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SMALL SCALE WASTE MANAGEMENT PROJECT

Wisconsin Mound Performance

by

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WISCONSIN MOUND PERFORMANCE

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The Wisconsin mound on-site wastewater soil absorption system was developed in the 1970's for use on some soil and site conditions unusable for the trench or bed in-ground soil absorption system. The system overcomes both hydraulic and treatment restrictions in an environmentally acceptable manner with reasonable maintenance and cost.

After researching and demonstrating several mound siting requirements, design concepts and construction alternatives, the Small Scale Waste Management Project (SSWMP) recommended the use of mounds for a trial period to the State of Wisconsin.. A trial period is a time of limited use to slowly introduce technology while required education is offered and the institutional framework is tested. A trial program was initiated by the Bureau of Plumbing (then in the Department of Health and Social Services, now in the Department of Industry, Labor and Human Relations) in cooperation with SSWMP of the University of Wisconsin-Madison and county zoning administrators and sanitarians..

A design and construction manual was developed (Converse, 1978). Training sessions were held to instruct county sanitarians, site evaluators, designers, and installers on siting, design, and construction procedures for mounds. During the trial program, county participation was optional since a number of institutional restrictions were placed on the program, including certification of inspectors and state level plan review.

After completing the trail program and a comprehensive enviromental impact statement, the Wisconsin mound system was placed in the Wisconsin Plumbing Code as an alternative soil absorption system. Because of land use concerns, a yearly quota of alternative systems installed for new construction has generally been 3% of the previous year's permits for on-site disposal with the largest proportion being mounds. Currently there are between 7000 - 9000 mounds in Wisconsin; a majority of which replace failing systems. Because of waiting lists, the limit on the number of mounds for new construction in several counties was increased to accommodate a demand greater than the quota.

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The current soil-site criteria for the Wisconsin mound system are given in Table 1 along with the criteria for the in-ground trench and bed system. Recently a study was completed for mounds on more difficult sites, which showed that the criteria for mounds in Table 1 are very conservative. (Converse and Tyler, 1985a)

Table 1. Soil Site Criteria for In-Ground Beds and Trenches and the Wisconsin Mound.

Parameter	Units	In-Ground	Mound
Depth to High Water Table	ft (cm)	4-5 (122-152) ^a	2 (60) ^b
Depth to Creviced Bedrock	ft (cm)	4-5 (122-152) ^a	2 (60)
Slope	%	25	6-12 ^c
Percolation Rate	mpi(mpcm)	0-60 (0-24) ^d	0-120 (0-48)

- a: Need 3 ft (91 cm) of separation between the aggregate/soil interface and the limiting condition for both in-ground and mound. Depth will depend upon how close to the surface the in-ground system is located.
- b: Distance for new construction. For replacement systems depths have been less.
- c: Maximum slope depends upon the percolation rate. If 0-30 mpi (0-12 mpcm) maximum slope is 12%; if 30-120 mpi (12-48 mpcm) maximum slope is 6%.
- d: Zero percolation rate for in-ground systems is not recommended. The (mpcm) is minutes per centimeter.

Objectives

The goal of this project was to determine the performance of mound systems. The specific objectives were: 1) to determine the degree of success with the mound program, 2) to identify any technical problems that might be occurring, and, 3) to determine the seriousness of any technical problems identified.

Mound Principles

The mound system, consisting of a septic tank, dose chamber and mound, is shown in Figure 1. The mound is constructed with a medium sand, which is placed on the tilled natural soil. Within the fill is an absorption area (bed or trench of aggregate) and a pressure distribution network. The fill beneath the absorption area and the natural soil provides the necessary separation distance for treatment prior to the effluent reaching the restrictive layer. Arrows in Figure 2 indicate the wastewater flow from mounds for different soil-site conditions.

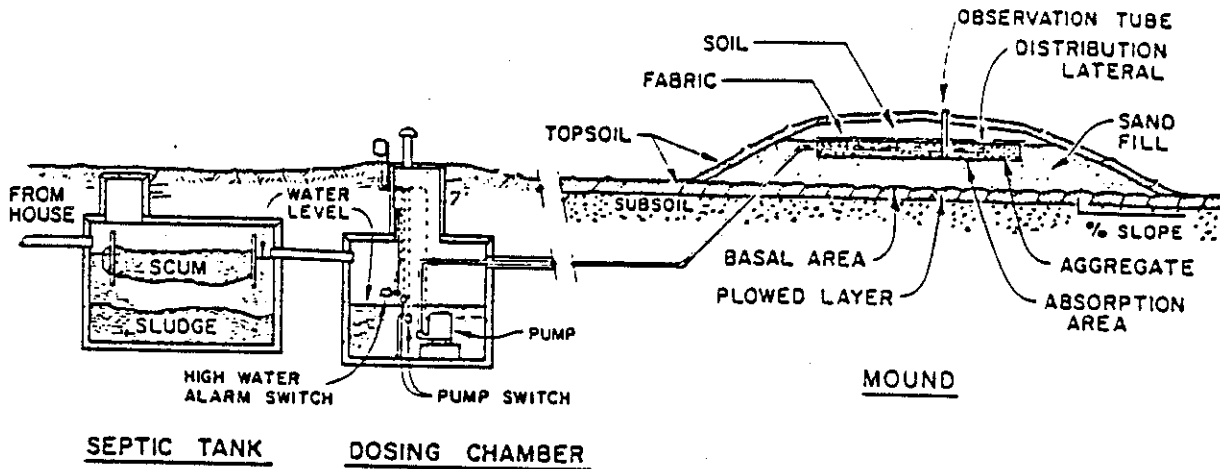


Figure 1. Components of the Wisconsin Mound System

Potential Problems

Potential problems with mounds are 1) continuous ponding in the absorption area (bed or trench) 2) seepage out the side of the mound near the absorption area; 3) spongy area on the side of the mound; 4) leakage out the toe of the mound; 5) spongy area near the toe of the mound; 6) excessive flowback of effluent to the dose chamber; and 7) most of the effluent remaining in the dose chamber after the pump or siphon is activated. Figure 3 shows the location of potential mound problems and Table 2 gives the symptoms and causes.

Ponding: Ponding is standing wastewater within the aggregate and observed in the observation tubes. In many cases ponding will occur for a short time during and after dosing. Normally, within a short time, the effluent infiltrates into the sand at the sand/aggregate interface. However continuous ponding occurs when a crust starts to develop at the sand/aggregate interface (Fig. 3) or when loading is too high. In the spring of the year it is not unusual to see ponding in the bed caused by clogging developed during cold weather or overloading due to excessive groundwater infiltration into the dose chamber. In many instances this ponding disappears by midsummer. However, continuous ponding has been observed in some mounds and can be caused by a number of factors (Table 2). The two most common causes of continuous ponding are overloading and too fine a sand fill.

Side seepage: Ponding alone does not constitute failure, but failure can occur if the ponding continues to increase causing either side seepage of raw effluent onto the surface of the mound, excessive flowback of effluent to the dose chamber after the pump shuts off, or a combination of both. Side seepage will occur at a weak spot located on the side or top of the absorption area. If there is no weak spot around the absorption area, then the effluent will flow back into the dose chamber and continue to accumulate. The pump will cycle frequently and eventually the alarm will be set off indicating pump failure.

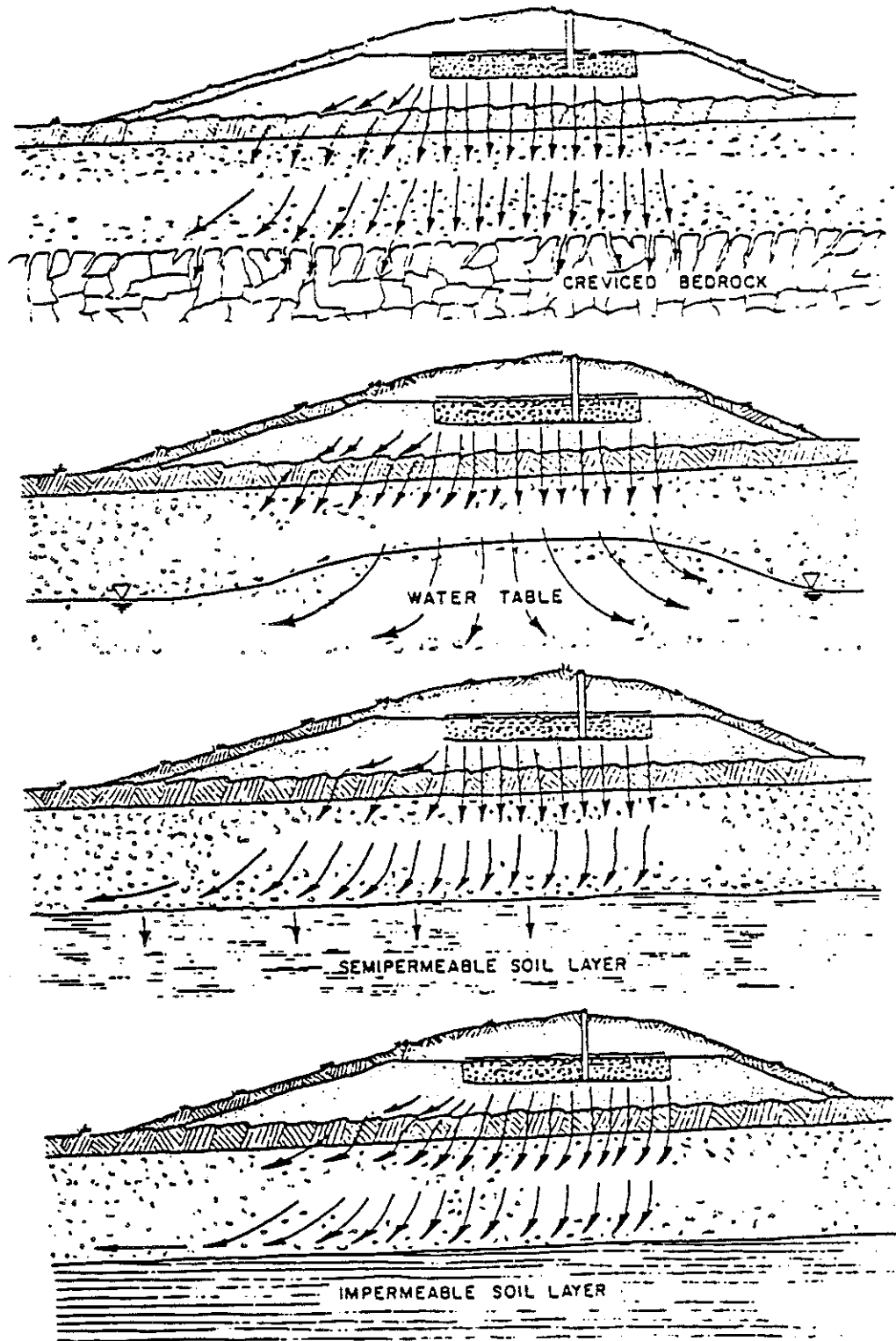


Figure 2. Effluent Movement Within and Away from Mounds Under Various Soil Profiles.

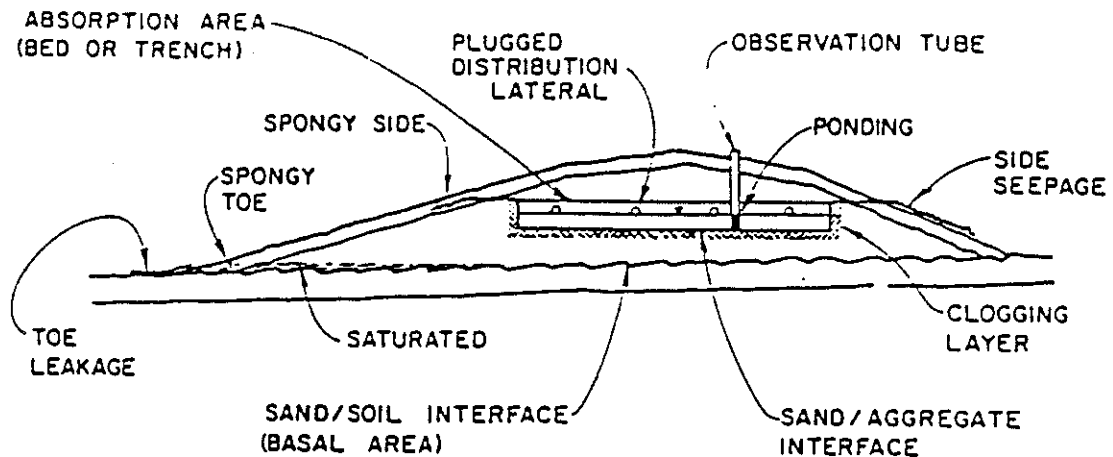


Figure 3. Cross section of Wisconsin Mound Showing Potential Problems.

Spongy side: On occasion a spongy or soft area will occur on the side of the mound near the absorption area (Fig. 3). This indicates that the soil is near saturation and there is undoubtedly ponded effluent in the absorption area.

Toe leakage: Toe leakage occurs at the downslope contact of the mound with the original soil surface. It is seen as water on the ground surface. Toe leakage occurs when the sand/soil interface (basal area) does not accept all of the wastewater moving at the sand/soil interface before it reaches the toe of the mound (Fig. 3). Table 2 gives some of the causes for the leakage. During wet weather, some leakage may occur for a few days, especially if the soil is saturated near the surface. On several occasions, leakage at the toe has occurred with the natural soil beneath the sand fill being dry. For some reason the effluent will not infiltrate into the natural soil from the saturated sand fill. Research is in progress to explain this form of leakage.

Spongy toe: A spongy or soft area may occur at the toe of the mound (Fig. 3). The sand fill in the mound near the toe is saturated indicating either insufficient basal area, too large a linear loading rate, or possibly wet weather conditions. Depending upon circumstances toe leakage may occur. (Converse and Tyler, 1985a, 1985b; and Tyler and Converse, 1985).

Excessive flowback into dose chamber: When the bed is severely ponded the pump will surcharge the absorption area and force effluent above the distribution lateral and into the overlying soil resulting in excessive flow back and possibly side seepage (Table 2).

Effluent level in dose chamber doesn't decrease: If an excessive amount of solids are carried over to the dose chamber, it is possible to plug the holes of the distribution network (Table 2). A siphon which trickles may result in the holes plugging (Converse et al., 1985; Falkowski and Converse, 1985).

Table 2. Potential Hydraulic Symptoms for Mounds and Probable Causes

SYMPTOMS	CAUSES
1. Ponding in Absorption Area	
a. Not accepting design loading	<ul style="list-style-type: none"> a) cold weather clogging b) too fine a sand fill material c) dirty aggregate forming a silt/clay layer at sand/aggregate interface d) solids carryover from tanks e) poor construction techniques resulting in stratification of the sand fractions sand fill compaction
b. Mound overloaded beyond design loading	<ul style="list-style-type: none"> a) excessive water use in the home b) ground water infiltration into collection pipes and septic tank and pump chamber
2. Side Seepage	<ul style="list-style-type: none"> a) manifestation of ponding (see above) b) non level absorption area
3. Spongy Side	<ul style="list-style-type: none"> a) manifestation of ponding but not as severe as side seepage (see above)
4. Toe Leakage	
a. Not accepting design loading	<ul style="list-style-type: none"> a) slowly permeable soils b) not sufficient basal area c) overestimated infiltration capacity of the natural soil d) poor siting e) poor construction techniques resulting in compaction of the natural soil f) too large a design linear loading rate g) weakly structured and high organic natural soil inhibiting infiltration
b. Mound overloaded beyond design loading	<ul style="list-style-type: none"> a) excessive water use in the home b) ground water infiltration into collection pipes, septic tank and dose chamber
5. Spongy Toe	<ul style="list-style-type: none"> a) manifestation of saturated toe area but not as severe as toe leakage (see above)
6. Excessive flowback into dose chamber after pump shuts off	<ul style="list-style-type: none"> a) manifestation of ponding (see above)
7. Most of effluent remains in dose chamber after pump or siphon is activated.	<ul style="list-style-type: none"> a) plugged holes in distribution pipe b) siphon malfunctioning c) faulty pump or controls d) solids carryover

METHODS AND MATERIALS

In early 1981 a list of all mound systems approved for installation was obtained from the Bureau of Plumbing and systems were randomly selected for each county in the State of Wisconsin. If the county had fewer than 10 mounds, all were used in the survey. A survey form was developed for the explicit purpose of hydraulically evaluating mound systems for most of the conditions shown in Table 2. The list of selected mounds along with the survey forms were sent to the county code administrators.

In early 1983 the list of mounds approved in 1981 and 1982 were obtained from the Plumbing Bureau, and systems randomly selected. The selected mounds from the 1981 and 1982 list, most of the mounds surveyed in 1981, and a slightly modified survey form were sent to the county code administrators.

In May 1984, 60 of the mounds surveyed in 1981, and not included in the 1983 survey, were sent out for completion, along with the survey form used in 1983. These were the mounds that had some ponding in 1981.

Wisconsin rules require each county to survey the mounds each year to evaluate performance. The survey report from the county with the largest number of mounds was obtained for 1985 and compared with the results of this survey.

RESULTS AND DISCUSSION

Table 3 gives the results of the surveys. For Survey A (1981) approximately 75% of those requested were completed and returned. For the combined B and C surveys (1983), approximately 65% of the forms were returned. For Survey D (1984) 100% of the forms were returned.

Survey A

Approximately 90 percent of the mounds installed were of the bed design. Mounds of this design are used for creviced bedrock or high water table sites. Mounds with trenches are used for slowly permeable soils. Considering the soils of Wisconsin this is very reasonable since the surface 2 ft (60 cm) of soil is generally permeable with the A horizon formed in silty loess. However, there are a many soils that are not sufficiently permeable in the B and C horizons for the in-ground soil absorption system.

The average age of the mound was slightly greater than 3 years with the oldest being 6.5 years. The average size mound served a 3 bedroom house with an average of 3.7 people per residence. Based on a water usage of 45 gpcd (170 lpcd), (Witt et al, 1975), these mounds are being loaded at the rate of 165 gpd (624 lpd), which is 37% of design, when based on an average of 3 bedrooms (Table 3). In a study reported by Converse and Tyler (1985), loading rates on experimental mound systems ranged from 29 - 82% of design with an average loading rate of 47%.

The major finding in this survey was that ponding occurred in about 20% of the beds, but 99% of the mounds did not have any side seepage. Average ponding depth in those ponded was about 5 in. (13 cm). During the evaluation

Table 3. Mound Survey on a State Wide Basis over a Several Year Period and a County Survey for One Year.

Parameter	Units	Survey ^a				
		A	B	C	D	County
Year of Survey	-	1981	1983	1983	1984	1985
Number in Survey	-	459	243	443	64	569
Average Age	yrs	3.3	5.2	1.3	6.9	- ^b
Ave. No. of People	-	3.7	3.8	3.5	4.2	-
Ave. No. Bedrooms	-	3.0	3.1	3.0	3.1	-
Mounds with Beds	%	89.6	85.2	91.6	81.5	-
No Ponding	%	80.5	90.6	90.7	19.0	95
No Side Seepage	%	99.1	98.8	98.6	90.6	-
Ave. Ponded Depth	in.	5.1	4.2	2.8	5.8	-
	cm	13.0	10.7	7.1	14.7	-
No Toe Leakage	%	99.4	99.6	100.0	95.3	99 ^c
No Spongy Area	%	98.9	98.8	97.0	79.7	100
Dose Chamber ^d	-	83.2	84.3	94.6	76.9	72.4

a: Survey A: Sent in 1981.

Survey B: The returned 1981 survey minus Survey D which were ponded in 1981. Sent out again in 1983.

Survey C: Survey of mounds built in 1981 and 1982.

Survey D: The returned 1981 survey with mounds that were ponded. Sent out again in 1984.

County: Survey done by county personnel during summer of 1985.

b: Average age unknown but age ranged from 1 to 10 years.

c: Survey unclear if leakage was at toe or side seep. Comment made that the amount was insufficient to take a sample. It was likely toe leakage as side seepage is raw septic tank effluent.

d: Dose chamber cover sufficiently above ground to exclude surface water from entering.

of the ponding depth, several of the depths were not included as it appeared that the sanitarian had measured the depths incorrectly. Any depth greater than 12 in. (30 cm) was not included in determining average depth of ponding but was included in the number of mounds ponded.

The survey was not complete enough to determine if observed ponding was due to 1) dosing just prior to inspection, 2) seasonal ponding or 3) permanent ponding. Seasonal ponding occurs over the winter months, with ponding disappearing after the temperature increases. Many of these systems are old enough that a clogging mat at the sand/aggregate interface (Fig.3) could have formed. Subsurface systems often form a clogging mat within a short period of initial operation, depending upon soil texture and loading rate.

It is conjectured, based on some field experience and analysis of sand fill, that ponding often results because the sand fill is too fine and often on the fine side of medium. Had a coarser fill been used, many of these systems probably would not have permanent ponding. Coarse sands with 20 - 30% fine, very fine sand and silt and clay may also cause ponding problems. This premise is currently being studied.

Over 99% of the mounds had no toe leakage with over 98% experiencing neither soft or spongy areas at the time of the inspection. Since the majority of the mounds were inspected during May and June and not during the wetter periods of March and April, some of the mounds may have experienced some toe leakage for a short period of time that was not observed. However, the number of mounds that may have experienced toe leakage is minimal as a large number of these mounds were installed on the more permeable soils, with mortling at least 24 in. (60 cm) (state code) below the surface. However, some of the mounds may be located on sites with mortling in the range of 15-18 in. (38-46 cm) (variance to code) from the surface. Converse and Tyler (1985a) reported some seasonal toe leakage on some experimental mounds located on sites much more restrictive than currently allowed by the code or variance to the state code and therefore more prone to leakage.

Approximately 83% of the dose chamber covers were sufficiently above the ground surface to keep surface water from flowing into the dose chamber. However 17% were not sufficiently above ground surface and surface water could have entered the dose chamber, adding excess load to the system. Water could also enter through joints in the risers but this was not evaluated.

Survey B

Two years later, the same mounds evaluated in Survey A were again inspected except for the 60 mounds ponded in 1981. The survey was completed between May and December, 1983. The average age of the mounds was 5.2 yrs with a range of 2.6 to 8.5 yr. The number of people and the number of bedrooms served by the mound was slightly higher in Survey B than in Survey A. The results show that 10% of the unponded mounds in 1981 were ponded in 1983, thus indicating that ponding may increase with time or that seasonal or intermittent ponding is common. One could expect some clogging to occur in mounds over time. Of those mounds ponded, the average ponding depth was 4.2 in. (10.7 cm) or 0.9 in. (2.2 cm) less than the average for Survey A.

However, this only includes mounds not previously ponded. The quality of sand fill may be a factor. Again the survey was unable to determine if the ponding was seasonal, permanent, or the result of dosing just prior to inspection. Over 98% of the resurveyed mounds did not experience side seep, toe seepage or soft and spongy areas, thus indicating not much change in performance except for the ponding. Approximately 84% of the dose chamber covers were sufficiently above ground surface to avoid surface flow into the dose chamber.

Survey C

Survey C, which was completed between May and December 1983 at the same time as survey B, had an average age of 15 mo. These mounds served an average of 3.5 people in 3 bedroom homes which is slightly less than Surveys A and B. Over 90% of the mounds had no ponding and over 98% experienced no side seep and 100% experienced no toe leakage. Approximately 4% had a spongy area. Average ponding depth was 2.8 in. (7.1 cm) with a range of 0.1 to 8.0 in. (0.25-20 cm). Approximately 95% of the mounds had dose chamber covers sufficiently above the ground surface indicating that contractors are more aware of proper construction than previously.

Survey D

Survey D evaluated the mounds which were ponded in Survey A (1981) and surveyed again in 1984. These mounds served an average of 4.2 people which is 0.5 people higher than in the other surveys. Using the same assumptions for loading as in Survey A, these mounds were loaded about 20 gpd (76 lpd) more than the non-ponded mounds. Instead of 100% ponded, 19% of these mounds were not ponded which is an improvement over 1981. This supports the contention that ponding is not always permanent.

Approximately 90% of these mounds had no side seepage while in the other surveys the percent of the mounds not seeping out the side was at least 98.6%. One would expect more seepage out the side, in this survey, because 90% of the mounds had ponding and those that were seeping must be some of the permanently ponded mounds.

Approximately 95% had no toe seepage but about 20% did experience some spongy areas at the toe or on the side of the mound. The survey did not differentiate between spongy areas at the toe and spongy areas on the side of the mound due to ponding. This survey also had the highest number of mounds with trenches, indicating that more of them were located on the slowly permeable soils and contributing to the higher percentage of toe leakage.

This survey showed that only 70% of the mounds had dose chambers with covers that were sufficiently above the ground surface. Thus 30% of the systems had the potential for surface water entry. This group also had the most ponding, side seepage and toe leakage. Of the 4 survey groups, this group had the highest number of people and probably loaded the highest, the least permeable soil, and gave the poorest performance in all categories.

County Survey

Table 3 also gives the results of a 1985 survey of the county with the most mounds (Morris, 1986). Of the 569 mounds surveyed, approximately 95% of the mounds did not have ponding during the time of the survey which was conducted during the summer months. There may have been some seasonal ponding but it was not evident when surveyed. It is known that mounds in this county are constructed with washed sands and in general are expected to perform better than mounds constructed with many pit run sands. About 99% of the mounds had no seepage or leakage from the mound. The survey does not differentiate side seepage from toe leakage. These results are very consistent with the findings of the state wide surveys.

The survey also showed, through interviews with the owners, (40% of the systems surveyed) that 21% of those interviewed had to have the pump replaced and 15% interviewed had float and wiring problems. These percentages are estimates as some of the homeowners were not sure if it was the pump or the controls and wiring. During the early years of mound use in Wisconsin, the quality of controls, wiring and pumps were not of the quality used today. About 16% of the mounds had rodent holes, which should not effect the performance of the mound. About 96% of those interviewed had the septic tank pumped during the last two years. Approximately 18% of the mounds showed evidence of erosion, indicating that the contractor did not effectively mulch the unit after construction.

SUMMARY AND CONCLUSIONS

Mound performance surveys were evaluated on a state wide and county basis over a several year period. The mounds were evaluated for age, number of people served, number of bedrooms served, ponding in the bed, side seepage, toe leakage, and spongy or soft areas.

Overall the mounds are performing very well. Over 99% of the mound do not have toe leakage and over 98.5% do not have side seepage due to ponding in the bed. Approximately 97% of the mounds do not have soft or spongy area near the toe or on the side of the mound and thus less than 3% of the mounds have any serious hydraulic problems.

The initial survey showed at least 80% of the mounds do not have ponding occurring at the sand/aggregate interface. There is concern about the 20% that showed ponding when inspected. More recent surveys show that over 90% of the mounds do not have any ponding. The ponding may be due to dosing just prior to inspection, seasonal ponding due to winter accumulation, or permanent ponding. Experience indicates that the sand fill used in some of the mounds is fine sand, sand which is on the fine side of medium, or coarse sand with a lot of fines. These sands can not be loaded at the recommended rates. It appears that mounds are being loaded on the average less than 50% of design. If they are loaded near design for medium sand, it appears that more of the systems will become permanently ponded and may result in more mounds having side seepage. If medium sand is used, then the recommendation is to reduce the design loading rate.

Using the design load of 1.2 gpd (5 cm/d), current recommendations are to use sand fills which are on the coarse side of medium sand or coarse sands with a minimum amount of fine, very fine and silt and clay content. ASTM C-33 sand specification (coarse to very coarse sand) may be the desired sand fill. Too coarse a sand fill may reduce the treatment capability of the mound. With the recommended change in sand fill quality, the number of mounds experiencing ponding should decrease in the future.

Thus, the Wisconsin mound system is performing hydraulically very well and is a viable system for on-site waste treatment. However it must be designed and installed properly with proper maintenance, which is no different than what is recommended for other on-site systems.

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