Alternative Onsite Sewage Disposal Technology: A Review

Richard Siddoway

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Washington State Institute for Public Policy
110 East Fifth Avenue, Suite 214
Post Office Box 40999
Olympia, Washington 98504-0999
Telephone: (360) 586-2677
FAX: (360) 586-2793
URL: http://www.wsipp.wa.gov
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EXECUTIVE SUMMARY

Affordable and effective onsite sewage disposal is a national problem—less than 35 percent of the land in the United States is suitable for conventional onsite sewage treatment and disposal systems. Nearly 30 percent of the homes in Washington are served by onsite sewage disposal systems, and up to one half of these systems do not perform satisfactorily or will fail entirely during their expected life. Pollution from failing onsite systems threatens public health and the quality of the environment.

Because of the problems and limitations of conventional systems, effective alternative systems have been developed over the last several decades. Most alternative systems are modifications or improvements to some aspect of conventional onsite systems.

* Improved soil absorption techniques, including dosing and pressure distribution systems and mound systems, are shown to be effective for some soils.

* Of the three alternative treatment devices evaluated, sand filters are the most common, most effective, and most expensive. Anaerobic filters are still in the experimental phase, and aerobic tanks in field conditions do not appear to offer an improvement over conventional septic tanks.

* The characteristics and volume of waste entering an onsite system greatly affect its performance. Water conservation measures have been shown to improve system performance and in some cases restore failed systems. In an effort to further reduce water use, several devices have been developed that separate toilet waste from the rest of the waste stream. None of these toilet systems have proven to be entirely satisfactory.

Washington State has a well developed program to evaluate the design and installation of alternative onsite systems. The Washington Department of Social and Health Services has developed guidelines for eight different alternative systems, as well as regulations for experimental systems.

One of the primary causes of failure in all onsite systems is lack of proper operation and maintenance. Although state regulations address the design and installation of onsite systems, there are no statewide requirements for maintenance of those systems. In other states, programs have been implemented to require periodic maintenance of onsite systems.

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1 INTRODUCTION

Nearly 30 percent (500,000) of the homes in Washington depend on onsite wastewater treatment and disposal. This percentage has remained constant over the last two decades and is expected to remain relatively constant in the future (Bureau of the Census, 1983). Onsite sewage disposal is currently, and will continue to be, an important sewage disposal method for this state.

It is estimated that up to one half of all septic systems do not perform satisfactorily, or fail entirely within their expected life (Dunlap and Kreissl, 1986). In Washington, the failure rate is estimated to be 3 percent (or approximately 15,611) systems per year (Dewalle, 1981). According to a Washington State Department of Ecology report:

> Failing onsite systems threaten ground and surface water quality in many areas of the state, causing water quality degradation, health hazards, disease outbreaks, and lowered property values (Washington State Department of Ecology, p. 23, 1987).

Nationally, septic tank leachate is the most frequently reported cause of groundwater contamination, and consumption of contaminated groundwater is responsible for over 50 percent of all reported waterborne disease outbreaks (Yates, 1985). Approximately 60 percent of the households in Washington receive their drinking water from ground water sources (Barret, 1987).

Lack of affordable and effective onsite sewage disposal is a national issue as well as a state issue. Less than 35 percent of the land in the U.S. is suitable for conventional septic tank–soil absorption systems (Otis, 1984). The limitations and failure rate of current onsite practices have spurred the search for alternative onsite technologies. This study discusses recent research on alternative onsite technologies and alternative onsite policy in Washington State.

2 BACKGROUND INFORMATION

2.1 THE SEPTIC TANK–SOIL ABSORPTION SYSTEM

The most common onsite treatment system is the septic tank–soil absorption system (Seabloom, 1980). The system consists of a septic tank, a large watertight container, and a soil absorption field, a series of buried perforated pipes (figure 2.1). The system performs two functions, treatment and disposal. The septic tank removes large solids and greases and provides biological treatment. The soil absorption field provides further treatment and final disposal.

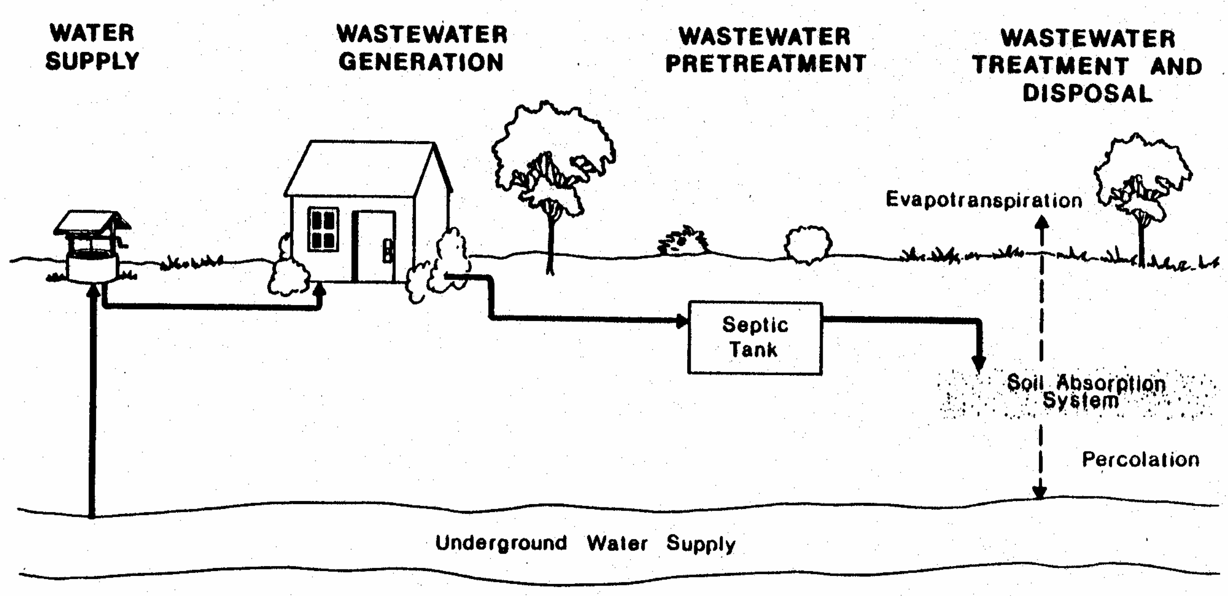

Figure 2.1
Typical Septic Tank–Soil Absorption System
(Adapted from Buchholz, 1980)

Septic tanks were originally developed in 1881 and have changed little over the past century. A septic tank is a large watertight container (approximately 1,000 gal.) which is generally buried slightly below the surface of the ground adjacent to the building it is serving (figure 2.2). In the tank, solids settle to the bottom and fats and greases collect in a layer on the liquid surface. The outlet of the tank is constructed so that liquid is discharged from the layer between the solids and the scum. The solids and scum are pumped from the tank approximately every three years. In a properly functioning septic tank, anaerobic[1] microorganisms act to treat or stabilize contaminants in the wastewater.

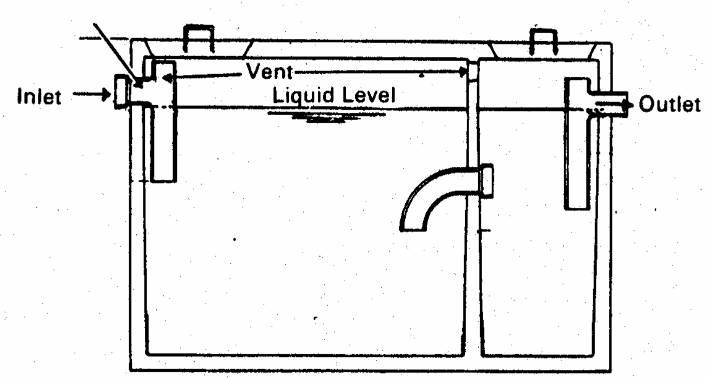

Figure 2.2
Septic Tank
(Adapted from Environmental Protection Agency, 1980)

[1] An **anaerobic** process occurs in the absence of oxygen.

The soil absorption field consists of a series of perforated distribution pipelines placed in trenches 2–3 feet wide and 2–4 feet deep (figure 2.3). The perforated pipe is placed in a layer of gravel, and the trench is covered with topsoil. Effluent from the septic tank flows down the pipes, out the perforations, and is absorbed by the surrounding soil. Organic material in the effluent is absorbed and treated by microorganisms in the soil below the distribution trenches (Buchholz, 1980). The treated water then percolates into the groundwater, or evaporates.

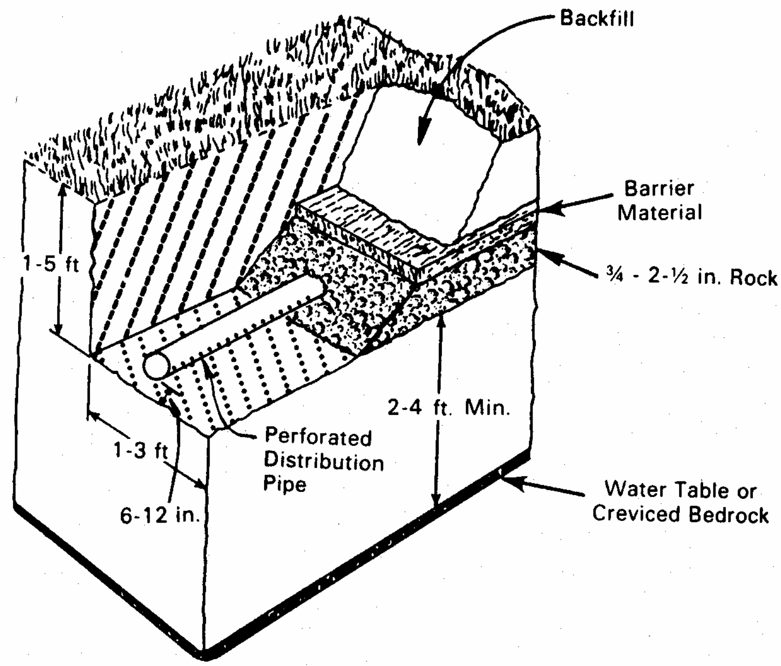

Figure 2.3
Soil Absorption Field Cross Section
(Adapted from Environmental Protection Agency, 1980)

2.2 SYSTEM FAILURES

Although the basic concept and design of the septic tank–soil absorption system is relatively simple, it functions as a “complex physical, chemical, and biological system” (Schalf and Dunlap, 1977). The successful performance of an onsite system depends on several factors, including design, construction technique, soil type, climate, operation, and maintenance.

The primary causes of onsite system failure are impermeable soils, high water table, inadequate design, improper construction, and lack of maintenance (Washington State Department of Social and Health Services, 1977).

> Health officers normally define a failed system as: 1) when sewage effluent collects on the ground surface, or 2) when toilets or drains no longer evacuate wastewater (Puget Sound Water Quality Authority, 1986).

These types of failures occur when soil under the system becomes clogged, the water table rises too close to the distribution trenches, or when the soil is impermeable.[2] Soil clogging is considered to be an inevitable occurrence for a soil absorption system over time. However, the rate at which clogging occurs is greatly influenced by system design, maintenance, and the quantity and characteristics of the wastewater being treated. Failure to pump a septic tank regularly results in rapid soil clogging and system failure.

System failures also occur when the soil under a soil absorption field is too permeable. In this case the effluent enters the ground water without proper treatment in the soil. This type of failure is more difficult to detect, because there are no noticeable problems with the disposal system. These failures are detected only through sampling the ground water.

Failing onsite systems have been identified as significant contributors to surface and groundwater contamination. However, some research suggests that even properly functioning systems may have a negative effect on groundwater. One researcher concludes that "the most important factor influencing groundwater contamination from onsite waste disposal systems is the density of systems in an area" (Yates, 1986). A thirty-year study of groundwater pollution in central Pierce County, Washington, shows increasing groundwater contamination with increasing septic system density (Dewalle and Schaff, 1980).

2.3 SOILS

In the state of Washington, surface discharge from onsite systems is not permitted (Washington Administrative Code 248-96-050). Therefore, all onsite systems depend on the soil for ultimate disposal of the liquid portion of the waste treatment process. In most onsite systems the soil also provides final treatment.

Contaminants are removed from wastewater when it passes through soil by contact with aerobic[3] microorganisms and absorption to soil particles. In order for the soil to effectively remove pathogens and contaminants, the wastewater must travel slowly through two to four feet of unsaturated soil (EPA, 1980). If the wastewater travels too quickly, effective treatment does not occur and the underlying groundwater becomes contaminated. If the wastewater travels too slowly, the soil becomes saturated and aerobic treatment does not occur.

The length of time it takes the wastewater to travel through the soil is determined by the permeability of the soil. Permeability is affected primarily by soil texture and soil structure (Brady, 1984). Soil texture refers to the physical nature of soil according to the relative portions of sand, clay, and, silt. Water will travel quickly through a coarse textured soil composed primarily of coarse sand and gravel. A soil composed primarily of clay (which as a very small particle size), on the other hand, will be virtually impermeable. Soil structure refers to the combination or arrangement of individual soil particles into definable

[2] **Soil permeability** refers to the ease with which water can pass through the soil. Most clays are virtually impermeable, that is, almost no water can penetrate them. Coarse sands and gravels, on the other hand, are very permeable.
[3] An **aerobic** process occurs in the presence of oxygen.

aggregates separated by areas of weakness (Bates and Jackson, 1987). Soils with a stable structure conduct water much more rapidly than do those with unstable structural units (Brady, 1984).

The type of soil absorption system suitable for any given site is primarily determined by the characteristics of the soil. A range of alternative systems have been developed to allow siting in a wide range of soil types. However, the less suitable the soil is the more expensive the alternative system is to build.

3 ALTERNATIVE ONSITE TREATMENT AND DISPOSAL SYSTEMS

Less than 35 percent of the land in the U.S. is suitable for conventional septic tank–soil absorption systems (Otis, 1984). Some areas that are otherwise appropriate for development have soils that are unsuitable for conventional systems. Over the last several decades alternatives to conventional systems have been developed to provide effective sewage treatment for soils which formerly were unusable.

Considering the large numbers of people served by onsite sewage systems (66 million in U.S.), relatively little research has been conducted (Seabloom, 1984). Many alternative technologies are still in the experimental phase. Monitoring the long-term performance of many systems has still not been carried out. This chapter describes the current status of research on a number of alternatives to the standard septic tank–soil absorption system.

The alternative systems presented in this chapter are divided into the three following groups:

* Alternative soil treatment and disposal systems
* Alternative treatment devices
* In-house alteration of wastewater

Within each group a description of each system is followed by an evaluation of the system and information concerning its regulatory status in the state of Washington. (An explanation of the Washington State regulatory framework is included in section 4.2.)

The cost of an onsite system is dependent on a wide range of factors. When available, some general cost estimates are included in the discussion. As a basis for comparison, costs for a conventional system are in the range of $1,200 to $1,600.

3.1 ALTERNATIVE SOIL TREATMENT AND DISPOSAL SYSTEMS

Soil is the primary limiting factor in siting onsite sewage treatment and disposal systems. For this reason, research has focused primarily on developing alternative soil absorption techniques. Five alternatives to the standard soil absorption field are described in the following section: three alternative methods of distributing effluent to a standard soil absorption field, a mound or fill system, and an evapotranspiration system.

Soil clogging over time is an inevitable occurrence for soil absorption systems. This problem is caused in part by the manner in which effluent is delivered to the system. Flows to a standard soil absorption field occur when effluent is displaced from the septic tank by a water-use event in the household. These low volume, irregular applications use only a small portion of the disposal trench area at any one time. This is thought to produce localized overloading, clogging, and progressive creeping failure (Kreissl, 1982). Figure 3.1 illustrates how in time the progressive failure reaches an equilibrium throughout the entire absorption field. Dosing and pressure distribution systems have been developed to provide a more uniform application of effluent over the entire trench area.

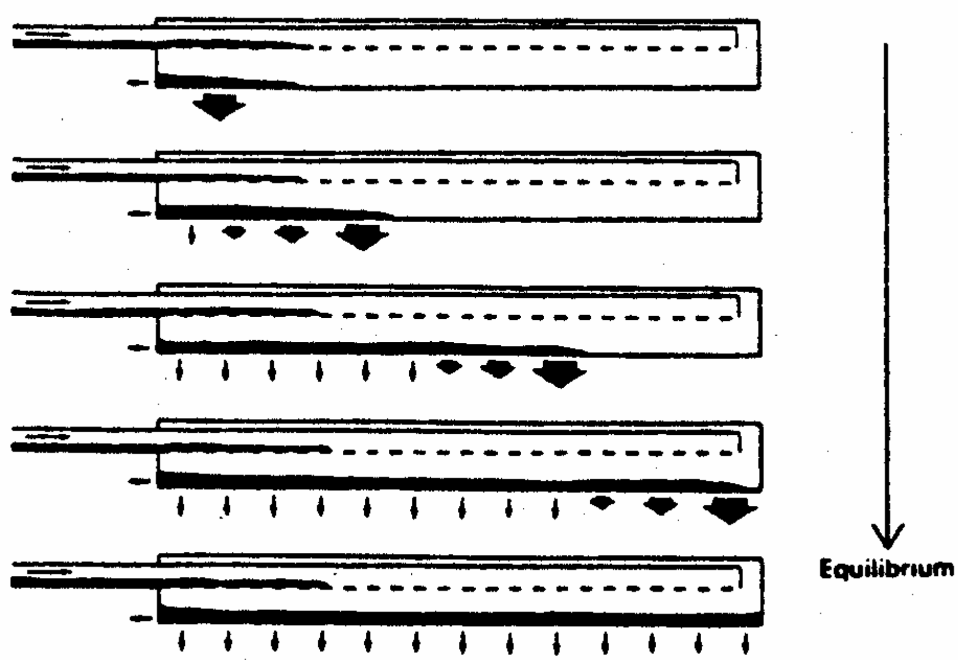

Figure 3.1
(Adapted from Kreissl, 1982)

Dosing Systems

Dosing systems store pretreated effluent in a dosing tank (figure 3.2) and periodically apply large doses to the soil absorption field by pump, siphon, or gravity. Each dose is distributed over a large portion of the absorption field. The system is then allowed to drain, which allows the soil surface to return to an unsaturated condition. The frequency of dosing is determined by soil type and ranges from one to four doses per day (Otis, 1984).

Evaluation: The precise causes of soil clogging are not well understood, and some question still exists whether dosing is effective. Kristiansen (1982) suggests that clogging will occur with dosing systems as well as standard systems. Further research and careful tracking of installed systems is necessary. The cost of the additional dosing chamber and pump adds approximately $800 to $1,000 to the price of a standard system.

Regulatory Status: Washington State guidelines for Dosing systems have been issued (revised January 1985). There are 57 systems on the state inventory.

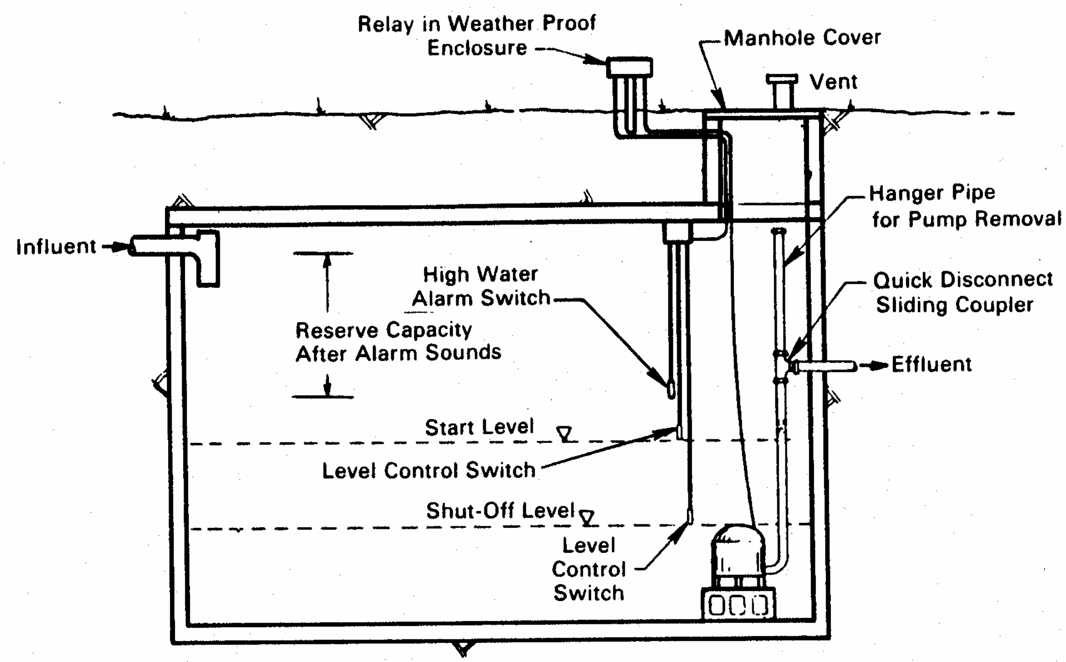

Figure 3.2
Typical Dosing Chamber With Pump
(Adapted from EPA 1980)

Pressure Distribution Systems

Pressure distribution systems, like dosing systems, store pretreated effluent for periodic distribution to the soil absorption field. Effluent is pumped throughout the entire absorption field through small diameter pipes. This method provides the most uniform distribution, thus avoiding localized overloading problems. The benefits of dosing are also achieved with this system.

Evaluation: Pressure systems are recommended for permeable and coarse-textured[4] soils as they maximize the potential for treatment (by distributing the effluent evenly over the entire absorption field) and minimize the potential for direct bypass of effluent to the groundwater (Ronayne et al., 1984). Because of the extra tank, pump, control devices, and power usage, they are more expensive to install, operate, and maintain than a gravity system. The cost of the additional dosing chamber and pump adds approximately $800 to $1,000 to the price of a standard system. The price of the absorption field is similar to the standard field. It is likely that these systems afford the most effective treatment in coarse textured soils, but it is not clear whether or not the life of the absorption field in fine soils is prolonged.

Regulatory Status: Washington State guidelines for pressure distribution systems have been issued (revised September 1984). There are 152 systems on the state inventory.

Alternating Distribution Systems

Alternating distribution systems do not store effluent, rather, the disposal of pretreated effluent is alternated between two separate absorption fields constructed in close proximity. The fields are usually alternated annually. This allows the unused field to drain and aerobic decomposition of the clogging mat to take place. Residential systems are usually constructed with two equal fields, each containing 75 percent to 100 percent of the required surface area (Otis, 1984).

Evaluation: Washington alternative system guidelines require each component field to contain 100 percent of the area required for a single field. The soil must also meet standards for a conventional system. Installation, therefore, is costly, and the primary benefit received is an increased lifetime for each absorption field.

Regulatory Status: Washington State guidelines have been issued. There are two systems on the state inventory.

Mound or Fill Systems

Mound or fill systems are a pressure distribution system installed in a mound constructed on top of the natural soil. These systems are used when the groundwater level is too close to the surface or when the soil is either too permeable or not permeable enough. The mound is constructed of a course-grained material (usually sand) through which the pretreated effluent travels before it reaches the original soil surface (see figure 3.3). The mound is covered with topsoil and planted with vegetative cover.

[4] **Soil texture** refers to the size of soil particles and range of particle sizes in a particular soil. The gradation of particle sizes ranges from coarse sand (2.0 millimeters) to fine clays (less than 0.002 millimeters), with silt being somewhere in-between.

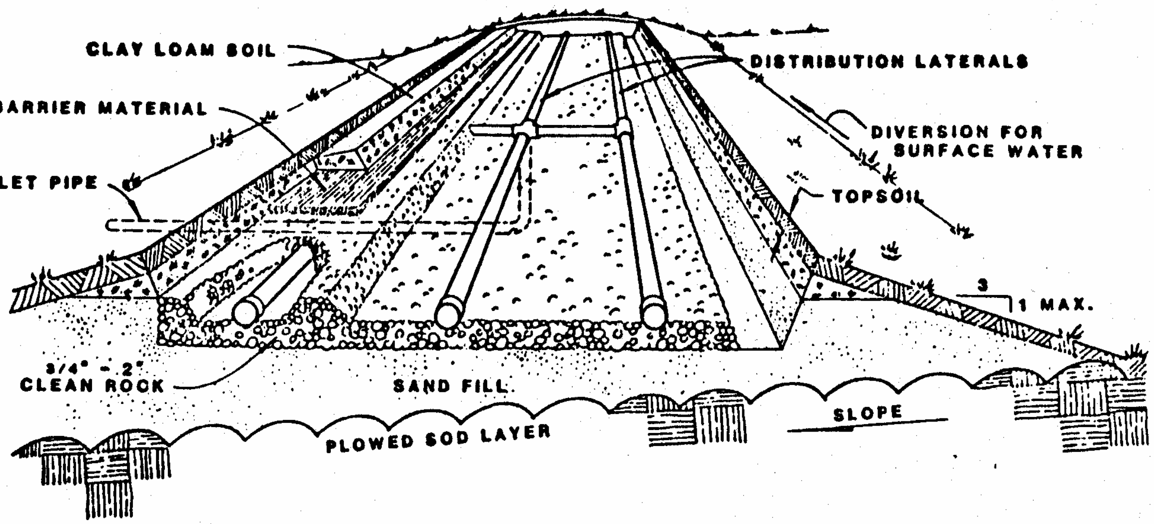

Figure 3.3
Mound System
(Adapted from Otis, 1984)

A standard soil absorption field is constructed below the topsoil. A mound system is constructed on top of the topsoil layer and thus gains the additional benefit of this soil layer for treatment. Treated effluent can spread laterally through the topsoil until it is absorbed into the subsoil.

Evaluation: Mound systems have emerged after much development as an effective alternative for sites with unsuitable soils. However, construction of a mound requires large quantities of new soil brought to the site, and the mound must be carefully designed and constructed to function properly. A mound system can cost between $4,000 and $8,000 to design and install, and is therefore usually the choice of last resort.

Regulatory Status: Final state guidelines for mound systems have been issued. There are 257 systems on the state inventory.

Evapotranspiration Beds

Evapotranspiration beds discharge to the air instead of the soil. Use is restricted to areas where annual evaporation exceeds annual precipitation (in Washington, this would be areas east of the Cascades). Beds are lined with a watertight liner such as plastic, filled with crushed rock and sand, and covered with top soil. Pretreated effluent is distributed to the beds with perforated pipelines in the same manner as conventional absorption systems.

Evaluation: Testing of 17 systems in eastern Oregon revealed poor performance. All but one of the systems developed holes in the liner, which allowed untreated effluent to enter the ground water. One system, constructed with a special heavy liner, and three times larger than the other systems studied (7500 sq.ft.), appeared to function satisfactorily (Ronayne et al., 1984).

Regulatory Status: No alternative system guidelines have been issued in Washington State for this type of system. An experimental system permit would be required for installation.

3.2 ALTERNATIVE TREATMENT DEVICES

Onsite research in the United States has focused primarily on disposal systems. There has been some interest, however, in improving the quality (purity) of the effluent from treatment devices in hopes of reducing clogging of soil absorption fields. It appears that improved effluent quality does reduce clogging in coarse, unstructured soils (Kreissl, 1982). There are two devices used in pretreatment of onsite wastewater, the septic tank and the aerobic tank. Several technologies have been developed to provide additional treatment for septic or aerobic tank effluent. Some devices are capable of producing effluent suitable for surface discharge. However, since surface discharge is not permitted in Washington State, these systems could only be used to enhance the performance of the soil absorption field.

Aerobic Tanks

An aerobic tank is a watertight container in which a mechanism has been installed to bring the wastewater into contact with air (figure 3.4). In the presence of air, the waste products then decompose. Solids and greases are separated and liquid effluent is discharged to a disposal system. Solids must be pumped from the final chamber regularly.

Aerobic tanks can reduce BOD (biological oxygen demand—a measure of the amount of oxygen used to decompose organic material in water) by 85 percent to 98 percent under ideal conditions and SS (suspended solids) by 40 to 80 percent. A septic tank reduces BOD by 25 percent to 65 percent and suspended solids by 40 to 80 percent (Buchholz, 1980).

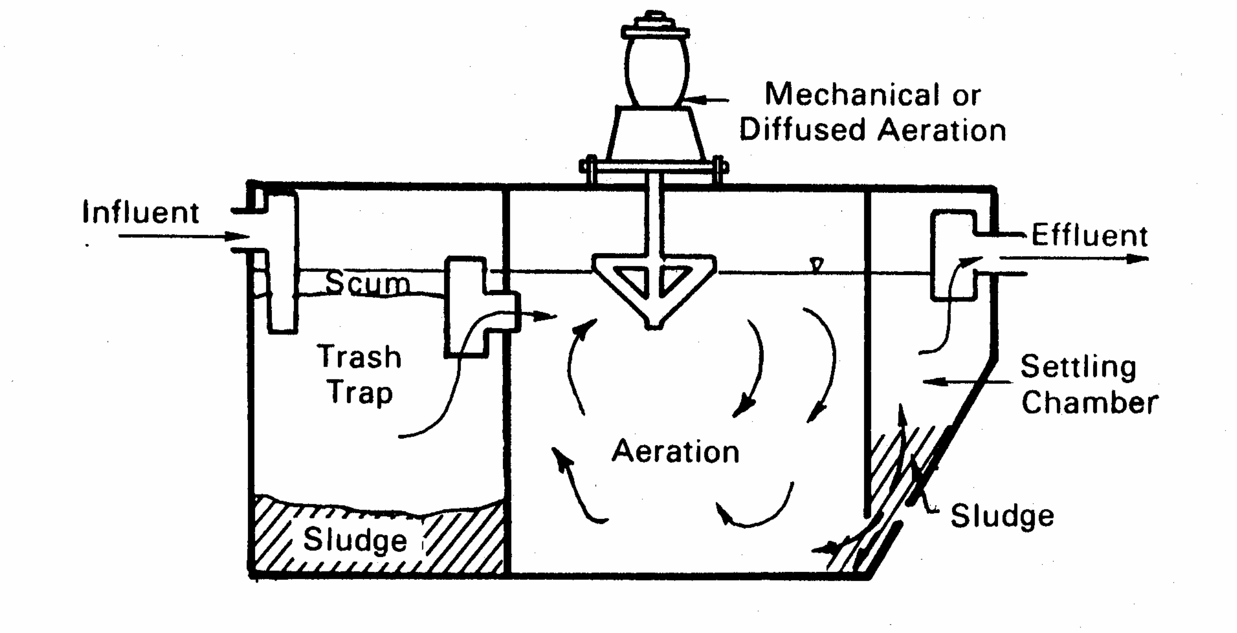

Figure 3.4
Aerobic Treatment Unit (Aerobic Tank)
(Adapted from Environmental Protection Agency, 1980)

Evaluation: Aerobic devices are sensitive to changes in quantity or characteristics of the wastewater they are treating. In field conditions, effluent has not been shown to be of a higher quality than septic tank effluent, and the quality of the effluent varies widely over time. These are mechanical devices which require knowledgeable operation and maintenance. Because of the need for regular inspection and maintenance, aerobic tanks are best suited for conditions where they are under the management of a wastewater management district or utility (see chapter 5).

Regulatory Status: Final state guidelines for aerobic devices issued were issued in 1975. No systems are listed on the state inventory.

Anaerobic Filters

Anaerobic filters are designed to provide further treatment to septic tank effluent before discharge to a soil absorption system. The filter is a watertight container filled with crushed rock or other solid medium which will support microbial growth. Effluent is treated as it comes in contact with anaerobic organisms on the surfaces of the filter material. Flow is generally from the bottom upwards (ensuring that the filter material is always saturated) to maintain anaerobic conditions in the filter (Kennedy, 1982; Viraraghavan and Kent, 1985).

Evaluation: Development is still experimental for small residential systems. It is reported than anaerobic filters can reduce the BOD of septic tank effluent by an additional 30 percent to 80 percent and can further reduce fecal coliform by 43 percent to 95 percent (Viraraghavan and Kent, 1985). These units require no extra energy and maintenance is similar to that for a septic tank. No cost estimates are available. More research and field testing are needed.

Regulatory Status: No state guidelines exist for anaerobic filters. An experimental system permit would be required.

Sand Filters

Many sand filter designs have been installed on an experimental basis for residential onsite use (Ronayne et al., 1984). In general, sand filters operate by directing pretreated effluent into or onto a layer of sand, allowing it to drain through the sand (where aerobic decomposition of waste products takes place) and collecting the filtrate in a perforated pipe at the bottom of the filter (figure 3.5). Filters can be constructed above or below the ground. Systems constructed below the ground can be contained in a watertight vault or uncontained in direct contact with the surrounding soil. Some designs recirculate part of the filtrate back through the filter for further treatment. The liquid filtrate is ultimately disposed of in a soil absorption field. Sand filters can produce effluent of very high quality with reported BOD and SS reductions of 99 percent and 97 percent, respectively (Ronayne et al., 1984).

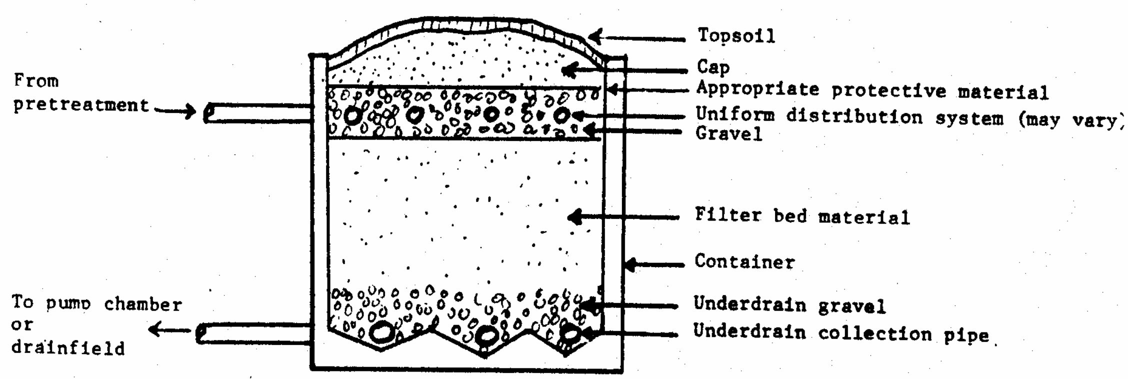

Figure 3.5
Sand Filter
(Adapted from Technical Review Committee, 1981)

Evaluation: The Oregon Department of Environmental Quality has conducted extensive research into the use of sand filters for residential onsite use (Ronayne et al., 1984). Their research has shown good success at improving the ability of soils to accept and treat effluent on sites with soils which are not acceptable for conventional systems. In some cases, with very poor soil conditions, a sand filter is installed to treat septic tank effluent before disposal in a mound system. However, a system of this type would cost in the neighborhood of $10,000.

Regulatory Status: Washington State interim guidelines for sand filters have been issued and are currently being revised. There are 171 sand filter systems listed on the state inventory.

3.3 IN-HOUSE ALTERATION OF WASTEWATER

The quantity and quality of wastewater being treated are the primary factors used when designing onsite treatment and disposal systems (Santala, 1984). These factors also have a profound effect on the long-term performance of those systems (Small Scale Waste Management Project, 1978). Wastewater is created, and its characteristics are determined, by the water-use habits of household residents. In the not too distant past, when all water used had to be carried, per capita water use was somewhere between 10 and 50 liters per day. With indoor plumbing, water usage can rise to over 200 liters per person per day (Santala, 1984). Water use habits also influence the quality of wastewater. The use of a garbage grinder, for instance, adds 28 percent more biological oxygen demand (BOD) and 36 percent more solids (SS) to household wastewater (Kreissl, 1981). Altering the waste stream is one technique considered to permit onsite treatment and disposal on sites with less suitable soils.

Characteristics of Household Wastewater

Wastewater characteristics vary widely from household to household, by time of day, and by season. Residential wastewater flows are affected by high water-use events such as wash day, or holidays and house guests, and periods of no flow, such as vacations. The following information describes average values for residential wastewater.

Typical household wastewater is 99.9 percent water (by weight), and 0.02 to 0.03 percent suspended solids, plus minor amounts of other soluble and insoluble organic and inorganic substances (Pelczar and Reid, 1972). Wastewater also contains bacteria, viruses, and other microorganisms from the digestive tract, respiratory tract, and skin (Miller, 1980). Some of the physical and chemical characteristics of wastewater produced by various activities are listed in table 3.1.

Table 3.1
Physical/Chemical Composition of Household Wastewater

Activity	Biological Oxygen Demand	Suspended Solids
Kitchen activities	42.3%	26.7%
Bathing, showering	6.2%	6.4%
Clotheswashing	29.8%	31.2%
Toilet flushing	21.7%	35.7%
Total	100%	100%

(Small Scale Waste Management Project, 1978)

Waste Segregation

Toilet wastes (blackwastes) contribute approximately 35 percent of the water, 36 percent of the suspended solids, and 68 percent of the total nitrogen to the household waste stream. If toilet wastes are treated separately without using water, then the volume and pollutant load of remaining water (greywater) is reduced. This section evaluates several treatment systems which segregate waste.

Vault Privies

Vault privies and holding tank systems store toilet waste products in a watertight storage vessel which is periodically pumped out.

Evaluation: Storage systems are not generally applicable to residential uses except to temporarily correct a failing system.

Regulatory Status: Washington State guidelines have been issued. Use is restricted to non-residential applications. There is one installation recorded on the state inventory.

Incinerating Toilets

Incinerating toilets use electricity or natural gas to incinerate toilet wastes. Liquids are evaporated and vented to the outside, and solids are reduced to ash. The ash is disposed of periodically.

Evaluation: Incinerating systems consume energy and must go through a 15 minute treatment cycle between each use. Five of six units installed in Kentucky in the early 1970s had been abandoned by 1978 because of high operating costs, associated odors, and frequent repairs (Abney, 1980).

Regulatory Status: Washington State interim guidelines for incinerating toilets were issued July 1984. No systems are listed on the state inventory.

Biological Toilets

Biological toilets treat human wastes by composting. Composting is a biological process that takes place under specific conditions of temperature, moisture, exposure to oxygen, and availability of carbon and nitrogen. Ideally, the composting process results in a relatively dry end product free from objectionable and harmful components (Enferadi et al., 1986). The end product is intended for disposal as a soil additive. To assure successful treatment of wastes, design and operation of composting toilets must maintain a proper balance of these conditions within the composting chamber. There are two common designs used, small units where the entire unit sits on the floor in the toilet room (figure 3.6a), and large toilets where the composting unit is below the floor (figure 3.6b).

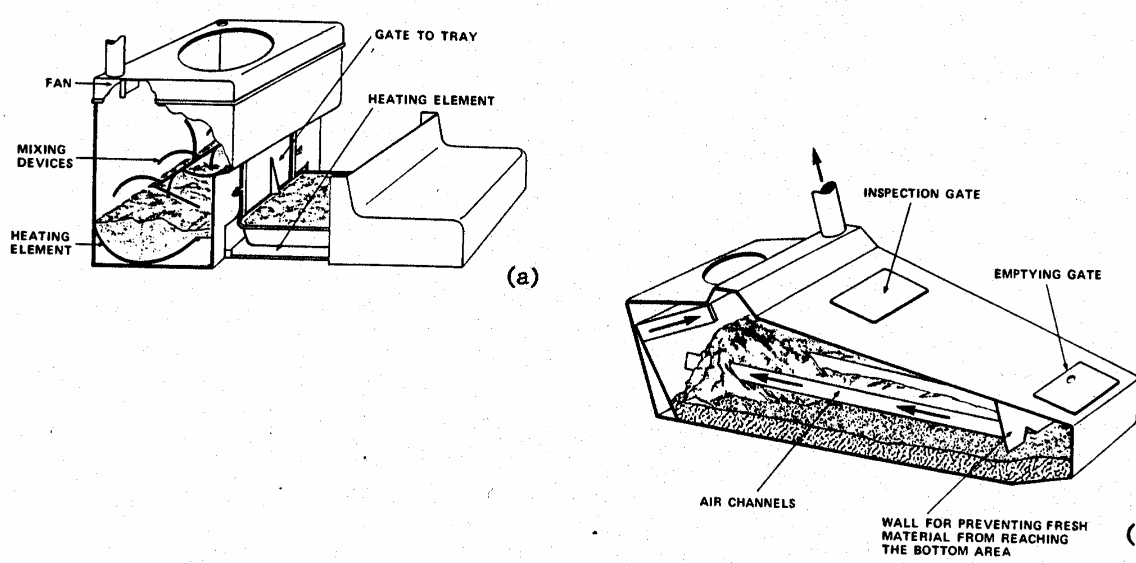

Figure 3.6
Biological Toilets
(Adapted from Molland, 1984 and Guttormsen, 1980)

Evaluation: The design of composting, or biological, toilets is still evolving even though they have been in use for many years. Field testing in both Scandinavia and the United States has demonstrated problems with many commercially available units (Molland, 1984; Enferadi et al., 1986). Two studies sponsored by the U.S. Environmental Protection Agency and conducted in California and Oregon report generally poor performance, including: excess liquid build up, insect and rodent problems, structural failures, and incomplete treatment of wastes (Ronayne et al., 1984; Enferadi et al., 1986). None of the units tested produced a final product considered safe for surface application (Enferadi et al., 1986). The two most difficult problems still to be resolved are maintaining proper temperature, and proper moisture content within the treatment unit. Theoretically, the composting process will only produce a maximum of 20 to 30 percent of the heat required to evaporate the excess liquid which is introduced to the system under normal use. It appears that added heat and forced ventilation are required for these units to operate efficiently.

Regulatory Status: Washington State guidelines for composting toilets were issued in 1975 and revised in 1984. There are no systems listed on the state inventory.

Greywater Treatment and Disposal

It was once thought that greywater might be suitable for surface application or subsurface discharge with minimal treatment. Several recent studies, however, indicate that household greywater contains significant concentrations of organic materials, solids, nutrients and fecal bacteria which require treatment equal to that of total household wastewater (Siegrist and Boyle, 1982; Enferadi et al., 1986). Segregating waste does significantly reduce the amount of wastewater created.

Evaluation: Even though conventional treatment and disposal methods are required, segregation of blackwastes allows the size of the system to be significantly reduced. Septic tank size can be reduced by 50 percent, and the capacity of the soil absorption field can be reduced by 40 percent (Technical Review Committee, 1984).

Regulatory Status: Guidelines for greywater treatment are included in the state guidelines for composting toilets.

Water Use Efficiency

Reducing water usage (which reduces wastewater flows) can correct failures in existing onsite systems (Sharpe et al., 1985), allow reductions in the size of new onsite systems, conserve energy, and reduce the potential for groundwater and surface-water pollution. A field study has shown that water-efficient fixtures can reduce wastewater flows by as much as 40 percent (Sharpe et al., 1985). This same study concluded that failing absorption fields can be corrected by employing water-efficient fixtures.

The quantity of wastewater to be disposed of is usually the limiting factor in siting onsite systems. State regulations (on which most county regulations are based) allow the capacity of the soil absorption field to be reduced, where it can be shown that the use of water efficient fixtures will result in lower flows. In some states, the use of water-efficient fixtures allows an automatic downsizing of absorption fields: 20 percent—Virginia, W. Virginia, S. Carolina, and Kentucky, and 30 percent—New York (Rocky Mountain Institute, 1987).

A study of rural American homes (most onsite systems are in non-metropolitan areas) determined the average household creates between 154 and 168 liters of wastewater per person per day (Small Scale Waster Management Project, 1978). Table 3.2 identifies the contribution of various household activities to the waste stream.

Table 3.2
Household Water Use

Activity	Liters/ Use	Use/ Capita/Day	Liters/ Capita/Day*	% of Total
Toilet Flush	16.3	3.5	61.2	35%
Bathing	92.6	.4	34.8	20%
Clotheswashing	141.4	.3	37.8	21%
Dishwashing	33.3	.3	12.1	7%
Garbage Grinding	7.6	.6	4.5	3%
Miscellaneous	-	-	24.9	14%
Total	-	-	172.4	100%

* Liters/capita/day may not equal the product of liters/use and use/capita/day due to differences in number of study averages used to compute means shown.

(Boyle et al., 1981)

Examples of four water-efficient fixtures and the potential waste/wastewater savings are listed in table 3.3

Table 3.3

Potential Flow Reductions From Water-Efficient Fixtures

Kitchen Faucet Reducer	30%
Basin Faucet Reducer	86%
Shower Head	50%
Toilet	80%

(Information from Rocky Mountain Institute, 1987)

Table 3.4 combines information from tables 3.2 and 3.3 to illustrate possible water savings by using a water-efficient toilet and shower head.

Table 3.4

Potential Per Capita Water Savings Using Water Efficient Fixtures

	Liters/Capita/Day Standard Fixture	Liters/Capita/Day Efficient Fixture	Savings
Toilet	61.6	18.4	42.8
Shower	34.8	17.4	17.4
Total	96.0	35.8	60.2

4 REGULATION OF ALTERNATIVE ONSITE SYSTEMS

4.1 BACKGROUND

The need for regulation of onsite sewage disposal became necessary to prevent the spread of disease, however . . .

> . . . specific construction requirements are many times difficult to justify in terms of preventing disease. (Plews, 1976)

This difficulty led to wide differences in policy and allowed regulations to be influenced by political purpose as well as public health considerations. A national survey of existing state codes in 1947 found substantial variation in requirements for onsite sewage disposal systems (Weibel, 1947, in Kreissl, 1982a). This finding prompted the U.S. Public Health Service to become involved, and in 1957 they published the Manual of Septic-Tank Practice. A survey of states conducted in 1971 showed that most state codes had incorporated the recommendations of the manual (Patterson, 1971, in Kreissl, 1984). Since that time, states have been revising their codes in response to local experience and new research. In 1980 the U.S. Environmental Protection Agency published a Design Manual for Onsite Wastewater Treatment and Disposal. (In Washington, all new onsite systems must conform to the standards published in this manual.) The federal government has not become directly involved with the regulation of onsite sewage disposal, although it is indirectly involved through research, the publication of design manuals, and administration of the Clean Water Act of 1977.

Authority to regulate onsite sewage disposal is generally assumed by either local or state health officials. In most states, including the state of Washington, regulation is shared by state and local authorities. This responsibility is shared in different ways in different states. In Washington the state sets minimum standards, and local jurisdictions have responsibility to enforce local regulations. In eight states the state has sole permitting authority, while in thirteen other states permitting authority is given exclusively to local government units (Ward 1981, in Kreissl, 1982a).

4.2 ALTERNATIVE ONSITE SEWAGE REGULATIONS IN WASHINGTON

The Washington State Board of Health is responsible for, among other things, adopting rules, regulations, and standards for the prevention, control, and abatement of health hazards and nuisances relating to the disposal of sewage and adopting standards and procedures governing the design, construction and operation of sewage collection, treatment, and disposal facilities (RCW 43.20.050). In 1974 the State Board of Health adopted minimum standards for regulating onsite sewage disposal (WAC 248.96). Prior to this time, each local health jurisdiction developed and administered their own onsite programs. In 1969 the state platting law (regulating the subdivision of land) was revised to require local health jurisdictions to review preliminary plats (plans for the division of land) for the provision of sewage disposal and public water supply. At that time inconsistencies in local regulations were causing a variety of problems and complaints, leading to the adoption of statewide minimum standards in 1974 (Washington State Department of Social and Health Services, 1977).

The regulations set out in WAC 248-96 (revised in 1983) require local jurisdictions to adopt standards at least as stringent as the state standard. The regulations are intended to provide a uniform framework through which local boards of health may establish a system of local regulation. Local jurisdictions then have responsibility for administration of the local regulations.

WAC 248-96 also provides for the development of guidelines for the use of alternative and experimental systems. Local authorities are not required to adopt these guidelines, but local regulations must be consistent with the purposes and objectives of state Board of Health guidelines.

Alternative systems are defined by the state regulations as: any onsite sewage system consisting of treatment and/or disposal components other than a septic tank and subsurface soil absorption system. Permits for installation of alternative systems may be issued by local jurisdictions only after guidelines are developed by a state technical review committee. This committee is composed of a maximum of seven representatives. Representatives may be selected from local health departments, consumer organizations, engineering firms, the Department of Ecology, a public sewer utility, or building and development industries.

The technical review committee, which was formed in 1974, has developed guidelines for the following alternative systems:

Aerobic treatment devices
Alternating or Dosing systems
Composting toilets
Fill or mound systems
Incineration toilets
Pressure distribution systems
Sand filters
Vault and pit privies

The technical review committee evaluates alternatives based on review of available information concerning a device or process. Interested parties, including manufacturers, designers, or distributors, may present information to the committee for consideration. The committee will issue final guidelines for a device or process if sufficient data exists to show that its use would not create a public health hazard or cause damage to the environment. If adequate technical information is available but field-testing is incomplete, the committee may establish interim guidelines and permit installation of a limited number of the alternative systems. If insufficient technical information or testing data is available no guidelines are issued. Proprietary devices[5] must be reviewed by Department of Social and Health Services staff and the Technical Review Committee before a permit can be issued (by the local jurisdiction) for the installation of a specific brand device.

Experimental systems are defined as "any alternative onsite system excluding a larger system which has not yet had guidelines established by the technical review committee." A limited number of experimental systems are allowed if sufficient supportive theory and/or applied research exists. A permit must be granted from the local health official, and provisions for the monitoring of performance are required. A detailed written proposal for an experimental system must be reviewed by the state technical review committee before a permit may be issued by the local health jurisdiction. Permits for experimental systems may only be granted to correct a failing onsite system or when it can be shown that an onsite system meeting standards could be constructed on the property if the experimental system failed.

The intended use of experimental systems is clearly defined in the following guidelines issued by the technical review committee:

> It is the intent of the committee that this activity be used to increase our knowledge of certain experimental approaches. It is not intended to serve as a method to circumvent the requirements or standards of WAC 248.96 or proven sewage disposal practices. The committee recommends that strong consideration be given to those proposals that

[5] Proprietary devices are equipment or processes which are protected by a patent.

offer the opportunity to obtain sufficient data which can be used for the development of alternative sewage disposal systems (Technical Review Committee, 1986).

Local jurisdictions are required to monitor and compile reports on all alternative and experimental systems for which they issue permits. Data from all local jurisdictions are collected by the Department of Social and Health Services and published in an annual report (Washington State Department of Social and Health Services, 1987).

5 CONCLUSION

The state of Washington has in place a comprehensive program for regulating alternative onsite sewage disposal technologies and encouraging research with experimental systems (described in section 4.2). The program, established by WAC 248-96, provides for minimum statewide standards, state guidelines for alternative systems, and state coordination of experimental systems. Although the program provides statewide consistency and technical expertise, the state regulation leaves final authority with local health officials. Since 1974 the technical review committee has published and revised guidelines for eight different processes or systems (listed in section 4.2). The Department of Social and Health Services (DSHS) has established a computer data base for tracking and compiling monitoring data from alternative and experimental systems. While Washington has made much progress since 1974, there are important problems not addressed by existing regulations.

1. Funding of Existing State Onsite Programs
The Department of Social and Health Services currently has 1.8 staff statewide for the entire onsite program. Department officials estimate that 4 to 5 full time staff would be required to adequately perform the state's duties (Lenning, 1987).

2. Operation and Maintenance
The U.S. Environmental Protection Agency Design Manual for Onsite Wastewater Treatment and Disposal Systems (1980) suggests that there are three distinct phases in the life of onsite systems that require control.

* Installation
* Operation
* Maintenance

System failures that threaten public health or damage the environment can be caused by problems in any of these phases. Current state onsite regulations address only the first phase for standard onsite systems. Guidelines for alternative and experimental systems require some monitoring of operation, as mentioned in section 4.2. However, in Washington State there are currently no requirements for the operation and maintenance of conventional systems or maintenance of alternative onsite systems.

Homeowners are sometimes not aware of the difference between using an onsite system and being connected to a municipal sewer. An onsite system must be operated and maintained carefully to function properly. For example, the use of garbage grinders or excessive water volumes can have a detrimental effect on the operation of an onsite system (see chapter 3.3). A critical maintenance function for most systems is pumping the septic tank; failure to do so can cause a rapid failure of the soil treatment and disposal system (see chapter 2.2). Most alternative onsite systems have special operation and maintenance requirements in order to function properly.

There are currently no statewide requirements for operation and maintenance of conventional or alternative onsite systems. Two possibilities for regulating onsite systems operation and maintenance are presented below:

*** Regular inspection and documentation of maintenance**
Onsite wastewater systems require regular maintenance to adequately protect public health and the environment. In some areas of the country, counties or local governments require property owners to provide local health authorities with evidence that their wastewater system is being operated and maintained properly (Effert, 1987; Kesnic, 1987). Inspections are conducted by health officials or licensed individuals, such as plumbers or septic tank pumpers, trained and certified to carry out inspections. A bill was introduced in the 1987 Washington Legislature which would have required the State Board of Health to set minimum standards for maintenance. The legislation was not passed.

*** Community or regional wastewater management districts**
During the 1950s and 1960s onsite wastewater systems were considered temporary solutions until an area was sewered. Since that time they have become recognized as a viable and important long-term wastewater treatment practice for many areas. In low density areas, onsite systems can help avoid “the induced, often dramatic, growth” and high costs associated with the construction of traditional centralized sewer and treatment systems (Lombardo and Neel, 1987). A management district ensures the maintenance of systems within the district, thus helping to avoid the degradation of ground water and the environment. In some states, wastewater management districts have been formed using a combination of onsite alternatives, including individual and communal systems. The management districts levy taxes and are responsible for management and maintenance of all individual and cluster systems within the district (Lombardo and Neel, 1987). Provisions for management districts were included in the 1974 Washington onsite regulations but were deleted in the 1983 revisions.

3. Failing Systems

Washington State onsite sewage disposal regulations are based on installation of approved technologies rather than continued acceptable performance of individual systems. As mentioned above, there are no requirements that systems be maintained. When a system fails, repairs are often difficult and costly.

Repairs to failing systems are required to meet the standards in effect when the system was originally constructed. For systems constructed before 1974 that means compliance with local standards (if any) that existed at the time, rather than more stringent standards developed since that time. Many systems failing now were constructed in the 1950s, and requirements for repairs vary widely by location (Puget Sound Water Quality Authority, 1986).

Failing systems are a special challenge to health officials. They are difficult to detect and even more difficult to get repaired. Two regulatory problems, related to alternative systems, that arise when a system fails are:

* A failing system may be located on a lot without sufficient land to construct an approved replacement system.

  Flexibility in the application of alternative system guidelines for replacement systems could allow people to improve their wastewater treatment system even if they are not able to meet all application standards.

* The property owner cannot afford the cost of an approved replacement system.

  Some funding assistance[6] is needed to help low income householders correct system deficiencies. For example, if the failing system is located on soil that is not suitable for a conventional system, an alternative system may be required. Alternative systems are generally more expensive to install and operate. The design and construction of a mound system, for example, costs between $4,000 and $8,000 (Puget Sound Water Quality Authority, 1986).

4. Water Conservation

The beneficial effects of water conservation on soil treatment and disposal systems are described in section 3.3. Some of these are: increased performance of soil absorption systems, savings in energy costs, and potential for correcting of failing systems. Several applications for water conservation to onsite regulation are:

* State onsite sewage disposal regulations (WAC 248-96-110) allow for soil-absorption field sizes to be decreased when it can be shown that low water-use fixtures justify such a decrease. Some officials are hesitant to allow decreases in soil absorption field size fearing that future occupants might install non-efficient fixtures and cause the system to fail.

* Water conservation can be a cost-effective method for correcting system failures (see section 3.3). There are currently no state guidelines for the application of this method.

* Some states, including Oregon and California, have enacted legislation requiring the installation of water-efficient fixtures in new construction (Puget Sound Water Quality Authority, 1986).

Onsite sewage systems currently provide sewage disposal for almost a third of Washington's households. These systems will continue to be an important long-term sewage disposal method in the state. Failing onsite systems are threatening the state's water quality, with the potential of health hazards and environmental degradation. A wide range of alternative systems exist, and have been approved by the state, which could be used to remedy existing failing systems. However, proper operation and maintenance of both alternative and conventional onsite systems is required to protect the state's water resources.

[6] The state of Wisconsin has a grant program to assist home owners with onsite systems repairs. Eligibility is restricted by income level and applies only to owner-occupied homes. The program is administered through the counties, and only counties with maintenance programs are eligible for funds.

GLOSSARY

(Adapted from Bates and Jackson, 1987; EPA, 1980)

Aerobic: Growing or occurring only in the presence of molecular oxygen, such as aerobic organisms.

Anaerobic: Growing or occurring in the absence of molecular oxygen, such as anaerobic organisms.

Biological Oxygen Demand (BOD): A measure of the amount of oxygen used to decompose organic material in water.

Evapotranspiration: The combined loss of water, from a given area, by evaporation from the soil and by transpiration from plants.

Permeability (soil): The ease with which water can pass through soil.

Saturated (soil): The condition in which the interstices of the soil are filled with water.

Septic Tank: A large watertight container with interior baffles used for treating wastewater.

Soil Absorption Field: A series of perforated pipes buried in gravel beds used for treatment and disposal of wastewater.

Soil Structure: The combination or arrangement of individual soil particles into definable aggregates, or peds, which are characterized and classified on the basis of size, shape, and degree of distinctness.

Soil Texture: The physical nature of soil according to the relative portions of sand, clay, and silt.

Suspended Solids (SS): Solids physically suspended in water.

Unsaturated (soil): The condition in which some soil interstices contain are (are not filled with water).

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