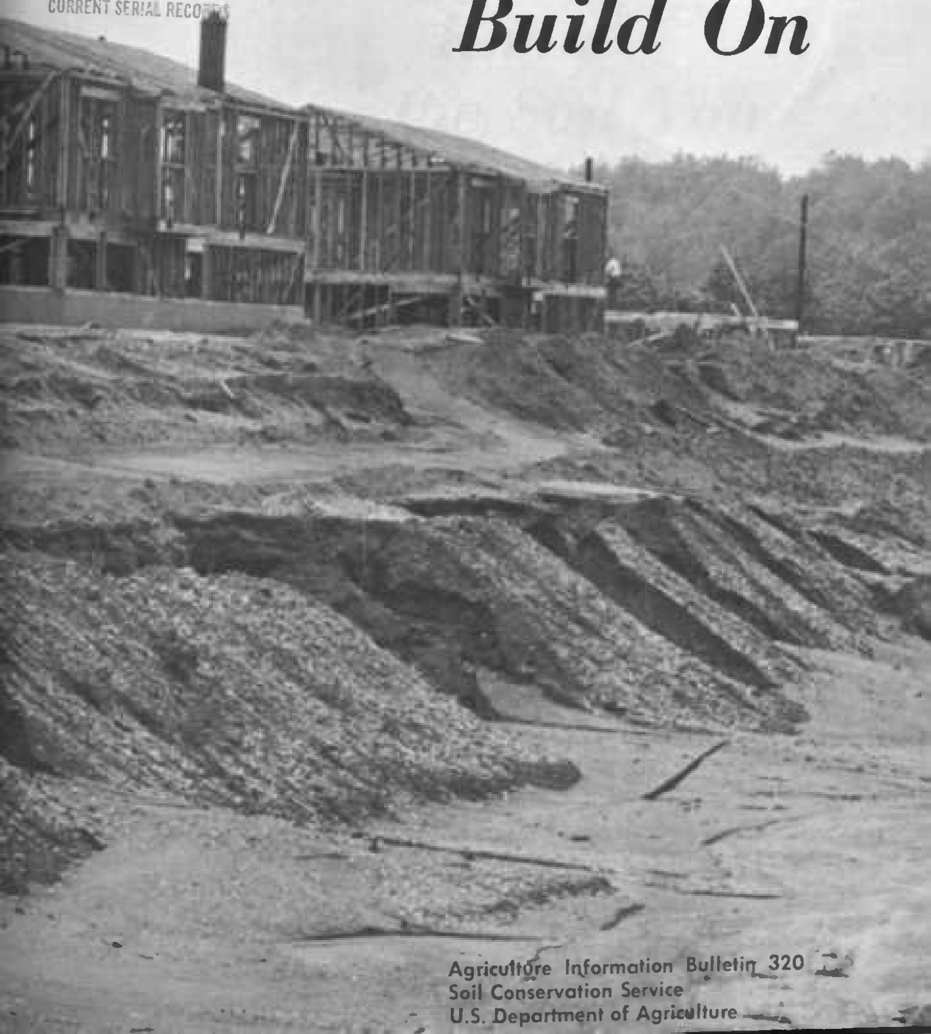
Know the Soil You Build On



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. . . *Dream House or Nightmare?*

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Know the Soil You Build On

By A. A. Klingebiel, *soil scientist, Soil Conservation Service*

You buy or build your dream house—after months of anxious looking, several visits to the bank, and hours of juggling costs, savings, and home needs.

The house has everything you think you need: beauty, nice location, satisfactory construction, modern conveniences, enough space, and a price you can almost afford.

So you move in anticipating, perhaps, some minor adjustments—the door may stick or the paint streak.

Then . . . the basement floods. The septic tank doesn't work. The foundation slips or cracks, a hillside slides down into your house, or your split level house really does split. Your dream house turns into an expensive nightmare.

It can't happen to *you*, you say—not after poring over blueprints, watching the construction daily, and meeting with your contractor, or after looking at dozens of houses before selecting one to buy. You were so careful to check everything.

Everything, that is, but the soil—the basic foundation of your house.

It can happen and it *has* happened to thousands of intelligent, prudent homeowners throughout the country. And down those ugly slips, cracks, and flooded houses often go the savings of a lifetime.

The home buyers looked at their houses from the foundations *up*, forgetting that underneath was soil. They forgot, or never knew, that different soils vary widely in their qualities and in their suitability for building purposes. In short, they ignored the soil on which they built or purchased their house.

If you are planning to buy or build a house, examine the soil carefully—*before* you buy or build, or ask a qualified specialist to do so.

What should you look for when considering where to buy or build? Among other things, ask yourself:

- Will the soil support my house without settling and cracking?
- What about the water table and the soil permeability? Can I dig a basement and keep it dry, or will it flood under certain conditions? Can I use a septic system, or does the soil absorb moisture so slowly that the effluent will come to the surface and cause a serious health hazard?
- Is the lot in a flood plain and subject to flooding from nearby waterways during a heavy storm?
- Is the lot on a hillside subject to slippage or severe soil erosion?
- Will the soil support grass, flowers, shrubs, and trees or is it "fill" or raw subsoil that needs added topsoil or special fertilizer and special care? Are certain parts of the lot best for certain uses—a swimming pool in a depressed area, a flower garden where the soil is good, or perhaps a rock garden on a soil poorly suited to most plants?

In general, the ideal soil for most uses is one that is more than 5 feet deep, moderately permeable to water, free from flooding or high water tables, and level to gently sloping. Such soils will generally support both buildings and growing plants.

With the abundance of good soils in the United States, it is obviously better to select a site with minimum building disadvantages than to try to correct troublesome—and costly—soil problems after construction has begun or been completed.

Of course, some soils *can* be changed if for some reason a poor site must be used. Soil poorly suited for growing most plants or for supporting foundations can be replaced with other soil material. Some plant can be found for almost any soil—but perhaps not one to your liking. Foundations can be designed to withstand the stresses. Problems caused by wetness can be overcome through drainage if there is some place to discharge the water. Slow soil permeability can be corrected for some uses by removing or altering the soil. But these changes can be costly; they can cost more than the original site.

To illustrate: The upper 5-inch layer of soil on a $\frac{1}{3}$-acre lot weighs about 250 tons. To make a soil pervious to water or roots may require changing it from one that is half clay to one that is one-fourth clay. This can be done by bringing in many tons of sandy or silty materials. But to buy, haul, and mix this new soil would skyrocket the cost. Many people add organic materials instead; this does improve the tilth, but it is only a temporary improvement and does not change the soil from clayey to loamy.

A good, hard scientific look at the soil before you buy or build may save you a great deal of grief—and money—afterwards!

Consider:

1. A sturdy looking brick house with a $30,000 mortgage was broken into bits when water seeped down to an impervious clay layer. The entire upper layer of the hillside became saturated and slid downhill—house and all. Ten other houses in this Washington, D.C., suburban area were also seriously damaged.

2. Eight disillusioned families have vacated their almost-new homes in a small Chicago suburb. The walls cracked, the doors and windows wouldn't open or close properly, and the entire foundations slipped out of line. Why? The houses were built on highly organic soil that acts like a sponge. As the water drained out, the organic matter decomposed and shrank and the building settled. Peat and muck soils are poor building sites.

3. Residents of a community in Lake County, Ill., had to leave in the middle of the night a few years ago as rising floodwaters threatened their homes. They had little time to remove their possessions before the rampaging river entered some 1,600 residences. Building contractors estimated structural damages at $1,100 a house—or a total of more than one and three-quarter million dollars—plus more hundreds of thousands of dollars for household furnishings and for cleaning up the mud.

4. A builder in Virginia was recently re-

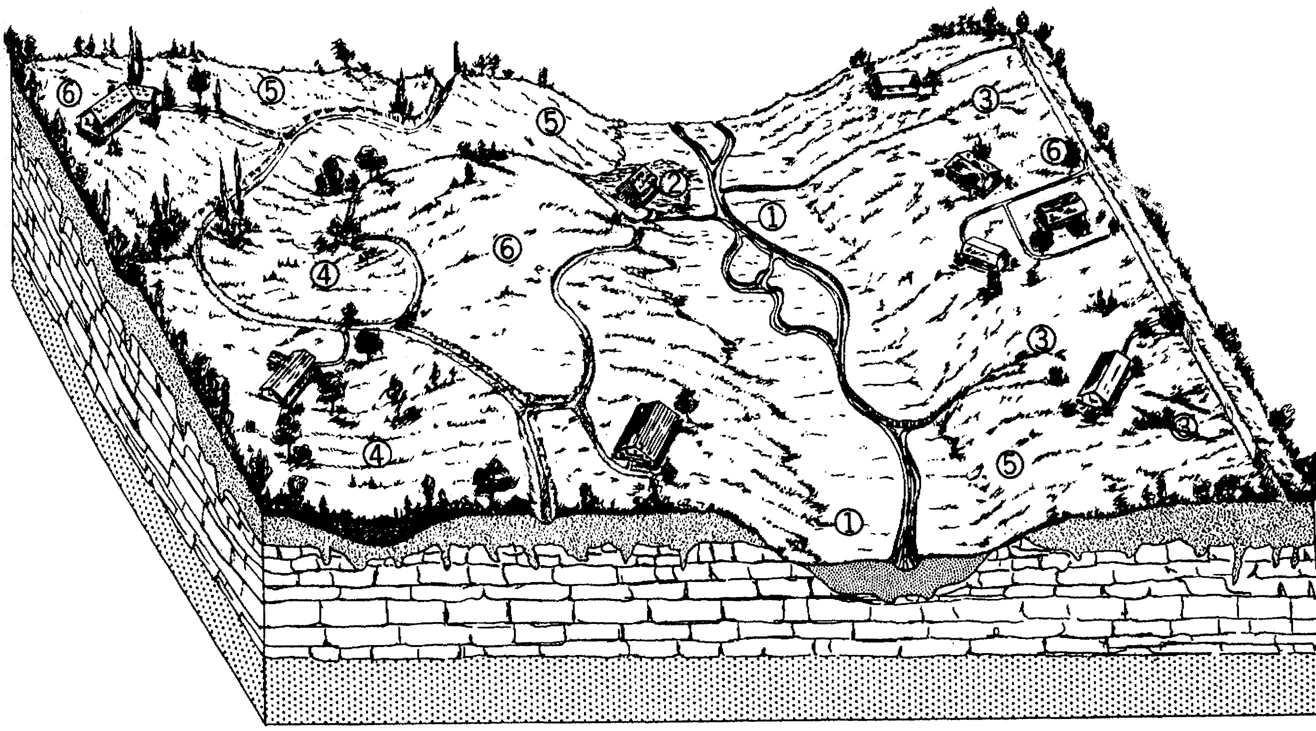


Figure 1.—Some common topographic positions:

Area 1 is a flood plain. It is subject to flooding during heavy storms. Ask yourself: If it should rain hard, where would the water flow in relation to the proposed house and site?

Area 2 is an alluvial fan. The soil has been forming over the years as a result of water eroding material from the watershed above and depositing it near the mouth of the waterway. An alluvial fan can be hard hit by flash floods after heavy rains unless an adequate water-disposal system has been provided to control the runoff from the watershed above.

Area 3 is an upland waterway where water flowing from the higher surrounding land will concentrate. Natural waterways should not be used unless an adequate ditch or diversion terrace has been constructed to divert water from the site.

Area 4 is a low depressed area where water accumulates from higher surrounding areas. These soils remain wet and spongy for long periods.

Area 5 is a steep hillside. Many soils on steep slopes are shallow to rock. Some are subject to severe slippage. On all slopes, one must be careful of soil movement through gravity or by water erosion. Yet some steep hillsides can be used safely as building sites. The problem can be solved by studying the soils and avoiding the bad ones.

Area 6 is a deep, well-drained soil found on ridgetops and gently sloping hillsides. Generally these areas have the smallest water-management problems. They are the best building sites, other things being equal.

fused occupancy permits for his three new $25,000 buildings. The soils absorbed water so slowly that on-site sewage-disposal systems could not be used without creating an intolerable health problem. Builders and homeowners lose millions of dollars annually because some of them assume the soils are suitable for sewage disposal where, in fact, they are not.

How can an individual choose good soils and a good location for his house? The most important rule might be: Read the clues written on the landscape itself.

Consider the topographic position of your prospective building area in relation to its surrounding landscape (fig. 1).

Figures 2-17 show examples of some soil problems that plague homeowners.

Figure 2.—These houses were built on a flood plain similar to that shown in figure 1, area 1. It is subject to periodic flooding. More than 10 percent of the land in the United States is subject to flooding, and millions of dollars worth of damage is done by floods every year. Much of this is along our thousands of small streams, not just near the large ones. Protective measures are costly and usually require community action.

Figure 3.—These flood-plain soils are always adjacent to a stream, ditch, or drainageway and are nearly level. Water may or may not be present in the waterway. You can judge the size of the flood plain by standing on a streambank and noting the width of the level area adjacent to the stream. If you dig in the soil, you usually find a dark surface layer but no naturally developed subsoil layers. Flood-plain soil is often uniform in texture (sand, silt, and clay content) down to 4 feet or so. In some places there are layers of coarse and fine materials.

Figure 4.—Soil with a high clay content often swells when wet and shrinks when dry, thus cracking foundations unless special provisions are made during construction. This soil can expand up to 50 percent between wet and dry conditions. In addition, it may have some of the other undesirable features described elsewhere.

Figure 5.—Unstable soil like this, which shrinks when dry and swells when wet, has a high clay content in the upper 3 to 4 feet. To check, press a small sample of the moist soil between the thumb and index finger. If it is clay, a ribbon forms. Such soil is fine textured, sticky when wet, commonly dark, and feels like putty. When dry, clay soil may have many cracks 2 to 4 inches wide and 10 to 20 inches deep. The surface may be sandy, silty, or clayey, underlain by dense plastic clay.

Figure 6.—Not all slopes are subject to slippage, but it is wise to doublecheck. Neither the builder nor the purchasers of these homes knew the soil would slip when it became saturated with water. To correct this problem costs a great deal and even then the results may be unsatisfactory.

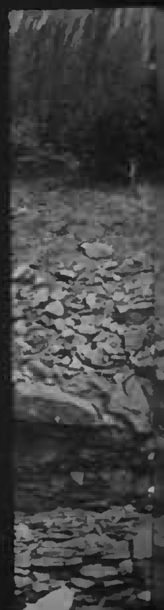
Figure 7.—Hillside slips occur on soils with a permeable surface 4 or more feet thick over a tight layer, usually clay or rock. Troublesome areas generally have a slope of 10 percent or more. You can be forewarned by studying adjacent undisturbed areas and noting any evidence of slips or steps from soil slipping down the slopes. Even in wooded areas you can see the natural slips if you look carefully. Road cuts or excavations may expose tight layers below. Soil and geology maps show potential slide areas.

Figure 8.—More than 20 houses costing about $20,000 each were built in a former swamp area with highly organic soil. The swamp had been drained, fill added, and a cement slab placed on deep piling. In 2 years, the soil around these houses had settled about 2 feet. The soil will continue to settle at about this rate for years to come. This problem is difficult and costly to correct.

Figure 9.—Deep organic soil can be detected b
It usually lies in low, swampy areas. Sedges an
or wet areas filled before construction should be
before purchase.

Figure 10.—Underground utilities, septic tanks, and basements all require excavation of the soil. Excavation costs for shallow soil over rock are 10 to 20 times greater than for deep mineral soil. Trees, shrubs, and grasses grow poorly on most soil shallow to rock because of too little room for roots and for storage of water and nutrients.

Figure 11.—Shallow soil over rock is rather easy to detect. Study nearby road cuts or excavations for rock or dig a hole in the soil and look.



...ows appearance, light weight, dark color, and spongy feel. ...water-loving grasses and trees grow on them. Soil like this ... examined by qualified specialists (soil scientists or engineers)

Figure 12.—Thousands of new houses are being built annually beyond existing municipal sewer lines. These areas must have on-site sewage disposal (see figure 13). Yet many soils do not absorb the effluent from a septic tank, and raw sewage is discharged as shown here. *This is a severe health hazard to the community.*

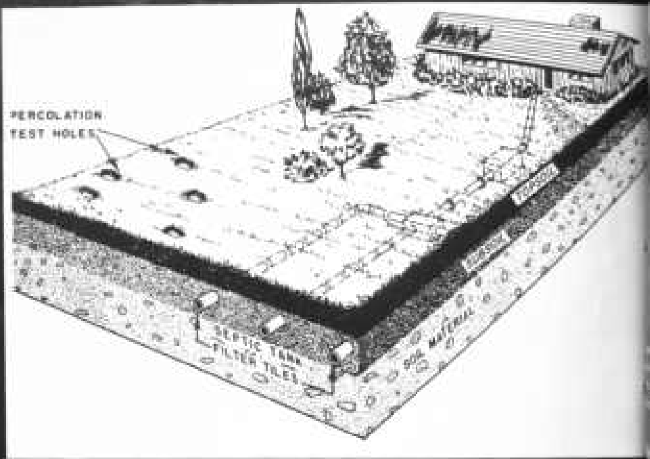


Figure 13.—Soil must absorb the effluent from the septic tank at a reasonable rate if a sanitary system is to be satisfactory. Deep, permeable, well-drained soils do this. On-site determinations of a soil's suitability can be made by digging pits when the soil is moist (at field capacity) and pouring water in to determine the absorption rate. Details of this method can be learned from your health department or from the publication "Soils Suitable for Septic-Tank Filter Fields," USDA Agriculture Information Bulletin No. 243. Tight layers, hard rock, or seasonal high water tables in the upper 4 feet of a soil make it unsuitable for on-site sewage disposal. Wet seepy areas, deep green lush grass, or water-loving plants over the prospective sewage filter field are indications that the soil is not likely to be suitable for sewage disposal.

Figure 14.—Soil with a permanent or seasonal high water table causes problems for on-site sewage disposal, for underground utilities, and for basements. A high water table usually means special building foundations for stability.

Figure 15.—Soil that is wet part of the time can be easily identified during wet periods by water standing on or near the surface. Most wet soil has a dark surface layer followed by layers of medium to light gray. The gray may be splotched with orange, yellow, and rust. During dry periods, you can check by digging a hole 3 to 4 feet deep to see the color and to see if water seeps in from the bottom and sides.

Figure 16.—To build on hillsides requires additional excavation for a solid foundation. Except for extremely steep slopes, however, runoff and erosion can be controlled with proper soil and water conservation practices. On most slopes that have clayey soil it is difficult to establish a good cover of grass and trees.

Figure 17.—Soil with a high erosion hazard is easy to detect. Generally, the steeper the slope, the greater the erosion hazard. Yet there are many exceptions. Even on gentle slopes, soil with shallow open surface layers over tight layers is susceptible to severe erosion. Shallow droughty soil that supports poor vegetation is likely to erode and is generally undesirable for homesites.

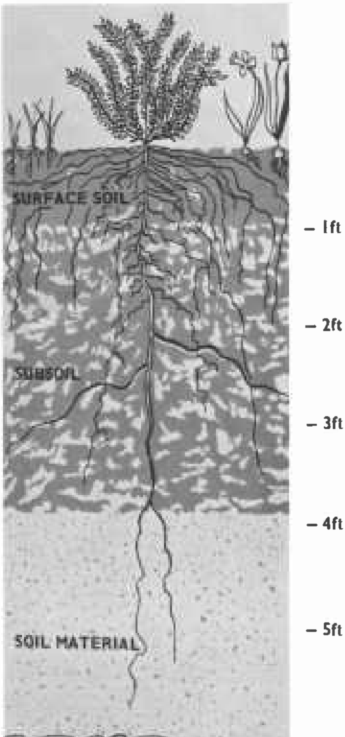


Figure 18.—Most soils are made up of contrasting layers soil scientists call horizons.

From the illustrations, it is clear that this country has numerous kinds of soil—more than 70,000—varying widely in their uses and characteristics (fig. 18). It is a major function of soil scientists in the Soil Conservation Service, U.S. Department of Agriculture, and coperating agencies to classify, to map, and to describe soils so that they may be used for their best purposes.

USDA soil scientists, in cooperation with State agricultural experiment stations and other agencies, have been at this work since 1899. Their soil surveys contain valuable information intended in the beginning mainly for farmers. Now they are widely used by developers, contractors, government planners, highway engineers, and individual homeowners as well. The same soil properties concern most soil users.

About 45 percent of all privately owned land in the United States has been surveyed. Many of the soil surveys are modern and up to date; many of those more than 25 years old are still useful for general land use planning but do not have all the detailed information needed for current interpretations.

It is entirely possible that the land you are considering buying has a soil survey. If so, it may be seen in the office of the local soil conservation district or the county extension service.

Soil scientists (fig. 19) are experts with years of experience in studying soils and interpreting soil properties for many uses. They walk over the land and, using various tools, stop frequently to dig into the soil and study its properties. They describe, name, and classify the soils according to a national classification system. Their field work is supported by laboratory examinations of samples of the soil layers. Soil boundaries and symbols are plotted on high-quality aerial photos (fig. 20). These lines and symbols show the location and extent of different soils. Soil descriptions and their interpretations are prepared to accompany the soil map. Soil scientists and other specialists use this information to advise on safe uses of the soil.

Traditionally, soil surveys have been used to identify farmland and to match suitable

Figure 19.— A soil scientist examines the soil, identifies it, and draws its boundaries on an aerial photograph.

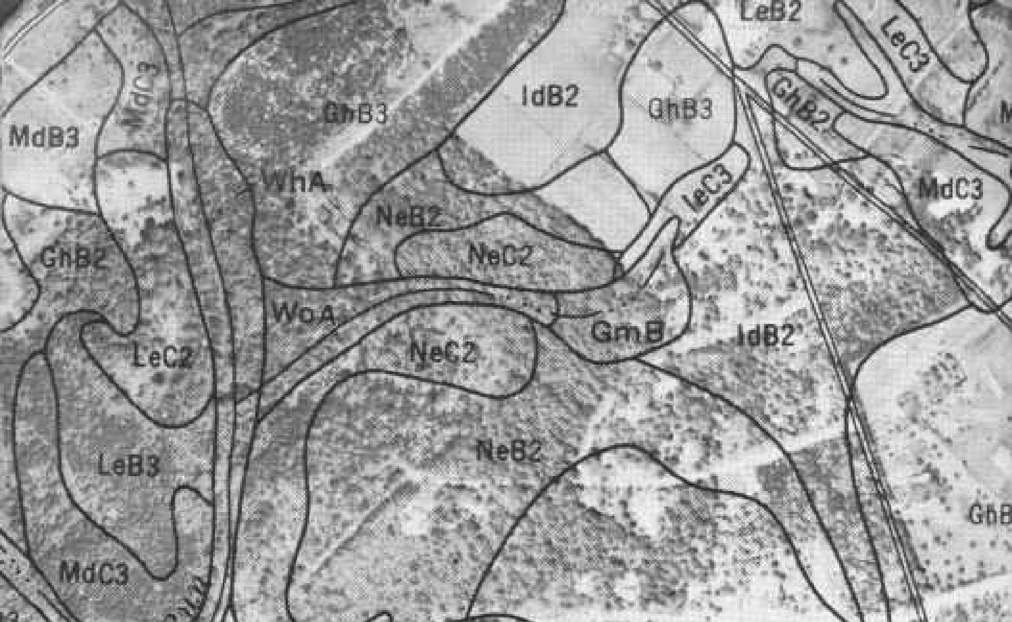


Figure 20.—Part of the soil map of Montgomery County, Md. The symbols indicate the different soils and the solid lines show the extent of each. WhA is a flood-plain soil (see figure 1, area 1) and presents the kind of problem shown in figures 2 and 3. WoA, a wet soil in upland drainageways, is similar to those shown in figure 1, areas 2 and 3; water from higher surrounding areas runs off and concentrates in the natural drainage courses, resulting in frequent flooding. IdB2, because of a dense layer of clay that is very slowly permeable to water and has a high shrink-swell potential, has problems similar to those shown in figures 4, 5, 12, and 13. LeB2, LeB3, LeC2, and LeC3 are shallow to rock and some have lost all original surface soil. The problems are similar to those shown in figures 10 and 11. Soil and water conservation practices to control erosion and reduce runoff are needed on all the steeper slopes, shown by C and D in the map symbol. They also require more excavation for construction and great care in installing filter fields for the effluent from septic tanks. The severely eroded areas, shown by a 3 in the map symbol, may need topsoil for good lawns and gardens.

land areas with suitable crops, vegetation, and soil and water conservation practices. But it was soon learned that the basic principles of soil behavior the farmer needs to know are also useful to many others. Now soil surveys are extensively used by both rural and urban people.

In fact, soil maps are especially important for urban users. If a farmer uses a soil in the wrong way he may suffer losses that year but he can adjust the next year. But an urban user can hardly do that if his "crop" on the land is a cracking superhighway or a sinking schoolhouse. These kinds of "crop failures" are followed by years of unusable or damaged roads and buildings and high taxes for maintenance.

Soil surveys show soil wetness, overflow hazards, depth to rock, hardpans, tight layers, erodibility, clay layers that crack when wet and swell when dry, and the hazard of slippage on slopes. They show the location and extent of different soils and provide information about their properties to a depth of about 6 feet.

For good living without excessive costs and taxes, advanced community planning is becoming more and more necessary. Such planning requires accurate knowledge of the available soils and their alternative potentials.

Estimates by community planners of the value of soil surveys for site selections run as high as $2 million per year per county for counties with rapid increases in population. Some communities report savings of one-quarter of a million dollars by choosing the right site for a school building. Specifically:

1. A developer in southeastern Wisconsin bought 80 acres which he divided into 60 lots. Each lot was to have an $18,000 house. The local board of health, using a soil survey, inspected the site and rejected 58 of the 60 lots because of poor soil conditions. The estimated savings to the community was about $1 million.

2. The planning board of Millis, Mass., estimates that soil-survey information will save the community around half a million dollars in its school building program. Soil surveys provide an inventory of suitable sites prior to purchase. This can save costs for land preparation and building foundations. Substantial savings are anticipated for other uses of the soil survey.

3. San Antonio, Tex., has many soils that are poor for building purposes. It costs between $1,000 and $1,500 more to put down a minimum house foundation in some San Antonio soils than it does in soils with good bearing strength. They shrink when dry and swell when wet and this makes it difficult to build and maintain good roads and underground utilities. Using a soil map, contractors and builders can either avoid these high shrink-swell areas or design their structures with the extra strength needed. This has saved them many thousands of dollars annually.

4. The Southeastern Wisconsin Regional Planning Commission estimates savings to local citizens of more than $300 million on housing alone in southeastern Wisconsin during the next 25 years through the use of soil surveys. Additional savings in other land uses are also expected.

The more that soil surveys and soil interpretations are used by builders and construction companies, the less will be the chance that any future house of yours will go off in floods or down in cracks.

As an individual home buyer or builder, you may spend months checking and considering the design, materials, and construction of your new home. You should be equally concerned about the soil underneath. The soil you build on can seriously affect the stability of your home, your repair bills, your comfort, and the resale value of your property.

If you buy or build a house, or do extensive landscaping on your present one, it will pay you to check on whether your area has a soil map and to have that map interpreted for you.

Soil maps made by soil scientists do not eliminate the need for on-site sampling and testing of soils for design or construction of specific engineering works.

The right soil can go a long way toward insuring you the house of your dreams. The wrong soil can wreck your house and your bank account.

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