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SMALL SCALE WASTE MANAGEMENT PROJECT

Wisconsin Mounds for Very Difficult Sites

by

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The Wisconsin Mound System is an above grade septic tank-soil absorption system which relies on a selected sand fill and the soil to purify and to convey the treated septic tank effluent hydraulically away (Bouma et al. 1973, 1975; Converse et al. 1977).

The Wisconsin Mound System was developed in the 1970's to overcome soil and site conditions which restricted the use of the in-ground septic tank-soil absorption system (Figure 1). To insure success and acceptance, conservative soil and site limitations were placed on the Wisconsin Mound System. These limitations, with slight variations, have been incorporated into many state codes or guidelines. In the late 1970's, an experimental program was initiated to evaluate mound performance under more difficult soil-site conditions, realizing that if the program were successful it would take highly trained and experienced soil evaluators, designers, installers and regulatory personnel to successfully implement the program on a state and local level. The objectives of this research were: 1) to determine if the existing soil-site limitations on mounds were too restrictive, and 2) to determine the minimum soil-site limitations under which mounds would function while ensuring public health and minimizing environmental impact.

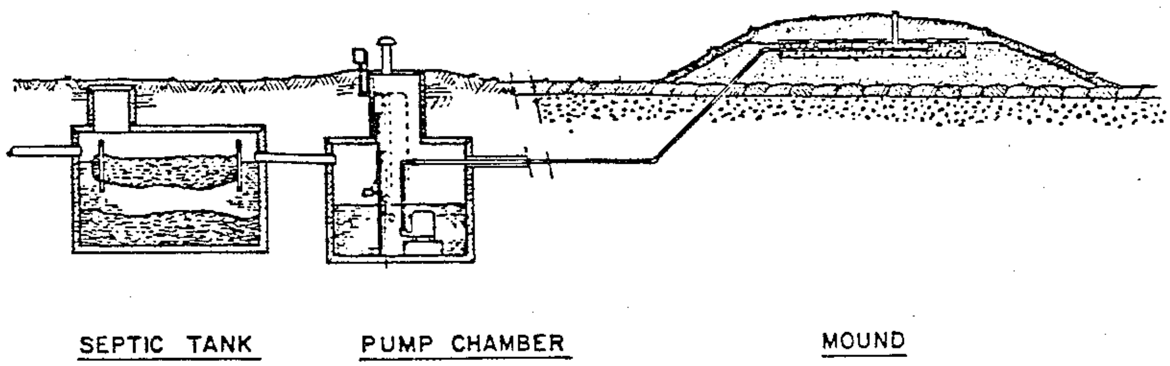

Figure 1. Components of the Wisconsin Mound System.

Mound Principles

Figure 2 shows a cross section and plan view of a mound. Design and construction procedures are found elsewhere (Converse, 1978; USEPA, 1980; Converse and Tyler, 1984). Before designing a mound, particularly for very difficult sites, the operating principles must be understood. Effluent entering the mound must leave through the soil or hydraulic failure will

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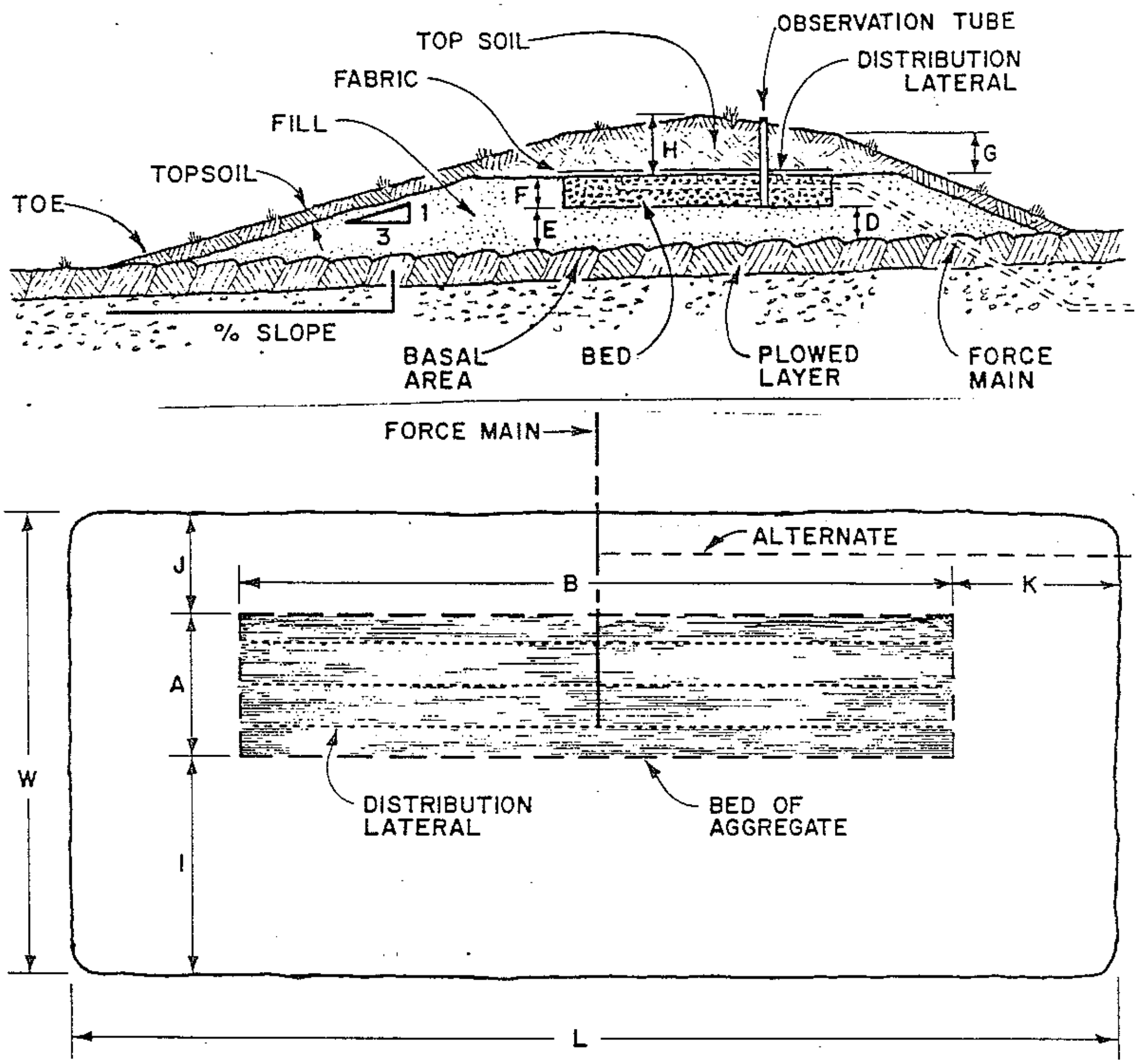

Figure 2. Detailed Cross Section and Plan View of the Wisconsin Mound.

result. Figure 3 shows the movement of effluent within and away from the mound system for several soil conditions.

The amount of bed area required in the mound depends upon the wastewater volume, the loading rate, and quality of fill. The required basal area which is the sand/soil interface beneath and downslope of the bed is dependent upon the wastewater volume and soil permeability. The linear acceptance rate is the amount of effluent that the soil is capable of moving vertically and laterally away from the system and is the sum of the vertical and toe acceptance rate. The linear loading rate is the rate wastewater is applied per unit length. If the linear loading rate exceeds the linear acceptance rate, failure will occur.

Therefore, a long narrow mound instead of a square mound may be required in order to reduce the toe loading rate to an acceptable level (Converse, 1978; Converse and Tyler, 1984). Thus these loading rates are important design parameters. Each one of these must be matched either to the mound fill or in situ soil/site conditions.

EXPERIMENTAL APPROACH

The approach used in this program was to design, construct and evaluate mound systems for private residences that had existing failing systems that did not meet code requirements. The cost of installation was borne by the homeowner with the understanding that this was an experimental program. A

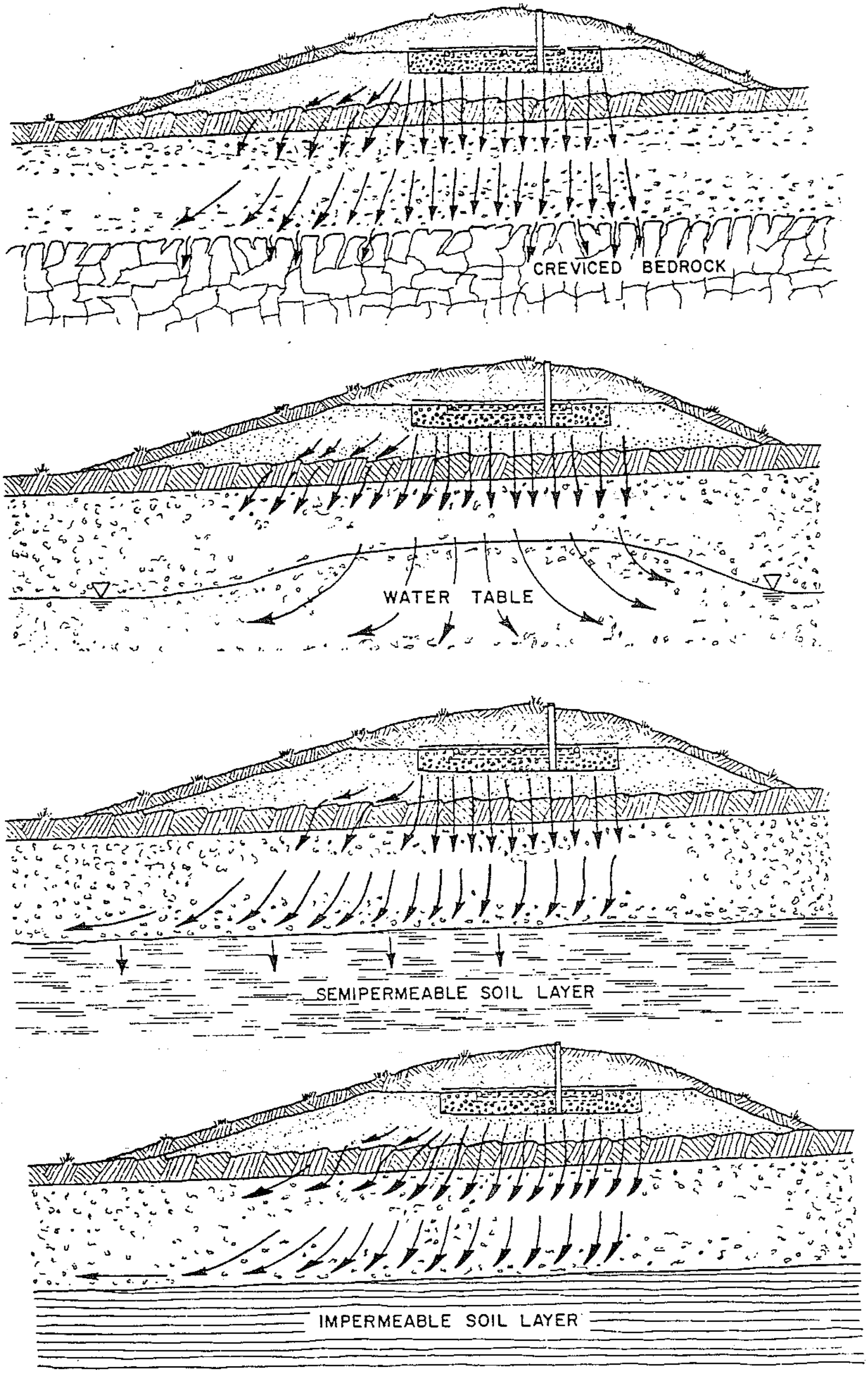

Figure 3. Schematics Showing Effluent Movement Within and Away from the Mound Under Various Soil Profiles. Figure 3a is on top; Figure 3d is on the bottom.

set of criteria was developed which helped in determining if a site was suitable for the research program. Namely, did the site fit the objectives of the research and was there a sufficient number of people in the home to generate a reasonable load on the system. Site criteria sought were: a) filled soil over natural soil, b) high water table, c) slowly permeable soils, d) steep slopes, and e) mounds over existing failing systems.

Normal institutional procedures were followed during the research. Certified Soil Testers (CST) did a site evaluation, private designers designed the systems, and state staff reviewed and approved the plans. Licensed installers installed the system, and the county sanitarian did the inspection during construction. The researchers cooperated at each stage to insure that research goals were met. In addition to the normal soil evaluation for the more difficult sites, the CST took elevations and probed the soil in a 5 m grid pattern. The purpose was to give accurate contours, check the variability of the soil, and to align the mound. Soil particle size analysis (PSA) was performed according to Soil Survey Investigations (1972).

Water meters were placed in the residence to measure the monthly effluent loading on the system and more detailed soil descriptions were prepared (Soil Survey Staff, 1981). Each year, sites were visited in the fall and spring. Observation tubes were inspected for ponding in the bed and the toe areas of the mound were probed for wetness due to lateral effluent movement. On occasion, soil, sand, fill or effluent samples were taken in the toe area for total and fecal coliform analyses, which were conducted according to Standard Methods (APHA, 1980).

RESULTS AND DISCUSSION

Site and Soil Conditions

The experimental program for mounds on more difficult sites was started in 1979. During the past five years over 40 mounds have been constructed on sites that did not fit the current site requirements or recommendations for mounds (Table 1). Eleven of the 40 sites are used as examples of the mound performance. Each system described is supported by other sites of similar or varying soil and site limitations, with these 11 mounds being on some of the most difficult sites in the program.

Site limitations in Table 1 are based on the CST reports of several borings during the initial site evaluation and also on the researchers estimates after examining the soil profile. As can be seen, many of them have more than one site limitation, such as Sites 2 and 5. Estimated seasonal high water table is present at all sites. In 7 of the 10 sites, the high water table is shallower than current recommendations.

An estimate of saturated hydraulic conductivity of A and B horizons and fill was made based on guidelines of the Soil Conservation Service (1981). Most of the surface horizons had moderate hydraulic conductivity, while 9 out of the 11 sites had B horizons of moderately low to low hydraulic conductivity. One system, which had a high hydraulic conductivity B horizon, had a seasonal perched water table at 0.38 m.

The estimated soil acceptance rates, which ranged from 0.6 to 2.0 cm/day, were used to size the basal area of the mound. These estimates were made by the CST/designer in conjunction with the researchers.

Table 2 gives a detailed description of the soils at each location based on one soil boring or pit located adjacent to the mound. These detailed descriptions were done after mound construction to confirm the CST results. Descriptions found in Table 2 may vary slightly from those found

Table 1. Current Soil and Site Recommendation and Experimental Mound Limitation Based on CST Reports of Several Borings Prior to Design.

Site	Depth to HGW[a] (m)	Depth of Fill[b] (m)	Estimated Hydraulic Conductivity[c]	Estimated Loading Rate[d] (cm/d)	Slope %	Comments[e]
			Current Recommendations[f]			
-	0.6	0	mod/mod	1	0-12	Not over old systems.
			Experimental Mound Limitations			
1	0.18	.05-.28	mod/mod low	1.1	8	Downslope basal area over old system
2	0.28	--	mod/mod low	0.8	6	--
3	0.67	.64	mod/low	1.0	5	--
4	0.36	--	mod/mod low	1.3	5	--
5	0.66	.23	mod/low	0.6	10	Bed area over old system
6[g]	0.91	--	mod/mod	0.8	18	--
7	0.38	--	mod/high	1.4	3	--
8	0.36	--	mod/mod low	0.8	4	--
9	0.41	--	mod/mod low	2.0	3	--
10	0.24	--	mod/low	1.0	4	--
11	0.20	--	mod/mod low	1.1	0	Curtain drain around system.

[a]Depth to high water table based on soil mottling.
[b]Fill is defined as soil placed on the site at some previous time.
[c]Estimated hydraulic conductivity of soil based on authors' interpretation of soil texture, structure and consistence (not reported), as per SCS guidelines (Soil Survey Staff, 1981) high-high; mod-moderate; low-low.
[d]Estimated rate at which soil should accept the septic tank effluent after it has filtered through at least one foot of sand fill; design load for basal area based on designers interpretation of soil.
[e]Old system refers to existing failing system prior to mound. All old systems were in-ground gravity trenches or beds.
[f]Current recommendations (Wisc. Adm. Code, 1980; Converse et al., 1979
[g]Site 6 had depth to bedrock at 1.1 m, all others greater than 3 m.

in Table 1 because of averaging and a slightly different location. Soil conditions range from sandy loam to silt loam in the surface horizon and from sandy loam to clay loam in the B horizon. At each site, the soil data is reported to the depth that would affect the mound performance and each mound was evaluated for both vertical and lateral water movement. For example, it is estimated that most of the wastewater at Site 10 would leave the mound laterally because the B horizon has a very low vertical hydraulic conductivity.

System Configuration: Both beds and trenches in the mounds have been recommended depending upon the permeability of the natural soil (Converse, 1978). However, based on added experience with mound systems and the dislike of trenches by contractors, trenches are no longer recommended within the mound for an individual home. Instead, the recommended mound configuration is long narrow beds, with the length/width ratio, or linear loading rate, based upon the soil hydraulic properties.

For equal wastewater volume and for sites with no restricting horizons, the length to width ratio is not as important as it is if the profile has a restricting layer (Figure 3). In Figure 3a, the basal and not the toe

Table 2. Soil Conditions of the Selected Eleven Sites.

Depth (cm)	Color	Mottles	Texture	Structure	Sand (%)	Clay (%)
Site 1: Ozaukee sil, fine, mixed, mesic, Typic hapudalf						
0 - 20	10YR 3/2		sicl	f2gr	16	30
20 - 41	5YR 4/3		sicl	vf2gr	17	40
41 - 58	5YR 4/3		cl	f-vf2abk	29	32
Site 2: Hocheim l, fine-loamy, mixed, mesic Typic Argiudoll						
0 - 13	10YR 3/2		l	m1abk&f2gr	53	17
13 - 28	10YR 3/1		sl	cs2bk&vf2gr	59	16
28 +	2.5Y 6/4	f1p	gsl	f1sbk&m1pl	57	6
Site 3: Hocheim l, fine-loamy, mixed, mesic Typic Argiudoll						
0 - 10	10YR 3/3		sil	f2gr	25	22
10 - 51	10YR 3/2 & 6/3		l	m1&2sbk&f2sbk	30	23
51 - 64	10YR 4/4 & 3/2		l	m1sbk to massive	32	20
64 +	10YR 6/4	f1p	gl	m1sbk	41	13
Site 4: Theresa Sil, fine-loamy, mixed, mesic Typic Hapludalf						
0 - 15	10YR 5/4 & 3/3		l	m1sbk&vf2sbk	38	22
15 - 36	10YR 3/3		l	c3abk&f2abk	48	11
36 - 53	10YR 5/4		sil	m1sbk&f&vf2sbk	21	20
53 +	10YR 6/4	f1p	sil	1fsbk	27	19
Site 5: Hocheim l, fine-loamy, mixed, mesic Typic Argiudoll						
0 - 15	10YR 3/3		sil	m2gr	17	18
15 - 23	7.5YR 3/4		l	f2abk	33	19
23 - 33	10YR 4/3 & 3/1		sil	f3pl	23	15
23 - 46 +	10YR 4/3	c2p	sil	m3pl	13	10
Site 6: New Glarus sil, fine-silty over clayey, mixed, mesic Typic Hapudalf						
0 - 30	10YR 2.2		sil	f2gr&f1pl		
30 - 71	10YR 5/4		sil	m3abk		
71 - 91	7.5YR 4/4		sic	m3pr&m2sbk		
91 -107	10YR 4/4	c2p	sicl	m2sbk		
107 -208	weathered dolomite					
Site 7: Colwood sil, fine-loamy, mixed, noncalcareous, mesic Typic Argiaquoll						
0 - 38	10YR 3/1		ls	vf&f1gr	78	7
38 -102	10YR 3/3	c2p	s	sg	88	4
Site 8: Pella sil, fine silty, mixed, noncalcareous mesic Tupic Haplaquoll						
0 - 8	10YR 3/2		sil	f&vf2gr	24	25
8 - 36	10 yr 3/1		sil	f&vf3gr	17	26
36 - +	10YR 6/1	m2p	sil	f&m2abk	12	22
Site 9: Drummer sil, fine silty, mixed, mesic Typic Haplaquoll						
* 0 - 18	10YR 3/2		sil	f&vf2gr	36	14
18 - 23	10YR 3/2 & 5/4		gcl	vf2sbk	42	33
23 - 46	10YR 5/4	f1p	gsl	sg	67	8
Site 10: Beecher sil, fine, illitic, mesic Udollic Ochraqualf						
0 - 6	10YR 6/4&2/1		sil	m1pl	14	22
6 - 16	5YR 3/1		sicl	f2gr	8	33
16 - 24	5YR 4/3		sicl	vf2sbk	8	38
24 - 41	10YR 5/3	c1p	sic	f2abk	9	44
41 - 66	5YR 5/1	m2p	sicl	m&f2abk	13	37
Site 11: Wauconda sil, fine-silty, mixed, mesic Udollic Ochraqualf						
0 - 20	10YR 2/1		sicl	m1abk&gr	9	34
20 - 41	10YR 2/1		sicl	f1abk	7	32
41 - +	2.5Y 5/2	m2p	sicl	f&m1bk		

Color--Munsel notation.
Mottles--Abundance: few (f), common (c), many (m); Size: fine (1), medium (2); Contrast: faint (f), distinct (d), prominent (p).
Texture--silt(y) (si), loam (l), clay (c), sandy (s), gravelly (g).
Structure--Grade: weak (1), moderate (2), strong (3); Size: very fine (vf), fine (f), medium (m); Type: platy (pl), angular blocky (abk), subangular blocky (sbk), granular (gr), single grain (sg).

loading is the limiting parameter as the effluent primarily moves vertically away from the system. In Figure 3b,c,d, the toe loading and not the basal loading is the limiting parameter as the effluent primarily moves horizontally away from the system. Thus the length to width ratio must be larger, resulting in a lower linear loading rate and thus lower toe loading.

For the 11 systems reported, the ratio of length to width ranged from 6 to 32, with a mean length to width ratio of 14. However, this ratio is only important when used to compare systems with similar soil and wastewater volumes because it is the linear loading rate, which has to be sized to the soil site conditions, which in turn determines the bed width.

Mound Characteristics and Loading

Based on the water meter readings, the actual loading to the mound ranged from 29% to 82% of the household design loading rate, with the mean and median at 47% and 48% of design, respectively (Table 3). Excluding Site 11, wastewater production averaged 208 L/d/c, which is higher than the 160 L/d/c reported by others (Witt et al. 1974). For research, it would be ideal to load these experimental units to design capacity, but realistically

Table 3. Mound System Characteristics As Used.

Syst.[a]	No.of People	Age[b] (mo)	Loading L/d	Loading %[c]	Bed[d] B m	Bed A m	Bed Ar m²	Bed Load cm/d[e]	Basal[f] I+A m	Basal Ar m²	Basal Load cm/d	Linear Load[g] L/m/d
1	4-5	14	1117	50	18.9	2.4	45.3	2.5	9.1	172	.7	59
2	4	37	1389	82	22.9	1.5	34.9	4.0	9.1	208	.7	61
3	3-5	48	772	45	19.2	1.8	35.1	2.2	9.1	174	.4	40
4	4	82	719	42	14.3	2.4	34.9	2.1	9.4	135	.5	50
5	3-6	60	995	58	22.9	1.5	34.9	2.9	12.2	279	.4	43
6	4	11	666	39	27.4	1.4	37.5	1.8	8.1	221	.3	24
7	3	25	495	29	22.9	1.5	34.9	1.4	5.5	126	.4	22
8	4	24	859	50	22.9	1.5	34.9	2.5	9.1	209	.4	38
9	5	75	813	48	14.3	2.4	34.9	2.3	6.1	87	.9	57
10	8	13	1124	50	38.1	1.2	46.5	2.4	5.2	197	.6	30
11[h]	B&A	24	882	30	18.4	1.5	27.6	1.5	5.6	103	.4	22
					21.2	1.5	31.8	1.5	6.5	137	.4	

[a]All mounds are sized for three bedrooms except at Site 1 and 10 which are sized for four bedrooms and Site 11, which is sized for a bar and apartment (B&A).
[b]Age, through October 1984.
[c]Loading rate in % of design which is 568 L/day/bedroom; based on water meter reading of water used inside the home.
[d]Bed characteristics, B-length of bed, A-width of bed, Ar is area of bed, see Figure 2.
[e]Actual loading based on water meter readings (Column 2). Design loading for sand fill is 5 cm/day.
[f]Basal characteristics, I+A = width of basal area, Ar = area of basal = B(A+I), see Figure 2. Basal length is same as bed length. Basal loading is based on actual loading (Column 4) ÷ Ar. Table 2 gives estimated design loading for A horizon.
[g]Linear loading rate (liters per linear meter per day) = actual loading in liters ÷ bed length; design linear loading rate, based on sand fill loading rate of 5 cm/d and bed width, equals 50(A) where A = bed width in m.
[h]This system consists of two parallel mounds with a curtain drain around the perimeter and between the mounds, discharging to a road ditch. The curtain drain is about 45 cm below grade and 90 cm from the mound toe.

these mounds are being loaded at about the same level as other residential on-site systems. The bed loading ranged from 1.4 to 4.0 cm/d with a design of 5 cm/d (Table 3). The basal loading ranged from 0.3 to 0.9 cm/d with the design varying from site to site because of soil variability (Table 2). The linear loading rate ranged from 22 to 61 L/m/d. The toe loading rate is very difficult to determine. It is the difference between the linear loading rate and the vertical flow in the basal area (Tyler and Converse, 1984). For Site 10, where there was very little vertical flow, the toe loading rate was 30 L/m/d, with a design flow of 60 L/m/d.

System Hydraulic Performance

Hydraulic failure in mounds can be either ponding within the bed or by leakage at the toe. Ponding within the bed, which is due to a clogging mat at the rock/sand interface, excessive bed loading, or poor quality sand fill, is not serious unless it becomes severe enough that the septic tank effluent (STE) breaks out the side of the mound or that it flows back into the pump chamber. Ponding may be seasonal or continuous. In many cases, ponding starts in the winter and disappears during mid-summer. This phenomena is probably related to inactivity of the bacteria and microflora during the cold months. Several of the experimental mounds have experienced this temporary ponding (Table 4). Several of the experimental mounds not reported here have experienced continuous ponding due to a combination of overloading or poor quality fill. In neither case did seepage or flow back to the pump chamber occur. Once the loading rate was reduced, ponding disappeared. Mound sand fill quality is currently being re-evaluated based on field experience.

Saturation at the toe sand/soil interface has occurred from time to time in eight out of these 11 experimental mounds, occurring for the most part during the wet season with a saturation depth of only a few centimeters (Table 4). Five of these eight systems have experienced some apparent leakage at the toe when surrounding soils are very wet due to snow melt and periods of heavy rain. This leakage is very clean and difficult to

Table 4. System Performance.

Site	Intermittent Ponding in Bed	Intermittent Saturation[a] at Toe	Cont. Saturation at Toe	Intermittent Leakage[b] at Toe	Cont. Leakage at Toe	Predominant Flow Direction[c]
1	-	-	-	-	-	H
2	x	x	-	x	-	H
3	-	-	-	-	-	H
4	-	x	-	x	-	H
5	x	x	-	-	-	H
6	-	-	-	-	-	V
7	-	x	-	-	-	V
8	x	x	x	x	-	H
9	-	x	-	x	-	H
10	-	x	x	x	x	H
11[d]	x	x	-	-	-	H

[a]Saturation in sand at toe did not always result in leakage through the topsoil. In most cases, it was only several centimeters in depth. Could walk on the area; may be a little soft.

[b]Leakage-Quality was very good. Very little to no odor, with bacteria count very low (Table 5). Hard to tell if it was surface water due to rain or leakage.

[c]Estimated by authors based on the estimated permeability of the A&B horizons. H-horizontal flow, V-vertical flow. The linear loading rate is another important factor.

[d]During periods of wet weather, there was flow out the curtain drain.

differentiate from rainwater. It is not at all similar to what one would expect from a failing system where no purification has taken place. At some sites the leakage was isolated to a small area along the toe, while at other sites it occurred along the total length of the toe. In at least one instance the mound was being overloaded due to groundwater leakage into the pump chamber. Others may have experienced this problem as well.

Closer evaluation of saturation and leakage shows that in almost all cases the saturation and leakage occurred at those sites where one would expect considerable horizontal flow and less vertical flow from the system. Extending the basal area downslope for most of them should reduce this problem as it would allow for more vertical flow and thus less horizontal flow, resulting in a lower toe loading.

However, Site 10 is an exception. The mound at this site has experienced toe seepage ever since it was first loaded. Hydraulically, this site is the most difficult one of all of the sites in the program. The A horizon, consisting of silt loam, ranges from 10-20 cm in depth, with a very slowly permeable clay loam horizon beneath (Table 2). Almost all of the wastewater moves laterally away from this site above the shallow A horizon.

Even though the silt loam topsoil is considered permeable, it does not appear to be accepting the STE as one would expect. Probing the toe area, the silt loam appeared to be somewhat dry, even though the sand fill above it was saturated. This same phenomenon has been found on several non-experimental mound systems which have been leaking and is currently under investigation. The other experimental mound systems with silt loam soils and occasional saturated conditions do not appear to be experiencing this phenomenon.

<u>System Treatment Performance</u>: Eight of the 11 systems have been sampled in the toe and evaluated for fecal coliforms. For the most part, the mounds did an excellent job in purifying the wastewater. Fecal coliform counts were less than 10 cols/100 ml in the soil solution or 10 cols/gram of soil (Table 5). Harkin et al. (1979) and Bouma et al. (1973) also reported good purification by the mounds. However, at Site 10, the fecal count varied from less than 10 up to 4.7×10^4 cols/100 ml from day to day and from location to location along the length of the mound for a given day. For example, on May 29, the two end samples had fecal coliform numbers in the range of 120-130, while in the middle, it was 4.7×10^4, while on other occasions it was reversed (Table 5).

Similar findings were also experienced for the surface soil just downslope of the toe, but not in the same relationship. For example, on May 29, the east toe sample had a fecal count of 130 cols/100 ml, while the east soil surface had a count of 1.3×10^4 cols/gram of soil and the middle sample experienced just the reverse. No explanation can be given for the phenomenon. Very little, if any, odor has been detected in this effluent. At site 8, some of the sand fill has turned to a grayish color and slight odor has been detected, but fecal counts have been relatively low.

<u>Performance on Difficult Sites</u>

The following comments are based on the field evaluation of over 40 mounds which have been placed on very difficult sites that do not meet current recommendations (Table 1).

<u>Filled Sites</u>: Placement of the Wisconsin Mound on filled sites has been prohibited because it was felt that an adequate soil evaluation to estimate loading rate on these filled soils could not be performed due to the variability in soil texture, density and possibly the lack of soil

structure, all of which affect permeability. However, this assumption does not appear to be the case, as Sites 1, 3 and 5, along with several others in the experimental program have performed very well.

These sites, like other sites, must be evaluated for soil texture, permeability, banding or layering, and platy structure. Additional probing between backhoe pits using a soil sampling tube or bucket auger is warranted to evaluate the variability of the fill. Mounds can be placed on fills.

High water table sites and slowly permeable soils: Eight of the 11 sites plus others in the program have estimated water tables, either seasonally or permanently, which are closer to the ground surface than currently recommended. Many of these same sites have soil permeability conditions which are restrictive. Therefore, in many cases it is difficult to separate out mound performance based on high water table from that of slowly permeable soils. In many field situations, the high water table is due to the slow permeability of the soil. At all these sites, except Site 10, the systems performed very well with only four of the sites experiencing some toe leakage which coincided with very wet weather conditions. The effluent quality of the leakage was very good (Table 5).

Table 5: Fecal Bacterial Counts.

Site	Date	Toe				Surface			
		Effluent[a] cols/100 ml			Sand[b] cols/gram	Liquid[c] cols/100 ml	Soil[d] cols/gram		
2	04/12/83		<10					<10	
	04/12/84		<10						
4	04/12/83		<10		<10	<10		<10	
	10/31/84		35						
5	04/12/83				<10				
7	04/12/83				<10			<10	
8	04/12/83		<10						
	04/10/84		<10					<1	
	10/31/84		<10						
9	04/10/84		<10		<1			<1	
10[e]	04/03/84	60	5	15			<105		<105
	05/29/84	130	4.7×10^4	120			1.3×10^4	269	9
	06/12/84	<10	<10	180			<1	30	9
	06/18/84	10	25	<10			1	2	13
	06/25/84	<10	1.5×10^4	1.5×10^3			<1	6×10^3	71
	07/12/84	<10	<10	<10					
	07/19/84	1.2×10^3	900	1×10^4			2	3	71
	08/13/84	<10	10	<10			3	1	1
11	04/12/84					<100[f]			
	03/25/84					<4			
	04/03/84					<1			
	10/21/84					<45			
	11/04/84		<10						

[a] Liquid samples taken at the toe of the mound in the saturated sand fill. Units are number of fecal coliforms per 100 ml of effluent.
[b] Sand/soil samples taken when not saturated. Units are number of fecal coliforms per gram of soil.
[c] Liquid sample taken in the soil just downslope of mound.
[d] Soil sample of surface taken just downslope of mound toe.
[e] At this site, samples were taken at the 1/4, 1/2 and 3/4 points along the mound toe with 1/4 point on east end.
[f] Samples taken from the curtain drain pipes which are located 90 cm from the toe and 45 cm below the surface.

Of the four sites which had some intermittent leakage, all had more slowly permeable B horizons than is currently recommended. Allowing for some possible leakage during extremely wet weather conditions, mounds can be placed on sites with water tables approaching 25-30 cm of the soil surface and B horizon permeabilities ranged from moderately low to low. To avoid leakage on severe sites, with very high water tables and slowly permeable soils, mounds need to be narrower than those reported.

Slopes

Several mounds have been installed with slopes of 18-21%. Unfortunately they have not been loaded very heavily. Site 6 has been loaded at 39% of design and is located on moderately permeable soil. At another site which is not reported, the mound is loaded at about 25% of design and is on a 21% slope with soil permeabilities ranging from moderate to moderately low. Both mounds are working satisfactorily. Addition research is needed to determine the relationship between loading rates, steepness and soil hydraulic properties before specific recommendations can be made. Based on this limited experience, mounds can be placed on slopes greater than the 12% currently recommended. Safety procedures for steep slope construction must be implemented to avoid injury.

Over Old Systems: Site 1 has the downslope area over the old failing soil absorption system, while at Site 5 it is beneath the bed area. At several other sites, mounds have been placed partially over old systems. In all cases, the mounds have performed very well with no seepage or saturated condition except at Site 5 where saturation is due to slowly permeable soils during wet weather. Thus, where space is limiting, mounds can be placed over old systems and will perform satisfactorily. Site preparation is the same as for all sites.

Summary

An experimental Wisconsin Mound program has been undertaken during the past six years on very difficult soil conditions. Over 40 mounds have been installed on sites which are more restrictive than the current code or recommendations.

The Wisconsin Mound has functioned satisfactorily on: 1) filled sites, 2) high water table sites where seasonal saturated conditions may come to within 25-30 cm of the ground surface, 3) on steep slopes up to 21%, 4) on slowly permeable soils with B horizon permeabilities in the moderately low to low categories, and 5) over old existing failing systems. Wisconsin mound systems, on the most severe site conditions, had some leakage during extremely wet weather, but effluent quality has been good with fecal coliform counts generally less than 10 cols/100 ml. Leakage could possibly be reduced further by making system even narrower.

The Wisconsin Mound must be long and narrow, with the mound length following the contour. If the linear loading rate, toe loading and basal loading rates are estimated based on soil texture, structure, density and permeability, mounds can be used successfully on sites which are considered very difficult and currently do not meet present code or guideline requirements for on-site wastewater disposal.

As technology advances the soil site limitation for on-site systems, as is suggested in this publication, it must be realized that the institutional and educational aspects must also be advanced. It will take more highly trained site evaluators, designers, installers, and regulatory personnel to implement and to successfully carry out the program. Without the institutional and educational aspects, the technology can not be successfully implemented.

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