Soil Survey Reports Residential Development
Michigan State University Extension Service
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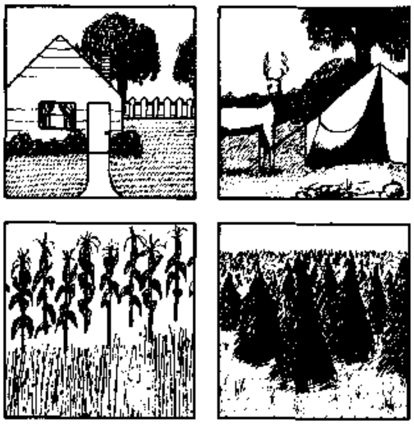

Soil Survey Reports

RESIDENTIAL DEVELOPMENT

By G. Lemme and W. Cook***
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Introduction

This bulletin is one of a series dealing with the use of soil survey information for wise resource management. The use of soil survey information for making decisions on the suitability of a location for residential and small commercial development will be explored in this bulletin. If you are unfamiliar with the type of information included in a soil survey report or how to interpret it, consult either *Soil Survey Reports: Using Available Information* (E-1586) or the inside cover of a soil survey report published after 1978.

The Ingham County Soil Survey Report has been used as an example throughout this series of bulletins. For definitions of unfamiliar terms, consult the glossary of technical terms in the soil survey report.

Soilscape parameters are important to consider when evaluating a potential building site or an existing structure. Many soil limitations can be overcome by special planning and design. However, these structural modifications add to the cost of construction and maintenance. Information within the soil survey report can be a guide to the severity of many soil limitations associated with different soils.

The scale of the maps published in a soil survey report does not allow a soil scientist to locate all soil differences that occur within a landscape. Some soils occur in such small areas that their delineation on a map is impossible. In other situations, the intricate pattern of soils necessitates that two or more soils be mapped together as one unit. The description of the mapping units that occur within an area of interest should be consulted to see what soils, in addition to the major ones, are commonly found within those units. Because of the smallness of many lots compared to the scale of the soil maps, onsite inspection of the soils on a building site is necessary to identify the types occurring in an area.

Building Site Development

The degree and kind of soil limitations that affect shallow excavations, dwellings with and without basements, small commercial buildings, local roads, lawns and landscaping are given in tabular form in soil survey reports. A *slight* limitation indicates that soil properties generally are favorable for the specified use; slight limitations are minor and easily overcome. A *moderate* limitation indicates that soil properties and site features are unfavorable for the specified use, but the limitations can be overcome or minimized by special planning and design. A *severe* limitation indicates that one or more soil properties or site features are so unfavorable or difficult to overcome that a major increase in construction effort, special design, or intensive maintenance is required. For some soils rated severe, such costly measures may not be feasible.

Shallow excavations are made for pipelines, sewerlines, communications and power transmission lines, basements, and open ditches. Such digging or trenching is influenced by soil wetness

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caused by a seasonal high water table; the texture and consistence of soils; the tendency of soils to cave in or slough; and the presence of very firm, dense soil layers, bedrock, or large stones. In addition, excavations are affected by the slope of the soil and the probability of flooding. Ratings do not apply to soil horizons below a depth of six feet unless otherwise noted.

In the soil series descriptions, the consistence of each soil horizon is given. Very firm or extremely firm horizons are usually difficult to excavate. This limitation is indicated.

Dwellings and small commercial buildings as indicated in soil survey reports, are built on undisturbed soil and have foundation loads of dwellings no more than three stories high. Separate ratings are made for small commercial buildings without basements and for dwellings with and without basements. For such structures, soils should be sufficiently stable so that cracking or subsidence of the structure from settling or shear failure of the foundation does not occur.

These ratings are determined from estimates of the shear strength, compressibility, and shrink-swell potential of the soil. Soil texture, plasticity and inplace density, soil wetness, and depth to a seasonal high water table were also considered. Soil wetness and depth to a seasonal high water table indicate potential difficulty in providing adequate drainage for basements, lawns, and gardens. Depth to bedrock, slope, and large stones in or on the soil are also important considerations in the choice of sites for these structures and were considered in determining the ratings. Susceptibility to flooding is a serious hazard.

Local roads and streets, as indicated in soil survey reports, have an all-weather surface that can carry light to medium traffic all year. They consist of a subgrade of the underlying soil material; a base of gravel, crushed rock fragments, or soil material stabilized with lime or cement; and a flexible or rigid surface, commonly asphalt or concrete. The roads are graded with soil material at hand, and most cuts and fills are less than six feet deep.

The load supporting capacity and the stability of the soil as well as the quantity and workability of fill material available are important in design and construction of roads and streets. The classifications of the soil and the soil texture, density, shrink-swell potential, and potential frost action are indicators of the traffic supporting capacity used in making the ratings. Soil wetness, flooding, slope, depth to hard rock or very compact layers, and content of large stones affect stability and ease of excavation.

Lawns and landscaping require soils that are suitable for the establishment and maintenance of turf and ornamental trees and shrubs. The best soils absorb water readily, hold sufficient moisture for plant growth, remain firm after rains, and are not dusty when dry. The surface layer should be free of stones. If shaping is required, the soils should be thick enough over bedrock or hardpan to allow for necessary grading. In rating the soils, the availability of water for sprinkling is assumed.

Sanitary Facilities

Favorable soil properties and site features are needed for proper functioning of septic tank absorption fields and sewage lagoons. The nature of the soil is important in selecting sites for these facilities and in identifying limiting soil properties and site features to be considered in design and installation. Also, soil properties that affect ease of excavation or installation of these facilities will be of interest to contractors and local officials. The degree and kind of limitations of each soil for such uses and for use of the soil as daily cover for landfills is given in soil survey reports. It is important to observe local ordinances and regulations.

If the degree of soil limitation is expressed as *slight*, soils are generally favorable for the specified use and limitations are minor and easily overcome; if *moderate*, soil properties or site features are unfavorable for the specified use, but limitations can be overcome by special planning and design; and if *severe*, soil properties or site features are so unfavorable or difficult to overcome that major soil reclamation, special designs, or intensive maintenance is required. Soil suitability is rated by the terms, *good*, *fair*, or *poor*, which are comparable to the terms, *slight*, *moderate*, and *severe*, respectively.

Septic tank absorption fields are subsurface systems of tile or perforated pipe that distribute effluent from a septic tank into the natural soil. Only the soil horizons between depths of 18 and 72 inches are evaluated for this use. The soil properties and site features considered are those that affect the absorption of the effluent and the construction of the system.

Properties and features that affect absorption of the effluent are permeability, depth to seasonal high water table, depth to bedrock, and susceptibility to flooding. Stones, boulders, and shallowness to bedrock interfere with installation. Excessive slope can cause lateral seepage and surfacing of the effluent. Also, soil erosion and soil slippage are hazards if absorption fields are installed on sloping soils.

In some soils, loose sand and gravel or fractured bedrock is less than four feet below the tile lines. In these soils the absorption field does not adequately filter the effluent, and ground water in the area may be contaminated.

On many of the soils that have moderate or severe limitations for use as septic tank absorption fields, a system to lower the seasonal water table can be installed or the size of the absorption field can be increased so that performance is satisfactory.

Sewage lagoons are shallow ponds constructed to hold sewage while aerobic bacteria decompose the solid and liquid wastes. Lagoons have a nearly level floor and cut slopes or embankments of compacted soil material. Aerobic lagoons generally are designed to hold sewage within a depth of two to five feet. Nearly impervious soil material for the lagoon floor and sides is required to minimize seepage and contamination of ground water. Soils that are very high in content of organic matter and those that have cobbles, stones, or boulders are not suitable. Unless the soil has very slow permeability, contamination of ground water is a hazard where the seasonal high water table is above the level of the lagoon floor. In soils where the water table is seasonably high, seepage of ground water into the lagoon can seriously reduce the lagoon's capacity for liquid waste. Slope, depth to bedrock, and susceptibility to flooding also affect the suitability of sites for sewage lagoons or the cost of construction. Shear strength and permeability of compacted soil material affect the performance of embankments.

Engineering Properties

Some of the engineering properties given in soil survey reports influence building site suitability. These properties have been used in determining the degree of limitation of soils for the uses discussed previously.

Many soils have, within the upper five or six feet, horizons of contrasting properties. The soil survey report gives information for each of these contrasting horizons in a typical profile. Depth to the upper and lower boundaries of each horizon is indicated. More information about the range in depth and about other properties in each horizon is given for each soil series under "Soil series and morphology" in the "Formation of the soils" section of soil survey reports.

Texture is described in the soil survey report in the standard terms used by the USDA. These terms are defined according to percentages of sand, silt, and clay in soil material that is less than two millimeters in diameter. Loam, for example, is soil material that is seven to 27 percent clay, 28 to 50 percent silt, and less than 52 percent sand. If a soil contains gravel or other particles coarser than sand, an appropriate modifier is added, for example, gravelly loam. Other textural terms are defined in the glossary section of the soil survey report.

Liquid limit and plasticity index indicate the effect of water on the strength and consistence of soil. These indices are used in both the Unified and AASHTO soil classification systems. They are used as indicators in making predictions on soil behavior.

Physical and Chemical Properties

In all soil survey reports, the estimated values for several soil characteristics and features that affect behavior of soils in engineering uses are given for each major horizon, at the depths indicated, in a typical pedon or representative profile of each soil. The estimates are based on field observations and on test data for these and similar soils.

Permeability is estimated on the basis of known relationships among soil characteristics observed in the field — particularly soil structure, porosity, and texture — that influence the downward movement of water in the soil. The estimates are for vertical water movement when the soil is saturated. Not considered in the estimates is lateral seepage or such transient soil features as plowpans and surface crusts. Permeability of the soil is an important factor to consider when planning a septic tank absorption or other waste disposal system.

Shrink-swell potential depends mainly on the amount and kind of clay in the soil. Laboratory measurements of the swelling of undisturbed clods were made for many soils. For others the swelling was estimated on the basis of the kind and amount of clay in the soil and on measurements of similar soils. The size of the load and the magnitude of the change in the soil moisture content also influence the swelling of soil. Unless special designs are used, shrinking and swelling of some soil can cause damage to building foundations, basement walls, roads and other structures. A high shrink-swell potential indicates that special design and added expense may be required if the planned use of the soil will not tolerate large volume changes.

Soil and Water Features

Soil survey reports contain information helpful in planning land uses and engineering projects that are likely to be affected by soil and water features.

Hydrologic soil groups are used to estimate runoff from precipitation. Soils not protected by vegetation are placed in one of four groups on the basis of the intake of water after the soils have been wetted and have received precipitation from long-duration storms:

Group A. Soils having a high infiltration rate (low runoff potential) when thoroughly wet. These consist chiefly of deep, well-drained to excessively-drained sands or gravels. These soils have a high rate of water transmission.

Group B. Soils having a moderate infiltration rate when thoroughly wet. These consist chiefly of moderately deep or deep, moderately well-drained, or well-drained soils that have moderately fine texture to moderately coarse texture. These soils have a moderate rate of water transmission.

Group C. Soils having a slow infiltration rate when thoroughly wet. These consist chiefly of soils with a layer that impedes the downward movement of water or soils with moderately fine texture or fine texture. These soils have a slow rate of water transmission.

Group D. Soils having a very slow infiltration rate (high runoff potential) when thoroughly wet. These consist chiefly of clay soils that have a high shrink-swell potential, soils that have a permanent high water table, soils that have a claypan or clay layer at or near the surface, and soils that are shallow over nearly impervious material. These soils have a very slow rate of water transmission.

Flooding is the temporary covering of soil with water from overflowing streams or with runoff from adjacent slopes. Water standing for short periods after rains or after snow melts is not considered flooding, nor is water in swamps and marshes. Flooding is rated in general terms that describe the frequency and duration of flooding and the time of year when flooding is most likely. The ratings are based on evidence in the soil profile of the effects of flooding, namely, thin strata of gravel, sand, silt, or, in places, clay deposited by floodwater; irregular decrease in organic-matter content with increasing depth; and absence of distinctive soil horizons that form in soils of the area that are not subject to flooding. The ratings are also based on local information about floodwater levels in the area, the extent of flooding and on information that relates the position of each soil on the landscape to historic floods.

The generalized description of flood hazards is of value in land-use planning and provides a valid basis for land-use restrictions. The soil data are less specific, however, than those provided by detailed engineering surveys that delineate flood-prone areas at specific flood frequency levels.

High water table is the highest level of a saturated zone more than six inches thick for a continuous period of more than two weeks during most years. The depth to a seasonal high water table applies to undrained soils. Estimates are based mainly on the relationship between grayish colors or mottles in the soil and the depth to free water observed in many borings made during the course of the soil survey. The depth to the seasonal high water table; the kind of water table, i.e., perched or apparent; and the months of the year that the water table commonly is high are included in soil survey reports. Only saturated zones above a depth of five or six feet are indicated.

Information about the seasonal high water table helps in assessing the need for specially designed foundations, specific kinds of drainage systems, and footing drains to insure dry basements. Such information is also needed to decide whether or not construction of basements is feasible and to determine how septic tank absorption fields and other underground installations will function. Also, a seasonal high water table affects ease of excavation.

Subsidence is the settlement of organic soils containing semifluid layers. Initial subsidence generally results from drainage. Total subsidence is initial subsidence plus the slow sinking that occurs over a period of several years as a result of the oxidation or compression of organic material.

Potential frost action refers to the likelihood of damage to pavements and other structures by frost heaving and low soil strength after thawing. Frost action results from the movement of soil moisture into the freezing temperature zone in the soil causing ice lenses to form. Soil texture, temperature, moisture content, porosity, permeability, and content of organic matter are the most important soil properties affecting frost action. It is assumed that the soil is not covered by insulating vegetation or snow and is not artificially drained. Silty and clayey soils that have a high water table in winter are most susceptible to frost action. Well-drained, very gravelly or sandy soils are the least susceptible.

Risk of corrosion pertains to potential soil-induced chemical action that dissolves or weakens uncoated steel or concrete. The rate of corrosion of uncoated steel is related to soil moisture, particle-size distribution, total acidity, and electrical conductivity of the soil material. The rate of corrosion of concrete is based mainly on the sulfate content, texture, and acidity of the soil. Uncoated steel intersecting soil boundaries or soil horizons is more susceptible to corrosion than an installation that is entirely within one kind of soil or within one soil horizon.

Windbreaks and Environmental Plantings

Windbreaks are established to protect buildings, yards, fruit trees and gardens from wind and snow. They also furnish habitat for wildlife. Several rows of low- and high-growing broad-leaved and coniferous species provide the most protection.

Environmental plantings reduce noise and help to beautify and screen houses and other buildings. The plants, mostly evergreen shrubs and trees, are closely spaced. A healthy planting stock of suitable species planted properly on a well-prepared site and maintained in good condition can insure a high degree of plant survival.

The height that locally grown trees and shrubs are expected to reach on various kinds of soil in 20 years is given in soil survey reports. The estimates are based on measurements and observation of established plantings that have been given adequate care. They can be used as a guide in planning windbreaks and screens.

Additional information about planning windbreaks and screens and the planting and care of trees can be obtained from local offices of the Soil Conservation Service, the Soil Conservation District, or the Cooperative Extension Service or from a nursery.

Example

Using the example area, NW 1/4 of section 24, T4N, R1W, in Ingham County, consider the potential of the area for single resident homes with basements but without a public sewage system. The soil mapping units listed in Table 1-A are found in the area. If you are evaluating a personal example, record the information in Table 1-B.

Several soils have severe limitations for a particular use but for a variety of different reasons. Both the Aurelius muck (Au) and Sisson fine sandy loam, six to 12 percent slope (SnC) have severe limitations for dwellings with basements. Very different design requirements would be necessary to minimize the limitations of the two soils.

The limitations of each soil and measures required to minimize them can be better understood by studying some of the other tables. USDA texture, liquid limit, and plasticity index for the Aurelius and Sisson soils have been recorded in Table 2-A. Look up the values for the soils in your example area (Table 2-B) or locate the information if you are following along with our example.

Table 1-A.

Map Symbol	Dwellings With Basements	Local Roads and Streets	Lawns and Landscaping	Septic Tank Absorption Fields	Sewage Lagoon
Ad	Sev 4, 2, 11	Sev 4, 2, 11	Sev 1, 2, 11	Sev 2, 11	Sev 2, 6, 11
Au	Sev 2, 11	Sev 2, 3, 11	Sev 1, 2, 11	Sev 2, 9, 11	Sev 11
CaA	Sev 11	Sev 3, 4	Mod 11	Sev 5, 11	Sev 11
Co	Sev 2, 11	Sev 2, 3, 11	Sev 2, 11	Sev 2, 11	Sev 11
Gr	Sev 2, 11	Sev 2, 11	Sev 2, 11	Sev 2, 11	Sev 6, 11
Hn	Sev 2, 4, 11	Sev 2, 4, 11	Sev 1, 2, 11	Sev 2, 5, 11	Sev 2, 6, 11
KbA	Sev 11	Sev 3, 4, 11	Mod 11	Sev 11	Sev 11
Ln	Sev 2, 11	Sev 2, 4, 11	Sev 2, 11	Sev 2, 5, 11	Sev 11
MaB	Mod 4, 11	Sev 4	Sli	Sev 5, 11	Sev 11
MaC	Mod 4, 8	Sev 4	Mod 8	Sev 5	Sev 8
MtB	Mod 4, 7	Mod 3	Mod 10	Sev 5	Sev 6
Na	Sev 4, 2, 11	Sev, 2, 4, 11	Sev 1, 2, 11	Sev 2, 11	Sev 1, 6, 11
OwB	Mod 7, 4	Sev 4	Sli	Sev 5	Mod 8
	Mod 4, 11	Sev 4	Sli	Sev 5, 11	Sev 11
SnB	Mod 4, 7	Sev 4	Sli	Sli	Mod 6, 8
SnC	Mod 4, 7, 8	Sev 4	Mod 8	Mod 8	Sev 8
SpB	Sli	Sli	Mod 10	Sli	Sev 6
SpC	Mod 8	Mod 8	Mod 8, 10	Mod 8	Sev 6, 8
ThA	Sev 11	Mod 3, 11	Mod 10, 11	Sev 11	Sev 6, 11

Type of Limitation

1. excess humus
2. floods
3. frost action
4. low strength
5. percs. slowly
6. seepage
7. shrink-swell
8. slope
9. subsides
10. too sandy
11. wetness

Degree of Limitation

Sev = Severe
Mod = Moderate
Sli = Slight

Table 1-B. Personal Example

Map Symbol	Dwellings With Basements	Local Roads and Streets	Lawns and Landscaping	Septic Tank Absorption Fields	Sewage Lagoon

Table 2. Some Engineering Properties and Classifications

Soil Map Symbol	Depth Inches	USDA Texture	Liquid Limit	Plasticity Index
Au	0-9	Sapric material	—	—
	9-13	Coprogenous earth	—	—
	13-30	Marl	—	—
	30-60	Stratified sand to clay loam	40	NP-10
SnC	0-8	Fine sandy loam	28	NP-10
	8-29	Loam, clay loam, silt loam	18-40	7-25
	29-60	Stratified silt loam to fine sand	35	NP-15

Table 2-B. Some Engineering Properties and Classifications Personal Example

Soil Map Symbol	Depth Inches	USDA Texture	Liquid Limit	Plasticity Index

Permeability and shrink-swell potential information was used in determining the limitations for septic absorption fields and dwellings with basements, respectively. Table 3-A gives this information for Aurelius muck and Sisson fine sandy loam, 6 to 12 percent slope. If you are evaluating a different example, record the information in Table 3-B.

Table 3-A. Some Physical and Chemical Properties of Soils

Soil Map Symbol	Depth Inches	Permeability in/hr	Shrink-Swell Potential
Au	0-9	0.2 -6.0	—
	9-13	0.06-0.2	—
	13-30	0.06-0.2	—
	30-60	0.6 -2.0	low
SnC	0-8	0.6 -2.0	low
	8-29	0.6 -2.0	moderate
	29-60	0.6 -2.0	low

Table 3-B. Some Physical and Chemical Properties of Soils Personal Example

Soil Map Symbol	Depth Inches	Permeability in/hr	Shrink-Swell Potential

Hydrologic group, flooding, water table and subsidence information is valuable for the interpretation of a site for residential development. The hydrologic groups are explained under "soil and water features" in the soil properties section of the report. This information has been recorded in Table 4-A for two of the soils in the sample area. If you are using a personal sample, fill in the information in Table 4-B.

The Aurelius muck had severe limitations for dwellings with basements because of subsidence and wetness, while the Sisson fine sandy loam, six to 12 percent slope, had moderate limitations because of low strength, shrink-swell, and slope.

The Aurelius soil, because of its topographic position, is subject to frequent flooding for long periods of time from September to May. Associated with the flooding hazard is the occurrence of a seasonal water table within one-half foot of the surface between the months of September and June. Drainage of the site to lower the water table would result in subsidence or settling of the soil surface. The largest magnitude of change in surface elevation would occur initially due to volume changes caused by the removal of water by the drainage system. Oxidation of the organic material would be responsible for the remainder of the total subsidence. Attempts to overcome these soil and site limitations would be extremely difficult and expensive.

Design changes are possible in the case of the Sisson soil. The low strength and shrink-swell limitations can be minimized by structural modifications to the foundation. Surface shaping during and after construction can reduce the slope limitations. These changes will add to the construction cost of a dwelling or commercial building but would allow the desired use of this soil.

The degree of limitation of the various mapping units for dwellings with basements and septic tank absorption fields are shown in Figures 1 and 2. The distribution of the mapping units and their degree of limitation can influence the use of an area. A relatively large area of Spinks loamy sand, zero to six percent slopes (SpB), has slight limitations for the proposed development. Some of the other mapping units with moderate limitations could be developed with structural and site modifications. The suitability of soils with more than slight limitations should be checked by the local health department prior to development of structures using on-site sewage disposal systems.

Figures 3 and 4 illustrate the relationship between natural soil drainage classes and the suitability of dwellings with basements. The importance of sump pumps and other structural modifications to overcome wetness limitations is illustrated in this figure.

Table 4-A. Soil and Water Features

Map Symbol	Hydrologic Group	Flooding			Water Table		
		Frequency	Duration	Months	Depth	Months	Subsidence
					ft.		
Au	B/D	frequent	long	Sept.-May	0-0.5	Sept.-June	7-23
SnC	B	none	—	—	6.0	—	—

Table 4-B. Soil and Water Features
Personal Example

Map Symbol	Hydrologic Group	Flooding			Water Table		
		Frequency	Duration	Months	Depth	Months	Subsidence

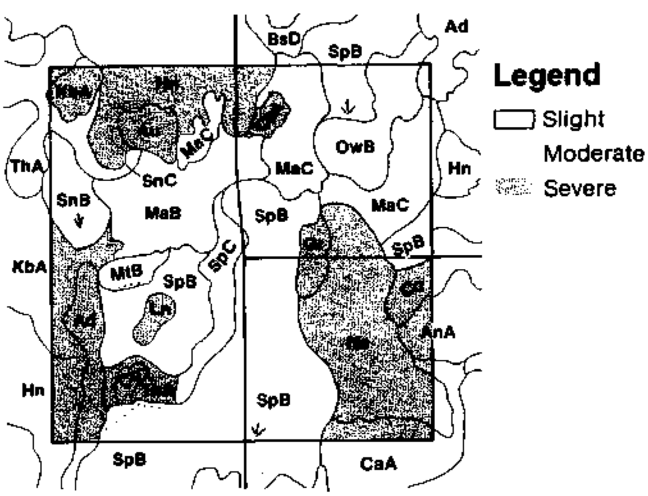


Fig. 1. Limitation map for dwellings with septic tank absorption fields.

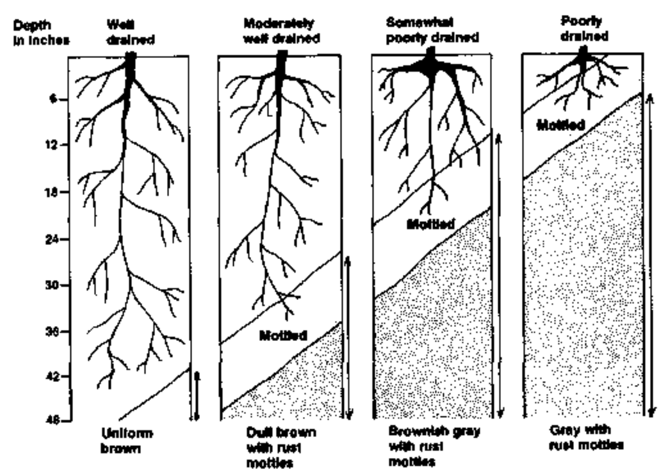


Fig. 3. Morphological characteristics of soil in each of the natural drainage classes. Arrows indicate zone of fluctuating water table.

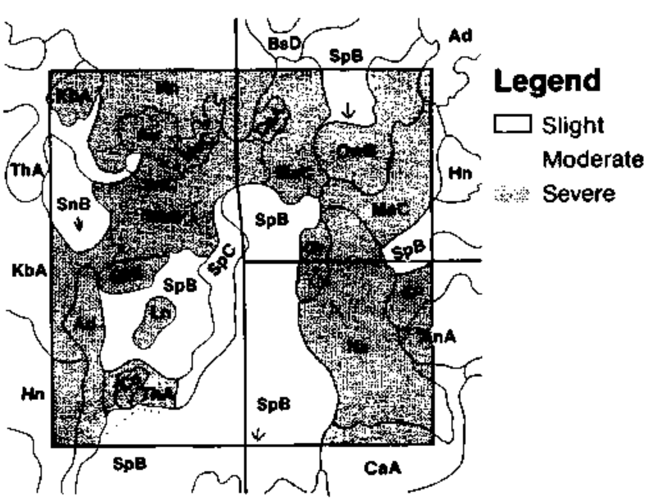


Fig. 2. Limitation map for dwellings with basements.

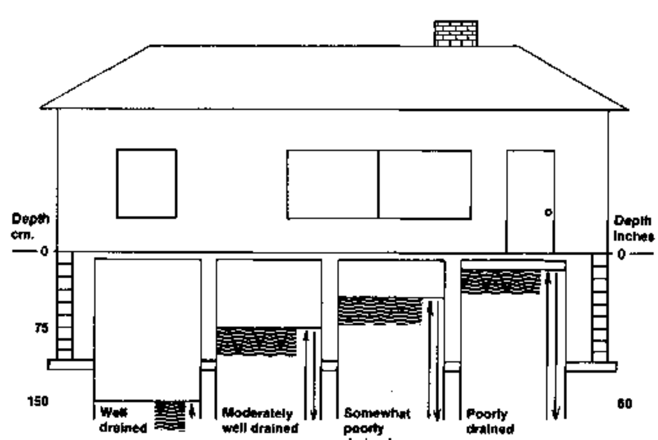


Fig. 4. Suitability of each natural drainage class for dwellings with basements.

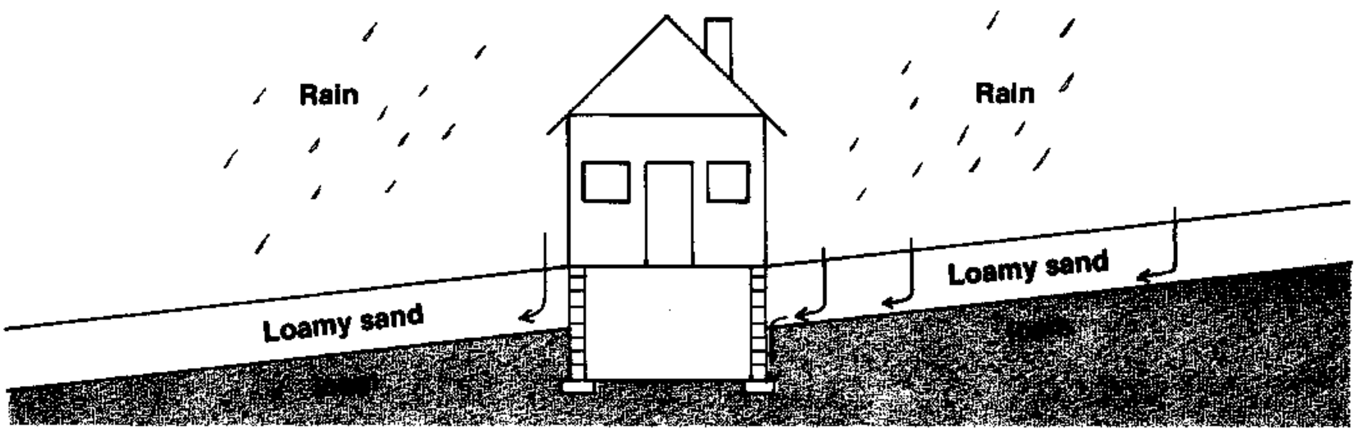


Fig. 5. Limitations for dwellings with basements caused by lateral movement of runoff and soil moisture.

Lateral movement by runoff and soil moisture can result in wet basements if the basement intercepts the natural flow of the water (Fig. 5). If you are aware of this prior to building, structural modifications can overcome the problem.

The ability of soil materials to support small commercial or residential buildings varies greatly. The bearing strengths of soils are evaluated in the soil survey report. Figure 6 illustrates that organic soil material should be avoided as a building site because of its poor ability to support the building along with wetness and subsidence problems.

Some common soil limitations that influence the performance of septic tank absorption fields are illustrated in Figure 7. Well-drained sandy loam soil (Fig. 7a) has no problems or only slight limitations for a septic tank absorption field. Effluent will move uniformly through this soil type. If a soil has a slowly permeable layer, effluent will move downward to the layer, then it will tend to flow horizontally (Fig. 7b) possibly causing seepage in road ditches or on hill slopes. Gravelly sand below the tile in the absorption field (Fig. 7c) is a poor filter of effluent, thus contamination of ground water may occur. If bedrock occurs below the line (Fig. 7d), effluent will flow horizontally until it reaches a crack; it then will flow into the bedrock. Bedrock is also a poor filter, possibly fostering contamination of ground water. The presence of a high water table also affects the performance of a septic tank absorption field (Fig. 7e). If the water table is below the tile, the effluent will move downward to the water table. Only the soil material below the tile and above the water table will filter the effluent. As a result, ground water may be polluted. If the water table is above the tile, effluent may move upward in the soil. The topsoil may become saturated with effluent causing a health hazard. Also, the water in soil may move through the tile into the septic tank causing sewage to back up into the house.

Consult the soil survey report before starting construction to see if the soils you are interested in building on have any of these problems. Many times modifications can be made during construction to minimize the problem, depending on the severity of the limitations.

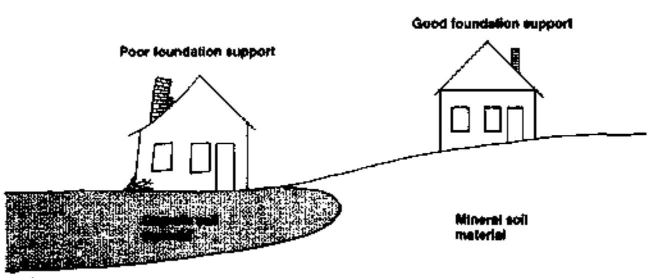
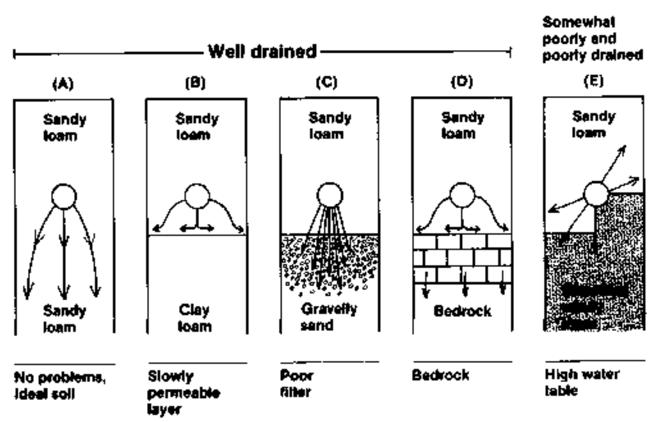


Fig. 6. Suitability of organic and mineral soils for building sites.



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