THE WISCONSIN AT-GRADE SOIL ABSORPTION SYSTEM FOR SEPTIC TANK EFFLUENT

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The Wisconsin at-grade soil absorption system was developed to overcome some
site conditions that restrict the use of in-ground soil absorption systems
and to reduce the need for a Wisconsin mound system. This paper describes
the siting, design and construction of the Wisconsin at-grade system and
reports performance.

DESCRIPTION OF THE SYSTEM

Figure 1 shows a schematic of a typical Wisconsin at-grade system. It is
designed following procedures similar to in-ground or mound systems but the
bottom of the aggregate is located "at-grade" or on the tilled soil surface.
Typically the site is tilled, aggregate placed on the tilled area,
distribution pipe positioned within the aggregate, synthetic fabric spread
over the aggregate, and final soil cover placed over the system. The
at-grade unit is preceded by a pretreatment unit such as a septic tank or a
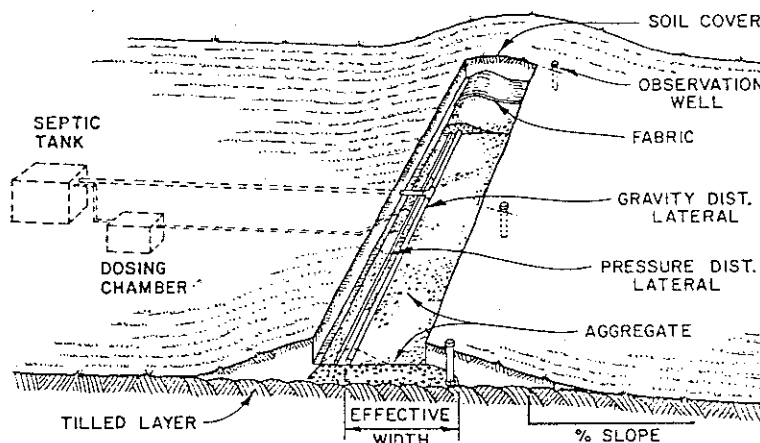septic tank and dose chamber.

Fig. 1   Schematic of the Wisconsin At-Grade System Showing Both Pressure and
          Gravity Distribution. A Dose Chamber is Required When Pressure
          Distribution (Recommended) is Used.

Soil and Site Criteria

The Wisconsin at-grade system is used on sites of intermediate soil and site conditions between those for in-ground units and the Wisconsin mound. Codes often require a separation distance between the bottom of the aggregate and the limiting soil condition (bedrock or seasonal high water table). In Wisconsin the separation distance is 90 cm (3 ft), while codes of other jurisdictions may have different depth requirements. For example, if the site has limiting conditions deeper than 90 cm (3 ft), an at-grade system may be placed on the site. If the depth is less than 90 cm (3 ft), a Wisconsin mound system may be appropriate. If the depth is substantially greater than 90 cm (3 ft), a shallow or deep in-ground system could be used. Figure 2 shows the relationships for the 4 system types and Table 1 lists the soil site limitations for the at-grade system in Wisconsin. Most codes also have limitations on soil permeability that must be followed.
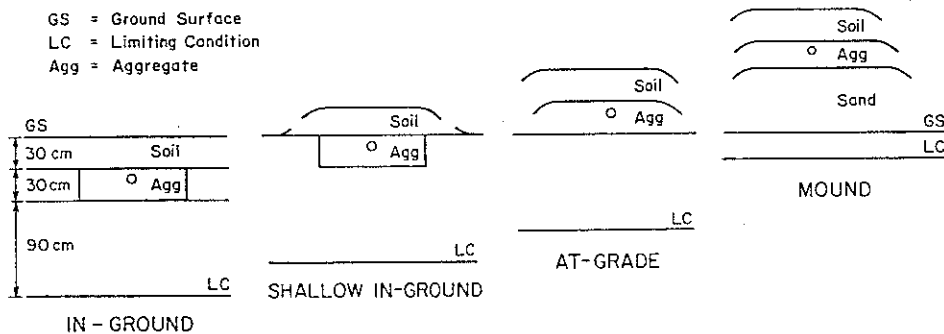

Fig. 2 Cross Sections of 4 Soil Absorption Systems in Relation to Ground Surface (GS) and Depths Using 90 cm (3 ft) as the Acceptable Separation Distance Between Aggregate (Agg) and Limiting Condition (LC)

Table 1. Soil and Site Criteria for the Wisconsin At-Grade System Used in Wisconsin

Parameter	Limit
Depth from surface to high water[a]	90 cm (3 ft)[b]
Depth from surface to bedrock	90 cm (3 ft)[b]
Surface slope	25%[c]
Permeability of soil (0-90 cm)	-[d]
Flood plain	no

[a] May be seasonal which would be estimated by mottles.
[b] Wisconsin code sets 90 cm separation distance to limiting condition.
[c] Limited experience on 25% slope. Recent systems, not reported here, have been placed on 25-30% slopes.
[d] The standard percolation test was not performed on the sites. The estimated percolation rates for the surface horizon are between 0 and 60 mpi with the majority of the sites having rates of 30 mpi or faster.

Table 2 gives the soil loading rates for the at-grade system which are similar to those often used for in-ground systems (Wisc. Adm. Code, 1983). These loading rates include a factor of safety. For example, many codes require a design loading rate of 568 Lpd/bedroom (150 gpd/bedroom) but the actual loading rate may range from 25 to 75% of that amount (Converse and Tyler, 1987). If actual loading rates are used in the design, then the design loading rates in table 2 should be reduced or increased proportionately.

Table 2. Design Loading Rates for Various Soil Morphological Conditions

Soil Morphological Condition[a]	Design Loading Rate	
	(cm/day)	(gpd/ft²)
Gravelly coarse sand and coarser.	Not Recommended	
Coarse sands but not cemented.	4.6	1.10
Medium sand with single grain structure and loose to friable consistence but not cemented.	3.7	0.90
Other sands and loamy sands with single grain or weak structure but not of extremely firm or cemented consistence; sandy loams, loams and silt loams with moderate or strong structure except platy and loose to friable consistence.	2.5	0.60
Sandy loams, silt loams and loams with weak structure and not of extremely firm or cemented consistence; sandy clay loams, clay loams and silty clay loams with moderate and strong structure but not platy and not of firm or cemented consistence.	1.7	0.40
Sandy clay loams, clay loams and silty clay loams with weak structure but not massive and not of firm or cemented consistence; some sandy clays, clays and silty clays with moderate and strong structure but not platy and not of firm or cemented consistence.	1.0	0.25
Other soils of high clay content with weak or massive structure, extremely firm or cemented consistence.	Not Recommended	

[a] Descriptions are estimates and assume that the soil does not have
   appreciable amounts of swelling clays. Soils with platy structure,
   compacted or high density should be used with care or avoided.
   does not have platy, massive structure, appreciable amounts of swelling
   clays, compacted or high bulk density.

Design Concepts

System Configuration: The system configuration must meet the soil site
criteria and also fit on the site. As with other soil absorption systems,
they should be designed long and narrow (Tyler and Converse, 1985; Converse
and Tyler, 1986). Necessary design configuration may not fit on some sites
thus requiring other alternatives. Prior to the design, the soil
evaluator/designer must evaluate the soil profile to 1) estimate the soil
acceptance rate and 2) determine the flow path of the effluent as it moves
through the soil profile and away from the system. For example, if there is a
restrictive layer such as soil banding, hardpan, or high water table, the flow
may be primarily horizontal when it reaches the restrictive layer and thus the
design must be long and narrow. If there is no restrictive layer, then the
flow will be vertical and the effective width of the system may be greater.
Unfortunately, it is very difficult to determine the exact effective width
that the system should be. A system that is too wide may leak at the
downslope toe. Other factors such as gas transfer and exchange beneath the
absorption area (aggregate/soil interface) are also affected by the width of
the system (Tyler et al., 1986).

Effective Absorption Area: The effective absorption area is the area that is available to accept effluent. The effective length of the absorption area is the actual length of the aggregate along the contour. The effective width on sloping sites is the distance from the distribution pipe to the toe of the aggregate and on level sites it is the width of the aggregate (Fig. 1).

Depending on the soil texture and other characteristics, the required absorption area can be determined using Table 2. The width is based on the linear loading rate acceptable to the site which, at this time, is based on designer experience. An effective width of 2 to 3 m (6 to 9 ft) is reasonable for most systems on permeable soils with minimum barriers restricting the vertical movement of effluent. Where restrictive subsurface boundaries or surface horizons of lower infiltration rates are encountered, the linear loading rate should be reduced and absorption widths of 1 to 1.5 m (3 to 5 ft) are more appropriate. Knowing the effective absorption area required and the effective width, the absorption length can be determined.

Total Length and Width: Once the effective length and width of aggregate/soil contact area are determined, it is necessary to add about 1.5 m (5 ft) on each side and end of the aggregate to tie the system into the existing soil surface with the cover soil. Greater widths are satisfactory if additional landscaping is desired. However, use of heavy machinery on the downslope toe should be avoided.

Distribution Network: The at-grade system can be designed for either gravity or pressure distribution. The pressure distribution network requires a dose chamber while the gravity network does not as long as the pretreatment tank outlet is at a higher elevation than the distribution network. Because of the limited experience with gravity units, pressure distribution networks are being installed in all gravity units with the manifold being stubbed just outside the unit. If gravity distribution should not function properly, or if continued research shows they do not function, the unit can be converted to pressure distribution easily.

Observation Tubes: Capped observation tubes, extending from the aggregate/soil contact to or above final grade, are placed at the toe of the aggregate. Their function is to provide easy access for determining ponding in the aggregate at the downslope toe. Seepage, the result of excessive ponding, is the most probable cause of failure which will occur at the toe of the unit.

Cover: After the aggregate, distribution pipe and observation tubes have been installed, a synthetic fabric is placed on the aggregate. Approximately 30 cm (1 ft) of soil cover is placed on the fabric and extended and tapered to a distance of at least 1.5 m (5 ft) beyond the aggregate edge. The surface is seeded to vegetation to reduce erosion.

SYSTEM PERFORMANCE

To evaluate the performance of the at-grade concept, a number of field units were installed. These were full size units that accepted all of the waste water from the home. A large number of units have been installed recently but only the first 14 units that were installed will be reported.

Soil Site Conditions

Table 3 gives the soil site conditions for the 14 units. The site descriptions were summarized from the report of the certified soil evaluator who performed the site evaluation. Seven systems were placed on silt loam, 4 on sandy loam, 2 on silty clay loam, and 1 on loamy sand. On several of these sites, the subsurface horizons are a clay loam. On most sites, the limitation was estimated high groundwater determined by soil mottles, which in most cases is the location of a less permeable horizon.

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Table 3. Summary of Soil and Site Conditions for the 14 At-Grade Systems.[a]

Site	Slope	Limitation[b]	Description by horizon: Depth, mottling, texture[c]		
1	2	42" Est. Sat	0-24" sil	24-42" cl	42"+ mot cl.
2	8	42" Est. Sat.	0-30" sil	30-42" sicl	42"+ mot sicl.
3	1	38" Est. Sat	0-20" sil	20-38" sicl	38"+ mot sicl.
4	10	36" Est. Sat.	0-18" sil	18-36" sicl	36"+ mot sicl
5	10	28" Est. Sat.	0-28" sil	28-50" mot sil	50"+ mot ls
6	12	42" Est. Sat.	0-11" sl	11-42" sl	42"+ mot. scl
7	6	37" Est. Sat.	0-37" ls		37"+ mot. ls
8	10	39" Est. Sat.	0-39" ls & s		39"+ mot s
9	0	42" banded s	0-42" sl		42-60"+ banded s
10	14	37" Est. Sat.	0-37" sil		37"+ mot. sicl
11	12	36" Est. Sat.	0-22" sil	22-36 sicl	36"+ mot. c
12	13	36" Est. Sat.	0-36" sil		36."+ mot. sil
13	19	40" Est. Sat.	0-10" sil	10-40" cl	40-54" mot. cl
14	15	38" Est. Sat.	0-4" sl	4-38" cl	38"+ mot. cl

[a] Most limiting or average soil condition of three observed soil profiles is reported. System design is based on most limiting site condition.

[b] Est. Sat. is Estimated Seasonal Saturation assuming that mottles are indicative of seasonal saturation; Banded s is banded sandy soil, some cementation of sand may be present.

[c] Mot. is soil mottling or variegations of soil colors; sil is silt loam; sicl is silty clay loam; cl is clay loam; scl is sandy clay loam; sl is sandy loam; ls is loamy sand; l is loam; s is sand; c is clay (Soil Survey Staff, 1981).

System Size and Configuration

Table 4 gives the system size and configuration. There are 5 configurations that have been used. A plan view and cross section of each are shown in Fig. 3. The preferred configuration is the long and narrow unit. Site restrictions may require using several short narrow sections to make up the total length required such as shown in configuration 3 and 4. Seven use pressure distribution and 7 have gravity distribution (two units use gravity distribution boxes as shown in Fig. 3).

Loading Rates and Age

The design loading rate on each system ranged from 1.9 cm/d (0.46 gpd/ft^2) to 3.8 cm/d (0.92 gpd/ft^2) (Table 4). On sites 1, 3, 4, 5, and 11, the system was designed so that individual portions of the system could be loaded. On site 6, the flow from the distribution box could be diverted to 3 locations in the unit. The loading rates on all of the systems ranged from 0.2 to 2.9 times the design rate. On site 11, the flow was confined to only 12% of the absorption area. The age of the systems ranges from 11 to 58 mo.

Performance

Hydraulic: All systems except site 11 have been performing satisfactorily (Table 5). There has been no seeping of effluent at the toe in 13 of the 14 sites. On site 11, seepage occurred after about a year, but as part of the experiment this unit was loaded at 2.9 times the design load (Table 4) as the flow was confined to about 12% of the absorption area. Had the flow not been confined to such a small area, seepage probably would not have occurred. Shortly after the flow was diverted to another part of the system, ponding in this section disappeared. Systems 1 and 3, both pressure distribution, do show some ponding in the half of the system that is being loaded after 58 and 44 mo. of operation, respectively. These systems have been loaded at 1.05 and

Table 4. System Characteristics for the 14 At-Grade Units

Site	Config (a)	No. Bed Rooms	No. People	Age (b)	Effective Absorption Area Area	Effective Absorption Area No. Units	Effective Absorption Area Length	Effective Absorption Area Width	Type Distr. (c)	Water Usage	Loading Rate (d) Design	Loading Rate (d) Actual	Linear Load (e) Design	Linear Load (e) Actual	Actual/Design	Used (f)
(-)	(-)	(-)	(-)	(Mo.)	(ft²)	(-)	(ft)	(ft)	(-)	(gpd)	(gpd/ft²)	(gpd/ft²)	(gpd/ft)	(gpd/ft)	(-)	(%)
1	2	3	6	58	850	2	85	5	P	280	0.53	0.66	5.29	3.29	1.24	50
2	1	2	2	50	330	1	66	5	P	197	0.91	0.60	4.55	2.98	0.66	100
3	3	3	5	44	500	2	100	2.5	P	158	0.60	0.63	1.50	1.57	1.05	50
4	4	3	9	42	1250	1	120 / 60	5.2 / 5.2	P	355	0.60	0.57	3.13	2.96	0.94	50
5	1	3	4	38	795	4	37.5	5.3	G	216	0.57	1.09	3.00	5.76	1.92	25
6	5	3	4	35	825	1	75	11	G-BOX	121	0.55	0.15	6.00	1.61	0.27	100
7	1	3	3	34	744	1	93	8	G	170	0.60	0.23	4.80	1.83	0.38	100
8	1	2	2	24	330	1	66	5	P	86	0.91	0.26	4.60	1.30	0.29	100
9	1	3	5	23	500	1	100	5	P	156	0.90	0.31	4.50	1.56	0.35	100
10	1	2	2	20	500	1	100	5	G	64	0.60	0.13	3.00	0.64	0.22	100
11g	5	4	4	16	1044	4	14.5	18	G-BOX	178	0.57	1.41	10.40	25.40	2.45	12
12	1	3	3	13	750	1	125	6	G	79	0.60	0.11	3.60	0.63	0.18	100
13	1	3	3	13	750	1	60	12.5	G	168	0.60	0.22	7.50	2.80	0.37	100
14	1	2	2	11	657	1	90	7.3	G	135	0.46	0.21	3.33	1.50	0.45	100

a See Fig. 3 for configuration of system.
b Age of system as of Oct. 1987.
c Effluent distribution in system, P is pressure distribution, G is gravity, G-Box is gravity with distribution box.
d Design loading rate on all sites was at 0.6 gpd/ft² except for sites 2, 8, 9 which was 0.90 gpd/ft².
  Site 2, a silt loam, was sized smaller due to site restrictions. Site 8 and 9, loamy sand and sandy loam, respectively,
  were sized one class higher (Wisc. Adm. Code, 1985). Site 14 was oversized for sandy loam.
e Design and Actual Linear Loading Rates.
  Values in column reflect design length and width and design flow rates of 150 gpd/bedroom.
f Used - Portion of system that is being used.
g Used an area of 7 ft long by 18 ft wide (1/2 of one unit).

CROSS   SECTIONS

Configuration 1 with cross section A

Configuration 2 with cross section B

Configuration 3 with cross section A

Configuration 4 with cross section A

DISTRIBUTION BOX

Configuration 5 with cross section A
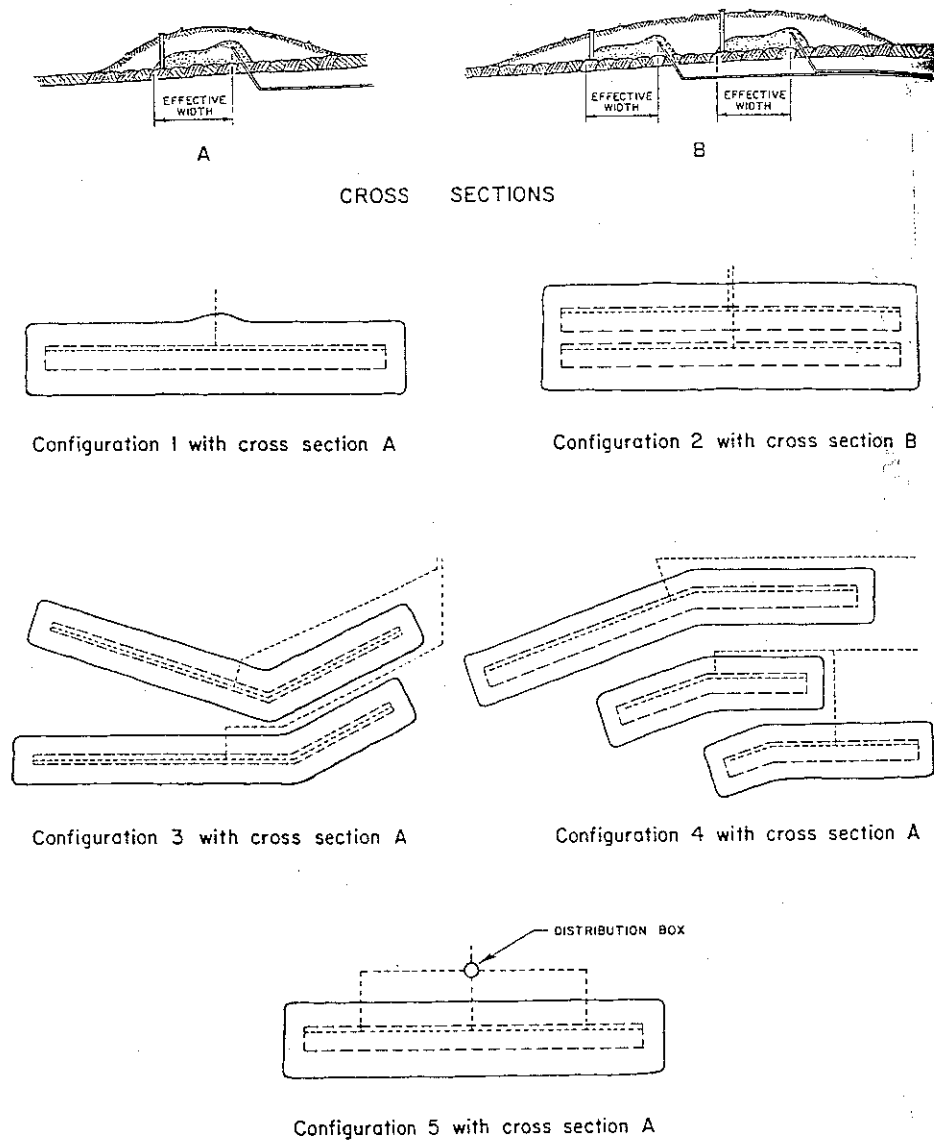
Fig. 3   Configurations of 14 At-Grades Studied.

Table 5. Performance of the Fourteen At-Grade Units

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Site	Performance

1   The upslope trench received all of the effluent for the first 4 mo.
    Two of the 3 observation tubes had about 2.5 cm (1") of effluent after
    4 mo. The flow was switched to both trenches. After 10 mo. 2 of the 3
    tubes in the upslope trench had about 3 cm (1 1/4") of water with all
    tubes in the downslope trench dry. The flow was diverted to the
    downslope trench. At least twice a year inspection over the next 42
    mo. showed no ponding in any of the tubes. During an inspection 56 mo.
    after start-up the center tube in the downslope trench had 10 cm (4
    in.) of effluent while the 2 end tubes were dry. There has been no
    seepage out the toe of this unit. Very little of the absorption area
    is ponded.

2   Based on 7 inspections over 50 months, no ponding or seepage observed.

3   During the first 4 mo. of operation both units received effluent with
    no ponding observed. During the next 22 mo. all of the effluent was
    directed to 1/2 of the system with no ponding observed during 4 visits.
    One year later, 1 cm (1/2") of effluent was observed in the middle
    observation tube while the end tubes were dry. Seven mo. later, same
    tube had about 2.5 (1") of effluent with a trace of ponding in one end
    tube.

4   One half of system has been receiving all of the effluent since the end
    of the first mo. of operation. Over the period of the next 41 mo. no
    effluent was observed in the tubes during the 7 visits made to the
    site. No soft spots or seepage were observed at the toe.

5   One fourth of the unit has received effluent by gravity from start-up.
    After 14 mo. both tubes were dry. At 20 mo. one of the tubes had 5 cm
    (2") of effluent. During the next 18 mo. (7 visits) depth in this tube
    varied from 5 to 10 cm (2 to 5") with no seepage or wetness apparent at
    toe. The ponding is confined to several feet along the toe.

6   All tubes dry during the 35 mo. period (6 visits). Flow has been
    redirected several times to either end via the gravity distribution box.

7   After 6 mo. of operation, all 3 tubes were dry. One year later, 4 cm
    (1 1/2") of effluent was ponded in the middle tube with the 2 end tubes
    dry. Similar depths of ponding continued over next 15 mo. (2 visits).
    Ponding confined to several feet along toe. End tubes are dry.

8-10   Based on 3 visits to each system over approximately 24 mo., all tubes
       are dry with no seepage or wetness observed at the toe.

11   There has been no ponding in tube after one year with effluent going to
       12% of system from start-up. One month later the tube had 17 cm (7
       in.) with some dampness in the toe. At 15 mo. surface seepage started;
       switched to another portion of system. A month later the observation
       tube was dry in previously ponded portion.

12-14   Based on 2 two inspections after start-up (about 1 year) there is no
        ponding in any tubes and no toe wetness or seepage.

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1.24 times their design loading rate. System 1 is on a sloping site and only one of the 3 observation tubes has ponding, indicating a very small portion of the absorption area is ponded. In system 3, the absorption area is level with one tube showing ponding. In this system more of the area is probably ponded.

System 5 and 7, both gravity systems, have some ponding in one of the observation tubes. In system 5, the effluent is being loaded at 1.9 times design as the flow is confined to 1/4 of the absorption area. Based on probing of the area adjacent to the tube, the ponding is confined to a small fraction of the currently used portion of the system. A similar conclusion can be stated for system 7. This localized ponding is due to poor distribution that is characteristic of gravity distribution. Localized ponding may be occurring in between the observation tubes in the other gravity systems and thus is not obvious. However, to date no wetness or spongy areas are evident along the toe of the units. None of the other systems have observed ponding.

Both gravity flow and pressure distribution are being evaluated in at-grade systems. Using gravity flow, the installation costs are less since a dose chamber is not needed. However, distribution by gravity is not very uniform along the length of the system (Converse, 1974) and localized ponding at the toe of the aggregate can occur (system 5 and 7). Typically in the gravity unit, the effluent will flow out of the distribution pipe at one or two locations and move down through the aggregate, and flow downslope at the aggregate/soil interface until it infiltrates into the soil surface. Over time the area becomes clogged as this portion of the soil is being overloaded. Eventually, ponding will occur at the toe of the aggregate at which time it starts to move horizontally along the toe of the aggregate. Thus there are large areas of the system that do not receive wastewater. In contrast, the pressure distribution network applies the effluent more uniformly along the length of the system, where the effluent moves downward through the aggregate and is absorbed by the soil as the effluent moves downslope at the aggregate soil interface.

Because of localized ponding and the lack of years of experience, the current recommendation for gravity networks is to 1) provide a means, such as a distribution box or an accessible tee at the inlet, to divert the flow to another portion of the absorption area and 2) install the pressure distribution laterals next to the gravity laterals with the force main stubbed just outside the system. If the gravity network fails, a dose chamber and force main can be installed very easily without disturbing the at-grade unit. On going research will confirm if gravity flow is a viable means of distributing effluent in at-grade systems.

Treatment Effectiveness: Five at-grade units (Sites 1, 3, 4, 5, and 7) were sampled for treatment effectiveness. Soil samples were taken beneath each of the systems, along with controls some distance from the absorption area, at 30 cm (1 ft) increments to a depth of 90 cm (3 ft). In the structured soil at 90 cm (3 ft), 11 of the 16 samples from the 4 sites showed fecal coliform counts ranging from 3 to 60 MPN/gram of soil with an average of 10 MPN per gram of soil for all 16 samples. In the one non-structured soil site, there were < 2 MPN per gram of soil of fecal coliforms found 30 cm (1 ft) below the aggregate/soil interface in four samplings. A more detailed report will be presented in another paper.

DESIGN AND CONSTRUCTION EXAMPLE

Design

When working with on-site wastewater treatment systems , the evaluator/designer must evaluate the soil site conditions and then select the

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best system for the site that meets the owner's needs and causes the least
impact on the environment. When evaluating the site the following should be
done:

1. Evaluate the landscape for surface water movement. Measure
   elevations and distances on the site so that slope, contours and
   available areas can be determined.
2. Describe several soil profiles where the system will be located.
   Determine the limiting conditions such as bedrock, high water table,
   and soil permeability.

The designer uses the information to design a system that will fit the site.
Not all sites meet the criteria for on-site soil absorption systems and an
alternative to soil absorption may be necessary.

Assume for the example the following site factors:

1. Soil profile is similar to Site 1 in Table 3.
2. Slope is 20%.
3. Distance available along the contour is 175 ft and along the slope it
   is 30 ft.
4. Design for a 3 bedroom house.

Based on the above information, it appears that an at-grade system is suited
for this site because estimated high water is at 42 in, the surface soil
horizon is permeable, and code setback requirements are assumed to be
satisfied.

Steps:

1. Determine the design daily flow rate (DDFR).

   Since this is a 3 bedroom house, use 150 gallons per bedroom or a
   design daily flow rate of 450 gpd.

2. Determine the effective absorption area (EAA) required for the site.

   Use table 2 for selecting the appropriate design loading rate (DLR)
   that matches the soil conditions. Since this is a silt loam soil
   with good structure, use a DLR = 0.6 gpd/ft^2.

   $$EAA = DDFR \div DLR$$

   $$= 450 \text{ gpd} \div 0.6 \text{ gpd/ft}^2$$

   $$= 750 \text{ ft}^2$$

3. Determine the design linear loading rate (DLLR) for the site.

   Evaluate the soil profile to estimate a design linear loading rate
   for the site. Since wastewater will move at the aggregate soil
   interface on this 20% slope, the system should be narrow to avoid toe
   seepage. Also, since the horizon is clay loam below 42", it will
   present a barrier to the vertical flow. Thus a narrower system is
   appropriate. An appropriate design linear loading rate for this site
   would be about 4 gpd/ft which is based on experience.

4. Determine the effective absorption width (EAW) of the unit.

   Since the estimated design linear loading rate is 4 gpd/ft and the
   loading rate is 0.6 gpd/ft^2 then:

$$EAW = DLLR \div DLR$$

$$= 4 \text{ gpd/ft} \div 0.6 \text{ gpd/ft}^2$$

$$= 6.7 \text{ ft}$$

This is the effective width of the aggregate. If this was on a non-sloping site, then the total aggregate width would be 6.7 ft. Since this is on a sloping site, the total aggregate width will be about 8.0 ft as approximately 1.5 to 2 ft of aggregate must be placed upslope of the distribution pipe to support the distribution network and satisfy the angle of repose of the aggregate (Fig. 1).

5. Determine the absorption length (AL) of the unit.

Since the required effective absorption area is 750 ft² then:

$$AL = EAA \div EW$$

$$= 750 \text{ ft}^2 \div 6.7 \text{ ft}$$

$$= 112 \text{ ft}$$

6. Determine the overall length (L) and width (W) of the unit.

It is necessary to tie the aggregate into the surrounding soil surface by placing a layer of soil about 5 ft wide around the perimeter of the aggregate (Fig. 1). Greater widths for landscaping purposes are satisfactory.

$$L = \text{aggregate length} + \text{soil cover end lengths}$$

$$= 112 \text{ ft} + 5 \text{ ft} + 5 \text{ ft}$$

$$= 122 \text{ ft}$$

$$W = \text{aggregate width} + \text{soil cover side widths}$$

$$= 8.0 \text{ ft} + 5 \text{ ft} + 5 \text{ ft}$$

$$= 18.0 \text{ ft}$$

7. Determine the height of the unit.

Design for a minimum of 6 in. of aggregate beneath the distribution pipe and about 2 in. above the pipe. As shown in Fig. 1, the aggregate will taper off at the edges. Place synthetic fabric over the aggregate and approximately 1 ft of soil cover over the fabric. Thus the height (H) of the unit above the original grade will be approximately 2 ft at the distribution lateral and tapering to the edges.

8. Design a distribution network for the unit.

Since the absorption area is relatively narrow and on a slope, a single distribution line along the length is satisfactory. It would be located 6.7 ft upslope of the aggregate toe. If the site was level, the distribution pipe would be located in the center of the aggregate. The distribution can either be gravity or pressure but pressure distribution is recommended.

Gravity: If gravity is used, provisions should be made so the flow can be diverted to at least 2 locations within the unit. Two vertical risers near the center inlet tee allow access to the network to close off one half the unit. Another approach is to use a distribution box as shown in Fig. 3. The gravity laterals consist of 4" perforated PVC drain pipe preferably with a center inlet. One distribution lateral along the length of the absorption area for gravity is sufficient regardless of the width of the absorption area. A pressure distribution line should be installed next to the gravity distribution line because gravity distribution in these systems have not been proven with time. If several absorption areas are installed (Fig 3, configuration 2, 3 or 4) gravity distribution is not recommended.

Pressure: Design the pressure network as per in-ground pressure networks and mound systems (Otis, 1981). Normally the network consists of a single lateral along the length of the absorption area. On wider absorption areas, some have installed several parallel laterals but only on relatively small slopes. Care must be taken to get equal distribution in the laterals if they are not at the same elevation. For a typical home size units, use a hole diameter of 1/4" spaced 30" apart which will require a 1" dia. lateral up to 30 ft long, 2" dia. lateral up to about 50 ft and a 3" dia. up to about 75 ft.

Construction

As with all soil absorption systems, proper construction is very important. The following steps should be followed when constructing the at-grade unit. There are variations to this approach, but the principles should be followed closely.

Steps:
1. Check for proper soil moisture prior to construction. If it is too wet (soil rolls into a wire) wait until it dries sufficiently well to minimize smearing and compaction.

2. Stake out the system with the length following the contour.

3. Till the area following the contour using a chisel plow. The tilled area should be at least the total length and width of the system. A mold board plow, chisel plow, or chisel teeth mounted on a backhoe bucket are satisfactory for tillage (the normal teeth on a backhoe are not satisfactory).

4. Install the inlet pipe from the pretreatment unit or dose chamber from the upslope side of the unit either prior to plowing or after plowing. If it enters from the downslope edge or the site is level, place the pipe prior to tilling. Avoid traffic on the tilled area especially beneath the aggregate area and downslope. If compaction or ruts occur in the upslope or downslope area during construction, retill the compacted or rutted area.

5. Place the three observation tubes at 1/6, 1/2, and 5/6 of the absorption length and exactly at the toe of the aggregate. The tubes must be constructed and placed so that ponded effluent at the downslope edge of the aggregate may be observed in the tubes.

6. Place the aggregate in the designated area of the tilled area, to a depth of 15 cm (6"). Work from the upslope edge of the system.

7. Place the distribution laterals level along the length of the unit and connect them to the inlet pipe from the pretreatment unit or dose chamber. Place 5 cm (2") of aggregate on top of the laterals.

8. Place non-biodegradable synthetic fabric (not building paper, burlap, hay, or straw) over the aggregate. Extend it only to the edge of the aggregate.

9. Place approximately 30 cm (12") of soil over the fabric and taper it to a distance of at least 1.5 m (5 ft) in all directions of the aggregate. Surface grade around the system to divert away surface water. Seed and mulch the exposed areas immediately after construction to control erosion.

SUMMARY AND CONCLUSIONS

An at-grade soil absorption unit has been developed for the treatment and disposal of pretreated domestic wastes. It is used on sites that are not suitable for an in-ground soil absorption unit and which exceed the requirements for a Wisconsin mound unit. It is constructed by tilling the soil, placing the aggregate and distribution system, and covering with synthetic fabric and soil.

Fourteen such units have been evaluated over a 1 to 5 year period. All systems are functioning satisfactorily using gravity or pressure distribution. Long term performance especially using gravity distribution is still under study.

Soil treatment beneath these systems has been very satisfactory with less than 2 MPN of fecal coliforms per gram of soil at 90 cm (3 ft) in non-structured soils. In structured soils slightly higher numbers were found.

REFERENCES

1. Converse, J.C.. 1974. Distribution of domestic waste effluent in soil absorption beds. Trans. of the ASAE 17: 299-304.

2. Converse, J.C. and E.J. Tyler. 1986. The Wisconsin mound system, siting, design, and construction. #15.13. Small Scale Waste Management Project. 240 Agriculture Hall, University of Wisconsin - Madison.

3. Converse, J.C. and E.J. Tyler. 1987. On-site wastewater treatment using Wisconsin mounds on difficult sites. Trans. of the ASAE 30: 362-368.

4. Otis, R.J.. 1981. Design of pressure distribution networks for septic tank-soil absorption systems. #9.6. Small Scale Waste Management Project. 240 Agriculture Hall, University of Wisconsin - Madison.

5. Soil Conservation Service. 1981 Examination and description of soils in the field. Ch. 4. Soil survey Manual. USDA-SCS. U.S. Government Printing Office. Washington, D.C.

6. Tyler, E.J. and J.C. Converse. 1985. Soil evaluation and design selection for large or cluster wastewater soil absorption systems. In. On-Site Treatment. Proceedings of the Fourth National Symposium on Individual and Small Community Sewage Systems. ASAE. St. Joseph, Mi. 49085.

7. Tyler, E.J., J.C. Converse, and D.E. Parker. 1986. Soil systems for community wastewater disposal-treatment and absorption case histories. Proceedings of Workshop on Disposal and Treatment of Waste on Land. Soil Science Society of America, Madison, Wi. 53711.

8. Wisconsin Administrative Code. 1985. Private sewage systems. Chapter ILHR 83. Bureau of Plumbing, Department of Industry, Labor and Human Relations. State of Wisconsin, Madison.