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Project Summary

Restoration of Failing On-Lot Sewage Disposal Areas

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Two techniques were evaluated for rehabilitating failing septic tank/soil absorption systems — water conservation and absorption bed resting. These techniques may offer less costly alternatives to complete replacement of the soil absorption area.

Eleven homes with failing soil absorption areas were identified in the Centre County, Pennsylvania, region. At each home, the soil and site were characterized, and baseline data were collected on household water flow and septic tank effluent quality. Water conservation devices were then installed at one of three levels of predicted water reduction capability — maximum, moderate, or minimum. At three of the minimum water conservation homes, effluent was also diverted to a specially designed alternative trench for 10 months to permit the main absorption area to rest. After conservation measures were applied, water flow and effluent quality were measured for periods comparable with the baseline data collection period. In addition, the soil absorption areas were characterized by weekly measurements of surface conditions and effluent ponding levels for up to 2 years.

Median in-house water use reductions were statistically significant and ranged from 9.8% to 42.5%. The water use reductions were in accord with the increased concentrations of most effluent quality parameters. Maximum levels of water conservation generally succeeded in restoring failing absorption beds, but lower levels of conservation did not.

Absorption bed resting also restored failing systems. None of the three rested systems malfunctioned in the 16 months after effluent was redirected to them. However effluent was ponded in them, and the level continues to rise, suggesting that the effluent will have to be directed to the alternative trench at regular intervals.

This Project Summary was developed by EPA's Municipal Environmental Research Laboratory, Cincinnati, OH, to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at back).

Introduction

This research project evaluated rehabilitative techniques for failing septic tank/soil absorption systems (ST-SAS) to find a less costly alternative to constructing a new drainfield. The subordinate objectives were: (a) to determine the ability of existing water conservation hardware to correct ST-SAS malfunctions; (b) to rest the main drainfield and restore its ability to absorb effluent, and to evaluate the feasibility of small auxiliary soil absorption areas for that purpose; (c) to document how water conservation hardware reduces wastewater and affects its quality, and to determine how the homeowner accepts these devices; and (d) to determine whether or not water conservation or absorption bed resting or both restored the failing system.

Site Selection and Characteristics

Solicitation of homeowners with failing onsite systems was initiated through newspaper advertisements. Responding homeowners were subsequently visited, and 12 homes in Centre County, Pennsylvania, were ultimately selected for this study. Most systems were new to moderately old (2 to 13 years), and most of the failures were relatively persistent in that homeowners had been having problems for more than a year. Eleven of 12 sites were identified as malfunctioning by surfacing of septic tank effluent in the yard. The severity of surface symptoms was not an adequate indicator of systems that could be corrected by water conservation, however, since soil permeability and age of malfunction were also important parameters.

A comprehensive characterization of the soil was performed at each site, and the detailed results are contained in the final report. Background data were also gathered on water table depth and soil permeability. Soils ranged from sandy loam to clay. Percolation rates varied from 7 to 1217 sec/mm. All systems were concluded to be failing either because the effluent/soil interface was clogged or otherwise compacted and smeared, or because the overall soil permeability was too low for the existing hydraulic loading.

Water Conservation Devices

The water conservation devices selected for installation at 11 of the sites are described in Table 1. The mean in-house water use before and after conservation device installation is summarized in Table 2. As expected, the three sites with maximum conservation devices reduced the peak hydraulic loads and produced the greatest mean water use reduction. These sites used 27.3% to 42.8% less water than for the comparable period the previous year. Moderate conservation sites showed mean water use reductions of 14.7% to 36.7%, and the reductions in minimum conservation sites ranged from 10.0% to 33.1%.

Impacts of Water Conservation

The maximum water conservation devices improved the existing malfunctions at the sites receiving this treatment. Only one of the moderate-level conservation sites showed a similar improvement, and none of the minimal-level sites showed any improvement. Even at the maximum conservation level, some intermittent problems still existed at two of the three sites (though in all cases there was considerable improvement over the continual problems that existed before water conservation).

Equipment costs for water conservation devices were substantial for the maximum conservation levels, with installed costs around $1000 (not counting $540 for automatic front-loading washers). Equipment and installation costs are shown in Table 3. The cost of water conservation refit was generally less than replacing the entire soil absorption area or constructing a small alternative soil absorption area.

Table 1. *Conservation Devices Installed at the 11 Sites Used in the Study*

Site	Aerators	Shower Heads[a]	Toilets[b]
Maximum[c] Level:			
2[d]	Bath 1 - 5.7 lpm Kitchen - none	Bath 1 - Lovo	Bath 1 Microphor
4[d]	Bath 1,2 - 1.9 lpm Kitchen - 9.5 lpm	Bath 1 - Navy Bath 2 - Lovo	Bath 1,2 Microphor
7	Bath 1,2 - 1.9 lpm Kitchen - 9.5 lpm	Bath 1,2 - Nova	Bath 1,2 Microphor
Moderate[c] Level:			
1	Bath 1,2 - 1.9 lpm Kitchen - none	Bath 1,2 - Lovo	Bath 1,2 pressure
5	Bath 1,2,3 - 1.9 lpm Kitchen - 1.9 lpm	Bath 1 - Nova	Bath 1,2,3 pressure
8	Bath 1,2,3 - 1.9 lpm Kitchen - 9.5 lpm	Bath 1,2 - Nova	Bath 1,2,3 pressure
Minimum[c] Level:			
3	Bath 1,2,3 - 1.9 lpm Kitchen - 9.5 lpm	Bath 1,2 - Lovo	Bath 1,2,3 low flush
6	Bath 1,2,3 - 1.9 lpm Kitchen - 9.5 lpm	Bath 1,2 - Lovo	Bath 1,2,3 low flush
9	Bath 1 - 1.9 lpm Kitchen - 9.5 lpm	Bath 1 - Lovo	Bath 1 Dams
10	Bath 1,2 - 1.9 lpm Kitchen - 9.5 lpm	Bath 1,2 - Nova	Bath 1,2 Dams
12	Bath 1 - 1.9 lpm Kitchen - 9.5 lpm	Bath 1 - Lovo	Bath 1 Dams

[a]All shower heads produce 7.6 lpm (liters per minute) maximum at 345 kPa except the Navy (1.9 lpm).
[b]Pressure toilet (3.8 to 5.7 liters per flush), microphor (1.9 liters per flush), and low flush (13.3 liters per flush).
[c]Designed levels of conservation were 40+% for maximum, 20% for moderate, and 10% for minimum.
[d]White-Westinghouse front loading automatic washing machine installed April 1981 and removed July 1981.

Table 2. *Mean In-House Water Use Before and After Installation of Water Conservation Devices[a]*

Site	Before[b] x	Before[b] 95%CI	After[b] x	After[b] 95%CI	% Reduction	Probability xbefore = xafter (α = .05)
Maximum Conservation Level:						
2[c]	197	±19	118	±13	40.0	.0000
4[c]	131	±14	95	±10	27.3	.0000
7	191	±19	109	±22	42.8	.0000
Moderate Conservation Level:						
1	97	±17	83	±15	14.7	.0964
5	239	±33	154	±28	35.6	.0001
8	248	±64	157	±36	36.7	.0072
Minimum Conservation Level:						
3	273	±41	245	±55	10.0	.2043
6	254	±53	204	±34	19.5	.0560
9	259	±48	218	±47	16.0	.1030
10	207	±55	167	±36	19.3	.1103
12	199	±39	133	±23	33.1	.0024

Water Consumption (lpcd)

[a]In-house use (liters per capita per day) was determined by subtracting outside hose bibb use from total site use for each site except 4 and 6. Additional outside bibb use occurred at sites 4 and 6, therefore total in-house water use was determined by summing toilet, shower, and laundry water use.
[b]Meters were read before devices were installed during the spring and summer 1980 (April 9, 1980, to May 9, 1980, for sites 1,2,3,4,6 and 9; and June 3, 1980, to July 3, 1980, for sites 5,7,8,10 and 12). After conservation devices were installed, monitoring was done in spring 1981 (May 19, 1981, to June 19, 1981, for all sites).
[c]Sites 2 and 4 also had front-loading washers from April 1981 to July 1981.

All water conservation devices were well received by individual homeowners except for the faucet aerator-flow controls and the Navy showers. Homeowner opinion tended to be negative on faucet aerator-flow controls, with seven reporting the device to be either poor or fair and five reporting it to be excellent or good. The Navy shower was rejected in two homes during a brief pretest period and conditionally accepted in a third home where it was little used during the study. Responses to all the other devices were mostly excellent or good, with air-assisted toilets drawing excellent ratings from all three homeowners using that device. Maintenance problems were minimal on all devices except the water pressure toilets.

The mean septic tank effluent quality before installation of the conservation devices is summarized in Table 4. As expected, the concentrations of most septic tank effluent parameters increased significantly at sites after installation of water conservation equipment, with the maximum water conservation sites having the most significant increases.

Though this study has clearly demonstrated that the installation of waste-flow reduction hardware will result in higher concentrations of pollutants in septic tank effluent, mass loading should remain constant or be reduced somewhat by virtue of improved septic tank treatment. Moreover, any increase in pollutant concentration should be more than offset by the significant decrease in hydraulic load on the septic tank/soil absorption system.

Two of the study systems used ion exchange water softeners to mollify the effects of hardness in the domestic water supply. These systems had septic tank effluent chloride concentrations that were more than 10 times those of homes without ion exchange water softeners.

Table 3. *Water Conservation Equipment and Installation Costs in 1980 Dollars*

Site	Labor Cost	Equipment Cost[a]	Total Cost
Maximum Conservation Level:			
2	$104	$1,248($708)[b]	$1,352($812)
4	154	1,474(934)	1,728(1,088)
7	181	984	1,165
Moderate Conservation Level:			
1	56	642	698
5	76	967	1,125
8	121	1,004	1,125
Minimum Conservation Level:			
3	76	295	371
6	76	295	371
9	0	19	19
10	0	42	42
12	0	19	19

[a]Costs of individual items in 1980 dollars were: Pressure toilet, $309.37; microphor toilet, $661.79 (includes toilet at $301.30, compressor at $195.50, installation kit at $44.99, air filter at $65.55, and pressure-reducing valve at $54.45); conventional water-saving toilet, $98.22, toilet dams, $5.00; Nova showerhead, $8.25; Lovo 1 showerhead, $5.50; 1.9-lpm Chicago Faucet faucet-flow control, $3.85; 9.5-lpm American Std. faucet-flow control, $3.11; faucet aerator adaptor, $1.85.
[b]Costs without automatic front loading washer machine ($540).

Table 4. *Septic Tank Effluent Quality Comparison*

Parameter	Study Homes[a] (before device installation)	Literature[a]
COD (mg/L)	485	360[b]
TOC (mg/L)	174	—
Nonfilterable residue (mg/L)	108	54[b]
TKN (mg/L)	77	55[b]
Ammonia-N (mg/L)	52	39[b]
Total P (mg/L)	18	15[b]
Ortho P (mg/L)	13	12[b]
Chloride (mg/L)	45	80[c]
pH	6.9	7.4[c]
Total Coliform (MPN/ml)	62,000[d]	1,100,000[c]
Fecal Coliform (MPN/ml)	1,100[d]	4,210[b]

[a]Arithmetic means except where noted.
[b]From Otis and Boyle (1976).
[c]From Salvato (1972) (median values).
[d]Geometric means.

Alternative Trench Systems

Alternative onsite trench systems were constructed at three sites, and effluent was diverted from the original failing soil absorption area. Trenches contained 100 mm of limestone sand on the trench bottom. The sand was covered with 150 mm of 2B-limestone gravel, with the distribution lateral placed above the gravel. A layer of untreated building paper separated the gravel and lateral from the trench backfill. The ST effluent was pumped to each alternative trench by a 0.25-kW pump located in a 2.2-m^3 dose tank positioned after the septic tank. Each pumped dose was 400 to 500 liters. Effluent flow was distributed to the alternative trenches for 283 to 325 days at the three sites.

Following the ST flow diversion, the oil soil systems naturally drained and returned to aerobic conditions. After approximately 10 months of flow diversion to the alternative trenches, flow to the previously failed SAS was resumed. Ponding was observed within a few months in all of the systems, but they continued to function satisfactorily for more than 16 months (the end of the study). The data (see Figure 1 for an example) indicated complex and almost unpredictable responses in the effluent ponding levels at each of the three sites. Each ponding level is affected by septic tank flow rates, precipitation, subsurface drainage, evapotranspiration, and infiltration and it can be explained only if each of these facators can be quantified. The data indicate that resting has restored the absorption area capability, but it also suggests that periodic resting will probably be needed in the future as well. These results indicate that an old system should not necessarily be abandoned, because at least part of its function can be restored after a period of resting.

The full report was submitted in fulfillment of Cooperative Agreement CR807115-01 by the Pennsylvania State University under the sponsorship of the U.S. Environmental Protection Agency.

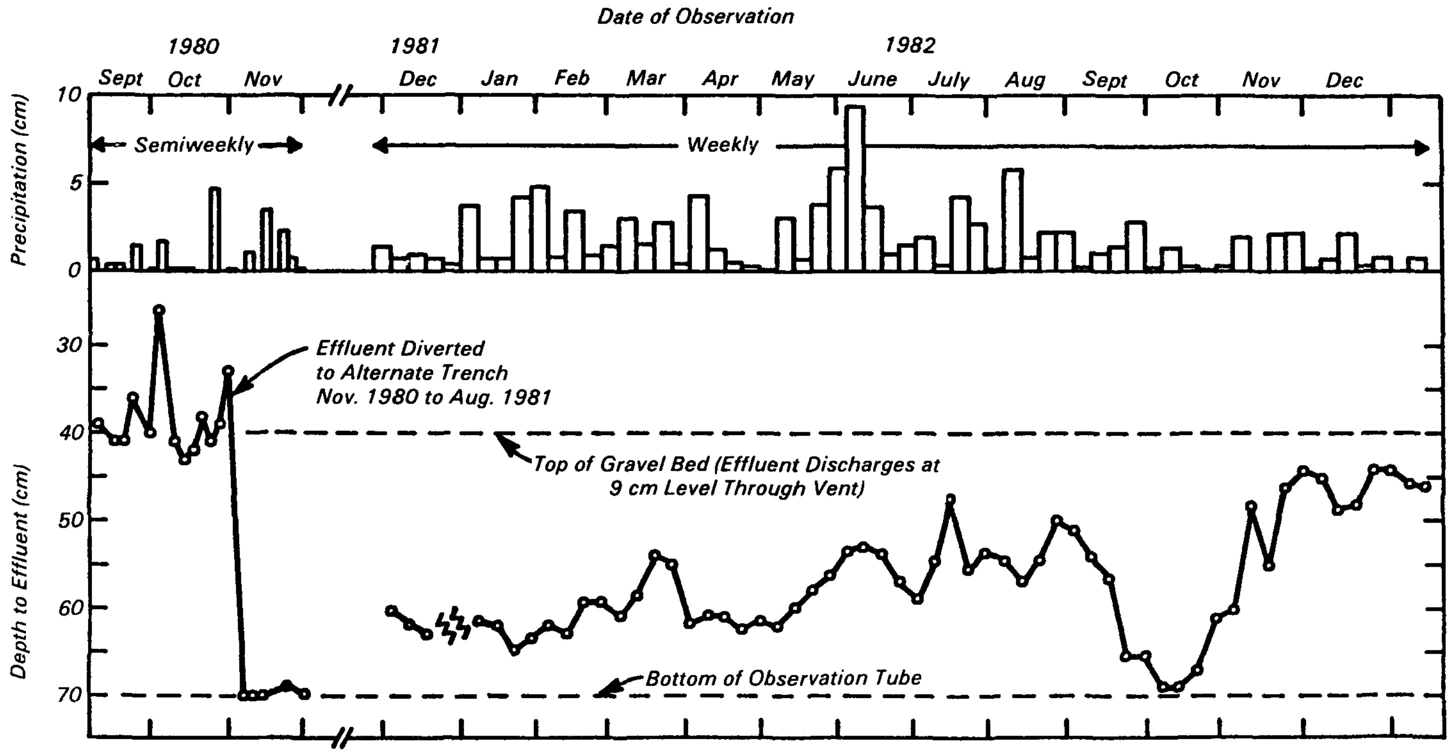

Figure 1. Effluent ponding levels in the soil absorption area and semiweekly or weekly precipitation for Site 9.

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The complete report, entitled "Restoration of Failing On-Lot Sewage Disposal Areas," (Order No. PB 84-168 970; Cost: $14.50, subject to change) will be available only from:

National Technical Information Service
5285 Port Royal Road
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