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.

This manual could not have been produced without the volunteer authors who wrote much of the material. I'd like to thank authors Dr. Peter Rentz M.D. of the AMC Massachusetts A.T. Committee; AMC Shelters Program Supervisor Hawk Metheny; AMC Huts Manager Chris Thayer; Paul Neubauer, a former GMC field supervisor U.S. Forest Service ranger, and Randolph Mountain Club (RMC) caretaker; former GMC and RMC caretaker Paul Lachapelle; RMC Trails Chairman Doug Mayer; RMC Field Supervisor Anne Tommasso; ATC New England Regional Representative J.T. Horn; ,ATC New England Associate Regional Representative Jody Bickel; Pete Irvine, U.S. Forest Service liaison to the Appalachian Trail Park Office in Harpers Ferry, W.Va.; and GMC and ATC volunteer Dick Andrews.

At the Green Mountain Club in Vermont, I'd like to thank Trail Management Committee Chair Peter Richardson, Executive Director Ben Rose, former Director of Field Programs Lars Botzojorns, and Director of Field Programs Dave Hardy for their support in the creation of this manual.

At the Appalachian Mountain Club's Pinkham Notch Visitor Center I'd like to thank Director of Outdoor Program Centers Paul Cunha and Construction Crew Director Tom Bindas for their technical information on sanitation systems at the AMC huts and shelters in the White Mountains in New Hampshire. I'd also like to thank David Boone of the AMC's Connecticut Trail Committee for his assistance with information on the regulatory process that governs the installation of composting toilets on the A.T. in Connecticut. And I'd like to thank Steve Clark at the Maine Appalachian Trail Club for his input and knowledge as the club's designated "Privy Czar."

At the Blue Mountain Eagle Climbing Club, I'd like to thank Dave Crosby for showing me his club's composting efforts on the Trail in Pennsylvania and for providing me with information used in this manual.

At the Mountain Club of Maryland and the Potomac Appalachian Trail Club my thanks go to Ted Sanderson, developer of the Pennsylvania composter, and Paul Ives for showing me their systems in Pennsylvania.

At the U.S. Forest Service I'd like to thank Tim Eling at the Mt. Rogers National Recreation Area; Brenda Land at the San Dimas Technology Center; and Jeff Harvey at the Green Mountain and Finger Lakes National Forest for sharing knowledge accumulated from the National Forests on backcountry sanitation.

I'd like to thank George Minnigh at the Great Smoky Mountain National Park and Pam Underhill at the Appalachian Trail Park Office, both of the National Park Service. Thanks also go to the National Park Service and its challenge cost-share program for the financial support that made this project possible.

Thanks to Bill Wall and Ben Canonica of Clivus New England for sharing their knowledge and providing me with materials on the Clivus for the manual. I'd also like to thank Allen White of Bio Sun Systems Inc., who was also generous with his time and resources in assisting me with this project.

At the Appalachian Trail Conference, thanks for energetic support—in addition to writing—go to New England Regional Representative J.T. Horn. I'd also like to thank ATC Board of Managers New England Vice Chair Brian Fitzgerald and Director of Trail Management Programs Bob Proudman (especially for his continual encouragement and support in the search for the "sanitation silver bullet"). Also: Mid-Atlantic Regional Representative Karen Lutz, Mid-Atlantic Associate Representative John Wright, Central and Southwest Virginia Regional Representative Mike Dawson, Southwest Virginia Associate Representative Teresa Martinez, Tennessee-North Carolina-Georgia Associate Representative Ben Lawhon, Bear's Den Hostel Manager Melody Blaney, ATC Editor Robert Rubin, and ATC Management Information Systems Specialist Hansen Ball.

I'd like to give special thanks to the ATC's Jody Bickel, associate regional representative for New England. Jody played many key roles in the development of this manual: volunteer author, associate editor, motivational coach (for helping me deal with the realities of deadlines), meeting facilitator, contact for the Appalachian Trail Conference, general source of information, and of course good cheer. Thank you, Jody, the *Sanitation Manual* will serve the Appalachian Trail well as a result of your efforts.

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.

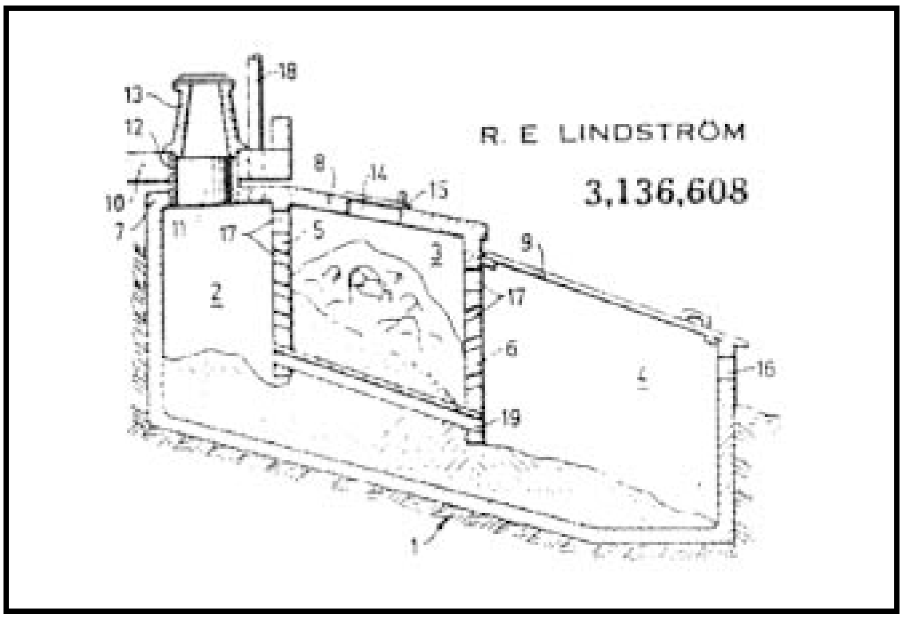

Figure 1.1—Original Clivus Multrum Toilet designed by R.E. Lindstrom of Sweden in the 1930s. Drawing From Stop the Five Gallon Flush (1980) taken from The Composting Toilet System Book by David Del Porto and Carol Steinfeld.

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."

See Section 5, "Following Policies and Regulations."

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.

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

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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

See Section 4—"Health and Safety Issues."

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.

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.

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.

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

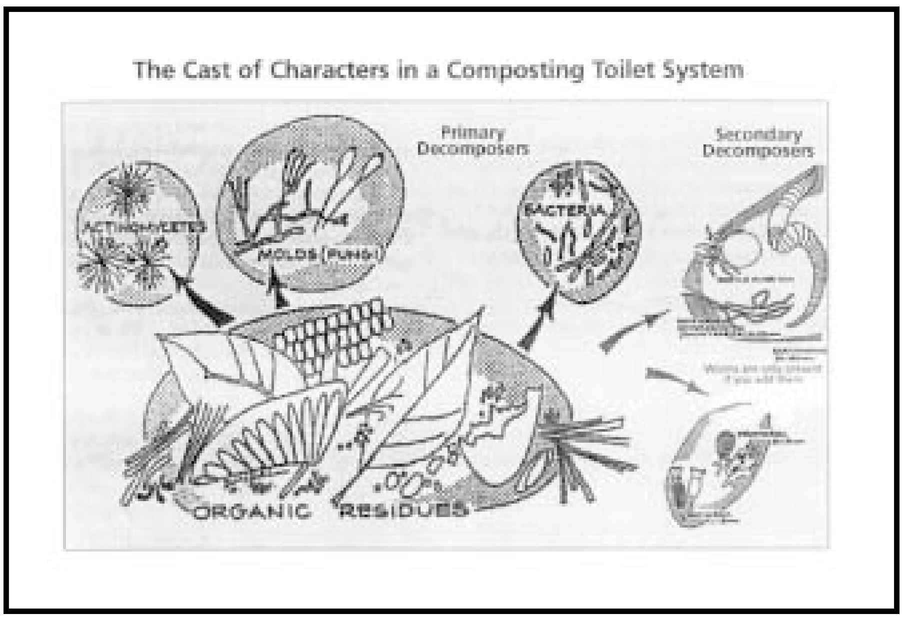


Figure 3.1—Types of decomposing organisms found in a composting toilet. Key organisms include actinomycetes, bacteria, and fungi. Red worms are a secondary player, and must be added by the operator." Drawing from The Composting Toilet System Book by David Del Porto and Carol Steinfeld. Drawing originally 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

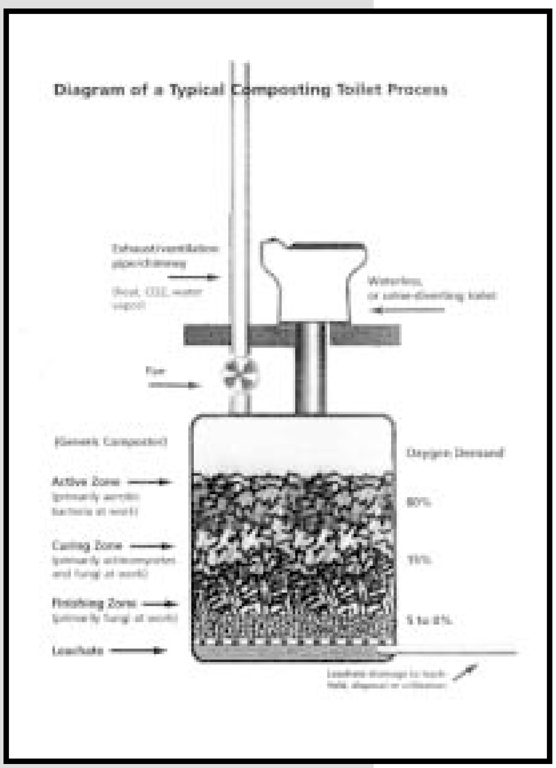
Traditionally, people have used pit toilets or pit privies (commonly called outhouses) in the backcountry. Returning to our cow pasture comparison, this practice is an attempt to keep popular backcountry sites from resembling septic barnyards, or the even more objectionable feedlot. Outhouses protect 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

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"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.).

   See Section 9, "Batch-Bin Composting.

   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

Typical Pathogen Survival Rates at 20° to 30°C in Various Environments*

Pathogen	Survival Time[a] in Days: Freshwater and wastewater	Crops	Soil
Bacteria			
Fecal coliforms	<60 but usually <30	<30 but usually <15	<120 but usually <50
Salmonella (spp.)	<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	<120 but usually <50	<60 but usually <15	<100 but usually <20

*Adapted from Feachem et al. (1983).
Includes polio, echo, and Coxsackie viruses.
In seawater, viral survival is less, and bacterial survival is very much less than in fresh water.
V. Cholerae survival in aqueous environments is a subject of current uncertainty.
(Ron 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

6—Introduction to the Regulatory Process

7—The Aesthetics of Backcountry Sanitation Systems

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 BACK-COUNTRY 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

9—Batch-Bin Composting

10—Liquid Separation in Composting 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

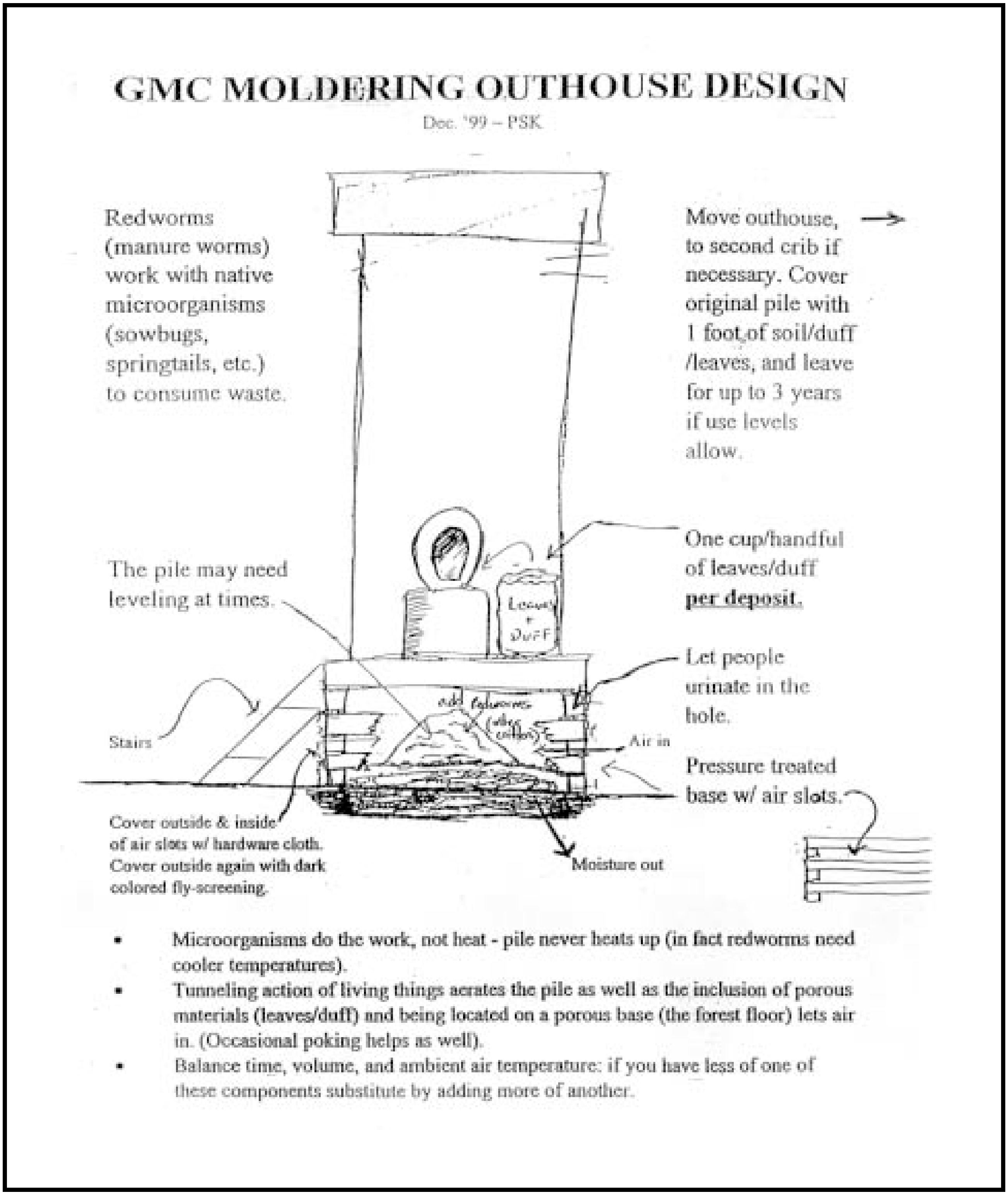


Figure 8.1—Conceptual diagram for the Green Mountain Club moldering privy. Not to scale. This diagram shows only one composting chamber. Current Green Mountain Club design utilizes a double-chambered system. When one chamber is full in the new design, it is capped with a lid, and the outhouse building 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.

See Section 11.8—Case Studies, "Prototype Wood-Fired Compost Incinerator."

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.

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.

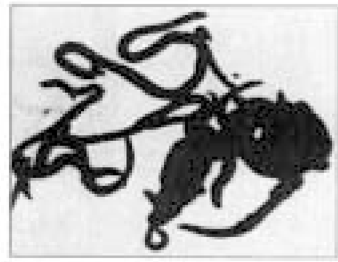
Worms transform organic material in their digestive tracts, so that their fecal matter, called "castings," is rich in nutrients that are ready for plants. Equally important, by virtue of their ability to burrow deep and come to the surface often, earthworms provide deep aeration for soils and prevent 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 worm's 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 (*Enchytraeids*). 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.

   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.

See Section 9—"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

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.

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.

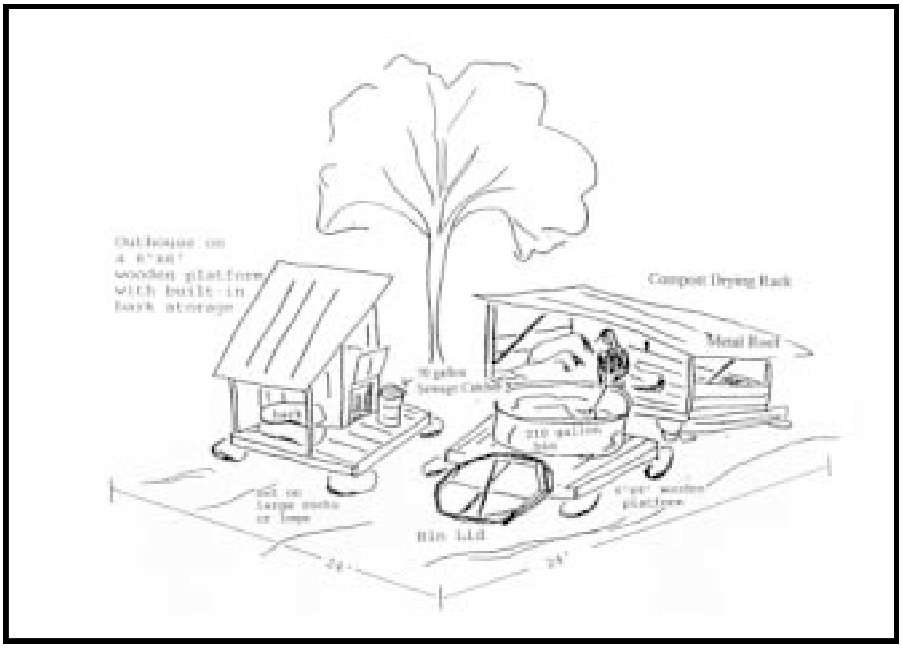


Figure 9.1—Diagram of Green Mountain Club batch-bin composting toilet systems depicting all of the system's components. Note that the outhouse design depicted is only one of several options. Not shown are the two 32-gallon storage cans the Green Mountain Club uses as part of their system. The Appalachian 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."

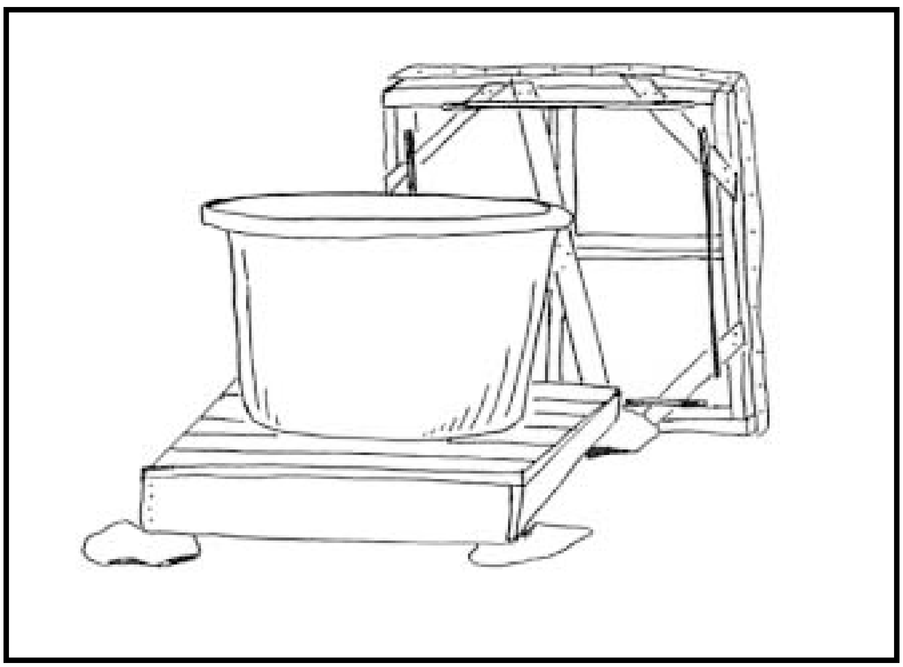


Figure 9.2—Diagram depicting the Green Mountain Club batch-bin compost system bin and lid. The lid is constructed of dimensional lumber. The Green Mountain Club recommends using manufactured plastic lids whenever possible because they have a longer life expectancy in the field and are less likely to 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,

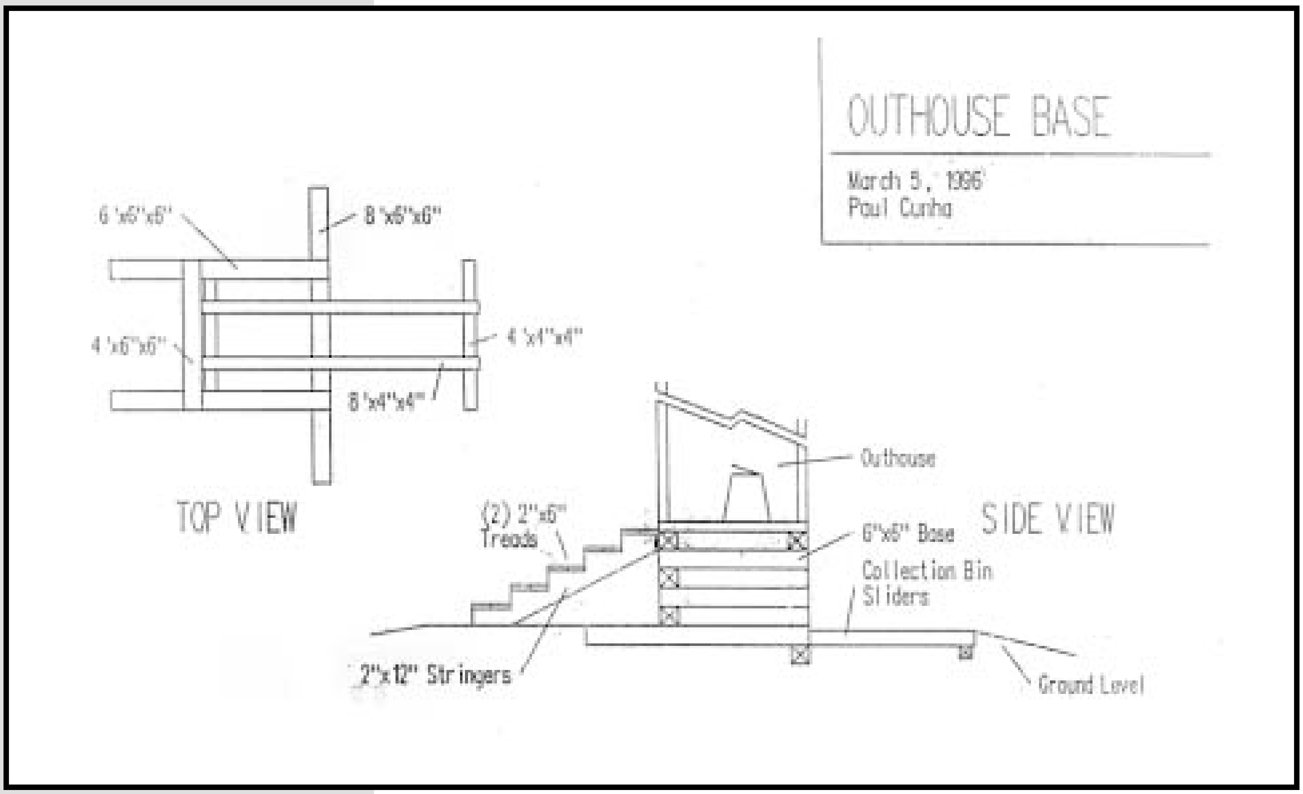


Figure 9.3—This diagram shows how to construct a chamber to house a 70-gallon sewage catcher in either a batch-bin or beyond-the-bin system. This plan is particularly useful for converting an existing outhouse. However, a new outhouse can accommodate a 70-gallon catcher without an elevated foundation 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.

See Appendix J, "Drying Rack Plans."

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.

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.

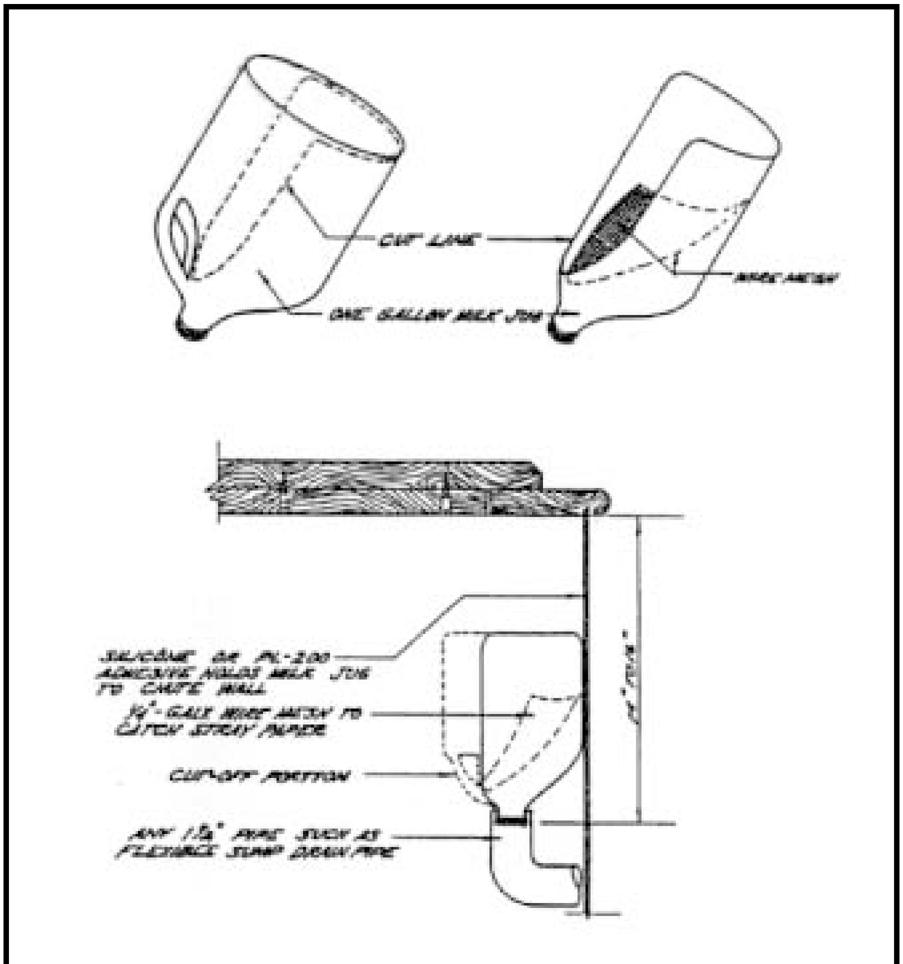


Figure 9.4—An example of a simple, home-made, urine diverting device that could have many applications with a variety of systems, both those described in this manual and others in use on the A.T. The drain pipe could lead to a beyond-the-bin liquid management system or a simple rock-lined dry well. State 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

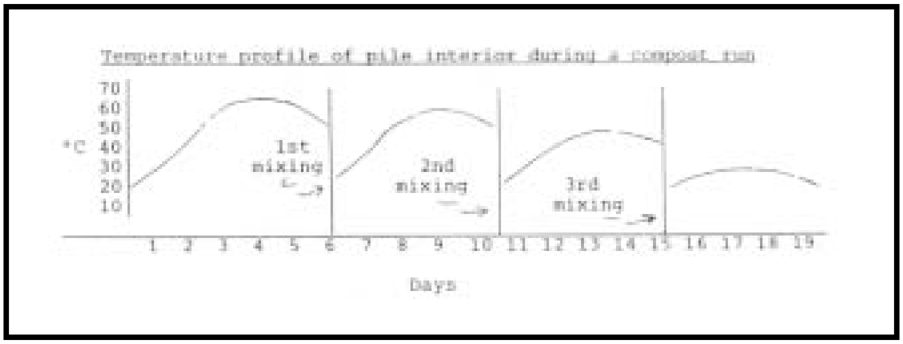


Figure 9.5—Temperature profile of compost pile in a batch-bin system during a compost run." From the Green Mountain Club.

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

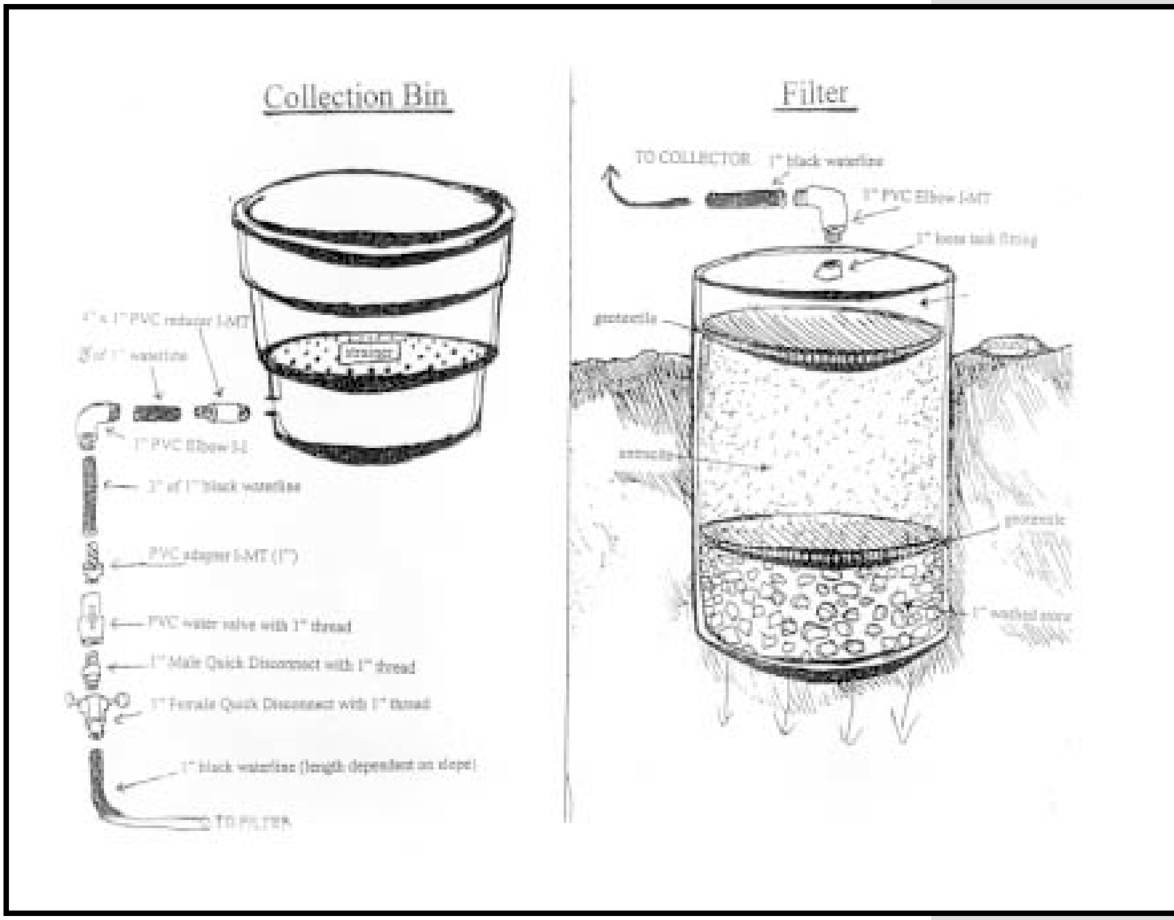


Figure 10.1—The beyond-the-bin liquid management system designed by the Appalachian Mountain Club's Trails Department. This system is an improvement to the Green Mountain Club and Appalachian Mountain Club batch-bin system. Not shown in this diagram is a second barrel that can be attached beyond filter 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.

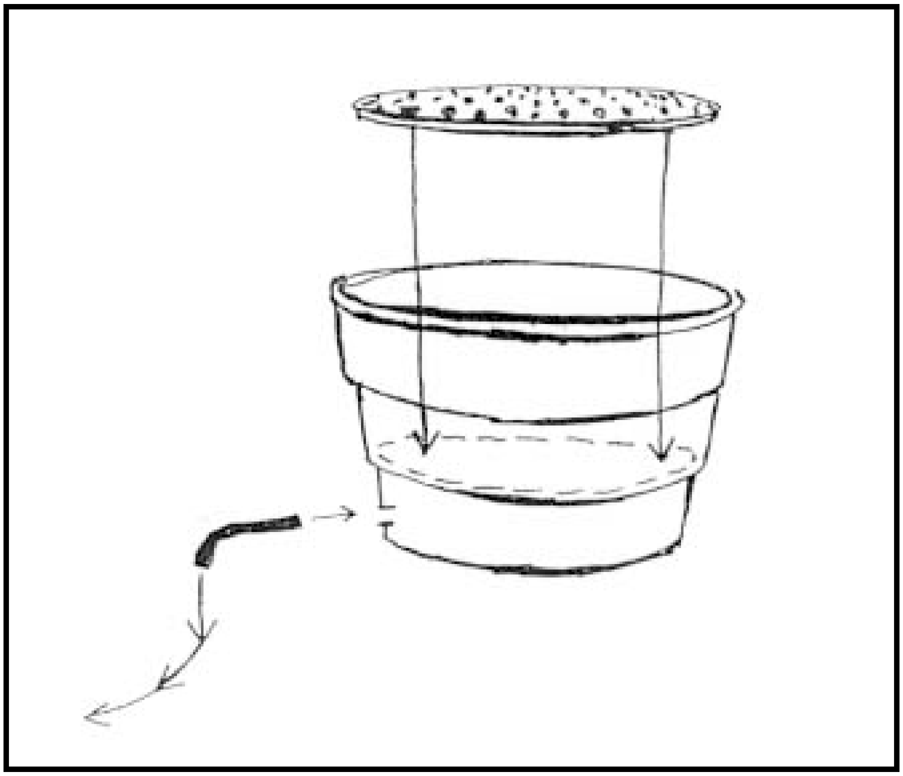


Figure 10.2—Diagram illustrating the placement of a perforated stainless-steel strainer plate in a 70-gallon sewage catcher. This is the first step to attaching a beyond-the-bin liquid management system. The hose leads liquid away for treatment. Diagram from the Appalachian Mountain Club Trails Department."

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

- Moldering Privy on the A.T. at Little Rock Pond, Vermont
- Moldering Privy on the A.T. in Massachusetts
- Appalachian Mountain Club Clivus Multrum Composting Toilet
- Randolph Mountain Club Bio-Sun Composting Toilet
- At Home with the Clivus Multrum Composting Toilet
- Airlift Haul-Out Systems
- Flush Toilets with Leach Field at High Mountain Huts
- Prototype Wood-Fired Compost Incinerator

12—The Decision Making Process

13—Gray Water Management in the Backcountry

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

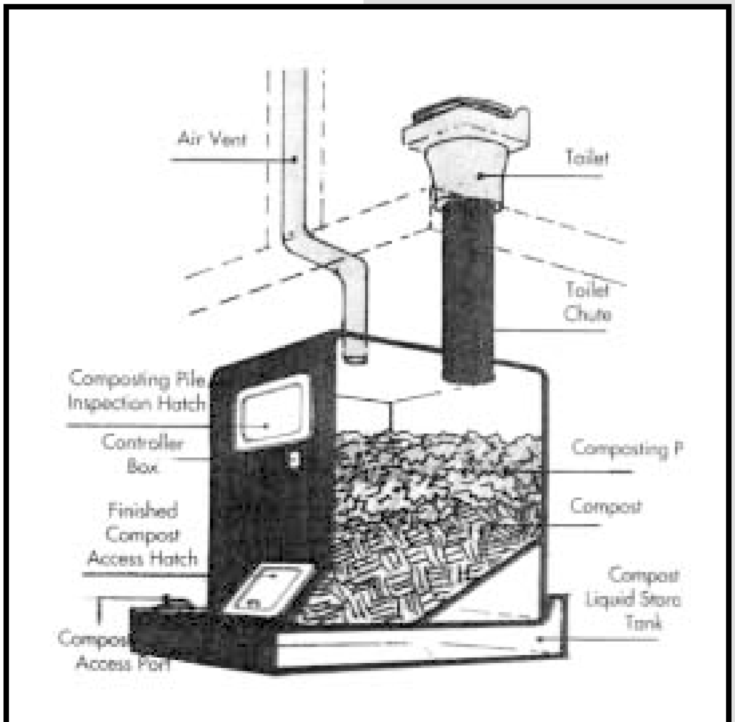


Figure 11.1—Example of large, commercially designed, continuous composting toilet. This example is a schematic cutaway view of a Clivus Multrum system, showing features common to most models. (Contact Clivus Multrum New England for specific model information. See Commercial Systems contacts in the Appendix.) 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 break-down 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 (CO2) 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.

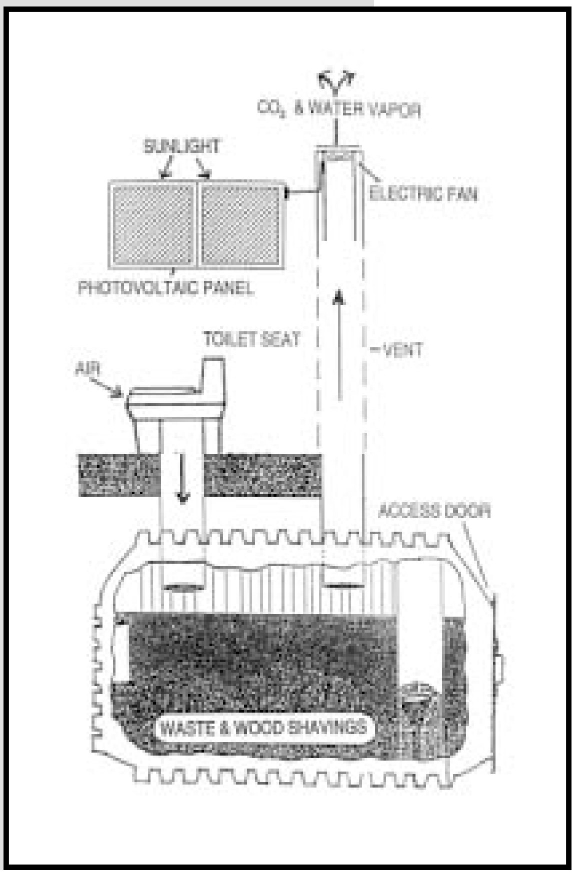


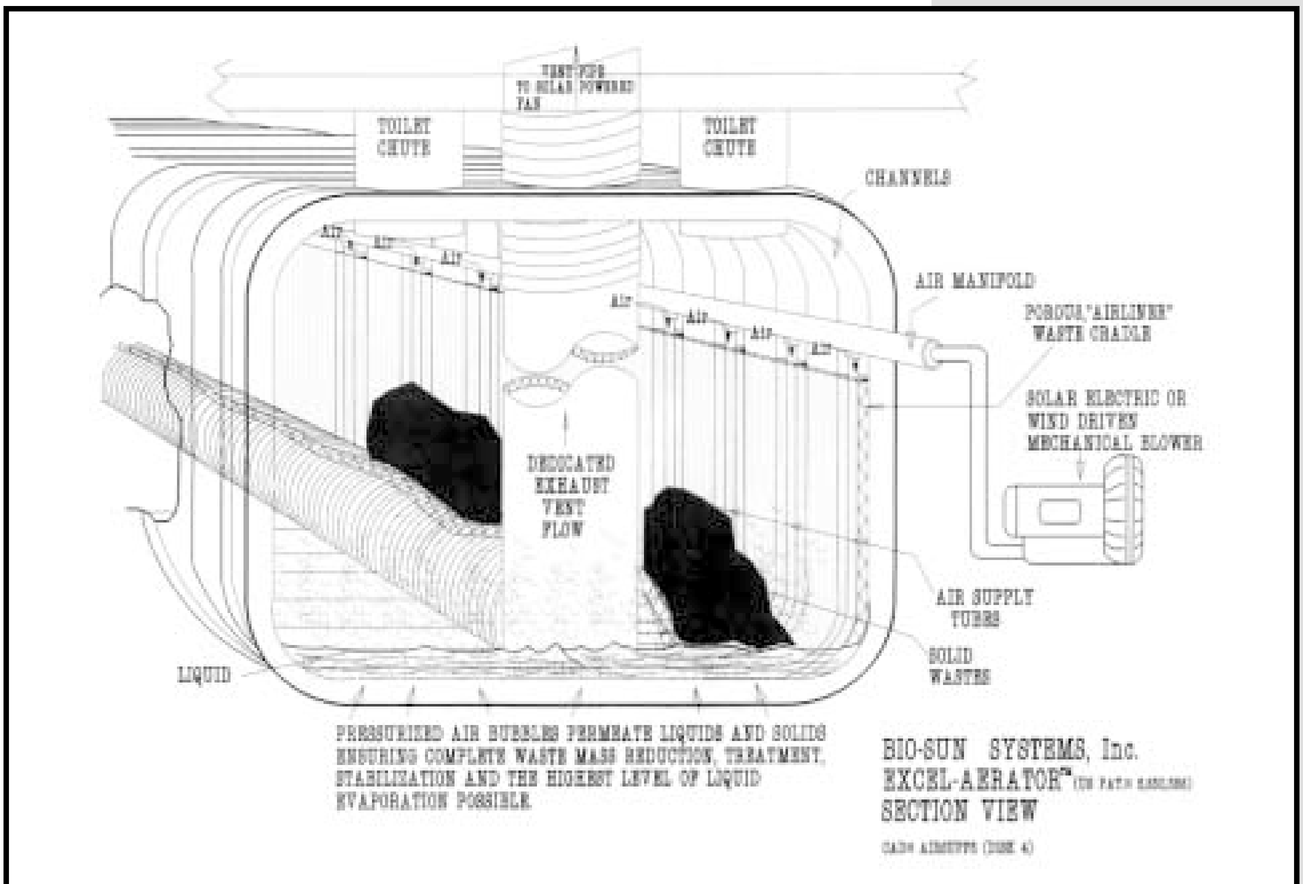
Figure 11.2—A cutaway view of a Bio-Sun WRS 1000, the model installed at the Randolph Mountain Club's Gray Knob Cabin in the northern Presidential Range of the White Mountains in New Hampshire. Note that the bottom of the tank does not slope. Aged compost must be raked towards the rear access door by 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

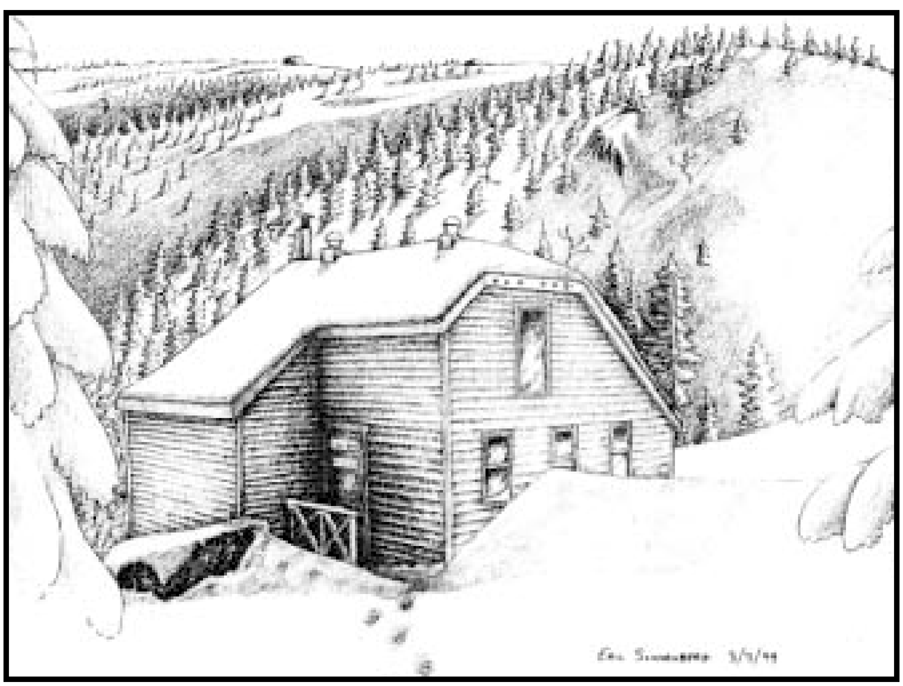


Figure 11.4 The Randolph Mountain Club's Gray Knob Cabin in the northern Presidential Range of the White Mountains in New Hampshire. Drawing by Eric Scharnberg, from the Randolph Mountain Club.

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 midwinter. Gray Knob may be the most challenging location for composting in the East

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

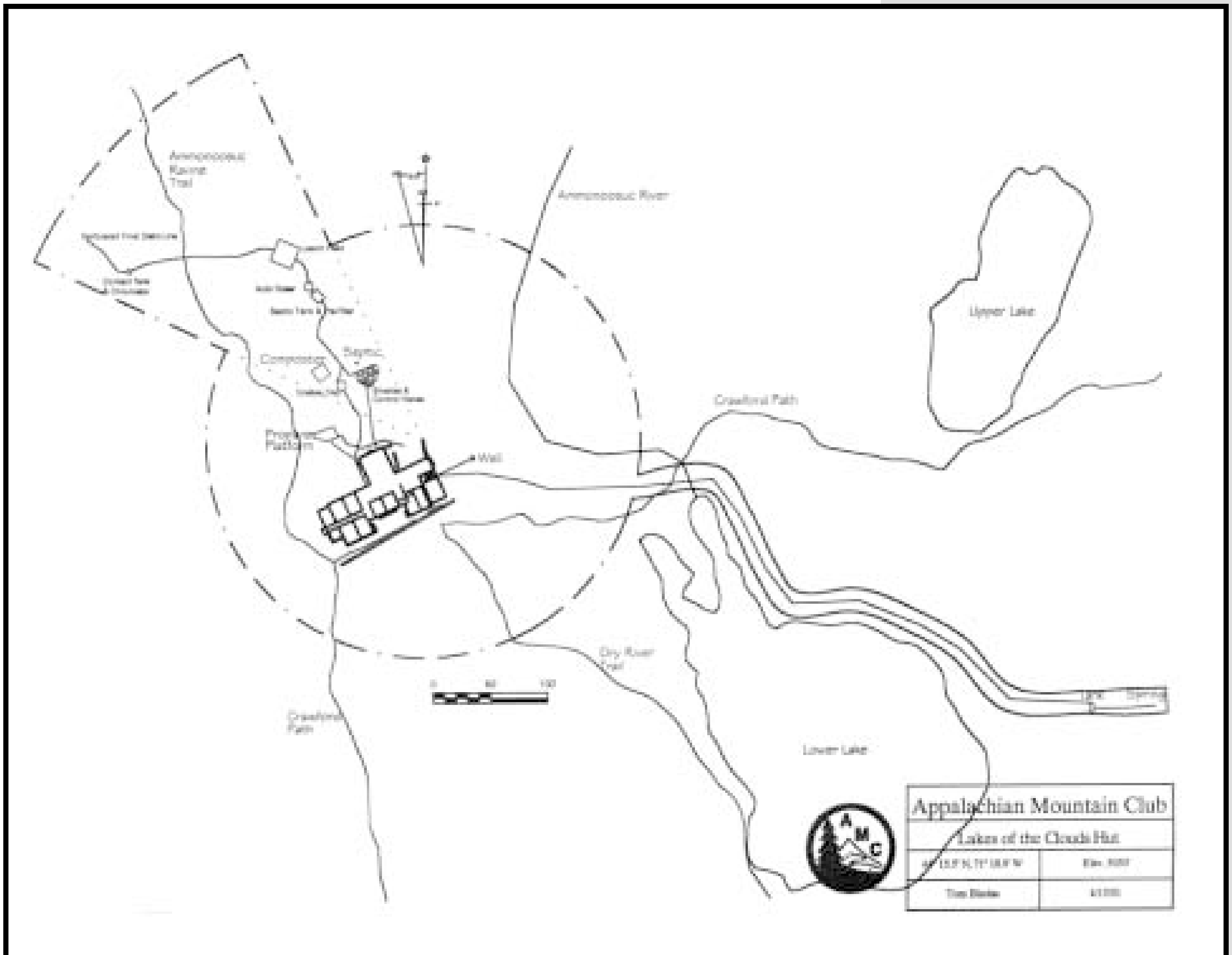
By Chris Thayer, Huts Manager, Appalachian Mountain Club

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.



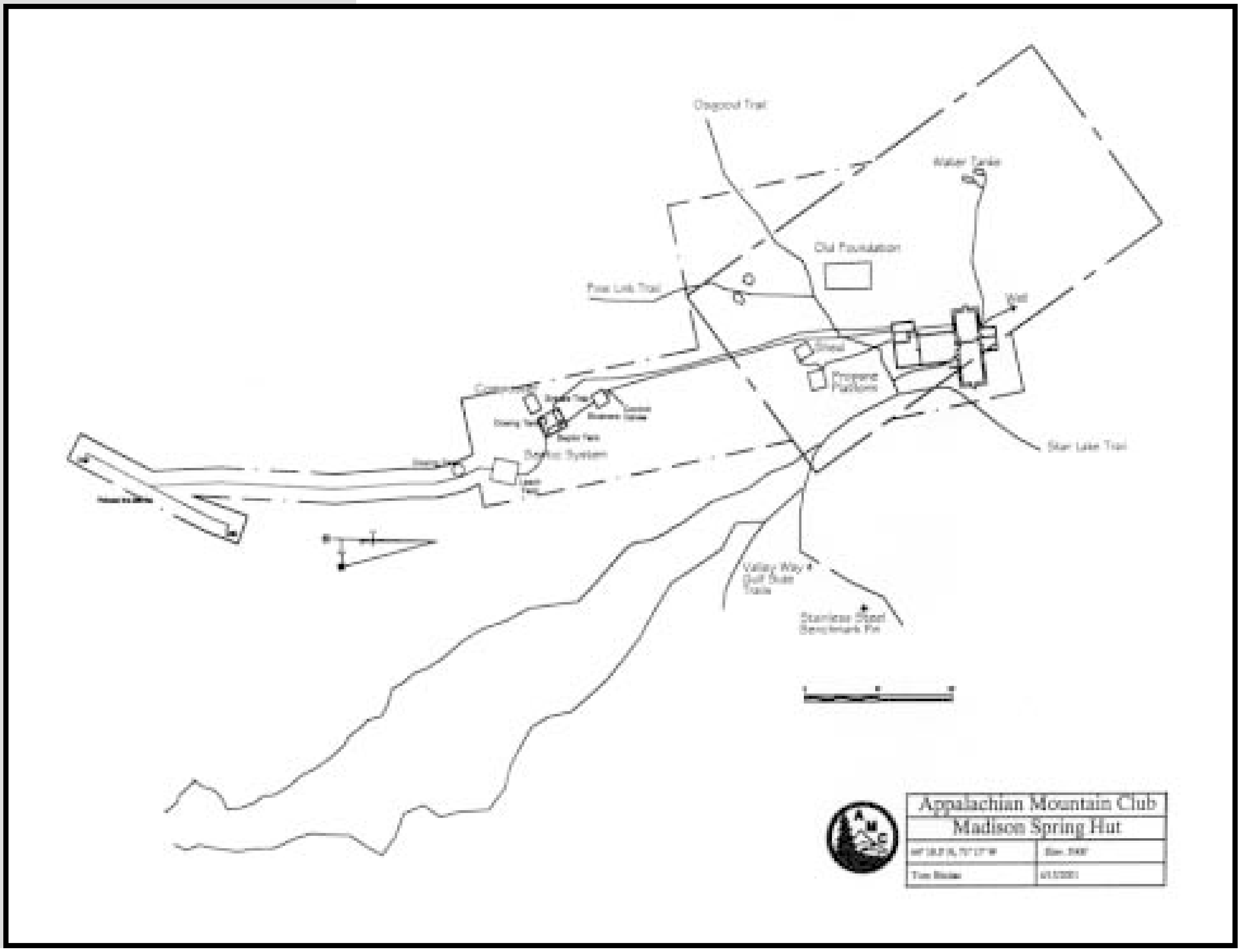
Our first leach fields were filled with sand, but new ones use black anthracite coal flakes instead. The grains of coal are more uniform in size and offer more surface area per grain, and coal is much lighter to airlift in to the location. The wastewater is sprayed on the top of the field, and as the 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

See Section 4, "Health and Safety Issues."

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.

- 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

B—Troubleshooting and General Composting Tips

C—About the Organizations behind this Manual

D—Contact List

E—Bibliography

F—Examples of Stewardship Signs

G—Sources of Materials for a Batch-Bin System

H—Lightweight Outhouse Plans

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K—Diagram of a Washpit

L—Backcountry Sanitation: A Review of Literature
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M—The Application of a Solar Hot Box to Pasteurize Toilet Compost
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N—Examples of Regulatory Correspondence

O—Article from ATC Newsletter, *The Register*

P—Owner-Built Continuous Composters

Q—Plans for a Wooden Packboard

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

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.

B.1 TROUBLESHOOTING BATCH-BIN AND BEYOND-THE-BIN SYSTEMS

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)*.

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Jenkins Publishing

Publisher of *The Humanure Handbook*. The author, Joseph Jenkins, and his book were an invaluable resource for the production of this manual.

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D

Contact List

April 2001

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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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Birchard, W.J.R. and R.D. Proudman. 2000. *Appalachian Trail Design, Construction and Maintenance* (Second Edition). The Appalachian Trail Conference, Harpers Ferry, WV

Campbell, S. 1975. *Let it Rot! The Home Gardeners Guide to Composting*. Storey Communications, Inc. Pownal, VT.

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Goldstein, J. 1977. *Sensible Sludge*. Rodale Press, Emmaus, PA. 184 pp.

Golueke, C.G. 1977. *Biological Reclamation of Solid Wastes*. Rodale Press, Emmaus, PA. 249 pp.

Grant, N. M. Moodie, and Weedon C. 1996. *Sewage Solutions, Answering the Call of Nature*. Centre for Alternative Technology Publications. Wales, UK

Harper, P. 1998. *Fertile Waste*. Centre for Alternative Technology Publications. Wales, UK.

Jenkins, J.C. 1999. *The Humanure Handbook: A Guide to Composting Human Manure*. Second Edition. Jenkins Publishing, Grove City, PA.

Leonard, R.E, E.L Spencer, and H.J. Plumley. 1981. *Backcountry Facilities: Design and Maintenance*. Appalachian Mountain Club, Boston, MA. 214 pp.

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Poindexter, J.S. 1971. *Microbiology, An Introduction to Protists*. The MacMillan Company, New York. 582 pp.

Ryn, S.V. 1978. *The Toilet Papers—Recycling Waste and Conserving Water.* Ecological Design Press. Sausalito, CA.

Stoner, C.H. 1977. *Goodbye to the Flush Toilet*. Rodale Press, Emmaus, PA. 285 pp.

Martin, J.P. and D.D. Focht. 1977. Biological Properties of Soils. pp. 115-162. In L.F. Elliot and F.J. Stevens, co-editors. *Soils for the Management of Organic Wastes and Waste Waters*, SSSA, ASA, CSSA, Madison, WI.

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Fay, S.C. and R.H. Walke. 1977. *The Composting Option for Human Waste Disposal in the Backcountry*. USDA Forest Service Research Note NE-246. The Northeastern Forest Experiment Station & Forest Service, US Dept. of Agriculture. Upper Darby, PA.

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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.

WELCOME TO THE BIRCH GLEN CAMP PRIVY

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.

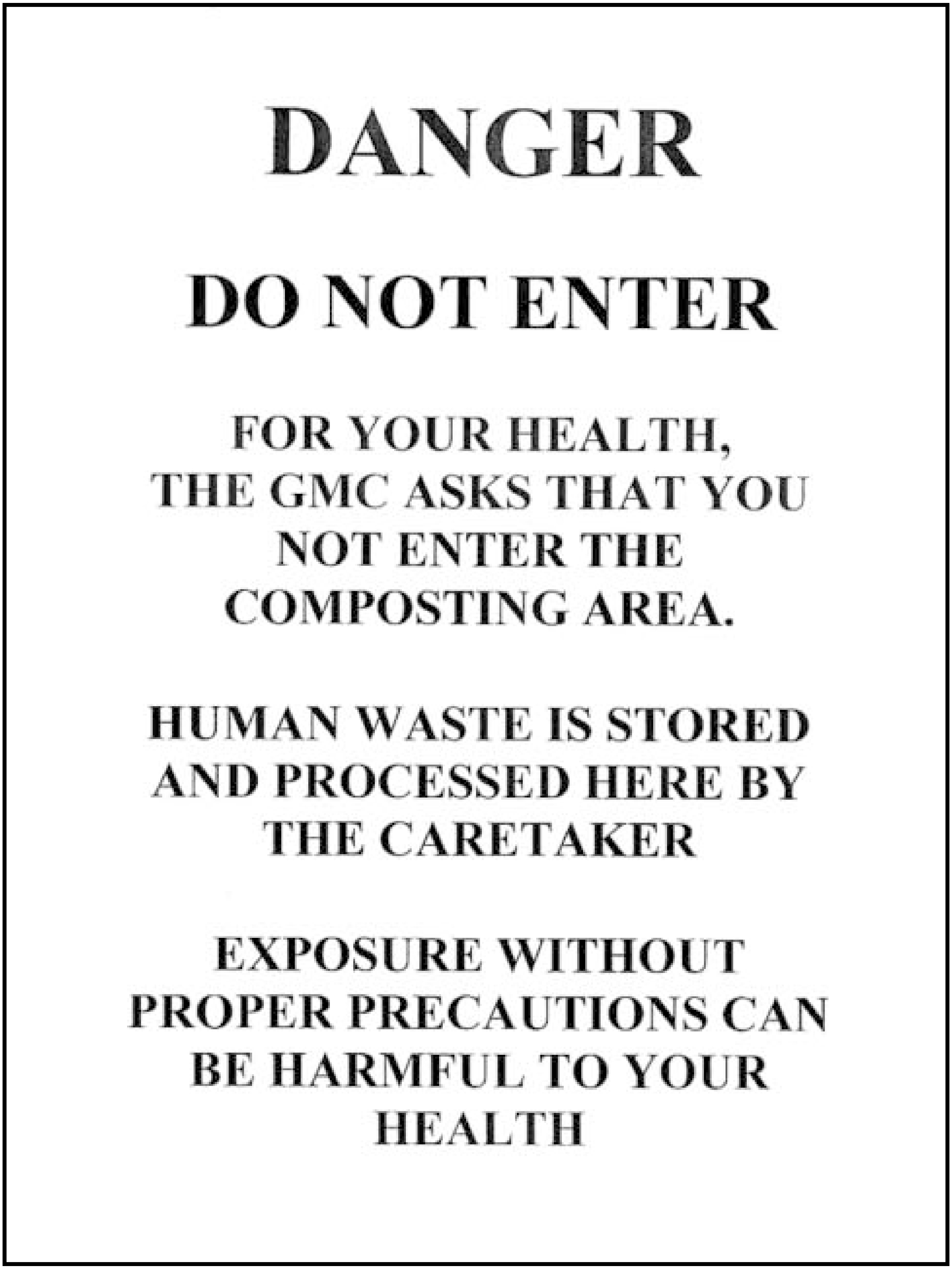

Figure F.6—A warning sign to keep the public out of a composting system area and components. Sign from the Green Mountain Club.

Please, help us maintain the efficient operation of this composting toilet by

NOT DEPOSITING GARBAGE IN TOILET !!

(Including feminine hygiene products, plastics, foil or cigarettes)

Garbage interferes with the composting process and must be removed by the caretaker

CLOSE TOILET SEAT and ***LATCH DOOR*** when finished

Thank you for your cooperation !!

RMC

Randolph Mountain Club
Randolph, New Hampshire 03570

FOREST SERVICE U S DEPARTMENT OF AGRICULTURE

Figure F.7—The outhouse stewardship sign used at the Randolph Mountain Club's Bio-Sun systems. Sign from the Randolph Mountain Club.

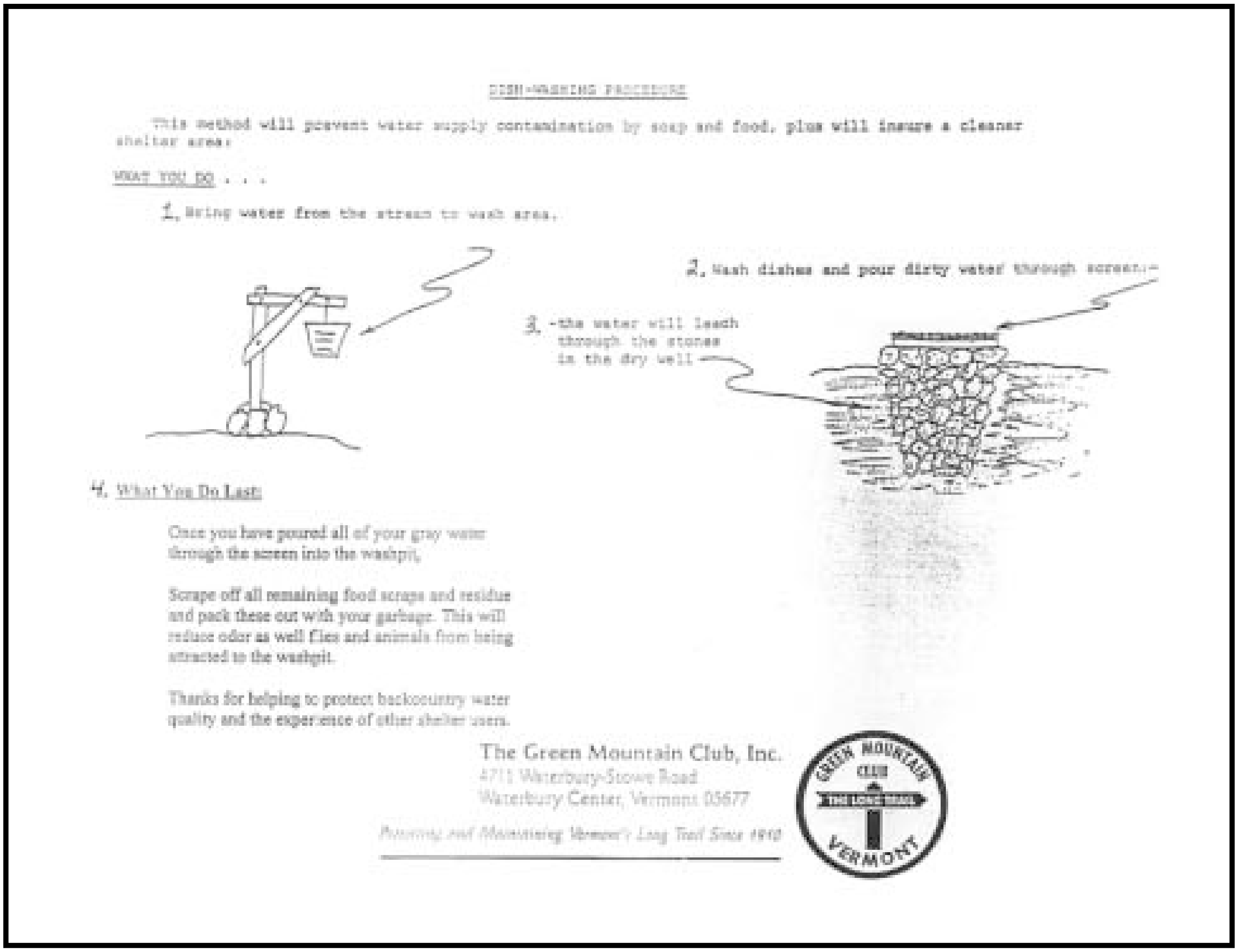

Figure F.8—A sign, including a schematic drawing, designed to be placed in shelters and near washpits to explain to hikers how and why to use the washpit. Drawing from the Green Mountain Club.

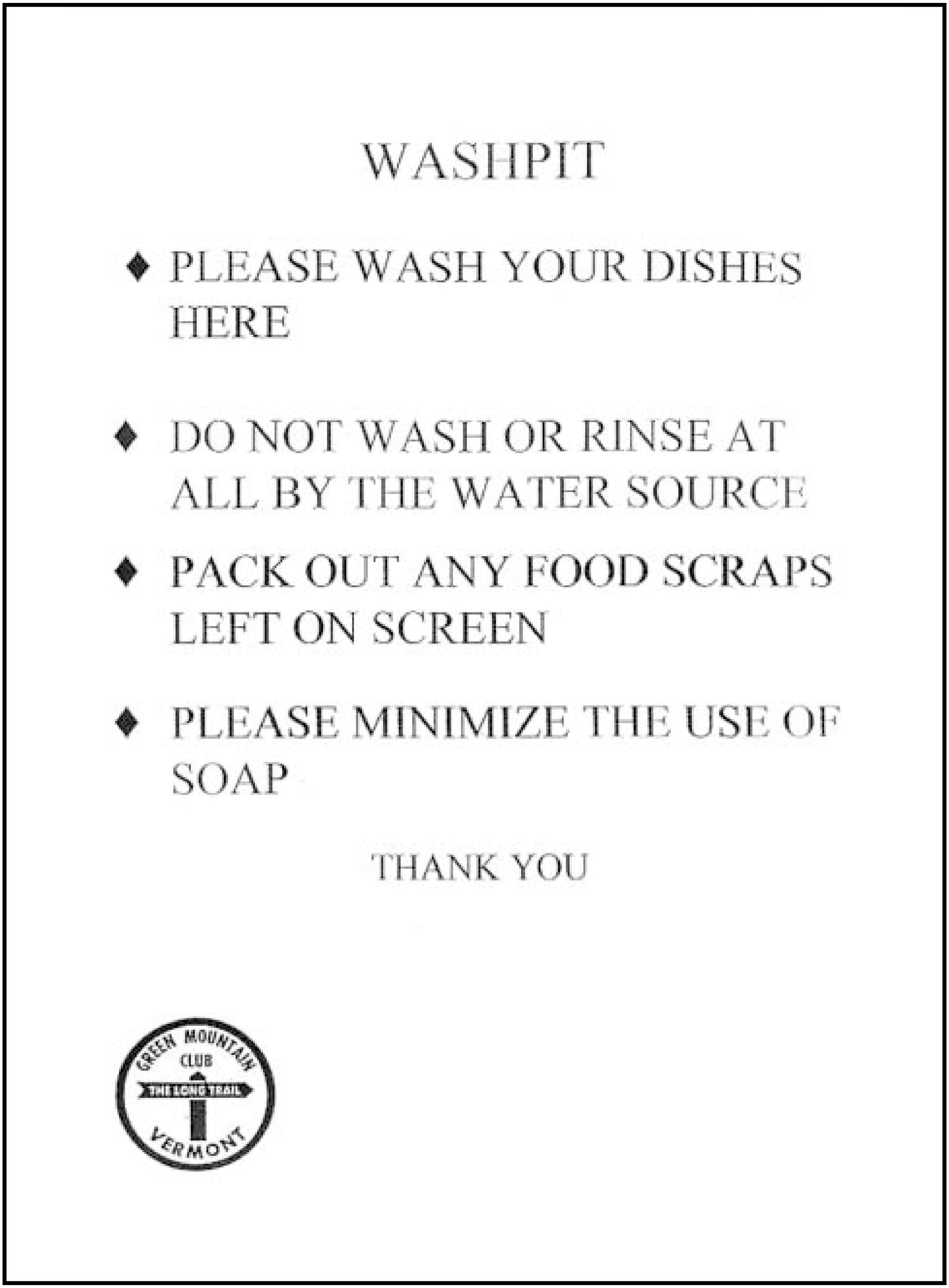

Figure F.9—A washpit stewardship sign. Sign from the Green Mountain Club.

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

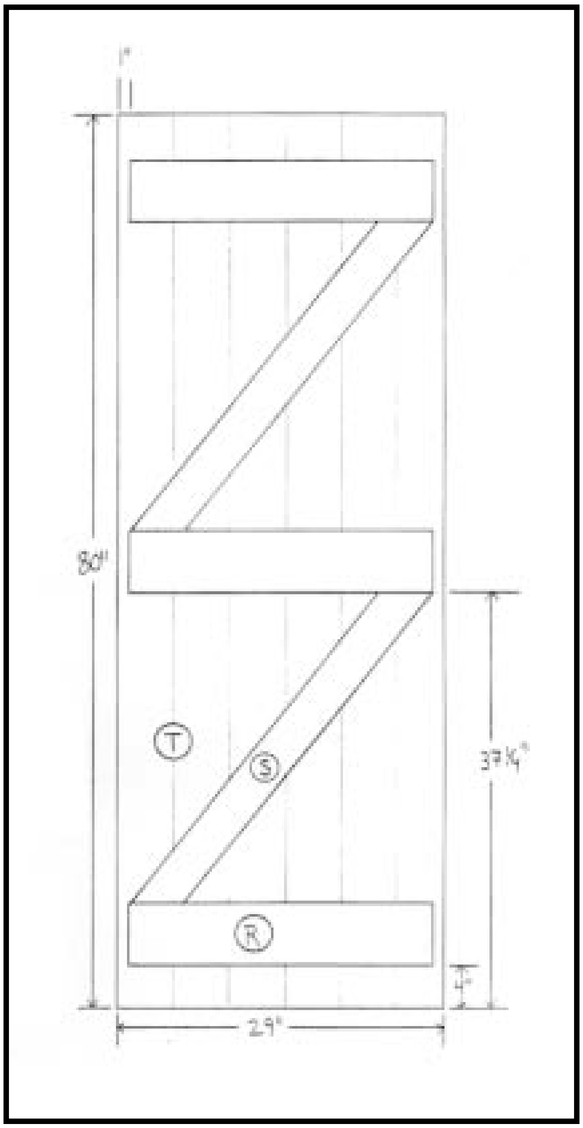

Figure H.1—Plans for a lightweight outhouse. It can be used with a moldering privy, or with a batch-bin or beyond-the-bin system when placed over a vault to hold the catcher (see Chapter 7, the Batch-Bin System). This plan does not show a lift-up bench seat or a rear access door, either of which makes it more convenient to inspect and manipulate the waste pile. Plans from Jeff Bostwick, Green Mountain Club.

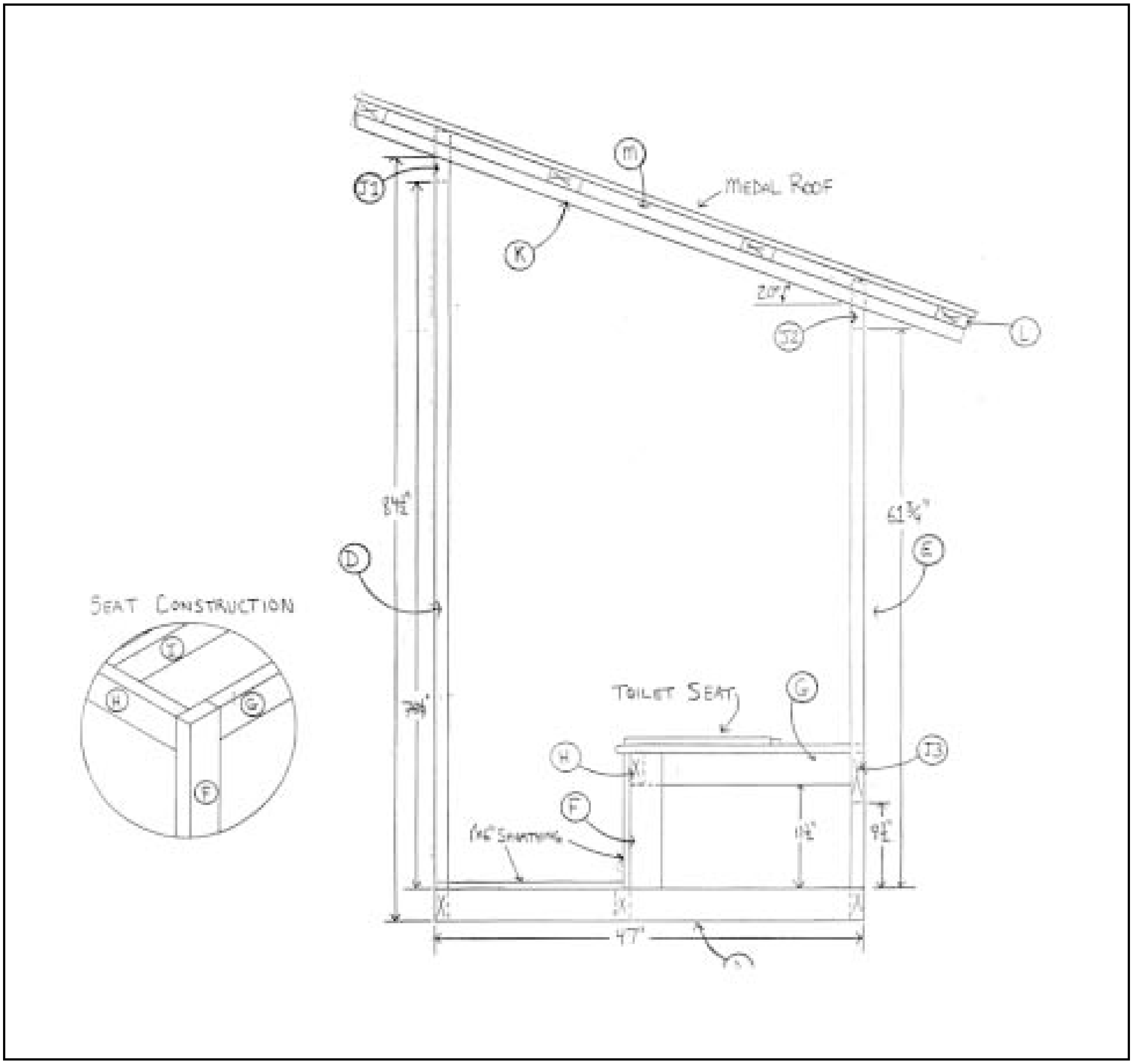
MEDAL ROOF
M
K
J1
J2
L
D
E
SEAT CONSTRUCTION
TOILET SEAT
G
H
I3
F
47'

Figure H.2

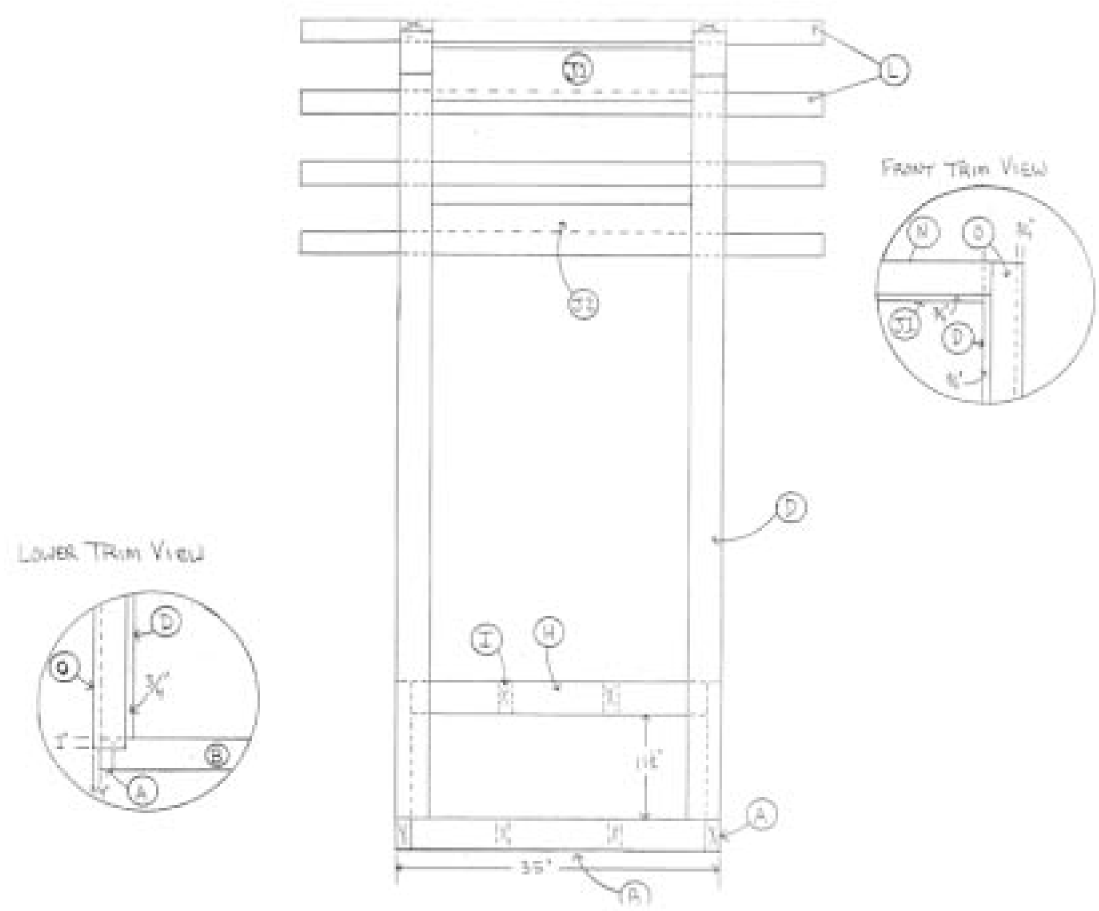

Figure H.3

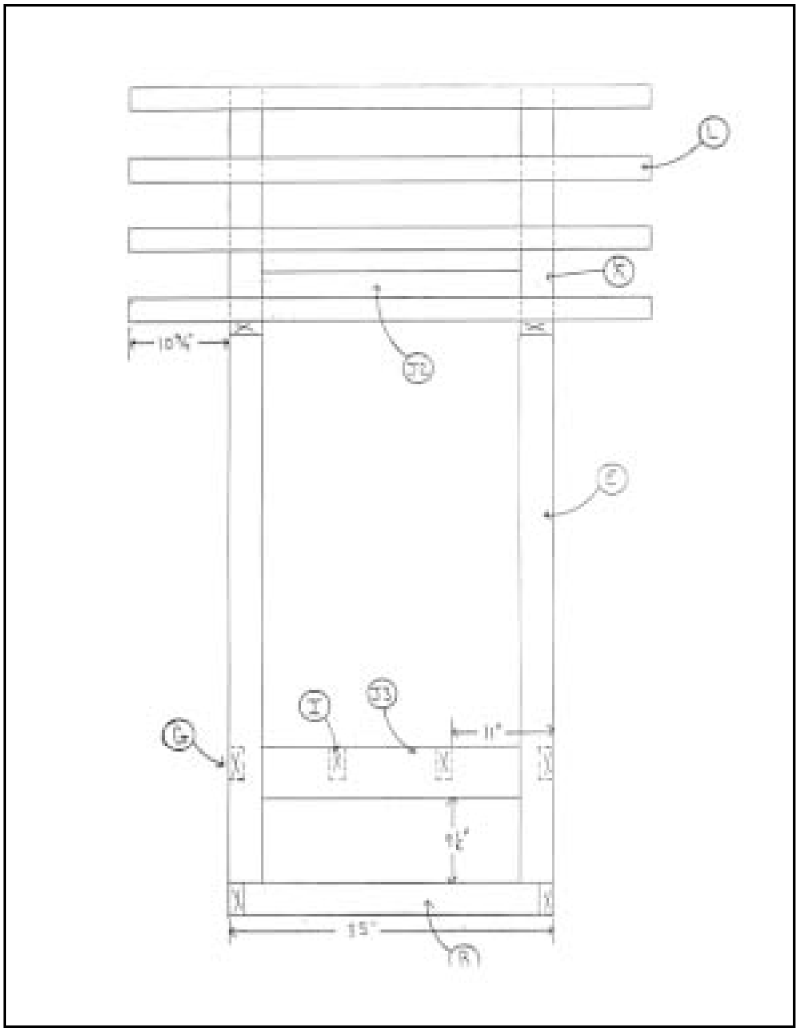

Figure H.4

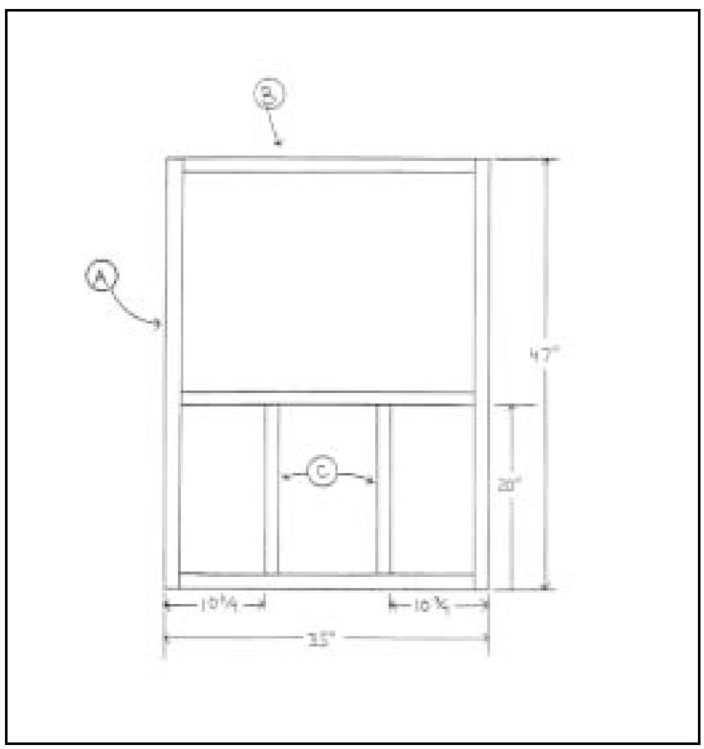

Figure H.5

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)

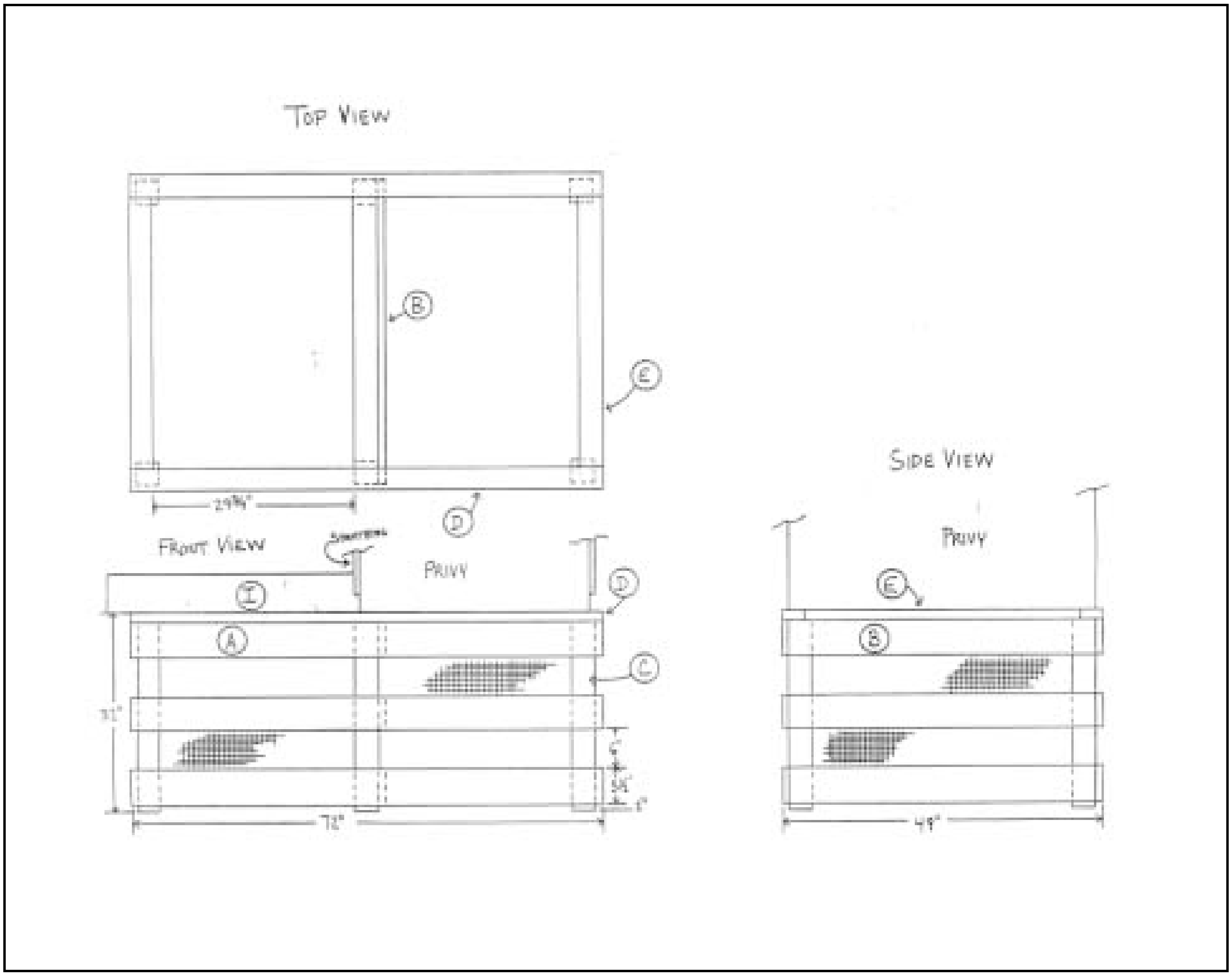

Figure I.1—Plans for the construction of the latest prototype of the Green Mountain Club moldering privy, a double-chambered design. Plans from of Jeff Bostwick, Green Mountain Club.

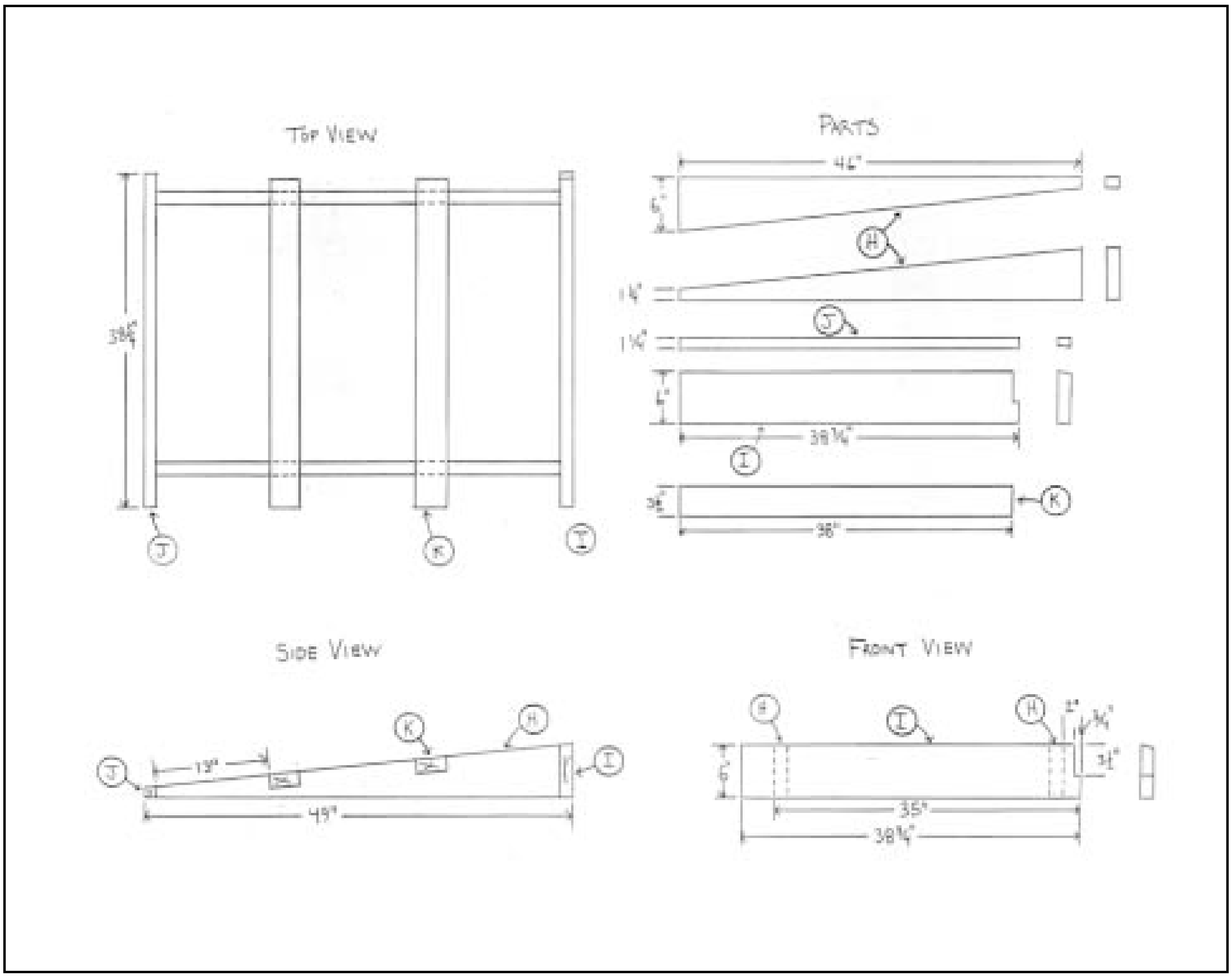

Figure I.2

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

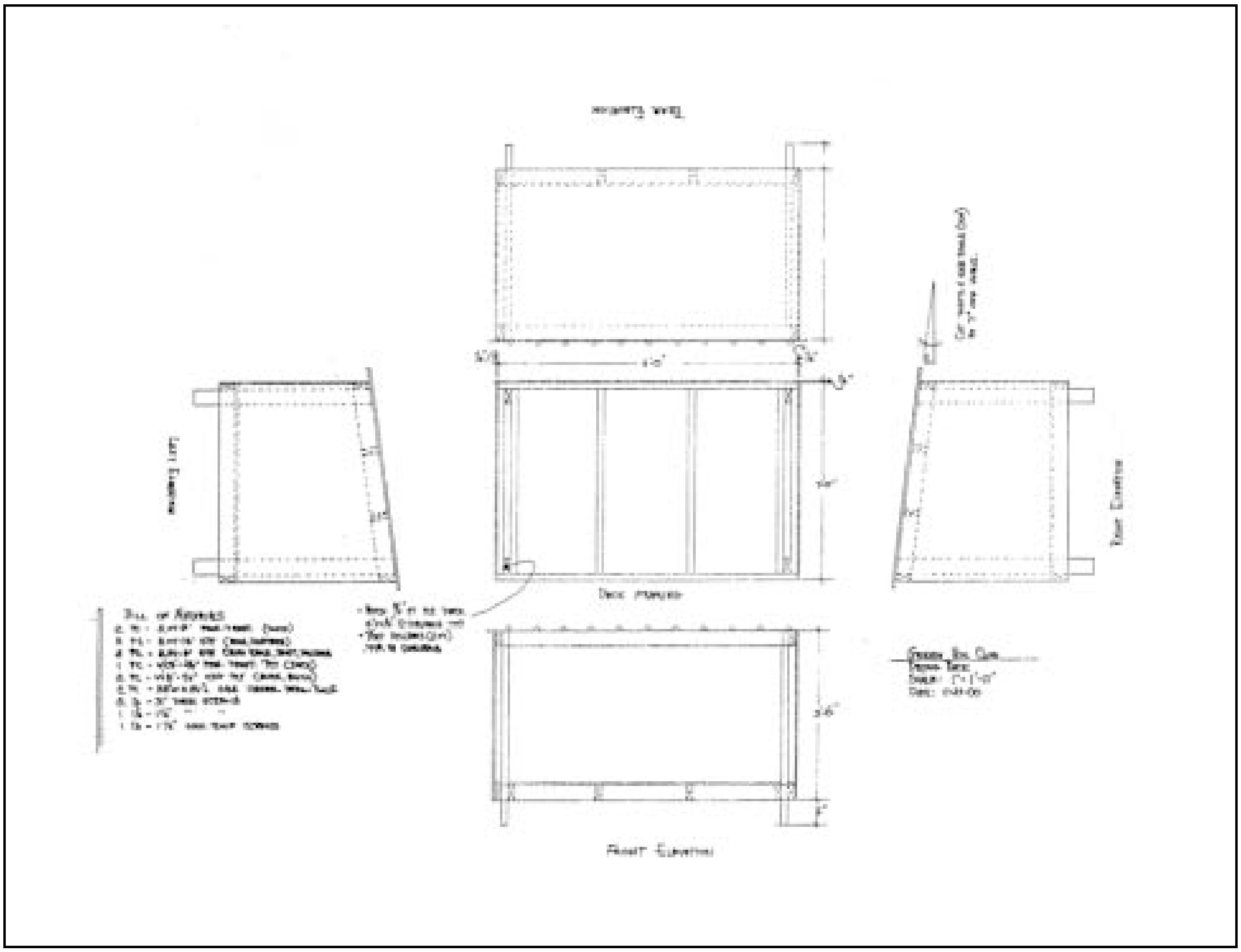

Figure J.1—Diagram of the Green Mountain Club's drying rack, used with their batch-bin and beyond-the-bin and moldering privy systems." Diagram from Eric Seidel and the Green Mountain Club.

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).

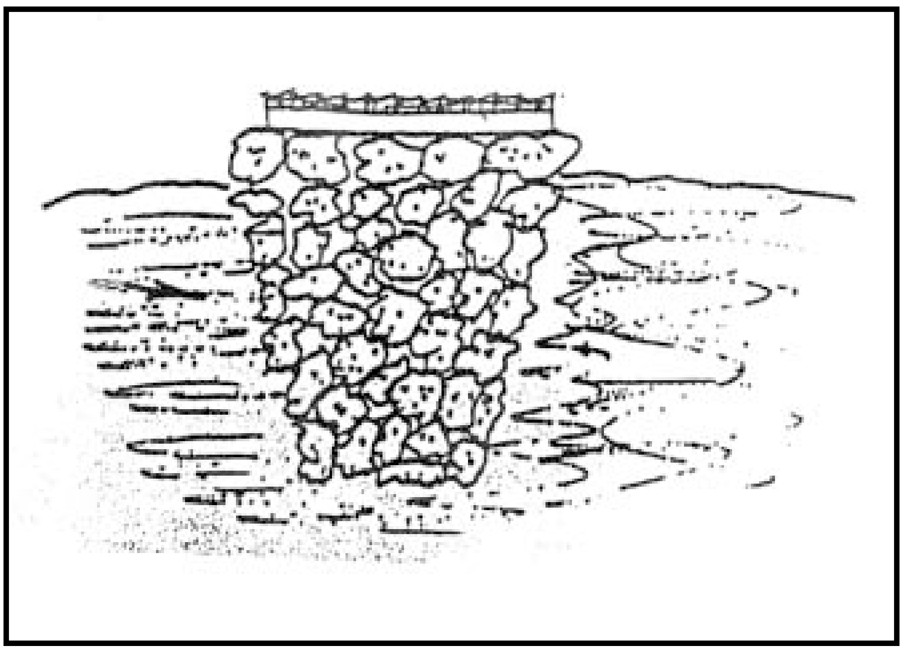

Figure K.1—Green Mountain Club style washpit. Drawing from the Green Mountain Club.

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.

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Editor's Note:

This article was originally published in Park Science, a resource management bulletin of the National Park Service, under the citation:

Lachapelle, P. R., and J. C. Clark, 1999. The application of a solar "Hot Box" to pasteurize toilet compost in Yosemite National Park. Park Science 19(1): 1, 20-21, and 24.

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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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.#** BR83-0001
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-5-1542, 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 pathagen 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 ______________ 9/25/2000
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-B103f 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

n/sewage/letter/red worm1

Phone: 860-509-7296
Telephone Device for the Deaf (860) 509-7191
410 Capitol Avenue - MS # 51 SEW
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.

O

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 back-country 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>.

P

Owner-Built Continuous Composters

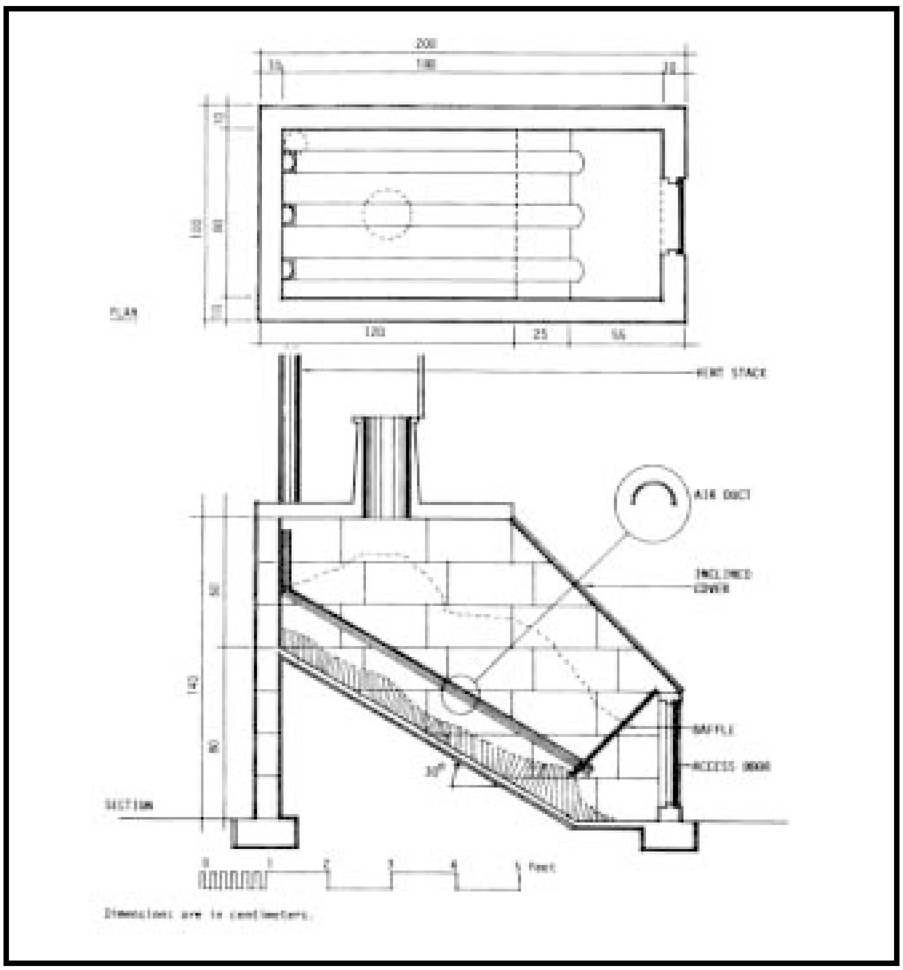

Figure P.1—This is an example of plans for the construction of an owner-built, continuous composting system. The plans pictured are for a Clivus Minimus, which is modeled after the Clivus Multrum. The Pennsylvania Composter, a unit in use on the A.T. in Pennsylvania, Maryland, and New Jersey, is a similar 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.

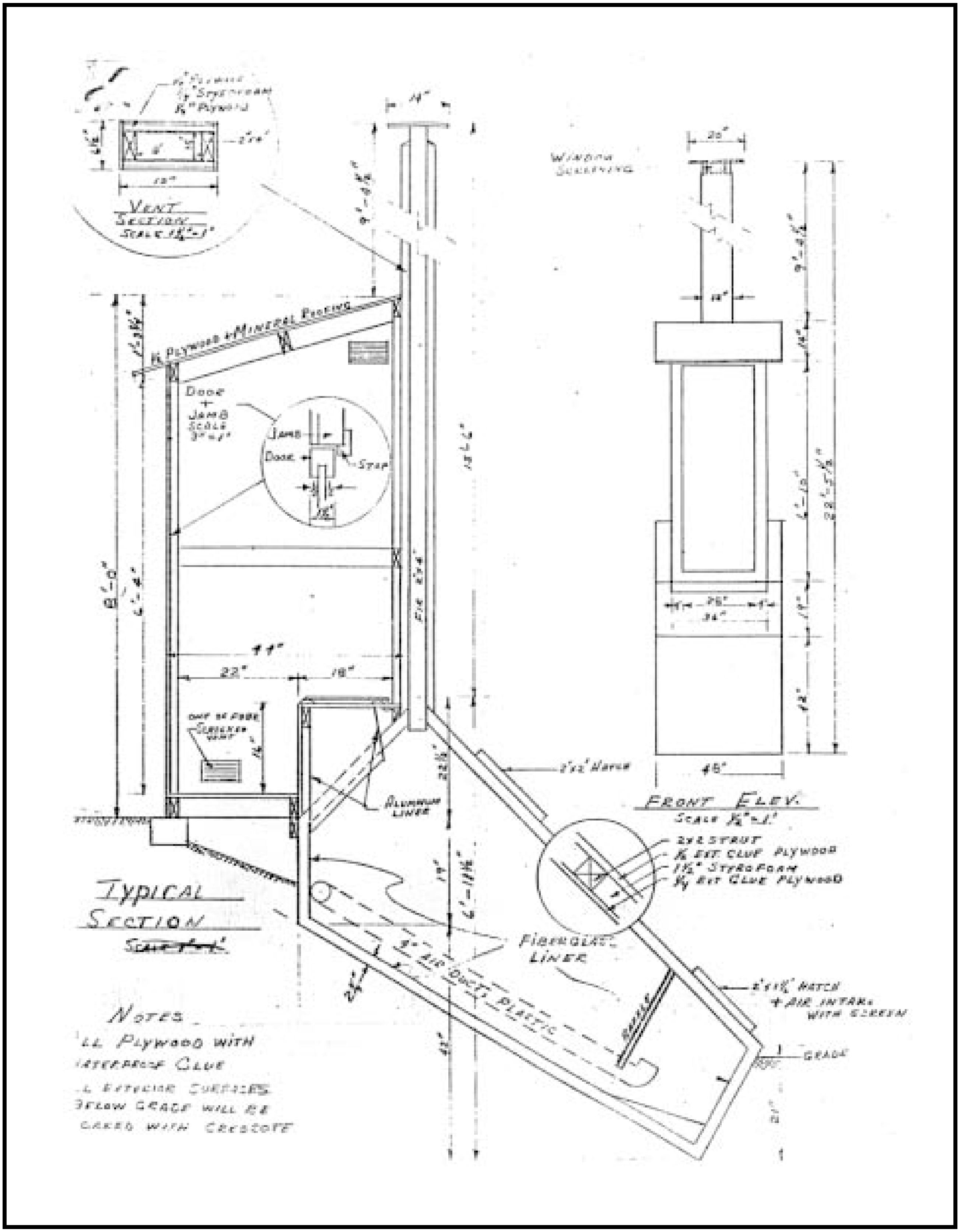

Figure P.2—A diagram of the Mountain Club of Maryland's "Pennsylvania Composter." This system is also referred to as a "Clivus Minimus," because it is an owner-built version of the Clivus system. For plans and additional information, contact the Mountain Club of Maryland's Ted Sanderson (Contact information is in the Contact List in this Appendix)." Diagram from Ted Sanderson and the Mountain Club of Maryland.

Q

Plans for a Wooden Packboard

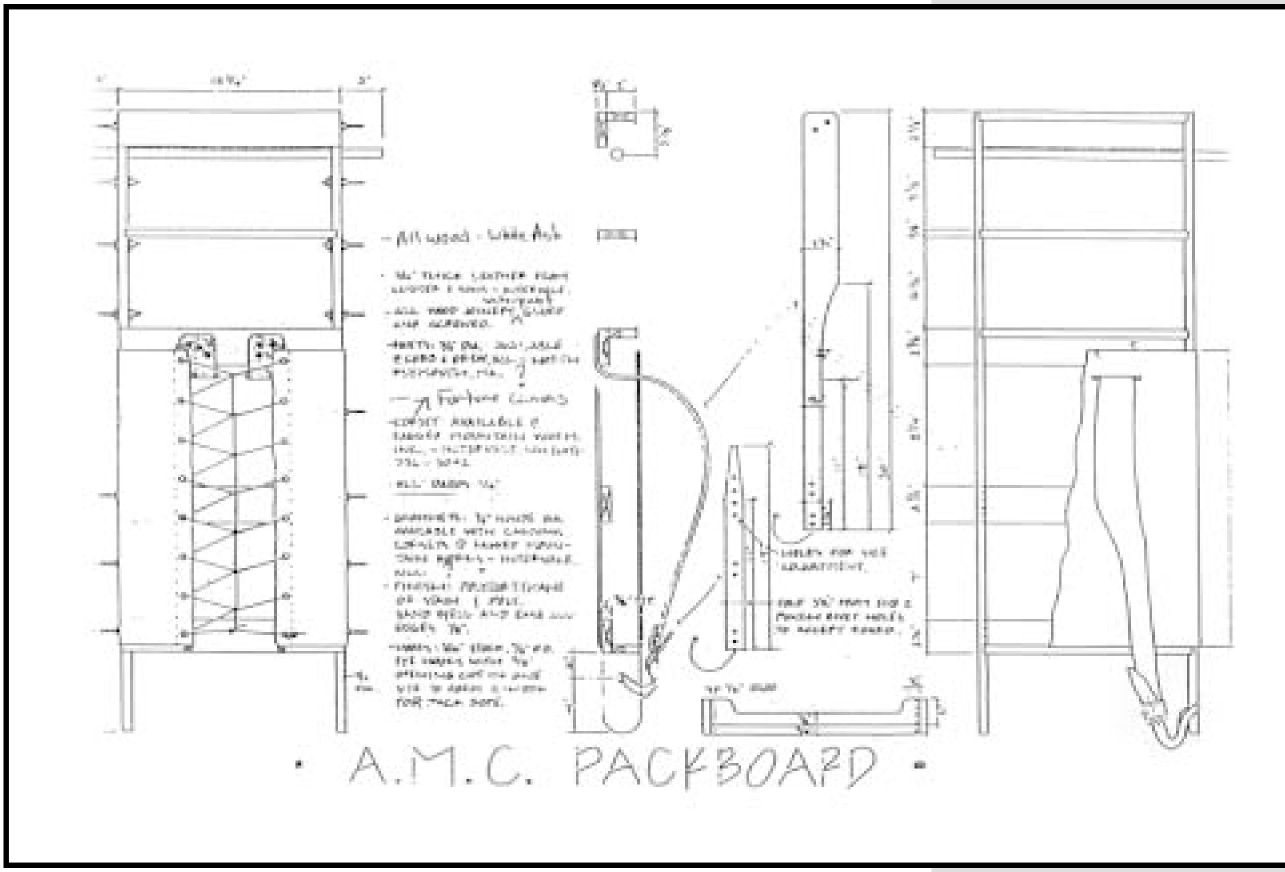

Figure P.3—Plans for construction of the Appalachian Mountain Club's wooden packboard. This packboard has been found to be the best for transporting composting toilet system components into the field as well as bark mulch or other bulking agents by the Green Mountain Club and Appalachian Mountain Club.

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