URBAN BMP COST AND EFFECTIVENESS

SUMMARY DATA

FOR 6217(g) GUIDANCE

ONSITE SANITARY DISPOSAL SYSTEMS

January 29, 1993

WOODWARD-CLYDE

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1.0
INTRODUCTION

In November 1990, the U.S. Congress passed the Coastal Zone Act Reauthorization and Amendments (CZARA). As part of this reauthorization, Congress created a new, distinct program to address nonpoint source (NPS) pollution of coastal waters (Section 6217). The U.S. Environmental Protection Agency (EPA) and the National Oceanic and Atmospheric Administration (NOAA) jointly drafted Proposed Program Guidance for Section 6217. EPA was given the lead responsibility for developing the Management Measures Guidance required under Section 6217(g) of CZARA.

EPA established five Federal/State Work Groups to assist in preparation of the 6217(g) Guidance. Woodward-Clyde has supported the Urban Work Group through the collection and analysis of information on Best Management Practices (BMPs) used to control urban NPS pollution. The results of these efforts includes four books that present cost and effectiveness information on BMPs for:

- Erosion and Sediment Control;
- Post Construction Runoff;
- Onsite Sewage Disposal Systems; and
- Roads, Highways and Bridges.

This report is a summary of the cost and pollutant removal effectiveness information that was obtained from published literature regarding onsite sanitary disposal systems (OSDSs). The report also contains options for management practices and systems of management practices for control of nonpoint source (NPS) pollution from OSDSs. These options are based on the information obtained from the literature review.

This document contains information from nearly 60 documents. The documents were obtained through literature searches and telephone contacts with all states and territories with approved Coastal Zone Management Plans. Cost and effectiveness data from the various management practices presented in the documents were reviewed and analyzed to summarize the information. Data were omitted from consideration where substandard field technique was used in the collection of the data or if results were influenced by atypical climatological or site characteristics (e.g. high water table or heavy water loads to the system). Also, only management practices that were applied in the field were considered. Experimental practices only applied in a research setting were not considered.

Many of these documents indicate the need to address NPS pollution originating from OSDSs. The Chesapeake Bay Program (1990) found that 55%-85% of nitrogen entering an OSDS can pass into the groundwater. OSDSs account for 74% of the nitrogen entering Buttermilk Bay (at the northern end of Buzzard's Bay) in Massachusetts (Horsely Witten Hegeman, 1991). Similar results were obtained from studies performed on the Delaware Inland Bays (Reneau, 1977; Ritter, 1986). These studies indicated that septic systems were major contributors of nitrogen entering into the Delaware Inland Bays. Assawoman Bay, Indian River Bay, and Rehoboth Bay received 15%, 16% and 11% of their nitrogen from septic systems, respectively. Groundwater discharges of NPS pollution were estimated to contribute 75% of the total nitrogen entering the Bays (Reneau, 1977).

Water flow reduction can help to diminish NPS pollution by increasing the residence time within OSDSs and reducing hydraulic load to the system. Flow saving devices such as water saving appliances, flow reducing fixtures, and low flush toilets can be installed in new buildings, or used to replace existing equipment as it wears out. When these devices are used in connection with management practices for new and replacement construction, the reduced flows save costs by reducing the size of new and retrofit treatment facilities, extending the life of OSDSs, increasing performance of existing facilities, and lowering costs of operation for holding tanks. Cost savings have also been documented due to reduced demands for potable water (Logsdon, 1990). The cost is minimal, especially for replacement when a fixture breaks.

Table 1-1 compares various sources of water usage with typical pollutant loadings.

Table 1-1. Water Use and Pollutant Loadings by Category

Water Use	Volume (l/capita)	BOD (g/capita)	SS (g/capita)	Total N (g/capita)	Total P (g/capita)
Garbage Disposal	4.54	10.8	15.9	0.4	0.6
Toilet	61.3	17.2	27.6	8.6	1.2
Basins and Sinks	84.8	22.0	13.6	1.4	2.2
Misc.	25.0	0	0	0	0
Totals	175.6	50.0	57.1	10.4	4.0

Source: EPA, 1980

Table 1-2 summarizes the effectiveness of eliminating garbage disposals in reducing the loadings of pollutants in wastewater.

Table 1-2. Reduction in Pollutant Loading by Elimination of Garbage Disposals

Parameter	Reduction in Pollutant Loading (%)
SS	25-40
BOD	20-28
Total N	3.6
Total P	1.7

This report contains descriptions of the management practices considered, summary cost and effectiveness information, and recommended management practices options for use in OSDSs. The appendices present the data analyzed to develop the summary cost and effectiveness information.

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2.0
ONSITE SANITARY DISPOSAL SYSTEMS MANAGEMENT SYSTEMS EFFECTIVENESS AND COST SUMMARY

This section describes the types of Onsite Sanitary Disposal System (OSDS) management practices considered, the limitations of these types of systems, and the cost and effectiveness of these systems.

Nearly 60 documents were reviewed to develop effectiveness and cost data for OSDSs. It should be noted that the documents obtained and reviewed do not include all of the published literature regarding OSDS management practices. However, many of the documents obtained were summaries of other investigations and the most widely used OSDS documents were reviewed. The influence of soil type, climate, water loads, and separation distance (distance to groundwater or limiting layer) on OSDS performance are also discussed.

2.1 DESCRIPTION OF OSDS MANAGEMENT PRACTICES

The following is a description of various OSDS management practices.

<u>Conventional Septic System</u> - A conventional septic system consists of a settling or septic tank and a leaching field. The traditional system accepts both greywater (wastewater from showers, sinks and laundry) and blackwater (wastewater from toilets). These systems are typically restricted in that the bottom invert of the leaching field must be at least 2 feet above the seasonally high water table or impermeable layer (separation distance) and the percolation rate of the soil must be between 1 and 60 minutes/inch. To ensure proper operation, the tank should be pumped every 3 to 5 years. Nitrogen removal of these systems is minimal and somewhat dependent on temperature. The most common type of failure of these systems is from clogging of the leaching field, insufficient separation distance to the water table, insufficient percolation capacity of the soil, and over loading of water. Table 2-1 shows estimates of lot areas required as a function of soil type, assuming that at least 5,000 square feet is needed for a house and its setbacks.

Table 2-1: Minimum Lot Sizes Required to Accomodate a Septic Tank Leaching Field

Soil Texture	Perc.Rate (min/in)	Bottom Area Application Rate (gpd/ft^2)	Leaching Field Area Required* (ft^2)	Lot Area Required incl. 5,000 ft^2 for house (acres)
Gravel, coarse sand	<1	not suitable	not applicable	not applicable
Coarse/medium sand	1-5	1.2	1357	0.2
Fine sand, loam sand	5-15	0.8	2035	0.2
Sandy loam, loam	15-30	0.6	2728	0.25
Loam, porous silt loam	30-60	0.45	3608	0.3
Silty clay loam, clay loam	60-120	0.2	8140	0.5

* Area of leaching field assumes the use of a series of five, 2 ft. wide trenches, spaced 6 ft. apart, and 5 ft. setback at each edge.

Setbacks are necessary to minimize the threat of public health or environmental problems in case a system should fail. The setback should be based on soil type, slope, presence and character of the water table. Setback guidelines should be set for both traditional and alternative OSDS.

EPA recommends the following setbacks for soil absorption systems although other setbacks may be required for normal high tide marks, pressurized water lines, etc.:

Water Supply Wells:	50 to 100 feet
Surface Waters, Springs:	50 to 100 feet
Escarpments:	10 to 20 feet
Boundary of Property:	5 to 10 feet
Building Foundations:	10 to 20 feet (30 feet when located upslope from a building in slowly permeable soils.)

<u>Mound Systems</u> - Mound systems operate in much the same manner as conventional septic systems except that effluent from the septic tank enters a dosing tank and then is pumped to a leaching field that is located in elevated sand fill above the natural soil surface. This system is used when insufficient separation distance or percolation conditions exist for a conventional system. It is maintained and performs in much the same manner as a conventional system. In

fact, the performance of the system is generally a little better because the pressure dosing provides for more uniform distribution of effluent throughout the leaching field.

For mound systems, the mound perimeter requires downslope setbacks to make certain that the basal area of the mound is sufficient to absorb the wastewater before it reaches the perimeter of the mound to avoid surface seepage. On level sites the entire basal area of the mound (i.e., the product of the length of the mound times the width) is used to determine the setbacks. On sloping sites, only the area downslope of the absorption bed is considered. The exact downslope setbacks will depend on the permeability of the soil. Upslope and side slope setbacks for sloped systems should be 10 feet, based on a 3 to 1 side slope.

Where adequate area is available for subsurface effluent discharge, and permanent or seasonal high ground water is at least 2 feet below the surface, the elevated sand mound may be used in coastal areas. This system can treat septic tank effluent to a level that usually approaches primary drinking water standards for BOD_5, suspended solids, and pathogens by the time the effluent plume passes the property line for single-family dwellings.

Low Pressure Systems - Low pressure systems are nearly identical to mound systems except that the leaching field is in natural soil. This system has the same design limitations as a conventional system and its main advantage is slightly better performance because the pressure dosing provides for more uniform distribution of effluent throughout the leaching field.

Alternate Trench - As stated in the description of the conventional septic system, the most common failure is from clogging of the leaching field and/or overloading of water to the field. Alternate trenches are simply a second leaching field that can be used to rest the primary leaching field. During the rest period of the primary field, the system reverts to aerobic clogging and the assimilative capacity of the field is usually improved. Alternate trenches are typically used 3 to 6 months a year.

Intermittent Sand Filter - Intermittent sand filters are used in conjunction with septic tanks and leaching fields. An intermittent sand filter receives and treats effluent from the septic tank before it is distributed to the leaching field. The sand filter consists of a bed (either open or buried) of granular material from 24 to 36 inches deep. The material is usually from 0.35 to

1.0 mm in diameter. The bed of granular material is underlain with graded gravel and collector drains. These systems have been shown to be effective for nitrogen removal, however, this process is dependent on temperature. Water loading recommendations for these filters is typically between 1 and 5 gallons per day/square foot (gpd/sf) but can be higher depending on wastewater characteristics. Primary failure of sand filters is from clogging. The following maintenance is recommended to keep the system performing properly: resting bed; raking surface layer; or removing top surface media and replacing it with clean media. In general, the filters should be inspected every 3 - 6 months to ensure that they are operating properly.

Intermittent sand filters are used for small commercial and institutional developments and individual homes. The size of the facility is limited by land availability. The filters should be buried in the ground, but may be constructed above ground in areas of shallow bedrock or high water tables. Covered filters are required in areas with extended periods of subfreezing weather. Excessive long-term rainfall and runoff may be detrimental to filter performance, requiring measures to divert water away from the system (EPA, 1980).

Recirculating Sand Filter - A recirculating sand filter is nearly identical to an intermittent sand filter except that effluent from the filter is recirculated through the septic tank and/or the sand filter again before it is discharged to the distribution field. Recirculating the effluent enhances performance and allows media size to be increased to as much as 1.5mm in diameter and water loading rates in the range of 3 to 10 gpd/sf to be used. Recirculation ratios of 3:1 to 5:1 are generally recommended.

Recirculating sand filters can achieve a very high level of treatment of septic tank effluent before discharge to surface water or soil. This usually means single-digit figures for BOD_5 and suspended solids and secondary body contact standards for pathogens (in practice, 100-900 per 100 ml). Dosed recycling between sand filter and septic tank or similar devices can result in significant levels of nitrification/denitrification, equivalent to between 50 and 75 percent overall nitrogen removal, depending on the recycling ratio. Recirculating sand filters may require as much as 1 square foot of filter per gallon of septic tank effluent.

Anaerobic Upflow Filter - An anaerobic upflow filter (AUF) resembles a septic tank filled with 3/8-inch gravel with a deep inlet tee and a shallow outlet tee. An AUF system includes a septic tank, AUF, a sand filter, and a leaching field. As with the sand filter, dose recycling can be used to enhance this systems performance. Hydraulic loading for an AUF is generally in the range of 3 - 15 gpd.

A growing body of data at the University of Arkansas and elsewhere suggests that an upflow anaerobic filter (UAF) can provide further treatment of septic tank effluent before discharge to a sand filter. This treatment allows a drastic reduction (by a factor of 8 to 20) in the size of sand filter needed to attain the performance described above, with major reductions in cost.

An upflow anaerobic filter resembles a septic tank or the second chamber of a dual-chambered tank. It is filled with 3/8-inch gravel, where wastewater enters at the bottom and exits at the top. It should be sized to allow retention times between 16 and 24 hours. There is a high degree of removal of suspended solids and insoluble BOD. Dosed recycling between sand filter and UAF can result in 60 to 75 percent overall nitrogen removal.

Trenches and Beds - Trenches are typically 1 to 3 feet wide and can be greater than 100 feet long. Infiltration occurs through the bottom and sides of the trench. Each trench contains one distribution pipe, and there may be multiple trenches in a single system. Like conventional septic systems, they require 2 to 4 feet between the bottom of the system and the seasonally high water table or bedrock, and are best suited in sandy to loamy soils where the infiltration rate is 1 to 60 minutes per inch. Gravelly soils or poor-permeability soils (60 to 90 minutes per inch) are not suitable for trench systems. However, where the infiltration rate is greater than 1 minute per inch, 6 inches of loamy soil can be added around the system to create the proper infiltration rate (Otis, undated).

Beds are similar to trenches except that infiltration occurs only through the bottom of the bed. Beds are usually greater than 3 feet wide and contain one distribution pipe per bed. Single beds are commonly used; however, dual beds may be installed and used alternately. The same soil suitability conditions that apply to trenches apply to bed systems.

Trenches are often preferred to beds for a few reasons. First, with equal bottom areas, trenches have five times the sidewall area for effluent absorption; second, there is less soil damage during the construction of trenches; and third, trenches are more easily used on sloped sites.

The effluent from trenches or beds can be distributed to gravity, dosing, or uniform application. Dosing refers to periodically releasing the effluent using a siphon or pump after a small quantity of effluent has accumulated. Uniform application similarly stores the effluent for a short time, after which it is released through a pressurized system to achieve uniform distribution over the bed or trench. Uniform application results in the least amount of clogging.

Maintenance of trenches and beds is minimal. Dual trench or bed systems are especially effective because they allow the use of one system while the other rests for 6 months to a year to restore its effectiveness (Otis, undated).

Water Separation System - A water separation system separates greywater and blackwater (toilet waste). The greywater is treated using a conventional septic system and the blackwater is contained in a vault/holding tank. The blackwater is later hauled offsite for disposal.

For extreme situations or for seasonal residents, some form of separation of toilet wastes from bath and kitchen wastes may be helpful. Most nitrogen discharges in residential wastewater come from human urine. A very efficient toilet (0.8 gallon per flush), if routed to a separate holding tank, would need pumping only three or four times per year even for a family of four permanent residents.

RUCK System - The RUCK system also requires separation of the greywater and the blackwater. However the blackwater is nitrified in a buried sand filter and then mixed with the greywater in an anaerobic tank for denitrification. The effluent is then dosed to a leaching field.

Constructed Wetlands - Constructed wetlands are usually used for polishing of septage effluent that has already had some degree of treatment. Pretreatment could include processing through a septic tank or some type of primary and secondary treatment of effluent from a group of individual properties. Constructed wetlands performance will be degraded in colder climates during winter months because of plant die off and reduction in the metabolic rate of aquatic organisms.

Central Sewage Treatment Facility - A central sewage treatment facility would include sewering of all units to a central facility, and primary, secondary, and tertiary treatment at the facility.

Cluster Systems - Cluster systems can take on many forms. For this document, a cluster system is defined as septic systems on individual properties for primary treatment of septage and then effluent from several of these systems being collected and provided with additional treatment. The additional treatment could include sand filters or AUF, constructed wetlands, chemical treatment, or aerobic treatment. The benefit of cluster systems is centralization of the secondary treatment which can provide some economy of scale in such things as filters or constructed wetlands.

Evapotranspiration (ET) Systems - ET systems combine the process of evaporation from the surface of a bed and transpiration from plants to dispose of wastewater. The wastewater would require some form of pretreatment such as a septic tank. An ET bed usually consists of a liner, drainfield tile, and gravel and sand layers. ET systems are useful where soils are unsuitable for subsurface disposal, where the climate is favorable to evaporation, and where ground-water protection is essential. In both types of systems, distribution piping is laid in gravel, overlain by sand, and planted with suitable vegetation. Plants can transpire up to 10 times the amount of water evaporated during the daytime. For an ET system to be effective, evaporation must be equal to or greater than the total water input to the system because it requires an impermeable seal around the system. In the United States, this limits use of ET systems to the Southwest. The size of the system depends on the quantity of effluent inflow, precipitation, the local evapotranspiration rate, and soil permeability (Otis, undated).

Vaults and Holding Tanks - Vaults and holding tanks are used to contain wastewater in emergency situations or other temporary functions. This technology should be discouraged because of high anticipated overloads due to difficult pumping logistics. Such systems require frequent pumping, which can be expensive.

Eliminating Garbage Disposals - Eliminating garbage disposals reduces the waste loads on OSDSs. The garbage can be composted by the homeowner and the compost has beneficial uses.

Low Phosphate Detergents - Several areas require the use of low phosphate detergents. Low phosphate detergents have been shown to be as effective in cleaning ability as other detergents.

Water Conservation Fixtures - Water conservation fixtures can consist of low flush toilets, and high efficiency shower heads and faucets. There are a variety of fixtures that are commercially available and their effect on performance of OSDSs can be significant. These modern, high efficiency fixtures include: 1.5 gallon or less per flush toilets, 2.0 gallon per minute (gpm) or less shower heads, faucets of 1.5 gpm or less, and front loading washing machines of up to 27 gallons per 10 to 12 pound load. These can result in a 30 to 70 percent reduction of total in-house water use. In fact, studies have shown that a majority of the failures of conventional septic systems can be attributed to water overloads.

Fixed Film Systems - A fixed film system employs media to which microorganisms may become attached. Fixed film systems include trickling filters, upflow filters, and rotating biological contractors. These systems require pretreatment of septage in a septic tank and the effluent can be discharged to a leaching field. Data were unavailable on this BMP so its cost and effectiveness were not evaluated.

Aerobic Treatment Units - Aerobic treatment units can be employed on site. There are a couple of commercially available packages. However, these systems require regular supervision and maintenance to be effective. These systems require pretreatment by a septic tank and effluent can be discharged to a leaching field. Power requirements can be significant for certain types of these packages. Data were unavailable on this BMP so its cost and effectiveness were not evaluated.

Disinfection Devices - In some areas, pathogen contamination from OSDS is a major concern. Disinfection devices may be used in conjunction with the above systems to treat effluent for pathogens before it is discharged to a soil absorption field. Disinfection devices include halogen applicators (for chlorine and iodine), ozonators, and UV applicators. Of these three types, halogen applicators are usually the most practical (EPA, 1980). Installation of these devices in an OSDS increases the system's cost and adds to the system's operation and maintenance requirements. However, it may be necessary in some areas to install these devices to control pathogen contamination of costal waters and ground water.

(NOTE: The use of disinfection systems should be evaluated to determine the potential impacts of chlorine and iodine loadings. Some States, such as Maryland, have additional requirements or prohibit the use of these processes).

General Information - Most septic tanks need to be pumped every three to five years; however, there are several household factors that need to be considered when determining pumpout needs, including:

- the capacity of the tank,

- the flow of wastewater (based on family size), and

- the volume of solids in the wastewater (more solids are produced if a garbage disposal is used) (Mancl and Magette, 1991).

Failure will not occur immediately if a septic system is not pumped; however, continued neglect will cause the system to fail because the soil absorption system is no longer protected from solids and may need to be replaced at considerable expense.

Table 2-2 shows an estimate of how often a septic tank should be pumped based on tank and household size.

Table 2-2. Suggested Septic Tank Pumping Frequency (Years)

Tank Size (gal)	Household Size (number of people)									
	1	2	3	4	5	6	7	8	9	10
500	5.8	2.6	1.5	1.0	0.7	0.4	0.3	0.2	0.1	--
750	9.1	4.2	2.6	1.8	1.3	1.0	0.7	0.6	0.4	0.3
1,000	12.4	5.9	3.7	2.6	2.0	1.5	1.2	1.0	0.8	0.7
1,250	15.6	7.5	4.8	3.4	2.6	2.0	1.7	1.4	1.2	1.0
1,500	18.9	9.1	5.9	4.2	3.3	2.6	2.1	1.8	1.5	1.3
1,750	22.1	10.7	6.9	5.0	3.9	3.1	2.6	2.2	1.9	1.6
2,000	25.4	12.4	8.0	5.9	4.5	3.7	3.1	2.6	2.2	2.0
2,250	29.6	14.0	9.1	6.7	5.2	4.2	3.5	3.0	2.6	2.3
2,500	31.9	15.6	10.2	7.5	5.9	4.8	4.0	4.0	3.0	2.6

Source: University of Maryland, 1991.

2.2 EFFECTIVENESS

Data on OSDSs were collected from nearly 60 different documents. Some of these documents were a little dated but reliable information about removal efficiencies still seemed to be relevant. In many of the publications, system performance was presented as quality of effluent and not a percent reduction in pollutant. In these cases, the percent removal was computed by using the following average household septage pollutant concentrations: Total Suspended Solids (TSS) - 220 mg/l; Biological Oxygen Demand (BOD) - 220 mg/l; Total Nitrogen (TN) - 60 mg/l; Total

Phosphorous (TP) 25 mg/l, and pathogens - 9 logs. The data that were used to develop these averages are presented in Section b of the Appendix. The following should be noted about the above household septage pollutant concentrations:

- The TN value of 375mg/l reported in Anderson and Machmeir (1988) was eliminated from consideration because it was deemed to be unrealistically high.

- The TP value of 8 mg/l reported in EPA (1984) was eliminated from consideration because it was deemed to be unrealistically low.

- The TP average is based on limited data.

- COD values reported in reference Swanson and Dix (1988) were eliminated from consideration because they were deemed to be unrealistically low (especially when compared to the BOD values reported in the same reference).

The following discusses the factors that influence the effectiveness of the various management practices and also discusses the development of the summary values presented in Table 3-1.

Conventional Septic Systems - The effectiveness values presented in the OSD Cost and Effectiveness Summary Table were based on the information from 5 references. Nitrogen removal in these systems can be influenced by temperature. The values assume that the system is properly maintained (e.g. pumped out every 3 - 5 years) and that water loading is not excessive. It should be noted that the effectiveness numbers reported in the literature generally also considered the assimilative capacity of the soil between the bottom of the leaching field and the water table.

Mound and Low Pressure Systems - No effectiveness data were obtained from the literature. However, the effectiveness numbers presented in the summary table were based on these systems being nearly identical to conventional septic systems. Some increased effectiveness was given to these systems because the pressure dosing to the leaching field provides a more even distribution of effluent throughout the field.

Alternate Trench - No effectiveness data were obtained from the literature. However, the effectiveness numbers presented in the summary table were based on these systems being nearly identical to conventional septic systems.

Trenches and Beds - No effectiveness data were obtained from the literature. However, the effectiveness numbers presented in the summary table were based on these systems being nearly identical to conventional septic systems.

Anaerobic Upflow Filters - Data reported for AUFs was generally from analysis of effluent from the filter. Given that in most cases that the effluent is generally also passed through a sand filter, and the assimilative capacity of the leaching field and soil beneath the field, the total effectiveness from a system with an AUF would be higher than the numbers presented in the summary Cost and Effectiveness Table.

Intermittent and Recirculating Sand Filters - These types of filters generally have improved TSS, BOD, TN and TP removal over conventional systems. It should again be noted that effectiveness numbers in the literature were generally based on analysis of filter effluent. Consequently, total system performance should be higher because of the removal that takes place in the leaching field. TN performance of these types of systems can be effected by temperature, however in Venhuizen (1991), the investigator concluded that these types of filters would be very effective in Wisconsin.

Water Separation System - The effectiveness information for these systems is based on data from 4 references. The TP effectiveness would be higher if consideration is given to soil removal capacity. Additionally, loads from the treatment facility processing the blackwater was not considered.

RUCK Systems - Most of the data presented in references for RUCK systems concentrated on nitrogen removal. The other effectiveness data are based on limited information.

Evapotranspiration Systems - Because of the evaporation requirements for these types of systems, they would only be effective in certain areas of the southwestern portions of the country. No data on the effectiveness of an operating system's performance were available.

However, since these systems do not discharge effluent, and assuming that they are maintained and properly lined, it is estimated that they would be 90% or higher effective at controlling OSDS pollution.

Constructed Wetlands - The summary of constructed wetlands effectiveness data also considered data on rock-plant filters. No data were available for TP effectiveness. Additionally, no lower limit was placed on the TN removal effectiveness because the performance may be severely impaired during the winter in very cold climates. However, these systems have been installed in areas such as Michigan, but the majority have been installed in the more mid- and southern-latitudes of the U.S.

Central Sewage Treatment Facility - Only limited effectiveness information has been included in the summary Table because performance is dependent on the type of system used. However, discharges from central facilities are generally regulated under NPDES and the systems performance must meet these requirements.

Cluster Systems - No effectiveness information has been presented for cluster systems because the effectiveness strongly depends on the types of treatment given to the effluent once it has been collected. Effectiveness information could be developed assuming that the collected effluent is only going to be processed to a leaching field.

Vaults and Holding Tanks - No effectiveness information has been presented for these types of practices. One could present that they are 100% effective but this would be misleading since the septage must eventually be treated and discharged by a facility.

Eliminating Garbage Disposals and Use of Low Phosphate Detergents -The effectiveness numbers presented for these practices only consider reductions in residential septage pollutant loads.

Water Conservation Fixtures - The only effectiveness numbers presented for these types of fixtures is reduction in water loads. This may not convey the proper message. For example, the majority of conventional septic system failures are due to excessive water loads. By implementing water conservation fixtures, the prolonged effectiveness of nearly all of the other

OSDS management practices is enhanced.

Disinfection Devices - With proper installation, disinfection devices can be 90% to 99% effective at eliminating pathogens in OSDS effluents.

2.3 COST

No regional cost variation conclusions could be drawn from the cost data obtained. It is believed that the cost could vary greatly within a state depending on local cost of living effects (e.g cost of installing a septic system in rural Garrett County, Maryland as opposed to the rapidly developing Carroll County, Maryland). The following is a discussion on how the cost numbers presented in the Cost and Effectiveness Summary Table were determined.

Conventional Septic System - Capital and maintenance costs for these systems varied greatly in the 6 references that reported cost information. The maintenance cost included the cost of pumping out the tank every 3 years but did not include inspection costs. It is has been assumed that homeowners could inspect their own systems with minimal inconvenience.

Mound and Low Pressure Systems - The maintenance costs for these systems is based on the same septic tank cleaning schedule as for conventional septic systems. However, a slightly higher maintenance cost is assumed because of maintenance on the pump for the pressure dosing.

Alternate Trench - Depending on the percolation rate and drain field size, the estimated capital cost of an alternate trench ranges from $2,500 to $5,600. The estimated maintenance cost is $40 a year (Heller et al, 1992).

Trenches and Beds - Depending on the percolation rate and the drain field size, the estimated capital cost of trenches and beds ranges from $4,900 to $11,100. These cost estimates include the cost of a 1,000 gallon septic tank, 100 feet of 12 inch plastic perforated pipe, and 35 cubic yards of soil excavation. The estimated maintenance cost is $40 a year (Heller et al, 1992).

Anaerobic Upflow, Intermittent Sand, and Recirculating Sand Filters - Although the literature did not include total system costs, the costs presented appeared to include the costs of a septic tank and a leaching field. The maintenance costs included replacement of filter media (e.g. sand) as necessary.

Water Separation System - The only cost information available for this type of system was from the Draft 6217(g) Guidance Document. It is unclear what the source was for the cost presented in that document.

RUCK System - Only one reference to cost was available for RUCK systems (Leak, 1986). The cost number presented in that report was taken from a New Alchemy Institute report on the cost of a system for Cape Cod ($10,000) and their assessment about what the cost of future systems may cost ($6,000).

Central Sewage Treatment Facility - The capital cost for these systems was based on the initial hookup fee for homeowners. It was felt that this would be reasonable even if a new system were built because the community would attempt to recover the initial construction cost in the hookup fees. The maintenance costs were based on average yearly user fees to the homeowners and did not include any cost that may be incurred by the community.

Cluster Systems - The capital cost for these types of systems was based on the per homeowner hookup fees from two projects (one in New York and one in Michigan). In both of these cases the homeowners already have septic tanks so that cost has not been included. The maintenance cost is based on the yearly user fee presented in the New York study.

Evapotranspiration (ET) Systems - The estimated capital cost of an ET system is $19,000. This cost includes a 1,000 gallon septic tank and a 2,250 square foot drain field. The estimated maintenance cost is $120 a year (Heller et al, 1992).

Eliminating Garbage Disposals and Use of Low Phosphate Detergents -No costs for these two source control measures have been included. It is felt that no significant cost would be incurred by eliminating garbage disposals. Additionally, many manufacturers produce low phosphate detergents at competitive prices.

Vaults and Holding Tanks - A fair amount of cost data are available for vaults and holding tanks. These costs (both capital and maintenance costs) vary greatly with the size of the tank and the water loading rate. This information should be included in the summary table, however some careful thought must be given on how to present the costs. The cost of a 2000 gallon tank may be a useful starting point for calculating capital cost, and maintenance could be computed based on the average water loading from a 4 person household.

Constructed Wetlands - The costs for constructed wetlands varied greatly. The costs included land cost and that could explain the wide range ($0.10/gpd to $3.00/gpd). The range of costs presented in the summary table covers nearly the whole range of costs reported. Minimal information was available on maintenance costs. The only reported value was for a wetland serving several households. It may be prudent not to present any values for the maintenance costs unless more data can be obtained.

Water Conservation Fixtures - No cost data were presented for water conservation fixtures in the summary table because costs can vary greatly from manufacturer to manufactures and on the level of fixtures installed (e.g. only low flush toilets). Additionally, savings in water use charges, size of distribution field, filter, and septic tank should also be considered when evaluating the total cost of installing these fixtures.

Disinfection Devices - Installation of these devices in an OSDS increases the system's capital and maintenance costs.

3.0
OSDS EFFECTIVENESS AND COST SUMMARY TABLE

This section presents quantitative effectiveness and cost summary information for various OSDS management practices in Table 3-1. The summary table is based on the detailed cost and effectiveness data presented in Appendix D and E. It should be noted that only practices that had sufficient quantitative data on which to base conclusions are presented in the Table.

Table 3-1 presents both cost and effectiveness information. The effectiveness information includes the average, the range observed in the reviewed literature, the probable range expected from a properly designed and maintained practice, and the number of data values considered in developing the averages and ranges. The cost information is presented in terms of capital cost and annual maintenance cost.

TABLE 3-1.-OSDS EFFECTIVENESS AND COST SUMMARY

	EFFECTIVENESS						COST		
PRACTICE	WATER	TSS	BOD	TN	TP	PATH.	CAPITAL COST[1]	MAINTENANCE COST[1]	REFERENCES
	(%)	(%)	(%)	(%)	(%)	(LOGS)	($/HOUSE)	($/YEAR)	
CONVENTIONAL SEPTIC SYSTEM									EPA, 1977; EPA, 1980; EPA, 1989; EPA, 1991; Sandy et al., 1988; Lamb et al., 1988; Rhode Island, 1989; Degen et al., 1991; Healy, 1982; Hanson et al., 1988; Dix, 1986; Fulhage & Day, 1988.
Average	NA	72	45	28	57	3.5	$4,500	$70	
Probable Range	NA	60-70	40-55	10-45	30-80	3-4	$2,000-$8,000	$50-$100	
Observed Range	NA	54-83	30-60	0-58	0-95	3-4	$2,000-$10,000	$25-$110	
No. Values Considered		7	7	13	12	2	8	4	
ALTERNATE TRENCH									Heller et al, 1992
Average	NA	NA	NA	NA	NA	NA	NA	NA	
Probable Range	NA	60-70	40-55	10-45	30-80	3-4	$2,400-$5,600	$40	
Observed Range	NA	NA	NA	NA	NA	NA	NA	NA	
No. Values Considered		0	0	0	0	0	1	1	
MOUND SYSTEMS									EPA, 1977; EPA, 1980; EPA, 1991; Small Flows Clearinghouse, n.d.; Hanson et al., 1988; Degen et al., 1991.
Average	NA	NA	NA	44	NA	NA	$8,300	$180	
Probable Range	NA	60-75	40-60	10-45	30-80	3-4	$7,000-$10,000	$100-$300	
Observed Range	NA	NA	NA	44-44	NA	NA	$6,800-$11,000	$90-$310	
No. Values Considered		0	0	1	0	0	4	4	
TRENCHES AND BEDS									Heller et al, 1992
Average	NA	NA	NA	NA	NA	NA	NA	NA	
Probable Range	NA	60-70	40-55	10-45	30-80	3-4	$4,900-$11,100	$40	
Observed Range	NA	NA	NA	NA	NA	NA	NA	NA	
No. Values Considered	0	0	0	0	0	0	1	1	
LOW PRESSURE SYSTEMS									EPA, 1980; Fulhage and Day, 1988.
Average	NA	NA	NA	NA	NA	NA	$5,100	$150	
Probable Range	NA	60-70	30-40	10-45	30-80	3-4	$4,000-$6000	$100-$200	
Observed Range	NA	NA	NA	NA	NA	NA	$2,800-$7,400	$150-$150	
No. Values Considered	0	0	0	0	0	0	2	1	
ANAEROBIC UPFLOW FILTER									EPA, 1991; Venhuizen, 1991; Mitchell, n.d.
Average	NA	44	62	59	NA	NA	$5,550	NA	
Probable Range	NA	30-60	50-75	40-75	60-80	3-4	$3,000-$8,000	$150-$400	
Observed Range	NA	24-89	46-84	20-75	NA	NA	$3,000-$8,000	NA	
No. Values Considered	0	6	6	6	0	0	2	0	

TABLE 3-1. OSDS EFFECTIVENESS AND COST (Continued)

PRACTICE	EFFECTIVENESS						COST		REFERENCES
	WATER	TSS	BOD	TN	TP	PATH.	CAPITAL COST[1]	MAINTENANCE COST[1]	
	(%)	(%)	(%)	(%)	(%)	(LOGS)	($/HOUSE)	($/YEAR)	
INTERMITTENT SAND FILTER									EPA, 1977; EPA, 1980; EPA, 1991; Small Flows Clearinghouse, n.d.; Venhuizen, 1991.
Average	NA	92	92	55	80	3.2	$5,400	$275	
Probable Range	NA	80-95	90-95	50-65	70-90	3-4	$4,000-$8,000	$250-$400	
Observed Range	NA	70-99	80-99	40-75	70-90	2-4	$2,300-$10,000	$100-$440	
No. Values Considered	0	7	10	7	2	6	7	5	
RECIRCULATING SAND FILTER									Hoxie et al., 1988; Small Flows Clearinghouse, n.d.; Fulhage & Day, 1988; EPA, 1991; Venhuizen, 1991; Swanson & Dix, 1988; Lamb et al., 1988; Laak, 1986; EPA, 1980; Sandy et al., 1988.
Average	NA	90	92	64	80	2.9	$3,900	$140	
Probable Range	NA	85-95	85-95	60-85	70-90	2-4	$5,000-$8,000	$250-$400	
Observed Range	NA	70-98	75-98	1-94	70-90	2-4	$1,850-$7,500	$15-$410	
No. Values Considered	0	12	15	13	2	8	8	7	
RUCK SYSTEM									Laak, 1986; Lamb et al., 1988; EPA, 1991.
Average	NA	85	86	51	83	4	$14,000	NA	
Probable Range	NA	80-90	80-90	50-80	70-90	3-4	$12,000-$16,000	$250-$400	
Observed Range	NA	85-85	86-86	6-80	83-83	4-4	$12,000-$16,000	NA	
No. Values Considered	0	1	1	5	1	1	1	0	
WATER SEPARATION SYSTEM									EPA, 1991; EPA, 1986; EPA, 1980; EPA, 1977.
Average	NA	60	42	83	30	3	$8,000	$300	
Probable Range	NA	55-70	35-55	70-90	30-55	2-4	$5,000-$11,000	$300-$750	
Observed Range	NA	36-75	22-55	68-99	14-42	NA	$5,000-$11,000	$300-$300	
No. Values Considered	0	4	3	6	6	0	1	1	
CONSTRUCTED WETLANDS									Reed, 1991; Small Flows Clearinghouse, n.d., EPA, 1980; Amberg, 1990; Dwyer et al., 1989.
Average	NA	80	81	90	NA	4	$710	$25	
Probable Range	NA	60-90	70-90	60-90	30-70	3-4	$1,000-$3,000	$25-$100	
Observed Range	NA	50-98	65-97	90-90	NA	4-4	$50-$350	$25-$25	
No. Values Considered	0	3	4	2	0	1	19	1	

TABLE 3-1. OSDS EFFECTIVENESS AND COST (Continued)

	EFFECTIVENESS						COST		
PRACTICE	WATER	TSS	BOD	TN	TP	PATH.	CAPITAL COST[1]	MAINTENANCE COST[1]	REFERENCES
	(%)	(%)	(%)	(%)	(%)	(LOGS)	($/HOUSE)	($/YEAR)	
CENTRAL SEWAGE TREATMENT FACILITY									Orr, 1989; EPA, 1980; Decker, 1987.
Average	NA	85	85	NA	NA	NA	$5,450	$180	
Probable Range	NA	80-90	80-90	75-95	30-70	3-4	$3,000-$10,000	$150-$250	
Observed Range	NA	85-85	85-85	NA	NA	NA	$40-$9,977	$70-$240	
No. Values Considered	0	1	1	0	0	0	4	3	
CLUSTER SYSTEMS									Decker, 1987; Small Flows Clearinghouse, n.d.
Average	NA	NA	NA	NA	NA	NA	$4,950	$370	
Probable Range	NA	NA	NA	NA	NA	NA	$5,000-$7,000	$300-$400	
Observed Range	NA	NA	NA	NA	NA	NA	$3,000-$6,900	$370-$370	
No. Values Considered	0	0	0	0	0	0	3	1	
EVAPOTRANSPIRATION SYSTEM									Heller et al, 1992
Average	NA	NA	NA	NA	NA	NA	NA	NA	
Probable Range	NA	95-100	95-100	95-100	95-100	3-4	$19,000	$120	
Observed Range	0	NA	NA	NA	NA	NA	NA	NA	
No. Values Considered		0	0	0	0	0	0	0	
ELIMINATING GARBAGE DISPOSALS									EPA, 1991; EPA, 1986; EPA, 1980.
Average	NA	37	28	5	2.5	NA	NA	NA	
Probable Range	NA	35-40	25-30	5-10	2-3	NA	Negligible	Negligible	
Observed Range	NA	37-37	28-28	5-5	2-3	NA	NA	NA	
No. Values Considered	0	3	2	2	2	0	0	0	
LOW PHOSPHATE DETERGENTS									EPA, 1991; EPA, 1980.
Average	NA	NA	NA	NA	50	NA	NA	NA	
Probable Range	NA	NA	NA	NA	40-50	NA	Negligible	Negligible	
Observed Range	NA	NA	NA	NA	50-50	NA	NA	NA	
No. Values Considered	0	0	0	0	2	0	0	0	

TABLE 3-1. OSDS EFFECTIVENESS AND COST (Continued)

	EFFECTIVENESS						COST		
PRACTICE	WATER	TSS	BOD	TN	TP	PATH.	CAPITAL COST[1]	MAINTENANCE COST[1]	REFERENCES
	(%)	(%)	(%)	(%)	(%)	(LOGS)	($/HOUSE)	($/YEAR)	
WATER CONSERVATION FIXTURES									EPA, 1991; EPA, 1980; EPA, 1977; Small Flows Clearinghouse, n.d.; Jarrett et al., 1985.
Average	45	NA	NA	NA	NA	NA	NA	NA	
Probable Range	25-80	NA	NA	NA	NA	NA	Varies	Negligible	
Observed Range	4-90	NA	NA	NA	NA	NA	NA	NA	
No. Values Considered	11	0	0	0	0	0	0	0	
HOLDING TANKS									Small Flows Clearinghouse, n.d.; Dix, 1986; Hanson et al., 1988.
Average	NA	NA	NA	NA	NA	NA	$3,900	$1,300	
Probable Range	NA	95-100	95-100	95-100	95-100	3-4	$4,000-$6,000	$1,000-$2,000	
Observed Range	NA	NA	NA	NA	NA	NA	$1,220-$6,670	$100-$2,400	
No. Values Considered	0	0	0	0	0	0	8	12	

[1]Cost are in 1988 equivalent dollars and an average household with 4 occupants was assumed.

4.0
MANAGEMENT PRACTICE OPTIONS

This section presents management practices options that were deemed, based on the literature review, technically and economically achievable for control of NPS pollution from OSDSs in the coastal zone. In general, new OSDSs should be designed, installed, operated, and maintained to prevent the discharge of pollutants to the surface of the ground and minimize the discharge of pollutants into ground water. A few conditions that should be met for all new OSDSs are the use of low-volume plumbing fixtures and the prohibition of the installation of garbage disposals. OSDSs that minimize nitrogen loadings to ground water should be used in areas where conditions indicate that nitrogen-limited coastal waters may be adversely affected by excess nitrogen loadings from OSDSs. The OSDS management practice options are presented in two sections, one for new OSDSs and one for replacement or enhancement of existing OSDSs.

4.1 NEW OSDSs

1. Conventional Septic System with Alternate Trench and Water Conservation Fixtures, Low Phosphate Detergents, and No Garbage Disposals

Description: Septic systems have been widely used as an OSDS practice. A septic system can be effective if it is installed with an alternate trench to the leaching field and if water conservation fixtures are installed in the house. An alternate trench is recommended so that the primary leaching field can be rested for 3 to 6 month intervals on a yearly basis. This will ensure that aerobic conditions are maintained in the soil below the leaching field. The majority of conventional septic system failures are due to water overload. Consequently, water conservation fixtures should also be installed in conjunction with the system. Finally, garbage disposals can be eliminated and low phosphate detergents can be employed at very minimal cost and can significantly reduce the waste loads to the system.

Maintenance: The conventional septic system should be inspected yearly, the septic tank should be cleaned out every 3 years, and the alternate trench should be used for 3 to 6 months each year.

Limitations: Conventional septic systems should not be used if the following conditions are present:

- Unsuitable site areas such as poorly or excessively drained soils (e.g. percolation rate less than 5 min/inch or greater than 120 min/inch), areas with shallow and/or rising water tables (e.g. depth to groundwater or limiting layer less than 2 feet), areas overlaying fractured bedrock that drain directly to ground water, areas within floodplains, or areas where effluent cannot be sufficiently treated before it reaches sensitive waterbodies, including ground or surface water.

- Nitrogen-limited coastal waters that may be adversely affected by excess nitrogen loadings from conventional OSDS exist.

Regional Factors: Conventional septic systems can be applied in every region of the country provided the above design limitations are not violated. There may be some slightly less effectiveness with regard to nitrogen removal in colder climates. However, these differences would be overshadowed by the variability in the performance of the systems based on differences in soil type within one region.

2. <u>Mound Systems with Water Conservation Fixtures, Low Phosphate Detergents, and No Garbage Disposals</u>

Description: This mound system would essentially function the same as the septic system described in 1. above with the notable exception that the leaching field would be elevated in a sand mound and pressure dosing would be used for discharging effluent to the leaching field. The effectiveness would be very similar to the septic system described above. Mound systems can be used when there is insufficient separation distance for a conventional septic system. Water conservation fixtures and low phosphate detergents should be used in conjunction with the mound system and the use of garbage disposals should be prohibited.

Maintenance: The system should be inspected yearly, the septic tank should be cleaned out every 3 years, and there should be routine maintenance of the dosing pump.

Limitations: Mound systems should not be used if the following conditions are present:

- Unsuitable site areas such as poorly or excessively drained soils (e.g. percolation rate less than 5 min/inch or greater than 120 min/inch), areas overlaying fractured bedrock that drain directly to ground water, areas within floodplains, or areas where effluent cannot be sufficiently treated before it reaches sensitive waterbodies, including ground or surface water.

- Nitrogen-limited coastal waters that may be adversely affected by excess nitrogen loadings from conventional OSDS exist.

Regional Factors: Mound systems can be applied in every region of the country provided the above design limitations are not violated. There may be some slightly less effectiveness with regard to nitrogen removal in colder climates. However, these differences would be overshadowed by the variability in the performance of the systems based on differences in soil type within one region.

3. <u>Anaerobic, Intermittent Sand, or Recirculating Sand Filter in Conjunction with Septic Tank, Leaching Field, Water Conservation Fixtures, No Garbage Disposals and Low Phosphate Detergent</u>

Description: In areas with known or suspected nitrate problems, or in areas with excessively drained soils (e.g. percolation rates are less than 5 min/inch), denitrifying devices such as anaerobic, intermittent sand, or recirculating sand filters should be used in conjunction with a conventional type septic system. These filters greatly enhance the nitrogen removal from septage (50 to 60% more effective than septic system alone). The type of filter selected can be based on local cost with the recirculating sand filter having slightly better performance than the intermittent sand or anaerobic upflow filters. Again, water conservation fixtures and low phosphate detergents should be used and garbage disposals should be prohibited.

Maintenance: Inspect system yearly, pump out septic tank every 3 years, replace sand as needed, and perform routine maintenance on pumps.

Limitations: Septic systems with one of the filters described above should not be used if the following conditions are present:

- Unsuitable site areas such as poorly drained soils (e.g. percolation rate greater than 120 min/inch), areas with shallow and/or rising water tables (e.g. depth to groundwater or limiting layer less than 2 feet), areas overlaying fractured bedrock that drain directly to ground water, areas within floodplains, or areas where effluent cannot be sufficiently treated before it reaches sensitive waterbodies, including ground or surface water.

Regional Factors: These types of systems can be applied in every region of the country provided the above design limitations are not violated. There may be some slightly less effectiveness with regard to nitrogen removal in colder climates. However, field studies have shown these differences to be very small even in the most northern latitudes.

4. Constructed Wetlands or Evapotranspiration Systems

Description: In areas with known or suspected nitrate problems, or in areas with poorly drained soils (e.g. percolation rates are greater than 120 min/inch), or where there is an insufficient separation distance (e.g. less than 2 feet to ground water or limiting layer), constructed wetlands or evapotranspiration systems should be used in conjunction with a conventional septic tank. The selection of either a constructed wetland or an evapotranspiration system will depend on the region of the country, available land, and cost. Again, water conservation fixtures and low phosphate detergents should be used and garbage disposals should be prohibited.

Maintenance: Inspect system yearly, pump out septic tank every 3 years, harvest plants from wetlands as needed, and perform routine maintenance on pumps.

Limitations: Constructed wetlands or evapotranspiration systems should not be used if the following conditions are present:

- Unsuitable site areas such as areas within floodplains, or areas where effluent cannot be sufficiently treated before it reaches sensitive waterbodies, including ground or surface water.

Regional Factors: Constructed wetland systems can be applied in every region of the country provided the above design limitations are not violated. There may be some slightly less effectiveness with regard to nitrogen removal in colder climates. However, field studies have shown these differences to be very small even in the most northern latitudes. Because of the high potential evapotranspiration rates needed, evapotranspiration systems can only be applied in the southwestern portion of the country.

4.2 REPLACEMENT OR ENHANCEMENT OF EXISTING OSDSS

This section assumes that the system that is being replaced or enhanced is a conventional septic system. If a system is being replaced, the management practices described in Section 4.1. above should be employed as appropriate. If a septic system is failing or if there are water quality problems due to septic systems (e.g. high nitrate concentrations in groundwater) then the following management practices should be considered.

1. <u>Install Water Conservation Fixtures with an Alternate Trench, Low Phosphate Detergents, and No Garbage Disposals</u>

As stated previously, the majority of all conventional septic system failures are due to water overloads. Water conservation fixtures with use of alternate trenches have been shown to correct failing septic systems in certain situations. Using low phosphate detergents and eliminating the use of garbage disposals should also be employed where the conventional septic system is failing. The alternate trench should be used a minimum of 3 months per year and its initial use should be until aerobic conditions have been restored in the original leaching field.

2. Install Anaerobic Upflow, Intermittent Sand, or Recirculating Sand Filters in Areas with Nitrogen Problems in Groundwater

In areas where high nitrogen concentrations are found in groundwater and where the source of the nitrogen has been attributed to conventional septic systems, the above mentioned filter systems should be installed. Water conservation fixtures should also be installed, low phosphate detergent should be used, and the use of garbage disposals eliminated.

3. Install Constructed Wetlands or Evapotranspiration Systems

In areas with failing septic systems due to either poorly drained (e.g. percolation rate greater than 120 min/in.) or insufficient separation distance (e.g. less than 2 feet to ground water or limiting layer) constructed wetlands or evapotranspiration systems should be installed. Again, water conservation fixtures and low phosphate detergents should be used in conjunction with the elimination of garbage disposals.

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APPENDICES

APPENDIX A
STATE REGULATIONS

SUMMARY OF STATE SEPTIC SYSTEM REGULATIONS

LOCATON	PERC. RATE	SET BACKS FROM BODIES OF WATER	SEPARATION DISTANCE (SHWT)
Alaska			4'
American Samoa			
Alabama	5 - 60 min./inch	50'	1.5'
California			
Region I	60 min./inch	50 - 100'	5 - 40'
Region II		100'	5 - 50'
Connecticut			1.5'
Delaware	6 - 60 min./inch	50'(Body of water) 100'(Wetland)	3'
Florida	Use soil classification to determine sizing of system	75'	2'
Georgia	50-90 min./inch	50'(Leach Field) 25'(Septic Tank)	2'
Guam			
Hawaii	10-30 min./inch	50'	3'
Indiana		50 - 100'	
Louisiana	20 min./inch		2'
Maine		100'	1 - 2'
Maryland	5-30 min./inch	25'	4'(May be waived but requires groundwater protection ?)

LOCATON	PERC. RATE	SET BACKS FROM BODIES OF WATER	SEPARATION DISTANCE (SHWT)
Massachusetts (Clint Watson)	1-30 min./inch	25'(Septic Tank) 50'(Leach Field)	4'
Michigan	30-60 min./inch	50'	4'
(Minnesota)	0.1 min./inch - 60 min./inch		3'
Mississippi	Use soil evaluation instead of perc. test	Slope greater than 8% = 100' Slope less than 8% - 50'	2' if no layer within 5' 2' if layer within 5'
North Carolina	None	50 - 100'	1'
New Hampshire	1-60 min./inch	75'	4'
New Jersey			2 - 9'
New York	1-60 min./inch	100'(Leach Field) 50'(Septic Tank)	2'
Northern Marianas			
(Ohio)			4'
Oregon			0.5'
Pennsylvania			4'
Puerto Rico			4'
Rhode Island			3'
South Carolina	None	50'	0.5'
Virginia	5-120 min./inch	50' 70'(Shellfish Water)	0.17 - 1.67'
Virgin Islands			

LOCATON	PERC. RATE	SET BACKS FROM BODIES OF WATER	SEPARATION DISTANCE (SHWT)
Washington			3'
Wisconsin			3'

APPENDIX B
RESIDENTIAL SEPTAGE POLLUTANT LOADS

		RESIDENTIAL SEPTAGE POLLUTANT LOADS													
ST	STUDY TYPE	WATER LOAD GPD	TSS		BOD		COD		TN		TP		PATHO.		REFERENCE
			LOW mg/l	HI mg/l	LOW mg/l	HI mg/l	LOW mg/l	HI mg/l	LOW mg/l	HI mg/l	LOW mg/l	HI mg/l	LOW LOGS	HI LOGS	
MA	MODEL	200							35	40					Frimpter et. al., 1988
RI									30	80					EPA, 1989(a)
NAT.		200													EPA, 1986
MI	IN-SITU	200													Decker, 1987
MD	IN-SITU			220		220									Dwyer et. al., 1989
WV	IN-SITU	175	45	102	95	250			30	80					Swanson and Dix, 1988
MN	IN-SITU									375				8	Anderson & Machmeier, 1988
WV	IN-SITU	100							42	83					Hoxie et. al., 1988
NAT.		240	200	290	200	290	680	730	35	100	18	29	8	10	EPA, 1980
NAT.				220		220		500		65		8	8	10	EPA, 1984
---				335		264				120		25			EPA, 1977
	AVERAGE	183		202		220		637		95		20		8.8	

APPENDIX C
IMPLEMENTATION RESTRICTIONS

PRACTICE	IMPLEMENTATION RESTRICTIONS						REFERENCE
	WATER LOADING	DEPTH TO WATER TABLE		INFILTRATION/ PERC RATE		OTHER	
		LOW FT	HI FT	LOW MIN/IN	HI MIN/IN		
ANAER. UPFLOW FILT	2.13–8.53*						Venhuizen, 1991
ANAER. UPFLOW FILT	8–15*						Venhuizen, 1991
AVERAGE	8						
RANGE	2 – 15						
INTER. SAND FILTER	1–5**					0.35–1.0 MM MAT.	Small Flows Clearing House
INTER. SAND FILTER	< 1**					0.5–1.0 MM MAT.	EPA, 1980
AVERAGE	2.3						
RANGE	1 – 5						
MOUND SYSTEM	NA	2			120	PUMP 3–5 YR	Small Flows Clearing House
MOUND SYSTEM	NA	3	5	0	120		EPA, 1980
AVERAGE			3.3		80.0		
RANGE			2 – 5		0 – 120		
RECIRC. SAND FILTER	3–5**					0.3–1.5 MM MAT.	EPA, 1980
RECIRC. SAND FILTER	3–5**						Small Flows Clearing House
RECIRC. SAND FILTER	5–13.8**						Venhuizen, 1991
RECIRC. SAND FILTER	5–10**					INSPECT EACH YR	Small Flows Clearing House
RECIRC. SAND FILTER	7.5–9**						Venhuizen, 1991
RECIRC. SAND FILTER	3–5**					0.3–1.5 MM MAT.	Small Flows Clearing House
AVERAGE	6.2						
RANGE	3 – 13.8						
SEPTIC SYSTEM	NA		4		60	PUMP 3–5 YR	EPA, 1986
SEPTIC SYSTEM	NA	2				PUMP 3 YR	Otis, 1983
SEPTIC SYSTEM	NA	2					Gunn, 1987
SEPTIC SYSTEM	NA	2	4	1	60		EPA, 1980
SEPTIC SYSTEM	NA	3	4		60	PUMP 3–5 YR	Small Flows Clearing House
AVERAGE			3		45.3		
RANGE			2 – 4		1– 60		

* GPD/CF
** GPD/SF
NA – NOT AVAILABLE

APPENDIX D
EFFICIENCY DATA

EFFECTIVENESS DATA FOR ONSITE SEWAGE DISPOSAL SYSTEMS

PRACTICE	ST	STUDY TYPE	WATER LOAD GPD	REDUCTION IN POLLUTANT LOADS TSS LOW %	TSS HI %	BOD LOW %	BOD HI %	COD LOW %	COD HI %	TN LOW %	TN HI %	TP LOW %	TP HI %	PATHO. LOW LOG	PATHO. HI LOG	WATER LOW %	WATER HI %	REFERENCE
ANAEROBIC UPFLOW FILT.		LAB		24	54	54	75			20	75							Venhuizen, 1991
ANAEROBIC UPFLOW FILT.	AK	LAB								50	75							Mitchell, n.d.
ANAEROBIC UPFLOW FILT.		IN-SITU		25	40	50	65											Venhuizen, 1991
ANAEROBIC UPFLOW FILT.	WA	IN-SITU		30	89	46	84											Venhuizen, 1991
ANAEROBIC UPFLOW FILT.										60	75							EPA, 1991
AVERAGE					44		62		*****		59		*****		*****		*****	
RANGE				24	89	46	84	*****	*****	20	75	*****	*****	*****	*****	*****	*****	
NO. VALUES CONSIDERED			0		6		6		0		6		0		0		0	
CENT SEPTIC SYS (170 UNIT)	NY		38000		85		85											Orr, 1989
AVERAGE			38000		85		85		*****		*****		*****		*****		*****	
RANGE				85	85	85	85	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	
NO. VALUES CONSIDERED			1		1		1		0		0		0		0		0	
CONST WETLAND(2200 UNIT)	MD	IN-SITU	100000		98		97				90				4			Reed, 1991
ROCK PLANT FILTERS					92	67	96											Amberg, 1990
CONST WETLAND	MD	IN-SITU	14000		50		65				90							Dwyer, et. al. 1989
AVERAGE			57000		80		81		*****		90		*****		4		*****	
RANGE			14K – 100K	50	98	65	97	*****	*****	90	90	*****	*****	4	4	*****	*****	
NO. VALUES CONSIDERED			2		3		4		0		2		0		1		0	
ELIM. GARBAGE DISPOSAL					37													EPA, 1986
ELIM. GARBAGE DISPOSAL					37		28				5		3					EPA, 1980
ELIM. GARBAGE DISPOSAL					37		28				5		2					EPA, 1991
AVERAGE					37		28		*****		5		2.5		*****		*****	
RANGE				37	37	28	28	*****	*****	5	5	2	3	*****	*****	*****	*****	
NO. VALUES CONSIDERED			0		3		2		0		2		2		0		0	
INT. SAND FILTER					97		91				60		70		4			EPA, 1977
INT. SAND FILTER				94	98	96	99			40	60		90	2	4			EPA, 1980
INT. SAND FILTER				70	90	85	95											Small Flows Clr. Hse.
INT. SAND FILTER	NY	IN-SITU			98		92											Venhuizen, 1991
INT. SAND FILTER	TX	IN-SITU					95				46							Venhuizen, 1991
INT. SAND FILTER		LAB			99		94			55	75				3			Venhuizen, 1991
INT. SAND FILTER						80	93				50			2	4			Venhuizen, 1991
AVERAGE					92		92		*****		55		80		3.2		*****	
RANGE				70	99	80	99	*****	*****	40	75	70	90	2	4	*****	*****	
NO. VALUES CONSIDERED			0		7		10		0		7		2		6		0	
RECIR. SAND FILTER	TN	IN-SITU	10500		87		95											Venhuizen, 1991
RECIR. SAND FILTER	WV	IN-SITU	200	84	93	91	98			69	94							Swanson & Dix, 1988
RECIR. SAND FILTER	WV	IN-SITU									80							Venhuizen, 1991

EFFECTIVENESS DATA FOR ONSITE SEWAGE DISPOSAL SYSTEMS

			REDUCTION IN POLLUTANT LOADS															
PRACTICE	ST	STUDY TYPE	WATER LOAD GPD	TSS		BOD		COD		TN		TP		PATHO.		WATER		REFERENCE
				LOW %	HI %	LOW %	HI %	LOW %	HI %	LOW %	HI %	LOW %	HI %	LOW LOG	HI LOG	LOW %	HI %	
RECIR. SAND FILTER	FL	IN-SITU									60							Venhuizen, 1991
RECIR. SAND FILTER					90	91	98											Venhuizen, 1991
RECIR. SAND FILTER	RI	IN-SITU								1	84							Lamb et. al., 1988
RECIR. SAND FILTER										30	80							Laak, 1986
RECIR. SAND FILTER				70	90	85	90											Small Flows Ctr. Hse.
RECIR. SAND FILTER	NY	IN-SITU			86		75											Small Flows Ctr. Hse.
RECIR. SAND FILTER					95		95				80			2	3			Small Flows Ctr. Hse.
RECIR. SAND FILTER				95	98	94	98											EPA, 1980
RECIR. SAND FILTER	WV	IN-SITU	100							57	81							Sandy et. al., 1988
RECIR. SAND FILTER						90	95					70	90	2	4			Small Flows Ctr. Hse.
RECIR. SAND FILTER	IL	IN-SITU			97		97							2	3			Small Flows Ctr. Hse.
RECIR SAND FILTER					95		95			50	70			3	4			EPA, 1991
AVERAGE			3600		90		92		*****		64		80		2.9		*****	
RANGE			100-10500	70	98	75	98	*****	*****	1	94	70	90	2	4	*****	*****	
NO. VALUES CONSIDERED			3		12		15		0		13		2		8		0	
RUCK SYSTEM					85		86			70	80		.83		4			Laak, 1986
RUCK SYSTEM	RI	IN-SITU								6	50							Lamb et. al., 1988
RUCK SYSTEM											50							EPA, 1991
AVERAGE					85		86		*****		51		83		4		*****	
RANGE				85	85	86	86	*****	*****	6	80	83	83	4	4	*****	*****	
NO. VALUES CONSIDERED			0		1		1		0		5		1		1		0	
LOW PHOSPHATE DETER.													50					EPA, 1980
LOW PHOSPHATE DETER.													50					EPA, 1991
AVERAGE					*****		*****		*****		*****		50		*****		*****	
RANGE				*****	*****	*****	*****	*****	*****	*****	*****	50	50	*****	*****	*****	*****	
NO. VALUES CONSIDERED			0		0		0		0		0		2		0		0	
CONV. SEPTIC SYSTEM													15					EPA, 1980
CONV. SEPTIC SYSTEM					65		30		50		45		30	3	4			EPA, 1977
CONV. SEPTIC SYSTEM	WV	IN-SITU	100							19	43							Sandy et. al., 1988
CONV. SEPTIC SYSTEM	RI	IN-SITU								0	6							Lamb et. al., 1988
CONV. SEPTIC SYSTEM	RI												90					EPA, 1989
CONV. SEPTIC SYSTEM	VA	IN-SITU										40	70					Rhode Island, 1989
CONV. SEPTIC SYSTEM	CT	IN-SITU										0	70					Rhode Island, 1989
CONV. SEPTIC SYSTEM	NY	IN-SITU									42							Rhode Island, 1989
CONV. SEPTIC SYSTEM	WI	IN-SITU									9		29					Rhode Island, 1989
CONV. SEPTIC SYSTEM	RI	IN-SITU											95					Rhode Island, 1989
CONV. SEPTIC SYSTEM	CAN	IN-SITU										60	90					Rhode Island, 1989
CONV. SEPTIC SYSTEM			60		70		60			0	35		90					Degen et al., 1991
CONV. SEPTIC SYSTEM					54		36				40							Healy, 1982

EFFECTIVENESS DATA FOR ONSITE SEWAGE DISPOSAL SYSTEMS

			REDUCTION IN POLLUTANT LOADS															
PRACTICE	ST	STUDY TYPE	WATER LOAD GPD	TSS		BOD		COD		TN		TP		PATHO.		WATER		REFERENCE
				LOW %	HI %	LOW %	HI %	LOW %	HI %	LOW %	HI %	LOW %	HI %	LOW LOG	HI LOG	LOW %	HI %	
CONV. SEPTIC SYSTEM							58				45							Healy, 1982
CONV. SEPTIC SYSTEM					79		59											Healy, 1982
CONV. SEPTIC SYSTEM					83						58							Healy, 1982
CONV. SEPTIC SYSTEM					78													Healy, 1982
CONV. SEPTIC SYSTEM					78						28							Healy, 1982
CONV. SEPTIC SYSTEM						30	40											EPA, 1991
AVERAGE			80		72		45		50		28		57		3.5		*****	
RANGE			60−100	54	83	30	60	50	50	0	58	0	95	3	4	*****	*****	
NO. VALUES CONSIDERED			2		7		7		1		13		12		2		0	
MOUND SYSTEM											44							Degen et al., 1991
AVERAGE			80		*****		*****		*****		44		*****		*****		*****	
RANGE			60−100	*****	*****	*****	*****	*****	*****	44	44	*****	*****	*****	*****	*****	*****	
NO. VALUES CONSIDERED			0		0		0		0		1		0		0		0	
RECYCLE WAST. WATER																36	90	EPA, 1980
LOW FLUSH TOILET																30	90	Small Flows Clr. Hse.
WATER CONS FIX.	PA	IN−SITU														25	60	Jarrett et. al., 1985
HIGH EFF PLUMB.																	33	EPA, 1977
HIGH EFF PLUMB (TOIL)																4	31	EPA, 1980
HIGH EFF PLUMB.																30	70	EPA, 1991
AVERAGE					*****		*****		*****		*****		*****		*****		45	
RANGE				*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	4	90	
NO. VALUES CONSIDERED			0		0		0		0		0		0		0		11	
WATER SEP. SYSTEM				36	67	22	49			68	99	14	42					EPA, 1977
WATER SEP. SYSTEM					61						82		30					EPA, 1986
WATER SEP. SYSTEM										78	90	20	40					EPA, 1980
WATER SEP. SYSTEM					75		55				83		32					EPA, 1991
AVERAGE					60		42		*****		83		30		*****		*****	
RANGE				36	75	22	55	*****	*****	68	99	14	42	*****	*****	*****	*****	
NO. VALUES CONSIDERED			0		4		3		0		6		6		0		0	

APPENDIX E
COST DATA

COST (1988$) DATA FOR ONSITE SEWAGE DISPOSAL SYSTEMS

PRACTICE	ST	CAPITAL COST LOW	CAPITAL COST HIGH	O&M COST LOW ($/YR)	O&M COST HIGH ($/YR)	REFERENCE
CLUSTER SYSTEM	MI	$3,075	$5,124			Decker, 1987
CLUSTER SYSTEM	NY		$6,900		$370	Small Flows Clr. House
AVERAGE			$5,033		$370	
RANGE		$3,075	$6,900	$370	$370	
NO. VALUES CONSIDERED			3		1	
CENT. SEWER SYSTEM	NY		$9,977		$237	Orr, 1989
CONV. TREATMENT SYS.	MI		$8,711			Decker, 1987
CONV. TREATMENT SYS.	VA	$49	$3,926	$86	$294	EPA, 1980
AVERAGE			$5,666		$206	
RANGE		$49	$9,977	$86	$294	
NO. VALUES CONSIDERED			4		3	
CONS WETLAND*****	AK		$800.00			Reed, 1991
CONS WETLAND*****	TN		$1,500.00			Reed, 1991
CONS WETLAND*****	OK		$150.00			Reed, 1991
CONS WETLAND*****	AL	$780.00	$905.00			Reed, 1991
CONS WETLAND*****	KY		$675.00			Reed, 1991
CONS WETLAND*****	LA	$50.00	$215.00			Reed, 1991
CONS WETLAND*****	NM		$1,000.00			Reed, 1991
CONS WETLAND*****	MA		$230.00			Reed, 1991
CONS WETLAND*****	NA'	$265.00	$495.00			Reed, 1991
CONS WETLAND*****	OR		$90.00			Reed, 1991
CONS WETLAND*****	CA		$155.00			Reed, 1991
CONS WETLAND*****	MS		$290.00			Reed, 1991
CONS WETLAND*****	FL		$375.00			Reed, 1991
CONS WETLAND*****	MI		$450.00			Reed, 1991
CONS WETLAND (120 SITES)	KY	$1,500.00	$3,500.00			Small Flows Clr. Hse., 1992
CONS WETLAND	VA				$24.54	EPA, 1980
AVERAGE			$706.58		$24.54	
RANGE		$50.00	$3,500.00	$24.54	$24.54	
NO. VALUES CONSIDERED			19		1	
HOLDING TANK(2000GAL)			$1,970	$1,200	$2,400	Small Flows Clr. House
HOLDING TANK(4000GAL)			$4,770	$1,200	$2,400	Small Flows Clr. House
HOLDING TANK(5000GAL)			$6,670	$1,200	$2,400	Small Flows Clr. House
HOLDING TANK(1000GAL)			$1,220	$1,200	$2,400	Small Flows Clr. House
HOLDING TANK(2000GAL)	CO		$4,104		$103	Dix, 1986
HOLDING TANK(4000GAL)	CO		$4,104		$205	Dix, 1986

COST (1988$) DATA FOR ONSITE SEWAGE DISPOSAL SYSTEMS

PRACTICE	ST	CAPITAL COST LOW	CAPITAL COST HIGH	O&M COST LOW ($/YR)	O&M COST HIGH ($/YR)	REFERENCE
HOLDING TANK(8000GAL)	CO		$5,335		$205	Dix, 1986
HOLDING TANK	WI		$3,422		$850	Hanson et. al., 1988
AVERAGE			$3,949		$1,314	
RANGE		$1,220	$6,670	$103	$2,400	
NO. VALUES CONSIDERED			8		12	
INT. SAND FILTER*			$2,373		$258	Small Flows Clr. House
INT. SAND FILTER**			$2,290		$98	Small Flows Clr. House
INT. SAND FILTER			$4,408		$134	EPA, 1977
INT. SAND FILTER	NY		$6,960		$440	Small Flows Clr. House
INT. SAND FILTER	NY		$6,700		$440	Small Flows Clr. House
INT. SAND FILTER		$5,000	$10,000			EPA, 1991
AVERAGE			$5,390		$274	
RANGE		$2,290	$10,000	$98	$440	
NO. VALUES CONSIDERED			7		5	
LOW PRESS. SYSTEM	VA		$7,361		$147	EPA, 1980
LOW PRESS. SYSTEM	MO		$2,833			Fulhage & Day, 1988
AVERAGE			$5,097		$147	
RANGE		$2,833	$7,361	$147	$147	
NO. VALUES CONSIDERED			2		1	
MOUND SYSTEM	VA		$11,041		$86	EPA, 1980
MOUND SYSTEM			$8,348		$134	EPA, 1977
MOUND SYSTEM	WI				$198	Hanson et. al., 1988
MOUND SYSTEM	NY		$6,800		$310	Small Flows Clr. House
MOUND SYSTEM			$7,000			EPA, 1991
AVERAGE			$8,297		$182	
RANGE		$6,800	$11,041	$86	$310	
NO. VALUES CONSIDERED			4		4	
PACKAGE TREAT. PLANT	VA		$4,416		$761	EPA, 1980
AVERAGE			$4,416		$761	
RANGE		$4,416	$4,416	$761	$761	
NO. VALUES CONSIDERED			1		1	
RECIRC. SAND FILTER				$15	$30	Hoxie et. al., 1988
RECIRC. SAND FILTER***			$1,874		$100	Small Flows Clr. House
RECIRC. SAND FILTER	NY		$1,900		$410	Small Flows Clr. House

COST (1988$) DATA FOR ONSITE SEWAGE DISPOSAL SYSTEMS

PRACTICE	ST	CAPITAL COST LOW	CAPITAL COST HIGH	O&M COST LOW ($/YR)	O&M COST HIGH ($/YR)	REFERENCE
RECIRC. SAND FILTER			$5,700		$20	Fulhage & Day, 1988
RECIRC. SAND FILTER	VA		$9,201		$196	EPA, 1980
RECIRC. SAND FILTER****			$2,514		$260	Small Flows Clr. House
AVERAGE			$4,238		$147	
RANGE		$1,874	$9,201	$15	$410	
NO. VALUES CONSIDERED			5		7	
RUCK SYSTEM	NY	$12,311	$16,415			Laak, 1986
AVERAGE			$14,363		ERR	
RANGE		$12,311	$16,415	ERR	ERR	
NO. VALUES CONSIDERED			2		0	
CONV. SEPTIC SYSTEM	WI		$2,815		$110	Hanson et. al., 1988
CONV. SEPTIC SYSTEM	CO		$8,207		$46	Dix, 1986
CONV. SEPTIC SYSTEM	VA		$3,680		$25	EPA, 1980
CONV. SEPTIC SYSTEM			$2,738		$83	EPA, 1977
CONV. SEPTIC SYSTEM	MO	$2,000	$2,500			Fulhage & Day, 1988
CONV. SEPTIC SYSTEM		$4,000	$10,000			EPA, 1991
AVERAGE			$4,493		$66	
RANGE		$2,000	$10,000	$25	$110	
NO. VALUES CONSIDERED			8		4	
ANAEROBIC UPFLOW FIL.		$3,000	$8,000			EPA, 1991
AVERAGE			$5,500		ERR	
RANGE		$3,000	$8,000	ERR	ERR	
NO. VALUES CONSIDERED			2		0	
WATER SEP. SYST.		$5,000	$11,000		$300	EPA, 1991
AVERAGE			$8,000		$300	
RANGE		$5,000	$11,000	$300	$300	
NO. VALUES CONSIDERED			2		1	

* Per household cost for a 5000 gpd system assuming 500gpd/household

** Per household cost for a 30000 gpd system assuming 500gpd/household

*** Per household cost for a 30000 gpd system assuming 500gpd/household

**** Per household cost for a 5000 gpd system assuming 500gpd/household

***** Per household cost assuming 500gpd/household