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# **Alternative Technologies for Onsite Wastewater Treatment**

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## EXECUTIVE SUMMARY

The park units in the North Atlantic Region have expressed concern about the degradation of the water quality due to nonpoint source input from input of nitrogen and phosphorus from onsite wastewater treatment systems within the parks and in adjacent private developments. Estuarine ecosystems at Cape Cod NS and Acadia NP are adversely affected by nitrogen loadings. At Fire Island NS, a barrier park with sandy, porous soils, and shallow water tables, more than 3,800 private residences exist with the majority being served by onsite wastewater treatment systems. In freshwater ecosystems phosphorus is the limiting nutrient of concern. A number of freshwater ponds in the parks have part of the shoreline within the park and part under private ownership.

Alternative onsite wastewater treatment systems offer viable options for reducing nonpoint source pollution to adjacent aquatic ecosystems. Given the "protected quality of National Park Service fresh water aquatic and marine ecosystems the NPS should be using the most efficient onsite wastewater treatment systems available. While land under private ownership is not under the jurisdiction of the NPS, demonstration projects at park visitor centers could be used to provide public education and enhance the public perception of alternative systems. These demonstration projects could also provide valuable information to the local regulatory officials who in turn could consider enhanced regulatory control of development adjacent to park boundaries.

In preparation for this report site visits were made to the Cape Cod NS and Acadia NP where brief discussions were held with park personnel about their priorities and specific local concerns. A number of existing systems were viewed during these visits.

Brief information about a number of available alternative systems is included with comments concerning their relative maintenance requirements, general design, complexity of construction, and effluent quality. Costs for specific installations are included where available as examples. Costs will vary widely from one area to another and from one manufacturer to another for proprietary systems.

Suggestions, including the rationale used for these recommendations, are included for a few site specific installations. Suggestions are included for possible public education projects.

#### CAPE COD NS SITE VISIT

The Cape Cod NS site visit took place in mid September, 1993. Most of the day was spent with park personnel in discussion about their specific concerns and visits to specific areas within the park. A second day was spent touring on my own and observing local conditions. Time was also spent in discussion with a member of the Cape Cod Commission.

A variety of sites including the main visitor's center, park headquarters, the Wellfleet ponds, the Coast Guard Station beach site, Herring Cove beach, and Nauset Marsh were visited. At the Nauset Marsh site there are three houses used by park personnel. At the time of the visit a final decision had not been made as to whether to tear down the houses, retrofit the existing onsite systems, or build totally new onsite wastewater disposal systems. Although this site may not have as much visibility as others, it could be a good location to demonstrate use of an alternative system for a single family residence.

The Nauset Marsh area is also affected by hundreds of privately owned houses and their onsite systems. Both the type and condition of these systems was not quantified. From discussion with local regulatory authorities and contractors it would seem that many of these systems are no more than buried seepage pits or "cesspools."

No soil borings were made at any of the sites visited. It seems that many of the sites have deep sand soils of the type that would accept a high rate of infiltration. Some sites had no water supply and/or electrical service. Options for those sites would be limited to holding tanks, chemical or composting toilets, or vault privies. Vault privies or holding tanks require periodic pumping. Composting toilets require regular maintenance including the regular addition of a bulking agent and periodic removal and disposal of the composted wastes. The use of a particular system would depend upon the level of use at the site combined with the comparative costs of maintenance..

A problem unique to the Cape Cod NS, and possibly to installations on Fire Island NS, has to do with the moving sand dunes and location of existing septic tanks. Some of these tanks are now buried beneath 20 to 30 feet of sand. Digging down to the tanks to have them periodically pumped out is prohibited. But if the tank is not pumped out excessive solids will carry over to the disposal area and will cause major problems requiring replacement of the entire disposal area.

Park facilities bordering on marine ecosystems require enhanced removal of nitrogen from the wastewater. Those bordering estuaries may require enhanced removal of both nitrogen and phosphorus, and systems located near fresh water habitats require enhanced removal of phosphorus. A further requirement is that any proposed onsite wastewater system be economical overall to construct, and require very limited personnel time and costs for maintenance and operation. (A comment heard at Cape Cod NS and at Acadia NP was that funds were not available to have the existing septic tanks pumped and many of

them had not been pumped in years. The importance of this minimum amount of maintenance cannot be over-emphasized.)

No single alternative onsite wastewater disposal or treatment system can provide the solution for all of the above sites, or requirements. An informed decision should be made based not only on the desired effluent quality, but also upon the availability of maintenance funding and trained personnel required to operate some of the systems.

#### MASSACHUSETTS REGULATIONS

Historically, regulations for onsite wastewater disposal systems have centered on disposal and not performance. It is only in recent years that efforts have been made toward obtaining enhanced treatment as well as disposal. For example, the office of the Board of Health, Town of Barnstable adopted revised regulations on September 16, 1986, that stated all septic systems shall consist of a septic tank discharging its effluent to a suitable subsurface disposal area. In interim regulations for the protection of groundwater supply the same board instituted the following: ...maximum allowable discharge of sanitary sewage flow estimates shall not exceed 330 gpd/acre;...permit may be issued if the applicant demonstrates that the total nitrate-nitrogen in the groundwater resulting from the proposed use will not exceed 5 mg/L. This determination shall consider the total predicted concentration of nitrate-nitrogen at the down gradient property line...Nothing in this regulation prohibits the maintenance, repair or alteration of existing individual sewage disposal systems...so long as a change of use is not involved. And onsite systems must be sited such that there is at least a four foot depth of naturally occurring pervious soil beneath the entire bottom of the leaching facility and the designated reserve leaching area. This four foot depth must be above maximum ground water elevation.

Systems described and approved in the regulations include leaching pits, leaching galleries, leaching chambers, leaching trenches, leaching fields, privies and chemical toilets, and humus toilets. The use of any disposal facility other than those described is prohibited UNLESS approved in writing by the Massachusetts Department of Environmental Protection. The intent of Title 5 revised (3/1/95) is that the Department encourages use of alternative systems and shall approve their use if it can be demonstrated that their impact on the environment and hazard to public health is not greater than that of other approved systems.

It has been my experience that the Department and local regulatory agencies will approve an alternative system if appropriate performance data is provided, and a design is also submitted for an approved system as a proposed backup system that must be installed if the proposed alternative fails. My experience is limited to using peat beds and EnviroPure systems on Cape Cod and Martha's Vineyard. The Department has requested designs for these type of systems to be used as replacements for cesspools in problem areas on Martha's Vineyard and appears to be favorably considering these systems. At least three sites for single family homes and one site located at a municipal pier have received approval but have not been installed at this date..

I assume that given appropriate data and history of use, any proposed alternative would be viewed conservatively but not completely negatively. The language is in the regulations to allow use of alternative systems.

### **ACADIA NP SITE VISIT**

Acadia NP was visited in mid November and discussions were held with Jim Vekasi, chief of maintenance, Len Bobinchock, deputy superintendent, and Bob Breen, biologist. It was found that replacement system designs have been initiated by Paul Saulnier of the North Atlantic Regional office for Cadillac Mountain, Hulls Cove Visitors Center, and Bear Brook picnic area. Agreement among those at the meeting was that alternative technologies should be considered for the current designs of replacement systems. In particular a peat system may be a viable alternative for the Hulls Cove Visitors Center.

Acadia NP had initiated a comprehensive inventory and evaluation of water and wastewater disposal systems now in use in the park. Data from this inventory was not available at the time of the site visit. A water resource management plan is under study by park personnel and the University of Maine Water Resources unit.

Potential problem areas identified were Seawall Campground (sand filter followed by chlorination and overboard discharge), Sieur de Mont Springs ("new" above ground mound system, high ground water table), Echo Lake (swimming beach), McFarland Hill (potential overloading and limited land area), Isle au Haut (employee health hazard, no power, homemade composting toilets), various parking areas (no toilets, water supply, or electrical supply), and Sand Beach.

The three sites given priority were Cadillac Mt., Bear Brook, and Hulls Cove Visitors Center. The Hulls Cove site appeared to be adequate in area for a peat bed. This would be an ideal location as it would have considerable public exposure and would be an ideal location for public education. The system itself could be viewed, and "sniffed" to prove that there is no odor emanating from these systems. A permanent set of story boards could be installed showing information about the use of these systems and the quality of their effluent.

One advantage of using the peat system in Acadia at one or more sites is that this system has already been approved for use in Maine and does not require special permitting. Also the park is not far from the source of peat approved and specified for use in these systems. A number of contractors in Maine are experienced in the installation of peat beds and could do this work without any special supervision.

Two peat systems were installed in Acadia National Park in 1995. One is a relatively small peat bed at Bear Brook site to serve public restrooms at this picnic area. Design flow was based on metered readings and reduced by 10% because of the installation of low flush toilets. Design flow was given as 630gpd and a 960 square foot peat bed was used to treat the wastewater. Although one square foot of peat is sufficient to provide treatment of one gallon per day of wastewater an increased area is required due to the long term infiltrative capacity of the existing native soil beneath the peat bed. The 24' X 40' peat bed was installed in approximately eight hours after the required fill was in place.

The other peat system is at the top of Cadillac Mountain and serves the existing restrooms. Records indicated the peak day flow is 2,500 gpd, the peak month average flow is 1,900 gpd, and the total annual flow is approximately 228,000 gallons per year. These figures were taken from the sewage hauling records. The system had three septic tanks which were being used as holding tanks. An old sand filter was removed and the fill was utilized in the downslope fill extensions. This peat system was estimated to have a \$90,000 construction cost. However an article in the Bar Harbor Times on September 28, 1995, gave the construction contract as \$72,000. The system required 600 cubic yards of specified peat and several thousand yards of fill material. There was minimum disruption to the public use of the site during construction.

#### MAINE RULES

In Maine onsite systems having a theoretical design flow of less than 2,000 gpd are designed by a licensed site evaluator. Systems approved for use include the conventional stone bed or trench system, concrete chambers, plastic chambers, peat beds, EnviroPure, Geoflow, and privies or other alternative toilets with a gray water disposal area. For other technologies considered as experimental the RULES require that a back-up design be submitted with the application and a back-up site be reserved for use if needed. Experimental systems require monitoring and formal reports must be made to the Department.

Systems having a theoretical design flow greater than 2,000gpd require design by a professional engineer. If the engineer can justify the proposed system design then the state will generally accept it.

**FIRE ISLAND NS**

The Fire Island NS was not visited and the following is taken from telephone conversations with park personnel and from the Fire Island NS Water Resources Scoping Report dated August 1992 (Technical Report NPS/NRwrd?nrtr-92/11)

Water supplies on Fire Island are mainly shallow surface wells and many of these wells have shown coliform levels that exceed drinking water standards. There are approximately 400 year round residents with 350 of them concentrated in Ocean Beach that has a municipal wastewater treatment system. Private communities on the island contain over 3,800 private residences and more than 150 seasonal commercial establishments that cater to a population that exceeds 20,000 during the summer. There are a number of marinas on the island and it is not known what population of boats utilize these facilities. Some have sewage pump out facilities but improper sewage disposal in these areas can be a major contributor to degradation of water quality and elevated levels of pollution.

Porous sandy soils, shallow to groundwater, allow a high percolation rate of sewage effluent to the underlying water table resulting in pollution. While sands do filter out particulate matter there is little or no reduction in total nitrogen concentration and die-off of fecal coliform bacteria. The island also has a number of freshwater, brackish, and marine wetland ecosystems. These ecosystems are, in all probability, being polluted by the effluent from the primitive sewage treatment facilities now in use.

Privately owned sewage systems consist largely of cesspools and there are probably a number of "straight pipes" that discharge raw sewage directly to surface water on older properties. Shoreline erosion has exposed a number of sewage systems, causing them to short circuit and adding to the pollution problems.

The park service has sewage collection and disposal systems at several sites. These systems are marina pumping stations, lift stations, primary treatment tanks, and mound leach fields. Both design and maintenance problems have occurred at these sites, almost from the time they were installed. One system may have been re-designed and constructed since the report was written. It seems that one of the major problems is associated with the pumping out of the treatment tanks on a more frequent basis than has been done in the past. The importance of this is emphasized in several sections of this report.

Although I did not visit Fire Island it seems that this facility has more sewage disposal related problems that require immediate attention than either Cape Cod NS or Acadia NP. Each of the three sites have existing "failed" systems; it seems that Fire Island has a much larger number of both failed systems and "non-systems" in current use. The replacement of systems within the park would only provide a limited solution to the overall problem. This site would be a prime location for an extensive public education program on the effects of improper onsite sewage disposal facilities. The site would also be ideal for a

highly visible demonstration project using one or more of the possible alternative systems.

## **TYPES OF ON-SITE WASTEWATER DISPOSAL AND TREATMENT SYSTEMS**

### **PRIMARY TREATMENT**

Primary treatment occurs in the septic tank where solids settle to the bottom and accumulate in the sludge layer, and floatables are collected between the baffles in the upper part of the tank. Some anaerobic degradation of the sludge occurs in the septic tank but the accumulation rate is greater than the degradation rate. For this reason septic tanks must be pumped out periodically to prevent the carry-over of excessive amounts of solids to the disposal area or treatment system.

Septic tank effluent for residential sewage typically contains:

- 90 mg/L - 400 mg/L BOD<sub>5</sub>
- 40-350 mg/L TSS
- 40 mg/L - 100 mg/L Nitrogen
- 18 mg/L Phosphorus
- 10<sup>10</sup> - 10<sup>12</sup> fecal coliforms

### **CONVENTIONAL STONE SUBSURFACE DISPOSAL SYSTEM**

**HISTORY-** most widely used method of onsite treatment under current use

#### **DESCRIPTION:**

Requires a septic tank for primary treatment. May be designed as a bed with multiple pipes or as a trench with a single distribution pipe. Generally has one foot of stone with a uniform size of 3/4" to 3" dia. The distribution network consists of 4" dia. perforated pipes spaced 5' apart and 5' from ends and sides of stone area for beds, and located 1" below top level of stone. The stone is covered with 2" of compacted hay or a layer of filter fabric and then backfilled with

10"-12" of clean loamy sand fill. Beds and trenches are sized according to the theoretical design flow and the long term infiltration rate of underlying soil.

#### **TREATMENT**

Treatment occurs in the soil immediately below the stone and in the biological mat that forms at the stone-soil interface. Nitrification occurs in the aerobic soil beneath and to the sides of the disposal area.

#### **LEVEL OF TREATMENT EXPECTED**

Ground water beneath conventional stone beds contains:

- 40-100 mg/L nitrogen, as nitrates where aerobic soil conditions prevail
- 12 mg/L phosphorus on avg.

**NOTE:** nitrates are not adsorbed to soil particles. Phosphorus is adsorbed to soil particles. Both may be taken up by plant rootlets to some degree, phosphorus more than nitrogen. It is generally accepted that the majority of the nitrogen is converted to nitrates that travel with the ground water.

Fecal coliforms are expected to die-off within 10 to 100 days and within 5 to 300 feet and are not considered to be a problem, especially when passing through clay soils or soils containing some organic matter.

**MAINTENANCE AND OPERATION:**

Septic tanks must be pumped out periodically to prevent solids from carrying over to the disposal area where they will plug the field and cause hydraulic failure indicated by a surfacing of the untreated effluent, and/or backup of sewage to the building. Surface grasses should be mowed during the growing season. No vehicular traffic should be allowed on the surface of the disposal area and fill extensions.

**COSTS**

Varies widely from one location to another. For instance, in Maine, the same system could cost from \$1,200 to \$5,000 for a single family home depending upon where in the state the system is located.

## **SAND FILTERS**

**HISTORY** -widely used for many years in many locations

### **DESCRIPTION**

Primary treatment is required. The granular material may be any inert granular material that is insoluble in water and contains less than 1% organic matter, and less than 3% acid soluble matter. Example are sand, anthracite, perlite, ground glass, activated carbon, mineral tailings, etc. Intermittent sand filters (open, buried, or recirculating) are beds of granular material 2-3" deep underlain by graded gravel and collecting tile. A means of disinfection is required to render the effluent free of pathogenic organisms. Disinfection may be by means of chlorination, ozonation, or ultra violet light. A separate disposal area or an overboard discharge is required for final disposal of the treated effluent. Sand filters are sized according to theoretical design flow and buried filters are usually designed at 1 gpd/ft<sup>2</sup> or less. NOTE: There may be a problem with odor from free access or open filters

### **TREATMENT MECHANISMS:**

Mechanisms include physical straining, chemical sorption, and biochemical transformations.

### **EFFLUENT QUALITY**

Buried Sand Filters

2-9 mg/l BOD

4-13 TSS

17-32 mg/L nitrate-N

Fecal coliforms varies, requires additional disinfection

Free Access Intermittent Sand Filters

11-23 mg/L BOD

<1 mg/L TSS

32-46 mg/L nitrate-N

requires additional disinfection to inactivate pathogenic organisms

Recirculating Intermittent Sand Filters

4-15 mg/l BOD

3-10 mg/L TSS

8.4 mg/L ammonium-N

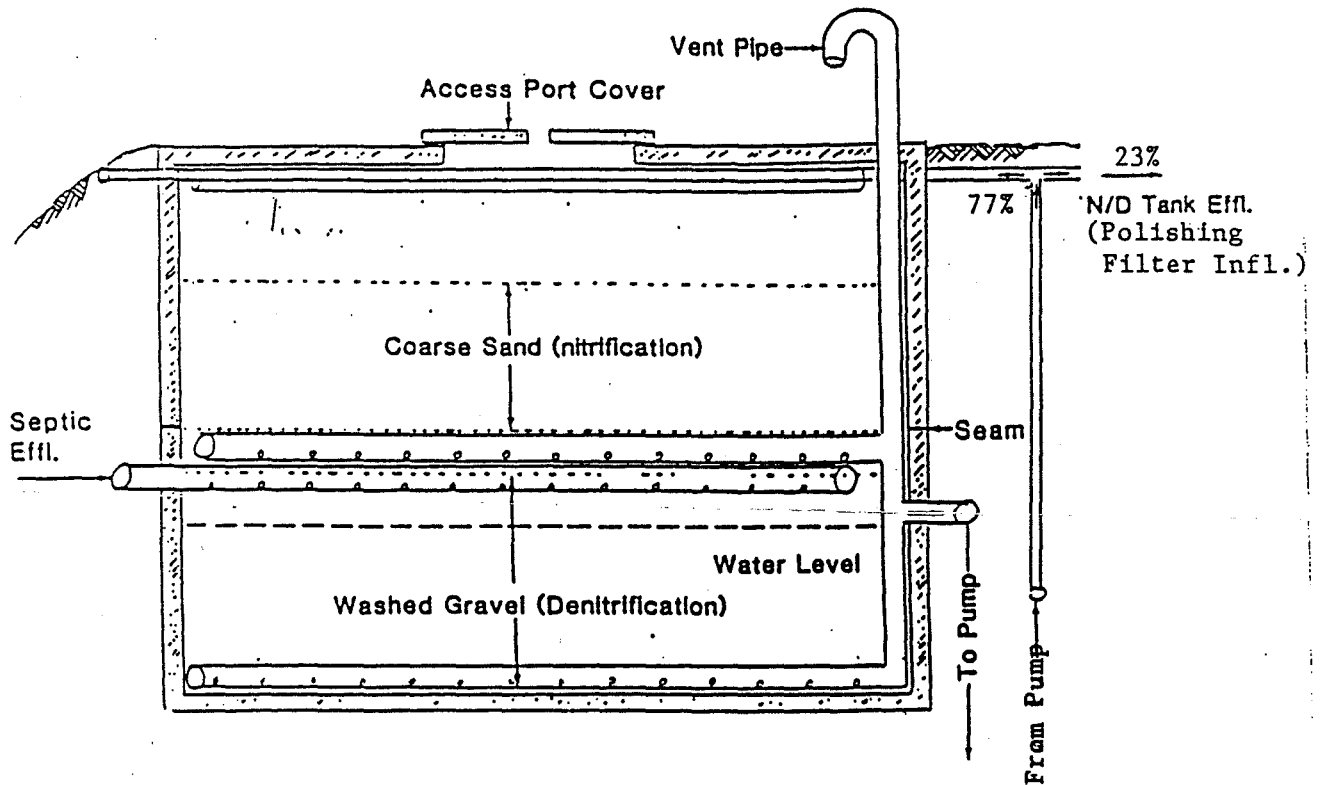
requires additional disinfection to inactivate fecal coliforms

### **MAINTENANCE AND OPERATION**

Media regeneration when clogged

Open filters require weed removal

Inspection and maintenance of pumps, siphons



Modified recirculating Sand Filter - N/D Tank (Piluk, 1989)  
 Operated in conjunction with septic tank (Figure 3)  
 and subsurface disposal area (Figure 4).

## **RUCK SYSTEM**

**HISTORY-** First installed in 1977. At least 205 systems were in operation in 1992. RUCK systems now in use treat design flows from 300 gpd to 11,700 gpd. According to the literature this system is expected to function more efficiently in warmer climates than in colder climates.

### **DESCRIPTION**

RUCK systems require separation of black water and gray water flows, a blackwater septic tank, a nitrification sand filter (in-drains), a graywater septic tank, and a small subsurface disposal area. An alternative design is available for facilities that do not produce graywater.

### **TREATMENT**

Primary treatment occurs in the blackwater septic tank. Nitrification occurs in the in-drain sand filter, and the effluent from the sand filter is combined with the graywater. The graywater provides sufficient carbon for denitrification to occur in the anaerobic graywater septic tank. Final disposal is to a subsurface disposal area sized four times smaller than a conventional stone bed would be for the same theoretical flow and specific soil conditions.

### **LEVEL OF TREATMENT EXPECTED**

Final effluent from RUCK system

20 mg/L BOD

13 mg/L TSS

3 mg/L nitrate-N

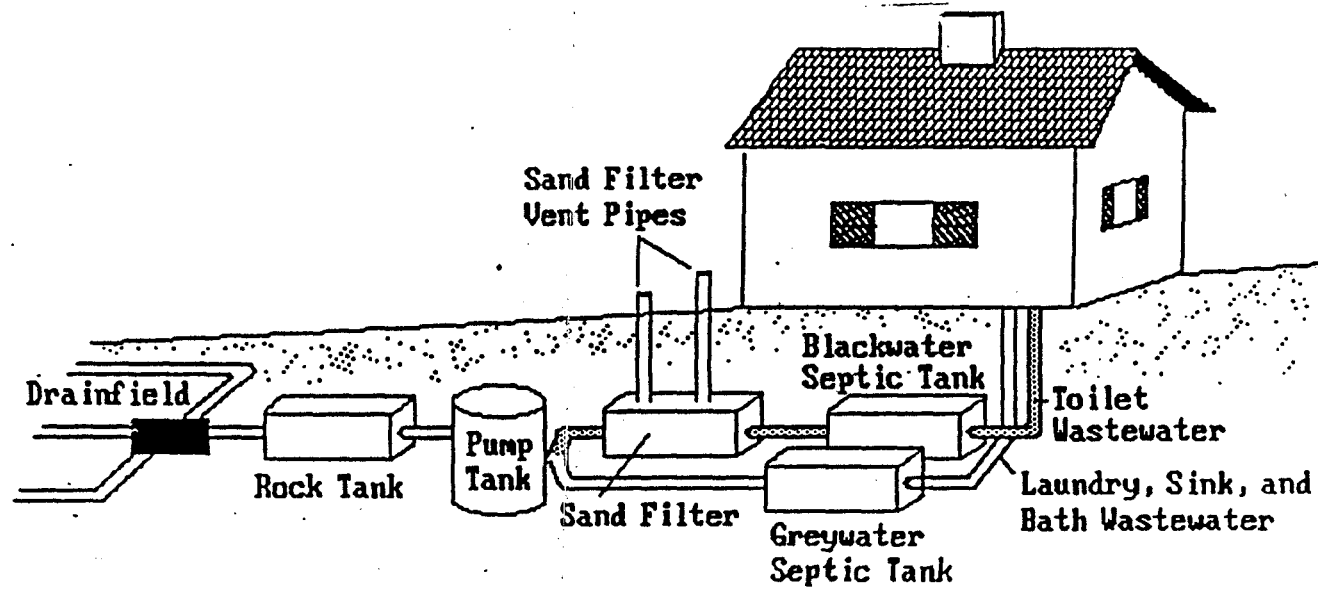
5 mg/.1 PO<sub>4</sub>

fecal coliforms-number not available; excreted bacteria virtually all removed prior to reaching the final subsurface disposal area

### **OPERATION & MAINTENANCE**

Blackwater septic tank pumped as required. For non-graywater sites the addition of liquid soap into a storage container is required once a week

**COSTS-** installation for a single family home in Rhode Island - approximately \$6,000



RUCK Sewage System (Windisch, 1990)

## ELJEN IN-DRAINS

**HISTORY** More than 200 systems are in use in New Hampshire. The In-drain system was approved for use in Maine in 1988. In Maryland more than 50 systems have been installed.

## DESCRIPTION

Primary treatment is required. Perforated distribution pipe is covered with an antisiltation fabric that keeps the fines out of the drains. Pipe delivers septic tank effluent to cusped plastic cores that provide separation between layers of Bio-Matt fabric and aid in oxygen transfer. The primary biomat layer forms on the Bio-Matt fabric. Up to 10 ft<sup>2</sup> of fabric is provided for every square foot of soil interface. Prepackaged units are placed in the excavation and a perforated distribution pipe is placed on top of the units. Both pipe and units are covered with a geotextile and backfilled. Type B Units are 36" wide X 48" long X 7" high. Each square foot of Type B units is equivalent to 4 square feet of conventional stone bed.

## TREATMENT MECHANISMS

Treatment occurs at the primary biomat layer on the biomat fabric in the units and at the secondary biomat layer that forms at the underlying soil interface.

## LEVEL OF TREATMENT EXPECTED

Results are available only as percent concentration reduction.

60% reduction in total nitrogen

85% reduction in suspended solids

97% reduction in BOD

No figures were available for phosphorus.

Assuming a typical residential use and average concentrations in the septic tank effluent applied to the Elgin Indrains results could be as follows:

28mg/L Nitrogen

29mg/L suspended solids

10mg/L BOD

phosphorus - unknown

## OPERATION & MAINTENANCE

Primary treatment tank requires periodic pumping.

## COSTS

Not available.



# ELJEN<sup>TM</sup>

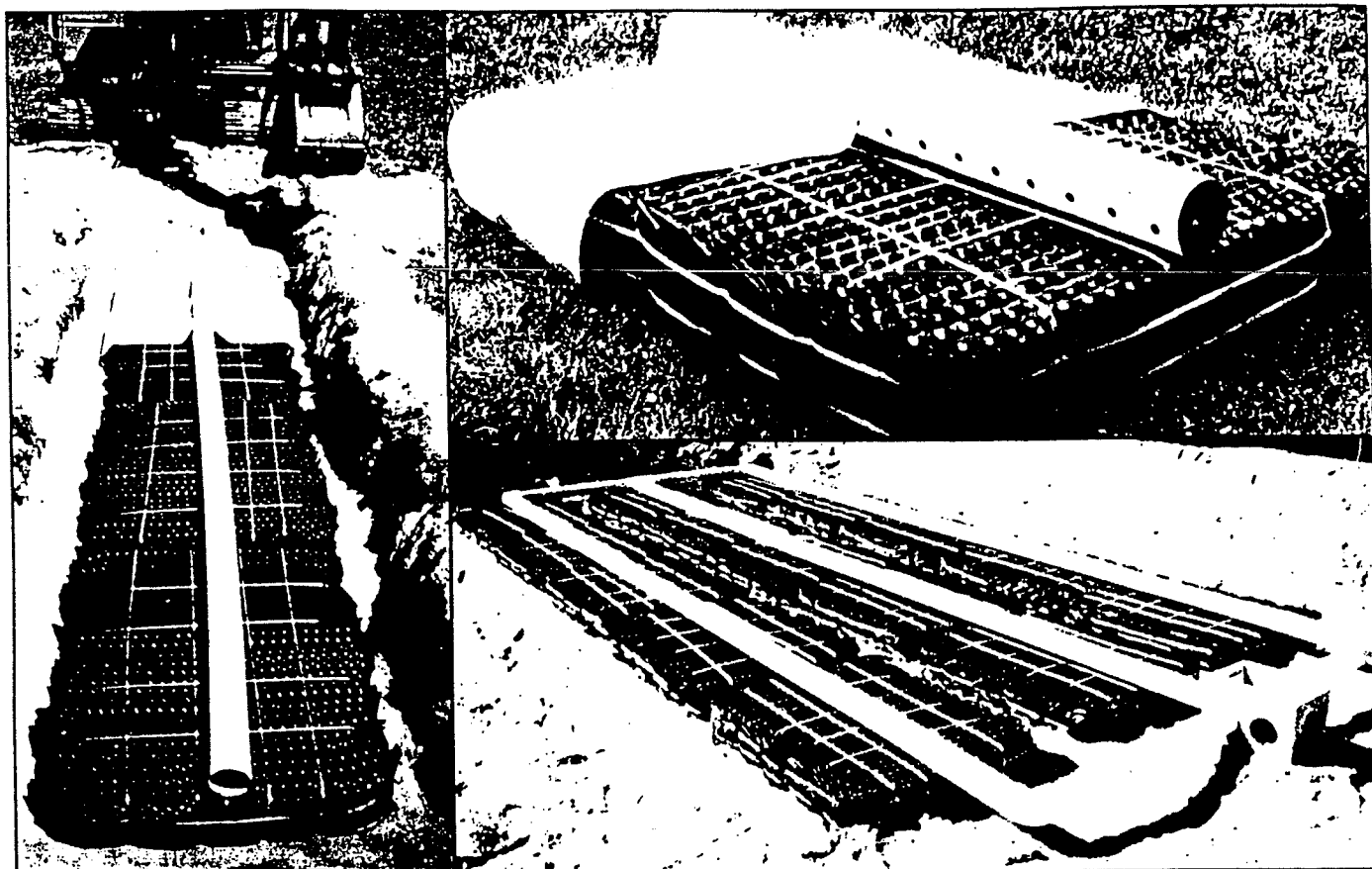
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## CONSTRUCTED WETLANDS

### HISTORY

Developed by NASA at the John Stennis Space Center during the past 15 years. Systems are reported to be in use in varying climates and many locations including Louisiana, Pennsylvania, Michigan, and Ontario.

### DESCRIPTION

A septic tank is required for primary treatment. An aquatic plant filter constructed of washed gravel or rock and planted to cattails, bullrushes or other plants has both aerobic and anaerobic zones. The filter may be lined with clay or plastic material. Requires a subsurface disposal area for final disposal of the treated wastewater.

### TREATMENT MECHANISMS

The plants and associated microorganisms provide treatment of the applied septic tank effluent. Products of the microbial degradation are assimilated by the plants along with the nitrogen, phosphorus and other minerals. Suspended particles are strained through the plant rootlets and adhere to them where the particles are assimilated by the plants and microorganisms. An aerobic zone occurs around the plant rootlets. The bottom of the constructed wetland can remain flooded and produce anaerobic conditions where denitrification can occur.

### LEVEL OF TREATMENT EXPECTED

70-90% BOD removal

Assuming application of typical residential septic tank effluent, the concentration in the effluent from the constructed wetland could be from 74mg/L to 24mg/L.

Effluent from constructed wetlands tends to be somewhat high in the concentration of suspended solids.

Nitrogen removal varies depending upon design

Phosphorus removal varies depending upon design

### OPERATION & MAINTENANCE

Operation consists mainly of inspecting dike integrity and vegetation health, mowing dike areas and other grounds keeping tasks. The properly constructed wetland has little need for daily adjustments. Construction is labor intensive.

### COSTS

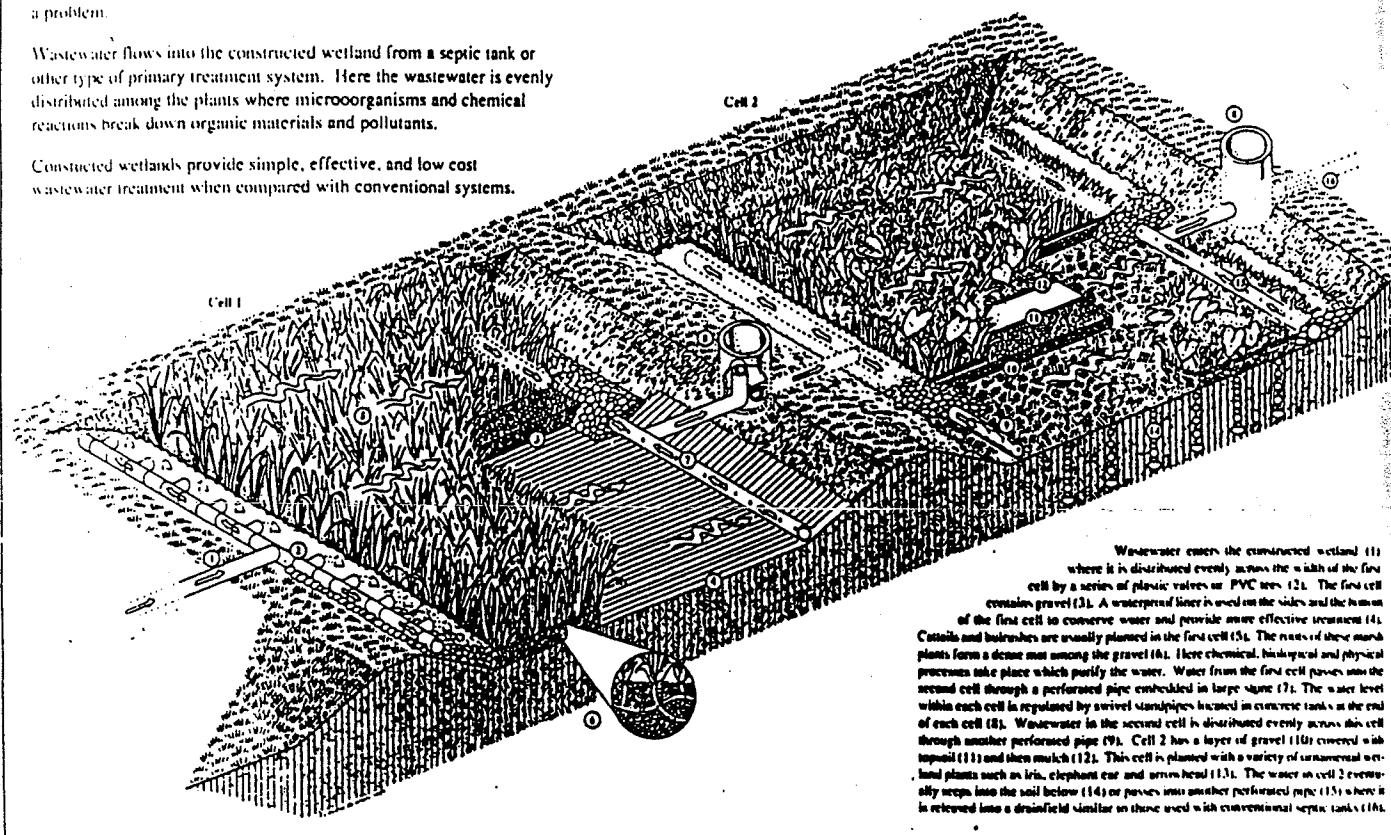
Typical construction costs are \$3-5/gpd and include land acquisition, earth grading and vegetation planting. Costs given for several specific systems are:

- \$260,000 for a 1 million gpd system
- \$208,000 for 100,000gpd
- \$360,000 for 100,000gpd

**Constructed wetlands** like this one are being built throughout the nation to handle wastewater from mostly small rural communities and homes where traditional treatment systems are a problem.

Wastewater flows into the constructed wetland from a septic tank or other type of primary treatment system. Here the wastewater is evenly distributed among the plants where microorganisms and chemical reactions break down organic materials and pollutants.

Constructed wetlands provide simple, effective, and low cost wastewater treatment when compared with conventional systems.



Wastewater enters the constructed wetland (1) where it is distributed evenly across the width of the first cell by a series of plastic valves or PVC tees (2). The first cell contains gravel (3). A waterproof liner is used on the sides and the bottom of the first cell to conserve water and provide more effective treatment (4). Cattails and bulrushes are usually planted in the first cell (5). The roots of these marsh plants form a dense mat among the gravel (6). Here chemical, biological and physical processes take place which purify the water. Water from the first cell flows into the second cell through a perforated pipe embedded in large stone (7). The water level within each cell is regulated by a riser standpipe located in concrete tanks at the end of each cell (8). Wastewater in the second cell is distributed evenly across this cell through another perforated pipe (9). Cell 2 has a layer of gravel (10) covered with topsoil (11) and then mulch (12). This cell is planted with a variety of unsaturated wetland plants such as iris, elephant ear and arrowhead (13). The water in cell 2 eventually seeps into the soil below (14) or passes into another perforated pipe (15) where it is collected into a drainfield similar to those used with conventional septic tanks (16).

Small flow Constructed Wetland (Steiner, 1990)  
- operated in conjunction with septic tank or aeration tank.

## PEAT BEDS

### HISTORY

The first peat bed for single family home use was installed in 1978 as an experimental system. Seven beds were installed and monitored by 1988, and in October 1988 the peat bed system was approved for use in Maine. Design criteria is contained in the Maine Subsurface Wastewater Disposal Rules. These RULES are currently undergoing modification and the new RULES are expected to be enacted early in 1995. Approximately 200 peat beds are in use in Maine; most are for single family homes; two are for schools. The largest peat bed system in Maine to date is for a theoretical design flow of 6,000 gpd.

Twelve large peat bed systems are in use in Ontario; 3 single family systems are in use in New Brunswick; two in Alberta; and more are planned for installation in Newfoundland. The system is being approved in the Canadian provinces on a case by case basis at this time. In New Brunswick full approval is planned for the system in the near future. Peat beds have been successfully used in Alaska, Massachusetts, and in Ireland.

### DESCRIPTION

Primary treatment is required. Two feet of a specific type and condition of peat is placed over a 6" layer of clean coarse sand. Clean 3/8" washed crushed rock is placed immediately beneath and to the sides of the 4" dia. perforated distribution pipe network on top of the 2 feet of peat. The pipes are covered with an additional 10" to 12" layer of peat. No soil is placed on top of the peat. Septic tank effluent may be applied by gravity feed or by dosing with a pump. Pressure distribution systems require design modifications and are normally not used. The effluent from the peat bed may be discharged directly to the soil beneath the peat. Where overboard discharge is allowed a plastic liner and an underdrain pipe are used to convey the treated effluent to a receiving body of water. Design criteria require one square foot of peat/gpd for optimum treatment with an adjustment to size based on the final infiltrative rate of the underlying soil.

### TREATMENT MECHANISMS

A combination of physical filtration, abiotic sorption, and microbiological activity provide treatment of the applied septic tank effluent.

### LEVEL OF TREATMENT EXPECTED

Where the proper design was used, the peat used met required specifications, and specified construction techniques were used for the placement of the peat the following results were obtained:

- 2-15 mg/L BOD
- <1 to 10 mg/L TSS
- 0.2 - 8 mg/L nitrate-N
- <10 mg/L total nitrogen species
- < 1 fecal coliform bacteria/100 ml

Phosphorus concentration in the septic tank effluent is generally reduced by 55-65% in the peat bed. Where there is an underlying layer of sand more phosphorus concentration reduction occurs.

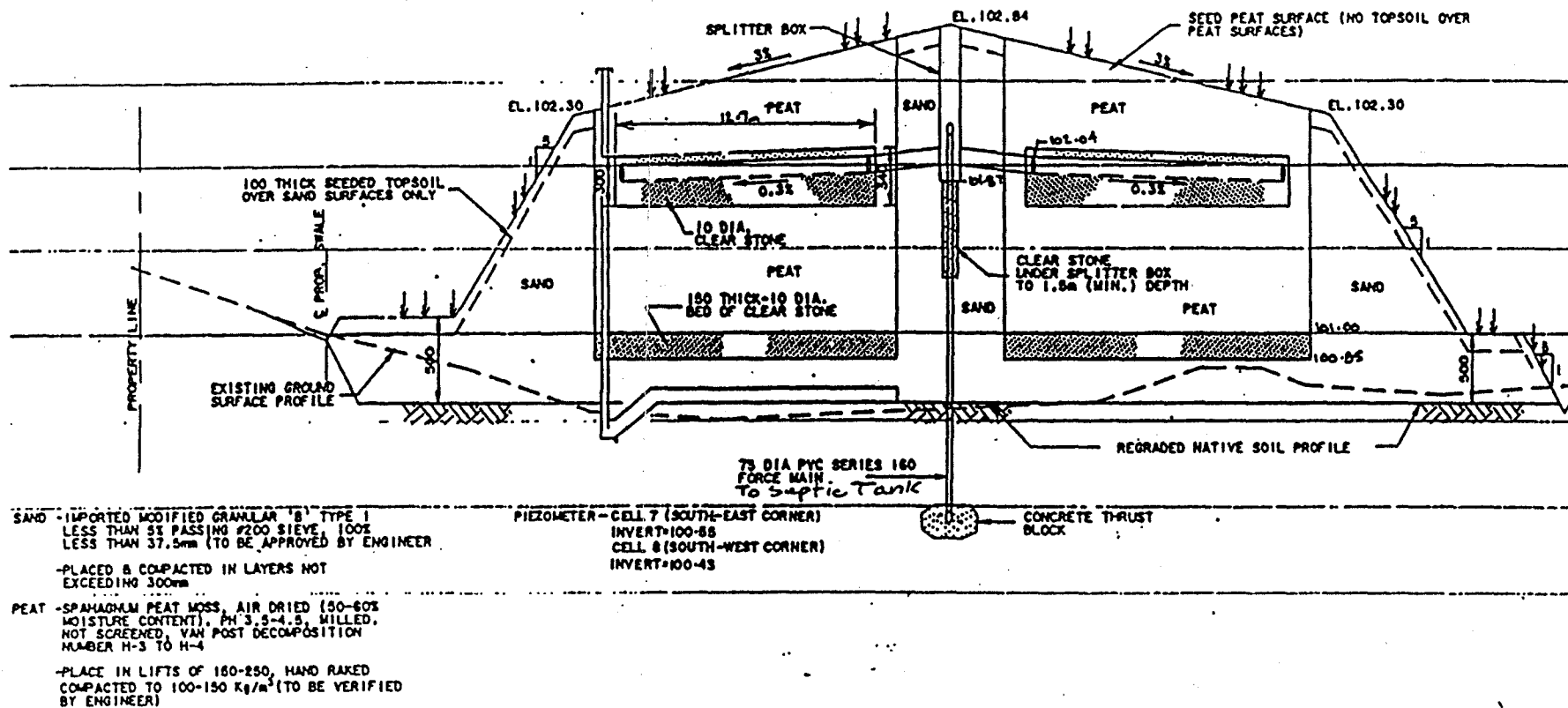
NOTE: These results are based on monitoring of 48 peat beds in Maine and in Ontario. For some beds results are for effluent collected in the underdrain pipes; other samples were collected from ground water monitoring tubes directly beneath the peat in the underlying soils.

#### OPERATION & MAINTENANCE

The septic tank must be pumped at appropriate intervals to prevent excessive carry over of solids to the peat bed. Peat beds may be planted to lawn grasses and mowed with walk-behind power mowers. No riding mowers or other vehicular traffic is allowed on the surface of the peat. Beds may be planted to shallow rooted ground covers and not mowed. Where the bed is not mowed all deep rooted vegetation that takes root on the surface of the peat must be removed by "weeding" the bed every couple of years. No additional disinfection is required where an overboard discharge to a receiving body of water is used for final distribution of the effluent from the peat bed. Construction supervision by a peat expert is not required by Maine state law. Several failures have occurred where the peat was overcompacted, the wrong type of peat was used, or the fill material did not meet specifications.

#### COSTS

Cost of the peat FOB the production bog is \$10-\$14/cubic yard. A single family system installed within 100 miles of the source of peat costs approximately the same as for a conventional stone bed.



Sphagnum Peat Sewage System (McKee, J.A., Brooks, J.L., 1992)

## **ENVIRO-PURE PEAT SYSTEM (proprietary system)**

### **HISTORY**

This proprietary system is essentially the same as the peat bed but the units are prepackaged to ensure quality control, avoid construction problems, and simplify inspection by those unfamiliar with judging the peat material specifications and compaction of the peat in the system. A two unit system was installed on Martha's Vineyard in April 1994 to serve the sanitary facilities for employees at a shellfish hatchery. Several systems are in the design phase for installation in Massachusetts at this time. In Maine the system is approved for use. Seven units are installed at single family homes; 5 units are installed to treat effluent from a milking parlor and milk room at a dairy farm. Additional systems are designed and construction is expected during this season.

### **DESCRIPTION**

Primary treatment is required. Each unit is composed of a concrete container measuring 10.5' long, 6.3' wide and 3' high, filled with the peat and the distribution piping. Each unit will treat 90 gpd of residential septic tank effluent. For stronger effluent with higher BOD and TSS concentrations a factor is used to determine the gpd that can be effectively treated in each unit. Two models of units are available. One contains drainage holes and discharges the treated effluent directly to the underlying 6" deep base of clean coarse sand, and then to the underlying native soil. The area of the base material is calculated to be large enough to spread the treated effluent over a sufficient area of native soil. This area is sized according to the long term acceptance rate of the soil. Where existing soils are coarse sands and gravels it is not necessary to use the above described 6" thick base.

The second model contains an underdrain pipe and may be used for pretreatment followed by a disposal area, or for final disposal to a receiving body of water. No additional disinfection of the effluent from the units is required. Distribution boxes are used to ensure equal flow to the units that are placed side by side with a foot space between the units. Application of the septic tank effluent is by gravity feed or dosing with a pump. Where a large number of units is required they may be placed end to end and used with a modified piping design to allow pressure distribution. Serial distribution is not allowed.

### **TREATMENT MECHANISMS**

A combination of physical filtration, abiotic sorption, and microbiological activity provide treatment of the applied septic tank effluent

### **LEVEL OF TREATMENT EXPECTED**

The systems have not required monitoring in Maine. It is expected that the effluent quality will be the same as that from the peat beds described above.

### **OPERATION & MAINTENANCE**

The septic tank must be pumped at appropriate intervals to prevent excessive carry over of solids to the Enviro-Pure units. The surface of the Enviro-Pure units may be planted to lawn grasses and mowed with walk-behind power mowers. No riding mowers or other vehicular traffic is allowed on the surface of

the peat. Enviro-Pure units may be planted to shallow rooted ground covers and not mowed. Where the unit is not mowed all deep rooted vegetation that takes root on the surface of the peat must be removed by "weeding" every couple of years. No additional disinfection is required where an overboard discharge to a receiving body of water is used for final distribution of the effluent from the units.

#### COSTS

Each Enviro-Pure unit costs \$1,250 FOB American Concrete Industries manufacturing plant in Veazie, Maine. The simplified construction at the site and the small footprint of the system allows rapid construction and attendant cost savings in construction.



## PURAFLOW SYSTEM (IRELAND)

### HISTORY

This system (U.S. Patent # 5,049,265 Dated Sept 17, 1991) was developed in Ireland based upon publications about the peat bed described above. A number of these systems are in use in Ireland. They have been installed at at least 2 sites in the U.S.

### DESCRIPTION

A septic tank is required for primary treatment of the sewage. The prepackaged system for single family homes consists of 4 plastic boxes filled with a mixture of cottongrass fibers and "young" peat and containing a distribution network. Each 4 unit system requires a pump to dose the units. Gravity feed is not used with this system. Larger systems are comprised of a concrete block container with the fiber and peat mix and distribution system added at the site. . Large units require a pump for effluent distribution. In Ireland the effluent from the units is discharged to a roadside ditch or receiving body of water. In the U.S. the system requires an additional subsurface wastewater disposal area for final distribution of the treated effluent to the soil. The units are covered with a solid plastic cover. Outlets from the filters are provided with filters containing organic heather material or stone chippings.

An experimental project in Alabama retrofitted 10-20 single family homes with these units. This project was funded by the U.S. E.P.A. and the units are being monitored.

### TREATMENT MECHANISMS

Treatment is provided by physical filtration and microbial activity.

### LEVEL OF TREATMENT EXPECTED

Test results given in the patent are as follows:

3-15mg/L BOD

1-16mg/L TSS

1-15mg/L ammonia-N

800-2,000 fecal coliforms/100ml

phosphorus-no data given

NOTE: No published results for all nitrogen species are available. Personal communication indicated there is no reduction in the concentration of total nitrogen species as the septic tank effluent passes through the units.

### OPERATION & MAINTENANCE

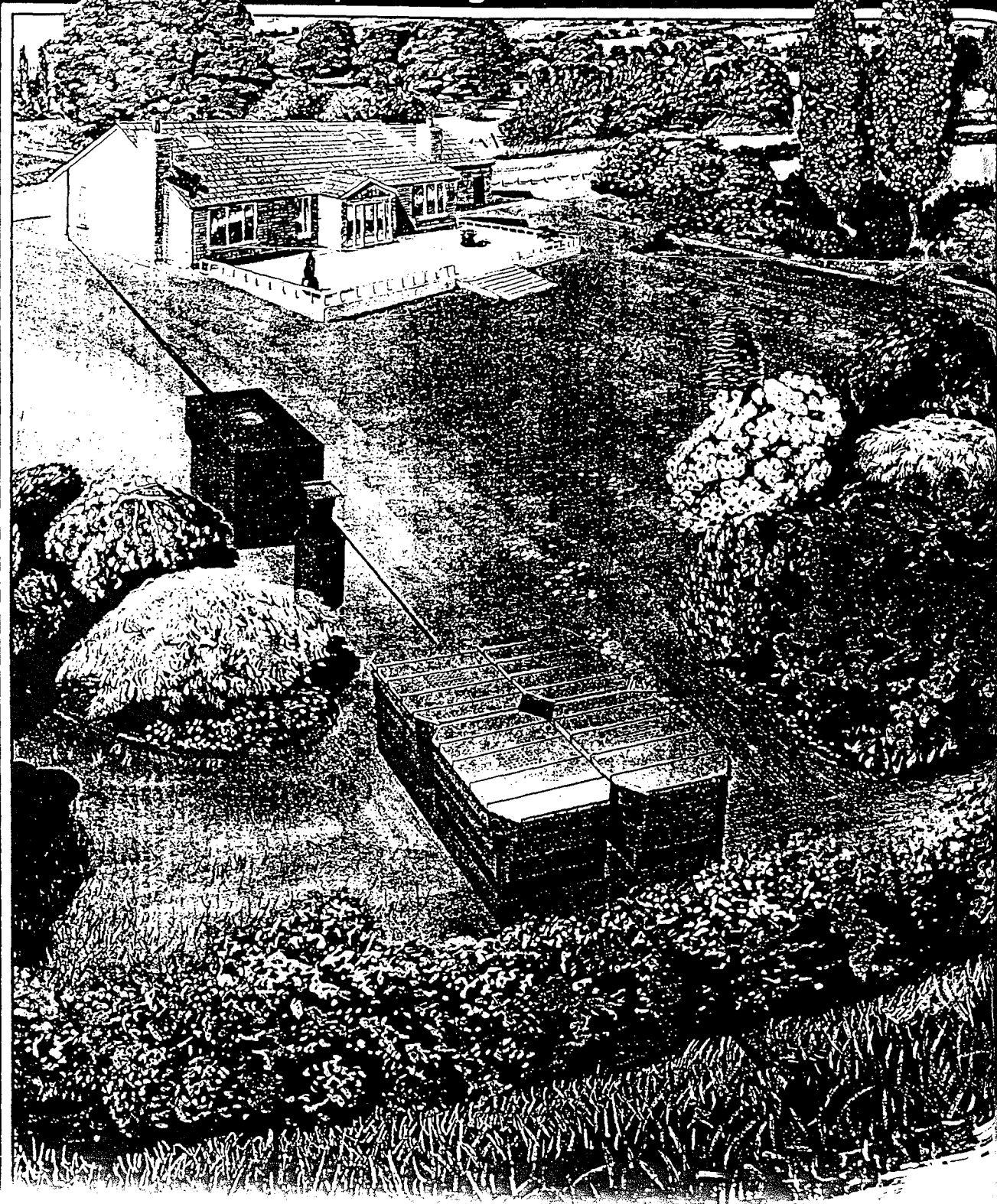
Septic tanks must be pumped to avoid excessive carryover of solids to the units.

### COSTS

Costs are reported to be between \$6,000 and \$10,000 per single family home installation. The units are imported from Ireland where they are manufactured.

# PURAFLO

## Septic Tank Effluent Treatment System



## **MECHANICAL TREATMENT SYSTEMS**

### **Rotating Biological Contactors**

#### **HISTORY**

Used for small communities and larger systems.

#### **DESCRIPTION**

Pretreatment of solids is obtained by primary treatment in a septic tank. The RBC consists of large diameter, closely spaced, synthetic drums mounted on a horizontal shaft. The primary drums are submerged 40% into the wastewater to permit aerobic conditions. The final drums are completely submerged to provide an anaerobic zone. An external carbon source is added to the final drums to facilitate denitrification. Final disposal of treated effluent is to a subsurface disposal area or to a receiving body of water via an underdrain with additional disinfection.

#### **TREATMENT MECHANISMS**

Biological growth occurs on the synthetic disks. This growth assimilates the soluble organic pollutants in the wastewater. Growth separates and settles to the bottom of the tank. In the completely submerged drum anaerobic bacteria grow on the disks and provide denitrification when an external carbon source is added.

#### **LEVEL OF TREATMENT EXPECTED**

Total nitrogen removal is proportional to contactor surface, thus the system can be designed to provide a specific final effluent quality. Typical results are as follows:

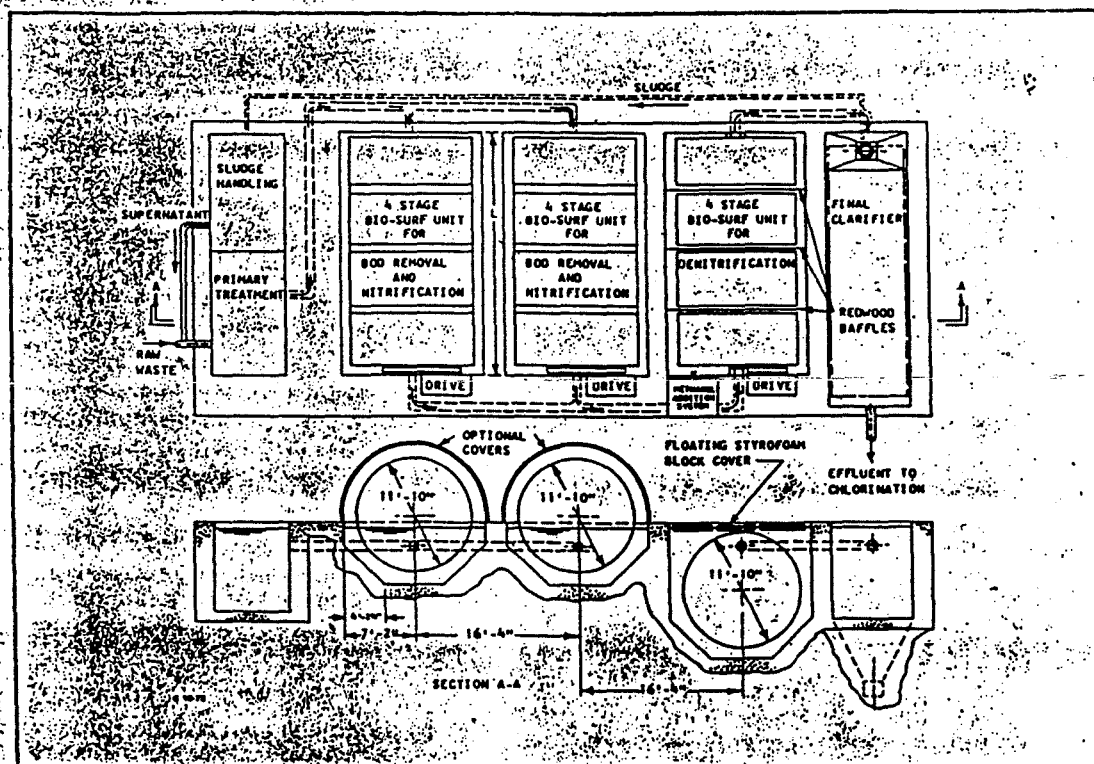
- 94% BOD reduction
- 81% nitrogen removal
- 95% TSS removal

#### **OPERATION & MAINTENANCE**

Requires a trained or professional operator. Accumulated sludge must be removed periodically from the drums and disposed of in an acceptable facility

#### **COSTS**

A complete RBC incorporating denitrification costs \$142,700 for a 3,500gpd installation. Operating costs for energy requirements and carbon addition for this system would be estimated at an additional \$750/year.



Bio-surf RBC Process/Small System (Antonie, R.L. Autotrol Corp.)

## **AEROBIC TREATMENT PACKAGE UNITS**

### **HISTORY**

A number of package units are marketed by different firms.

### **DESCRIPTION**

Wastewater enters the aeration chamber where blowers inject oxygen via air diffusers in the tank. The effluent is then pumped to a denitrification chamber. A portion of the flow is recirculated back to the aeration chamber. The remaining flow is mixed with an added carbon source in a separate anaerobic chamber for denitrification. The treated effluent is discharged to a subsurface disposal area for final distribution to the soil, or is discharged to a receiving body of water with additional disinfection.

### **TREATMENT MECHANISMS**

Organic matter is converted to stable end products in the aeration process. Additional suspended solids are removed in the backwash filter. Denitrification occurs in the anaerobic chamber.

### **LEVEL OF TREATMENT EXPECTED**

As reported by one manufacturer the following results are obtained:

- 98% BOD reduction

- 98% TSS reduction

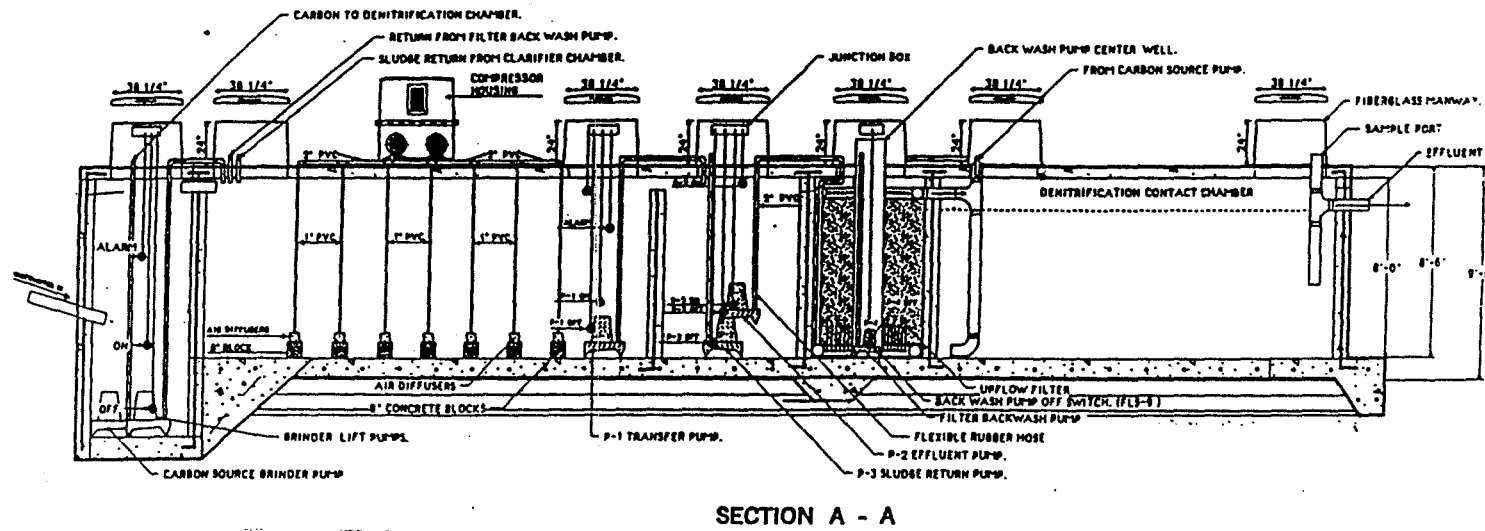
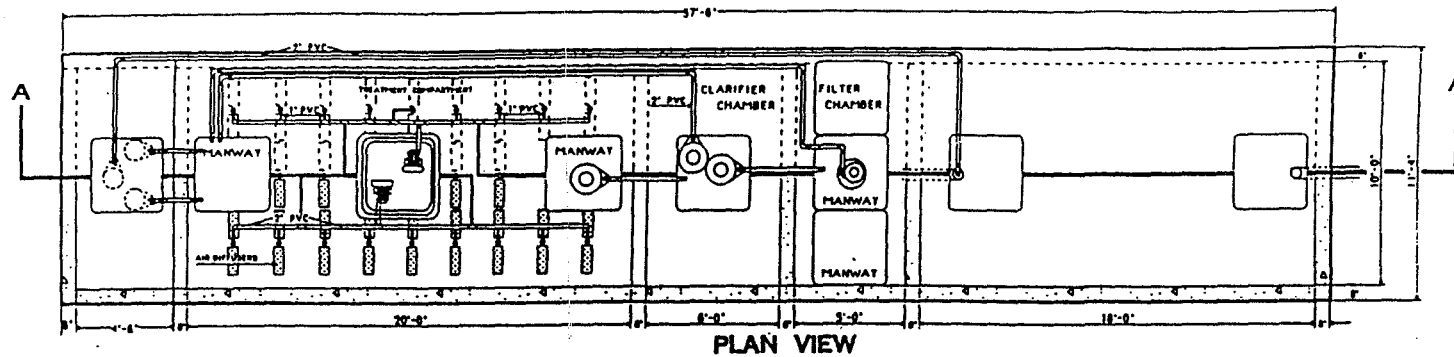
- 90% of total nitrogen species removed

### **OPERATION & MAINTENANCE**

Requires a trained operator for optimum treatment.

### **COSTS**

Vary with manufacturer.



Aerobic Treatment Package Plant Incorporating Denitrification  
(Pavon, D., Aquarobic Ltd.)

Diagram is for the demonstration of the technology  
and not for construction.

## **SEQUENCING BATCH REACTORS**

### **HISTORY**

There are a number of manufacturers of this system.

### **DESCRIPTION**

This is essentially an aerobic plant that is modified to allow a settling phase in the same compartment. There are two types of systems, one can be operated on a fixed fill period and the other on a continuous fill basis. In the fixed fill system wastewater enters over a period of approximately 4 hours and then the wastewater is mixed and aerated by means of aeration jets. Then the contents are allowed to settle for approximately 6 hours. The treated effluent is then discharged over a period of approximately 4 hours and at the end of this time the settled sludge is removed over a four hour period.

The continuous flow system eliminates the need for more than one tank. Inflow is baffled from the main compartment in a pre-react zone to prevent disturbance of the tank during the settling phase. Final disposal of treated effluent is to a subsurface system or to a receiving body of water via a discharge pipe with additional disinfection.

### **TREATMENT MECHANISMS**

The aeration of the wastewater converts organics into a microbial mass that can be settled out of the wastewater, and provides for nitrification. In the settling phase anaerobic conditions occur. The settling mass provides a carbon source for denitrification to take place. Treatment mechanisms are temperature dependent.

### **LEVEL OF TREATMENT EXPECTED**

On large systems the following results are obtained:

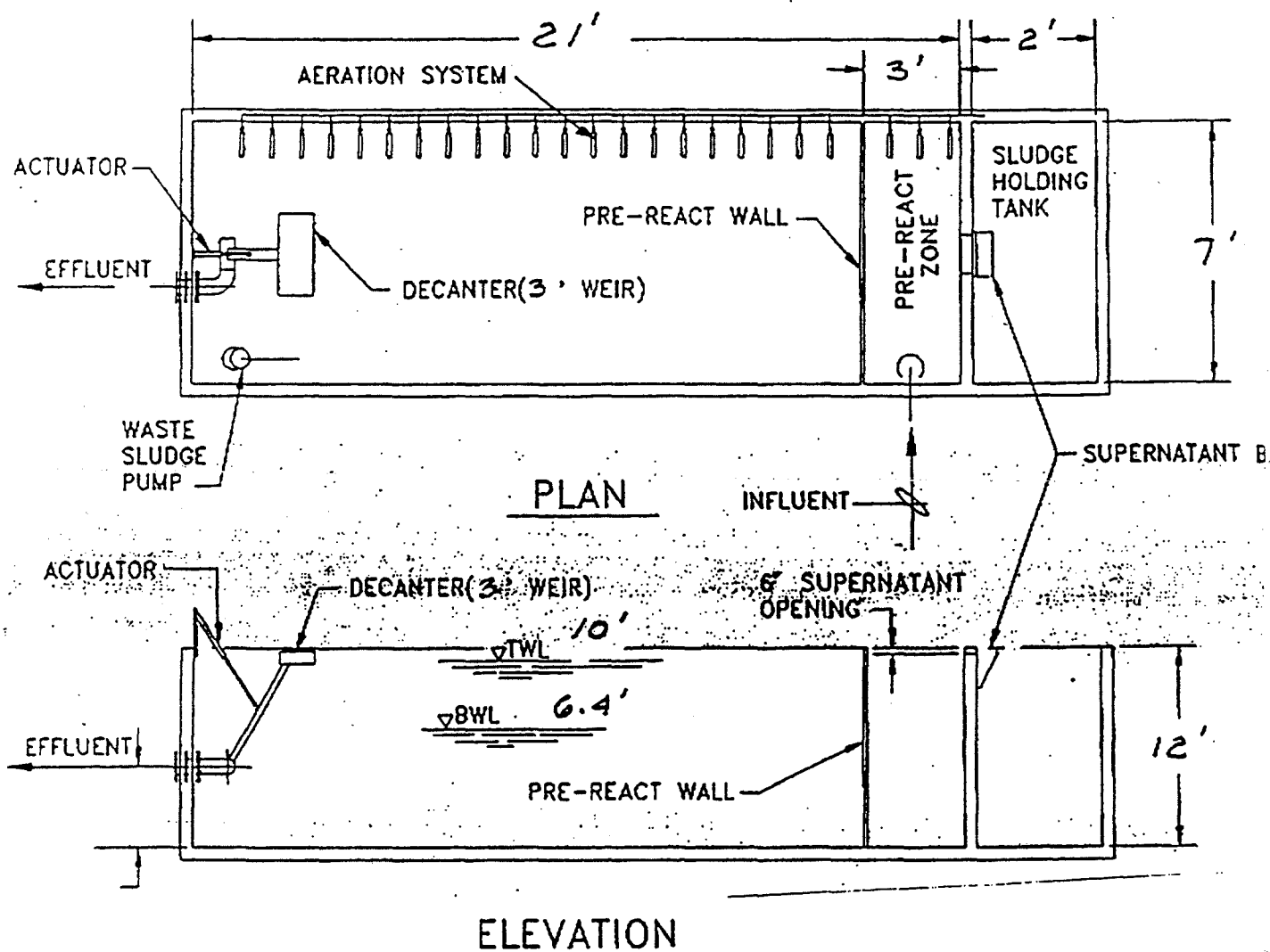
- 94% BOD reduction
- 96% TSS reduction
- 89% total nitrogen species removal
- 98% nitrogen removal with altering aerobic and anaerobic conditions
- 88% total phosphorus reduction.

### **OPERATION & MAINTENANCE**

Requires a trained or professional operator.

### **COSTS**

One package plant for a school system was estimated to cost approximately \$68,000.



ICEAS System (SBR System)  
 Example preliminary layout (Austgen Biojet) operated in  
 conjunction with a subsurface disposal system (Figure 4).

**REVERSE OSMOSIS****HISTORY**

Package plants are available from manufacturers.

**DESCRIPTION**

The system requires pretreatment to remove solids, a lift station, a pressure tank, a replaceable filter cartridge, replaceable membrane cartridges, and a waste brine storage tank. Treated effluent is discharged to a subsurface disposal area. Brine generated during the reverse osmosis stage is drained to a storage tank for later disposal at an acceptable facility.

**TREATMENT MECHANISMS**

The pretreatment unit removes organic and inorganic suspended solids. Physical separation of most pollutants, including nitrogen takes place as the wastewater passes through the filter and membrane. Pretreatment may be by an extended aeration package plant or intermittent or recirculating sand filters.

**LEVEL OF TREATMENT EXPECTED**

No data is available. However, exceptional quality could be expected in a properly sized unit.

**OPERATION & MAINTENANCE**

This will depend on the type of pretreatment unit used. For the reverse osmosis unit both filters and membranes must be replaced on a periodic basis.

**COSTS**

Not available.

## SUMMARY

Alternative systems are available that will reduce the amount of nitrogen and phosphorus in the applied wastewater. Effluent from some of these systems will meet guidelines of <10 mg/L nitrate-nitrogen that is the standard for drinking water. Excellent fecal coliform bacteria removal can be obtained as well.

The systems may be generally divided into three categories. The first is an essentially passive system requiring low maintenance. This includes conventional stone beds, Elgin Indrains, Peat beds, and Enviro-Pure units. These systems have the additional advantage that they do not require an additional area for the final distribution of the treated effluent to the soil.

The second category requires some energy input, some training in operation, and an additional area for final distribution of the treated effluent to the native soil. Examples of this category include the RUCK system, constructed wetlands, and sand filters.

The third category are those systems which require considerable energy input and operation by trained personnel or a professional. This category includes mechanical and chemical systems. Most of these systems have a number of mechanical parts that may be subject to periodic breakdown and repair. As expected, mechanical systems are considerably more expensive to install than passive systems. Mechanical systems require an additional area for final discharge of treated effluent to the native soils.

Where allowed by regulatory agencies, an alternative to final distribution of the effluent to soils would be to add a disinfection unit and discharge the effluent overboard to a receiving body of water. In Maine only commercial systems may be permitted for overboard discharge and the Maine Department of Environmental Protection is reluctant to issue these permits except in cases of extreme need. Like Maine most states are attempting to remove existing overboard discharge systems and replace them with subsurface discharge systems whenever possible in order to open potential shellfishing areas.

Any proposed site must be individually evaluated to determine the optimum type of system to be used on the site. There is no single onsite wastewater treatment system that will solve problems and requirements at all sites.

## SUMMARY OF ON-SITE WASTEWATER TREATMENT SYSTEMS

| Effluent Quality mg/l   | RUCK system                   | Elgen In-Drain                 | Constructed Wetland                        | Peat Bed                                                                          | Enviro-Pure          | Puraflow      | Sand Filter                               | Mechanical                                               |
|-------------------------|-------------------------------|--------------------------------|--------------------------------------------|-----------------------------------------------------------------------------------|----------------------|---------------|-------------------------------------------|----------------------------------------------------------|
| BOD                     | 20                            | 10                             | 24-74                                      | 2-15                                                                              | *See below           | 3-15          | 2-23                                      | 2-5                                                      |
| TSS                     | 13                            | 29                             | "high"                                     | <1-10                                                                             |                      | 1-16          | <1-13                                     | 2-10                                                     |
| NO <sub>3</sub> -N      | 3                             | 28                             | varies                                     | 0.2-8                                                                             |                      | ?             | 17-46                                     | 2-5                                                      |
| P                       | 5                             | ?                              | varies                                     | ?                                                                                 |                      | ?             | ?                                         | ?                                                        |
| Fecals #/100ml          | ?                             | ?                              | ?                                          | <1                                                                                |                      | 800-2,000     | requires additional disinfection          | requires additional disinfection                         |
| Energy required         | Yes                           | No                             | No                                         | No                                                                                | No                   | Yes           | Yes                                       | YES                                                      |
| Separate disposal area  | Yes                           | No                             | Yes                                        | No                                                                                | No                   | Yes           | Yes                                       | YES                                                      |
| Operation & maintenance | Add carbon source once a week | None. Mow surface if vegetated | Periodic removal of accumulated vegetation | None. Mow surface if vegetated with grass. Remove deep rooted plants if not mowed | Same as for peat bed | Maintain pump | Remove or rake layer of sand periodically | Requires trained operator and high degree of maintenance |

\*Expected to be the same as for peat beds - very limited data available

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