering" or "mesophilic"). Uses lots of oxygen to speed the breakdown process. Also, red worms aid in breakdown by "turning" the pile through "wriggling" and eating.

Regulatory issues—System remains experimental: Has been approved for where it has been implemented. Check with the appropriate land manager and ATC regional office before installing.

Sanitation issues—Crib must be constructed properly to ensure adequate and safe operation since it is an above-ground system. The number of cribs needed will depend on use levels; you will need at least two. The goal is to have enough storage capacity to allow a long retention time for the waste in the crib—six months to a year is ideal. Having enough storage minimizes the amount of handling of the material and ensures the greatest level of pathogen reduction. An alternative to ensure maximum pathogen reduction would be to have finished material sit on a drying screen for up to a year. Health hazard to the maintainer is a potential risk. There is some tolerance to error in operation.

Aesthetic issues—Few. If you build multiple cribs, the area can become more cluttered in appearance.

Installation issues—Crib work must be constructed properly for efficient and safe function.

Installation costs—$200 to $600 plus the outhouse.

Installation labor—More than installing a traditional pit privy, but less than other composting toilets.

Operation issues—Red worms should be added every spring. Maintainers should visit the unit periodically to make sure enough wood shavings are being added and to knock over the waste cone and mix the pile.

Operation costs—Red worms must be added periodically. A two-pound container of worms is about $20. Worms can be cultivated, once purchased, to reduce ongoing annual costs.

Operation labor—Minimal. Periodically packing in compressed wood shavings and adding them to the crib. Also adding worms each spring.

Batch-bin composting—Described in Section 9 of this manual.

Principle at work—Sewage is caught in a collector (catcher). It is then mixed with hardwood bark chips by hand and put into a bin where it is composted, reducing pathogens and reducing volume. Pathogens are primarily killed by exposure to high temperatures (100 degrees Fahrenheit and up). Remaining byproduct is placed on a platform (drying rack or screen) to cure and then is eventually scattered and some bark chips re-used.

Site preferences—Can be adapted to a variety of site conditions.

Environmental limitations—Very adaptable system. Environmental factors that challenge use: extreme slope combined with ledge; extreme cold (where the average mean temperature never gets above 40 degrees Fahrenheit.

Level of use tolerated—High: in excess of 1,000 overnight visitors during the typical hiking season of twenty weeks.To accommodate higher use, a second compost bin and drying rack/screen can be added; a beyond-the-bin system can be added to reduce amount of bark mulch needed and thus volume.

Breakdown process—Rapid aerobic ("thermophilic"). Uses hardwood bark chips as a bulking agent to increase airflow around waste and uses manual turning on a periodic basis to ensure thorough breakdown.

Regulatory issues—Should not require NEPA documentation, but check with the appropriate land manager and ATC regional office before installing.

Sanitation issues—Tests indicate that a "run" that is done properly leaves few pathogens. Health hazard to the operator is a potential risk. Low tolerance for error in operation.

Aesthetic issues—The batch bin system has many components (bark chips, run bins, drying rack/screen, mixing bin, *etc*.) that must be stored on site, making it quite bulky, and possibly intrusive in a primitive area.

Installation issues—Must purchase a "catcher," one or more compost bins, and a sifting screen. Depending on the system used, two storage cans must also be purchased and a drying rack/screen built. Those are bulky items that are difficult to transport without vehicle or helicopter access.

Installation costs—$1000 to $3,000 plus the outhouse.

Installation labor—Fairly labor-intensive installation to build a new outhouse base, pack in the catcher and bin, build a bark-chip storage unit, and build a drying rack/screen.

Operation issues—Operator must pay careful attention to the system and must actively compost on a frequent basis to keep the system operational. Operator must ensure a supply of bark chips is transported to the site.

Operation costs—A good source of hardwood bark chips is needed. They can usually be had for free, but not always so there may be an annual cost for mulch. Labor is an ongoing cost, as the process is labor-intensive.

Operation labor—Labor-intensive. Requires operator to mix and turn waste by hand. High-use sites may need to be composted biweekly, which takes several hours. Ongoing transport of bark chips to site as a bulking agent, which may require intensive backpacking or an airlift.

Beyond-the-bin composting—Described in Section 10 of this manual.

Principle at work—Same concept as the batch-bin composting, but uses a special system to drain the liquids off and then treat them. That reduces the amount of bark required and the risk to the operator from "splash back." Pathogens are primarily killed by exposure to high temperatures (100 degrees Fahrenheit and up).

Site preferences—Can be adapted to a variety of site conditions. A slope is preferable to get gravity flow of liquid to the filtering barrel.

Environmental limitations—Very adaptable system. Environmental factors that challenge use: extreme slopes combined with ledges; extreme cold (where the average mean temperature never gets above 40 degrees Fahrenheit; clay soils that do not drain at all.

Level of use tolerated—High: in excess of 1,000 overnight visitors during the typical hiking season of twenty weeks.

Breakdown process—Rapid aerobic ("thermophilic"). Same as batch-bin, but removal of liquid makes the composting runs work more efficiently, getting hotter temperatures and requiring less outside bark mulch.

Regulatory issues—Should not require NEPA documentation. May require a state wastewater permit.Check with appropriate land manager and ATC regional office before installing.

Sanitation issues—Tests indicate that the liquid that is separated out is treated sufficiently to be released into the ground. Hazards for the operator are still present. Appropriate precautions are advised. Low tolerance for error in operation.

Aesthetic issues—Same as batch-bin system, plus an additional pipe and leaching area that must be installed.

Installation issues—Complex installation that requires some basic plumbing experience. Otherwise, same as batch-bin.

Installation costs—$1,100 (assumes a batch-bin system and existing outhouse).

Installation labor—Same as the batch-bin system, but with the addition of a more complex liquid separator in the collector and associated drain pipes and filter barrel to treat the liquids.

Operation issues—Same as batch-bin system. Beyond-the-bin reduces the bark consumption by a third. The beyond-the-bin piping must be disconnected in the winter months where freezing is an issue.

Operation costs—Same as batch bin, but reduces per-person bark required by a third. Labor intensive.

Operation labor—Same as batch-bin system, except that the liquid-management system must be hooked up in the spring and then drained and disconnected in the fall. Replacement of filter components is labor-intensive, but fortunately is infrequent.

Bio-Sun—Commercially designed continuous-composting system, described in Section 11.4 of this manual. For more information, contact the manufacturer.

Principle at work—A commercial system sold by Bio-Sun Systems, of Millertown, Pa. Waste is collected in a large, ventilated, waterproof tank. Waste material is mixed and segregated by the operator. A beyond-the-bin liquid management system may need to be added to deal with liquid build-up. There needs to be some way to drain and treat liquids. Wood shavings, biological enzymes, and bark chips are added that accelerate breakdown. Pathogen reduction is achieved through retention time in the system, not heat.

Site preferences—The system is designed to take advantage of solar gain to power a vent fan, so the site should be south-facing; some trees may need to be cut. May require substantial excavation in the area of installation.

Environmental limitations—Environmental factors that challenge use: sites that face north or west and get little direct sunlight (system requires use of solar photovoltaic panel for power); steep slopes; extreme cold (where the average mean temperature never gets above 40 degrees Fahrenheit; clay soils that do not drain at all. The system needs some soil to drain treated effluent into. Could be difficult to site on steep slopes with major ledge; major excavation or blasting could be necessary.

Level of use tolerated—The manufacturer says it will accommodate 90,000 uses per year (under "optimal conditions"). Figure that the number will be slightly lower when the unit is placed at higher elevations where the composting season is shorter. Use levels can be better managed with the addition of a liquid management system. Contact Bio-Sun Systems Inc. for more information.

Breakdown process—Slow serobic ("moldering" or "mesophilic"). The incline in the collection chamber allows the waste to be "self-turning." The addition of bark, wood shavings, redworms, and enzymes all stimulate the breakdown process.

Regulatory issues—Will require NEPA compliance. Check with appropriate land manager and ATC regional office before installing.

Sanitation issues—A proven technology in a new system format with minimal sanitation issues. Unit must be emptied on a periodic basis with proper disposal of processed wastes. Unit is challenged at higher elevations with high ambient air moisture. To solve the problem, a beyond-the-bin liquid-management system can be installed. Since the tank does not gravity-separate the material, that must be done by the maintainer. Great care must be taken that new sewage and aged material do not get mixed. To ensure maximum pathogen reduction, finished material should sit on a drying rack or screen for up to a year. Health hazard to the maintainer is a potential risk due to lack of physical segregation between fresh waste and composted waste. There is some tolerance for error in operation.

Aesthetic issues—The Bio-Sun requires a large structure to house the unit and may be out of place in some primitive areas.

Installation issues—Complex installation that will require an airlift to a remote site. A substantial building is required to house unit. A beyond-the-bin filter barrel is also necessary to deal with liquids.

Installation costs—$10,000 to $20,000, but costs are highly variable. Contact Bio-Sun for the exact costs of your proposed system.

Installation labor—Extensive. Installing a Bio-Sun requires building a major structure, digging a substantial leaching field, perhaps adding a beyond-the-bin liquid-management system, and putting together the parts of the system that form the chamber.

Operation issues—An on-site presence is desirable, if not mandatory. Weekly maintenance is called for to add bark chips /shavings and enzymes, and to rake the pile.

Operation costs—Periodically add bulking agents (usually free) red worms (initial cost) and enzymes (ongoing minor annual expense). Labor is required to rake pile periodically.

Operation labor—Minimal, but regularity is the key. About ½ hour per week is ideal. Most often this will include someone hiking into the site and "knocking down the cone." Additional periodic duty includes adding additional bulking agent.

Pennsylvania Composter—Also known as "Clivus Minimus"; owner-built continuous-composting system. For more information, see Appendix for plans and club contact.

Principle at work—A system styled after the Clivus Multrum. Waste is collected in a large, ventilated, waterproof, sloping tank that has an incline that stimulates self-turning as the waste decomposes. Wood shavings, biological enzymes and bark chips are added that accelerate breakdown. A beyond-the-bin liquid-management system could need to be added to deal with liquid build-up. There needs to be some way to drain and treat liquids. Pathogen reduction is achieved through retention time in the system, not heat.

Site preferences—Designed to take advantage of solar gain to assist in temperature management. The sloping tank and vent stack are painted black. The unit is situated with a southern exposure and the overstory is thinned to increase solar gain. Therefore, the site should be south-facing and some trees may need to be cut. May require excavating an area for installation.

Environmental limitations—Environmental factors that challenge use: ledges, lack of sunlight, lack of some wind, extreme cold (where the average mean temperature never gets above 40 degrees Fahrenheit; clay soils that do not drain at all. Needs some soil to drain treated effluent into. Could be difficult to site on steep slopes with major ledge; major excavation or blasting could be necessary.

Level of use tolerated—Medium to high use, 500 or more overnight visitors a season. Contact the Mountain Club of Maryland for more specific information from their use of the systems in the field.

Breakdown process—Slow aerobic ("moldering" or "mesophilic"). The incline in the collection chamber allows the waste to be "self-turning." The addition of bark, wood shavings, redworms, and enzymes all stimulate the breakdown process.

Regulatory issues—Will require NEPA compliance and compliance with state regs. Design will need to be approved. Check with appropriate local land manager and ATC regional office.

Sanitation issues—Systems have been operating on the A.T. in the mid-Atlantic region for several seasons with reasonable success. They were originally designed to meet the sanitation needs along the A.T. in Pennsylvania where the state had enacted new extremely tough waste-management standards (they banned pit toilets on the A.T.). Currently, systems do not have a liquid management system and that affects the ability of the material to thoroughly compost.

Those systems would benefit greatly from the addition of such a liquid drainage/management system (provided state authorities would accept it). Additional improvements include adding enzymes and redworms. To ensure maximum pathogen reduction, finished material should sit on a drying rack or screen for up to a year. Health hazard to the maintainer is a potential risk. There is some tolerance for error in operation.

Aesthetic issues—The Pennsylvania Composter ("Clivus Minimus") requires a large structure to house the unit and may be out of place in some primitive areas.

Installation issues—Semi -complex installation that could require an airlift to a remote site. For less-remote sites, four-wheel drive or horse access is desirable. A substantial building is required to house unit. A beyond-the-bin filter barrel could be useful, if not mandatory, to deal with liquids. In Pennsylvania, the stringent regs regarding ground discharge will allow leachate from the system to drain into a drywell or "french-drain."

Installation costs—$1,900-$2,500. Cost will vary depending on whether or not a double-chambered system is constructed.

Installation labor—Fairly labor-intensive. Installing a Clivus Minimus requires building a major structure, digging a substantial foundation for the unit, and putting together the parts of the system that form the chamber. The system may require a beyond-the-bin system as well as a drying screen to be constructed.

Operation issues—An on-site presence is desirable, if not mandatory. Weekly maintenance is called for by adding bark chips /shavings and enzymes and raking the pile.

Operation costs—Periodically add bulking agents (usually free) redworms (initial cost) and enzymes (ongoing minor annual expense). Labor is required to rake pile periodically.

Operation labor—Minimal, but regularity is the key. About ½ hour per week is ideal. Most often this will include someone hiking into the site and "knocking down the cone." Additional periodic duty includes adding additional bulking agent.

Clivus Multrum—Commercially designed continuous-composting system. For more information, see Sections 11.3 and 11.5 of this manual, orcontact Clivus New England.

Principle at work—A commercial system sold by the Clivus New England Co. of North Andover, Massachusetts. Waste is collected in a large, ventilated, waterproof, sloping tank that has an incline that stimulates self-turning as the waste decomposes. Wood shavings, biological enzymes, and bark chips are added that accelerate breakdown. A beyond-the-bin liquid-management system could need to be added to deal with liquid build-up. There needs to be some way to drain and treat liquids. Pathogen reduction is achieved through retention time in the system, not heat.

Site preferences—May require excavating a substantial area for installation. May require exposure to sunlight for power needs.

Environmental limitations—Environmental factors that challenge use: Extreme cold (where the average mean temperature never gets above 40 degrees Fahrenheit; clay soils that do not drain at all. Could be difficult to site on very steep slopes or slopes combined with ledge; major excavation or blasting could be necessary to prepare such a site. Some systems need a power supply; in a backcountry setting, photovoltaic (solar cells) may be needed to produce power, therefore having exposure to sun is critical. System needs some soil to drain treated effluent into, or a collection system and then means to transport collected leachate away for safe disposal.

Level of use tolerated—Medium to high use, 500 or more overnight visitors a season. Contact Clivus New England for more specific information.

Breakdown process—Slow aerobic (“moldering” or “mesophilic”). The incline in the collection chamber allows the waste to be “self-turning.” The addition of bark, wood shavings, redworms, and enzymes all stimulate the breakdown process.

Regulatory issues—Will require NEPA compliance. Check with appropriate land manager ATC regional office before installing.

Sanitation issues—A proven technology with minimal sanitation issues. Unit must be emptied on a periodic basis with proper disposal of processed wastes. High-use sites in the White Mountains have been running these systems with great success. Carter Notch Hut went for five seasons before material had to be removed! To ensure maximum pathogen reduction, finished material should sit on a drying rack or screen for up to a year. Health hazard to the maintainer is a potential risk when interacting with waste. There is some tolerance for error in operation.

Aesthetic issues—The Clivus requires a large structure to house the unit and may be out of place in some primitive areas.

Installation issues—Complex installation that will require an airlift to a remote site. A substantial building is required to house unit. A Beyond-the-Bin filter barrel may also necessary to deal with liquids. -

Installation costs—Several thousand to upwards of $20,000 but costs are highly variable. check with Clivus for the cost of your specific needs

Installation labor—Extensive. Installing a Clivus requires building a major structure, digging a leach field (a substantial one at high-use sites), perhaps adding a beyond-the-bin liquid-management system, and putting together the parts of the system that form the chamber.

Operation issues—An on-site presence is desirable, if not mandatory. Weekly maintenance is called for by adding bark chips /shavings and enzymes and raking the pile.

Operation costs—Periodically add bulking agents (usually free) redworms (initial cost) and enzymes (ongoing minor annual expense). Labor is required to rake pile periodically.

Operation labor—Minimal, but regularity is the key. About ½ hour per week is ideal. Most often that will include someone hiking into the site and “knocking down the cone.” Additional periodic duty includes adding additional bulking agent.

13

Gray Water Management in the Backcountry

Pete Ketcham, Field Supervisor, Green Mountain Club

Chris Thayer, Huts Manager, Appalachian Mountain Club

13.1

WHAT GRAY WATER IS AND WHY IT NEEDS MANAGEMENT

Gray water is waste water that has not come into contact with feces or urine. It includes food waste, soaps and detergents, and hygienic wastes (see descriptions below). Typically gray water is free of pathogens. But, there are exceptions, which is why it needs management.

See Section 4, "Health and Safety Issues."

- Campers and hikers should always wash their hands after bowel movements. *Therefore, gray water may contain pathogens, so it is a potential hazard to campsite managers and users, and it may contaminate surface and ground water.* When you may come into contact with gray water, take the same safety precautions you would when managing raw sewage.

- Gray water can ruin backcountry water sources aesthetically. There is nothing less appealing than dipping a cup into a spring with gobs of floating oatmeal, or a campsite spattered with toothpaste and spit.

- Gray water also can biologically alter backcountry ponds and streams. Nutrients can contribute to plant and algal blooms that rob aquatic animals of oxygen when excess plants and animals die and decompose. Michael J. Caduto, in *Pond and Brook*, defines this process, called *eutrophication*, as "the overfertilization of aquatic ecosystems resulting in high levels of production and decomposition. Eutrophication can hasten the aging process of a pond or lake due to the rapid buildup of organic remains."

Usually hikers and campers create so little gray water that this threat is minimal. However, their gray water could add to other human-caused sources of nutrients (old outhouse pits, for example) and natural sources to hasten eutrophication.

A properly sited designated washing area, washpit, or gray water management system, coupled with the education about low-impact washing practices described in the Leave No Trace ethic, can alert backcountry users to the growing scarcity of pure drinking water, the threat of eutrophication, and the need to keep finite potable backcountry water sources as clean as possible.

13.2 SOURCES OF GRAY WATER IN THE BACKCOUNTRY

Dish washing—Dish washing in water sources water is a widespread undesirable practice that disperses food residues and nutrients from soap or detergents. Designated washing areas and gray water management systems have helped teach hikers not to wash dishes in drinking water sources. However, inappropriately sited, poorly constructed, or improperly maintained sites and systems can themselves create point sources of surface and ground water pollution at medium- to high-use overnight sites.

Hand washing—Hygienic waste water comes from hand washing after bowel movements, and must be considered at all backcountry sites with toilets. Sanitation systems should separate toilet users from water, especially drinking water collection points, as much as possible. Sites with the toilet and shelter on opposite sides of watercourses tempt users to wash their hands in streams after using the toilet.

Toiletry—Bathing, shaving, and toothbrushing can contaminate water, especially when soaps, shaving creams, and toothpastes are used.

13.3 MANAGEMENT OPTIONS FOR GRAY WATER

Fire ring—A designated fire pit can be used to dispose of limited amounts of gray water where fires are legal. A washpit is better, but campers at a site without a washpit may be encouraged to use the fire pit.

Charcoal helps absorb odors and filter effluent, and the next fire will burn food particles too small to be packed out. However, this technique should be discouraged where bears and other animals have been habituated to human food. The fire will not eliminate all odors, and remaining odors will attract problem animals. Signage should always remind campers to pack out all food scraps. The sign might suggest that food scraps can be essentially eliminated by cooking a little less than you want to eat, scraping pots and dishes clean, and then filling up on snacks.

Designated washing area and washpit—All washing should take place well away from surface water. At a lightly or moderately used site, wash water should be scattered over a broad designated washing area for maximum biological assimilation. However, at high-use sites washpits should be provided to discourage users from washing in or near water supplies.

13.4 DESIGNATED WASHING AREAS

Siting and establishing a designated washing area—Most overnight sites need only designated washing areas to keep them attractive and clean.

1. Site a designated washing area on the opposite side of the campsite or shelter from the site's water source, so the washing area will be convenient, but as far as possible from drinking water.

2. Pick a well-drained spot with plenty of soil. Look for vigorous undergrowth, which indicates biologically active soil, so gray water will be utilized by plants as much as possible. Avoid gullies with slopes to surface water. If necessary, divert surface water away from the washpit by ditches or waterbars.

3. Try to choose an area that is unlikely to expand and increase its adverse impact on the site. When possible, pick a spot that is already degraded. For example, try turning an illegal tenting area into the dishwashing area, if it meets the other criteria of a good spot.

4. Make the area easy to find. Mark it with signs, build a trail to it, and post an area map delineating the washing area.

5. Post an obvious sign asking campers to pack out all food waste and to minimize their use of soaps or detergents, because they pollute the backcountry.

Washpit construction and maintenance—Consider the following guidelines when building and maintaining a designated washpit:

1. Site a new washpit on the opposite side of the campsite or shelter from the drinking water source. This increases the likelihood that dishes, *etc.*, will stay away from the water source. If possible, make sure the washpit is visible from the shelter.

2. Pick a well-drained spot with plenty of soil. Avoid gullies with slopes to surface water. If necessary, divert surface water away from the pit with ditches or waterbars.

See Appendix K for a diagram of a properly constructed washpit.

3. Dig a hole at least six inches deep—up to eighteen inches deep if soil depth permits—but not to bedrock or hardpan. An impervious bottom will not properly filter wash water.

4. If the soil is shallow (less than twelve inches deep), dig a runway leading from the primary pit to a second pit.

5. Fill all pits and runways loosely with flat rocks standing on edge. Use larger rocks near the bottom, smaller rocks toward the top. Leave plenty of spaces between the rocks so the pit will not silt up quickly. Cover secondary pits and runways with large flat rocks to prevent them from filling with dirt, leaves and other debris.

6. Ring the washpit with large flat rocks for users to set pots on, and to stand on, because soil compaction around the pit quickly leads to the formation of puddles.

7. Mount an obvious "DO ALL WASHING HERE" sign on a post adjacent to the pit. Hang an instruction sign on the post.

8. Place a fine mesh hardware-cloth screen in a frame made of pressure-treated lumber covering the washpit to exclude food scraps. Even better, provide a durable metal colander with instructions to campers use it to strain washwater.

9. Re-dig and re-rock all pits and runways at least once a year, depending on use levels. Silt, food particles, and grease will eventually clog the pit, although the evil day can be put off by regularly dumping a generous amount of boiling water into the pit.

Because washpits tend to be anaerobic when clogged, odors are very strong when a pit is dug up. Wash the rocks in a five-gallon bucket and replace them. Then pour the water in the bucket into the pit for disposal, following with hot water if possible.

10. Information on the instructional sign should remind hikers:

- Except for washing dishes and for handwashing after bowel movements, soap and detergents are not necessary in the backcountry. The use of shaving cream should be minimized.
- Wash nothing in streams, ponds or lakes.
- Pack out all food scraps. Food scraps can be essentially eliminated by cooking a little less than you need and scraping the pot and dishes clean; then fill up on snacks.
- Do not dispose of grease in the pit.
- Use as little soap and water as possible to avoid overtaxing the pit.

13.5 GRAY WATER CHUTES

A gray water chute is simply a riser that caps a washpit. Chutes are especially useful at sites that receive significant snow and winter use, because campers can find the riser as long as it is taller than the snowpack. Deep snow usually protects the ground and washpit from freezing, so the washpit will work through the winter.

Chutes also help identify washpit sites, and promote their use. On the other hand, chutes can be obtrusive, so artful placement behind at least some natural screening is desirable.

A chute should be made of durable rust-resistant metal, or wood covered with metal to keep animals from chewing it or vandals from burning it. The top of the chute should expand like a funnel and have screen cover. This generous surface area provides placement for a dishpan or camping stove, so dishes can be washed in hot water to minimize the use of soap or detergent. For gray water chute plans, contact the AMC Huts Department .

See contact information in Appendix D.

Regular maintenance is vital—Remember that washpits and gray water chutes require inspection and maintenance annually, if not more frequently. Consider carefully whether gray water systems actually are necessary, and whether your club can monitor and maintain them properly. Designated washing areas are adequate for most sites.

13.6 REGULATORY ISSUES

Some states may require consultation or permits in the process of establishing a gray water management area or system. Check with your ATC regional office before establishing an area or system. See the Appendix for contact information for regional offices and regulatory agencies.

13.7

CASE STUDY: GRAY WATER MANAGEMENT AT APPALACHIAN MOUNTAIN CLUB HUTS

By Chris Thayer, Appalachian Mountain Club Huts Manager

Appalachian Mountain Club (AMC) huts in the White Mountains of New Hampshire use several methods for dealing with gray water waste generated by kitchen and bathroom sinks. In some cases, gray water is combined with toilet effluent for treatment.

Huts where sewage is airlifted out by helicopter, and those with composting toilets, have running water in the kitchen and in the toilet rooms for washing and drinking. These huts have grease traps and septic systems for kitchen and lavatory sink water. After gray water leaves a grease trap, it typically goes through a pre-filter, an automatic doser, and an open valve to a filter tank and leach field.

The same basic system is used in huts with flush toilets, except that gray water enters the sewer line after the strainer units that separate feces from waste water. Then sewage enters the septic tank for further treatment. Every hut but one has a grease trap with a capacity of 1,000 gallons. Lakes of the Clouds Hut, with a capacity of more than 90 guests, has a 1,500-gallon grease trap.

Caretakers clean grease traps daily by skimming and removing the contents. They check pre-filters to guard against overflowing, and check dosers to ensure the flappers swing freely. Leach fields are rotated daily by opening or closing valves beyond the automatic doser. Each hut has from one to four sets of filter tanks and leach fields; only one field or tank is used at a time. Conforming with state requirements, the AMC is eliminating chlorine based dosing systems, and is changing to simple doser systems.

Zealand Falls Hut and Carter Notch Hut have gray water chutes, which are essentially dry wells (a washpit with a waist-high metal chute and screen—see above description), for disposing of dish water in winter. They are left idle through the spring, summer and fall, which allows them to dry and prevents odor. Caretakers are responsible for maintaining screens so trash and food do not go down the chutes, and for seeing that grease is excluded, because it will not decompose under the anaerobic conditions typical of the pits.

Though the AMC has used a variety of methods of disposing of gray water, the club strives for subsurface disposal through perforated pipes conforming to state codes, because of the ease of maintenance and monitoring.

For further information on the gray water systems used by the AMC, contact Huts Manager Chris Thayer (see Appendix for contact information).

Appendices

A

Glossary of Terms

Compiled by Dick Andrews, Volunteer, Green Mountain Club

ACTINOMYCETES—Single-celled, mostly aerobic organisms, closely related to bacteria, but structurally similar to fungi. They function mainly in the breakdown of cellulose and other organic residues resistant to bacterial attack. Several, such as *Streptomyces*, produce antibiotics.

AEROBIC—Requiring the presence of air or free oxygen for life.

ANAEROBIC—Living in the absence of air or free oxygen.

BACTERIA—A numerous class of both aerobic and anaerobic microscopic organisms. They may be harmful or beneficial: Some cause disease in humans and animals; others fix nitrogen from the air and decompose toxic wastes. Aerobic bacteria are active in composting.

BATCH-BIN—The technique of composting organic material in large, covered waterproof containers at elevated temperatures, one batch at a time.

BEYOND-THE-BIN—A refinement of batch-bin composting in which liquid is separated from solids and treated separately.

BIOLOGICALLY ACTIVE SOIL LAYER—Soil near the surface of the ground in which organic material is abundant and many organisms live, including but not limited to bacteria, fungi, worms and insects. This soil layer typically is moist, but loose enough to contain many small air-filled voids.

BULKING AGENT—A material added to dense, wet and/or nitrogen-filled organic materials to facilitate composting. Bulking agents typically are high in carbon, are capable of absorbing liquid, and are finely divided to provide a lot of surface area. They have enough strength to resist compaction and provide numerous small air pockets, but do not tangle or otherwise impede mixing. In some cases it is useful if the bulking agent contains splinters or other strong, sharp pieces to help chop wet wastes during mixing. Examples of bulking agents useful in composting human waste include bark mulch, shavings, forest duff, and chopped straw.

CHUM TOILET—A toilet without a shelter to provide privacy or protection from weather. Chum toilets typically have been installed at pit privies, but they can also be installed on moldering privies, vault privies and any other type of toilet that needs no protection from the weather.

COMPOSTING—The decay or decomposition of organic material by the action of fungi, micro-organisms and invertebrates in the presence of air. Bulk is substantially reduced, and the end product is a humus-like material with an earthy odor.

CONTINUOUS COMPOSTING—Composting in which organic material is added a little at a time and in which decomposition proceeds at a rate approximately equal to the rate of addition of wastes. Since the rate of adding waste is usually slow, an elevated temperature does not normally occur, although it could happen in a large compost pile that is receiving new waste at a high rate.

FUNGI—Plants, both microscopic and visible, which do not have chlorophyll, and therefore cannot synthesize their food from air, water and sunlight. Fungi live on dead or living organic matter, and include mushrooms, mildews, molds, rusts and smuts. They are a principal agent of decomposition during composting.

LEACHATE—Liquid which has percolated through a porous mass, dissolving some of the solids in the mass on the way. In systems composting human waste, leachate is formed when urine or rain water percolates through feces and/or bulking agents. It may or may not contain pathogens, depending on the conditions under which it formed.

MESOPHILIC—Growing best at moderate temperatures, from 10 degrees C. to 40 degrees C. (50 degrees F. to 104 degrees F.). Mesophilic organisms also will grow between 4 degrees C. and 10 degrees C. (40 degrees F. to 50 degrees F), and between 40 degrees C. and 45 degrees C. (104 degrees F. to 112 degrees F.), but at these temperatures they grow more slowly.

MOLDERING PRIVY—A mesophilic continuous -composting toilet in which human waste and bulking agent are deposited directly on a pile contained in a crib beneath the toilet but above ground level, separated by screening or other barriers from insects or other disease-carrying vectors, and decomposes at ambient temperature. Redworms (also known as manure worms) may be added to speed composting.

PARASITE—An animal or plant that lives in an organism of another species, known as the host, from which it obtains nourishment. Except in symbiotic relationships, parasites impair the health of the host.

PATHOGEN—Any disease-producing organism.

PATHOGEN ENCAPSULATION—A process in which pathogens form durable hard outer coatings that protect them from damage by adverse environmental conditions.

PH—A numerical representation of the acidity or alkalinity of a solution. A pH of 7 indicates a solution neither acidic nor alkaline; lower numbers indicate acidity, and higher numbers indicate alkalinity. Each unit up or down indicates a tenfold change in the strength of acidity or alkalinity. Composting is inhibited if the pH is too high or too low.

Pit privy—A toilet in which feces and urine are deposited directly into a pit in the ground.

Protozoa—Microscopic animals consisting of one cell or a small colony of similar cells. Some species cause serious intestinal diseases in people.

Septage (domestic)—Sewage generated by households. Domestic septage contains human waste and wash water, but not industrial or commercial waste.

Substrate—The base or material on which an organism lives. In composting, it is mostly the pieces of bulking agent.

Thermophilic—Growing best at elevated temperatures, from 45 degrees C. (112 degrees F.) to as high as 75 degrees C. (167 degrees F.).

Vault toilet—A toilet in which feces and urine are deposited into a waterproof vault, or tank, which is periodically pumped out. The sewage is then hauled to a central sewage plant for treatment.

Watershed—The area drained by a stream or river.

Water table—The upper surface of ground water. Below the water table, the soil or rock is saturated with water; above the water table, soil may be moist, but it includes small voids filled with air.

B

Troubleshooting and General Composting Tips

Pete Ketcham, Field Supervisor, Green Mountain Club

B.1 TROUBLESHOOTING BATCH-BIN AND BEYOND-THE-BIN SYSTEMS

Below are descriptions of the most common problems in composting systems. Potential causes are listed after each problem, followed by recommended or suggested solutions.

Problems affecting batch-bin and beyond-the-bin composting systems are addressed first, followed by those affecting continuous composting systems. Finally, there are a few general composting hints.

PROBLEM: The temperature of the compost pile won't climb into the mesophilic or thermophilic range.

Cause 1: Too much decomposition occurred while material accumulated in storage cans, so the final addition of sewage from the full catcher was not enough to send temperatures into the mesophilic or thermophilic range. (That does not happen with the AMC system, since storage cans are not part of the system.)

Solution: Do not re-contaminate the pile with more fresh sewage. Turn and mix the center portion only, and adjust moisture by adding water if the pile is too dry, or adding bulking agent if it is too wet. Allow composting to run again for as long as possible, at a lower temperature if need be. If storage capacity permits, add several extra turnings to the run. Store compost on the drying rack for additional aging.

Cause 2: Compost left in the bin over winter has decomposed and lost enough nutrients to keep the pile from heating. (That situation is of no concern in the AMC system, since compost is left over winter in only one bin, and it has already been through one or more cycles of heating in the first bin.)

Solution: If the compost does not appear finished, proceed as for Cause 1. If the compost does appear finished, add no fresh sewage; transfer the most composted portions to the drying rack or screen, and continue to turn it on the rack.

Cause 3 : The pile is too dry. Water in the waste may have been absorbed by excessive bulking agent in the catcher, storage container or compost bin.

Solution: Adjust moisture in the pile, and allow the compost to run again. Use compost from the bin in place of bark when mixing and breaking up any new wastes. Add water if needed. Water can be sprinkled on, or the bin lid can be removed during light rain (do not leave the bin unattended with the lid removed, or a downpour could reverse the problem). The ideal moisture level is just below that at which water will appear on the bottom of the bin.

Cause 4: The pile is too wet. This also tends to compact the pile, reducing oxygen availability. The wastes may have been too wet to begin with; there may not have been enough bulking agent; the bulking agent may have been the wrong kind or too wet; or a lid may have been displaced by wind, curious hikers or some other cause, letting rain or snow into the system.

Solution: Soak up excess water by adding dry bulking agents to the wettest part (usually the lowest point in the bin). Peat moss is more absorbent than hardwood bark mulch, so it will not bulk up the pile as much as bark mulch, but it is a poor composting substrate, and should be used only as a last resort.

If bark or peat moss are not available, add old dry compost (you can spread compost on the bin lid to dry on windy, sunny days), well crumbled dry leaves, or sawdust. If need be, remove a drier portion of the pile to make room in the bin for more bark or peat moss. If sawdust is used, allow several days for full absorption, or the bin can easily become over dried. Because the carbon/nitrogen (C/N) ratio may be pushed too high by a large volume of sawdust, fresh green plants or a little fresh sewage should be added to the compost to increase the nitrogen content.

Under extreme circumstances, bail the water out. Use a five-gallon plastic bucket, dig a sump in deep dry soil well away from the site, water and trails, and pour the contaminated water a little at a time into the sump.

Secure the bin lid if it is easily dislodged. Several large rocks may help hold it in place. Small hooks can be used, but they can scratch the operator. The GMC drills holes through the bin lid and the lip of the composting bin and fastens the lid to the bin with carriage bolts to deter unwanted opening during the winter. The AMC has a fitted 60-pound plywood lid that is tied down in winter.

Cause 5 : The pile of sewage is too small to self-insulate.

Solution: Continue storing wastes, and when an appropriate amount has been gathered (based on the remaining room in the compost bin—you want your bin filled almost to the brim), attempt to re-ignite the biological furnace and get the run going again..

PROBLEM: There is a backlog of sewage in the middle of processing a compost run.

Causes: Not enough storage capacity; an unexpected surge of use; a slow composting run.

Solution: In the GMC system: add another 32-gallon storage container to the site. In the AMC system: add another composting bin. Begin a second run with a batch of fresh sewage.

PROBLEM: Raw sewage has been inadvertently added to a bin full of finished compost.

Causes: Winter users, or unwitting help, dumped the catcher into the bin. The run may have been completed in fall and left in the bin, but records were not passed on to spring operator.

Solutions: If the sewage has been dumped on but not mixed with finished compost, remove visible raw sewage to the storage cans (in the GMC system) or to the empty compost bin (in the AMC system). Remove to the drying rack those portions of the compost pile which are composted but have not been in contact with raw sewage. Create enough space in the bin to add a batch of fresh sewage and do a run (in the GMC system), or start a run in the empty bin (in the AMC system).

If sewage has been mixed with finished compost, and there is not enough new sewage to constitute a batch, remove enough compost from the bin to add a batch of fresh sewage and begin a run. Put the removed (but recontaminated) compost in an extra storage can if possible; otherwise, put it on the drying rack, separated from other compost stored there. Use this recontaminated compost to top the working pile, or recycle it back into the bin in the next run.

PROBLEM: Compost wintered in the bin appears stable, but the bottom is wet.

Causes: Water may have gotten in as a result of the lid of the compost bin being askew, or wastes may have been wet when left in the fall.

Solution: Check the previous fall's records to determine the status of the compost. Transfer drier portions of compost to the drying rack or to storage cans to make room for a batch of fresh sewage. Use this drier compost as insulation on top and sides of the bin if needed to fill the bin in the next run. Recycle any remaining compost through the bin in future runs.

PROBLEM: The bin leaks.

Causes: A hole was punched in the bottom by the turning fork; porcupines have chewed a hole in the bin, etc. (This does not happen with the AMC's stainless steel bins.)

Solution: Patch the hole(s). The bin must first be emptied. Use whatever containers are readily available to hold the contents; pack more in if necessary. Clean and dry the interior and locate the hole(s).

The best way to patch a bin is with a high quality outdoor silicone caulking compound. Apply the compound generously to both sides of the hole. Apply several layers, with ample curing time between applications. Smooth the inside to prevent the turning fork from catching on the caulk and pulling it out.

If possible, cover the caulking compound with a waterproof sealing paint or with an epoxy-resin compound which will be hard when dry. The outside can be sealed with roofing cement.

If the hole can't be patched, replace the bin.

PROBLEM: Water appears mysteriously in the bin.

Causes : The lid leaks, or a small leak has developed in the bottom of the bin, and water is seeping *in*.

Solution: Examine the lid for leaks; repair any you find. Drain water from the compost operation by ditching around the bin, finish the run, and patch the hole in the bin as described above. Build a platform for the bin, and place the bin on the platform.

B.2

TROUBLESHOOTING CONTINUOUS COMPOSTING SYSTEMS

PROBLEM: There is an odor of fresh waste in or around the system.

Cause 1: Insufficient bulking agent is mixed with the waste.

Solution: Dense, wet waste in the composting chamber is evidence of insufficient bulking agent. Supply a larger scoop for users to add bulking agent with each use, or have an attendant add bulking agent periodically, stirring the waste pile if necessary to mix the bulking agent into the pile. Make sure the supply of bulking agent does not run out.

Cause 2: Inadequate ventilation.

On commercially made and owner-built continuous composters with waterproof tanks, a common cause of odor in the toilet room is improper installation of the ventilation stack, or a broken vent stack. Air can then flow down the vent stack and into the compost chamber and then back up the toilet chute.

Solutions: To check ventilation, hold a smoldering splinter, blown-out match or a lit cigarette near the toilet seat and observe the flow of smoke. *(Take care not to drop any source of ignition into the compost tank or chamber.)* If smoke does not go down the toilet chute, there is not enough draft, which allows odors to rise up the toilet chute and out the seat.

Does the toilet room have good ventilation? There must be some way for air to enter the room, or it cannot flow down the toilet chute when the toilet seat is opened. However, make sure that there are no windows or other openings in the ceiling or in the walls, especially on the lee side of the outhouse, where they will tend to suck air out of the toilet room. The only openings should be small and near the floor, ideally on the windward side. In windy locations with changeable wind direction, try installing lightweight hinged flaps hanging downward on the inside of ventilation openings in the toilet room, so they will open when wind blows inward, but close when air tries to leave the room.

Make sure the top of the vent pipe is not blocked. A rain cap may have fallen down over the top of the pipe. Insect screening may have become clogged (sometimes with dead cluster flies!). Try to locate insect screening on the outside of the rain cap so it will not restrict air flow, and it will be washed by rain. If odor appears in winter, check the downwind portion of the vent cap for frost buildup (which clogs the outlet of the vent and causes wind to drive downward into the vent), and remove the frost if possible.

If there is a fan, is it running? Be sure it is installed to blow in the right direction, and that the vent pipe is continuous. If your system has a fan and the fan is not working, it may be acting as an obstruction to the flow of air.

In a unit without a fan, try raising the stack higher above the roof and adding a cap designed to enhance draft in wind. Adding a turbine ventilator to the top of the stack (instead of a cap) may help, although turbines tend to freeze in winter.

Is the exhaust vent as straight as it could be? Just like a chimney from a wood stove, your best draft will come if there are minimal elbows or turns in the pipe.

Make sure the toilet seat is closed when not in use; post a sign in the outhouse to that effect.

Make sure the outhouse door is kept closed, especially if it is on the downwind side of the building. Post a sign asking hikers to keep the door closed, or install an automatic door closer.

Make sure trees and seasonal vegetation are kept clear of the air intake areas and the exhaust stack. Tall trees near the toilet building can reduce draft. It may be possible to remove a few nearby trees. Check first with your ATC regional office and the land manager.

If the smoke test indicates air is flowing down the toilet chute but there is still an odor, you may need to check for leaks and improperly fastened pipes and fittings. If found, repair them.

Be sure the inspection door and emptying hatch on the compost chamber are closed tightly, all air vents are open and unblocked, and there is a way for air to enter the space sheltering the compost chamber.

If problems persist, one last thing you could try is to block the supplemental air inlets to see if that forces more air to be drawn down through the toilet chute.

Problem: There is a strong odor of sewage or rotten eggs.

Causes: Strong odors of this nature indicate the system may have become anaerobic (due to compaction or liquid build-up) or that there is an imbalance of nutrients within the pile.

Solutions: Increase aeration to increase the level of oxygen in the pile, and facilitate the evaporation of liquids, by adding more bulking agent, and perhaps red worms and/or compost enzymes.

Often odors can be neutralized by covering the compost pile with a healthy layer of bulking agent. Make sure there is a sign in the outhouse instructing hikers to add bulking agent after each use, and provide a larger scoop if they are not using enough.

Urine mixed with feces can increase objectionable odors, especially ammonia. Separating urine or excluding it will often reduce odor. If you choose the latter plan, check the pile regularly and sprinkle it with water if it appears dry. A drop or two of biodegradable hand dishwashing detergent in the water helps it penetrate the pile rather than run off the surface.

Compost toilet manufacturers sell filters, generally containing granulated activated carbon, that can scrub odors from compost exhaust, but this requires forced ventilation with a fan.

Cold wood ash is a useful and free odor control additive readily available at many backcountry campsites. If fires are not permitted at your site, wood ash can be packed in—not much is needed. *Be certain the ash is cold*. *Even a single spark can cause a destructive fire*. Add ash *lightly* to the pile to avoid forming an impenetrable layer of ash or contributing to organic concrete (see below).

Other options are livestock odor-control additives, oxidizing agents, absorbents, and digestive deodorants. Contact your local agricultural extension office for more information. However, be cautious: some of these products may be incompatible with the health of decomposer organisms. Also, the land management agency may not permit these substances.

PROBLEM: The composter doesn't seem to be filling up, even after a year of use.

Cause: Low use of the system. This is usually not a problem on the Trail, because these systems are generally located at heavily used sites. At lightly used sites with a large composting chamber, it may take several seasons before the system has any composted material to empty. Consider this a blessing! Material is decomposing as fast as it is being added, and the composting process is working very well.

Solution: None needed.

PROBLEM: Material isn't completely composted.

Cause: This is a major concern. In most cases, the cause is improper management of the composting process—insufficient warmth, air or moisture; premature removal of material; or inadequate capacity in the system.

Solutions: Avoid overloading the system. The rating of each manufactured composting system depends on a certain minimum temperature. Most systems base their capacity ratings on a temperature of 65 degrees F. (18 degrees C.) or higher, and capacity usually is drastically reduced at lower temperatures.

An overloaded system develops a saturated compost mass. There is visible standing liquid, and the material drips when it is handled. There also may be a strong odor of rotten eggs, a sure sign that the pile has gone anaerobic. Composting slows or stops entirely, and a soupy mixture of solid and liquid accumulates.

Reducing the urine load may solve the problem. Increased evaporation also may help: check the exhaust stack for blockage, and be sure the fan (if present) is working. Try adding more bulking agent, or install a urine diverting toilet and urinal, and manage urine separately. If there is a heating element (unlikely on the A.T., unless your system is at a trailhead), check to see if it is operating properly.

In moldering privies or commercially produced toilets with large compost chambers, liquid drains away, so upper layers of the pile may get too dry, and the composting process will stop. If this happens, water the pile regularly with a spray bottle or a watering can. A drop or two of biodegradable hand dishwashing detergent in the water helps it penetrate the pile rather than run off the surface.

Some systems now include liquid leachate re-spraying systems. This practice is not recommended, because the leachate (urine percolated through the composting mass) contains concentrated salts, ammonia, etc. that hinder the growth of decomposer organisms. Other systems include fresh water sprinkler systems. These are useful if they can be operated manually. Some have moisture sensors, and automatically spray the pile when it becomes too dry. Unfortunately, this is seldom practical on the A.T.

If you must remove uncomposted material, you have several options:

- Place it in storage containers, hold it until you stabilize your composting system, and then run the material through the system again.
- Nearly finished material can be placed on a drying rack for aging.
- Bury material at a shallow depth well away from trails, water, and camping areas, or incinerate it.

If you must dispose of partially finished material more than once, you need to analyze your system, and make changes or implement a system that will work correctly.

PROBLEM: Organic concrete forms in the unit.

Causes: A common cause is compaction of the compost pile due to infrequent removal of finished material.

The mixture of the salts, urine, excrement, toilet paper, and bulking agent may be both too dense and too dry. This is can be aggravated by too much heat in commercial systems with heating elements, a contributing factor unlikely in the backcountry.

Some bacteria and fungi naturally produce a material called *glomulin*, which acts like a glue to hold together particles. On the forest floor or in gardens, this is a naturally occurring process that is important in producing soil structure.

Concrete-forming bacteria working in the presence of certain minerals in excrement and some bulking agents can create additional organic concrete materials. An example of this is bacteria that use urea (a component of urine) as their source of nitrogen. As they break down the urea, they create ammonia and ammonium hydroxide, which react with calcium, yielding calcium carbonate, the principal constituent of limestone and concrete.

Solutions: Keep composting material uniformly moist and porous. Mixing is crucial.

However, in large continuous composters it is difficult to reach the lower parts of the pile. Therefore, it is essential to remove finished material as it accumulates in the cleanout chamber, so compost mixes as it tumbles toward the cleanout door. Remove finished product at least once every two years if you have a large, single chamber composter such as Clivus Multrum or Minimus, Bio-Sun, CTS, or Phoenix.

If the material you remove doesn't appear to be fully done, it can be placed on a drying rack for additional aging and treatment.

Try to manage heat input so it evaporates some water, but keeps the pile moist. However, too much heat is highly unlikely on the Appalachian Trail. Instead, excessive liquid is more likely. In this case, consider a system to drain and treat excess liquid, yet keep the pile moist.

Once it has formed, organic concrete is difficult to deal with. Break it up with a turning fork or other long handled tool, remove it, and try to work it back into the system after it has softened with exposure to fresh waste and moisture. If it doesn't soften, it will have to be incinerated or buried away from water, trails, shelters, and campsites.

B.3 GENERAL COMPOSTING TIPS

Pay attention to moisture.

Moisture is in the optimum range when a shovelful of material appears moist and glistening, like a wrung-out sponge. It should not drip, and no visible standing liquid should be present in the pile. If you want to be more precise, you can use a moisture meter. Follow the instructions for the meter, and check different parts of the pile and various depths. However, excellent results are possible without a meter.

Keep the toilet and chute clean.

Clean surroundings encourage hikers to use the toilet rather than the woods. A little biodegradable soap or detergent and warm water (don't forget to pack in your Thermos or camp stove for heating water) will not harm the composting process. Actually, this mixture is beneficial, because it reduces the surface tension of water in the pile, which helps water penetrate areas that might otherwise become too dry. It also can help make organic molecules and nutrients more available to decomposers by enabling modest amounts of water to penetrate materials more thoroughly.

However, never introduce chemicals, disinfectants, bleach or other poisons into the compost pile. These kill *beneficial* organisms as well as the pathogens you are trying to eliminate. If you use them to clean the toilet seat and the area around it, dispose of them elsewhere.

Ammonia and water is a good cleaning solution compatible with composting. Most compost piles produce some ammonia on their own, and a little more does no harm.

A 3-percent solution of hydrogen peroxide, available at drug stores, is a disinfectant reasonably compatible with composting. Apply it to a rag or sponge, and wipe down the surfaces of the system. If a little gets down the toilet, it may be a little hard on the first organisms it encounters, but as it becomes diluted through dispersal, it will add beneficial oxygen to the system.

Discourage hikers from depositing food waste in the composting system.

Place signs asking folks to pack out all garbage. Food waste adds nutrients to the compost pile, but this minor advantage is overwhelmed by the evil of attracting wildlife to the pile. Also, it is a short step from food wastes to bottles, cans, plastic bags and foil packages.

If food attracts rodents to a composter, they may get contaminated with fresh sewage, and then travel to the campsite or shelter. Do all you can to avoid attracting wildlife, and block any way animals might enter contaminated portions of the composting system.

C

About the Organizations Behind this Manual

The Appalachian Trail Conference

The Appalachian Trail Conference (ATC) is a nonprofit educational organization with more than 31,000 members dedicated to protecting and promoting the Appalachian National Scenic Trail (A.T.) along its 2,160 mile length from Maine to Georgia. The Conference is also a federation of 31 Trail-maintaining clubs whose volunteers manage and maintain the A.T. The Conference maintains a headquarters office in Harpers Ferry WV, and regional offices in Lyme NH; Boiling Springs PA; Newport VA; and Asheville NC. ATC maintains a staff of approximately 40 employees, and through the Trail-maintaining clubs there are approximately 4600 volunteers that contributed 201,000 hours to Trail management and maintenance in 2000.

The Appalachian National Scenic Trail is a unit of the US National Park system, and is America's first National Scenic Trail. A footpath running primarily along the crest of the Appalachian Mountains, the Trail provides opportunities for outdoor recreation in a natural, undeveloped environment to many thousands of people each year. The Trail is managed as a scenic, natural and recreation resource for those desiring a challenging outdoor recreation experience or for those who wish to get away from the trappings of modern civilization.

The lands surrounding the Appalachian National Scenic Trail have been protected through an extensive public land acquisition process led by the National Park Service. Under a unique series of cooperative agreements with the Department of Agriculture (USDA Forest Service) and Department of Interior (National Park Service), ATC has accepted management responsibility for a corridor of land surrounding the Appalachian Trail footpath. These "Delegation Agreements" assign responsibility for Trail management and protection to the Appalachian Trail Conference, which in turns has delegated that responsibility to its member clubs. In effect, this makes the Appalachian National Scenic Trail America's only volunteer-managed National Park.

Appalachian Trail Conference
Attn: Director of Trail Management Programs
P.O. Box 807
799 Washington St.Harpers Ferry WV 25425
(304) 535-6331
<www.appalachiantrail.org>

The Appalachian Mountain Club

The Appalachian Mountain Club (AMC) is the oldest conservation club in the United States, with more than 88,000 members. Since 1876, the AMC has helped people experience the majesty and solitude of the Northeast outdoors. The AMC offers more than 100 workshops annually on a variety of outdoor subjects and many guidebooks and maps. The AMC maintains visitor centers, backcountry shelters and huts, and hiking and cross country ski trails in the White Mountains of New Hampshire and the Berkshires of Massachusetts and Connecticut as well as visitor centers throughout the Northeast from Maine to New Jersey. The club's mission is to promote the protection, enjoyment, and wise use of the mountains, rivers, and trails of the Northeast.

Headquarters
Appalachian Mountain Club
5 Joy St.
Boston MA 02108
(617) 523-0636
<www.outdoors.org>

Pinkham Notch Visitor Center
Attn: Huts Manager and Shelters Supervisor
P.O. Box 298, Route 16
Gorham NH 03581
(603) 466-2721

The Green Mountain Club

Established in 1910 to build the Long Trail, the Green Mountain Club (GMC) is a private, nonprofit organization with more than 9,000 members. Vermont's historic Long Trail, the first long-distance hiking trail in the United States, was the inspiration for the Appalachian Trail. The GMC is dedicated to maintaining, managing and protecting Vermont's Historic Long Trail System, which includes 70 overnight facilities and 124 miles of the Appalachian Trail, and advocating for hiking opportunities in Vermont. Every year, more than 800 volunteers work so that future generations may enjoy the 445 mile Long Trail System.

Green Mountain Club
Attn: Director of Field Programs and Field Supervisor (Facilities)
4711 Waterbury-Stowe Rd.
Waterbury Center VT 05677
(802) 244-7037
<gmc@greenmountainclub.org>
<www.greenmountainclub.org>

The Randolph Mountain Club

Founded in 1910, the Randolph Mountain Club (RMC) maintains a network of 100 miles of hiking trails and four shelters on the northern slopes of the Presidential Range on the White Mountain National Forest in New Hampshire, and on the Crescent Range in the town of Randolph NH. The club has approximately 500 members, and is managed by an active volunteer board of directors. The RMC is funded by dues and donations from members, cost challenge trails contracts with the US Forest Service, and other state and local grants.

RMC's four shelters consist of two cabins near treeline on Mount Adams: Crag Camp, with a capacity of 20, and Gray Knob, with a capacity of 15. There are also two Adirondack-style shelters, The Perch and The Log Cabin, each with a capacity of 10. Overnight fees, ranging between $5 and $8, are set to cover the basic operating expenses of the cabins. The RMC is dedicated to keeping fees as low as possible.

Caretakers at Gray Knob and Crag Camp manage the four shelters during the summer. During the rest of the year, one caretaker is in residence at Gray Knob. The club also has two trail crews, which perform basic maintenance and erosion control projects. In the summer, a field supervisor oversees the caretakers and trail crews, and acts as a liaison to the board of directors.

Randolph Mountain Club
Attn: Camps Director
Randolph NH 03570
<campsdirector@randolphmountainclub.org>
<www.randolphmountainclub.org>

Appalachian Trail Park Office

The Appalachian Trail Park Office (ATPO) is the National Park Service (NPS) office charged with carrying out the Secretary of the Interior's responsibilities for oversight and administration of the Appalachian National Scenic Trail under the National Trails System Act.

Equivalent to the Park Superintendent's office in a traditional national park, ATPO is directed by a Park Manager. Under the unique cooperative management system for the A.T., many traditional park-management responsibilities have been delegated to the Appalachian Trail Conference and its member clubs. ATPO has retained responsibility for the non-delegated functions, and has broad authority for coordinating protection and management efforts along the entire length of the A.T. ATPO works closely and cooperatively with ATC, the 31 A.T. Clubs, other NPS units, the USDA Forest Service, other federal agencies, and state agencies within the 14 Trail states.

Appalachian Trail Park Office
Harpers Ferry Center
Harpers Ferry WV 25425
(304) 535-6737fax: (304) 535-6270
<pirvine@fs.fed.us>

The Center for Ecological Pollution Prevention

The Center for Ecological Pollution Prevention (CEPP) develops, promotes and demonstrates better waste management technologies, with an emphasis on source separation and utilization approaches. The CEPP graciously allowed the GMC and ATC to utilize information and illustrations from their latest book *The Composting Toilet System Book (CEPP, 1999)*.

David Del Porto and Carol Steinfeld
The Center for Ecological Pollution Prevention
P.O. Box 1330
Concord, MA 01742-1330
(978) 318-7033 <ecop2@hotmail.com>
<http://www.cepp.cc/>

Jenkins Publishing

Publisher of *The Humanure Handbook*. The author, Joseph Jenkins, and his book were an invaluable resource for the production of this manual.

Joseph Jenkins
c/o Jenkins Publishing
P.O. Box 607
Grove City, PA 16127
Phone/fax: (814) 786-8209
<jcjenkins@jenkinspublishing.com>
<www.jenkinspublishing.com>

D

Contact List

April 2001

D.1

APPALACHIAN TRAIL CONFERENCE AND REGIONAL OFFICES

Appalachian Trail Conference
Attn: Director of Trail Management Programs
P.O. Box 807
799 Washington St.
Harpers Ferry WV 25425
(304) 535-6331
<www.appalachiantrail.org>

ATC New England Regional Office
P.O. Box 312
18 On the Common, Unit 7
Lyme, NH 03768-0312
(603) 795-4935
Fax: (603) 795-4936
<atc-nero@appalachiantrail.org>

Regional Representative—J.T. Horn <jthorn@appalachiantrail.org>
Associate Reg. Representative—Matt Stevens <mstevens@appalachiantrail.org>

ATC Mid-Atlantic Regional Office
P.O. Box 625
4 East First Street
Boiling Springs, PA 17007
(717) 258-5771
Fax: (717) 258-1442
<atc-maro@appalachiantrail.org>

Regional Representative—Karen Lutz <klutz@appalachiantrail.org>
Associate Reg. Representative—John Wright <jwright@appalachiantrail.org>
Associate Reg. Representative—Michelle Miller <mmiller@appalachiantrail.org>

The Mid-Atlantic Regional Office is a good source of information on how to work effectively with strict state regulators when contemplating sanitation system upgrades on the A.T. Pennsylvania has stringent regulations for management of human waste in the backcountry.

ATC Central and Southwest Virginia Regional Office
P.O. Box 10
103 Old Newport Road, Suite A
Newport, VA 24128
(540) 544-7388
Fax: (540) 544-7120
<atc-varo@appalachiantrail.org>

Regional Representative—Teresa Martinez <tmartinez@appalachiantrail.org>

Associate Regional Representative—Jody Bickell <jbickell@appalachiantrail.org>

ATC Tennessee, North Carolina, and Georgia Regional Office
P.O. Box 2750
160 Zillicoa Street
Asheville, NC 28802
(828) 254-3708
Fax: (828) 254-3754
<atc-gntro@appalchiantrail.org>

Regional Representative—Morgan Sommerville
<msommerville@appalachiantrail.org>

Associate Regional Representative - VACANT - TBA

D.2 APPALACHIAN TRAIL PARK OFFICE

Appalachian Trail Park Office
Harpers Ferry Center
Harpers Ferry WV 25425
(304) 535-6737
Fax: (304) 535-6270
<pirvine@fs.fed.us>

D.3 TRAIL-MAINTAINING CLUBS

New York-New Jersey Trail Conference
156 Ramapo Valley Road (Route 202)
Mahwah, NJ 07430
(201) 512-9348 M-F 11a.m.-5:30 p.m. or leave a message any time.
Fax: (201) 512-9012
<info@nynjtc.org>
<www.nynjtc.org>

New Jersey Field Office
PO Box 169
McAffee, NJ 07428
(973) 823-9999
Fax: (973) 823-9999

Appalachian Mountain Club Headquarters
5 Joy St.
Boston MA 02108
(617) 523-0636
<www.outdoors.org>

AMC Pinkham Notch Visitor Center
Attn: Huts Manager and Shelters Supervisor
P.O. Box 298, Route 16
Gorham NH 03581
(603) 466-2721

The Green Mountain Club, Inc.
4711 Waterbury-Stowe Road
Waterbury Center, VT 05677
(802) 244-7037
Fax: (802) 244-5867
<gmc@greenmountainclub.org>
<www.greenmountainclub.org>

Director of Field Programs—Dave Hardy Ext. 20 <dave@greenmountainclub.org>

Field Supervisor *(ATC Sanitation Manual Co-Author and Contact)* —Pete Ketcham. Ext. 17 <pete@greenmountainclub.org>

Randolph Mountain Club
Attn: Camps Director
Randolph NH 03570
<campsdirector@randolphmountainclub.org>
<www.randolphmountainclub.org>

The Mountain Club of Maryland
4606 Waterfall Court #A,
Owings Mills, MD 21117
(410) 377-6266
< http://www.mcomd.org>

Contact: Ted Sanderson

MCM manages the Pennsylvania Composting System or "The Clivus Minimus." Ted Sanderson designed the Pennsylvania Composter and is a good source of information on owner-built composters.

Blue Mountain Eagle Climbing Club
P.O. Box 14982
Reading, PA 19612-4982
< info@bmecc.org>
<www.bmecc.org>
Contact: Dave Crosby

Dave has extensive experience operating batch-bin composters without paid seasonal staff.

D.4

REGULATORY CONTACTS FOR THE APPALACHIAN TRAIL, LISTED BY STATE

Compiled by Pete Ketcham, Field Supervisor, Green Mountain Club

Please use this contact list for general purposes only. Many parties must be consulted before a backcountry sanitation system can be installed, and regulations and the agencies enforcing them often change. Please contact your ATC regional office for more detail.

Sometimes local health officials have the authority to make final decisions. If they deny permission for a backcountry sanitation system, check with state officials, especially if they are familiar with innovative sanitation systems. Many composting toilet projects in residential areas are approved this way.

The following information comes to the ATC courtesy of David Del Porto and Carol Steinfeld, authors of *The Composting Toilet System Book*. Del Porto and Steinfeld sent out a questionnaire in 1999 to every state, and followed it with several phone calls. Some states were not forthcoming, so the information may be incomplete. Also, Del Porto and Steinfeld asked mainly about frontcountry and residential applications of composting toilet system technology, so make sure you ask about regulations concerning the backcountry.

It is best to consult your local club leadership, your ATC regional office staff, and the local land manager(s) first, to learn the best way to approach regulatory officials. Then call your state department of health or environment protection agency.

For More Information on Regulations

The National Small Flows Clearinghouse (NSFC)—NSFC, sponsored by the U.S. Environmental Protection Agency, offers a free list of state contacts for onsite systems, as well as a regulations repository. For a fee you can get your state's onsite system approval regulations, although you will have to determine the which requirements are relevant on your own. Call (800) 624-8301.

According to the clearinghouse, "homeowners and developers may have a hard time getting approval for some systems because of inflexible regulations or because health officials are unaware of certain alternative system designs or have questions concerning their performance, operation or maintenance." The clearinghouse offers many technical bulletins and publications about onsite and small community systems (Del Porto & Steinfeld, *The Composting Toilet System Book* pp. 202).

National Small Flows Clearinghouse
P.O. Box 6064
Morgantown, WV 26505-6064
<www.nsfc.wvu.edu>

The National Sanitation Foundation (NSF)—NSF International, Inc. is an independent, nonprofit organization that develops standards for public health technologies, including sanitation systems. The group works closely with the American National Standards Institute (ANSI) to develop standards of performance. NSF is internationally recognized by regulators, who will usually approve a product or system listed or approved by the NSF.

Commercially made composting toilets are tested against ANSI/NSF 41-1998 Non Liquid Saturated Treatment Systems. This test covers a wide range of specifications, but most importantly it covers pathogen testing. For more details on what specifications and pathogens are tested, see pg. 202 in the *Composting Toilet System Book* by Del Porto and Steinfeld.

Listing by NSF almost guarantees that a state or local regulator will approve a commercially designed composter.

NSF International
3475 Plymouth Road
P.O. Box 130140
Ann Arbor, MI 48113-0140
(734) 769-8010
<info@nsf.org>
<www.nsf.org>

Local Certifying Agencies

Some states, such as Massachusetts, have developed their own testing facilities, and offer their own state approvals. Call your regional ATC field office to see if your town, county or regulators have pertinent regulation information on sanitation systems.

When discussing a proposed backcountry sanitation system with regulators, always bring as much literature on your proposal as you can, to help educate them. Often they are unaware of technologies suitable for the backcountry, and if you give them information and time to absorb it, they may become remarkably cooperative—possibly even helpful and grateful.

For example, the Green Mountain Club had to apply for a wastewater permit when installing a beyond-the-bin system at Butler Lodge on Mt. Mansfield in Vermont. When the permit administrator was given the Appalachian Mountain Club's Manual for the beyond-the-bin system, which was designed by a licensed septic designer, the GMC received its permit.

State Regulatory Agencies

Georgia

Georgia Department of Human Resources
Environmental Health Section
2 Peachtree St. NW
Atlanta, GA 30303-3186
(404) 657-6534

Composting toilets (commercially manufactured) must be NSF or equal certified. Systems certified by an engineer may be approved as an experimental system. Check with the ATC Georgia, North Carolina, Tennessee Regional Office before contacting the state with a sanitation project request.

Tennessee

Tennessee Department of Environment and Conservation
Division Of Groundwater Protection
10th Floor, L7C Tower
401 Church Street
Nashville, TN 37243-1540
(615) 532-1540
<www.state.tn.us/environment/gwp/index.html>

Composters must be listed with NSF up to standard 41. A non-traditional gray water system could be applied for as experimental. Check with the ATC Georgia, North Carolina, Tennessee Regional Office before contacting the state with a sanitation project request.

North Carolina

Environmental Permit Information Center
(919) 715-3271

Composters may be permitted if you can present plans and/or manufacturer's specifications to the permitting officials. Gray water must be disposed of subsurface (although some alternatives have been approved). Check with the ATC Georgia, North Carolina, Tennessee Regional Office before contacting the state with a sanitation project request.

Virginia

Virginia Office of Environmental Health Services
Main Street Station, Suite 117
P.O. Box 2448, Rm. 119
Richmond, VA 23218-1448
<www.vdh.state.va.us>
<dalexander@vdh.state.va.us>

A composting toilet that meets NSF Standard 41 can be approved for a site in Virginia wherever a pit privy can be used. The regulations can be found on the state's web site listed above. Check with the ATC Virginia Regional Office before contacting the state with a sanitation project request.

West Virginia

Environmental Health Services
Public Health Sanitation Division
815 Quarrier St., Suite 418
Charleston, WV 25301

Composting toilets and gray water systems are addressed in West Virginia Interpretive Rules (BoH) which was updated by Title 64, Series IX, and apply to local boards of health. They will require design data sheet and plans for the system you are proposing. Check with the ATC Mid-Atlantic Regional Office before contacting the state with a sanitation project request.

Maryland

Maryland Department of Environment
Water Management Administration
2500 Broening Highway
Baltimore, MD 21224
(410) 631-3780
<www.mde.state.md.us>

NSF listing will approve a commercially designed composter. Gray water management systems are approved on a case by case basis under the Innovative and Alternative Program (make sure you inquire about this program and see if owner-built composters can get approval). Check with the ATC Mid-Atlantic Regional Office before contacting the state with a sanitation project request.

Pennsylvania

Department of Environmental Resources
Division of Certification, Licensing and Bonding
Market Street State Office Building, 1st floor
400 Market Street
Harrisburg, PA 17101-2301
(717) 787-6045

Pennsylvania is known among AT maintainer circles for the toughest regulations on the Trail. However, the Mountain Club of Maryland and the Blue Mountain Eagle Climbing Club have successfully gotten composters approved. The main challenges are how to treat leachate and gray water. Check Msection 73.1 (V) of the Pennsylvania Code, Title 25, which addresses composting toilets. Check with the ATC Mid-Atlantic Regional Office before contacting the state with a sanitation project request.

New Jersey

New Jersey Department of Environmental Protection
Division of Water Quality
Bureau of Nonpoint Pollution Control
P.O. Box 29
Trenton, NJ 08625-0029
(609) 292-0407

Apply at the county level. Composting toilets are subject to Chap. 199 of the New Jersey code for individual onsite systems. Composters require approval of building codes and local health departments. Composters and gray water systems must comply with the Uniform Plumbing Code. Check with the ATC Mid-Atlantic Regional Office and the New Jersey Field Representative of the New York-New Jersey Trail Conference before contacting the state with a sanitation project request.

New York

New York State Department of Health
Bureau of Community Sanitation and Food Protection
2 University Place, Room 404
Albany, NY 12203-3300
(518) 458-6706

Composters must be NSF listed and have a five-year warranty (this obviously applies to commercially designed systems). Currently New York is approving the installation of more than 100 composters for a lakeside community so this state may be very amenable to owner-built composting toilet systems, provided they have a well-thought-out, tested plan and have been approved in other states. Check with the ATC Mid-Atlantic Regional Office and the New York-New Jersey Trail Conference before contacting the state with a sanitation project request.

Connecticut

Connecticut Department of Environmental Protection
Permits & Enforcement
State Office Building
165 Capitol Ave.
Hartford, CT 26115
(860) 240-9277

Local and state health departments have been designated by the DEP to permit onsite systems. Plans must be certified by a professional engineer. Check with the ATC New England Regional Office before contacting the state with a sanitation project request.

Massachusetts

Executive Office of Environmental Affairs
Department of Environmental Protection
1 Winter Street
Boston, MA 02108
(617) 292-5500
<www.state.ma.us/dep/>

Composting toilets are generally approved. Gray water systems are also generally approved if submitted to the state by a professional engineer or a registered sanitarian. Check codes 310 CMR 15.289(3) (a) of the State Environmental Code and 240 CMR 2.02 (6)(b) Basic Principles of the Uniform State Plumbing Code.

Pete Rentz (one of this manual's authors) and the Appalachian Mountain Club (AMC) Berkshire Chapter Massachusetts Appalachian Trail Committee have installed several successful hybrid moldering privies. (For a case study of this system, see Chapter 8, Case Studies.) Contact Pete Rentz to get a copy of the Moldering Privy Manual produced by the AMC Berkshire Chapter.

Check with the ATC New England Regional Office before contacting the state with a sanitation project request.

Vermont

Agency of Natural Resources &
Department of Environmental Conservation
Waste Water Management Division
103 South Main St.
Sewing Building
Waterbury, VT 05671-0405
(802) 241-3027

The Green Mountain Club (GMC) has many batch-bin, beyond-the-bin, and moldering privies in the backcountry of Vermont. In general, all that is needed is the permission of the land managing agency. This is the US Forest Service on the Green Mountain National Forest or the Vermont Department of Forests, Parks and Recreation on state lands.

Check with the GMC Field Office and the ATC New England Regional Office before contacting the state with a sanitation project request.

New Hampshire

New Hampshire Department of Environmental Services
Bureau of Wastewater Treatment
6 Hazen Drive
Concord, NH 03301
(603) 271-3711

New Hampshire approves composting toilets, and the Appalachian Mountain Club (AMC) has many composting toilets on the A.T. Gray water systems are approved on a case-by-case basis. AMC has several alternative gray water management systems. Check with the AMC Trails Department and the ATC New England Regional Office before contacting the state with a sanitation project request.

Maine
Wastewater and Plumbing Control Program
Division of Health Engineering
10 Statehouse Station
Augusta, ME 04333-0010
(207) 287-5695
<james.jacobsen@state.me.us>
Contact: James Jacobsen, Environmental Specialist IV

Maine is generally friendly to composting toilets. The Maine Appalachian Trail Club (MATC) has installed AMC-styled beyond-the-bin and GMC-styled batch-bin composters, and plans to install moldering privies. Commercial systems must generally be NSF listed. Check with the ATC New England Regional Office before contacting the state with a sanitation project request.

D.5 OTHER ORGANIZATIONS

David Del Porto and Carol Steinfeld
The Center for Ecological Pollution Prevention
P.O. Box 1330
Concord, MA 01742-1330
(978) 318-7033
<ecop2@hotmail.com>
<http://www.cepp.cc/>

Joseph Jenkins
c/o Jenkins Publishing
P.O. Box 607
Grove City, PA 16127
Phone/fax: (814) 786-8209
<jcjenkins@jenkinspublishing.com>
<www.jenkinspublishing.com>

D.6 COMMERCIAL COMPOSTING TOILET MANUFACTURERS

Companies in the following list have supplied information used in this manual, but the list is not an endorsement of them or their products. There are many other companies in this business, and a more complete listing can be found in *The Composting Toilet System Book, by David Del Porto and Carol Steinfeld*. (See the Bibliography, also in the Appendix, for information on the book.)

Clivus New England, Inc.
P.O. Box 127
North Andover, MA 01845
(978) 794-9400
Fax: (978) 794-9444
<123cne@clivusne.com>
< http://clivus.com/ClivusNE/clivusne.htm>
Contact: Bill Wall or Ben Canonica

Clivus Multrum New England, Inc. is the East Coast distributor of Clivus Multrum Systems. Clivus New England has several composting systems. They provide consultation, turnkey systems, and in some instances, maintenance services. Even if you are not considering a Clivus, it is worth calling and getting an information package. To see Clivus systems in operation on the A.T., contact the Appalachian Mountain Club's Pinkham Notch Visitor Center (see above for listing).

Bio-Sun Systems, Inc.
RR#2, Box 134A
Millerton, PA 16936
(800) 847-8840
(570) 537-2200
Fax: (570) 537-6200
<info@bio-sun.com>
<www.bio-sun.com>
Contact: Allen White

BioSun Systems, Inc. is the manufacturer and distributor of the Bio-Sun line of composting toilets. Like Clivus, Bio-Sun offers several systems and services for special needs, including backcountry applications. To see Bio-Sun systems in operation in the backcountry near the A.T., contact the Randolph Mountain Club (see above for listing).

E

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F

Examples of Stewardship Signs

Do's and Don'ts

Do:

- Keep the toilet seat cover down and/or keep the waste valve to the toilet when not being used, to prevent odors
- Put toilet paper down the toilet (paper used for urine only could be excluded)
- Put a handful of organic bulking agent down the toilet periodically
- Use a mild soap when cleaning the toilet seat area
- Bury finished compost in a shallow hole or trench around the roots of nonedible plants

Don't:

- Throw trash, cigarettes, matches or burning material into the toilet
- Use harsh chemicals, chlorine bleach or toxic chemicals in the washbasin, shower or the toilet
- Pour lots of water down the toilet
- Empty composter until it is ready

Figure F.1—Composting Toilet Do's & Don'ts" from The Composting Toilet System Book by David Del Porto and Carol Steinfeld.

FORESTS, PARKS & RECREATION VERMONT

WELCOME TO THE BIRCH GLEN CAMP PRIVY

GREEN MOUNTAIN CLUB THE LONG TRAIL VERMONT

This waste management system is maintained by the Birch Glen Camp Volunteer Shelter Adopter, the VT Department of Forests, Parks, and Recreation, and field staff from the GMC. Proper disposal of human waste is one of our primary concerns in the backcountry. Please help us run this system effectively:

- **PEE IN THE WOODS** -- this will keep odors in the outhouse down and help provide the proper moisture balance for full decomposition.
- **PACK OUT TRASH** -- including tampon applicators, maxi-pads, their wrappers, food waste, paper, etc.
- **THROW IN A HANDFUL OF LEAVES WHEN YOU ARE DONE** -- this also keeps odors down and gets those microbes and bacteria to do their job right away.
- **CLOSE THE LID AND THE DOOR**

THANK YOU!

If you have any questions or comments about this subject or about our backcountry facilities in general, please contact: Director of Field Programs, The Green Mountain Club, Inc., 4711 Waterbury-Stowe Rd. Waterbury Center, VT 05677. (802) 244-7037 <gmc@greenmountainclub.org> <www.greenmountainclub.org>

Figure F.2—An outhouse stewardship sign for a pit toilet. Sign from the Green Mountain Club.

FORESTS, PARKS & RECREATION
VERMONT

WELCOME TO THE
JAY CAMP
MOLDERING PRIVY

GREEN MOUNTAIN CLUB
THE LONG TRAIL
VERMONT

This composting system is maintained by the Jay Camp Adopter, Don Hill, and volunteers and field staff from the Green Mountain Club. Proper disposal of human waste is one of our primary concerns in the backcountry. Please help us run this system effectively:

- **PEE IN THE WOODS** -- this will help keep odors in the outhouse down and provide the proper moisture balance for full decomposition.
- **PACK OUT YOUR TRASH** -- including tampon applicators, maxi pads, food waste, paper, etc.
- **THROW IN A HANDFUL OF LEAVES** -- this also keeps odors down and facilitates the microbial break down of the waste.
- **CLOSE THE LID AND THE DOOR**

THANK YOU

In this privy, redworms and other common soil microorganisms decompose the waste mass of mixed leaves and human manure in aerobic conditions (using oxygen) above the ground level. This is why the outhouse is elevated. Pathogens are destroyed by bacterial and invertebrate competition. If you have any questions or comments on this subject or on our backcountry facilities in general, please contact: Director of Field Programs, The Green Mountain Club, Inc., 4711 Waterbury-Stowe Road Waterbury Center, VT 05677. (802) 244-7037 <gmc@sover.net> <www.greenmountainclub.org>

Figure F.3—An outhouse stewardship sign for a moldering privy composting system. Sign from the Green Mountain Club.

YOU ARE USING A MOLDERING OUTHOUSE

A moldering outhouse is a new design and method to process human waste to lessen the biological impact of human pathogens to the backcountry and it's water sources

We are using red worms to aerate and process the organic material and eventually turn it into a humus-like soil matter which we can spread into the woods. These are the same redworms commonly used in backyard composters.

Please do not pee in outhouse, moisture levels will greatly reduce the amount of worms needed to breakdown the waste.

Please do not throw trash and scraps into outhouse. These worms are not able to make garbage into soil and we have to pack out the contaminated material.

Thank you for complying.

The Green Mountain Club

Figure F.4—One of the Green Mountain Club moldering privy outhouse stewardship signs. Note that this sign asks users not to urinate in the toilet. In this system, the maintainer periodically waters the pile to keep it moist. Some in the backcountry sanitation community feel that excluding urine reduces odors and curtails pathogen travel into the soil. Sign from the Green Mountain Club.

This Is a Moldering Privy

Please:

- **Get a handful of mulch (shavings, rotted leaves or shredded bark) from the container next to the toilet and put it into the privy after each use.**
- **Feel free to urinate in the privy. Moisture benefits this type of composting.**
- **Do not put in trash. This makes the compost hard to handle.**
- **Do not put in food waste. This attracts vermin.**

In this privy, redworms and other organisms decompose the pile of mixed mulch and human waste in aerobic conditions (using oxygen) above ground level, which is why the outhouse is elevated. Moldering, or low-temperature composting, takes longer than high-temperature composting, but requires minimal handling of the material.

Pathogens are destroyed by competition and scavenging by other micro-organisms. Liquid is aerobically treated as it filters through the pile and is absorbed into the biologically active root zone of the soil.

Thank you for your cooperation.

Figure F.5—A moldering privy outhouse stewardship sign on the A.T. in southern Vermont at Little Rock Pond Shelter. Notice that this sign recommends folks urinate in the toilet. There is some debate in the backcountry sanitation community about the desirability of including urine urine in moldering privies. Sign from Dick Andrews, Green Mountain Club.

DANGER

DO NOT ENTER

**FOR YOUR HEALTH,
THE GMC ASKS THAT YOU
NOT ENTER THE
COMPOSTING AREA.**

**HUMAN WASTE IS STORED
AND PROCESSED HERE BY
THE CARETAKER**

**EXPOSURE WITHOUT
PROPER PRECAUTIONS CAN
BE HARMFUL TO YOUR
HEALTH**

Figure F.6—A warning sign to keep the public out of a composting system area and components. Sign from the Green Mountain Club.

Figure F.7—The outhouse stewardship sign used at the Randolph Mountain Club's Bio-Sun systems. Sign from the Randolph Mountain Club.

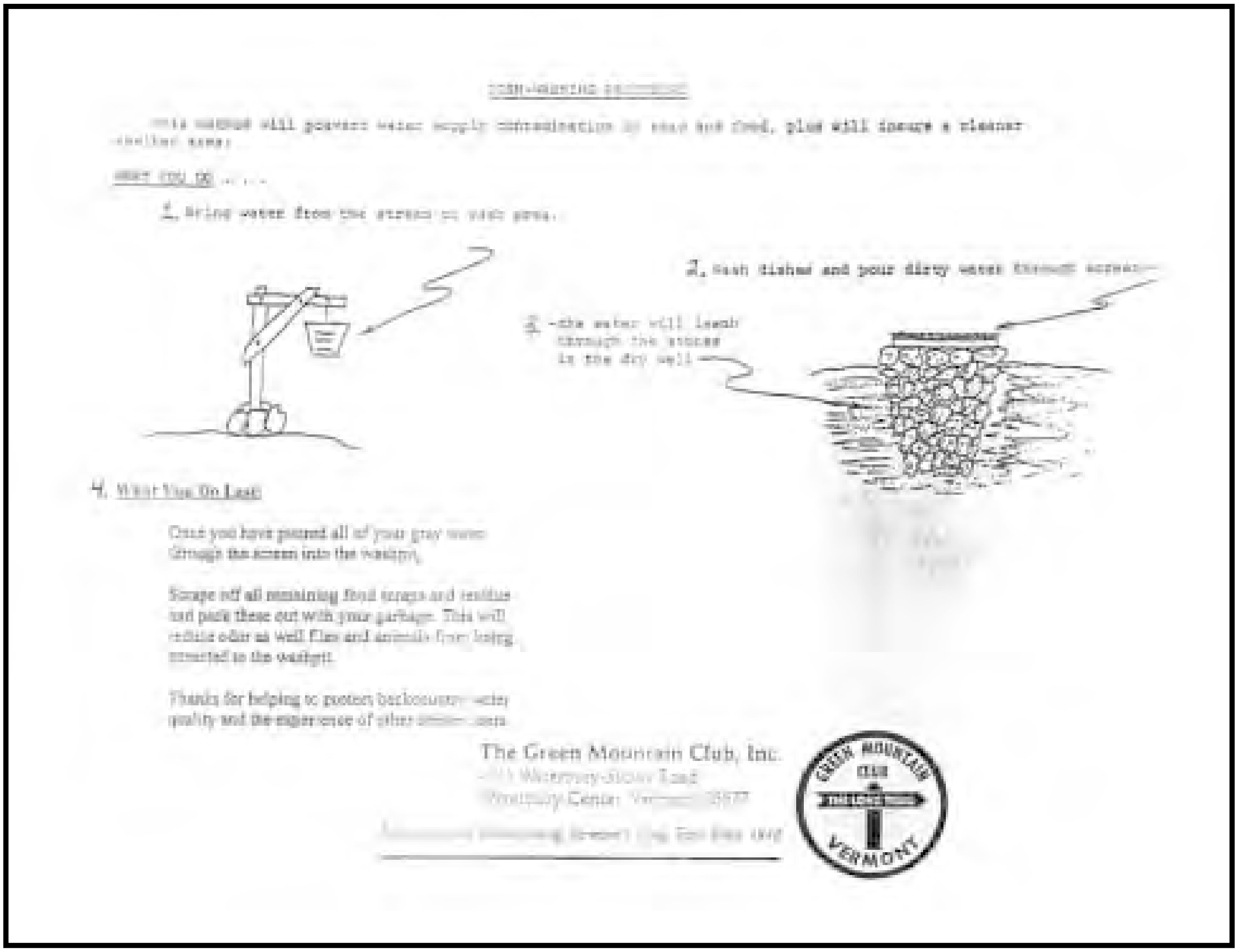

Figure F.8—A sign, including a schematic drawing, designed to be placed in shelters and near washpits to explain to hikers how and why to use the washpit. Drawing from the Green Mountain Club.

Figure F.9—A washpit stewardship sign. Sign from the Green Mountain Club.

WELCOME TO THE
STERLING POND SHELTER
COMPOSTING PRIVY

This composting system is maintained by the Sterling Pond Shelter Adopter, the VT Department of Forests, Parks, and Recreation, and field staff from the Green Mountain Club. Proper disposal of human waste is one of our primary concerns in the backcountry. Please help us run this system effectively:

- **PEE IN THE WOODS** -- this will keep odors in the outhouse down and help provide the proper moisture balance for full decomposition.
- **PACK OUT TRASH** -- including tampon applicators, pads, food waste, paper, etc.
- **THROW IN A HANDFUL OF BARK MULCH WHEN YOU ARE DONE** -- this also keeps odors down and gets those microbes and bacteria to do their job right away.
- **CLOSE THE LID AND THE DOOR**

THANK YOU!

Composting is a method of waste management in which materials of a biological origin are decomposed by common soil microorganisms to a state where they can be applied to the land with little environmental stress. If you have any questions or comments on this subject or on our backcountry facilities in general, please contact: Director of Field Programs, The Green Mountain Club, Inc., 4711 Waterbury-Stowe Road Waterbury Center, VT 05677. (802) 244-7037
<Gmc@greenmoutainclub.org> <www.greenmountainclub.org>

Figure F.10—An outhouse stewardship sign for a batch-bin or a beyond-the-bin composting toilet system. Sign from the Green Mountain Club.

G

Sources of Materials for GMC Batch-bin System

CATCHERS STORAGE CANS AND COMPOST BIN-SIZE CONTAINERS AND LIDS

Polyethylene, round, blue aquaculture tanks 210, 250, 400 gallons 25 year life expectancy GMC uses 210 gallon size for new and replacement bins.

Bonar Plastics
125 N. Christopher Ct.
P.O. Box 1080
Newman, GA 30264

The Tank Depot of RI, Inc.
530 Wellington Ave.
Cranston, RI 02910
(401) 941-8151
Contact: Robin Jones, Pres.

NVF Container Division
P.O. Box 340
Hartwell, GA 30643
1-800-241-8044
Call for catalog.
Makes a wide variety of collection and round tubs, and rectangular bin size containers.

Custom Fabricated Cylindrical Compost Bin Lid (designed to fit compost bin listed above)

The Tank Depot of RI, Inc.
530 Wellington Ave.
Cranston, RI 02910
(401) 941-8151
Contact: Robin Jones, Pres.

70 Gallon Stock Tank with Built-in Drain Plug.

United States Plastic Corp.
1390 Neubrecht Road
Lima, Ohio 45801
(800) 537-9724

Consolidated Plastics Company, Inc.
8181 Darrow Road
Twinsburg, Ohio 44087
(800) 362-1000

32 Gallon Square Storage Cans

Obtain or Order from your local hardware store or garden supply center (These are typically used as trash cans.)

AMC Style Packboard Supplies
Page Belting
Concord, NH 03301
(603)225-5523
(Leather harness pieces)
$50 minimum order

Fortune, Inc190 Route 1
Falmouth, Maine 04105
(AMC packboard corset)

Composting Thermometer
Scale - 200 to 2200

Johnny's Selected Seeds
Foss Hill Rd. Albion, Maine
04910-9731
(207)437-4301

Additional supplies of materials for Batch-Bin composting may be located in the:

Thomas Register of American Manufacturers
Thomas Publishing Company
One Penn Plaza, New York, NY 10001
(available through many libraries)

H

Lightweight Outhouse Plans

H.1 PRIVY

The hardware used on this project consists of three inch screws used on the framing and 5d galvanized box nails for attaching the shiplap sheathing. When I mention to toe nail something I mean to use screws not nails. This entire frame should be constructed before going out into the field, this will prevent any unforseen problems and make it easier to construct at the site. Also the exact dimensions of the interior sheating are not given, especially for the toilet seat, so you will need to figure these out and cut them to size.

1. Cut the two by fours into the lengths shown on the materials list. For parts D, E and K cut a 20 degree angle and then cut to length.

2. Begin with the base frame, this includes all of the pressure treated material used for this structure. Assemble parts A, B and C as shown in Base view.

3. Take pans F and G and screw them together as shown in the seat construction detail.

4. Next screw parts J2 and J3 between parts E.

5. Toe nail the previous section to the base and then attach both sections of F/G to it. Sections F/G can then be attached to the base frame. Now the back wall is secure.

6. Fit part H between the two sections of F/G as shown in the seat construction detail.

7. Next screw both parts I between parts H and J3.

8. Attach part JI between parts D and toe nail this section onto the front of the base frame.

9. Screw both parts K onto parts D and E, the angled end should be towards the front as shown on the side view. Leave an approximately 10 inch overhang on both the front and back.

10. Attach the four parts L as they are shown on the side view. There should be a 19 inch space between the interior parts. In the space will go the spacers M

At this point the framing is finished.

11. Attach parts 0 to parts D, making sure there is a 3/4 inch reveal on the interior (see Front Trim view). This reveal will act as a stop for the door. The resulting 3/4 inch overhang will cover the butt ends of parts Q. Parts O should also go one inch below the joint between part D and the base frame (see the close up on Lower Trim view). Part N will fit between parts O on top to finish off the molding, again provide a 3/4 inch reveal to act as a stop.

12. Start the first course of sheathing on the back, snug, up against parts K. There should be 13 pieces of part P. Then start attaching the 26 pieces of Q (13 courses per side) to the sides. These will butt up against trim part O and cover the ends of parts P.

13. Next start fastening down the interior sheating of the seat, seat front and the floor, this should take around 14 pieces of part P. Three pieces of part P will cover the seat front. Also you will have to cut a hole slightly larger than the toilet seat opening.

14. The last step is to attach the metal roofing. This consists of one piece of three by six foot roofing and another six foot section cut in half widthwise. Make sure this half piece has a "raised" ridge on both sides, so that the pieces overlap and you have something to screw into. Also make sure that it overhangs half an inch over parts K on the front and back.

15. The door will consist of six boards (T) attached with a double Z-brace (parts R, S) along the back (see Door view). Attach this to the door frame. Install the toilet seat. Take a four foot section of the fiberglass screening and install it between part K and the top course of part Q on both sides.

The privy is now completed.

H.2

MATERIALS LIST-PRIVY

A. 2" x 4" x 47" Pressure Treated (2)

B. 2" x 4" x 32” Pressure Treated (3)

C. 2" x 4" x 18 1/2" Pressure Treated (2)

D. 2" x 4" x 81" (2)

E. 2" x 4" x 64 1/2" (2)

F. 2" x 4" x 15" (2)

G. 2" x 4"x 20 1/2" (2)

H. 2" x 4" x 32" (1)

I. 2" x 4" x 22 1/2" (2)

J. 2" x 6" x 28" (3)

K. 2" x 4" x 71" (2)

L. 2" x 4" x 56 1/4" (4)

M.2" x 4" x 19" (6)

N. 1" x 4" x 29 1/2" (1)

0. 1" x 4" x 83 1/2" (2)

P 1" x 6" x 35" (27) Shiplap

Q. 1" x 6" x 47 3/4" (26) Shiplap

R. 1" x 6" x 27" (3)

S. 1" x 4" x 40" (2)*

T. 1" x 6" x 80" (6) Shiplap

* cut to this size first

H.3

RECOMMENDED WOOD PURCHASE

—2" x 4" x lO' (2) Cut one piece into two parts A and one part C. For the other piece, cut it into three parts B and one part C.

—2" x 4" x 8' (9) Cut each piece into the parts () One part D, one part D, parts (E, l), part (E, l), parts (K, G), parts (K, G), parts (L, M, M), parts (L, M, M) and parts (L, M, M)

—2" x 4" x lO' (1) Cut this piece into parts L, F, F and H.

—2" x 6" x 8' (1) Cut this piece into JI, J2 and J3.

—1" x 4" x 8' (1) Cut this for part O.

—1" x 4" x lO' (1) Cut this into one part 0 and one part N.

—1" x 6" x lO' (9) Shiplap. Cut each piece into three parts P, for a total of 27 pieces.

—1" x 6" x 8' (13) Shiplap. Cut each piece into two parts Q, for a total of 26 pieces.

—1" x 6" x 8' (6). Shiplap. Cut each piece into one part T.

—1" x 6" x 8' (1) Cut piece into three parts R.

—1" x 4" x 8' (1) Cut piece into two parts S.

H.4

HARDWARE
MISCELLANEOUS

Metal Roofing: 3' x 7' (2)
Roofing Screws (Minimum 30)
3" Screws (3 lbs. for privy and platform)
5d Galvanized box nails (1/2 lbs.)
1 1/4 Screws for assembling door; platform and cover hardware (50)
6" T-hinge for door (1 pair)
Handle (2), Hook and eye (2 pairs)
Toilet seat

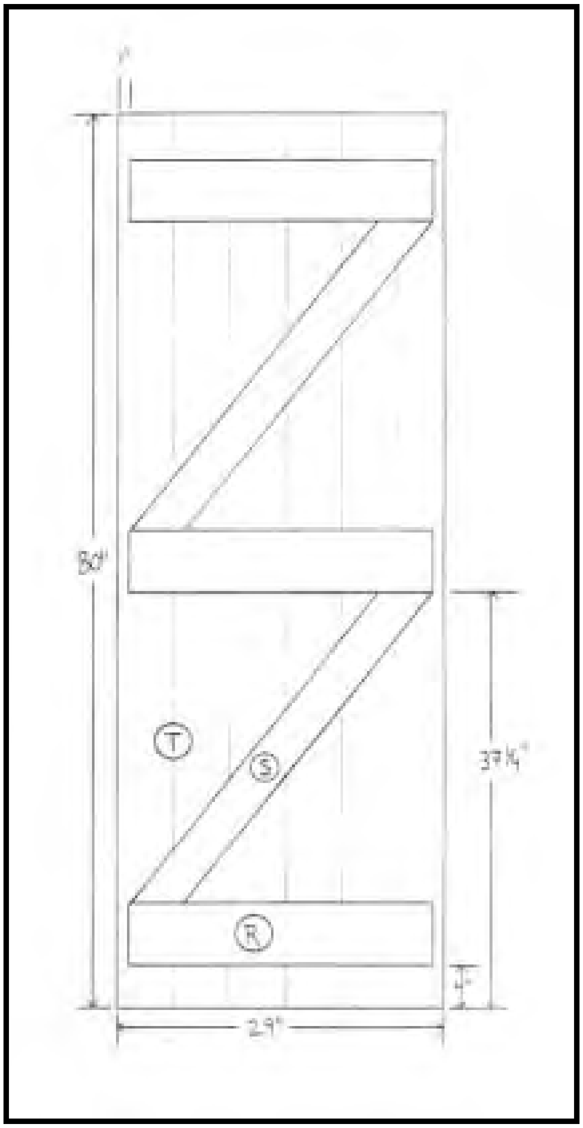

Figure H.1—Plans for a lightweight outhouse. It can be used with a moldering privy, or with a batch-bin or beyond-the-bin system when placed over a vault to hold the catcher (see Chapter 7, the Batch-Bin System). This plan does not show a lift-up bench seat or a rear access door, either of which makes it more convenient to inspect and manipulate the waste pile. Plans from Jeff Bostwick, Green Mountain Club.

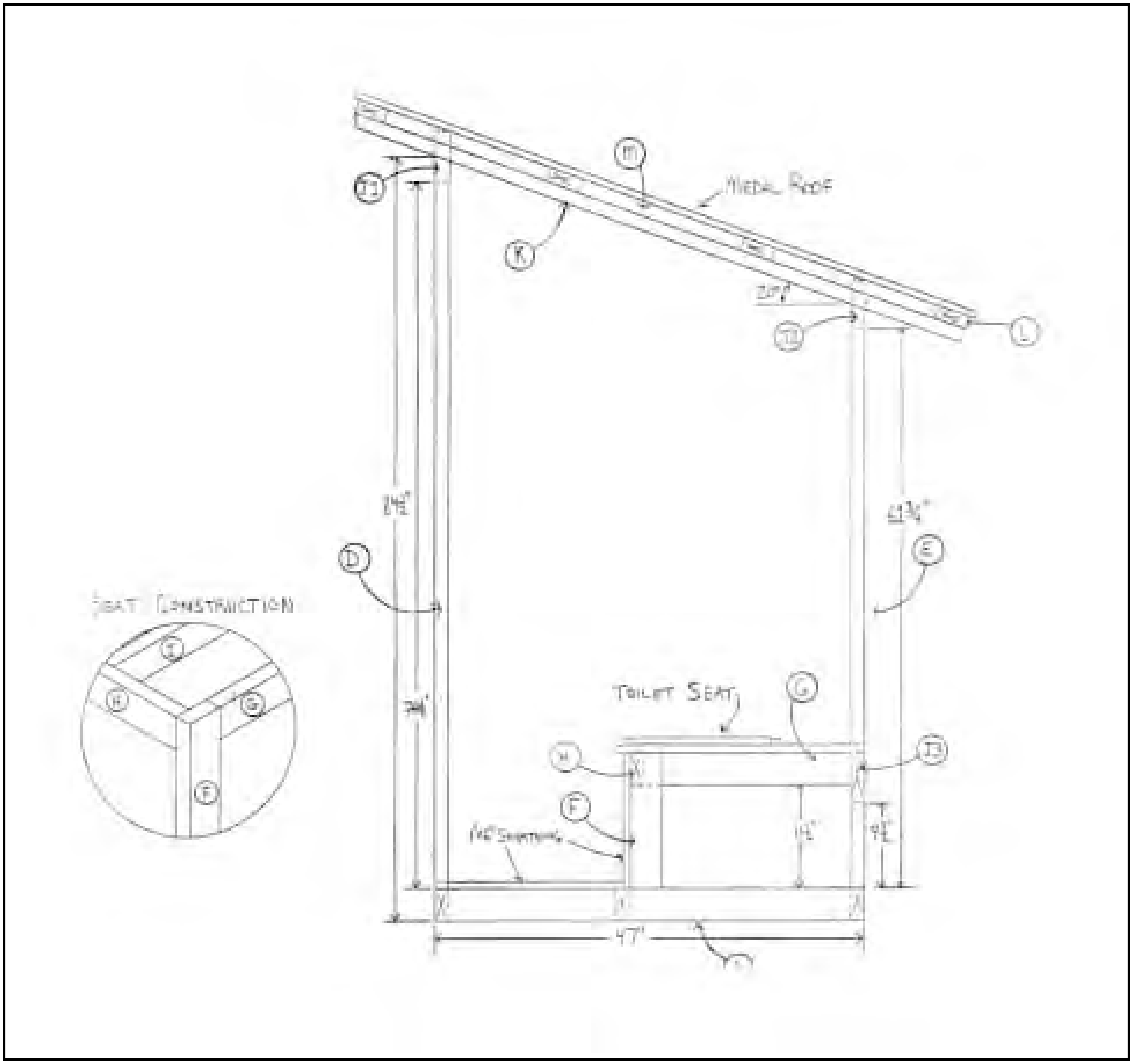

Figure H.2

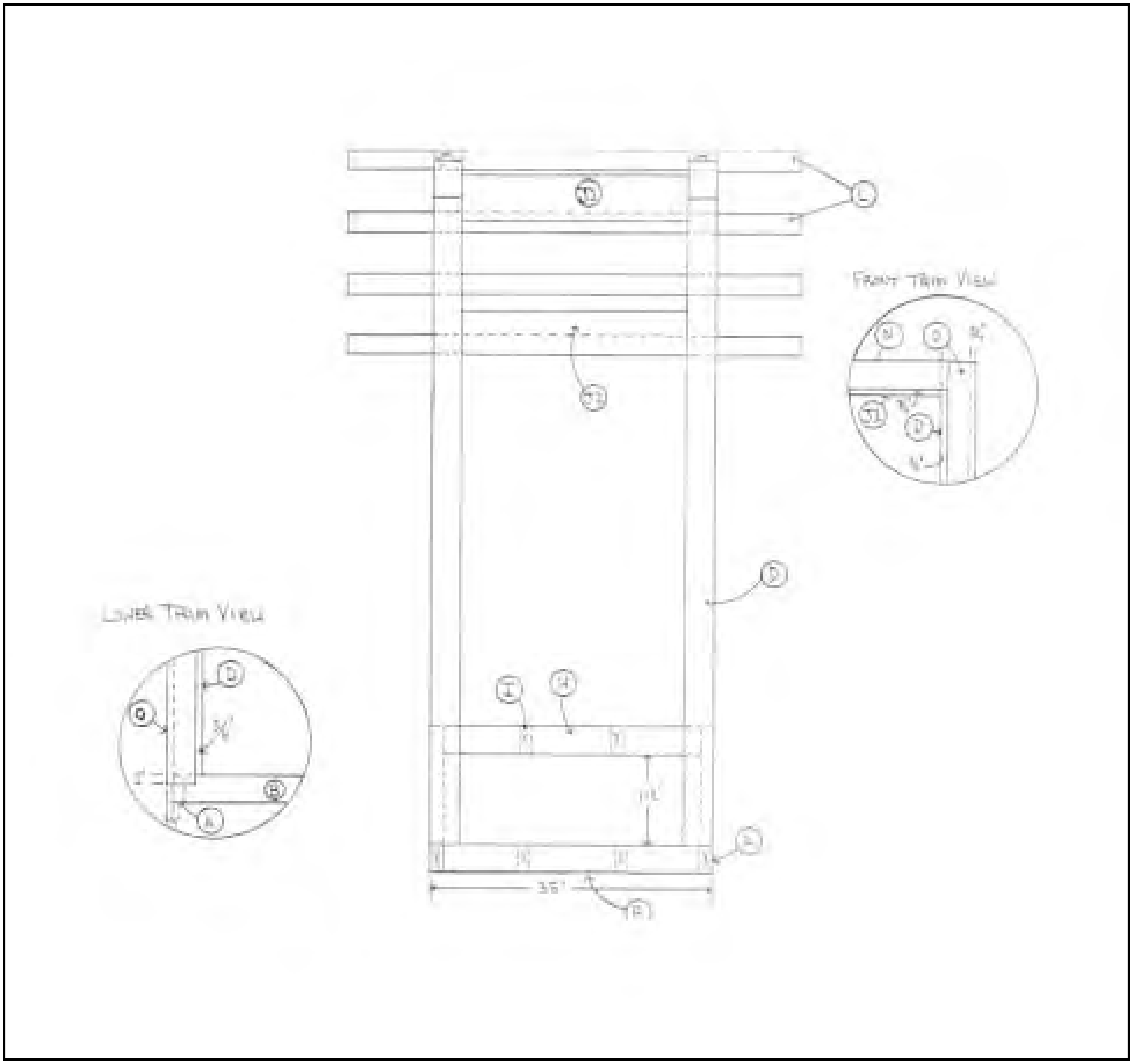

Figure H.3

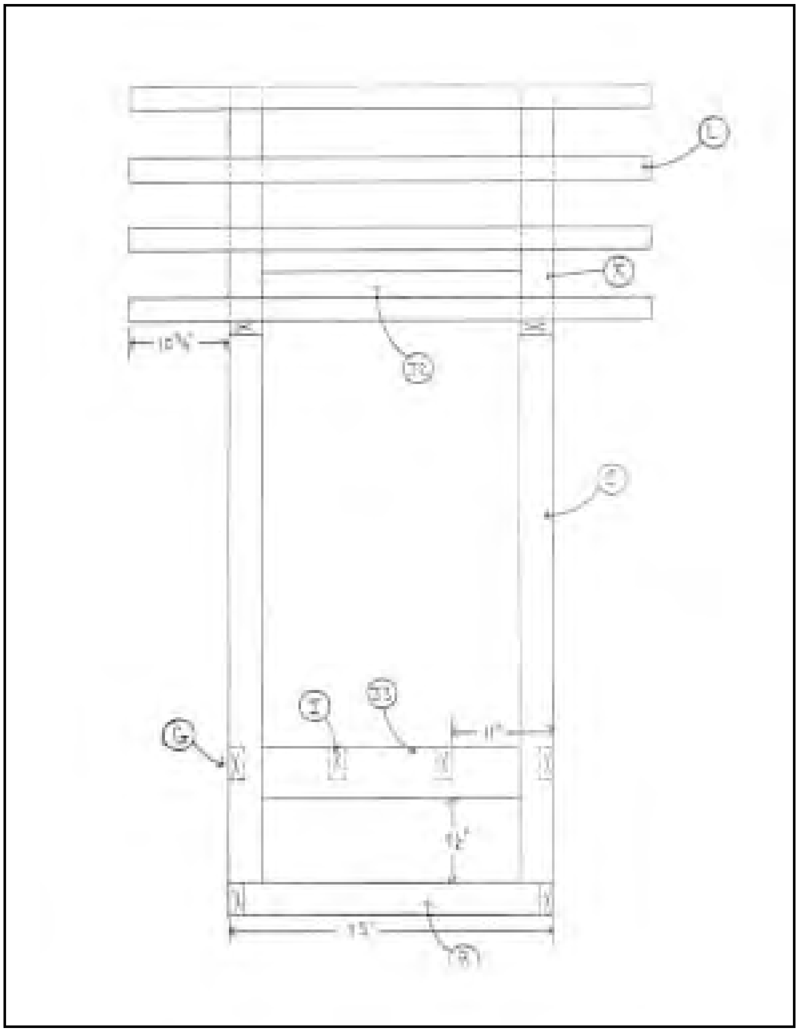

Figure H.4

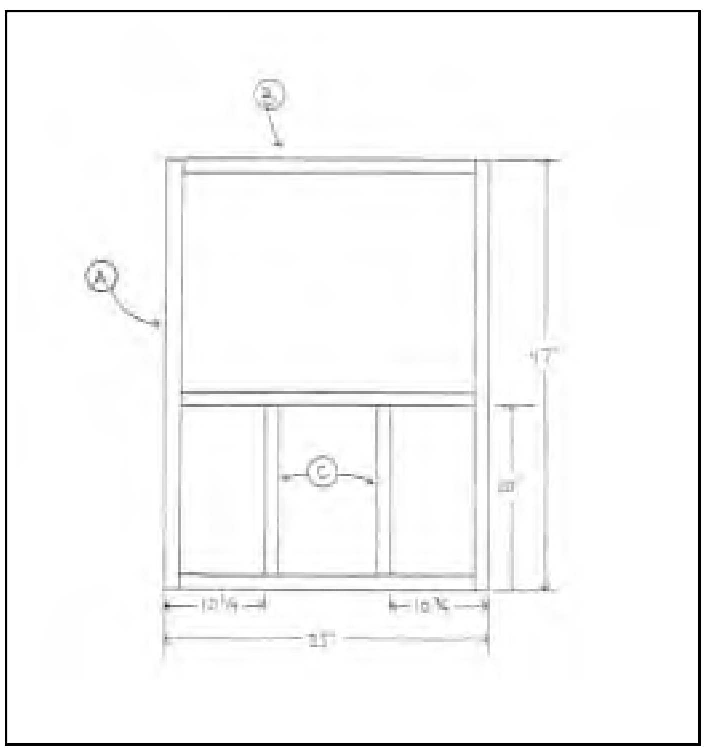

Figure H.5

I

Plans for a Double-Chambered Moldering Privy

I.1

PRIVY PLATFORM/COVER

The screws used on this project are three inches long. The hardware cloth, fiberglass and metal roofing should be cut before heading out into the field (see steps 7, 9 and cover instructions, part 9). I would assemble both structures before going to the site.

Platform

1. Cut material to length as shown on Materials list.

2. Take three of parts C and three of parts A, lay parts A across parts C as shown on front view. Make sure the bottom course is one inch above the bottom of parts C. This will allow for any uneven surface at the site. There also should be a one inch overhang over the end parts C for parts B to butt into. The middle part C is evenly spaced between the other two.

3. Make sure the spacing of parts A is as shown on the front view.

4. Take the other parts A and C and repeat steps 2 and 3.

5. Take six parts B and attach three parts to each end between the front and back sections as shown on the side view. Then attach the remaining parts B to the two middle parts C. The structure is now free standing.

6. Attach parts D and E to the top of the structure. The framing is now complete.

7. The next step is to cut the 3' x 25' hardware cloth into four nine inch wide strips. A jigsaw with a metal blade is best for this.

8. Cut and attach the hardware cloth to both inside and outside of the openings of the platform. Also attach it to both sides of the interior divider. A staple gun works well for this.

9. Next take an 11 foot section of the fiberglass screening and cut if into four nine inch wide sections. Staple this to the outside only of the openings.

10. Attach the joist hangers to the front of the structure where the privy will sit and attach the stringers (F) to that. Then screw down the steps (G) to the stringers.

11. The last step is to attach the privy to the platform. Use the 2" L-brackets, keep the privy two inches from the side edge and one inch from the front and back.

Cover

I. Take a 2" x 8" x 8' and cut into two pieces, one 46 inches long, the other 38 3/4 inches long.

2. With the 46 inch piece measure 1 1/4 inches in width from one edge and 1 1/4 inches in width from the other end and opposite edge. When you connect the two points, there will be a diagonal line (see Parts close up). Cut along this line so that you have two equal parts that look like part H. The angle on this diagonal will be around six degrees.

3. With the 38 3/4 inch section, measure 1 1/4 inches wide along its length. Set your saw to approximately six degrees and make a bevel cut, this will result in part J (see Parts close up). Make sure the width is 1 1/4 inches. The remaining piece (I) will have the same angle and have a maximum width of around six inches. These parts should match up with the ends of parts H as shown on the side view.

4. With part I, a notch will be cut so that it slides under the exterior sheathing of the privy. This notch will measure 3/4” x 3 1/2" (see front view). Make sure that this is cut into the correct end. See Front view.

5. With both parts H, cut a 1 1/2" x 3 1/2" notch 13 inches from each end into the top edge. This notch will accept parts K.

6. Screw parts H between parts I and J. Make sure they are placed in the positions shown on the front view.

7. Secure the frame to the platform with the mending strips, the frame should be flush with the outside edges of the platform.

8. Screw parts K into the notches on parts H.

9. Lastly, cut the metal roof to 51 1/4 inches and attach to the frame. Leave a one inch overhang over the front and back edges.

I.2

MATERIALS LIST-PLATFORM/COVER

All wood for the platform and cover is pressure treated.

A. 5/4" x 6" x 72" (6)

B. 5/4" x 6" x 47" (9)

C. 4" x 4" x 29 1/2" (6)

D. 2" x 4" x 72" (2)

E. 2" x 4" x 42" (3)

F. 4-Step stringer (2)

G. 2" x 8" x 32" (3)

H. 2" x 6" x 46" (2)*

I. 2" x 6" x 38 3/4" (1)*

J. 2" x 1 1/4" x 38 3/4" (1)*

K. 2" x 4" x 38" (2)

* Overall size

I.3 RECOMMENDED WOOD TO PURCHASE

—5/4" x 6" x 10' (6) Take the six pieces and cut each into one part A and one part B.

—5/4" x 6" x 12' (1) Cut this piece into three parts B.

—4" x 4" x 8' (2) Cut each piece into three parts C.

—2" x 4" x 10' (3) Take two pieces and cut each into one part D and one part E. The third piece can be cut into one part E and two parts K.

—2" x 8" x 8' (2) Cut the first piece into parts H and parts I and J. The second piece can be cut into three parts G.

I.4 HARDWARE/ MISCELLANEOUS

Metal roofing: 3' x 5' (1)
Roofing Screws (20)
2" L-Brackets (2 pair) and screws
2" x 8" Joist Hangers (2)
3' x 25' 1/4" Hardware Cloth
3' x 15' Fiberglass Screening (for privy and platform)
Staples
3" Mending strips (4)

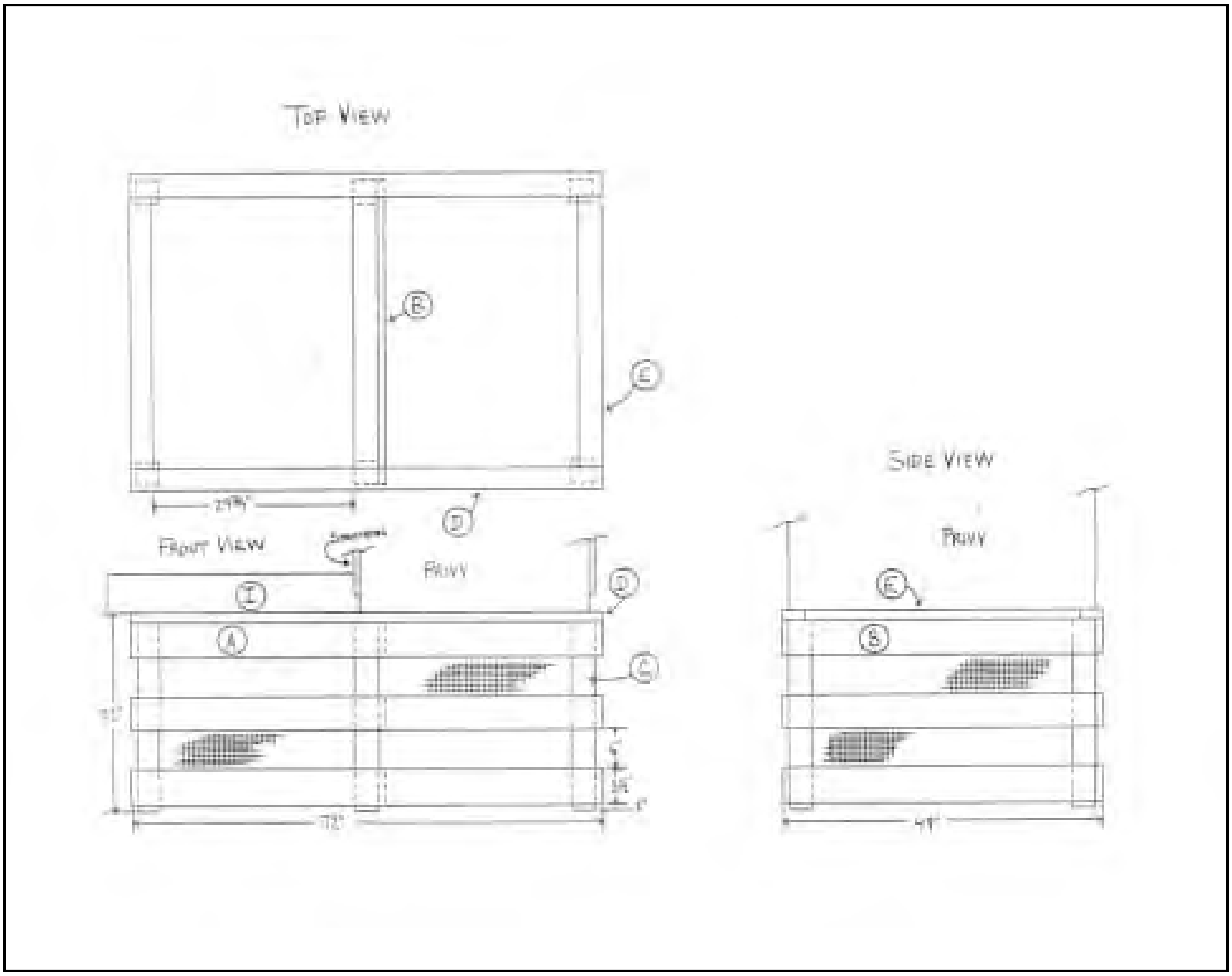

Figure I.1—Plans for the construction of the latest prototype of the Green Mountain Club moldering privy, a double-chambered design. Plans from of Jeff Bostwick, Green Mountain Club.

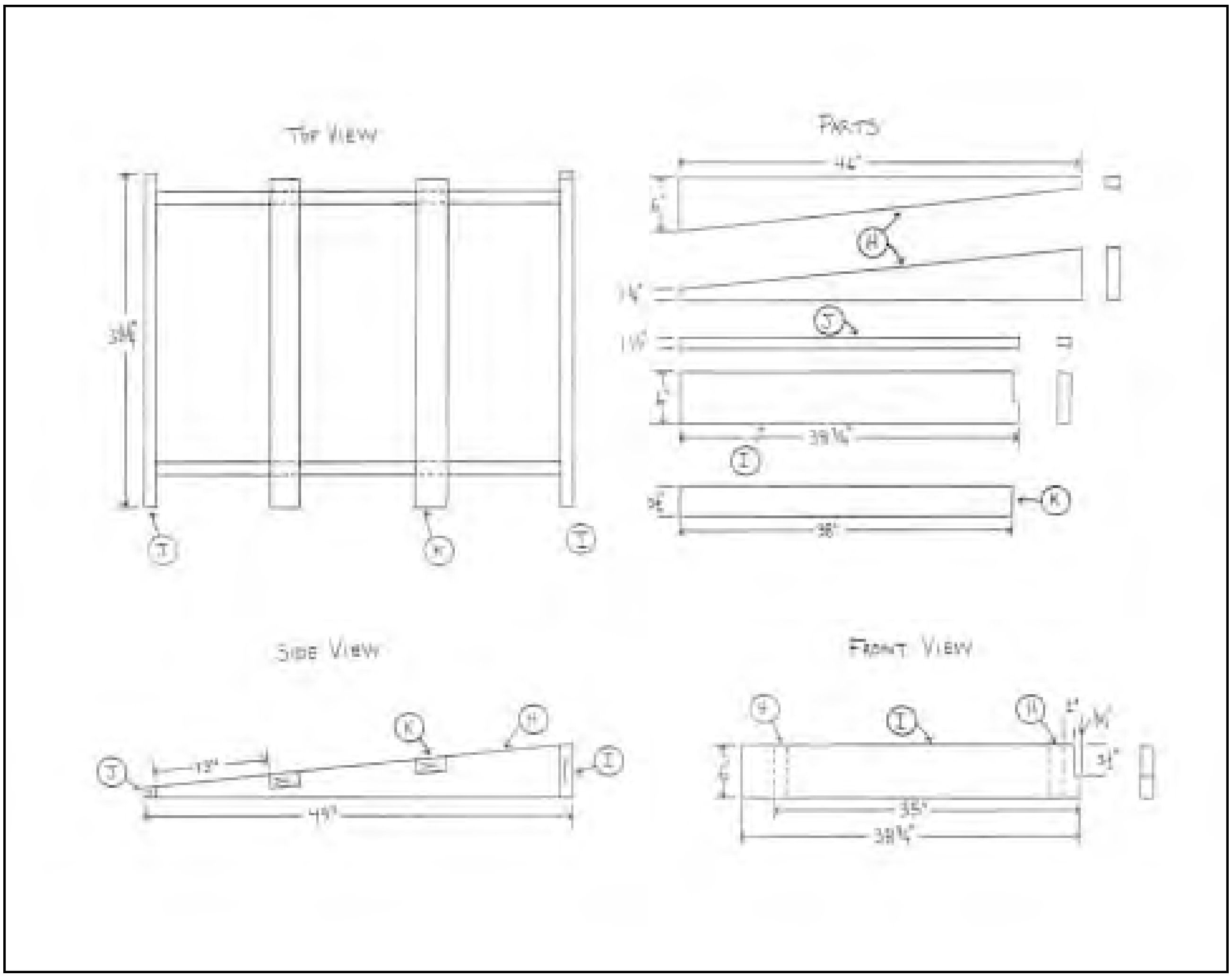

Figure I.2

J

Plans for a Drying Rack

Bill of Materials

Notch $^3/_4$ inch PT Ply. Deck
3 inch x4 inch @ corners type.

Post fillers (2x4)
typ. @ corners

2 PC — 2 x 4 x 8 foot pres. treat. (posts)

3 PC — 2 x 4 x 12 foot SPF (rails, rafters)

5 PC — 2 x 4 x 8 foot SPF (end rails, joists, fillers)

1 PC — 4 x 8 foot — $^3/_4$ inch pres. treat. ply (deck)

2 PC — 4 x 8 foot — $^1/_2$ inch cdx ply (ends, back)

2 PC — 38 inches wide x 54 inches long Galv. Channel Drain Roof

2 lbs. — 3 inch deck screws

1 lbs. — $1^1/_2$ inch deck screws

1 lbs. — $1^1/_2$ inch galv. Roof screws

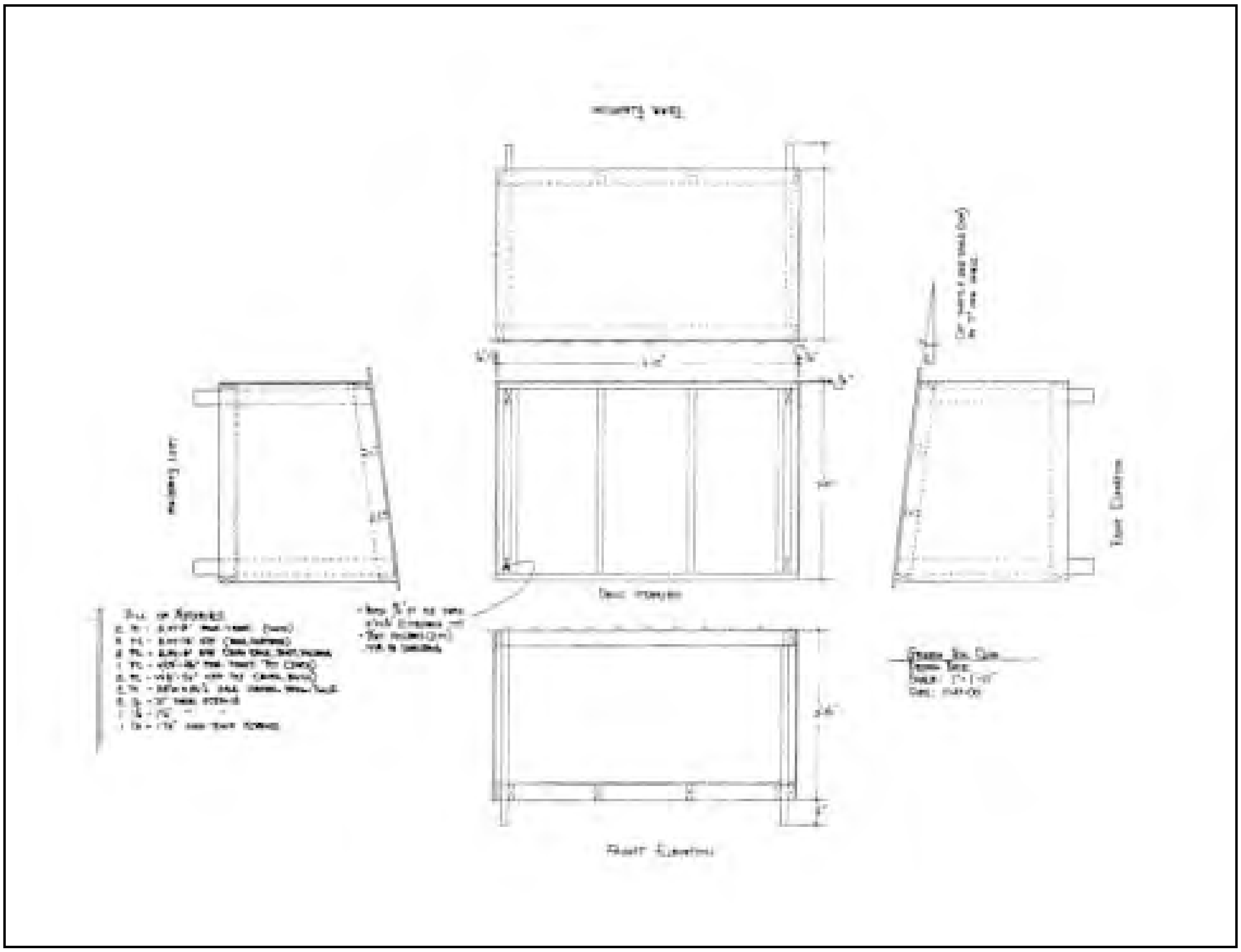

Figure J.1—Diagram of the Green Mountain Club's drying rack, used with their batch-bin and beyond-the-bin and moldering privy systems." Diagram from Eric Seidel and the Green Mountain Club.

K

Diagram of a Washpit

A washpit is composed of a 12" deep hole filled with rocks of varying sizes. It is best to place smaller rocks and gravel towards the bottom of the pit and larger rocks towards the top. On the top of the pit is a wooden frame covered with hardware cloth and screen. This filter will prolong the life of the pit and allow people to pack out their food waste. If you can't dig a 12" deep hole, you will have to construct a runway that leads to a second pit or consider using a designated dishwashing area (see Section 13 for more info).

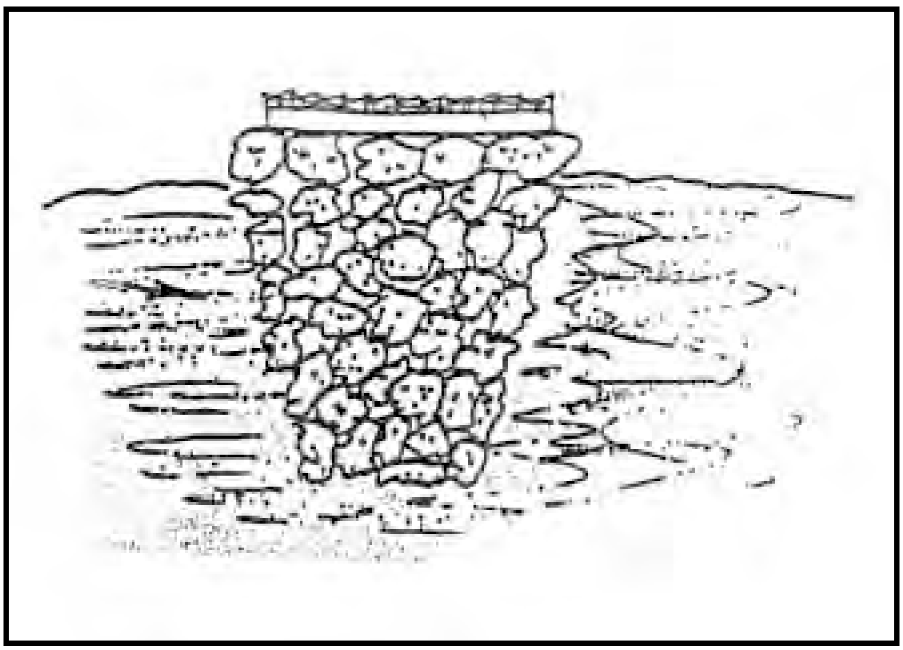

Figure K.1—Green Mountain Club style washpit. Drawing from the Green Mountain Club.

L

Backcountry Sanitation: A Review of Literature and Related Information

By Paul R. Lachapelle, Volunteer, Green Mountain Club

L.1 INTRODUCTION

Sanitation issues associated with recreational activities are often difficult to resolve, particularly in cold climates. Managers and users need information, but literature on sanitation in backcountry settings is scarce, and information on sanitation is often hidden in general outdoor and recreation-related literature.This chapter provides a review of literature, case studies, proceedings and related works dealing with sanitation as it applies to recreation and backcountry use, and presents a chronicle of related research on water quality, recreation and sanitation infrastructure.

L.2 THE EARLIEST RESEARCH

Backcountry sanitation research began in the mid 1970's in response to increased visitation at backcountry sites with low assimilative capacity for human waste. Researchers under the direction of the U.S. Forest Service (USFS) Northeastern Forest Experiment Station in Durham, NH, began to investigate methods of treating and disposing of human waste on-site using a batch (also termed bin or thermophilic) composting system.

Some of the earliest studies, including the work of Fay and Walke (1977), Ely and Spencer (1978), Leonard and Fay (1978), Fay and Leonard (1979) and Plumley and Leonard (1981) detail the batch composting method using a fiberglass-covered plywood bin intersected with perforated PVC (polyvinyl chloride plastic) tubes to increase aeration. The technique used in these early trials was adopted at many sites in New England, and has remained a viable method for managing high volumes of human waste in the backcountry. Contemporary bin composting systems often use high-density plastic containers and liquid treatment devices detailed later in this chapter.

Early studies established that, "(A) bark-sewage mixture can be composted to produce a pathogen-free substance " (Fay and Walke 1977:1) in which "(T)he final product of the compost process is a dark brown, humus-like substance that can be scattered on the forest floor" (Fay and Leonard 1979:37-38).

Leonard and Fay (1978:6) said the composting process was "...as much an art as it is a science," explaining, "(T)he temperature of a compost pile is probably the best indicator of good, aerobic composting."

Ely and Spencer (1978:9) tested the end-product from the batch composting system and found that "...enteric disease-causing organisms (which generally occur in smaller numbers) [sic] could also survive the compost process," and further refined the process by incorporating a drying rack to make the end product safer. "(T)o obtain an end product containing little or no enteric organisms, a six to twelve month holding period is recommended. ...(H)igh pile temperatures are not a guarantee that each and every undesirable organism has been sufficiently exposed to a fatal wet heat. For this reason, composted material should be handled with care at all times."

Leonard and Plumley of the USFS (1979:351, 352) detail the use of both batch composters and a Clivus Multrum continuous composting toilet at several sites in the White Mountain National Forest in New Hampshire. They comment, "(C)omposting systems may be cheaper than the fly-out system or chemical toilets. ...A comparison of total costs over a period of 10 years indicates that composting can be cheaper than other methods despite the additional maintenance time required."

The authors concluded that the batch system offered numerous advantages to other human waste treatment and disposal systems: (1) batch systems are effective in reducing (but not necessarily eliminating) both the volume and pathogenic characteristics of human waste; (2) batch systems can be utilized at diverse backcountry locations; and (3) batch systems offer a cost-effective and economical method of human waste disposal at backcountry sites.

Cook, (1981) also of the USFS, began research of composting toilets in the same period, and described and evaluated the use of 33 bin composters and continuous composting toilet systems in five backcountry locations in the United States. After laboratory tests of fecal coliform content of the end-product from these toilets, Cook (1981:95) found that "(N)either bin nor continuous composting was capable of reducing fecal coliforms to recommended levels," but added, "(I)f the waste after composting can be shallow buried at or near the site [and] results in no detrimental health effects to the public, then perhaps the system of composting can be considered in selected areas."

Passive solar-assisted continuous composting toilet have been used in numerous locations. Franz (1979) and Ely and Spencer (1978) document the use of a Soltran model continuous composting system using large solar panels and an insulated heat storage area to aid the composting process at several sites in the White Mountains of New Hampshire. These units have since been removed because of the expense of installation and maintenance, and their failure to accelerate composting.

Leonard and others (1981) detail sanitation techniques at backcountry sites, including individual disposal, pit toilets, haul-out systems, chemical toilets, advanced composting systems and waterborne waste disposal using filtration and spray disposal systems.

L.3

DEVELOPMENT OF METHODS AND RESEARCH

The National Park Service (NPS) began an active research program in the mid 1980s with the investigation of a dehydrating system and nine Clivus Multrum continuous composting systems in “remote sites that lack power, water, soil depth and vehicle access” in several national parks in the United States (Jensen 1984:1-1). The report states that “(A)ll the compost toilets were found to require a liquid disposal system ...None of the ventilation systems were operating as designed ...Compost systems operating at less than 50% of the recommended loading rate appeared to function with a minimum, or no attention to the process [and] ...None of the units demonstrated the sliding of the solid material on the inclined bottom of the tank.” (Jensen 1984:1-1). The dehydrating toilet detailed in the report is a Shasta model and “...required modifications to provide satisfactory performance, [since] drying the large accumulation of solids was not successful” (Jensen 1984:1-2).

The National Park Service also commissioned a study and report on the use of nine batch composting system in North Cascades National Park in Washington (Weisburg 1988) to determine the feasibility of this technique in high-use humid environments.

Further refinement of the batch system was conducted by the Green Mountain Club in Vermont, which coordinated four editions of the “Manual for Bin Composting and Waste Management in Remote Recreation Areas” beginning in 1977, and most recently updated by Pete Ketcham, Field Supervisor of the Green Mountain Club, as part of this Backcountry Sanitation Manual (2001). This edition details the compost process, the operation of the batch system and troubleshooting techniques. It includes schematics of the composting bin, drying rack and outhouse structure, and lists suppliers of plastic bins useful for composting.

Additional refinements to the batch system include the availability of a commercial bin manufactured by Romtec employing a small solar glazing to increase passive solar gain (Drake 1997). Refinements to continuous composting systems include Phoenix composters with tines to mix waste (Land 1995 a) and Bio-Sun Systems continuous composting toilets with large access doors and geotextile fabric to support waste above the floor of the chamber to increase aeration (Lachapelle 1996).

Increasing backcountry use also prompted research relating on the breakdown of fecal coliform and other bacteria using the “cathole” method. Temple and others (1982:357), in their study of shallow catholes in the Bridger Mountains of Montana, “disappointingly” found that even after a year, “(B)acterial numbers remained on a plateau [meaning pathogen levels had not significantly decreased and] ...Depth of burial made no difference.”

In the 1980s numerous empirical studies were conducted on water quality in backcountry recreation settings (Silsbee and Larson 1982; Tunnicliff and Brickler 1984; Carothers and Johnson 1984; Bohn and Buckhouse 1985; Suk and others 1986; Flack and others 1988; Aukerman and Monzingo 1989). These studies document bacterial contamination of backcountry surface water, the increase of giardiasis in backcountry waters and methods of examining and quantifying water quality. They reinforced the importance of hygienic behavior in the backcountry.

Solar dehydration has been investigated as a potential backcountry sanitation method by the Forest Service and the Park Service. It has been used with varying success on Mt. Whitney in California (McDonald and others 1987) and in Mt. Rainier National Park in Washington (Drake 1997). In addition, the surface water runoff from the dehydrating toilet at Mt. Rainier was tested by Ells (1997), who was not able to document water contamination. However, the dehydrated end product from these toilets is often high in pathogens, difficult to handle and cannot be disposed of on-site.

L.4

WORKSHOPS AND PROCEEDINGS

Numerous conferences and workshops have focused either peripherally or specifically on waste management options in the backcountry. The Alpine Club of Canada (ACC) held the symposium "Water, Energy and Waste Management in Alpine Shelters" in 1991 at Chateau Lake Louise, Alberta, the first meeting on backcountry waste management. The proceedings describe waste management technologies at various ACC backcountry sites, including septic and gray water systems, fly-out systems and incineration systems (Jones and others 1992).

The "Backcountry Waste Technology Workshop" held March 30-31, 1993, at Mt. Rainier National Park in Washington hosted about 25 participants from Canadian and United States organizations. It considered professional experiences with pit and vault toilets, composting, dehydration, and fly-out and carry-out techniques (Mt. Rainier National Park 1993). Workshop participants identified a need for a document covering design considerations for backcountry waste systems and a need to give higher priority to management of and budgeting for human waste. The agenda was continued the following year in Yosemite National Park in California with a workshop that resulted in a document on continuous composting toilets and issues of compliance, design, construction, operation and maintenance (Yosemite National Park 1994).

The conference "Environmental Ethics and Practices in Backcountry Recreation" in Calgary, Alberta, in 1995, sponsored by the Alpine Club of Canada, contained a session on backcountry waste management, and produced a proceedings of conference papers (Josephson 1997). The proceedings contain an analysis by Drake (1997), who documents the use of a "blue bag" policy for an individual pack-out requirement on several of the popular climbing routes of Mt. Rainier. Drake reports that compliance is much lower than expected.

Most recently, the Australian Alps Best Practice Human Waste Management Workshop was held in Canberra, Australia, March 27-31, 2000, hosted by the Australian Alps National Parks. The proceedings contain more than 30 papers covering such subjects as personal carry-out techniques using "pootubes," and accounts from site managers in Australia and New Zealand of on-site and off-site treatment and disposal techniques including composting, septic and vermiculture systems (which use worms to aid decomposition of waste) (Australian Alps National Parks 2000).

L.5

CURRENT STATE OF KNOWLEDGE

Recent research on perceptions of backcountry waste issues reveals that 25 percent of National Park Service managers find human waste to be a common problem in many or most areas, and 43 percent consider it a serious problem in a few areas (Marion and others 1993). In their study of social and ecological normative standards, Whittaker and Shelby (1988) found that the standard for human waste represented a no-tolerance norm, in which 80 percent of the respondents reported that it was never acceptable to see signs of human waste.

Voorhees and Woodford (1998) document the recent controversy over the expense of several continuous composting toilets in Delaware Water Gap National Recreation Area in New Jersey and Pennsylvania and in Glacier National Park in Alaska. The authors argue that although the project was widely criticized, by using environmentally-sensitive materials the structure actually minimized the life-cycle cost of the facility (Voorhees and Woodford 1998:63).

Further refinements of bin composting have been investigated by the Appalachian Mountain Club White Mountain Trails Program with funding from the Appalachian Trail Conference and the National Park Service. The resulting document describes the "Beyond the Bin Liquid Separation System" used to treat excess liquid from the standard batch-bin composting system (Neubauer and others 1995).

The U.S. Forest Service has continued its commitment to an active research program, particularly through its Technology and Development Center in San Dimas, California, including two documents by Land (1995a,b) describing various bin and continuous composting toilets and other remote waste management techniques.

In addition, the Aldo Leopold Wilderness Research Institute has been active in research on visitation management and low-impact recreational practices, including sanitation in federally designated Wilderness in the US (Cole 1989; Cole and others 1987). Lachapelle (2000) examines human waste treatment and disposal methods in designated Wilderness, and supplies a decision-making matrix and flow chart to help managers consider the pros and cons of various backcountry waste management techniques and their social and biophysical implications.

It is now possible to use DNA testing to reveal the sources of fecal coliform colonies in backcountry water sources. This technique has been used to document human fecal contamination in high-use backcountry areas of Grand Teton National Park in Wyoming (Tippets 1999, 2000).

Studies directed by the USFS examine the use of a passive solar device to further treat and inactivate the end product of composting toilets. These studies indicate that a solar "hot box" can pasteurize compost and save transport and disposal costs, while providing more safety for field personnel (Lachapelle and Clark 1999; Lachapelle and others 1997).

Most recently, Cilimburg and others (2000) have produced a comprehensive examination of various backcountry waste management practices with a focus on past studies of the pathologies of water contamination and their implications for recreational activities.

Many books describe commercial composting toilets and other methods of disposal and treatment of human waste in the backcountry. These include the books by Meyer (1994), who explores anecdotal and often amusing accounts of handling human waste in the backcountry; Hampton and Cole (1995), who describe waste treatment and disposal techniques in a variety of environmental situations; Del Porto and Steinfeld (2000), who detail choosing and planning a composting toilet systems with a focus on commercial systems and related state statutes; and Jenkins (1999), who describes a more homemade approach to batch composting.

L.6

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Editor's Note:

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The Application of a Solar Hot Box To Pasteurize Toilet Compost In Yosemite National Park

November 11, 1998

Paul R. Lachapelle, John C. Clark

Land managers today are continually searching for sustainable backcountry management techniques while decreasing operational expenditures and the use of human resources. The public is also increasingly concerned about expedient backcountry infrastructure projects including the construction of innovative toilet facilities (Voorhees & Woodford, 1998). Past research has documented composting toilet technologies as a low-cost, efficient and sustainable method of backcountry human waste treatment (Davis & Neubauer, 1995; Land, 1995 a,b; Yosemite NP, 1994; Mount Rainier NP, 1993; Weisberg, 1988; McDonald *et al*. 1987; Jensen, 1984; Cook, 1981; Leonard *et al.*, 1981).

While considerable research has demonstrated the operation and maintenance of composting toilets in the backcountry, few studies have explored proper methods of composting toilet end-product disposal. In 1996, the USDA Forest Service, San Dimas Technology and Development Center and the USDI National Park Service, Yosemite National Park, conducted a cooperative study in the development and operation of a passive solar insulated box (termed the “Hot Box”) to treat the end-product from composting toilets used by hikers in the backcountry. The study demonstrated that the Hot Box could consistently meet U.S. Environmental Protection Agency heat treatment requirements and produce a class A sludge that could be surface-applied as outlined in 40 Code of Federal Regulations (CFR) Part 503 (Lachapelle *et al*. 1997). According to the regulation, this heat treatment is a function of time and temperature.

The study demonstrated that the time-temperature requirement could consistently be met in Yosemite NP, an area that proved ideal because of high ambient air temperatures and consistent sunlight throughout much of the summer.

Field staff at Yosemite NP tested the application of the Hot Box to pasteurize large quantities of end-product during the summers of 1997 and 1998. Field staff report that the Hot Box operated well and required minimal labor under optimal conditions.

All of the end-product removed from backcountry toilets in Yosemite NP was previously sealed in plastic bags, deposited into designated dumpsters and then thrown away in a local landfill. The end-product is now surface-applied out of the park in local flower gardens near the park headquarters in El Portal.

Background

The development of backcountry composting toilet methods resulted from the need to reduce impacts including surface water pollution at overnight sites. Research of backcountry composting systems began in the mid-1970's and focused on sites with up to 2,000 overnight visitors per season (Fay & Walke, 1977; Ely & Spencer, 1978).

Composting technologies became increasingly popular as research documented the ineffective break-down of coliform bacteria using the "cat-hole" disposal technique (Temple *et al*. 1982) and as certain composting toilet technologies were shown to be a low-cost solution for human waste treatment and disposal (Leonard & Fay, 1979; Leonard & Plumley, 1979). Thermophilic composting (also termed batch or bin) and mesophilic composting (also termed moldering or continuous) have been used with varying degrees of success in numerous National Parks (Yosemite, Mt. Rainier, Olympic, Grand Canyon) and National Forests (White Mountain, Green Mountain).

The aim of any composting technology is to optimize conditions for microbial growth. Combining the proper amount of carbon (also termed bulking agent and usually consisting of woodchips or shavings), moisture, ambient heat and oxygen enhances the living conditions within the compost pile for natural oxygen-using microorganisms (aerobes). These aerobes use human waste as a food source and consequently, the waste decomposes over time into a soil-like substance. Disease-causing organisms (pathogens) within the human waste are reduced or eliminated due to competition, natural antibiotics, nutrient loss and heat.

The human waste and the carbon are in most cases manually mixed in an enclosure or sealed bin. The term *end-product* refers to the composted woodchips and human waste. The composting process functions optimally with a carbon to nitrogen ratio of 25-35:1 and a moisture content of 60% (Davis & Neubauer, 1995).

The aim of thermophilic composting, which requires frequent mixing (several mixes per week) and high woodchip input (approximately 1 kg of carbon to 1 liter of human waste), is to kill pathogens quickly and with hot temperatures. These temperatures result from microbial activity and can exceed 45 degrees C. Once a sufficient amount of human waste has been collected, a compost "run" is started and can take up to several weeks to complete.

Mesophilic composting in comparison is a long-term method that can take years to effectively reduce pathogens within the waste. Additionally, the frequency of mixing and the amount of carbon added are considerably lower than thermophilic methods with temperatures within the waste pile ranging between 10 degrees C to 45 degrees C.

However, complete pasteurization of composting toilet end-product by either treatment method can never be guaranteed and depends on the quality of maintenance and site conditions. Heat treatment, such as the Hot Box can provide, is one method to ensure pathogen reduction and meet 40 CFR Part 503. Consequently, the Hot Box can help in a number of ways.

First, if land management policy dictates that the end-product can be surface-applied at the backcountry toilet site, significant savings in transportation costs could result. Additionally, the biophysical and social impacts from using either pack animals or helicopter resources could be reduced.

Second, while land management policy may dictate that the end-product be transported outside of a protected area boundary, heat-treated compost is less of a health and safety issue to field staff. Since, for example, a fundamental tenet of the Wilderness Act states that the wilderness area be “protected and managed so as to preserve its natural conditions” (Wilderness Act of 1964, Sec 2c), surface-applied compost in these areas could be problematic. Unquestionably, increased nutrient levels resulting from on-site disposal could upset natural species assemblages by shifting the competitive advantage to invasive non-native plant species. However, end-product that is heat-treated in the backcountry would be a considerably lower health hazard to field staff regarding accidental spillage during transport or disposal.

Third, if the end-product cannot be surface-applied at the site and the Hot Box cannot be used in the field because of staffing or ordinance issues, landfill disposal savings could result.

Lastly, the treated end-product could be reintroduced into the composting toilets as bulking agent which would reduce the amount of additional bulking agent needed.

Hot Box Description and Application

The Hot Box is a nearly air-tight container that allows the sun’s short-wave radiation or light energy to pass through the glazing. The contents of the Hot Box absorb the light energy and convert it to long-wave radiation or heat energy which becomes trapped inside the box.

The 1996 USFS/NPS study demonstrated that temperatures of over 100 degrees C (212 degrees F) can be reached and temperatures of 88 degrees C (190 degrees F) can be sustained for several hours.

The outside walls, floor and removable tray are fabricated from an approximately .5 cm thick aluminum sheet. A single transparent Lexan® Thermoclear polycarbonate sheet is used as the solar glazing and is bolted at an angle specifically designed to maximize the angle of incidence during the summer solstice for the chosen latitude (at Yosemite NP, 38 degrees north latitude, a 15 degree angle was chosen). This angle could be adjusted for other locations. The inside walls and floor are insulated with 5 cm poly-isocyanurate closed-cell foam. A door is positioned at the back of the Hot Box in order to gain access to the tray. The original Hot Box measured 122 cm x 94 cm x 69 cm at the highest end and 46 cm at the lowest end.

Four new Hot Box’s, measuring 122 cm x 122 cm x 61 cm at the highest end and 20 cm at the lowest end have recently been built and appear to be more efficient because of their larger glazing and decreased internal air volumes.

Yosemite NP field staff operated the Hot Box during the 1997 and 1998 summer seasons at the park headquarters in El Portal. Yosemite contains 6 backcountry composting toilets that collectively produce approximately 20 cubic meters (700 cubic feet) of end-product. Since most of the backcountry composting toilets are located in federally designated wilderness areas, the end-product has been transported outside of the boundaries. End-product is transported in double plastic bags by pack animals to trailheads and then trucked to El Portal. Approximately 9 cubic meters (300 cubic feet) was pasteurized in 1998. Field staff emptied a portion of the bags into the Hot Box tray and allowed the compost to pasteurize for up to one week. It took one operator one-half hour per day two days per week to process approximately one cubic meter (30 cubic feet) of end-product.

The 1996 USFS/NPS study concluded that end-product pile depths in the tray of 12 cm or less and two and one-half hours of direct sunlight with ambient air temperatures exceeding 28 degrees C (83 degrees F) were most effective at meeting the time-temperature requirement. Additionally, a moisture content of 60 percent or less allowed for maximum temperature attainment.

Field staff would mix the end-product in the Hot Box tray several times during the heat-treatment process to ensure thorough pasteurization. After pasteurization, the finished compost was again bagged and brought to local flower gardens and spread thinly on the surface. Operators reported that the pasteurized compost resembled mulch and not human waste in both texture and odor and was therefore more tolerable to work with.

Conclusion

The passive solar Hot Box has been used for two field seasons in Yosemite NP, a location shown to be ideal to effectively pasteurize the compost from backcountry toilets. This application stems from the 1996 USFS/NPS study that demonstrated the use of the Hot Box as an effective method of composting toilet end-product pasteurization. Field staff report that the developed Hot Box technology required a minimum level of attention and maintenance by the operator and produced a compost that is dryer and appears less offensive to handle and transport. It is anticipated that further use of the Hot Box will refine design and performance imperfections.

While stringent regulations may negate the possibility that finished compost be surface-applied in wilderness and national park areas, the Hot Box holds tremendous potential to save either transportation costs and associated impacts in areas where the end-product can be surface-applied on-site, or disposal costs where the end-product must be transported and disposed off-site. Conceivably, this passive technology can serve as a sound and sustainable backcountry management technique, alleviating impacts, costs and extensive use of human and animal resources while providing an added safety margin to field personnel.

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Paul Lachapelle is a Research Assistant at the University of Montana. He can be reached at School of Forestry SC 460 University of Montana Missoula, MT 59812; Tel: (406) 243-6657 Fax: (406) 243-6656 Email: <paullach@selway.umt.edu>

John C. Clark is Facility Management Specialist at Yosemite National Park. He can be reached at El Portal, California 95318 USA Tel: (209) 379-1039 Fax: (209) 379-1037 E-mail: <John_C_Clark@nps.gov>

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Examples of Regulatory Correspondence

State of Vermont

AGENCY OF NATURAL RESOURCES
WATER SUPPLY AND WASTEWATER DISPOSAL

LAWS/REGULATIONS INVOLVED 10 V.S.A., Chapter 61, Water Supply and Wastewater Disposal and Environmental Protection Rules,
Chapter 1, Small Scale Wastewater Treatment and Disposal Rules
Subchapter 4, Water Supply and Wastewater Disposal
Subchapter 7, Sewage Disposal
Appendix A, Design Guidelines
Chapter 21, Water Supply

CASE No: WW-5-1542 PIN No.# 0833-0001
APPLICANT: University of Vermont
Attn: Rick Paradis
ADDRESS: 153 South Prospect Street
South Burlington, VT 05401

This project, consisting of the construction of a composting-type toilet facility at Butler Lodge, located at Mt. Mansfield State Forest, Stowe, Vermont, is hereby approved under the requirements of the regulations named above subject to the following conditions:

1. GENERAL CONDITIONS

1.1 The project must be completed as described on the plans and/or documents listed as follows:
Butler Lodge Trail Site Plan, Dated 12/93, VT Department of Forests, Parks, & Recreation;
A Study of System Improvements to Traditional Batch Composting, Dated 1995, Appalachian Mountain Club,
and which have been stamped "APPROVED" by the Wastewater Management Division. No alteration of these plans and/or documents shall be allowed except where written application has been made to the Agency of Natural Resources and approval obtained.

1.2. A copy of the approved plans and the Water Supply and Wastewater Disposal Permit shall remain on the project during all phases of construction and, upon request, shall be made available for inspection by State or Local personnel.

1.3. No alterations to the existing building other than those indicated on the approved plan, which would change or affect the water supply or wastewater disposal shall be allowed without prior review and approval from the Wastewater Management Division.

1.4. This authorization does not relieve you, as applicant, from obtaining all approvals and permits as may be required from the Department of Labor and Industry (phone 479-4434) and local officials PRIOR to construction.

1.5. By acceptance of this permit the permittee agrees to allow representatives of the State of Vermont access to the property covered by the permit, at reasonable times, for the purpose of ascertaining compliance with Vermont environmental and health statutes and regulations and with the permit.

1.6. This permit shall in no way relieve you of the obligations of Title 10, Chapter 48, Subchapter 4, for the protection of groundwater.

2. WATER CONDITIONS

2.1. There shall be no domestic water system connected with this project without prior written approval from the Wastewater Management Division.

3. SEWAGE DISPOSAL CONDITIONS

3.1. This project is approved as an innovative composting system, as described in section 1-203 of the Environmental Protection Rules, to address wastewater disposal at Butler Lodge. The system is designed to reduce the impact of an inadequate wastewater disposal system at the existing lodge. As such, the Wastewater Management Division grants variances under section 1-202 of the Environmental Protection Rules.

Figure N.1—Copy of the wastewater permit issued to the Green Mountain Club in 2000 for the installation of a beyond-the-bin system at Butler Lodge on the Long Trail. This situation was a great example of how a state agency, unaware of composting technology, learned about it when the Green Mountain Club provided a credible plan and specifications for the system. The state subsequently approved the system. Letter from the Green Mountain Club.

WATER SUPPLY AND WASTEWATER DISPOSAL PERMIT
WW-5-1342, University of Vermont
PAGE 2

3.2. The construction of the composting toilet system shall be done in accordance with the approved Appalachian Mountain Club specifications. Representatives of the Green Mountain Club shall submit written documentation verifying proper construction of the system. Any variations required during construction shall be described outlining the need for the variance and the solution.

3.3. The system shall be maintained in accordance with the Appalachian Mountain Club specifications and a maintenance log shall be maintained at the site. During maintenance exposure to all pathogen containing waste shall be minimized and reasonable human and environmental protection required. Prior to the removal and burial of composted waste, representatives of the Green Mountain Club shall contact the Wastewater Management Division so a representative from that office may have the option of viewing and approving the burial site.

3.4. Compost burial sites shall be selected to avoid exposed bedrock, wetland areas, the most environmentally sensitive areas, and areas commonly accessible to hikers.

Canute Dalmasse, Commissioner
Department of Environmental Conservation

By ______________________ 9/21/2000
Donald Wernecke, Regional Engineer

CC Green Mountain Club
Stowe Planning Commission
VT Dept. of Labor & Industry
Central Office of Wastewater Management Division

STATE OF CONNECTICUT

DEPARTMENT OF PUBLIC HEALTH

January 29, 2001

David Boone
CT Chapter AMC Trails Committee
370 Gilead Street
Hebron, CT 06248

RE: INSTALLATION OF SHALLOW RED WORM MOLDERING PRIVIES

Dear David

I have received your letter dated January 11, 2001 requesting clarification as to whether installation of shallow privies which take advantage of red worm moldering to assist in the decomposition process are acceptable for use in Connecticut. As you know, Section 19-13-B103 of the Connecticut Public Health Code does make provisions for construction of non-discharging sewage disposal systems that do not require use of a water supply.

Based upon the description and information, which you submitted concerning this privy, it appears installation would be, suitable in Connecticut provided the bottom of such privy was located at least 18 inches above maximum ground water levels and 4 feet above ledge rock. Installation of privies would still be subject to review and approval by local health agencies. Soil testing could be simplified to crowbar borings to confirm depths to bedrock and shallow post hole excavations to log color, soil characteristics and ground water potential if not excavated during the wet time of the year. The important aspect of any privy is to maintain the structure free from insects, rodents and other animals. The screening should be of adequate strength and opening size to deny access for both insects and animals. We understand the application of red worms is beneficial in speeding up the decomposing process. This will reduce the frequency for privy relocation, as pit privies tend to fill up in time thereby requiring abandonment and relocation to a new pit.

Please feel free to use this letter as a means of notifying local health agencies as to the acceptability of this process and their involvement in the review, testing and approval of such units where applicable.

If you have any questions or would like to further discuss the red worm privy, please contact me.

Very truly yours

Frank A. Schaub
Supervising Sanitary Engineer
Environmental Engineering Section

FAS/jm

Phone: 860-509-7296
Telephone Device for the Deaf (860) 509-7191
410 Capitol Avenue - MS # 51SEW
P.O. Box 340308 Hartford, CT 06134

Figure N.2—A copy of a letter written by the Appalachian Mountain Club's Connecticut Chapter Trails Committee to State of Connecticut's Department of Public Health when seeking permission to install moldering privies on the A.T. in Connecticut. This is an excellent example of one of the key steps in the process of seeking approval for the installation of a sanitation management system on the A.T. Please keep in mind that in other states the process may require writing more than one letter to the state, and may also include town and county health departments." Letter from David Boone, Connecticut Chapter Trails Committee of the Appalachian Mountain Club.

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GMC Improves Sewage Management Along Long Trail

From *The Register,* vol. 23, number 4 (Winter 1999).

By Pete Ketcham

During the 1999 field season, the Green Mountain Club (GMC) enhanced backcountry waste management at several sites on the northern portion of Vermont's Long Trail through several innovations in both technology and technique.

"Beyond the Bin" (BTB) liquid-separating composting toilets were built at both the base of Camels Hump and at Taft Lodge, located just below the summit of Mt. Mansfield, Vermont's highest peak (4,395'). In addition, moldering privies were constructed at Taylor Lodge, Jay Camp, Laura Woodward Shelter, and Shooting Star Shelter. Those projects were made possible by an outpouring of dedicated volunteers and funding from the Vermont Department of Forests, Parks, and Recreation, the National Park Service, and the Appalachian Trail Conference.

Like many overnight sites along the Appalachian Trail (A.T.), local environmental conditions on the Long Trail in northern Vermont present challenges to maintainers trying to manage sewage. Those conditions include thin, poor soils, cold temperatures, high ambient air moisture, and heavy use. Conditions such as those, coupled with a lack of field staff or volunteers, make dealing with sewage effectively nearly impossible. The preferred method of dealing with sewage traditionally has been the pit privy, which still represents the majority of waste-management systems on both the Appalachian Trail and Long Trail. At most sites where the use is low to moderate throughout the season, a pit privy is still the best option. However, when use increases, particularly at those sites with marginal environmental conditions, pit privies fill up and become major headaches.

At many shelter sites, wastes decompose slowly simply because the pit extends well below the biologically active layer of the forest floor (typically the first six inches) or this layer does not exist at all. The waste that accumulates decomposes so slowly that the rate of input from users exceeds the level of decomposition, and the pit eventually will fill up. At many sites, there are no longer places to dig pits. Something must be done to provide adequate sanitation facilities or the future of these overnight sites will be jeopardized. For clubs wishing to develop new overnight sites and facilities, ATC direction requires that the proposed site be able to manage sewage in a way that protects the Trail experience for users, the health of visitors, and the area's resources. With public use on the rise, finding qualified sites is becoming increasingly difficult.

Recently, moldering privies have emerged as a possible alternative for those challenging management situations. GMC, along with several other A.T.-maintaining clubs, has been experimenting with them. Longtime GMC volunteer Dick Andrews constructed the first prototype moldering (slow-composting) privy on the Long Trail/ Appalachian Trail in Vermont at Little Rock Pond Shelter in 1995. A moldering privy utilizes the biologically active, upper six inches of the soil to better advantage by doing away with a pit entirely. Instead, the waste pile sits in a wooden crib constructed on the surface of the soil (see photo). With the waste pile above the ground, a variety of desirable common soil decomposers are attracted to it. Intense scavenging and competition created in the pile by these organisms helps destroy disease-causing pathogens. The pile also receives a lot of aeration from air slats built in the wood cribbing. This higher level of oxygen helps reduce odors. Liquid is allowed to seep into the soil, where it is naturally treated by soil decomposers.

To further aid the decomposition process, field staff and maintainers introduce red-wiggler worms, which have a voracious appetite for wastes of all kind. The worms are particularly useful at colder, high-elevation sites with thin/ poor soils, where the local population of soil decomposers is low. The worms are available from most

Figure O.1—The author stands by a new moldering privy at Talor Lodge on the lomg Trail. (Note two-by-fours for moving privy onto the cribbing.

garden-supply companies. Because the worms will not survive winter freezing, GMC has been “growing” its own worm supply at GMC headquarters. The worms are distributed to volunteers for introduction into toilets each spring.

The above-ground crib (4’ x 4’ x 30") is constructed using 6" x 6" timbers of either pressure-treated or a rot-resistant wood, such as hemlock, stacked to create air slats to promote thorough ventilation. Air slats are covered on both sides with 1/4" hardware cloth and fine-mesh fly screening that helps to keep the waste in and debris and undesirable creatures out. Systems ranged in price from $90 to $400 per unit, depending on whether the privy building needs replacing.

After two seasons of planning and fund-raising, “Beyond the Bin” (BTB) technology arrived at Taft Lodge on Mt. Mansfield and at the Monroe trailhead at Camels Hump. The BTB was originally developed through a challenge cost-share grant to the Appalachian Mountain Club (AMC) in 1995. AMC, along with former GMC Field Assistant Paul Neubauer, constructed the first BTB along the AMC-maintained portion of the A.T. in New Hampshire. Today, nearly all of AMC’s shelter sites along the A.T. have BTB systems.

The BTB is a modification of the GMC’s batch-bin method of composting. The system adds a perforated, stainless-steel straining plate in the outhouse waste catcher that allows all liquids to be gravity-separated away from the solids. Once separated, the liquid then flows through a hose to a filter barrel (see photo). The 55-gallon barrel contains layers of anthracite coal and washed septic stone. A biological community will develop in the barrel that will consume pathogens and organic material in the liquid as it percolates through the barrel, before being discharged into the ground.

Figure O.2—The beyond-the-bin liquid filter barrel at Taft Lodge. The barrel contains anthracite coal and washed septic stone and drains out from the bottom into the soil, once filtered. (Photo by Pete Ketcham)

The main advantage of that system is a drastic reduction in the amount of wood chips needed for composting, which also significantly reduces the volume of sewage that needs to be composted. In batchbin systems, excess liquid needs to be sopped up with hardwood bark mulch or wood chips, which soaks up the moisture but expands the volume of the waste. This season, GMC caretakers composted approximately 630 gallons of sewage with the batch-bin system at Taft Lodge, due to the presence of copious amounts of liquid. The BTB should reduce sewage volumes by up to two-thirds annually. In addition, the drier sewage will compost at higher temperatures, producing a stable, pathogen-free end-product that can be safely spread in the woods without threatening the area's water quality.

After two months of operation, caretakers in the field reported a dramatic reduction in the amount of sewage they have had to compost, as well as a decrease in odors from their privies. During the 2000 field season, plans are to retrofit more privies to moldering systems and to modify other existing batch-bin composters over to BTB systems. A batch-bin system with a BTB filtering component will cost between $800 and $1,500. The entire BTB system weighs about 600 pounds and requires many volunteers, to transport to backcountry sites. The BTB is one of the more effective waste-management systems that has been used on the A.T. in New England. The cost is higher than a moldering privy, and it does require frequent maintenance and tending, so it may not be appropriate for some clubs or organizations with smaller budgets or labor forces. Funding for the BTB projects was made possible through generous grants from the Vermont Department of Forests, Parks, and Recreation, the Burlington Section of GMC, and Concept II (a local business) from Morrisville, Vt.

GMC is using the knowledge gained to develop a moldering-privy manual, which will be available in February. Thanks to an NPS challenge cost-share, a backcountry sanitation manual for Trail maintainers will be completed by 2001.

Pete Ketcham is a regional field supervisor for the Green Mountain Club. He also has worked with the Appalachian Mountain Club and Randolph Mountain Club in New Hampshire as a backcountry hut naturalist and facility caretaker.

A version of this article was printed in the Spring 1999 issue of the Long Trail News, GMC's quarterly newsletter.

For more information on backcountry waste management, contact Pete Ketcham at the Green Mountain Club; 4711 Waterbury-Stowe Road, Waterbury Center, Vermont 05677; (802) 244-7037 ext. 17; or <Pete@~greenmountainclub.org>.

Owner-Built Continuous Composters

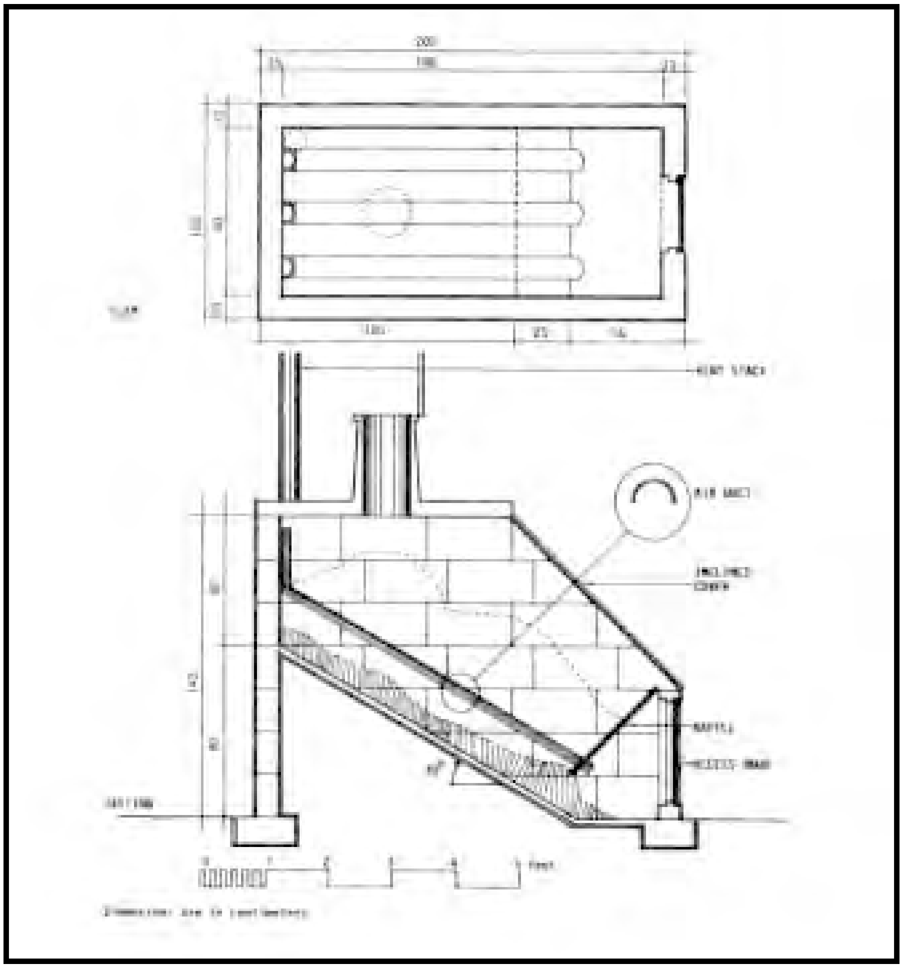

Figure P.1—This is an example of plans for the construction of an owner-built, continuous composting system. The plans pictured are for a Clivus Minimus, which is modeled after the Clivus Multrum. The Pennsylvania Composter, a unit in use on the A.T. in Pennsylvania, Maryland, and New Jersey, is a similar design. Diagram from the Center for Low-Cost Housing of McGill University and The Composting Toilet System Book by David Del Porto and Carol Steinfeld.

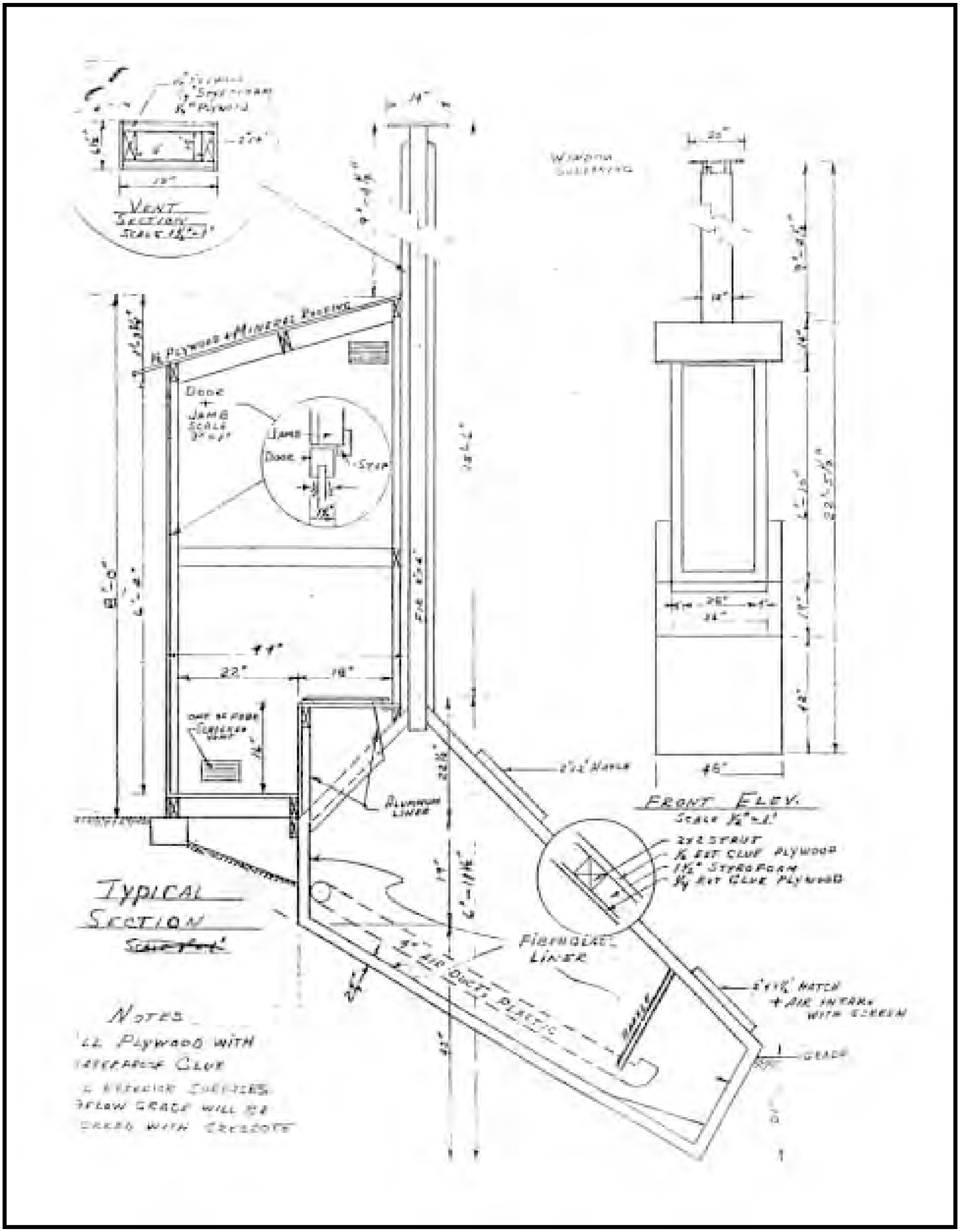

Figure P.2—A diagram of the Mountain Club of Maryland’s “Pennsylvania Composter.” This system is also referred to as a “Clivus Minimus,” because it is an owner-built version of the Clivus system. For plans and additional information, contact the Mountain Club of Maryland’s Ted Sanderson (Contact information is in the Contact List in this Appendix).” Diagram from Ted Sanderson and the Mountain Club of Maryland.

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Plans for a Wooden Packboard

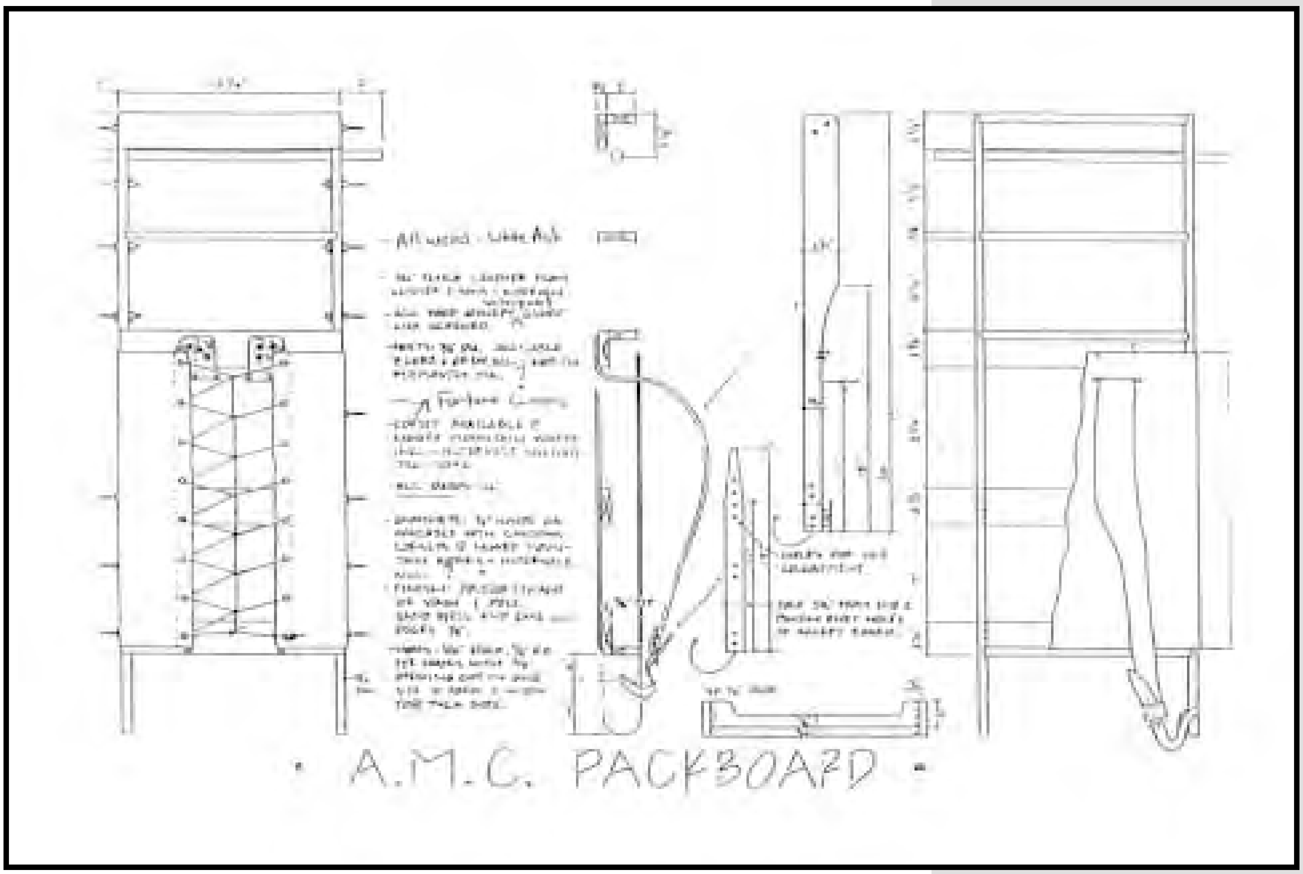

Figure P.3—Plans for construction of the Appalachian Mountain Club's wooden packboard. This packboard has been found to be the best for transporting composting toilet system components into the field as well as bark mulch or other bulking agents by the Green Mountain Club and Appalachian Mountain Club.

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Avoiding Septic Shock

How Climate Change Can Cause Septic System Failure and Whether New England States are Prepared

By Elena Mihaly, Staff Attorney, Conservation Law Foundation

February 2017

"As sea-level rise causes a rise in groundwater levels, it will saturate onsite septic systems, increase failure rates and exacerbate groundwater pollution problems. Residents are investing significant dollars to elevate and flood proof homes with the expectation that these areas will be livable; however, if groundwater levels become too high the use of onsite septic systems may become impossible. The future impacts of sea-level rise in these areas needs to be more thoroughly investigated."[1]

1 Report of Findings from a Study of the Effects of Sea-level Rise and Climate Change on Old Saybrook, Connecticut, 16 (December 2015), https://perma.cc/2BLQ-EJJQ.

Introduction

Climate change poses a number of difficult challenges to New England's infrastructure. The most commonly discussed impacts include flooding of roads, bridges, and culverts, or water damage to buildings and electric utilities. A less discussed, but equally alarming challenge to infrastructure is how climate change is impacting onsite wastewater treatment systems, more commonly known as septic systems. Almost half of homes in New England depend on septic systems to dispose of wastewater. When functioning properly, these systems filter out harmful bacteria and pathogens to ensure nearby groundwater and surface waters are safe for human health and the environment. But rising sea levels, increased precipitation, and warmer temperatures due to climate change are all adversely impacting these systems.

This white paper addresses whether states in New England are adequately addressing the issues presented by climate change in septic system regulation. Part One describes how climate change impacts can adversely affect septic systems. Part Two discusses the human health and environmental harms associated with septic system failure. Part Three summarizes the results of a state-by-state comparison analyzing if and how each New England state is addressing the issue of climate change impacts on residential septic systems (the complete results of the analysis are contained in the Appendix). Part Four identifies common problem areas in septic system regulation, and suggests recommendations and best practices for how states and municipalities can work to change laws, amend rules, or adopt new policies or incentives to better construct, manage, and regulate septic systems to be resilient to climate change. Part Five concludes with a call to action, imploring state and local municipal leaders to review their regulatory frameworks for septic systems and ensure that they adequately account for the rising groundwater, warmer temperatures, and heavier rainstorms we anticipate in the near future.

PART ONE

How Climate Change Can Cause Septic System Failure

Conventional septic systems collect sewage from residential or smaller-scale commercial properties and store it in a septic tank. There, bacteria begins to break down the solids, while septic tank effluent flows through a pipe into a soil treatment area (also referred to as a "leachfield"). Treatment takes place as wastewater percolates through the unsaturated portion of the soil profile beneath the leachfield, where moisture and oxygen levels are conducive to the removal of pathogenic organisms, and where chemical and microbial processes can help reduce the concentration of other contaminants.[2]

New England households rely much more on septic systems than homes in the rest of the country. New Hampshire, Maine, and Vermont reported that approximately half of all homes in their states are served by septic systems.[3] By comparison, about one in five households across the U.S. depend on septic systems.[4] But no matter the location, reliance on these onsite wastewater treatment systems is continuing to grow throughout the country. About one-third of all new development in the U.S. is served by a septic or other decentralized treatment system.[5]

Climate change poses several challenges to septic systems. First, rising sea-levels associated with climate change cause near-shore groundwater tables to rise and reduce separation distances to the leachfield base, compromising the systems' ability to treat bacteria and pathogens in wastewater. Leachfields rely on unsaturated soil for proper physical and biochemical treatment of wastewater. When sea-level rises, saltwater from the ocean intrudes into groundwater reservoirs. The saltwater then displaces the less dense, lighter freshwater, causing the groundwater to rise into the soil profile above, limiting the amount of unsaturated soil beneath the leachfield.[6] Research out of Cape Cod, Massachusetts showed that the ground water table rises at a rate of about 35 percent of sea-level rise.[7] In other words, if sea-level rises 10 feet, the groundwater table would rise by about 3.5 feet (35 percent of 10 feet).

Second, increased heavy precipitation events associated with climate change add to the problem of a rising groundwater table. Increased water percolating into the soil from above refills, or "recharges" the groundwater table, resulting in an even higher groundwater table.[8] When increased recharge of groundwater tables (caused by increased precipitation) is combined with rising sea-levels, the groundwater levels could rise as much as an additional foot higher than the projected median sea-level rise at some coastal locations during these precipitation periods.[9]

Third, the saturation from increased precipitation depletes oxygen in soils, compromising aerobic microbial activity and resulting treatment of wastewater.[10] And rising temperatures from climate

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2 Jennifer A. Cooper, et al., *Hell or High Water: Diminished Septic System Performance in Coastal Regions Due to Climate Change*, PLOS ONE, 2 (Sept. 1, 2016), https://perma.cc/K6KF-73C5.
3 *Id*.
4 Learn about Septic systems: Septic System Overview, EPA, http://perma.cc/VQX9-WGXE (last updated September 23, 2016).
5 *Id*.
6 Cooper, *supra* note 2, at 2.
7 Donald A. Walter, et al., *Potential effects of sea-level rise on the depth to saturated sediments of the Sagamore and Monomoy flow lenses on Cape Cod, Massachusetts*, USGS, 41 (October 2016), https://perma.cc/F6DN-ZVPZ.
8 Cooper, *supra* note 2, at 2.
9 David M. Bjerkile et al., *Preliminary Investigation of the Effects of Sea-Level Rise on Groundwater Levels in New Haven, Connecticut*, USGS (May 1, 2012), https://perma.cc/6NFM-YQ32.
10 Cooper, *supra* note 2, at 2; *see also* D.M. Linn and J.W. Doran, *Aerobic and Anaerobic Microbial Populations in No-till and Plowed Soils*, 48 SOIL SCI. SOC. AM. J. 4, 794-799, 797-98 (1984).

change further compromise healthy aerobic microbial function due to greater oxygen demand that effects biochemical treatment processes in the soil.[11]

Climate scientists predict that sea-level rise and increased extreme precipitation events will be the two dominant climate change impacts to New England.[12] Sea-level in the Northeastern U.S. is projected to rise anywhere from three to six feet by 2100 (depending on the location and emissions scenario).[13] In addition, precipitation events are expected to increase in occurrence and severity over the same time period.[14] Accordingly, it is incredibly important to consider how to best prepare our septic systems to handle warmer and wetter, or saturated, soil conditions.

PART TWO

Human Health and Environmental Implications of Septic System Failure

Septic system failures result in unpleasant and potentially unsafe conditions for residents surrounding the system, as well as those who depend on groundwater or enjoy recreating on surface waters that come into contact with a failed system. This is because residential wastewater contains bacterial and viral pathogens, as well as nitrates, which pose public health risks if left untreated.[15] In fact, the U.S. Environmental Protection Agency identified contaminated residential wastewater from failed septic systems as the third largest contributor to groundwater pollution in the country.[16]

In addition, residential wastewater can be a significant source of nitrogen to coastal ecosystems.[17] Nitrogen limits primary production in coastal ecosystems, and excessive nitrogen inputs to marine environments can lead to harmful ecological and human health impacts.[18]

Several communities in New England have already begun seeing the impacts of water contamination from septic system failures. For example, the town of Rye—a small coastal town in New

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11 Cooper, *supra* note 2, at 2-3.
12 *Climate Impacts in the Northeast*, EPA, https://perma.cc/S8ES-T5QQ (last update September 29, 2016).
13 Huber et al., *Sea-level Rise, Storm Surges, and Extreme Precipitation in Coastal New Hampshire: Analysis of Past and Projected Future Trends,* N.H. Coastal Risks and Hazards Commission Science and Technical Advisory Report (2014) https://perma.cc/EFN6-KVZY; *see also* Donald A. Walter *supra* note 7, at 6.
14 Huber, *supra* note 13.
15 United States Environmental Protection Agency. *Onsite Wastewater Treatment Systems Manual* (2002). Available at: http:/nepis.epa.gov/Adobe/PDF/30004GXI.pdf.
16 *Id.*
17 Valiela et al., *Couplings of watersheds and coastal waters: sources and consequences of nutrient enrichment in Waquoit Bay, Massachusetts*. ESTUARIES, 15(4), 443-457.
18 *See, e.g.,* Bergondo et al., *Time-series observations during the low sub-surface oxygen events in Narragansett Bay during summer 2001*. MARINE CHEMISTRY, 97 (1), 90-103 (2005).

Hampshire— is experiencing first-hand the problems of failed septic systems. Namely, high levels of bacteria are being carried into the ocean at Wallis Sands Beach—a favorite summer spot for locals and tourists alike—by a local waterway known as Parsons Creek.[19] The beach may soon be unsafe to visit if pollution issues go unchecked. The New Hampshire Department of Environmental Services categorized Parsons Creek as an impaired water body in 2008 due to test results showing high fecal bacteria counts, causing area residents to nickname Parsons as "Stinky Creek."[20] In 2011, after extensive studying, the town of Rye discovered the major source of the bacterial contamination was coming from malfunctioning residential septic systems.[21] The town is now struggling to gain residents' cooperation in identifying which septic systems are leaking the bacteria into the creek. While rising sea-level and other climate-related impacts to septic systems have not been identified as the sole cause of the system failures, people within the community acknowledge the threat of climate change impacts to these often old and fragile systems.

Rhode Island's Narragansett Bay has repeatedly experienced the negative effects of nitrogen pollution from residential wastewater, including hypoxia and anoxia, alterations to food web dynamics, loss of biodiversity and habitat, and increased frequency of algal blooms.[22]

With such high reliance on septic systems in New England, it is imperative that state and local governments take preemptive measures now before more systems fail and cause problems similar to those experienced in the town of Rye. Many local and state governments are engaged in robust adaptation efforts to ensure communities are resilient in the face of climate change impacts. A few local municipalities across New England are taking action to specifically address this particular issue of septic failures, including the town of Rye, whose adaptation measures are discussed below. But for the most part, state and local leaders are not focusing on how regulatory reform of septic system management to account for climate change could better protect communities from health and environmental risks.

PART THREE

State-by-State Comparison of Septic System Laws and Regulations

The Appendix of this white paper contains a detailed analysis of each state's regulatory framework for septic systems. However, the chart below summarizes and compares the major design and inspection parameters in each state's regulations that are relevant to a systems' preparedness for climate change.

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19 Nicole Anderson, *Rye Urges Residents to Help Fix 'Stinky Creek'*, SEACOASTONLINE, (Jan. 10, 2016), https://perma.cc/84KL-FZJ2.
20 *Id.*
21 *Id.*
22 Bergondo et al., *supra* note 18.

State	Septic System Regulation	Date of updated regulation	Minimum Separation Distance	Post-construction Inspections Required?	Inspections recommended?
CT	Regs. Conn. State Agencies §19-13-B100a.	2015 (Technical Design Standards)	1.5 ft (non-coastal areas) to 2 ft (if soil percolation is faster than 1 min per inch).	No.	Local directors of public health perform inspections "when deemed necessary."
MA	310 CMR 15.000 ("Title V")	2016	4ft (if soil percolation is slower than 2 min per inch) to 5 ft (if soil percolation is faster than 2 min per inch).	Yes. Septic systems must be inspected when property is sold, increased flow, or expanded. If alt/ innovative system, then required quarterly inspections.	N/A
ME	10-144 CMR Ch. 241	2011	9 inches (outside the shore land area) to 1.25 ft (within the shoreland area).	No.	State recommends new buyers get septic inspected.
NH	Env-Wq 1000	2016	2ft-4ft, depending on slope of site and components of system.	No.	State recommends local health officers conduct inspections once every three years.
RI	R.I. Code R. 25-16-17:32, 39	2016	2ft in all watersheds, except 4ft in "critical resource area" watersheds. Mandatory advanced N-removal technologies in CRA watersheds. Requires new system (conventional or alternative/innovative) if the current system is a cesspool near a public drinking water supply, a public well, or a bordering tidal water area.	No.	State *may* at its discretion inspect any aspect of the installation, but not statutorily required (system designer is responsible for this). Existing systems inspected under town wastewater management programs.
VT	Vt. Admin. Code §16-3-300	2007	Prescriptive = 2 ft Enhanced Prescriptive = 1.5 ft Performance Based = 6 inches plus calculated induced groundwater mounding	No.	After installation, inspections are done at the discretion of the State.

PART FOUR

Recommendations for Climate-Ready Septic System Regulations

State regulations governing septic systems across New England are not adequately addressing the issue of groundwater rise associated with climate change. Nor are these regulatory programs contemplating other equally damaging impacts of climate change to septic systems, such as the impact of increased precipitation or higher temperatures on the microbial activity upon which septic systems rely. Primarily, this regulatory failure is because states and municipalities are relying on historic (as opposed to predicted) values for groundwater table height, and focusing regulatory programs only on permitting and installation, neglecting operation and maintenance of the systems.

There are, however, some examples of state and local governments taking positive steps towards more climate resilient septic system regulation. The recommendations below highlight some best practices that states and local municipalities should consider adopting to ensure septic systems are built and operated in a manner that is resilient to climate change.

1. **Incorporate future seasonal high water table projections when siting septic systems.**

One of the most egregious problem areas for all of New England states' septic system regulations is the inadequate accounting of future groundwater table rise due to sea-level rise. All states require a varying degree of separation distance between the bottom of the leachfield and the seasonal high water table (between six inches to four feet, see chart above). However, this begs the question of how system installers are measuring the seasonal high water table. All the states in New England currently base the seasonal high water table measurements on present or past data from Federal Government soil and flood maps (such as those produced by the Natural Resource Conservation Service, the United States Geologic Survey, or the Federal Emergency Management Agency). This is problematic because these maps are often several decades old and do not contemplate the impact that sea-level rise will have on the water table. Accordingly, none of the regulations take future groundwater rise into account when approving a new septic systems.

To remedy this problem, states should revise their regulations to account for dynamic (rather than static) seasonal high water table in coastal areas. At a minimum, state regulations should contain vertical distance requirements between the leachfield and the groundwater table deep enough to provide a margin of safety for if/when the groundwater table rises. But in addition, states should also require the use of future high water table projections when determining the seasonal high water table. At the federal level, agencies like NRCS and USGS should update their analyses to account for rising sea-level and groundwater levels, and provide states with needed resources to assist in making future seasonal high water table projections.

2. **Implement state-level mandatory inspections, at least at the point of sale of any home.**

On occasion, septic system installers will supplement Federal Government-issued soil maps with on-site water table monitoring to determine the seasonal high water table. But problems still arise with regard to this kind of snapshot-in-time data collection because it presumes that once the seasonal high water table is measured (or soil moisture levels) are measured, that those conditions will not ever change over the lifespan of the septic system. As discussed in Part One above, research shows this is not the case. Sea-level rise and more heavy rain events are predicted in New England, and those effects will invariably alter the seasonal high water table and soil saturation levels. Frequent inspections are needed in order to make sure that existing septic systems are retrofitted where necessary if soils or water table heights no longer support a safe system set-up.

At a minimum, states should require septic system inspections when a property is sold (currently, Massachusetts is the only state to have this requirement, in addition to requiring inspections when design flow is increased or the home is expanded).

Several municipalities in New England have wastewater management plans and ordinances that require inspection and pump-outs of all septic systems on an as-needed basis, based upon inspection findings. In Rye, New Hampshire, the town recently adopted a pump-out ordinance effective June 1, 2016 that requires septic systems in the Parsons Creek watershed to be pumped out once every three years.[23] But *state* level inspection requirements would ease administrative burdens on municipalities who are enforcing stricter inspection or maintenance ordinances on their own.

3. **Heighten State-level Regulations to ease burden on municipal enforcement.**

In all New England states, local municipalities may set more stringent septic system design standards or inspection requirements than the state. However, when it comes to enforcement, the state will only step in to assist with regard to violations of *state* standards. This lack of enforcement support makes imposing stricter standards more burdensome and less desirable for municipalities. Accordingly, states should consider heightening select standards in state-level septic system regulations to ease the burden on municipal-level enforcement.

23 Town of Rye, Health Reg., Onsite Wastewater Treatment System Pump-out and Inspection Parsons Creek Watershed, https://perma.cc/W5KK-755D (June 6, 2016).

4. **Monitor system treatment performance, as opposed to just system operability.**

Septic system operability does not necessarily equate to adequate treatment. A system's components could appear in good condition, but for some reason, the system is not treating wastewater as intended. For example, septic system performance data collected from advanced nitrogen-removal systems installed in Massachusetts showed that these systems do not always perform as assumed.[24] Another study in Rhode Island showed that 25 to 30 percent of tested systems failed to comply with nitrogen removal standards that the systems were designed to achieve.[25]

The most effective monitoring approach from a water quality standpoint would check not only the functionality of system components, but also that the system is properly *treating* the wastewater (i.e., treatment performance). On Cape Cod, for example, Barnstable County requires that septic system treatment performance for nitrogen be monitored on a quarterly basis. A recent study of the Cape Cod monitoring system found that more frequent operation and maintenance visits including actual analysis of system final effluent allowed for service providers to make adjustments necessary to facilitate effective system performance.[26] The study authors concluded that analysis of wastewater properties likely translates into more proactive system maintenance because service providers can learn more about how the system is performing internally, rather than rely solely on visual observations to make assessments.

5. **Create, or further implement a risk-based tiered approach, where areas susceptible to groundwater rise or other contact with surface waters are more protected from wastewater contamination.**

Various factors contribute to the risk profile of a certain property's septic system, including historic land use of the site, proximity to the coast, or other environmental factors. A state's regulations governing the minimum vertical separation distance between the bottom of the leachfield and the groundwater table should account for these parameters. For example, several New England states require that septic systems located in coastal areas subject to future groundwater rise or flooding have a greater vertical distance between the bottom of the leachfield and the seasonal high water table. This risk-based tiered approach should be incorporated into all states' regulatory framework.

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24 Barnstable County Health Dep't of the Env't, *Study of factors controlling nitrite build-up in biological processes for water nitrification* (2012). WATER, SCIENCE, AND TECHNOLOGY, 26 (5-6), 1017-1025.
25 Lancellotti et al., *Performance evaluation of advanced nitrogen-removal onsite wastewater treatment systems*, manuscript submitted to WATER, AIR & SOIL POLLUTION in late 2016 (manuscript on file with author).
26 *Id*.

6. **Require advanced/innovative septic treatment systems in high-risk areas.**

States should require use of advanced/innovative septic treatment systems (such as those with advanced treatment and shallow narrow leachfields) in certain high-risk areas where groundwater tables are expected to rise in the future. New septic systems that contain shallow narrow leachfields receive effluent that has undergone a secondary treatment in an advanced treatment component, which allows the infiltrative surface to be placed higher in the soil profile than a conventional leachfield.[27] In addition, the shallow narrow leachfield designs incorporate frequent time-dosing of small volumes of wastewater, preventing prolonged periods of soil saturation.[28]

While these advanced treatment systems cost more than conventional septic systems (roughly two to three times more) they also have some cost advantages. Specifically, they may open up the use of a site for development that was otherwise constrained by a high water table, and they can prevent harmful water quality problems and associated adverse impacts to human health and the environment. Rhode Island is the first state in New England to require such advanced nitrogen removal systems in high risk zones state-wide (Barnstable County in Massachusetts does so on a regional level). Rhode Island is also the first state in New England to use shallow narrow leachfields and bottomless sand filters to mitigate potential impacts of sea-level rise.

7. **Create incentive programs to encourage residents to address failing septic systems, and/or switch over to advanced/innovative septic treatment systems.**

Incentives could include nitrogen credits for new developments, which is done in Massachusetts; tax rebates for purchasing the systems; free inspections of the systems for a length of time; or, for residents living near sensitive watersheds, offering a certain dollar amount to put towards the new system.

For example, officials in Rye, New Hampshire have offered to inspect twenty-five conventional systems free of charge, and offered up to $5,000 to five owners of failing systems who commit to repair or upgrade their system. The Rhode Island Clean Water Finance Agency has a financial incentive program to help homeowners who have failed septic systems. Residents can get a low interest loan from this program that allows up to $25,000 for the installation of an appropriate septic system for that location. The Rhode Island Department of Environmental Management requires a continuous operation and maintenance contract for all advanced treatment technologies in the state. This requirement is entered into the land evidence records, so at the time of property transfer the new owners are aware that they own an advanced technology and it needs operation and maintenance. Rhode Island also provides a line of credit to communities with state-approved wastewater management plans.

27 Cooper, *supra* note 2, at 3.
28 *Id.*

In Vermont, the town of Colchester identified a gap in funding for repair and replacement of decentralized wastewater treatment systems, especially when compared to the funding available for centralized systems.[29] In order to fill this funding gap, Colchester established a local, low-interest loan program specifically for decentralized wastewater system repairs and replacements.[30]

8. **Create a public outreach program to inform residents on septic maintenance, inspection, and pumping.**

For many homeowners, this is an out-of-sight or smell, out-of-mind issue. So long as there is no obvious failure, residents do not realize their systems could be leaching pollutants into the groundwater. In Rye, New Hampshire, town officials have been trying a number of public outreach tactics in order to remediate water quality issues in Parsons Creek, a watershed dealing with contamination due to failing septic systems. Town officials first went door-to-door with surveys designed to locate malfunctioning systems. But the surveys received a very low rate of participation. Rye's next step is to hold a public forum highlighting the difficulty of reversing the effects of septic system failure through public outreach to promote system maintenance, including the location of faulty systems. The Rhode Island communities of Charlestown, Jamestown, North Kingstown, and Portsmouth have active wastewater management programs, where educating residents is a high priority and a key component of their programs. They have found that residents embrace wastewater management when they understand the importance of sound wastewater treatment and its connection to public health, and protecting ground and surface waters.

9. **Support local research to identify areas at risk of septic system failure due to anticipated groundwater rise, and test the treatment effectiveness of various alternative technologies.**

For example, researchers at the University of New Hampshire are using a groundwater rise model to identify hazardous waste sites, such as unlined landfills, that require attention due to sea-level rise. The same modeling should be done to determine which septic systems should be evaluated for current functionality/retrofitting. Conventional systems that were installed 20 to 40 years ago may have complied with the bare minimum vertical separation standard at the time they were installed. Now, however, many years later and with no required sampling for treatment performance in the intervening years, it is unknown what systems are failing or at the brink of failure. Researchers in this field predict that we are likely already seeing the implications of sea-level rise through septic system failure. Research in URI's Laboratory of Soil Ecology and Microbiology—sponsored by the

29 *Discussion of Wastewater Management Options*, STONE ENVIRONMENTAL INC. (January 2011), 27-28, https://perma.cc/LB7Q-TNMJ.
30 *Id*. at 27 ("The Town of Colchester administers a long-term, low-interest (20-year term, 3% interest) loan fund with Clean Water SRF funding originating from the Vermont [Department of Environmental Conservation].").

Rhode Island Agricultural Experiment Station—currently focuses on measuring changes in separation distance beneath the leachfield of septic systems in coastal communities, and the possible use of vegetation above the leachfield to lower nutrient and water inputs to the leachfield. A joint study between the Barnstable County Dept. of Health and Environment and URI's Laboratory of Soil Ecology and Microbiology—sponsored by the USEPA—is testing non-proprietary leachfield designs that remove nitrogen from wastewater and increase the separation distance below the leachfield, which can help address the impact of sea-level rise.

Conclusion

Currently, New England states are not adequately addressing rising groundwater and other climate change impacts when regulating the location, operation, or inspection of septic systems. When the waters begin to rise, conventional septic systems will start to fail because there will not be enough unsaturated soil to treat effluent. The untreated effluent will migrate into and through groundwater and surface waters, putting the health of people and the environment at risk. Residents may not see the effluent, but they will smell it. Rye's "Stinky Creek" will no longer be a rare occurrence. Everyone will start to smell the result of failing septic systems, or worse, fall ill due to contaminated drinking water.

If regulators start taking action now, there is a chance to avoid mass septic systems failure. Regulators need to start considering using future calculations of the seasonal high water table, begin requiring innovative and alternative systems in sensitive areas, and offer incentives to help people transition over to these new systems more quickly.

Some states have taken steps to protect sensitive water sources. Using a tiered system for vertical separation will be helpful for coastal communities. However, it is not enough. Regulators need to acknowledge that it is not only going to be a select number of septic systems that will fail due to climate change. Septic systems located inland, in high elevations, or in areas where it is usually dry will all be affected to varying degrees by climate change. This is an area where an ounce of prevention is worth a pound of cure. Regulators need to start taking steps now to address this issue head on to prevent potential catastrophic system failures.

Appendix: State-by-State Analysis of New England Septic System Regulations

This Appendix contains the full analysis of the current regulatory framework of each New England state to see if and how the states are addressing the issue of climate change impacts on residential septic systems. The major topics analyzed include: when the regulations were last revised; the vertical separation requirements between the leachfield and the seasonal high water table; if there is a stricter vertical separation requirement for septic systems located on the coast or near water bodies; whether the requirements address groundwater rise; and when/if the systems are required to be inspected.

Connecticut

The Connecticut Department of Health ("DOH") is responsible for governing and establishing minimum requirements for septic systems within that state.[31] The DOH's complete regulations governing individual sewage disposal systems are codified in the Connecticut Public Health Code and titled: "Technical Standards for Subsurface Sewage Disposal Systems" ("Technical Standards").[32] The Technical Standards were last amended in January 2015.

The Technical Standards begin by generally requiring that leaching systems not be constructed in areas where the seasonal high water table will interfere with its operation. The Technical Standards follow a tiered approach, requiring a distance of separation of at least eighteen inches above the seasonal high water table in *non-coastal areas*, and a minimum distance of separation of twenty-four inches in *coastal areas*.[33] The Technical Standards define coastal areas as those areas which have a groundwater table that is tidally impacted.[34]

Similar to coastal areas, areas of "special concern" are subjected to more stringent standards. These areas of special concern include sites where the maximum groundwater table height is less than three feet below the ground surface.[35] In these areas of special concern, the local director of health may require investigation for maximum groundwater level at any time where it is determined to be

31 Regs. Conn. State Agencies, §19-13-B103a.
32 Connecticut Public Health Code, *Technical Standards for Subsurface Sewage Disposal Systems*, http://www.ct.gov/dph/lib/dph/environmental_health/environmental_engineering/pdf/011916_final_technical_standards.pdf (2015).
33 *Id*. at 36.
34 *Id*.
35 Regs. Conn. State Agencies. §19-13-B103d(e)(1)(A)-(H) (some other examples include areas located within the drawdown area of an existing public water supply, and areas designated as wetlands).

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at or near its maximum level.[36] Additionally, plans for these systems of special concern must: (1) be prepared by a professional engineer; (2) demonstrate an ability to solve the particular difficulty or defect associated with the area of special concern; and (3) may be required to have a professional engineer supervise the construction.[37]

The Technical Standards do not expressly incorporate future groundwater table heights that may increase due to rising sea-level as affected by climate change.[38] With that said, there are several significant resilience efforts taking place in Connecticut. For example, the coastal town of Guilford, Connecticut, issued a detailed resiliency plan in July 2013 addressing "the current and future social, economic and ecological resilience of the town's shoreline to the impacts of sea-level rise and anticipated increases in the frequency and severity of storm surge, coastal flooding, and erosion."[39] The plan specifically highlighted the concern of septic system failure in coastal areas due to sea-level rise, and put forward some potential solutions in that regard:

> First and foremost, septic systems can be elevated to maintain an appropriate vertical separation between effluent leach fields and the surface of the groundwater table. . . . Engineering erosion control techniques may be needed to assist with reduction of the erosion. If elevating a system is not possible, a suitable site for a new system may be found elsewhere on a property. . . . In cases where the full area needed for renovation of wastewater is no longer available, property owners could attempt to install and maintain advanced sewage treatment facilities. . . . Incinerating toilets, composting toilets or heat-assisted composting toilet can be utilized for replacing failing subsurface sewage disposal systems. . . . In cases where septic systems cannot be improved, it may be possible to install effluent holding tanks. The tanks would then be pumped out and sanitary wastewater would be delivered to a sewage treatment plant elsewhere.[40]

Furthermore, the United States Geological Survey ("USGS") performed investigations in New Haven, Connecticut and found a direct correlation between sea-level rise and seasonal high water table rise:[41]

> The results of this preliminary investigation indicate that under two scenarios for rise in sea-level, increases in groundwater levels in coastal areas such as New Haven can be expected. .

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36 *Id*. at §19-13-B103d(e)(2)-(3).
37 *Id*.
38 *But see* Conn. Public Health Code *supra* note 23, at 36 ("Maximum groundwater determinations in tidally affected coastal areas shall take into account water level rise associated with high tides); *Id*. at 51 (on application Form #2, the applicant is to consider the "probable high groundwater").
39 *Community Coastal Resilience Plan,* Town of Guilford (2013), ES-1, 16,https://perma.cc/JHE4-8BZM.
40 *Id*. at 16 (emphasis added); *see also* Climate Adaptation Committee Town of Saybrook, *Report of Findings from a Study of the Effects of Sea-level Rise and Climate Change on Old Saybrook, Connecticut* (December 2015), https://perma.cc/2BLQ-EJJQ ("As SLR causes a rise in groundwater levels it will saturate onsite septic systems, increase failure rates and exacerbate groundwater pollution problems. . . . if groundwater levels become too high the use of onsite septic systems may become impossible.").
41 Bjerkile, *supra* note 9.

. . Under the scenarios for rise in sea-level simulated in this study, basements of buildings and conduits for some underground utilities may be flooded. Some of the aging storm drains and sanitary sewers may intercept the water table and act as a conduit for groundwater flow.[42]

When it comes to inspecting septic systems, Connecticut requires only that individuals seeking to construct a subsurface sewage disposal system submit applications for a permit and be subject to compliance inspections by the local director of health.[43] Inspections of subsurface sewage disposal systems are performed by the local director of health to ensure compliance with the standards at two different times: (1) after construction and prior to covering, and; (2) "at such other times as deemed necessary."[44]

Connecticut laws and regulations do not expressly acknowledge the affects that sea-level rise and other factors associated with climate change have on groundwater rise and septic systems. With that said, there are some communities in Connecticut taking steps to change this approach, and to start considering plans to prevent and mitigate the effects of climate change.

Maine

Maine state laws and regulations governing septic systems are the responsibility of the Maine Department of Health and Human Services ("DHHS").[45] The "Subsurface Wastewater Disposal Rules" ("Rules") issued by the DHHS regulate the design and siting requirements, construction and inspection procedures, and administrative policies of subsurface wastewater disposal systems.[46] The Rules were last amended in January 2011.

The Rules follow a tiered approach when calculating the vertical separation between the disposal field, Maine's term for a leachfield, and the seasonal high water table. The Rules require that disposal fields:

> [B]e located upon soils with the following depths to limiting factors: (a) All systems located *outside of the shoreland area*[47] of major water bodies . . . must be located on soils with a

42 *Id*. at 25.
43 Conn. Agencies Regs. §19-13-B103e; *see also* Department of Public Health, The Connecticut Department of Public Health Office of Local Health Administration and Local Health Infrastructure Overview, https://perma.cc/VYX2-BNWS ("Connecticut's local public health system is decentralized. Local health agencies [and the local director of health] are autonomous and under the jurisdiction of the towns/municipality or health district served.").
44 Conn. Agencies Regs. §19-13-B103e(g).
45 22 M.R.S. §42(3) ("The department shall adopt minimum rules relating to subsurface sewage disposal systems. . . but this does not preempt the authority of municipalities . . . to adopt more restrictive ordinances.").
46 10-144 CMR Ch. 241.
47 10-144 CMR Ch. 24, §14 (defining "shoreland area" as: "All land area within 250 feet horizontal distance of the normal high-water line or upland edge of any great pond, river, salt water body, coastal wetland, non-forested wetlands greater than 10 acres or within 75 feet horizontal distance of the normal high-water line of a stream, or designated as Municipal Shoreland

minimum depth to [seasonal high water table] . . . of 9 inches and minimum depth to bedrock of 9 inches; (b) all systems *within the shoreland area* . . . must be located on soils with a minimum depth to [seasonal high water table] . . . of 15 inches and a minimum depth to bedrock of 15 inches, except [if a variance is issued].[48]

The DHHS' Division of Health Engineering released a Technical Guidance Manual relating to these Rules which adopts a policy recommending that disposal fields be constructed "as shallowly as practical to . . . stay as far as possible above the [seasonal high water table]."[49]

In order to determine the seasonal high water table, the rules require that groundwater level and temperature monitoring be performed on or before April 1st; subsequent monitoring and readings are required at least every seven days until June 15th.[50] The monitoring data must be compared and modified with information from the USGS to determine whether it is at or is near its normal level.[51] Similar to United States Department of Agriculture (USDA) and Natural Resource Conservation Service (NRCS) maps, the USGS does not incorporate *future* groundwater table heights that may increase due to rising sea-level, but are rather based on historical levels. After the initial inspection, Maine does not require routine inspections of the system. Instead, the DHHS recommends that inspections be done by buyers before the buyer purchases a house.[52] The USGS does acknowledge the threat that climate change and sea-level rise poses on our subsurface disposal systems.[53]

At the local level, some towns in Maine have adopted ordinances that increase the standards contained in DHHS rules.[54] Other towns have even acknowledged the threat of sea-level rise,[55] and conducted reports on the effects it will have on their disposal systems.[56] Additionally, the island town of Georgetown, Maine, has conducted a resiliency report with the National Oceanic and

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Zoning or an equivalent. . . .").

48 10-144 CMR Ch. 24, §4(A)(3); *see also* 10-144 CMR Ch. 241, §7(C) (discussing the criteria used for approval of a variance: (1) applicant must fill out a form; (2) applicant must demonstrate that there are no practical alternatives for wastewater disposal; (3) must be no conflict with the Shoreland Zoning; (4) Department evaluates the potential for malfunction, contamination, and other potential impacts; (5) shoreland areas are subjected to higher scrutiny and expectations on the application form.).

49 *Technical Guidance Manual for the Maine Subsurface Wastewater Disposal Rules*, Maine Dept. of Health and Human Services (2012), https://perma.cc/TVY4-WGFL.

50 10-144 CMR Ch. 241, §4(L)(7).

51 10-144 CMR Ch. 241, §(4)(L)(12)-(13).

52 *Septic System Inspection: A Guide for Lending Institutions, Realtors and Prospective Home Buyers*, MAINE DEP, https://perma.cc/EX23-4Q2J (last visited December 14, 2016).

53 *Sea-level Rise Hazards and Decision Support – Coastal Groundwater Systems*, USGS (last modified Nov. 24, 2014), https://perma.cc/R6EL-JA6U. ("Changes in climate and sea-level will drive changes to the coastal groundwater system that will impact both human populations and coastal ecosystems. Increases in sea-level will raise the fresh water table in many coastal regions. . . . Impacts to humans may include an increase in the potential for basement or septic system failure.").

54 *See, e.g.*, *Supplemental Plumbing Ordinance*, York, ME (November 6, 2012), https://perma.cc/3M8E-9GTA (increasing the design flow for residential systems by 33 percent, and prohibiting any reduction in design flows for water conservation devices).

55 *Natural and Marine Resources*, Ogunquit, ME (October 7, 2004), 27-29, https://perma.cc/QGW6-%LED.

56 Woodard & Curran, *Ogunquit Sewage Treatment Plant Preliminary Engineering Report* (2012),https://perma.cc/EF5A-3AY8 (considering the risks of sea-level rise and Ogunquit's current sewage treatment plan, and estimating that mitigation measures will need to take place in the next 20-30 years).

Atmospheric Administration, which briefly discussed the implications of climate change on septic systems.[57] Nevertheless, the State of Maine's requirement of a nine or fifteen inch protective barrier between the seasonal high water table and the disposal field is one of the lowest separation distance requirements in New England.[58] This is cause for concern, especially considering that Maine has one of the largest coastlines in the U.S., and over half of Maine's population lives in coastal counties.[59]

Massachusetts

Massachusetts' septic systems rules are known as "Title V" and are issued and enforced by the Massachusetts Department of Environmental Protection ("DEP").[60] The newest regulation amendments took effect in September 2016.

DEP's septic systems regulations determine minimum separation distance based on soil percolation rates. Accordingly, in soils with a recorded percolation rate of slower than two minutes per inch, Title V requires a minimum vertical separation distance of four feet between the bottom of the stone underlying the soil absorption system and the high groundwater elevation mark.[61] If the recorded percolation rate of the soil is faster than two minutes, then the requirement increases to a five foot vertical separation between the bottom of the stone underlying the soil absorption system and the high ground water elevation mark.[62]

In addition, certain areas that are given a special designation require additional strict standards. For example, when a potential septic system placement is in the Special Flood Hazard Area[63] and is subject to high velocity wave action or seismic sources, it is considered to be in a "velocity zone."[64] No new septic tanks or humus/composting toilets are allowed to be constructed in a velocity zone on a coastal beach, barrier beach, or dune, or in a regulatory floodway.[65] The only exception is if there needs to be a replacement to an already existing tank and the placement of the tank outside

57 *Climate Change Adaptation Report: Georgetown, Maine*, GEORGETOWN CONSERVATION COMMISSION (2015), 11, https://perma.cc/PUB4-F4FG ("The main way that climate change affects . . . wastewater treatment is sea-level rise, especially for residences near the shoreline. Higher seawater elevations increase seawater . . . flooding of septic systems, causing their failure. In addition, extreme precipitation events can lead to . . . high groundwater tables. . . .").
58 *Compare* Maine's fifteen-inch coastal protective barrier, *with* New Hampshire's four-foot protective barrier, *and* Connecticut's twenty-four-inch coastal protective barrier.
59 Steven G. Wilson & Thomas R. Fischetti, *Coastline Population Trends in the United States: 1960-2008*, U.S. CENSUS BUREAU (2010), https://perma.cc/AA9T-LVK5 (*see* Table 2 on page 4).
60 310 CMR § 15.
61 *Id*. at § 15.212 (1).
62 *Id*.
63 *Special Flood Hazard Area*, FEDERAL EMERGENCY MANAGEMENT AGENCY, https://www.fema.gov/special-flood-hazard-area (the land area covered by the floodwaters of the base flood is the Special Flood Hazard Area (SFHA) on NFIP maps. The SFHA is the area where the National Flood Insurance Program's (NFIP's) floodplain management regulations must be enforced and the area where the mandatory purchase of flood insurance applies).
64 310 CMR § 15.213 (1).
65 *Id*.

the velocity zone is not feasible.[66] Additionally, for new constructions in "Nitrogen Sensitive Areas,"[67] the septic system's design cannot have a design flow of more than 440 gallons per day per acre.[68] Systems with advanced nitrogen removal, however, are not subject to the nitrogen loading limitation of 440 gallons per day per acre.[69] As a result, more homeowners pursue alternative systems with advanced nitrogen removal because it will allow them to receive nitrogen credits, which in turn increases the amount of allowable bedrooms per square foot of land.[70]

According to DEP, there are a number of acceptable methods of estimating the high ground water elevation, including the following: the disposal system's plans; observation on site; determination from local conditions; consulting the local board of health, the local water department, or the local sewer department; consulting the USDA; consulting the Federal Emergency Management Agency ("FEMA") floodplain maps; or subscribing to the USGS groundwater records.[71] None of the aforementioned methods consider how the groundwater table may rise in the future; rather, they are all retrospective assessments based on past observations.

Before a system receives a certificate of compliance, DEP must conduct a final inspection of the system.[72] The system must also be inspected within two years of a title transfer, if there is any increase in the design flow, or prior to any expansions (such as adding an additional bathroom or bedroom).[73] In addition, any residence that has a recirculation sand filter system or alternative technology system with a design flow of less than 2,000 gallons per day must have both the influent and effluent quality monitored quarterly.[74] The system owner shall then submit all monitoring results to the local approving authority[75] and the MA DEP by January 31st of each year.[76]

The most progressive and forward-thinking regulation of septic systems on the local level in Massachusetts can be found in Barnstable County. With rapid development in the last 30 years and approximately 85 percent of sewage from residents on Cape Cod being disposed of in conventional on-site septic systems, county officials were struggling to keep up with the new changes.[77] As a solution, so-called "innovative/alternative" septic systems have been installed across Barnstable County as a means to reduce nitrogen output on a case-by-case basis. Innovative/alternative

66 *Id*.
67 Nitrogen Sensitive Areas are designated in 310 CRM 15.215.
68 310 CMR § 15.214(1).
69 *Id*. at § 15.217(1).
70 Alex Elvin, Wastewater: Plumbing All the Alternatives, Vineyard Gazette (Sept. 17, 2015), https://perma.cc/74NC-BL2Q.
71 Guidance for the Inspection of On-site Sewage Disposal Systems, MassDEP, https://perma.cc/85CN-KU6R (last visited on December 14, 2016).
72 310 CMR § 15.021(2).
73 *Id*. at § 15.301(1),(5).
74 *Id*. at§ 15.2002(4)(c).
75 *Id*. at § 15.002 (the board of health or its authorized agent or an agent of a health district constituted pursuant to M.G.L. c. 111, § 27 acting on behalf of the applicable board of health).
76 *Id*. at § 15.202(4)(c).
77 *Id*.

systems are those that are not designed or constructed in a way conventional with Massachusetts' Title V rules governing septic systems. Some examples of innovative/alternative systems are products developed using proven wastewater methods such as recirculating sand filters, aerobic treatment units, humus/compositing toilets, and intermittent sand filters. Innovative/alternative systems are often better than conventional septic systems at removing solids and other pollutants from wastewater before discharging into a leaching area along with reducing nitrogen content.

Because innovative/alternative systems are more complex than standard on-site wastewater treatment systems, the mechanical components must be maintained on a regular schedule. Individual towns are tasked with ensuring that this upkeep is completed as required. However, to assist with monitoring, the Barnstable County Department of Health and Environment created an online-accessible database management program.[78] The database includes when a system is inspected, if the system passes inspection, and what steps are needed to bring a failed system into compliance. According to preliminary (and yet to be published) research, this quarterly monitoring and database accounting system is proving to be a more effective method to maintaining system performance and resulting water quality than relying solely on visual observations.[79]

Massachusetts's government agencies and councils have discussed changing Title V in order to address groundwater rise, but so far DEP has not indicated that these changes will be made. In a 2011 climate adaptation report, the Executive Office of Energy and Environmental Affairs briefly considered whether Title V should be changed for additional protective separation distances for septic systems.[80] However, there seems to be no follow up to this report to determine whether any actual action is taking place. More recently in 2015, the Metropolitan Area Planning Council (MAPC) released another adaptation report. This report states MAPC will work with its partners to "persuade" DEP to consider the redesign of septic system standards in floodplain areas to offset climate change impacts such as saltwater intrusion, elevated groundwater table, and flooding.[81] Again, no follow-up action from this report could be found.

New Hampshire

The Subsurface Systems Bureau of the New Hampshire Department of Environmental Services ("DES") is responsible for regulating septic systems. The new amendments of the rules, codified under Env-Wq 1000, recently came into effect on October 1, 2016. The Bureau conducts on-site inspections, licenses septic system installers and designers, and manages complaints. Cities and municipalities also have the right to regulate septic systems, as they affect local health issues

78 Innovative/Alternative Septic System Tracking, BCDHE, https://perma.cc/992W-35LS.
79 Lancellotti et al., *supra* note 25.
80 Massachusetts Climate Change Adaptation Report, EXECUTIVE OFFICE OF ENERGY AND ENVIRONMENTAL AFFAIRS, 118 (Sept. 2011), https://perma.cc/8BWC-P3WP.
81 Metropolitan Area Planning Council, *Metro Boston Regional Climate Change Adaptation Strategy Report*, 3-35 (March 2015), https://perma.cc/S67U-KV2A.

(especially groundwater contamination).[82] However, most local health officers seem to only engage in septic system oversight at the approval level, rather than through post-construction inspections.

New Hampshire state laws and regulations governing septic systems[83] generally require the leachfield (referred to in New Hampshire as the "effluent discharge area") to be four feet above the seasonal high water table.[84] There are some exceptions to this rule, such as when replacing an existing system or on sloping sites, where only two feet of distance is required.[85] According to the regulations, the seasonal high water table is defined as "the depth from the mineral soil surface to the level at which the uppermost soil horizon that contains 2% or more distinct or prominent redoximorphic features that increase in percentage with increasing depth."[86] Estimated seasonal high water table is determined from USDA/NRCS maps or actual data, if available.[87] Because USDA/NRCS maps indicate present or historical seasonal high water table data (as opposed to any anticipated future data),[88] septic system designs do not incorporate *future* groundwater table heights that may increase due to rising sea-level.

Any individual who installs or otherwise acquires a septic system must operate and maintain the system to prevent a nuisance or potential health hazard due to failure of the system.[89] Accordingly, in the event that the water table did rise to the point where it was causing a septic system to fail, the owner has a duty to remediate. However, there is little by way of routine inspection required, at least at the state level (select local level inspection policies are described below). DES is authorized to enter any premises to inspect and evaluate maintenance of septic systems and issue compliance orders,[90] but this is complaint-driven (i.e., there is no routine state inspection).

Septic tanks must be inspected for accumulation of sludge and scum at a frequency sufficient to allow the tank to be pumped by a licensed septage hauler when the combined thickness of the sludge and scum layers equal one third or more of the tank depth.[91] A DES-published "Health Officer's Manual" recommends pumping the tank once every three years.[92] But again, this

82 RSA 147:1.
83 *See* RSA 485-A:29-44; Chapter Env-Wq 1000.
84 Env-Wq 1014.08(a).
85 Env-Wq 1014.08 (b-d); Env-Wq 1014.09.
86 Env-Wq 1002.61.
87 Env-Wq 1025.04(g)(6).
88 For USDA/NRCS soil maps, the "high water table (seasonal)" is "the highest level of a saturated zone in the soil in most years"; estimates of soil properties are based on field examinations, on laboratory tests of samples from the survey area, and on laboratory tests of samples of similar soils in nearby areas. *See*, e.g., *Soil Survey of Grafton County Area, New Hampshire*, USDA/NRCS, 217-219 (1998), https://perma.cc/539F-LAFT.
89 RSA 485-A:37.
90 RSA 485-A:37.
91 Env-Wq 1023.01.
92 *Health Officer's Manual for Septic systems*, NH DES (September 2011), https://perma.cc/52C5-B57B.

maintenance requirement does not address whether the system as a whole is failing due to a rise in groundwater table. Lastly, if a homeowner is selling developed waterfront property, a site assessment study is required. But, such a site assessment is not considered an "evaluation" of the existing septic system on the property,[93] and this assessment only occurs at the point of sale, not on a routine basis.

On the local level, using New Hampshire RSA 147, and any health regulations adopted at the local level, municipal health officers have direct enforcement authority over septic system failures and may conduct inspections. However, many local health officers merely participate in the application process to install septic systems and do not require annual inspections. The town of Rye is pursuing strategies to remediate water quality problems due to failed septic systems, including implementing a mandatory pump-out and inspection ordinance.

Rhode Island

The rules regulating septic systems in Rhode Island were adopted by the Rhode Island Department of Environmental Management ("RIDEM") in accordance with Chapter 42-35 of the Rhode Island General Laws and the R.I. Cesspool Act of 2007 (R.I. Gen. Laws 23-19.15).[94] The most recent updates of the regulations occurred in June 2016 in order to incorporate revisions made to the R.I. Cesspool Act.

The regulations require a minimum of two feet between the bottom of the leachfield and the seasonal high water table (four feet in the Critical Resource Areas of the state).[95] Rhode Island also has a tiered system, where septic systems located within critical watersheds must utilize advanced nitrogen reducing technology instead of conventional systems.[96] Concerns about nitrogen loading in Rhode Island's watersheds started back in the mid-1980s, and have led to the widespread use of advanced technology systems in the Critical Resource Area watersheds that reduce nitrogen output from effluent.

To determine the depth to the seasonal high water table, a Soil Evaluator primarily uses the depth to, type, location and abundance of hydromorphic features and other characteristics.[97] The groundwater table observations may also be made using a minimum of two groundwater test wells placed to a depth of ten feet.[98] Wet season determinations are intended to measure the

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93 Env-Wq 1025.01(a).
94 R.I. Code R. §42; https://perma.cc/WCS7-L33G.
95 Reg. R.I. Code R. 25-16-17:32, 39. CRAs are defined by rule and include coastal ponds, the Narrow River, and drinking water reservoir watersheds.
96 Reg. R.I. Code R. 25-16-17:39 (specifically identifying the salt pond and narrow river critical resources area).
97 Reg. R.I. Code R. 25-16-17:15.
98 Reg. R.I. Code R. 25-16-17:15.9.3.

groundwater table at its annual highest level.[99] However, when there are fluctuations in the seasonal high water table, RIDEM may adjust factors to compensate for periods of low groundwater recharge that results in the seasonal high water table to be lower than normal.[100] There is nothing in the rules that allows for adjustments for periods of *higher* groundwater elevations, as is anticipated with climate change.

When a septic systems is installed, RIDEM may, at its discretion, inspect any aspect of the installation.[101] By statute however, a license designer must inspect the system installation and make a report to RIDEM.[102]

Although not universally done in every community, inspection of existing septic systems in Rhode Island is done at the town level, and many towns have wastewater management ordinances requiring periodic inspections and results reported electronically to the town. At the time of inspection, system deficiencies and failures would be identified by private sector inspectors and reported to the town wastewater management specialist who would follow up to assure upgrades are done.

Discussion of Rhode Island's regulatory framework around septic systems necessarily requires mention of the state's leading efforts to eradicate cesspools. Cesspools are an antiquated, less reliable type of sewage disposal system used throughout New England. Any system that was installed prior to 1968 (when the state published its first septic rules) was probably a cesspool. Cesspools are dry-fit stone or concrete block structures into which sewage flows. Cesspools store solids and infiltrate wastewater into the surrounding soil. Cesspools tend to concentrate the wastewater in one location, unlike a conventional septic systems which has a distribution box and leaching field.[103]

Rhode Island is the only New England state working to eliminate cesspools. By statute, all hydraulically failed cesspools are required to be replaced immediately. If a house has a cesspool and is undergoing a home improvement project that will add one or more bedrooms, will affect 50 percent or more of the floor space, or the cost of the improvement is 25 percent of the replacement value of the home, then the resident is required to update their septic system.[104] If the cesspool is within 200 feet of the inland edge of all shoreline features bordering tidal water areas, within 200 feet of all public wells, or within 200 feet of a public drinking water supply, then the

99 Reg. R.I. Code R. 25-16-17:15.5.3
100 *Id.*
101 Reg. R.I. Code R. 25-16-17:43.5
102 *Id.*
103 *Frequently Asked Questions: Cesspools and the Rhode Island Cesspool Act*, RHODE ISLAND DEPARTMENT OF ENVIRONMENTAL MANAGEMENT OFFICE OF WATER RESOURCES, 3 (Sept. 2015), https://perma.cc/EL98-BKZV.
104 *A Guide for Homeowners Planning Home Improvements: Does Your Septic System Meet State Standards?:* RHODE ISLAND DEPARTMENT OF ENVIRONMENTAL MANAGEMENT- OFFICE OF WATER RESOURCES, https://perma.cc/9CRM-FY68.

cesspool must be removed or abandoned immediately.[105] The most significant change to the Cesspool Act in the 2015 session was that any cesspool serving a property subject to sale or transfer must be removed from service within one year of the closing date.[106]

Rhode Island has also implemented various programs to incentivize homeowners to address septic system concerns. The Rhode Island Clean Water Finance Agency has a financial incentive program to help homeowners who have failed septic systems. The State provides a line of credit to communities with RIDEM-approved wastewater management plans. Residents can get a low interest loan from this program that allows up to $25,000 for the installation of an appropriate septic system for that location. RIDEM requires a continuous operation and maintenance contract for all advanced treatment technologies in the state. This requirement is entered into the land evidence records, so at the time of property transfer the new owners are aware that they own an advanced technology and it needs operation and maintenance.

Though Rhode Island regulations address nitrogen reduction, there are no new regulations dealing with the issue of groundwater rise due to climate change. Scientists at the Laboratory of Soil Ecology and Microbiology at the University of Rhode Island ("LSEM") have conducted research to better understand the impact of climate change on septic systems and have informed regulators of their findings.[107] The LSEM study looked at different types of septic systems leachfields to see how those systems operate under various climate change conditions, such as the low, medium, and high sea-level rise scenarios, increased temperature, and increased precipitation conditions predicted to occur in New England in the next 100 years. The New England Onsite Wastewater Training Program, the outreach group of the LSEM team, conducts classes and seminars across the region for septic system designers, wastewater practitioners, and decision makers to inform them of climate change impacts to these systems.

Vermont

The Agency of Natural Resources ("ANR") is responsible for the regulation of septic systems in Vermont. The last time ANR amended these regulations was in 2007, when ANR overhauled their preceding regulatory approach.[108]

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105 R.I. Gen. Laws § 23-19.15-6.
106 R.I. Gen. Laws § 23-19.15-12.
107 Welcome to the New England Onsite Wastewater Training Program, (2016) https://perma.cc/PF25-G6CC; See also Cooper, supra note 2.
108 24 V.S.A. §§3631-3635; Amendments to the Wastewater System and Potable Water Supply Rule and a Summary of Significant Changes Made to the Statute That Authorizes the Rule, AGENCY OF NATURAL RESOURCES (November 2007), https://perma.cc/4FDU-33TA.

Under these regulations, an individual seeking to install or replace a sewage system must undergo a permitting process and receive approval from ANR.[109] Minimum standards for separation of septic systems to the seasonal high water table are split up into three sets of requirements, only one of which needs to be met for approval: (1) prescriptive approach; (2) enhanced prescriptive approach, and; (3) performance based approach.[110] A site to be used for wastewater disposal under the prescriptive approach must have at least 24 inches from the surface of the naturally occurring soil down to the seasonal high water table.[111] A site using the enhanced prescriptive approach must have at least 18 inches from the surface of the naturally occurring soil down to the seasonal high water table.[112] A site using the performance-based approach must first determine the amount of rise in the groundwater table that will occur when the effluent from the leachfield is added to the existing water table. This rise is called induced groundwater mounding. The level must be six inches plus the calculated induced groundwater mounding. For example, if the induced groundwater mounding in the water table is eight inches, the separation distance must be 14 inches.[113]

The applicant is to indicate on the Permit Application which approach has been satisfied and will be used if the permit is approved.[114] In determining seasonal high water table, monitoring is performed by ANR from March 1 until May 31, and groundwater level readings must be taken once every seven days during that monitoring period.[115] Once the seasonal high water table is determined, the determination may be used for two purposes: (1) to determine if the site is suitable for wastewater disposal under the regulations; and (2) to help decide what type of system may be used.[116] Vermont's approach to providing a margin of safety in the design of septic systems is quite different from other New England states. Depending on which of the three approaches is employed, there could be anywhere from a six-inch to a twenty-four-inch separation distance.

The permitting process requires inspections of the site before approval, and if a project does not conform to the guidelines, the Secretary may condition approval upon requiring periodic inspections to ensure that the project is functioning as designed.[117] Subsequent monitoring and inspections of a project is not mandatory, but is performed at the discretion of ANR.[118]

Tropical Storm Irene caused catastrophic erosion and inundation throughout Vermont's river valleys in 2011, reminding Vermonters of the risk of placing infrastructure near river beds. Some

109 24 V.S.A. §3634.
110 Vt. Admin. Code 16-3-300:1-805.
111 Vt. Admin. Code 16-3-300:1-903(b).
112 *Id*.
113 *Id*.
114 *See* Vermont Department of Environmental Conservation Drinking Water & Groundwater Protection Division, Wastewater System & Potable Water Supply Permit Application Instructions, 3, https://perma.cc/585Q-QHF9.
115 Vt. Admin. Code 16-3-300:1-903(e).
116 Vt. Admin. Code 16-3-300:1-903(a).
117 Vt. Admin. Code 16-3-300: Appendix 1-A.
118 Vt. Admin. Code 16-3-300:1-910.

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wastewater systems fared well while others sustained significant damage. ANR issued a resiliency report highlighting the community and individual wastewater systems that fared well during Hurricane Irene.[119] The Report also discussed how ensuring the long-term resilience of new or expanded infrastructure will require a careful evaluation of planning and siting to avoid septic systems encroaching on floodplains and river corridors. "When possible," the report noted, "we should consider alternative locations for water and wastewater systems that lie outside of high risk areas."[120]

Municipalities are permitted to adopt more stringent standards relating to sewage systems, as long as they are approved by the Vermont Department of Environmental Conservation. Municipalities also have the ability to request delegation of permitting and enforcement authorities that is initially vested in the state. Additionally, Vermont towns have begun managing the financing of individual (or "decentralized") septic systems. For example, the town of Colchester identified a gap in funding for repair and replacement of decentralized wastewater treatment systems, especially when compared to the funding available for centralized systems.[121] In order to fill this funding gap, Colchester established a local, low-interest loan program specifically for decentralized wastewater system repairs and replacements.[122] These kinds of voluntary local funding programs provide an opportunity for an affordable transition into a more sustainable, efficient, and effective decentralized wastewater infrastructure.

Although Vermont's septic systems may be sheltered from the effects of sea-level rise, the region is still expected to experience an increase in extreme precipitation events, flooding, increased rises in temperatures, and erosion, which could have serious consequences on infrastructure like septic systems. Additionally, over half of Vermont homes use decentralized wastewater systems, which is the highest use rate in the United States.[123]

119 *Resilience: A Report on the Health of Vermont's Environment*, VERMONT AGENCY OF NATURAL RESOURCES (2011), https://perma.cc/4TWB-4XCJ.
120 *Id.* at 22.
121 *Discussion of Wastewater Management Options*, STONE ENVIRONMENTAL INC. (January 2011), 27-28, https://perma.cc/LB7Q-TNMJ.
122 *Id*. at 27 ("The Town of Colchester administers a long-term, low-interest (20-year term, 3% interest) loan fund with Clean Water SRF funding originating from the Vermont [Department of Environmental Conservation].").
123 Vermont Legislative Research Service, *Decentralized Wastewater Management* Systems, UNIVERSITY OF VERMONT (April 2015), https://perma.cc/X8FE-JWP7.

<table>
<tr><th>State</th><th>Depth to Groundwater</th></tr>
<tr><td>Alabama</td><td>24-36 inches</td></tr>
<tr><td>Alaska</td><td>Four feet</td></tr>
<tr><td>Arizona</td><td>Five feet</td></tr>
<tr><td>Arkansas</td><td>Moderate Hydraulic Conductivity: 24 inches
High Hydraulic Conductivity: 36 inches</td></tr>
<tr><td>California</td><td>Tier 1 – Low Risk New or Replacement OWTS New or replacement OWTS meet low risk siting and design requirements as specified in Tier 1, where there is not an approved Local Agency Management Program per Tier 2.

<table>
<tr><th colspan="2">Table 2: Tier 1 Minimum Depths to Groundwater and Minimum Soil Depth from the Bottom of the Dispersal System</th></tr>
<tr><th>Percolation Rate</th><th>Minimum Depth</th></tr>
<tr><td>Percolation Rate ≤1 MPI</td><td>Only as authorized in a Tier 2 Local Agency Management Program</td></tr>
<tr><td>1 MPI< Percolation Rate ≤ 5 MPI</td><td>Twenty (20) feet</td></tr>
<tr><td>5 MPI< Percolation Rate ≤ 30 MPI</td><td>Eight (8) feet</td></tr>
<tr><td>30 MPI< Percolation Rate ≤ 120 MPI</td><td>Five (5) feet</td></tr>
<tr><td>Percolation Rate > 120 MPI</td><td>Only as authorized in a Tier 2 Local Agency Management Program</td></tr>
<tr><td colspan="2">MPI = minutes per inch</td></tr>
</table>

Tier 2 – Local Agency OWTS Management Program.
Tier 2: Separation of the bottom of dispersal system to groundwater less than two (2) feet, except for seepage pits, which shall not be less than 10 feet.

Tier 3 – Advanced Protection Management Programs for Impaired Areas.
Tier 3: Separation of the bottom of dispersal system to groundwater less than two (2) feet, except for seepage pits, which shall not be less than 10 feet.
Supplemental treatment requirements for pathogens (Tier 3): The minimum soil depth and the minimum depth to the anticipated highest level of groundwater below the bottom of the dispersal system shall not be less than three (3) feet.
All dispersal systems shall have at least twelve (12) inches of soil cover.</td></tr>
<tr><td>Colorado</td><td>Four feet, unless designed by an engineer and approved by the Department of Public Health.</td></tr>
<tr><td>Connecticut</td><td>The bottom of any leaching system shall be at least eighteen (18) inches above the maximum groundwater level. Additional separation must be provided if the natural soil has a percolation rate faster than one minute per inch and for large sewage disposal systems. Whenever the design percolation rate is faster than one minute per inch the minimum separation to maximum groundwater must be increased to twenty-four (24) inches,

Special Provisions. For large (2,000 GPD or greater) subsurface sewage disposal systems the minimum separation above maximum groundwater shall be increased to twenty-four (24) inches unless the design engineer conducts a mounding analysis that demonstrates the mounded maximum groundwater table</td></tr>
</table>

	is at least eighteen (18) inches below the bottom of the leaching system.
Delaware	All Full Depth Gravity and Capping Fill Gravity Trench and Bed Treatment and Disposal Systems: a minimum of three (3) feet below the bottom of the trench ≥ 48 inches beneath the soil surface. All Low Pressure Pipe Treatment and Disposal Systems: a minimum of 18 inches below the bottom of the trench. All Wisconsin At-Grade Treatment and Disposal Systems: ≥ 24 inches All Elevated Sand Mound Treatment and Disposal Systems > 20 inches All Pressure-Dosed Full Depth and Capping Fill Treatment and Disposal Systems: ≥ 48 inches from original grade and three (3) feet below bottom of filter aggregate (e.g. a minimum of five (5) feet below existing grade for two (2) foot deep trench and bed systems). All Sand-lined Treatment and Disposal Systems: ≥ 48 inches from original grade and three (3) feet below bottom of filter aggregate (except for impermeable, slowly permeable, or very slowly permeable materials proposed for removal).
Florida	(1) The effective soil depth throughout the drainfield installation site extends 42 inches or more below the bottom surface of the drainfield. Paragraphs (a), (b) and (c) list soil texture classes with their respective limitation ratings. (a) Coarse sand not associated with an estimated wet season high water table within 48 inches below the absorption surface, sand, fine sand, loamy coarse sand, coarse sandy loam, loamy sand, and sandy loam are considered to be slightly limited soil materials. (b) Very fine sand, loamy fine sand, loamy very fine sand, silt loam, silt, loam, fine sandy loam, very fine sandy loam,sandy clay loam, clay loam, silty clay loam, sandy clay and silty clay soil are considered to be moderately limited soil materials and are subject to evaluation with other influencing factors and local conditions. (c) Clay, bedrock, oolitic limestone, fractured rock, hardpan, organic soil, gravel and coarse sand, when coarse sand is associated with an estimated wet season high water table within 48 inches of the absorption surface are severely limited soil materials. If severely limited soil material can be replaced with slightly limited soil material, see Footnotes 3 and 4 of Table III for minimum requirements. Where limestone is found to be discontinuous along the horizontal plane and is dispersed among slightly or moderately limited soils, the Department Policy for Drainfield Sizing in Areas With Discontinuous Limestone,August 1999, herein incorporated by reference, shall be used. (2) The water table elevation at the wettest season of the year is at least 24 inches below the bottom surface of the drainfield.
Georgia	Wisconsin Mounded System: 10 inches to high water (permanent or seasonal) Pressurized Subsurface Absorption Fields Utilizing Emitters: There shall be a minimum vertical separation of 12 inches between the bottom of the absorption

	field and any seasonal groundwater table, rock or impervious soil strata. Greater vertical separation may be required if a site is hydraulically limited as determined by soil investigations by the soil classifier or design engineer.
Hawaii	At least three feet.
Idaho	Two feet
Illinois	Two feet Three feet: Loading rate greater than .62 gallons per day per square foot or soils where the percolation rate equivalent is less than or equal to 25 minutes/inch.
Indiana	Greater than or equal to 24 inches. If Elevated Sand Mound On-site Sewage Systems, then greater than or equal to 20 inches.
Iowa	Three feet
Kansas	Slight limiting range for soil absorption = less than 6 feet Moderate limiting range for soil absorption = 4-6 feet Severe limiting range for soil absorption = less than 4 feet
Kentucky	Suitable: 42 inches or greater. Provisionally suitable: Less than 42 inches, but at least 24 inches. Unsuitable: Less than 24 inches. (If special system design and installation modifications can be made to provide at least eighteen (18) inches of undisturbed naturally occurring soil between the bottom of the lateral field, the soils may be reclassified PROVISIONALLY SUITABLE as to depth.)
Louisiana	Two feet
Maine	12 to 24 inches.
Maryland	48 inches.
Massachusetts	Four feet in soils with a recorded percolation rate of more than two minutes per inch. Five feet in soils with a recorded percolation rate of two minutes or less per inch. For systems with a design flow of 2,000 gpd or greater, the separation to high groundwater as required by 310 CMR 15.212(1) shall be calculated after adding the effect of groundwater mounding to the high groundwater elevation as determined pursuant to 310 CMR 15.103(3).
Michigan	4 feet minimum below proposed absorption field fill allowed; two feet minimum of natural permeable soil before fill allowed
Minnesota	1. Twenty-four (24) inches but less than forty-two (42) inches - a six (6) to twenty-three (23) inch deep modified conventional trench, or other approved system with a minimum separation distance of eighteen (18) inches between trench bottoms and rock, water table, or restrictive horizon. 2. Eighteen (18) inches to less than twenty-four (24) inches - a mound system; other approved system that maintains a minimum separation distance of eighteen (18) inches between trench bottoms and rock, water table, or restrictive horizon; or, sufficient filling of the area with suitable soil to allow installation of a modified or alternative system after a one (1) year settling period.

	A minimum separation distance of twelve (12) to eighteen (18) inches between trench bottoms and rock, water table, or restrictive horizon may be considered on a case-by-case basis with additional approved treatment technology such as: peat filter systems, sand filter systems, aerobic units, and drip irrigation systems, two (2) tanks in a series, dual compartment septic tanks, approved effluent filters, and constructed wetlands cells. 3. Less than eighteen (18) inches - filling of the area with suitable soil to sufficient depth to allow modified or alternative system installation after a one (1) year settling period.
Mississippi	Restrictive horizon within five feet of the surface (fragipan, chalk, bedrock, clay or silty clay): 12 inches Otherwise: 24 inches.
Missouri	At least one foot for standard systems. Greater vertical separation may be required where water-bearing formations are in danger of contamination. Highly permeable soils: Minimum of four feet Cherty clay soils: Four feet or more
Montana	Four feet
Nebraska	Four feet. Lagoon – two feet
Nevada	Four feet
New Hampshire	Offsets to restrictions (i.e. groundwater and bedrock) should be maintained as indicated in the New Hampshire rules and generally allow a 4‘ offset from the drip tubing to the seasonal high water table or bedrock for septic tank effluent, and a 2’ offset from the drip tubing to the seasonal high water table or bedrock for treated effluent.
New Jersey	At least 24 inches.
New Mexico	Four feet
New York	A minimum of four (4) feet of useable soil shall exist above bedrock, impermeable strata, and groundwater with a minimum separation of two (2) feet to the lowest part of any trench.
North Carolina	Sandy soil: 18 inches All other soils: 12 inches
North Dakota	At least 24 inches.
Ohio	36 inches
Oklahoma	See Appendix A in attachment
Oregon	At least four feet. 24 inches where it is determined that less separation will not degrade groundwater or threaten public health. In these cases, 24 inches.
Pennsylvania	At least four feet (if an absorption area is proposed).
Rhode Island	At least two feet. On lots twenty thousand (20,000) square feet or larger that are not located in the Salt Pond or Narrow River Critical Resource Areas as defined in Rule 38, the leachfield may be located in an area where the seasonal high groundwater table is less than twenty-four (24) inches but greater than or equal to eighteen (18) inches from the original ground surface if the OWTS utilizes a bottomless sand filter in accordance with DEM guidelines, the applicant has no variance requests pursuant to Rule 47, and the design flow is less than or equal to six

	hundred ninety (690) gallons per day of residential strength wastewater. Depth to Restrictive Layer or Bedrock From Original Ground Surface- The leachfield shall be located in an area where a restrictive layer or bedrock is a minimum of four (4) feet below the original ground surface. The minimum depth to a restrictive layer or bedrock shall be met within twenty-five (25) feet of all sides of the leachfield. Leachfield Design Point- Where the seasonal high groundwater table is greater than or equal to four (4) feet below the original ground surface, the leachfield shall be designed using the original ground surface elevation at the center of the leachfield. Where the seasonal high groundwater table is less than four (4) feet below the original ground surface, the leachfield shall be designed using the highest original ground surface elevation within the leachfield. OWTS Separation Distance to Groundwater- The bottom of the stone underlying the leachfield (or surface upon which the biomat develops) shall be at least three (3) feet above the seasonal high groundwater table. OWTS Separation Distance to a Restrictive Layer or Bedrock- The bottom of the stone underlying the leachfield (or surface upon which the biomat develops) shall be at least five (5) feet above a restrictive layer or bedrock….In the upgradient direction, the five (5) foot vertical separation requirement may be waived as long as a restrictive layer or bedrock is no higher than the bottom of the stone within twenty-five (25) feet of the leachfield (Figure 1). Excavating into a restrictive layer or bedrock is not permitted unless otherwise approved by the Director.
South Carolina	Soil texture, depth of soil to restrictive horizons and depth to the zone of saturation shall meet minimum standards approved by the Department. These characteristics shall be determined using accepted methodologies in the field of soil science. Soils exhibiting massive or platy structure, and soils which have been identified as having substantial amounts of expansible layer clay minerals or smectites, are unsuitable for onsite wastewater systems. Where the estimated peak sewage flow will not exceed fifteen hundred (1500) gpd, the minimum vertical separation between the deepest point of effluent application and the zone of saturation shall be at least six (6) inches. Where the estimated peak sewage flow will exceed fifteen hundred (1500) gpd, the depth to the zone of saturation shall be at least thirty six (36) inches below the naturally occurring soil surface, and at least six (6) inches below the deepest point of effluent application. Depth to rock and other restrictive horizons shall be greater than twelve (12) inches below the deepest point of effluent application.
South Dakota	At least four feet.

Tennessee	Four feet, unless soil conditions permit otherwise.
Texas	Two feet
Utah	Absorption trenches: 24 inches Deep wall trenches: 48 inches Packed bed media absorption systems: 12 inches Sand-lined trenches: 12 inches
Vermont	Prescriptive Approach: At least 24 inches with a percolation rate of 120 min/inch. Enhanced Prescriptive Approach: At least 12 inches, or the thickness of the "A" soil horizon plus four inches (whichever is greater) of natural occurring soil. Sites with less than 18" of naturally occurring soil above the seasonal high water table must lower the water table as described below: (i) A site may be approved without pre-testing of the drain when a designer prepares a plan incorporating drainage of the site and asserts that the drainage will lower the seasonal high water table to provide at least 18" of permeable soil below the surface of the naturally occurring soil, and the Secretary agrees with the designer's assertion; or (ii) if the Secretary does not agree, the designer may demonstrate through construction of a drainage system and the performance of groundwater monitoring in accordance with section 1-806 below, that the seasonal high water table is lowered to at least 18" below the surface of the naturally occurring soil. (ii) if the Secretary does not agree, the designer may demonstrate through construction of a drainage system and the performance of groundwater monitoring in accordance with §1-903 below, that the seasonal high water table is lowered to at least 18" below the surface of the naturally occurring soil.
Virginia	≥18" (requires naturally occurring, undisturbed soils) <18" to 12" (requires minimum 6" of naturally occurring, undisturbed soils) when the minimum effluent quality equals is TL-2 0" to <12" when the minimum effluent quality is TL-3 and standard disinfection.
Washington	36 inches (Plus 12 inches of trench depth)
West Virginia	At least three feet.
Wisconsin	Three feet
Wyoming	Four feet